BEVA CONGRESS
12-15 September 2018
ICC, Birmingham, UK

Handbook of Presentations
BEVA CONGRESS
11th - 14th Sept 2019, Birmingham, UK

Where the world’s equine vets come together
How can you best help a client with an overweight pony?

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End of Life

Disease prevention

Laminitis

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Disclaimer: The authors, editors and publishers do not accept responsibility for any loss or damage arising from actions or decisions based on information contained in this publication or presented at Congress. Ultimate responsibility for the diagnosis and treatment of patients and interpretation of published material lies with the veterinary surgeon managing a case.
Welcome to BEVA Congress 2018

BEVA Congress is back at the popular ICC, Birmingham and we have plenty to smile about with an exceptional scientific programme, a packed exhibition hall and superb socials.

The Congress Committee, chaired by David Rendle, have worked extremely hard over the last 12 months to plan a programme that is flamboyant, colourful and potentially unpredictable. They’ve done a fantastic job of thinking outside of the box and come up with a congress programme that not only includes something for everyone but features world-renowned speakers from all four corners of the globe. Our programme will see speakers contribute to seven sessions which offer state-of-the-art updates as well as some instruction on fundamental skills and group discussion of difficult areas.

This year’s Plenary lecture will be given by a good friend of mine, Juan Samper who will discuss the challenges and opportunities in equine practice. I am looking forward to hearing his perspective on why the profession is at a junction and how to face some of the major challenges we have ahead of us.

Maybe unsurprisingly, you will see breeding horses are taking centre stage in this year’s scientific programme. With leading names in equine reproduction, including the likes of Harald Sieme, Dickson Varner, Juan Samper and Margo Macpherson, I can assure you the discussions around stallions, semen processing through to preparing mares, dealing with twins and coping with foaling and more will be ones not to miss.

We’ve complemented the sessions on breeding with a focus on neonatology and I’m excited to tell you that you will be able to hear from experts including Peter Morresey, Nathan Morresey, Bettina Dunkel and Emily Haggett. Back by popular demand, the medicine stream also features Nicola Pusterla who will provide an update on different infectious diseases.

In 2018 we have gone further than ever before in addressing the non-clinical aspects of being a veterinary surgeon. With a session on thriving in practice and another focusing on the changing times of veterinary practice with speakers from parliament, Defra, the RCVS, NGOs, vet schools and BEVA itself they will give different perspectives on where we are and where we need to be as the world changes around us. And, there is a whole stream focused on practice management covering everything from finance and profitability through to marketing and succession planning.

With so much happening within the scientific programme, let’s not forget about the exhibition hall. The demonstration area will be busy almost continually and provides an alternative to lectures for delegates who want to get more hands on and are looking for an opportunity for one-to-one discussion and practical help from renowned experts in their field. I would also encourage you to look around the exhibition hall at some of the latest products and services available from our fantastic exhibitors. Don’t forget to visit the exhibition hall on Friday where the demonstration area will be taken over by actors, giving you the opportunity to practice managing the difficult situations we often encounter in equine practice.

BEVA Congress wouldn’t be complete without our unrivalled socials, and this year I’ve made sure they will be bigger and better than ever before. The focus for my presidential year has been about reminding everyone about the positives of being an equine vet so I want to make sure we can celebrate our profession with everyone.

Lastly, I would like to take this opportunity to thank the whole Congress Committee for all their hard work over the last year to put together an outstanding programme, as well as a huge thank you to everyone else who has been busy behind the scenes including the fantastic staff at BEVA HQ, who without them Congress really wouldn’t happen.

The only thing that is left to say is have a great Congress! (and don’t forget to save the date for next year, 11-14 September 2019).

Jon Pycock
BEVA President 2018
CONGRESS COMMITTEE

David Rendle
BVSc MVM CertEM(IntMed) DipECEIM MRCVS
Congress Chair

James Crabtree
BVM&S CertEM(StudMed) MRCVS

Andrew Fiske-Jackson
BVSc MVetMed FHEA DipECVS MRCVS

Kristopher Hughes
BVSc(Hons) FANZCVS DipECEIM

Colin Mitchell
BVM&S CertEP CertVBM MRCVS

Richard Reardon
BVSc MVM CertEM(IntMed) DipECEIM MRCVS

Michael Schramme
DrMedVet CertEO PhD HDR DipECVS DipACVS AssocECVDI
The British Equine Veterinary Association gratefully acknowledges the support of all companies who are taking part in the Commercial Exhibition, which not only provides considerable financial input to Congress but also enables delegates to see the vast range of products of specific interest to the equine veterinary profession.

In addition we are very much indebted to the following companies and organisations for their specific sponsorship.
**BEVA Journals**  
Sponsors of the Endocrinology Session (Thurs Hall 9 Session 1), Ophthalmology Session (Thurs Hall 9 Session 3), News Hour Session (Thurs Hall 1 Session 4) and Neonatology: State of the Art Discussions Session (Fri Hall 8B Session 2)

**BEVA Trust**  
Sponsors of the BEVA Trust Peter Rossdale EVJ Open Award

**Blue Cross**  
Sponsors of the BEVA/Blue Cross Equine Welfare Award

**CVS Equine**  
Advertising

**Hallmarq Veterinary Imaging**  
Sponsors of the Fetlock Session (Thurs Hall 1 Session 1) and the Feet and Farriery: Foot Lameness Session (Sat Hall 1 Session 1)

**Horserace Betting Levy Board (HBLB)**  
Sponsors of the John Hickman Memorial Plenary Lecture (Thurs Hall 1 Session 2), the Cardiology Session (Fri Hall 10 Session 1), the Fractures Session (Fri Hall 1 Session 3), the Orthopaedic Imaging Session (Fri Hall 1 Session 4), the Upper Airway Disease Session (Sat Hall 9 Session 2), the Infectious Diseases We Should All Know About Session (Sat Hall 9 Session 3), all of the Clinical Research Sessions and the provision of a Free HBLB Online Education Package (post event)

**IMV Imaging**  
Sponsors of the EVJ Literary Award for Video Abstracts and Practical Demonstration Area Equipment Provider

**MSD Animal Health**  
Sponsors of the Student Stewards and Advertising

**PG Mutual**  
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**Pool House Equine Clinic**  
Practical Demonstration Area Equipment Provider

**Rossettes LLP**  
Umbrella Sponsor of the Practical Demonstration and Advertising Sponsor

**Stablelab**  
Sponsors of the Respiratory Disease Session (Fri Hall 10 Session 2) and the Neonatology Session (Fri Hall 8b Session 1)

**The Horse Trust**  
Sponsors of the Adapting to Changing Times Session (Fri Hall 1 Session 2), the Farriery Solutions Session (Sat Hall 1 Session 3), the Responsible use of Medicines in Practice Session (Fri Hall 10 Session 3), the Dentistry Session (Sat Hall 5 Session 4), the Infectious Disease: OMG Moments Session (Sat Hall 9 Session 4), the General Emergencies Workshop (Sat Hall 10 Session 4), the BEVA Staff Uniform and the Awards Lunch

**Twemlows Stud Farm**  
Sponsors of the Reproduction Stream: Non Pregnant Mare, Twin Management and Mare and Foal (Thurs Hall 5 all day)

**Virbac UK**  
Sponsor of the Joints and Bursae Session (Thurs Hall 1 Session 3)

**World Horse Welfare**  
Advertising

**Wiley**  
Sponsors of the BEVA Clinical Practice Guidelines Session (Sat Hall 10 Session 1)
Scientific Programme

THURSDAY 13 SEPTEMBER

**ENDOCRINOLOGY**
Chair: John Keen
Sponsor: BEVA Journals

8.30 Diagnosing PPID: art or science? David Rendle
8.50 EMS: what test and what does it mean? Harry Carslake
9.10 Tackling the obesity epidemic Caroline Argo
9.30 When nutritional management of obesity fails... Mark Bowen
9.50 Discussion

**PRACTICE FINANCE**
Chair: Colin Mitchell

8.40 Starting a new equine practice: will it work for me? Nicola Mason
8.55 Benchmarking and what it helps make Harry Harkness
9.00 Raising capital – funding that new project Mark Tabachnik
9.25 Monitoring and maximising the bottom line Simon Biles
9.50 Discussion

**CLINICAL RESEARCH**
Chair: Tim Mair
Sponsor: HBLB

Epidemiology
8.30 UK horse-owners and their horse’s health - a snapshot of the provision of veterinary services in equine practice S. Allen
8.40 Outcome of critical out-of-hours cases in one veterinary hospital J. Lightfoot
8.50 Impact of owner educational resources K. Lightfoot
9.00 Bossecure on British culture A. Redpath
9.30 Telephone triage of colic cases C. Hodgkinson
9.40 Discussion

**THE NON-PREGNANT MARE**
Chair: Andrew Richardson
Sponsor: Twemlows Stud Farm

8.30 Managing mares for natural cover Andrew McGladdery
8.50 Stimulating early season cyclicity John Spencer
9.10 Seasonal/lactational anoestrus Charles Cooke
9.30 Managing mares for chilled and frozen semen Tom Stout
9.50 Discussion

**THE FETLOCK**
Chair: Michael Schramme
Sponsor: Hallmarq Veterinary Imaging

8.30 Short, incomplete fractures of the proximal phalanx in the sport horse Anton Fürst
8.50 Sagittal groove osseous trauma of the proximal phalanx – a distinct injury in the sport horse? Ellen Singer
9.10 Prevention and screening of metacarpal condylar injuries in racing Thoroughbreds John Peloso
9.30 Surgical management of marginal tears of the suspensory ligament branches in Thoroughbred racehorses Ian Wright
9.50 Discussion

**THE JOHN HICKMAN MEMORIAL PLENARY LECTURE**

10.30 Challenges and opportunities in equine practice Juan Samper

**OPENING ADDRESS**

12.00 Opening address Jonathan Pycock

12.15 BEVA AWARDS
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<tr>
<th>Time</th>
<th>Session Title</th>
<th>Speaker(s)</th>
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<tr>
<td>17.00</td>
<td>Happy Hour</td>
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<tr>
<td>17.30</td>
<td>Endocrinology/The autophagy</td>
<td>Tim Mair, Babs Anthony, Richard Hepburn</td>
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<td>17.45</td>
<td>Ultrasound-guided twin reduction</td>
<td>Richard Reardon, Neil Townsend, Patrick Pollock</td>
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<td>17.50</td>
<td>Clinical signs and clinical significance in equine disease</td>
<td>Richard Reardon, Neil Townsend, Patrick Pollock</td>
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<td>18.00</td>
<td>Induction of lactation</td>
<td>Madeleine Campbell</td>
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<td>18.10</td>
<td>Medication in the pregnant mare and foal</td>
<td>Peter Daels</td>
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<td>18.45</td>
<td>Event planning for equine events</td>
<td>Anne-Marie Svendson Aylott, Nikki Driscoll</td>
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<td>18.50</td>
<td>The marketing mix: what is it and how do you make it stick?</td>
<td>Ben Sykes, Peter Daels, Jane Manning</td>
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<td>19.00</td>
<td>Social media: why should I do it? and how do I write one?</td>
<td>Michelle Dearby, Mark Bowen, Ben Sykes</td>
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<td>19.10</td>
<td>Impact vibration in military horses</td>
<td>Simon York, Charlie Dancer, Eoin Tennyson</td>
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<td>19.30</td>
<td>The marketing mix: will it work? and how do I know?</td>
<td>Michelle Dearby, Mark Bowen, Ben Sykes</td>
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<td>19.40</td>
<td>Veterinary nurse registered to be Hex 2.5</td>
<td>Karen Brown, Elizabeth Williams, Michelle Dearby</td>
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<td>20.00</td>
<td>Medical and nursing aspects</td>
<td>Karen Brown, Elizabeth Williams, Michelle Dearby</td>
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<td>20.10</td>
<td>The VNB: the role of the veterinary nurse in the hospital setting</td>
<td>Karen Brown, Elizabeth Williams, Michelle Dearby</td>
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Scientific Programme
FRIDAY 14 SEPTEMBER

**HALL 1**

**POOR PERFORMANCE INVESTIGATION**
Chair: Will Barker
- 8.30 The role of ridden lameness evaluation
  - Elizabeth Davidson
- 8.50 Evaluation of the ‘sore backed horse’ – is an objective evaluation possible?
  - Andrew Fiske-Jackson
- 9.10 The equine neck: diagnostic and treatment strategies
  - Elizabeth Davidson
- 9.30 Sacral sac injury – is objective evaluation actually possible?
  - Carolin Gerdes

**HALL 2**

**THE STALLION**
Chair: Harald Sieme
- 8.40 Ultrasound examination of the stallion Juan Samper
  - Dickson Varner
- 9.00 Managing penile and preputial injuries and abnormalities
  - Dickson Varner
- 9.20 Post-mortem epididymal sperm extraction
  - Tullis Matson
- 9.40 International trade of equine semen
  - Huw Griffiths

**HALL 3**

**SARCOIDS**
Chair: Shaun McKane
- 8.30 Radiotherapy
  - Anna Hollis
- 8.40 Electro-chemotherapy
  - Moses Brennan
- 8.50 Laser therapy
  - Richard Payne
- 9.00 Caspian and bleomycin
  - Yvonne Elke
- 9.10 Antiviral drugs
  - Mark Bowen
- 9.20 Endocarditis and pericarditis
  - Celia Marr
- 9.40 New frontiers in equine cardiology
  - Gunther van Loon

**HALL 4**

**CARDIOLOGY**
Chair: Kristopher Hughes
- 8.40 Updates in echocardiography
  - John Keen
- 9.00 ECG interpretation
  - Mark Bowen
- 9.20 Endocarditis and pericarditis
  - Celia Marr
- 9.40 New frontiers in equine cardiology
  - Gunther van Loon
- 9.50 Talk and discussion

**HALL 5**

**ORTHOPAEDIC SURGERY**
Chair: Christoph Lischer
- 11.00 What is the current best approach to treatment of subchondral cyst-like injuries?
  - Anton Fürst
- 11.20 Decision making with OCD fragments – significance and management
  - John Petito
- 11.40 Management of penetrating injuries to the calcaneal bursa
  - Ellen Singer
- 12.00 Orthopaedic surgery – can we make it safer?
  - Bruce Blandon
- 12.20 Discussion

**HALL 6**

**SEMEN PROCESSING**
Chair: James Crabtree
- 10.50 General principles of semen evaluation
  - Dickson Varner
- 11.10 Which semen extender?
  - Harald Sieme
- 11.30 When is semen processing necessary?
  - Dickson Varner
- 11.50 Sperm selection and concentration techniques
  - Marco Alvarenga
- 12.10 Discussion

**HALL 7**

**ADAPTING TO CHANGING TIMES**
Chair: Neil Hudson
- 10.40 A view from the House of Commons: Angela Smith MP
  - Graeme Cooke
- 11.00 A view from BEVA
  - David Mountford
- 11.20 A view from the RVCS
  - Chris Tuffnell
- 11.35 A view from Defra
  - Gainer Cooke
- 11.50 A view from the NGOs
  - Roly Owers
- 12.05 A view from the vet schools
  - Mark Bowen
- 12.20 Discussion

**HALL 8**

**NEONATOLOGY**
Chair: Sarah Smith
- 10.30 Neponatal neurological disease
  - Nathan Slovis
- 10.50 A view from the NGOs
  - Nicola Pusterla
- 11.10 A view from Defra
  - Ellen Singer
- 11.35 A view from the vet schools
  - Dickson Varner
- 11.50 A view from the NGOs
  - Emily Haggett
- 12.20 Discussion

**HALL 9**

**SARCOIDS**
Chair: Shaun McKane
- 8.30 Radiotherapy
  - Anna Hollis
- 8.40 Electro-chemotherapy
  - Moses Brennan
- 8.50 Laser therapy
  - Richard Payne
- 9.00 Caspian and bleomycin
  - Yvonne Elke
- 9.10 Antiviral drugs
  - Mark Bowen
- 9.20 Endocarditis and pericarditis
  - Celia Marr
- 9.40 New frontiers in equine cardiology
  - Gunther van Loon

**HALL 10**

**CARDIOLOGY**
Chair: Kristopher Hughes
- 8.40 Updates in echocardiography
  - John Keen
- 9.00 ECG interpretation
  - Mark Bowen
- 9.20 Endocarditis and pericarditis
  - Celia Marr
- 9.40 New frontiers in equine cardiology
  - Gunther van Loon
- 9.50 Talk and discussion

**HALL 11**

**ORTHOPAEDIC SURGERY**
Chair: Christoph Lischer
- 11.00 What is the current best approach to treatment of subchondral cyst-like injuries?
  - Anton Fürst
- 11.20 Decision making with OCD fragments – significance and management
  - John Petito
- 11.40 Management of penetrating injuries to the calcaneal bursa
  - Ellen Singer
- 12.00 Orthopaedic surgery – can we make it safer?
  - Bruce Blandon
- 12.20 Discussion

**HALL 12**

**SEMEN PROCESSING**
Chair: James Crabtree
- 10.50 General principles of semen evaluation
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- 11.10 Which semen extender?
  - Harald Sieme
- 11.30 When is semen processing necessary?
  - Dickson Varner
- 11.50 Sperm selection and concentration techniques
  - Marco Alvarenga
- 12.10 Discussion

**HALL 13**

**ADAPTING TO CHANGING TIMES**
Chair: Neil Hudson
- 10.40 A view from the House of Commons: Angela Smith MP
  - Graeme Cooke
- 11.00 A view from BEVA
  - David Mountford
- 11.20 A view from the RVCS
  - Chris Tuffnell
- 11.35 A view from Defra
  - Gainer Cooke
- 11.50 A view from the NGOs
  - Roly Owers
- 12.05 A view from the vet schools
  - Mark Bowen
- 12.20 Discussion

**HALL 14**

**NEONATOLOGY**
Chair: Sarah Smith
- 10.30 Neponatal neurological disease
  - Nathan Slovis
- 10.50 A view from the NGOs
  - Nicola Pusterla
- 11.10 A view from Defra
  - Ellen Singer
- 11.35 A view from the vet schools
  - Dickson Varner
- 11.50 A view from the NGOs
  - Emily Haggett
- 12.20 Discussion

**HALL 15**

**ORTHOPAEDIC SURGERY**
Chair: Christoph Lischer
- 11.00 What is the current best approach to treatment of subchondral cyst-like injuries?
  - Anton Fürst
- 11.20 Decision making with OCD fragments – significance and management
  - John Petito
- 11.40 Management of penetrating injuries to the calcaneal bursa
  - Ellen Singer
- 12.00 Orthopaedic surgery – can we make it safer?
  - Bruce Blandon
- 12.20 Discussion

**HALL 16**

**SEMEN PROCESSING**
Chair: James Crabtree
- 10.50 General principles of semen evaluation
  - Dickson Varner
- 11.10 Which semen extender?
  - Harald Sieme
- 11.30 When is semen processing necessary?
  - Dickson Varner
- 11.50 Sperm selection and concentration techniques
  - Marco Alvarenga
- 12.10 Discussion

**HALL 17**

**ADAPTING TO CHANGING TIMES**
Chair: Neil Hudson
- 10.40 A view from the House of Commons: Angela Smith MP
  - Graeme Cooke
- 11.00 A view from BEVA
  - David Mountford
- 11.20 A view from the RVCS
  - Chris Tuffnell
- 11.35 A view from Defra
  - Gainer Cooke
- 11.50 A view from the NGOs
  - Roly Owers
- 12.05 A view from the vet schools
  - Mark Bowen
- 12.20 Discussion

**HALL 18**

**NEONATOLOGY**
Chair: Sarah Smith
- 10.30 Neponatal neurological disease
  - Nathan Slovis
- 10.50 A view from the NGOs
  - Nicola Pusterla
- 11.10 A view from Defra
  - Ellen Singer
- 11.35 A view from the vet schools
  - Dickson Varner
- 11.50 A view from the NGOs
  - Emily Haggett
- 12.20 Discussion
BEVARewards Excellence

Each year BEVA presents awards to the brightest and best in equine veterinary medicine to honour their outstanding contributions in the field.

The BEVA Equine Welfare Award sponsored by the Blue Cross

The winner of this year’s prestigious BEVA Equine Welfare Award, sponsored by the Blue Cross is Dr Peter D. Rossdale OBE, FRCVS.

There surely have been no veterinary surgeon of our times who has done as much to promote education for forum and discussion.

As agreed and shared by the British Equine Veterinary Association the best way to improve welfare of the horse is via continuing education of equine veterinary surgeons and the allied sciences and professions. Providing such education and forums for discussion will help to tackle the welfare problems faced by equids both here in the United Kingdom and around the world.

Peter’s key achievements have helped to improve or ensure equine welfare. Working on stud farms around Newmarket in the 1950s stimulated his interest in the newborn foal when there was almost complete lack of knowledge of equine neonatal and paediatric medicine.

From practice he undertook some critical and extremely innovative studies including the recognition of a fascinating condition of convulsive foals, later known as Neonatal Maladjustment Syndrome. Peter became the leading figure in establishing equine perinatology as a scientific discipline, and in doing so stimulated research collaboration around the world.

Peter was editor of the Equine Veterinary Journal from 1980 to 2011 increasing its scientific rating and putting it in the top 10 of the world’s veterinary journals. In 1989 he launched Equine Veterinary Education and, during his tenure as editor, he saw it become the world’s leading journal for equine practitioners.

The BEVA Richard Hartley Clinical Award

The winner of this year’s award is Dr James Rushton for the paper “Effects of three blood derived products on equine corneal cells, an in vitro study” by J.O. Rushton, E. Kammergruber, A. Tichy, M. Egerbacher, B. Nell and S. Gabner. First published online in October 2017 and then in May 2018, Volume 50 of Equine Veterinary Journal.

The award is given in memory of Richard Hartley, a founder member of BEVA and President from 1974 to 1975. It is awarded to the senior author of the best paper published in Equine Veterinary Journal or Equine Veterinary Education with direct clinical application. The prize is intended to support travel of the senior author and/or co-authors.

The BEVA Trust Peter Rossdale EVJ Open Award

The winner of this year’s award is Miss Sarah Allen for the research study paper “Description of veterinary events and risk factors for fatality in National Hunt flat racing Thoroughbreds in Great Britain (2000-2013)” by S. Allen, S. Rosanowski, A. Stirk and K. Verheyen. First published online in February 2017 and then in November 2017, Volume 49 of Equine Veterinary Journal.

This award is given for the paper that best achieves EVJ’s mission to publish articles which influence and improve clinical practice and/or add significantly to the scientific knowledge that underpins and supports veterinary medicine in relation to the horse. The award is made by the BEVA Trust in recognition of Peter Rossdale’s immense contribution to BEVA and EVJ.

The Voorjaarsdagen and BEVA Awards

In 2005 the Voorjaarsdagen and BEVA Awards were introduced to mark the close relationship between the two Associations. The award is selected and presented biannually, once at the Voorjaarsdagen Congress and once at BEVA Congress and is open to all those presenting a Clinical Research paper.

This year’s BEVA Award winner is Inge J.M. Slenter for her paper on “Clinical ultrasonographic and histopathologic findings in seven horses with Descemet’s membrane detachment”. Inge’s presentation won the award at the Voorjaarsdagen Congress in April 2018; she will present it again during the Clinical Research Sessions at BEVA Congress.

The reciprocal Voorjaarsdagen Award winner will be selected from those presenting Clinical Research papers at this year’s BEVA Congress. Their prize will be free registration to Voorjaarsdagen Congress 2019 where they will have the opportunity to present their paper again.

The EVJ Literary Award for Video Abstracts

The winner of this new award is Dr Thomas van Bergen for the paper “Foramen epiploicum mesh closure (FEMC) through a ventral midline laparotomy” by T. van Bergen, A. Rötting, P. Wiemer, S. Schauvliege, K. Vanderperren, F. Ugahary and A. Martens. The article was published online in September 2017 and then in the March 2018, Volume 50, of Equine Veterinary Journal. The video abstract was available online in December 2017 and can be viewed here: https://vimeo.com/243828009.

This award sponsored by IMV Imaging, previously BCF Technology Ltd is given to the author who provides a video abstract which best communicates how their research is relevant to clinical practice and/or supports veterinary medicine in relation to the horse.

The Sam Hignett Award

All Clinical Research presentations from general equine practice are eligible for the Sam Hignett Award. A continuous process of assessment will take place throughout the Clinical Research Sessions and the winner of the award will be announced after Congress through the BEVA website and newsletter.

The Vet Practice Stand Awards

On the Thursday of Congress (during Happy Hour), awards will be presented to the Best Large Stand (free-design space) and Shell Scheme Stand (most imaginative use of shell) in the Commercial Exhibition. 

AWARDS
Marco Alvarenga
DVM MSc PhD
Marco has been professor of animal reproduction at the veterinary school of São Paulo State University (UNESP) in Botucatu, Brazil since 1989. He graduated in veterinary medicine from the Universidade Federal Rural do Rio de Janeiro in 1983 and went on to complete a residency in animal reproduction at UNESP in 1984, followed by an MSc in veterinary medicine in 1989 and a PhD in clinical pathology in 1996. He was a postdoctoral researcher and visiting scientist in the equine reproduction laboratory at Colorado State University, USA between 1997 and 1999 and scientific director of the Brazilian Association of Equine Practitioners from 2006 to 2018. He is a member of the International Equine Reproduction Symposium committee and the International Symposium on Stallion Reproduction committee. He has experience in equine theriogenology, focusing on mare infertility, stallion semen preservation and embryo transfer in horses. He is author and co-author of more than 100 scientific articles and has written several chapters in books on equine reproduction.

Jonathan Anderson
BVMS&D DipACVS MRCVS
Jonathan is a director and equine surgery clinician at the Rainbow Equine Hospital. He is an RCVS equine surgical specialist, a diplomate of the American College of Veterinary Surgeons and a Fédération Equestre Internationale accredited veterinary delegate (eventing). Jonathan graduated from the Royal (Dick) School of Veterinary Studies in 2000 and completed an internship at the San Luis Rey Equine Hospital, California, before moving back to the Rainbow Equine Hospital for 3 years. He completed an equine clinical fellowship at Oregon State Veterinary Teaching Hospital followed by an equine surgical residency at the University of California, Davis (UC Davis). He achieved diplomate status in 2008. He remained as a clinical instructor at UC Davis before moving back to the Rainbow Equine Hospital in 2009. Jonathan lectures and publishes on his main interests of orthopaedic surgery, poor performance and lameness diagnosis and has a specific interest in diagnosis and surgical treatment of cervical stenotic myelopathy.

Debra Archer
BVMS PhD CertES(Soft Tissue) DipECVS MRCVS PHEA
After graduating from the University of Glasgow in 1996, Debra worked in mixed practice in Bedfordshire for 2 years before undertaking a practice internship in Yorkshire. She completed residency training in equine surgery at the University of Liverpool in 2003 and then did a PhD on the epidemiology of equine colic at Liverpool. She is currently professor in equine surgery and head of equine surgery at the University of Liverpool. Debra’s interests include all areas of equine surgery, particularly surgery of the abdomen, head and neck, and laser surgery. Her research interests include epidemiology, equine gastrointestinal physiology and parasitology, veterinary sociology, vector biology and wound healing.

Caroline Argo
BSc BVSc PhD DipECAR MRCVS
Caroline is dean of faculty for Scottish Rural College’s (SRUC) Northern Region. Caroline graduated from the University of Aberdeen in 1981 with a BSc(Hons) in zoology. Her interests in ruminant metabolism and reproduction led to a PhD in 1985 from the Rowett Research Institute, funded by the University of Aberdeen’s Kilgour Scholarship. Postdoctoral research fellowships and a lectureship at the Universities of Leeds, Liverpool and the Zoological Society of London followed. During this time, her studies incorporated diverse work in deer, sheep and horses. Caroline returned to Liverpool, first as a lecturer then senior lecturer at Liverpool John Moores University before gaining her veterinary degree from the University of Liverpool in 2003. Caroline became a European specialist in animal reproduction, focused on equine reproduction, in 2005. She joined the University of Liverpool’s School of Veterinary Science as lecturer then senior lecturer in 2004, developing interests in equine metabolic and reproductive research before moving to the School of Veterinary Medicine at the University of Surrey in 2014 as professor in veterinary reproduction and head of department for veterinary clinical sciences. Caroline returned to Scotland in 2018 and continues to pursue interests in equine research.

Neal Ashton
BVetMed CertEP CertES(soft tissue) MRCVS
Neal qualified from the Royal Veterinary College in 1991, worked in mixed practice in Newcastle, then in equine practice in Kent and Sussex before joining the Oakham practice as surgeon and ‘leg man’ in 1998. He became a partner at Oakham in 2000 and was responsible for the development of the new Oakham Veterinary Hospital in 2005, and the link to Nottingham Veterinary School as clinical associate in 2010. He is an advanced practitioner and currently divides his time between general equine surgery and sports horse practice, with some teaching and clinical research. Neal is a keen sailor and skier and less keen rider.

Kayleigh Barker
BVetMed(Hons) CertAVP(Stud Med) MRCVS
Kayleigh graduated from the Royal Veterinary College (RVC) and, having developed a keen interest in equine reproduction at Keros Embryo Transfer Centre (Belgium), went on to complete an internship at Goulburn Valley Equine Hospital (Australia) where she published work on granulosa cell tumours. In the UK Kayleigh then spent a season with Jonathan Pycock, before moving south to a large private equine practice. She spent a year at the RVC as an ambulatory stud vet, teaching students equine reproduction, prior to spending two seasons at a private stud running the embryo transfer programme. Kayleigh has now returned to Yorkshire to Equine Reproductive Services (UK).

Will Barker
BVSc MVetMed DipECVS MRCVS
Will graduated from Liverpool Veterinary School in 2008. He carried out a 2-year internship at Newmarket Equine Hospital (NEH) and then went on to undertake a 3-year surgical residency at the Royal Veterinary College from 2010–2013. In 2013 he returned to NEH to take a post as a consultant in equine surgery and became an associate partner there in 2017. Will is a European and Royal College of Veterinary Surgeons recognised specialist in equine surgery. His publications focus on equine orthopaedics and sinus disease.

Timothy P. Barnett
BSc(Hons) BVMS&MS CertAVP DipECVS MRCVS
Tim qualified from the University of Edinburgh in 2005 and began working as a general practitioner at Swanbridge Veterinary Group in East Yorkshire. He moved to Rossdales, Newmarket in 2007, working initially as an orthopaedic diagnostic assistant and then completing an 18-month internship. In 2010 he embarked upon a surgical residency at Edinburgh University. Tim returned to Rossdales in 2013 and now spends the majority of his time working within the
hospital surgical team. As well as emergency admissions, he sees a wide variety of elective cases and has a particular interest in upper airway and dental conditions.

**Simon Biles**  
FCCA CTA  
Simon is an associate partner in Moore Scarrott Chartered Accountants, Taunton, where he works solely with veterinary surgeons, offering a superb service and a wealth of experience to his clients. These services include detailed performance reviews, partner buy-ins and exits, buying and selling practices, practice start-ups, assisting with remuneration planning and tax mitigation and many other areas of running a successful veterinary practice. Simon qualified as a chartered certified accountant and then went on to qualify as a chartered tax adviser. He leads a team of accountants dedicated to helping veterinary practices grow and develop, providing them with a seamless compliance service. In addition, he and his team provide real-time financial and commercial information and assist clients in interpreting this information to benefit their practice.

**Bruce Bladon**  
BVM&S CertEP DESTS DipECVS FRCVS  
Bruce graduated from Edinburgh University in 1988. He spent 1 year in mixed practice and then 6 years in two equine practices, before joining Bristol University as resident in equine surgery. He was awarded the Royal College of Veterinary Surgeons (RCVS) certificate in equine practice in 1992, the RCVS diploma in equine soft tissue surgery in 1999 and the diploma of the European College of Veterinary Surgeons in 2001. He returned to Donnington Grove Veterinary Group (as it is now) in 1998 and is now a director. He has been recognised as a specialist in equine surgery since 2000 and was awarded fellowship of the Royal College of Veterinary Surgeons in 2016. He has lectured extensively, including to the South African, Australian and New Zealand Equine Veterinary Associations, as well as the British, Dutch, Italian and Israeli Equine Veterinary Associations and to the European and American Colleges of Veterinary Surgeons. Bruce is the principle equine surgeon at Donnington Grove Veterinary Surgery. The practice treats many racing Thoroughbreds, but also has a substantial leisure horse population, including a large referral caseload. The practice performs a large number of MRI scans, using the Hallmarq® standing low field scanner. Bruce’s key interest is surgery, especially fracture repair and colic surgery, although he undertakes all procedures presented to him. He is also involved with advanced imaging, particularly magnetic resonance imaging. Bruce was emergency services team leader at the Rio 2016 Olympics. He is a (low level) rugby union referee and a rather disappointing skier, although he is an effective eco warrior who drives a zero emissions vehicle. He does not go outside, except in the summertime, and spends his time either in an operating theatre or looking at black and white images.

**Karen Blissitt**  
BVSc PhD DVA DipECVAA SFHEA MRCVS  
Karen graduated in veterinary science from the University of Liverpool in June 1982. After 3 years in general practice she joined the Royal (Dick) School of Veterinary Studies in Edinburgh, where she is currently a senior lecturer. She was awarded her PhD in 1993 for her work on echocardiographic studies of valvar and ventricular function in horses. Karen obtained the Royal College of Veterinary Surgeons diploma in veterinary anaesthesia in 1995 and became a diplomat of the European College of Veterinary Anaesthesia and Analgesia in 1997. Her research interests include transoesophageal echocardiography for assessing ventricular function in anaesthetised horses, sudden cardiac death in racing Thoroughbreds and 3D echocardiography.

**Jane C. Boswell**  
MA VetMB CertVA CertES(Orth) DipECVS MRCVS  
Jane qualified from the University of Cambridge in 1993 and then worked for 2 years in mixed practice before undertaking junior and senior clinical training scholarships in equine surgery at the Royal Veterinary College. In 2000 she joined the surgical team at the Liphook Equine Hospital, Hampshire, UK and became a partner there in 2006. She is a diplomate of the European College of Veterinary Surgeons and a Royal College of Veterinary Surgeons recognised specialist in equine surgery. She is a former examiner and chief examiner for the Royal College of Veterinary Surgeons Equine surgery certificate exams and the ECVS diploma in equine surgery and is currently a regent of the board of the European College of Veterinary Surgeons.

**Nick Bova**  
BPharm  
Nick is the international managing director of Bova, a veterinary specials manufacturer. With roots in retail pharmacy, Nick founded Bova Australia in 2010, which quickly developed as one of Australia’s largest compounding facilities for the veterinary market and the first to receive an APVMA cGMP licence. Nick launched Bova UK in 2017, which is the first specials manufacturer to receive a VMD sterile licence. Growing rapidly, Bova UK now has over 25 employees. Outside of Bova, Nick holds a black belt in Brazilian Jiu-Jitsu and was placed 3rd in the world in the 2014 world professional Jiu-Jitsu cup.

**Mark Bowen**  
Mark has worked in equine clinical practice throughout his professional career and has particular interests in equine cardiology. He completed internship, residency and PhD training at the Royal Veterinary College before moving to the University of Nottingham as a founding member of staff in the new veterinary school. As past president of BEVA, Mark has particular interests in medicines availability and authored the BEVA PROTECT ME guidelines. During his presidency Mark helped to deliver member guidance on the safe use of unlicensed medicines, safe working around horses and employment of overseas graduates, while also expanding the scope of the internship awareness project and lobbying over the European Union medicines regulations.

**Tim Brazil**  
BVSc PhD CertEM(IntMed) DECEIM MRCVS  
Since graduating from Liverpool in 1988, Tim has worked exclusively with large animals. He has taught, provided clinical service and carried out research at several university teaching hospitals. Since 1999 he has worked in private equine first opinion and referral practice, also providing ambulatory equine internal medicine services based in the Cotswolds, most recently at Bourton Vale Equine Clinic. He gained a Royal College of Veterinary Surgeons (RCVS) certificate in 1995, a PhD from Edinburgh University in 1999 for studies on lung inflammation in the horse and a European diploma in equine internal medicine in 2005, becoming a European and RCVS recognised specialist in equine internal medicine. He has contributed to training, continuing education and examinations for veterinary students and practitioners internationally. For over 10 years he has been a consultant to The Brooke, a charity that provides free health care and education to working equids and their owners in some of the world’s poorest communities, for whom he helped to develop and implement a clinical audit programme for their veterinary teams worldwide. Tim was appointed as a claims consultant for the Veterinary Defence Society in 2017.
Moses Brennan  
BVsC CertES(Orth) MRCVS
Moses graduated from Liverpool University in 1999 and initially worked in mixed practice before working at the Ashbrook Equine Hospital. In 2006 he travelled to the Southern Hemisphere, first working in a private equine hospital in New Zealand and then starting a surgical residency at the University of Sydney. He left his residency program early to join the Rainbow Equine Hospital in 2008 and became a partner there in 2010. Moses passed his RCVS certificate in equine surgery in 2009 and now works as one of the three full time surgeons at Rainbow Equine Hospital. His interests include equine surgery, equine dental surgery and treatment of equine sarcoids.

John Brentnall  
BVsC MRCVS
John qualified from Liverpool in 1983 and after 5 years in mixed practice in Dorset, followed by spells in New Zealand and Wiltshire, he moved to a mixed practice in Shropshire. Coming from a farming background where horses were a large part of his life, his clinical interest has evolved along the equine route. In 2003/4 John took a sabbatical at the University of Pretoria as a visiting professor in medicine. In recent years his professional interests have gravitated towards management; he has overseen the development of his current practice from a three-veterinary surgeon business in 1988 to a firm of 37 veterinary surgeons employing 110 staff. In April 2017 the business was sold to CVS Group plc. In addition to his professional memberships, he is a member of the Institute of Directors and the Financial Times Non-Executive Directors’ Club.

Jill Bryan  
BSc(Hons) MVB DipECEIM FRCPath MRCVS
Jill works as an equine veterinary pathologist at Rossdales Laboratories, Newmarket. She graduated from University College Dublin in 2003, having also completed a BSc in veterinary pathology as part of her undergraduate training. After 3 years in first opinion practice she undertook a residency in equine internal medicine and became a diplomate of the European College of Equine Internal Medicine in 2011. She subsequently completed a residency in veterinary pathology and obtained her fellowship of the Royal College of Pathologists in 2016. She enjoys all areas of equine diagnostic pathology and has particular interests in infectious diseases and antimicrobial resistance.

Patrick Burns  
BVsC MANZCVS DACVAA MRCVS
Following his graduation from the University of Queensland, Australia in 1992, Patrick worked in private practices, at an emergency referral centre and at his alma mater before completing a residency in anaesthesia at the University of Pennsylvania in 2005. He subsequently worked at various universities in the USA and Canada before departing for the University of Edinburgh, where he became the director of the hospital for small animals and head of the anaesthesia service. He currently leads the equine anaesthesia service at Langford Vets.

Madeleine Campbell  
BvetMed MA(Oxon) MA(Keele) PhD DipECAR DipECAWBM MRCVS
Madeleine is a Royal College of Veterinary Surgeons and European recognised specialist in equine reproduction. She is the sole partner at Hobgoblins Equine Reproduction Centre, and has active research interests in clinical equine reproduction and in the ethics of using assisted reproductive technologies in animals.

Harry Carslake  
MA VetMB DipACVIM MRCVS
Harry is a senior lecturer in equine medicine at the Philip Leverhulme Equine Hospital, University of Liverpool. His clinical and research interests include endocrinology, gastroenterology, ophthalmology and oncology. Before moving to Liverpool, he worked for 7 years in mixed and equine practice, and 6 years at Massey University, New Zealand where he was a resident, then lecturer, in equine medicine. He became a diplomate of the American College of Veterinary Internal Medicine in 2010.

Hans Castelijns  
DVM Certified Farrier
Hans has worked as a professional farrier since 1987 and as a veterinary surgeon specialising in equine podiatry since 1999. He works with a wide variety of horses, including Thoroughbred and Standardbred mares, foals and yearlings on studfarms; race, endurance and show Arabs; showjumpers; international dressage and reining horses. In addition to his equine podiatry practice, which includes referral and consulting, he teaches specialist courses, both to farriers and veterinary surgeons, which are eligible for continuing education credits for veterinary surgeons in countries including Italy, Germany, Austria and the USA. Hans is a frequent speaker at international conferences and seminars; having been invited in this capacity to 29 countries, speaking six different languages, he doesn’t usually get ‘lost in translation’. He has developed a valuable aid to both lameness examination and hoof balance assessment, in the form of a digital extension device that measures tolerance to dorsal, palmar/plantar, lateral and medial elevation of the digit in the standing horse. The use of this device permits a more rational approach to remedial farriery. His numerous publications and speaking engagements at veterinary and farriery conferences and seminars can be accessed at www.farriery.eu. Hans is past president of the Italian Association of Equine Podiatry (SIPE) and is a member of the International Equine Veterinarian Hall of Fame (Kentucky, 2011). In 2010 he was honoured by the Spanish Foundation for the Promotion of Equine Sports, receiving his prize from Her Royal Highness Doña Elena, Infanta of Spain, for his teaching contributions.

Javier Castillo-Olives  
DVM MSc PhD MRCVS
Javier is a veterinary virologist with more than 20 years’ experience in vaccine research and development. He was a research fellow at the Pirbright Institute as well as an OIE (World Organisation for Animal Health) designated expert on African horse sickness (AHS). He is a visiting reader in vaccinology at the Faculty of Health and Medical Sciences, University of Surrey and continues his virology research at the Department of Veterinary Medicine, University of Cambridge. After obtaining his degree in veterinary science and an MSc in microbiology at the University of Madrid, Javier worked at Instituto Llorente S.A. (manufacturer of polio, tetanus and diphtheria vaccines). In 1994 he moved to the UK and joined the virology department of the Animal Health Trust (AHT), Newmarket, where he conducted his PhD studying the effector mechanisms of immunity against equine arteritis virus (EAV). During this time, Javier developed an equine challenge model and recombinant DNA (differentiation of infected from vaccinated animals) vaccines. For EAV, at the AHT he also established diagnostic laboratory capabilities for West Nile fever and gained funding from the Biotechnology and Biological Sciences Research Council to develop improved AHS vaccines. Javier joined Professor Peter Mertens’ group at Pirbright in 2009 and focused his work on the antigenic structure of AHSV and the effector mechanisms of anti-AHSV immunity.

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work showed that vaccines based on recombinant modified vaccinia virus expressing the outer capsid VP2 proteins of AHSV were: a) protective; b) DIVA compatible; c) suitable for polyvalent vaccination; and d) the immunity they conferred was mediated mainly by antibodies. In addition to his virology research, in the last 3 years, Javier co-ordinated international initiatives aimed at improving the global control of AHS. This work resulted in the validation of RT-PCR and ELISA diagnostic tests for AHS up to Stage 3 of the OIE diagnostic test validation pathway. In addition, he led an international group of AHS experts reviewing the current status of AHS vaccine development. Javier currently works on the development of vaccines and immunotherapeutics for AHS and other viral diseases.

**Sébastien Caure**
DVM
Sébastien graduated in 1994 from the Veterinary School of Nantes (France). He started working at the Equine Clinic of Livet, France in 1995, and became a partner there in 1999. In 2016 he and his partners developed the clinic into the Equine Hospital of Livet (Centre Hospitalier Vétérinaire Equin de Livet). He has worked in all fields of equine medicine but now works exclusively in the diagnosis and treatment of lameness. His main field of research is the foot and shoeing.

**Charles Cooke**
BSc(Hons) BVetMed CertEM(Stud Med) MRCVS
Charles qualified from the Royal Veterinary College, University of London in 2000 and worked with Dr Jonathan Pycock at Equine Reproductive Services Ltd, Malton, UK and in the Southern Hemisphere for 4 years. In 2004 he moved to Rossdale and Partners, Newmarket where he worked predominately on Thoroughbred studs but was also involved with the breeding of Suffolk Punch horses and Connemaras. He spent a short time in Somerset and then moved back to Yorkshire before rejoining Equine Reproductive Services (UK) Ltd in 2013, becoming a director in 2016. He completed the Royal College of Veterinary Surgeons certificate in equine medicine (studi medicine) in 2008, has been an honorary lecturer at Liverpool University since 2014 and also lectures regularly at veterinary conferences. He is involved in all aspects of equine stud medicine including natural and artificial insemination and embryo transfer, breeding methods on all types of horses and ponies. Aside from reproductive work, he is regularly involved in racing, sport horse and pleasure horse veterinary care. Charles’s areas of interest include youngstock management and preventive medicine on the studfarm (particularly worm control), treatment of the ‘subfertile’ mare, fetal sexing and the management of hormone-related behavioural problems in competition horses.

**Graeme Cooke**
MA VetMB(Cantab) MBA MRCVS
Graeme was appointed the United Kingdom Deputy Chief Veterinary Officer (CVO) by Defra in January 2017. His responsibilities include supporting the Government on animal health and welfare issues at the national and international levels, acting as a lead Government spokesperson, ensuring appropriate advice to Ministers, strategic planning and leading the Defra response to outbreaks of exotic animal disease and other threats, including foot and mouth disease. He works across all the UK administrations and is part of the representation of the UK in the EU and internationally, negotiating widely on behalf of the UK Government. He has a particular lead on import policy, regulatory enforcement, surveillance and international engagement. Defra is one of the government departments most affected by EU exit with a wide range of its areas based on EU frameworks. Based in Westminster, London, he worked at Defra previously from 2001 to 2007, leaving to undertake a fulltime MBA at a London Business School. He became a director of the Fédération Equestre Internationale (FEI), based in Switzerland, taking the veterinary department through required changes in approach to meet the demands of the horse sport in the modern era. This necessitated a co-ordinated uplift of all veterinary policies and their means of delivery through 2500 veterinarians in over 120 countries. Prior to re-joining Defra, Graeme had a non-veterinary role within MOD. He is a past member of expert groups at the World Animal Health Organisation (OIE), EU expert panels, and the International Horse Sports Confederation (IHSC) board, helping devise the concept of the high health high performance (HHHP) horse. Previously a clinician, Graeme is from a farming background in Northern Ireland, and is a Cambridge graduate. An active reservist, he deployed to Afghanistan in 2009. He is a trustee of The Brooke equine charity, Graeme and his wife are enthusiastic horse-owners. He completed the 2017 London Marathon raising funds for both The Brooke and for neuroendocrine cancer.

**Anne Couroucé**
DVM PhD DipECEIM
Anne is professor of equine internal medicine at Nantes Veterinary School in France (ONIRIS). Her special interests are sports medicine and cardiac, respiratory and muscular diseases and her main area of research is respiratory disease. In 2014, Anne was the veterinary services manager for the World Equestrian Games held in Normandy, France. She has been secretary of the European College of Equine Internal Medicine since 2015 and is a member of the board of the World Equine Veterinary Association.

**James R. Crabtree**
BVMS CertEM(StudMed)
James is director of Equine Reproductive Services (UK), a first opinion general equine practice specialising in equine reproduction and stud medicine. He has worked in the UK, Australia and New Zealand. James holds the Royal College of Veterinary Surgeons certificate in equine stud medicine and is presently an honorary lecturer at Liverpool University.

**Carolyne Crowe**
BSc(Hons) BVetMed(Med) MSc MRCVS Dip Coaching Dip Stress Management and Wellbeing MRCVS
Carolyne is an experienced equine vet, an award winning personal performance coach, mentor, international speaker, researcher and lecturer. Carolyne has a master’s degree in workplace health and wellbeing and continues to do research in veterinary team health, wellbeing, performance and engagement. She is a master trainer in DISC behavioural profiling, a Counselling and Psychotherapy Central Awarding Body trainer in stress management and wellbeing, a certified trainer in resilience, a mental health first aider and an honorary lecturer at the University of Liverpool and University of Liverpool, helping with CVEs across the UK. After successfully running her coaching and training business for several years, Carolyne now works as a training consultant with the Veterinary Defence Society training team, developing, training and coaching individuals, teams and practices to be the best they can be and to thrive both personally and professionally. Carolyne loves a challenge and in 2017 she ran 10 marathons in 10 days raising over €18,000 for the Brooke charity.
Ollie Crowe
BVSc CertES(Orth) DipEVCS MRCVS
After graduating from the University of Liverpool in 1997, Ollie undertook an internship at Greenwood, Ellis and Partners in Newmarket. He then completed a surgical residency at the Royal Veterinary College. He worked in Lambourn before joining the Willesley Equine Clinic and, following the merger of that practice with Bushy Equine Clinic, he became a surgeon at the newly formed B&W Equine Hospital. Ollie holds the Royal College of Veterinary Surgeons certificate in equine surgery; the diploma of the European College of Veterinary Surgeons and is a Royal College of Veterinary Surgeons and European recognised specialist in equine surgery.

Simon Curtis
FWCF BSc(Hons) PhD HonAssocRVCS
Simon has lectured and demonstrated farriery in more than 20 countries on six continents including the USA, Australia, India, Russia and Brazil. He has published three textbooks on farriery and had papers published in numerous journals. He was awarded an honorary associateship of the Royal College of Veterinary Surgeons in 2002. He is a fellow of the Worshipful Company of Farriers by examination and is currently an examiner. Simon completed a PhD degree in equine physiology and biomechanics in 2016 and was awarded the Sir Colin Speidelling award by the National Equine Forum in 2018 for his contribution to equine science and welfare.

Peter Daels
DVM PhD DipACT DipECAR
Peter obtained his veterinary degree at the University of Ghent. After completing his resident training and obtaining his PhD in reproductive physiology at the University of California, Davis, he held a faculty position at Cornell University before becoming director of research at the reproductive unit at INRA-Nouzilly in France. He was responsible for the embryo transfer services at Embryo-Technic in France and subsequently at Keros Insemination and Embryo Transfer Center in Belgium. Presently, Peter is professor in equine reproduction at the University of Ghent. He is a dedicated teacher and is regularly invited to teach at international meetings and veterinary courses on equine reproduction.

Elizabeth J. Davidson
DVM DipACVS DipACVSMR
Elizabeth is an associate professor of sports medicine at the University of Pennsylvania’s New Bolton Center. She received her DVM from Michigan State University and completed an equine internship at Pilchuck Veterinary Hospital in Snohomish, Washington followed by a residency in large animal surgery at the New Bolton Center. She is a diplomate of the American College of Veterinary Surgeons and the American College of Veterinary Sports Medicine and Rehabilitation. Her expertise includes sport horse lameness and upper airway abnormalities. Other interests are horses with neck and/or back pain and the ‘hard to diagnose’ horse.

Jonathon Dixon
BVetMed My VetMed DipECVDI MRCVS
Jonathon graduated from the Royal Veterinary College (RVC) and, following a short period of work for a charity practice, undertook a rotating internship at Rainbow Equine Hospital in North Yorkshire. Subsequently, he returned to the RVC to undertake a 3-year European College of Veterinary Diagnostic Imaging (ECVDI) residency in large animal diagnostic imaging, which he completed in 2016, since completing the residency Jonathon returned to Rainbow Equine Hospital to take responsibility for the hospital imaging services. In February 2017 he obtained the ECVDI diploma and in 2018 became an Royal College of Veterinary Surgeons recognised specialist in large animal diagnostic imaging. His main interests lie in advanced imaging, in particular computed tomography and magnetic resonance imaging.

Padraic M. Dixon
MVB PhD DipEVDC(Equine) FRCVS
Paddy is a graduate of University College Dublin. Later he obtained a PhD in equine respiratory disease from the University of Edinburgh, where he has worked for most of his professional life including as a lecturer, senior lecturer and reader. He is currently professor of equine surgery at Edinburgh University, where his main clinical and research interests are equine dental disorders and head and neck surgery. He is a Royal College of Veterinary Surgeons recognised specialist in equine soft tissue surgery and a European specialist in equine dentistry. He has written over 200 refereed publications, with six literary awards, many book chapters and edited books on these topics. He has also presented hundreds of international lectures and numerous wet labs on equine upper respiratory and dental disorders.

Niklas J. Drumm
DmMedVet DipACVS-LA DipECVS
Niklas qualified from the Ludwig Maximilian University of Munich, Germany in 2008. He completed an internship at Rood and Riddle Equine Hospital in Lexington, Kentucky, USA and a large animal surgery residency at Pferdekinlinik am Kottenforst in Wachtberg, Germany. Niklas became a diplomate of the American College of Veterinary Surgeons in 2012, a diplomate of the European College of Veterinary Surgeons in 2015 and obtained a doctoral degree from the University Berlin, Germany in 2012. In 2014 he started working for Tierklinik Lüsche, Germany and became a shareholder in 2017. His main areas of interest are orthopaedics, sport horse medicine and orthopaedic surgery.

Nicole du Toit
BVSc MSc CertEP PhD DipEVDC(Equine) DipAVDC(Equine)
Nicole qualified in 2000 and then worked in a small animal/ equine clinic for 2 years. In 2002 she undertook a 3-year equine residency at Edinburgh University, followed by a PhD in equine dentistry with Professor Paddy Dixon. From 2011, she worked full-time in equine dentistry in South Africa until May 2017, when she returned to the UK to work at the Equine Dental Clinic where she spends 95% of her time doing equine dentistry referral work.

Bettina Dunkel
DVM PhD DipACVIM DipECEIM DipACVECC FHEA MRCVS
After graduating from Berlin University, Bettina completed a fellowship at Tufts University, an internship at the Marion duPont Equine Medical Center, Leesburg, and a large animal internal medicine and emergency and critical care residency at the University of Pennsylvania. Since 2005, she has been a member of the American College of Veterinary Internal Medicine and of the American College of Veterinary Emergency and Critical Care. After she attained her PhD from the University of London in 2008, Bettina was employed as a lecturer and then senior lecturer at the Royal Veterinary College.

Andy Durham
BSc BVSc CertEP DEIM DipECEIM MRCVS
Andy graduated from Bristol University in 1988 and, following an initial 2 years in mixed practice, has spent the last 28 years in equine practice. Andy is a director of the Liphook Equine Hospital (LEH), a large practice employing
24 equine veterinary surgeons in ambulatory, clinical referral and diagnostic laboratory roles. He also holds a position as visiting professor at the University of Surrey Veterinary School. Andy has personal responsibility at LEH for internal medical inpatients and referrals as well as overseeing the diagnostic laboratory and still has just a little time for ambulatory calls. Andy is an RCVS and European Specialist in Equine Internal Medicine.

**Sue Dyson**
MA VetMB PhD DEO DipECVSMR FRCVS

Sue is head of equine clinical orthopaedics at the Centre for Equine Studies of the Animal Health Trust, running a clinical referral service for lameness and poor performance. She is a fellow of the Royal College of Veterinary Surgeons and is a Royal College of Veterinary Surgeons recognised specialist in equine orthopaedics. Sue is also an associate of the European College of Veterinary Diagnostic Imaging and a founding diplomate of the European College of Veterinary Sports Medicine and Rehabilitation. She has published more than 280 papers in peer-reviewed journals concerning lameness and diagnostic imaging and has lectured worldwide. Sue is a former president of the British Equine Veterinary Association.

**Yvonne Elce**
DVM DipACVS MRCVS

Yvonne works in the equine hospital at Langford Vets. She graduated as a veterinary surgeon in Canada, then completed an internship at Washington State University and a residency at the New Bolton Center. She worked for many years in the USA and Canada before moving to England. Yvonne is a Royal College of Veterinary Surgeons recognised specialist in equine surgery.

**Andrew Fiske-Jackson**
BVSc MVetMed FHEA DipECVS MRCVS

Andy graduated from the University of Liverpool in 2004 and worked for the Society for the Protection of Animals Abroad for the following 3 months. He then worked in mixed practice in Somerset. In July 2006 he undertook an 18-month internship at the Liphook Equine Hospital, followed by a 6-month ambulatory position. He then completed a 3-year senior clinical training scholarship and Master of veterinary medicine at the Royal Veterinary College. He took up the senior clinical training scholarship and Master of veterinary medicine at the Royal Veterinary College. He took up the position of staff clinician in equine surgery in February 2012, becoming a lecturer in 2014 and a senior lecturer in 2017. He is a Royal College of Veterinary Surgeons and European specialist in equine surgery and has a particular interest in the use of the objective gait analysis system and the work-up of poor performance cases.

**Sarah Freeman**
BVetMed PhD CertVA CertVR CertES DipECVS FHEA FRCVS

Sarah qualified from the Royal Veterinary College, University of London in 1994. She worked in mixed practice, before returning to the Royal Veterinary College to undertake an internship, a PhD in equine anaesthesia and then a residency in equine surgery, becoming a lecturer in equine surgery in 1999. She was a private consultant between 2002 and 2005 and became a diplomate of the European College of Veterinary Surgeons in 2005. She joined the School of Veterinary Medicine and Science, University of Nottingham in 2005 as one of the founding members of staff and was awarded a personal chair there in 2014. Sarah is currently the equine clinical subdean at Nottingham, leads the equine colic research group behind the ‘REACT’ vet and owner colic educational campaigns, and heads the panel developing BEVA guidelines for equine clinical practice on wounds.

**Anton Fürst**
FHV DECVS

Anton completed a degree in veterinary medicine at the University of Zürich in 1988. From 1990 to 1997 he worked in the Department of Veterinary Surgery, University of Zürich, as an intern, resident and then staff surgeon. During this time, he became a diplomate of the European College of Veterinary Surgery. In 1998, Anton received a Willenegger Fellowship to study at Ohio State University, Columbus, Ohio. In 2007, he completed his habilitation and in 2011 he became a professor of equine surgery and director of the equine from a wide variety of disciplines. In May 2018 she moved back to Germany to be based at the equine hospital of Tierklinik Hochmoor. Carolin has been invited to speak at a number of national and international meetings and lectures regularly at CPD events. Her special interests are orthopaedics, diagnostic imaging and poor performance investigations.

**Huw Griffths**
BVSc BVSc CertES MRCVS

Huw has worked at the Liphook Equine Hospital, Hampshire as an ambulatory practitioner since 2004. The practice has a varied demographic which includes studs representing most equine breeds. Huw’s interests centre around the broodmare and youngstock management. He is currently a BEVA council member chairing the clinical practice committee, within which he organises the AI list and associated AI refresher course. He holds the Royal College of Veterinary Surgeons certificate in equine stud medicine and has a committed interest in this area.

**Emily Haggett**
BVSc DipACVIM MRCVS

Emily graduated from the University of Bristol in 2003 and worked in equine and small animal practice for 18 months before completing an equine internship at the Liphook Equine Hospital. Between 2006 and 2009 she has been working at Rossdales Equine Hospital in Newmarket, where she has special interests in neonatology and critical care and takes primary responsibility for the neonatal intensive care unit. She became a partner in 2017. Emily is a Royal College of Veterinary Surgeons recognised specialist in equine internal medicine.

**Dave Hanlon**
BVMS(Hons) MVSc MACVS PhD DipIAC

Dave graduated from Murdoch University, Western Australia in 1992 with a Bachelor of Veterinary Medicine and Surgery. He then completed a three-year clinical residency and master’s degree in large animal reproduction at Massey University, New Zealand. This research led on to the development of the Cue-Mate device for reproductive management in dairy cattle, and later, the Cue-Mare device for reproductive
management of mares. In 2001 Dave became a diplomate of the American College of Theriogenologists, and in 2002 was an assistant professor in the theriogenology department at Cornell University. Dave relocated to Cornell University in 2007 as a visiting research scientist at the Baker Institute in Professor Doug Antczak’s laboratory where he investigated the physiological effects of ectopic transplantation of equine chorionic girdle in non-pregnant mares. A number of publications and a patent in the USA were generated from this NIH-funded project. In 2013 Dave completed a sabbatical as a visiting associate professor in the theriogenology department at Louisiana State University, USA. He is currently an adjunct associate professor in theriogenology at both Louisiana State University and North Carolina State University. He has supervised numerous PhD and master’s students and several theriogenology residents. As Matamata Veterinary Services is an associate teaching hospital (AVMA Accredited) for Massey University, Dave also provides tutorials and lectures to senior veterinary students. Dave was awarded a PhD from Massey University in 2012. His thesis was entitled ‘Reproductive performance and the transition period of Thoroughbred mares in New Zealand: Evidence and implications for future alternative management strategies’. Dave is currently involved in several research projects, which include: investigating endometritis in the mare (with Melbourne University researchers); using the pregnant mare to develop a model for human infertility (with researchers at the medical school at Auckland University); and has recently started a collaborative project with Colorado State University and Auckland University on the application of intratubine stem cells as a treatment for endometritis. Dave is a registered specialist in equine reproduction. He is currently a partner at Matamata Veterinary Services, Waikato, New Zealand where he provides specialised equine reproduction services to a number of large Thoroughbred studs, which involves the breeding management of around 850 mares. He also provides a referral service for equine artificial insemination/embryo transfer using fresh and frozen semen, equine fetal sexing, reproductive management of infertile mares, reproductive surgery, stallion breeding soundness examinations and semen collection and processing for shipment and freezing. Dave has given numerous presentations on equine reproduction throughout the world to both the general public and the veterinary profession. In his spare time Dave enjoys being a part-time farmer of purebred Angus cattle and a handful of Suffolk sheep.

Andrew Harrison
BVSc CertEP CertVA MRCVS
Andrew qualified from Liverpool University in 1988 and is currently a partner at Three Counties Equine Hospital, which he joined in 1993. He has a keen interest in veterinary anaesthesia, which he has taught both nationally and internationally. He was involved in the development of much of the sedation and anaesthesia content for the Safer Horse Resuscitation Initiative. He gained the Royal College of Veterinary Surgeons certificate in veterinary anaesthesia in 2000. He is a past president of the British Equine Veterinary Association.

Mark Harwood
Mark has been with Hazlewoods since 2003 and works solely with veterinary practices. He advises on a whole range of matters including profit improvement, tax planning, valuations, ownership change and buying and selling practices. Mark regularly writes for the veterinary press and presents to the profession.

Richard Hepburn
BVSc MS(Hons) CertEM(IntMed) DipACVIM(LA) FRCVS
Richard graduated in 1997 and worked in equine practice in the UK and New Zealand for 3 years before undertaking a 3-year residency and master’s program in equine internal medicine in Virginia, USA. In 2004 he returned to the UK joining Willesey Equine Clinic, which became B&W Equine Hospital, part of the 38-veterinary-surgeon B&W Equine group which is now owned by CVS Ltd. He is a Royal College of Veterinary Surgeons recognised specialist in equine internal medicine and a member of the European College of Equine Internal Medicine consensus committee on equine gastric ulcer syndrome.

Michael Hewetson
BSc BVSc CertEM DipECVIM
Michael graduated from Onderstepping, South Africa in 1999. He spent a year in private equine practice before completing a residency in equine internal medicine, critical care and anaesthesia at the University of Glasgow. He holds the Royal College of Veterinary Surgeons certificate in equine internal medicine and is a diplomate of the European College of Veterinary Surgeons. He currently works as a senior lecturer in equine internal medicine at the Royal Veterinary College and has recently completed a PhD in equine gastroduodenal permeability studies. He has published extensively in the field of equine gastroenterology and co-authored the ECEIM consensus statement on equine gastric ulcer syndrome (EGUS) in 2014.

John F.R. Hird
MA BVSc(Hons) DVA DipECVAA MRCA FRCVS
John qualified with BVSc(Hons) from Liverpool in 1970 and achieved the Royal College of Veterinary Surgeons diploma in veterinary anaesthesia in 1974. He is a former president of the Association of Veterinary Anaesthetists and a founding diplomate of the European College of Veterinary Anaesthesia and Analgesia. He was president of the British Small Animal Veterinary Association (BSAVA) from 1998 to 1999. He received the BSAVA Melton Award for meritorious contribution to small animal practice and was awarded the Francis Hogg Prize by the Royal College of Veterinary Surgeons for his work towards improving standards of anaesthesia in general practice. He was awarded fellowship of the Royal College of Veterinary Surgeons in 2017 for meritorious contributions to clinical practice. John retired from general practice after 25 years and worked until 2012 as a claims consultant for the Veterinary Defence Society, where he is now retained as a claims adviser. He currently acts as an independent consultant in veterinary anaesthesia and works part-time as an equine anaesthetist at Hird & Partners, Halifax.

Karl Holliman
BVM&S CertEP MRCVS
Karl qualified from the Royal (Dick) School of Veterinary Studies, Edinburgh in 1991. After a short period in mixed practice in Scotland he moved to a mixed practice in Yorkshire. In 1994 he joined Cliffe Veterinary Group as an equine vet. In 1997 he was awarded the Royal College of Veterinary Surgeons certificate in equine practice. His main veterinary interests are all aspects of equine surgery, lameness, study work and equine dentistry. Karl is also a qualified equine dental technician, having passed the joint British Equine Veterinary Association (BEVA) and British Veterinary Dental Association (BVDAA) Exams and is now himself an examiner.

Anna Hollis
BVetMed DipACVIM DipECEIM MRCVS
Anna graduated from the Royal Veterinary College (RVC) in 2004. After a short stint in mixed practice she returned to the RVC for an internship and an equine medicine fellowship; after this she completed a residency in internal medicine at the University of Pennsylvania’s New Bolton
Linda J.I. Horspool
BVMS PhD DipECVPT MRCVS
Linda received her veterinary degree from the University of Glasgow Veterinary School, Scotland, in 1988 and completed a PhD programme in equine pharmacology at the same university in 1992. She is a diplomate of the European College of Veterinary Pharmacology and Toxicology and a Royal College of Veterinary Surgeons recognised specialist in equine medicine and pharmacology. She spent 6 years in general practice and a year teaching veterinary pharmacology before joining Intervet International B.V. in Boxmeer, The Netherlands where, as a technical services director for companion animal and equine products, she has worldwide responsibilities. She has published more than 90 peer-reviewed articles, abstracts and book chapters as well as reviewing articles for a number of journals.

Neil Hudson
MA VetMB PhD DEIM DipVetClinStud SFHEA FRCVS
Neil qualified from the University of Cambridge in 1994. He worked in mixed practice in England and then undertook a rotating mixed practice internship at the University of Sydney where he was awarded the diploma in veterinary clinical studies in 1995. After a further short period in mixed practice in England, Neil moved to the University of Edinburgh where he completed a PhD in grass sickness and equine gastroenterology and a residency in equine internal medicine. He achieved his certificate in equine internal medicine in this period. Neil then joined the faculty at the Royal (Dick) School of Veterinary Studies (R(D)SVS) as a lecturer in equine medicine. He has also pursued postdoctoral research in equine and comparative gastroenterology. He was awarded the Royal College of Veterinary Surgeons diploma in equine internal medicine in 2006 and then spent a period as director of undergraduate admissions and is currently a senior veterinary clinical lecturer at R(D)SVS. Here, he introduced and leads the undergraduate certificate in veterinary medical education. In 2018 Neil was awarded fellowship of the Royal College of Veterinary Surgeons for his research thesis on veterinary admissions.

Kristopher Hughes
BVSc(Hons) FANZCVS DipECVIM
Kris graduated from the University of Sydney in 1995 and, after spending 3 years in mixed practice, undertook a residency in equine internal medicine at the University of Sydney and was awarded fellowship in equine medicine by the Australian and New Zealand College of Veterinary Scientists in 2004. In 2005, Kris moved to the Faculty of Veterinary Medicine, University of Glasgow as a senior lecturer in equine medicine. He attained diplomate status of the European College of Equine Internal Medicine in 2007. After two Ashes defeats while in the UK and enduring the British weather for 5 years, he returned to Australia in 2009 and is currently an associate professor in equine medicine at Charles Sturt University, New South Wales. His research interests include inflammatory disorders of the lower airways, gastrointestinal disease, equine endocrinology and intensive care of horses.

Lynn Irving
RVN REVN DipAVN(Equine) BSc(Hons)
Lynn qualified as a registered veterinary nurse and worked in a mixed practice in Guildford, Surrey for 4 years before moving to Newmarket. She commenced work at Rossdales LLP in 2003, where she gained her equine veterinary nursing qualification in 2006. Her main area of interest is surgery and being head theatre nurse allowed her to excel in this area. Lynn achieved the diploma of higher education in clinical veterinary nursing, the Royal College of Veterinary Surgeons diploma in advanced veterinary nursing and in 2017, achieved a 2:1 in her Bachelor of Science degree in advanced veterinary nursing. Currently she is lecturing equine nursing students and continuing with her own studies within veterinary academia. In her spare time she enjoys competing her horse and improving her gun dog abilities with her Labrador.

John Keen
BvetMed PhD CertEM(intMed) DipECEIM MRCVS
Following graduation from the Royal Veterinary College in 1996, John spent 4 years in mixed and then equine practice before being appointed the Royal College of Veterinary Surgeons (RCVS) Clarke and Sparrow resident in equine studies at the Royal (Dick) School of Veterinary Studies in 2000, where he has remained ever since. John is currently a senior medicine clinician in the equine hospital and director of the equine hospital and practice. He gained an MSc and PhD investigating the pharmacology and physiology of digital laminar microvasculature, became a diplomate of the European College of Equine Internal Medicine in 2007, and is an RCVS recognised and European specialist in equine internal medicine. His clinical and research interests are focused on cardiovascular disease, metabolic/endocrine disease, laminitis and the potential links between these disorders.

Jeremy Kemp-Symonds
BA(Hons) BSc(Hons) MSc BVMS PGCHE MRSB AFHEA MRCVS
Jeremy qualified from the University of Glasgow’s Veterinary School, but also holds degrees from the University of Birmingham, Nottingham Trent University and the Royal Veterinary College, London. After working at the world-renowned Animal Health Trust in Newmarket for a number of years, his private practice now concentrates entirely on the treatment of horses, ponies and donkeys with skin tumours, and Jeremy works with numerous veterinary practices and equine charities throughout the UK. Jeremy is a member of both the British Medical Laser Association (BMLA) and the European Laser Association (ELA); he is also a member of the Royal Society of Biology, an associate fellow of the Higher Education Academy and a senior visiting fellow at Nottingham Trent University. In addition, he is a member of the British Equine Veterinary Association (BEVA), the British Veterinary Association (BVA), is a trustee (and former treasurer) for the BEVA Trust and is the veterinary consultant for the rescue and welfare charity Bransby Horses. Jeremy has contributed to a number of publications and books related to equine oncology and speaks about the subject widely both in the UK and overseas.

Tim Knott
BSc(Hons) BVSc CertVOphthal MRCVS
Tim graduated from Bristol in the beautiful south west of England in 1995. He had always wanted to be James Herriot, but after 10 years in mixed practice he became a full time ophthalmologist. He set up a dedicated private ophthalmic referral practice, Rowe Referrals eye clinic, in 2000, and this was followed in 2003 by the equine ophthalmology consultancy service, the Equine Eye Clinic. Tim is a past chair.
of the British Association of Veterinary Ophthalmologists, past chief examiner on the Royal College of Veterinary Surgeons ophthalmology certificate, board member of the International Equine Ophthalmology Consortium and is currently honorary senior teaching fellow in ophthalmology at the University of Bristol.

**Derek Knottenbelt**

**OBE BVMS DVM&$ DipECOphthalm DAVCOV MRCVS**

Derek qualified from Edinburgh in 1970 and spent the first year as a resident in the equine veterinary hospital at the Royal (Dick) School of Veterinary Studies. After 12 years in mixed and equine practice he turned to the academic world in South Africa where he became a lecturer at the University of Pretoria. In 1994 he returned to the University of Bristol as a senior lecturer in equine ophthalmology and in 2000 became the director of the School of Veterinary Science. Since 2001 he has been a Fellow of the University of Bristol.

**Casper Lindegaard**

**DVM PhD DipECVS**

Casper Lindegaard graduated from the University of Copenhagen in 2002 and, after a couple of years in mixed rural practice, went back to the university where he was awarded his PhD in 2009. In 2012 he became a diplomate of the European College of Veterinary Surgeons. Casper has been head of equine surgery at the Evidensia Helsingborg Equine Specialist Hospital for the last 6 years, but now works as a consultant surgeon specialising in orthopaedic and upper respiratory surgery. Casper has worked, researched and lectured extensively within the fields of pain, pain assessment and pain management and is a strong advocate for improved pain management for our horses.

**Christoph Lischer**

**DrMedVet DipECVS AssocECVDI MRCVS**

After graduating from the University of Zürich in 1989, Christoph undertook postgraduate training at Zürich, completing an internship and then a residency in large animal surgery in the Division of Veterinary Surgery. Appointment to the position of chair of surgery at the University of Zürich in 1997 was followed in 2001 by the position of assistant professor of equine surgery. From 2006 to 2009 Christoph held the position of chair of equine surgery at the University of Veterinary Zürich. In 2009, Christoph became a diplomate of the European College of Veterinary Surgeons and was based in the Weipers Centre for Equine Welfare. In October 2009 he was appointed as director of the equine clinic of the Freie Universität of Berlin. Christoph has received education in equine acupuncture in both the USA and China and is a certified member of the International Veterinary Acupuncture Society. In 1996 Christoph became a diplomate of the European College of Veterinary Surgery. From 2002 to 2008 he was a member of the exam committee, from 2007 to 2010 he was on the board of ECVS and this year he is president of the organisation. Christoph’s interests are broad and include orthopaedic surgery and diagnostic imaging as well as abdominal surgery and diagnostic and surgical laparoscopy. A particular area of expertise is fracture repair and as a result he teaches (as a member of Faculty) equine fracture repair courses that are organised by AO-Vet. Current research activities include the evaluation of new technologies to improve fracture repair and arthrodesis, including new orthopaedic implants and 3D intraoperative imaging.

**David Lloyd**

**BVMS CertES(Orth) DECVS MRCVS**

David qualified from the University of Glasgow in 1994. His first job in mixed practice in Cornwall combined work and a little surfing; during these 3 years he specialised in equine practice and surgery. To further his knowledge, he went on to complete an internship back at the University of Glasgow before moving to Newmarket where he spent 4 years as the surgical resident at Ro ssdales Equine Hospital, dealing with the racing elite! David then moved to the West Country to build the referral caseload at Liphook Equine Hospital and became a partner in 2008. He qualified as a European diplomate in equine surgery in 2009 and was recognised by the Royal College of Veterinary Surgeons as a specialist in all areas of equine surgery in 2010. David has extensive surgical experience in elective and emergency surgery, including complicated arthroscopic and laparoscopic procedures, laryngeal surgery, fracture repair and spinal (‘wobbler’) surgery. He also lectures on a wide range of surgical subjects. He maintains a keen interest in the investigation, diagnosis and treatment of neck pain, back pain, poor performance and lameness issues. In his spare time, he pretends to train his spaniels and enjoys biking, skiing and the occasional hack across the Hampshire hangers, providing it incorporates a pub along the way!
Kate Loomes  
**BVSc(Hons) MSc CertAVP(EP) CertAVP(VA) DipECVAA MRCVS**  
Kate qualified from the University of Sydney and worked in farm and equine practice in the UK prior to undertaking an internship and residency in veterinary anaesthesia and analgesia at the University of Liverpool. She became a Royal College of Veterinary Surgeons recognised and European specialist in veterinary anaesthesia and analgesia in 2016 and moved to the University of Liverpool the following summer. She is actively involved in the provision of general anaesthesia and standing sedation of horses in the hospital and assists with the intensive and critical care of hospitalised horses and foals. Kate’s research interests include the effect that mechanical ventilation has on the time to resume spontaneous ventilation in horses and total intravenous anaesthetic techniques in horses undergoing CT contrast myelography.

Margo L. Macpherson  
**DVM MS DiplACT**  
Margo received her DVM degree in 1990 from Michigan State University. She completed a residency and a master’s degree in equine theriogenology at Texas A&M University, afterwards spending time at the University of Pennsylvania and in private practice in central Kentucky. Margo is presently a professor of reproduction at the University of Florida and president of the American Association of Equine Practitioners. She is interested in all aspects of equine reproduction, but has a special interest in problems affecting late pregnancy in the mare. For more than a decade, Margo has been unraveling strategies for treating mares with bacterial placentitis.

Christine Magrath  
**BVMS HonFRCVS**  
Christine was appointed by the Veterinary Defence Society in 1999 to initiate and develop a programme dealing specifically with everyday communication with clients and addressing difficult situations. The programme has had an impact at practice level and on undergraduate training and, in recognition of this, Christine was awarded an honorary fellowship of the Royal College of Veterinary Surgeons in 2009 and presented with the Chiron award from the British Veterinary Association in 2010. Christine is recognised as a leader in this field and has co-authored books on the subject. She is a past president and treasurer of the Society of Practising Veterinary Surgeons and was a partner for 12 of her 17 years in practice.

Tim Mair  
**BVSc PhD DEIM DESTS DipECEIM AssocECVDI FRCVS**  
Tim Mair works at Bell Equine Veterinary Clinic in Kent; he is also equine clinical director of CVS Ltd. His clinical interests include internal medicine, soft tissue surgery and diagnostic imaging. He is a diplomate of the ECEIM and an associate of the ECVDI, as well as a Royal College of Veterinary Surgeons (RCVS) recognised specialist in both equine internal medicine and equine soft tissue surgery. He is editor of Equine Veterinary Education and is the current chair of BEVA’s education committee. He is also BEVA’s representative on the practice standards group and is a trustee of RCVS Knowledge.

Fernando Malalana  
**DVM DipECEIM FHEA MRCVS**  
Fernando graduated from the Complutense University of Madrid in 2001 then spent 6 years in mixed practice in East Yorkshire. In 2008 he moved to the University of Liverpool where he completed a residency in equine internal medicine, He is a European specialist in equine internal medicine and currently works as a senior lecturer at the University of Liverpool. Fernando is interested in all aspects of equine medicine but has a particular interest in general, ophthalmology, ophthalmic oncology and ophthalmic surgery.

Jo Malone  
**BVMS MRCVS**  
Jo qualified from Glasgow vet school in 1998 and has been actively involved in both clinical and all business aspects of veterinary life throughout her career. Jo worked for Minster Vets for the last 16 years up until 2016 where she focused on small animal clinical practice. In the last 10 years she has become increasingly involved in managing the practice alongside her clinical role, being instrumental in growing the practice, improving performance and developing the people within the practice. Jo is passionate about the veterinary profession and the people involved in it. In 2015 she became managing director of VetPartners and then CEO in 2016.

Jane Manning  
Jane is a PR consultant with 22 years’ experience working in agriculture and animal health. She was director of Splash Marketing from 2002, and since 2015 has led InnoVet Consulting, specialising in veterinary and animal health. She is currently chairman of the Veterinary Marketing Association (VMA), a membership organisation with a mission to help its members achieve marketing excellence in animal health.

Celia Marr  
**BVMS MVim PhD DEIM DipECEIM FRCVS**  
Celia graduated from the University of Glasgow in 1985 and her clinical career has focused on cardiovascular medicine, internal medicine, intensive care and medical imaging, and she has held positions at the University of Pennsylvania, University of Cambridge and the Royal Veterinary College. She is based at Rossdales Equine Hospital and Diagnostic Centre, Newmarket. Celia also acts as a consultant to Troytown Grey Abbey, Kildare and Ardene House Veterinary Practice, Aberdeen. Celia has published widely on medical disorders of the horse. She is an honorary professor of the University of Glasgow and editor-in-chief of the Equine Veterinary Journal.

Nicola Mason  
**BVMS MRCVS**  
Nicola qualified from Glasgow Vet School with commendation in 2002. Since then she has worked in first opinion and referral equine practice. In May 2010 she established her own ambulatory equine practice which has grown year-on-year since inception. Over the last 8 years she has frequently attended business and management courses and has a very active interest in management and finance.

Tullis Matson  
**ARAgS**  
Tullis is managing director of Stallion AI Services Ltd. The company was formed in 1996 and is one of the most successful stallion collection centres in Europe; it offers semen collection services, fertility assessment and worldwide semen export and has collected from over 1000 stallions across 51 different breeds. In recent years, Tullis has carried out research into semen collection, stallion fertility and methods for cryopreservation of equine semen and embryos. He has developed bespoke extenders for stallions and harvested semen from post-castration testicles. He lectures worldwide on equine breeding and stallion management and also works with organisations such as Chester Zoo to help cryopreserve semen from endangered species, e.g. rhino and lion. In 2011, Tullis, through the Rare
Bredes Survival Trust, received the Marsh Christian Trust award for the technological advances he has brought to the field of equine semen freezing.

**Andy G. Matthews**  
BVMS(Dist) PhD DipECCEIM(Ret) Hon Member ACVO FRCVS  
After graduating with distinction from Edinburgh in 1976 and being awarded his PhD in equine immunology and protein genetics in 1981, Andy’s subsequent career has been primarily in equine clinical practice. His long-term clinical interest is in equine ophthalmology, in particular, ocular immunobiology. He was awarded the British Equine Veterinary Association Richard Hartley Clinical Prize for published work in 1991. He was awarded fellowship of the Royal College of Veterinary Surgeons in 1994 and became a diplomate of the European College of Equine Internal Medicine in 2004. In 2011 Andy was awarded honorary membership of the American College of Veterinary Ophthalmologists; he was awarded honorary lifetime membership of the British Equine Veterinary Association in 2013 and in 2018 will receive a lifetime achievement award from the British Association of Veterinary Ophthalmologists.

**Colm McGinn**  
DipM MBA MCIM  
Colm has over 25 years’ experience working in a variety of commercial roles in the veterinary industry in the UK and Ireland. He spent 10 years with Fort Dodge Animal Health, where he was responsible for their livestock business unit. Thereafter he moved to Centaur Services, the veterinary wholesaler, where he was director of customer service, sales and marketing. He is a member of the Chartered Institute of Marketing and completed his master’s in business administration (MBA) in 2012. He is responsible for marketing and communications for XLVets.

**Andrew McGladdery**  
BVMS CertESM MRCVS  
Andrew graduated from Glasgow University in 1985 with a degree in veterinary medicine and surgery. After a brief period in equine practice in Devon and Kent, he joined Rossdale and Partners in 1988 as a Horserace Betting Levy Board resident in equine studies for a 3-year period under the guidance of Peter Rossdale and with a special interest in perinatology and ultrasonography. At the end of his residency he remained working on the studfarm side of the practice and became a partner in the practice in 1994. He is a holder of the Royal College of Veterinary Surgeons certificate in equine stud medicine. He has co-authored a number of publications, presented at conferences and lectured around the world on a number of studfarm medicine-related topics. Andrew was an International Symposium on Equine Reproduction committee member for the Caxambu and Pretoria symposia. His main areas of interest are all aspects of studfarm medicine (Thoroughbred and non-Thoroughbred), especially involving mare infertility investigation and hysteroscopy and the high-risk pregnant mare, and Doppler flow studies of the umbilical and uterine circulation.

**Shaun A. McKane**  
BVSc BSc(Vet) PhD DipACVIM DipECCEIM MRCVS  
Shaun gained his veterinary degree from the University of Sydney in 1993, where he also completed an intercalated degree in equine respiratory responses to exercise with Prof. Reuben Rose. After a time in equine practice he moved to take up a PhD at the University of Melbourne, centred on the effects of exercise-induced pulmonary haemorrhage on racehorse lungs. Wanting to continue his development as an equine specialist, Shaun moved to Oregon State University in 1999, to undertake a residency position and become a boarded specialist with the American College of Equine Internal Medicine. In 2002 he moved to Leahurst, University of Liverpool, where he worked as a senior lecturer in equine medicine, training veterinary students and became a RCVS recognised and European specialist in equine medicine. Shaun has a wide range of clinical interests including respiratory disease, cardiology, ophthalmology and neurology. His clinical research at Liverpool has helped develop new methods for the treatment of headshakers, sarcoids and squamous cell carcinomas in horses. Shaun now brings all of this training and experience with him as he moves to west Wales to take up a position at Cotts Equine Hospital.

**Lucy Meehan**  
BVSc MSc CertAVP(VDI) DipECVCI(US) MRCVS  
Lucy graduated from the University of Liverpool in 2007 with a veterinary degree and a master’s in veterinary infectious disease. She went on to an internship at the Animal Health Trust in Newmarket. Following this, she returned to her roots in Yorkshire, working in a well-regarded equine practice with primary responsibility for lameness and imaging. Lucy subsequently undertook a residency in equine orthopaedics and diagnostic imaging at the University of Edinburgh, during which she gained the Royal College of Veterinary Surgeons (RCVS) certificate in advanced veterinary practice (veterinary diagnostic imaging). In September 2015 she became a large animal diplomate of the European College of Veterinary Diagnostic Imaging and in 2016, an RCVS recognised specialist in diagnostic imaging. Lucy joined the team at Langford, University of Bristol in January 2016 to further the diagnostic imaging capability within the small animal and equine hospitals before moving to her current role as senior teaching fellow in equine lameness in March 2017. Outside work, she enjoys walking, shooting, slowly and photography. She has recently acquired a puppy to accompany her exploring the Somerset countryside.

**Colin Mitchell**  
BVMS & BSc CertEP CertVBM MRCVS  
Colin qualified from the Royal (Dick) School of Veterinary Studies in 1995 and moved to Northumberland in 1998 after 3 years in farm and equine practice in North Yorkshire. He became a partner and attained the Royal College of Veterinary Surgeons certificate in equine practice in 2004. He completed the certificate in veterinary business management in 2016 and has a special interest in finance, leadership and strategy. Outside practice life, Colin’s interests include mountain biking, running and skiing.

**Peter Morresey**  
BVSc MVM MACVSc DACT DACVIM(LA) CVA  
Peter graduated from Massey University in New Zealand and spent 8 years in mixed veterinary practice. He attended the University of Florida to undertake a residency in theriogenology followed by a large animal internal medicine residency. He then joined the faculty at the New Bolton Center, University of Pennsylvania School of Veterinary Medicine, as a field service clinician. He is a diplomate of both the American College of Theriogenologists and the American College of Veterinary Internal Medicine (Large Animal). Currently he is in private practice at Rood and Riddle Equine Hospital in Lexington, Kentucky. His interests include general equine medicine, reproductive health, neonatal medicine, neurology and respiratory therapies.

**David Mountford**  
MA VetMB MRCVS  
David joined the Royal Army Veterinary Corps in 1992 after graduating from Cambridge University Veterinary School. After commanding in Cyprus and Hong Kong and serving as
veterinary officer to the King’s Troop Royal Horse Artillery. David left the Services and joined the International League for the Protection of Horses (now World Horse Welfare) where he spent 4 years managing the charity’s operations. In 2003, David, together with Roger Smith from the Royal Veterinary College, set up a company, VetCell Bioscience, to develop novel veterinary therapies. David also joined BEVA Council in 2003, was elected as honorary secretary in 2006 and then honorary treasurer in 2007. VetCell was sold in 2010 and David was asked to take on the new role of BEVA chief executive as an interim measure. This appointment has now been made permanent. Most of his free time is now spent either as lorry driver/groom to his children or as coach to his local U16s rugby team.

Huw Neal
MA VetMB MRCVS
Huw graduated from Cambridge in 1983 and came to Newmarket after 2 years in Thirsk. He provides veterinary care for a number of commercial and private studfarms. Huw’s special interests include fertility evaluations in mares and stallions, fetal sex determination, laparoscopic investigation and treatment of fertility disorders and surgery of the reproductive organs.

Richard Newton
BVSc MSc PhD FRCVS
Richard is director of epidemiology and disease surveillance at the Animal Health Trust, Newmarket. His group runs programmes on equine infectious disease surveillance and research in the UK, including preparation of quarterly disease reports for Defra and regular updates on global equine disease occurrence through the International Collating Centre. Richard has worked on the epidemiology of a variety of diseases of companion animals, including grass sickness, exercise-induced pulmonary haemorrhage and strangles in horses, and influenza, including cross-species transmission from horses to dogs. He currently oversees dedicated research programmes on grass sickness surveillance and vaccination and epidemiological research of equine laminitis.

Seth O’Neill
PhD MSc BSc PGCE HE MCSP MMACP
Seth is a lecturer in physiotherapy at the University of Leicester. He recently completed a PhD entitled ‘A Biomechanical Approach to Achilles Tendinopathy Management’, within this Seth has identified prevalence rates of tendinopathy in UK runners and developed a greater understanding of risk factors surrounding Achilles tendinopathy. His later work has completed a more in-depth analysis of how tendinopathy affects the plantar flexors: this has focused on how the strength and endurance is affected and which of the plantar flexors is most involved and has highlighted the involvement of the soleus muscle in human Achilles tendinopathy. Seth is currently examining tendon structure and changes that occur during health and disease.

Maarten Oosterlinck
DVM PhD DipECVS
Maarten graduated from Ghent University in 2004 and gained extensive experience in equine orthopaedics and surgery in the busy university clinic. Combining clinical work with research, he earned his PhD on the subject of equine pressure plate analysis in 2011. He became a diplomate of the European College of Veterinary Surgeons in 2014. Maarten has published on orthopaedic and surgical topics in peer-reviewed journals and is regularly invited to speak at international courses and conferences. He is an editorial board member of The Veterinary Journal and Equine Veterinary Education. Maarten’s daily work involves equine orthopaedics, gait analysis, podiatry and surgery, while enjoying clinical research and consulting in his field of expertise.

Roly Owers
MA MSc VetMB MRCVS
Roly gained his veterinary degree from Cambridge University in 1992 and his master’s degree in nutrition from the London School of Hygiene and Tropical Medicine in 1997. He has been chief executive of the charity World Horse Welfare since 2008, having previously performed veterinary roles at the Blue Cross and in the Royal Army Veterinary Corps. Roly is currently treasurer of BEVA, Chairman of the UK Equine Disease Coalition, a member of the steering group of the British Horse Council, and a board member of the European Horse Network.

Andrew Parks
MA VetMB DipACVS MRCVS
Andrew received his VetMB from the University of Cambridge in 1981. He is a diplomate of the American College of Veterinary Surgeons and received his certificate in veterinary radiology from the Royal College of Veterinary Surgeons in 1982. He currently serves as professor of large animal surgery at the University of Georgia. Andrew has made over 160 professional presentations and has peer-reviewed and authored articles and book chapters. His clinical interests are large animal surgery, lameness and diseases of the foot.

Rob Pascoe
BVSc BAEDT DipAVDC(Eq) MRCVS
Rob graduated in 1999 from Bristol University. In 2003 he became one of the first veterinary surgeons to pass the British Equine Veterinary Association (BEVA)/British Veterinary Dental Association (BVDA) equine dentistry examination. Recognised as a leading expert in equine dentistry, he lectures on courses internationally and has held advisory roles with the BEVA and BVDA. He is a founding diplomate of the American Veterinary Dental College, the only veterinary surgeon in the UK to achieve this, and in 2015 became the first Royal College of Veterinary Surgeons recognised specialist in equine veterinary dentistry. He currently works in a large referral hospital in Kent, handling first-opinion and referral caseloads.

Richard Payne
BSc BVSc CertES(Orth) DipECVS MRCVS
Richard graduated from Bristol University in 1995, having also obtained a degree in pharmacology. He joined Rossdales in 1996 where he completed a 3-year residency in equine surgery. He is a diplomate of the European College of Veterinary Surgeons. As head of surgery and partner in charge of Rossdales Equine Hospital, his day to day work includes an equal proportion of orthopaedic and soft tissue surgery. He has a specialist interest in standing surgery and minimally invasive surgery, including arthroscopy, fracture repair, laparoscopy and laser surgery. Outside work, his interests include sport, farming, flying and spending time with his young family.

Chris Pearce
BVSc CertEM(IntMed) CertES(SoftTissue) DipEVDC(Equine) BAEDT MRCVS
Chris has considerable experience at all levels of equine dentistry. He was the first veterinary surgeon to pass the British Equine Veterinary Association/British Veterinary Dental Association equine dental technicians exam in 1990, has Royal College of Veterinary Surgeons (RCVS) certificates in internal medicine and soft tissue surgery,
and in 2014 passed the first full examination for the new European diploma in equine dentistry, making him a European veterinary specialist as well as RVCS recognised specialist. Chris lectures, teaches and examines regularly at courses and conferences around the world. In 2012 he set up a 100% equine dental referral practice providing visiting and clinic-based referral services throughout the UK. He has a particular interest and wide experience in novel minimally invasive, restorative and preservative therapies.

John Peloso  
DVM MS DipACVS  
John was born in Ontario, Canada, and graduated from the Ontario Veterinary College in 1987. He worked for 2 years in a Standardbred racetrack practice in Ontario then moved to Michigan State University where he completed the 3-year residency and master’s program in equine surgery in 1992. He was a staff equine surgeon at Texas A&M University from 1992 to 1995 and then returned to private practice for 3 years as a surgeon in Louisville, Kentucky. In October 1998, John moved to Ocala, Florida, where he is a founding partner and an equine surgeon at the Equine Medical Center of Ocala.

Justin Perkins  
BVetMed MS CertES DipECVS MRCVS  
Justin graduated from the Royal Veterinary College (RVC) in 1997 and stayed there to complete a junior clinical training scholarship in 1998. He then completed a 3-year senior clinical training scholarship in equine surgery and Master of Science at the University of Edinburgh and Auburn University, USA. He worked as a lecturer in equine surgery at University College Dublin, Ireland before returning to the RVC in 2003 as a lecturer in Equine Surgery.

Patrick Pollock  
BVMS PhD CertES(SoftTissue) FHEA DipECVS FRCVS  
After qualifying from the University of Glasgow in 1998, Patrick worked in mixed general practice in north-east Scotland before moving to Ireland to undertake an internship and then residency in large animal surgery at University College Dublin (UCD). After his residency he worked as college lecturer in equine surgery at UCD for several years before moving to Denmark. He has since worked in private and academic practice and, after 11 years at the Weipers Centre Equine Hospital in Glasgow, he has recently taken up the position of senior lecturer and head of surgery at the Royal (Dick) School of Veterinary Studies, University of Edinburgh. Patrick is a diplomate of the European College of Veterinary Surgeons, a European and Royal College of Veterinary Surgeons recognised specialist in equine surgery and a fellow of the Royal College of Veterinary Surgeons. He is involved with a number of projects around the world with working equidae, including training veterinary surgeons and equid owners in resource-limited settings. His clinical and research interests include equine poor performance, the upper airway, ophthalmic surgery, trauma and wound healing and he has been instrumental in the development and validation of the technique of overground endoscopy. He has recently successfully completed a PhD, looking at the use of acute phase proteins for monitoring disease in horses, and a particular interest and wide experience in novel minimally invasive, restorative and preservative therapies.

Nicola Pusterla  
DVM PhD DipACVIM  
Nicola graduated from the school of veterinary medicine at the University of Zurich, Switzerland in 1991. He worked in the private and academic sector, focusing on large animal internal medicine. He earned his PhD degree from the University of Zurich researching vectorborne diseases. He joined the University of California, Davis in 1998 where he currently holds an appointment as a professor in equine internal medicine. He is a diplomat of the American College of Veterinary Internal Medicine (Equine) and he has an ongoing interest in all aspects of equine internal medicine and dentistry. Nicola’s research focuses on selected aspects of equine infectious diseases with an emphasis on epidemiology, clinical disease understanding, diagnostics, prevention and treatment.

Jonathan F. Pycock  
BVetMed PhD DESM MRCVS  
Jon graduated from the Royal Veterinary College, University of London. He has been awarded the Royal College of Veterinary Surgeons (RCVS) certificate (1991) and diploma (1994) in equine stud medicine and is a RCVS recognised specialist in equine medicine (reproduction). He has worked in various areas of the veterinary profession, including teaching and research, as well as in clinical practice. Jon developed a first opinion and referral equine practice in Texas. He has acted as an expert witness for the Veterinary Defence Society (VDS) on many occasions and became one of three equine claims consultants for the VDS in 2012. With a long-standing commitment to continuing professional development (CPD) Jon delivers around 65 days of CPD annually, both within the UK and overseas. He has been a member of the BEVA council for 7 years and is the current BEVA President. He is responsible for one of the longest running annual BEVA courses, the reproductive ultrasound course, which has been a sold-out course every year for the past 20 years. He has either spoken or been chair of a session (or both!) at almost every BEVA congress for the past 25 years. He has participated in congresses, training courses and seminars all over the world and is internationally recognised for his writing and presentations skills. He has written many book chapters in major equine textbooks. He is an experienced horseman and avid squash player, off-piste skier, road cyclist, slow triathlete and climber.

Richard Reardon  
BVetMed(Hons) MVM PhD CertES(Orth) DipECVS MRCVS  
Richard graduated from the Royal Veterinary College in 2004 and worked in mixed practice before undertaking an equine internship in Newbury. He then spent 6 years at Glasgow University, undertaking a residency in equine surgery as well as a master’s degree and a PhD. Richard moved to the Royal (Dick) School of Veterinary Studies at Edinburgh University in 2012 as a senior lecturer in equine surgery. He currently helps to run the soft tissue and dental services at the hospital and enjoys all aspects of equine surgery, with research interests in both soft tissue and orthopaedic surgery.

David Rendle  
BVSc MVM CertEM(IntMed) DipECEIM MRCVS  
David runs the referral laboratory at Rainbow Equine Hospital, North Yorkshire, and is a specialist in equine medicine and a director within the hospital. He splits his time between providing advice and support on external laboratory samples, and seeing referred medicine and critical care cases. Since graduating from the University of Bristol in 2001 and completing a residency at the University of Glasgow, he has worked in universities both in the UK and Australia, but has spent most of his career in private practice and has taught at the Royal (Dick) School of Veterinary Studies at Edinburgh University in 2001 and completing a residency at the University of Glasgow, he has worked in universities both in the UK and Australia, but has spent most of his career in private practice.
equine referral practice in the UK. David is a Royal College of Veterinary Surgeons recognised and European specialist in equine internal medicine. He is actively involved in all fields of equine medicine and has published on a range of topics. His particular interests are endocrine, respiratory and gastrointestinal disease.

David Renney
BVetMed MRCVS
David graduated from the Royal Veterinary College in 1983. He went into mixed practice in the Midlands, then joined the veterinary pharmaceutical industry. In 2007, he founded Nimrod Veterinary Products, a company which brings new or neglected products and ideas for horses and farm animals to the veterinary market place. He has always had an interest in riding, hunting and racing. He has a point-to-pointer in training and various other horses at home.

Andrew Richardson
BVSc CertAVP(Stud Med) MRCVS
Andrew graduated from Bristol University in 2006. He completed his internship at the world-renowned Dubai Equine Hospital in the UAE, working with high performance Thoroughbreds and Arab endurance horses, alongside specialists from across the world in orthopaedics, surgery, medicine and foal care. Returning to the UK, he worked at a large hospital in Gloucestershire, dealing with a mixture of first opinion cases and referral clients. In 2011/2012 Andrew moved to work as a resident veterinary surgeon at Cambridge Stud, the largest Thoroughbred studfarm in New Zealand. In 2012 he joined Wessex Equine as director. In 2013 he passed his RCVS examination in equine stud medicine – recognition of his expertise in this field. He spends his time looking after several professional studfarms, small breeders, as well as general equine work. His main interest is in Thoroughbred breeding. As an owner of several broodmares himself, he understands the highs and lows of breeding work. He regularly attends the major Thoroughbred sales in the UK and Ireland, working on behalf of his clients. He often contributes articles on breeding-related topics to the Equine Health publication. He is a member of the Doncaster Bloodstock veterinary team, providing on-site veterinary care during their sales.

Fabrice Rossignol
PhD DVM DipECVS
Fabrice graduated from the National Veterinary School of Toulouse in 1993, followed by an internship in Toulouse. He then worked as a veterinary assistant at the Equine Clinic of Grosbois, becoming a partner in 1998. He is a diplomate of the European College of Veterinary Surgeons and is the lead surgeon operating at the equine clinic of Grosbois and Chantilly where he is engaged in full-time surgical activity. Fabriche’s favourite specialties are upper airway, surgery, fracture fixation and laparoscopy. He has been in the AOEVET Faculty since December 2016. He is involved in a multicentre research programme on fracture fixation and upper airway surgery including the development of a laryngeal neurostimulator. He enjoys skiing, diving, sun and French wine.

Juan C. Samper
DVM PhD DipACT
Juan graduated in 1982 and earned his PhD and completed a residency at the University of Minnesota. He is board certified by the American College of Theriogenologists (ACT) and has been on the faculty of the Ontario Veterinary College, Kansas State University, Ross University School of Veterinary Medicine and most recently at the University of Florida, where he also serves as the associate dean for student and academic affairs. In addition to his academic career, Juan was an equine practice owner in Vancouver, British Columbia, for over 20 years, initially as a solo practitioner and later in a group setting. He has consulted extensively in North and South America and in Europe. In addition to writing several scientific articles, he is the editor of Equine Breeding Management and Artificial Insemination and co-editor of Current Therapy in Equine Reproduction. He is an active member of the American Association of Equine Practitioners and is past president of the Society for Theriogenology and the North East Association of Equine Practitioners. Juan served as a consultant for sexing technologies and as chairman of the International Symposium on Stallion Reproduction and chairman of the board of directors of the ACT.

Michael Schramme
DrMedVet CertEO PhD HDR DipECVS DipACVS AssocECVDI
Michael qualified from the Rijksuniversiteit Gent, Belgium, in 1985. He has since worked as an equine surgeon at the University of Ghent, the Royal Veterinary College, the Animal Health Trust, Cornell University, North Carolina State University and the Ecole Nationale Vétérinaire de Lyon in France, where he is a full professor in equine surgery. He is a diplomate of the American College of Veterinary Surgeons and an associate of the European College of Veterinary Diagnostic Imaging. He is the current president of the European College of Veterinary Surgeons and a past president of the European Society of Veterinary Orthopaedics and Traumatology. Michael has an interest in all aspects of equine surgery, lameness and diagnostic imaging, with special emphasis on magnetic resonance imaging and regenerative medicine.

Mark Senior
BVSc PhD SFHEA CertVA DipECVAA MRCVS
Mark graduated from the University of Liverpool and then spent 2 years working in mixed practice. He returned to the University of Liverpool to complete a residency in equine anaesthesia and cardiology between 1999 and 2002 and never left! Mark was awarded a PhD for his thesis ‘Complement and Endotoxin in Equine Colic’ in 2009. He is now a senior lecturer in veterinary anaesthesia and is head of equine anaesthesia at Leahurst. He is a European and RCVS recognised specialist in veterinary anaesthesia and analgesia.

Ceri Sherlock
BVetMed MS MVetMed DipACVS-LA DipECVS-LA DipECVDI-LA MRCVS
Ceri graduated from the RVC in 2004 before joining Bell Equine as an intern. She then completed a surgical residency and master’s degree at the University of Georgia and became a diplomate of the American College of Veterinary Surgeons in 2010. After completion of the residency, Ceri remained in America until 2011 when she returned to the UK to take up a surgical position at the University of Nottingham. In 2012, Ceri returned to Bell Equine and has since completed a residency in diagnostic imaging in conjunction with the Royal Veterinary College. Ceri became a diplomate of the European College of Veterinary Diagnostic Imaging in 2015.

Harald Sieme
DVM DrMedVet DrHabil
Harald achieved the degrees of DVM in 1988, DrMedVet. in 1989 and DrHabil in 2004. He worked as a veterinarian at the National Stud at Celle in Germany from 1991 to 2006 and is a professor of equine reproductive medicine at the University of Veterinary Medicine, Hannover, Germany. Besides his teaching and clinical activities, his research interests are mainly focused on stallion fertility, cryobiology of sperm and reproductive biotechnology, including artificial insemination and embryo transfer.
Ellen Singer  
**BA DVM DVSc DipACVS DipECVS MRCVS**  
Ellen graduated from Tufts University School of Veterinary Medicine, after which she spent 3 years in general equine practice in the north-east United States. Following a surgical residency and Doctor of Veterinary Science degree at the Ontario Veterinary College, she spent time working at the Koret School of Veterinary Medicine in Israel. In 1995, Ellen joined the University of Liverpool where she was employed as a senior lecturer and a key member of the orthopaedics and surgery team for 22 years. Ellen has diplomas in both the European and the American Colleges of Veterinary Surgeons. Her main passion is surgery and the equine athlete. Her clinical interests are primarily lameness diagnosis and orthopaedic surgery, but she also loves colic surgery, the reason she became interested in being a surgeon in the first place. Ellen’s research interests are divided into clinical projects that address common problems in her orthopaedic patients, as well as more basic science projects that focus on the biomechanics of horse limbs and the response of bone to exercise. Ellen loves nothing more than figuring out why horses are lame and providing a practical, and hopefully successful, solution for the horse’s owners.

Josh Slater  
**BVM&S PhD DipECEIM MRCVS**  
Josh graduated from the University of Edinburgh in 1985 and spent 4 years in equine practice before embarking on an academic career, initially in Cambridge and then at the RVC where he is professor of equine clinical studies and clinical director of the equine referral hospital. His research is in equine infectious diseases, in particular strangles and equine herpesviruses, and he has a wide range of interests in equine medicine. He is a past president of BEVA, the Federation of European Equine Veterinary Associations and the European College of Equine Internal Medicine and is currently a BEVA council member and chair of the Health and Medicines committee. He is currently also a co-director of the British Animal Rescue Trauma Association, chairman of the Horse Trust and secretary to the European Board of Veterinary Specialisation.

Nathan M. Slovis  
**DVM DipACVIM CHI**  
Nathan is the director of the McGee Medical and Critical Care Center at the Hagyard Equine Medical Institute in Lexington, Kentucky. He is a native of Annapolis, Maryland. He received his Bachelor of Science from Radford University, Doctor of Veterinary Medicine from Purdue University, interned at Arizona Equine Center and completed his residency in internal medicine at the University of California, Davis. He has written numerous book chapters and published over 50 manuscripts in both national and international peer-reviewed veterinary journals. He is the editor of both the *Atlas of Equine Endoscopy* and the *Atlas of Diseases and Disorders of the Foal*, both distributed by Elsevier. He implemented the current infectious disease and equine emergency response programmes at Hagyard Equine Medical Institute and holds the positions of infectious disease officer and equine emergency response co-director. Nathan is also a certified hyperbaric technologist and a member of the veterinary infectious disease society.

Angela Smith MP  
A member of the Labour Party since the age of 16, her first experience of politics was helping out in the General Election of 1979. While at Cambridge she stood twice for election as a councillor, being unsuccessful on both occasions. In the mid-1990s she moved to Sheffield and again stood for council, taking Broomehill ward from the Conservatives. In 1999 she became Chair of Finance, guiding the city through some very difficult years. When Labour lost control of the city in 1999 she became the opposition spokesperson for Education, taking over as Cabinet Member for Education when Labour won the election in 2002. Under her leadership Sheffield became regarded as one of the leading educational authorities in the country, piloting many government initiatives. At the 2005 general election she won the Sheffield Hillsborough parliamentary seat. From 2005 until 2008 she was the Parliamentary Private Secretary to Yvette Cooper at the Department of Communities and Local Government and Treasury. In 2009 she joined the select committee for Transport. At the 2010 election she was re-elected to Parliament as the member for the new constituency of Penistone and Stocksbridge. After a spell as an opposition Whip, Angela was promoted to the front bench as the Shadow Deputy Leader of the House in October 2010.

Roger K.W. Smith  
**MA VetMB PhD DEO FHEA LAAsscECVDI DipECVS FRCVS**  
Roger is professor of equine orthopaedics at the Royal Veterinary College, London, UK. He qualified as a veterinary surgeon from Cambridge University in 1987, having obtained a first for his undergraduate degree and a Cambridge blue at swimming. After 2 years in practice, he returned to academia to undertake further clinical training as a resident in equine studies at the Royal Veterinary College. Following his residency, he undertook a 3-year research project culminating in the award of a PhD for his studies on the extracellular matrix of equine tendon. He remained at the Royal Veterinary College, first as a lecturer in equine surgery, then as senior lecturer in equine surgery, before his appointment to professor in equine orthopaedics in December 2003. He holds the diploma in equine orthopaedics from the Royal College of Veterinary Surgeons and is a diplomate of the European College of Veterinary Surgeons and a Royal College of Veterinary Surgeons recognised specialist in equine surgery. He is also a large animal associate of the European College of Veterinary Diagnostic Imaging. In 2016, he was awarded the fellowship of the Royal College of Veterinary Surgeons for meritorious contribution to knowledge and was elected to president of the European College of Veterinary Surgeons in July 2017. He currently divides his time equally between running a specialist orthopaedic service within the Royal Veterinary College and continuing to direct research into equine tendon disease. His principal research interests are understanding the pathogenesis of tendon disease, developing a serological assay for tendonitis, and stem cell therapy for tendons in both horses and humans. He is married to a medical doctor and has two sons.

Sarah Smith  
**MA VetMB MvetMed DipACVIM MRCVS**  
Sarah graduated from the University of Cambridge before undertaking an internship in Lambourn, Berkshire. She then worked as an ambulatory vet in Sussex prior to joining the Royal Veterinary College as a resident in equine medicine. During her residency she undertook research into testing for insulin dysregulation and into the impact of maternal obesity on the development of Thoroughbred foals. After her residency, Sarah worked as an equine medicine specialist at Rossdales Equine Hospital, in Newmarket, before joining the equine referral hospital at Langford Vets, University of Bristol in May 2017.

Katie Snalune  
**BSc MA VetMB CertEM(IntMed) CertES(Soft Tissue) MRCVS**  
Katie graduated from Cambridge, then completed an internship at a large referral hospital. In 2005, she passed the Royal College of Veterinary Surgeons (RCVS) certificate in the treatment and management of acute brain disorders and internal medicine. In 2014, she completed the RCVS advanced diploma in emergency and critical care and in 2016, the RCVS advanced diploma in oncology. Katie has experience in the treatment of several cases of brain and soft tissue tumours and the use of targeted therapies like immunotherapy. She is currently working as a senior referral clinical assistant within the emergency and critical care service.
John W. Spencer
BVSc MRCVS

John joined Fynwy Equine Group following his graduation in 2007 and became a partner in 2011. He is a member of the stud veterinary team at Fynwy, working with large studs across Shropshire and beyond. He is the centre veterinary surgeon for Stallion AI Services in Whitchurch and has extensive experience with fresh, chilled and frozen semen, together with embryo transfer and reproductive surgery. As a member of the Thoroughbred Breeders Association veterinary committee he works to support the breeding of quality bloodstock and represent breeders’ interests both within Great Britain and the European Commission. John is actively involved with the teaching of stud medicine through the British Equine Veterinary Association. Alongside the stud medicine side of the practice, he is involved with the management of several large sports horse yards, with a particular interest in lameness and poor performance. He is also a Fédération Equestre Internationale permitted treating veterinary surgeon as well as an Association of Racecourse Veterinary Surgeons veterinary surgeon, and is on the veterinary panel for Uttoxeter and Haydock racecourses together with several point-to-points. When he has the time, John enjoys mountaineering, skiing, sailing and country pursuits with his dog Uishinn.

Michael Stanford
BVSc FRCVS

Michael qualified from Liverpool University in 1987 and subsequently set up a practice specialising in the veterinary care of exotic pets, zoo and wildlife animals, including an on-site pathology laboratory for these species. He was awarded the Royal College of Veterinary Surgeons Diploma of Fellowship by thesis in 2006 for his work on calcium metabolism in Grey parrots and is a recipient of the British Veterinary Association William Hunter medal. He has been a claims consultant for the Veterinary Defence Society since 2007 and is their current newsletter editor. He is a recent past president of the British Veterinary Zoological Society.

Richard Stephenson
BVMS CertVR CertEP MRCVS

Richard qualified from the University of Glasgow in 1987. He went to work at the Pool House Veterinary Group where he began his career in mixed practice; he became a partner in 1994 and for the last 20 years has focused exclusively on equine work. He obtained the Royal College of Veterinary Surgeons (RCVS) certificate in veterinary radiography in 1991 and the certificate in equine practice in 2001. Richard was subsequently appointed as examiner and then chief examiner in equine practice by the RCVS. He was appointed to the examinations board of the Worshipful Company of Farriers in 2002 and later to its executive committee. Currently he is chairman of the examinations board. He was elected to the Council of the RCVS between 2008 and 2016 and served on all the major statutory committees, including the Disciplinary and the Education and Public Affairs Committees and spent many years on the Preliminary Investigation Committee. Richard is currently the senior partner in a 17-veterinary surgeon equine practice and has just completed a multimillion-pound project to build a new equine hospital facility at the practice’s main site. He regularly contributes to both the lay and veterinary press on diverse subjects ranging from the regulation of the veterinary profession to foot abscesses! His main professional interests include the application of farriery to veterinary practice and the regulation of the veterinary profession, particularly how to lighten the regulatory burden on veterinary practitioners.

Tom A.E. Stout
MA VetMB PhD DipECAR MRCVS

Tom is professor of equine reproduction at Utrecht University and extraordinary professor at the University of Pretoria. He started his career with a PhD on ‘Maternal Recognition of Pregnancy in the Mare’ at the Equine Fertility Unit in Newmarket (supervised by Prof Twink Allen) and has been in Utrecht since 1999, running a busy five-veterinary surgeon clinic addressing all aspects of horse reproduction including obstetrics and reproductive surgery, stallion semen quality evaluation, mare fertility examination, artificial insemination, embryo transfer, ovum pick-up and in vitro fertilisation. His primary research interests are in assisted reproduction, early embryonic development and pregnancy loss.

Anne-Marie Svendsen Aylott
CANDmedVet MRCVS

Anne-Marie is an inspirational leadership coach and trainer and NLP Master Practitioner. Her focus is on helping organisations and individuals create a culture of positive change, both within themselves and in the organisation, where employee motivation and happiness is in focus. Her training focuses on the skills of strong and inspirational leadership and is especially suitable for a visionary organisation that wants to go the extra mile to engage their teams. All her training is grounded in research and psychology and provides in-depth skills in superb communication, emotional intelligence skills and driving high-end resilience in leaders and their teams. Anne-Marie has a background as a veterinary surgeon and has worked for many years in sales, marketing and training.

Ben Sykes
BSc BVMS MS MBA DipACVIM DipECIM PhD

Ben graduated from Murdoch University in 1997 and immediately afterwards undertook an internship at Randwick Equine Centre in Sydney. Following 3 years in academia and private practice he moved to Virginia, USA to complete a residency in equine internal medicine at the Marion DuPont Equine Medical Center. He became boarded in large animal internal medicine in 2004. Following this he had a 7-year stint in Finland, initially at the university and then in private practice. As of 2009 Ben has resided back in his homeland of Australia where he has recently completed his PhD on equine gastric ulcer syndrome. Ben is currently employed by Bova Australia, works as a consultant to Luoda Pharma, an advisor to Bova UK and holds adjunct positions at the University of Queensland and the University of Liverpool.

Mark Tabachnik
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Mark graduated from the Royal (Dick) School of Veterinary Studies in 2002. He is managing partner of Wright & Morten Veterinary Group in Macclesfield, Cheshire. His clinical responsibilities are focused around equine dental services and routine first opinion equine practice. In 2016 Mark became the chairman of the XL Equine executive committee, who are responsible for setting strategies and implementing actionable plans for a large group of independent practices working collaboratively to bring best
practice to their businesses and best value to their clients. In 2017 he completed the further qualification, certificate in veterinary business management.

**Stuart Thorne**

**BSc BVSc PhD MRCVS**

Stuart graduated from the University of Liverpool and has worked in equine practice ever since, first in Cheltenham and now at Fellows Farm Equine Clinic in Cambridgeshire, where he is a director. He considers himself to be an equine general practitioner whose interests and responsibilities are varied. He is on the veterinary panel at Goffs Bloodstock Sales, the veterinary team at the Burghley International Horse Trials and the executive of the XL Equine group. He is senior veterinary surgeon at Huntington Racecourse, a Fédération Equestre Internationale accredited treating vet, and has served as a council member of BEVA. As well as his veterinary qualifications, he has a BSc in physiology and biochemistry and a PhD in veterinary physiology; he is a regular speaker at veterinary conferences and a contributor to articles for the national press. Stuart enjoys all aspects of equine work but has a special interest in the competition horse.

**Neil Townsend**

**MSC BVSc CertES(SoftTissue) DipECVS DipEVDC(Equine) MRCVS**

Neil qualified from Bristol University in 2004 and, after a brief period in mixed practice, embarked on an equine-only career starting with an equine internship at Liverpool University and a surgical residency at the University of Edinburgh. He rejoined Liverpool University in 2010 as a surgical clinician, setting up an advanced dentistry service including standing computed tomography. He joined Three Counties Equine Hospital, Tewkesbury in 2015, where he provides both an in-house and periapatic advanced dentistry and surgery service. Neil is a Royal College of Veterinary Surgeons recognised specialist both in equine surgery and in veterinary dentistry (equine).

**Henry Tremaine**

**BVetMed CertES(SoftTissue) MPhil DipECVS DipEVDC FHEA FRCS**

Henry joined B&W Equine Vets in 2017. Prior to this he was a senior lecturer in equine surgery at the University of Bristol for 14 years and was also head of equine clinical services until 2015; in this role he was responsible for teaching soft tissue surgery and dentistry to veterinary undergraduates. Henry is a Royal College of Veterinary Surgeons specialist in equine surgery and dentistry and his particular interests are upper airway surgery, maxillofacial surgery and dentistry. He has published widely in these fields and lectured and taught at conferences and courses around the world. Born and educated in Gloucestershire, Henry's other interests include playing tennis, cycling, skiing, kite surfing and occasional field sports.

**Rebecca Trousdale**

**REVN**

Rebecca started working at Rainbow Equine Hospital in 2005 and in 2010, qualified as a registered equine veterinary nurse from Myerscough College. Her main interest at Rainbow is diagnostic imaging, including magnetic resonance imaging, nuclear scintigraphy and radiography.

**Chris Tufnell**

**BSc(Hons) BVMS MRCVS**

Chris is an equine practitioner and a council member and past-president of the Royal College of Veterinary Surgeons (RCVS). During his time on RCVS council he has taken a specific interest in veterinary education, having chaired the education committee for 3 years. Chris is the council lead on the innovation project, ViVet, chairs the Brexit taskforce and co-chairs the veterinary capacity and capability project within the British Veterinary Association and Defra. He is passionate about the future of the profession and believes strongly that we need to be in the driving seat of our contribution to animal health and welfare.

**Gunther van Loon**

**DVM PhD DipECEIM AssocECVDI**

Gunther graduated from Ghent University, Belgium, in 1992 and has worked in the department of large animal internal medicine ever since. In 2001 he finished his PhD on 'Atrial pacing and experimental atrial fibrillation in equines'. In 2004 he became a European College of Equine Internal Medicine diplomate and in 2011, an associate member of the European College of Veterinary Diagnostic Imaging. In 2015 he received the World Equine Veterinary Association research award for outstanding research regarding 'advances in equine cardiology'. He is professor of large animal internal medicine at Ghent University, president of the Belgian Equine Practitioners Society, head of the equine internal medicine clinic and head of the equine cardio team. His major interests are cardiology (arrhythmias, electrocardiography, echocardiography, tissue Doppler imaging, two-dimensional speckle tracking, biomarkers), and thoracic and abdominal ultrasound.

**Dickson D. Varner**

**DVM MS DipIACT**

Dickson practised in Lexington, Kentucky for 4 years before completing a residency at the University of Pennsylvania. He has been on the faculty at Texas A&M University since 1986, where he is professor of theriogenology and Pin Oak Stud chair of stallion reproductive studies. He is author or co-author of over 500 manuscripts, research abstracts, and textbook chapters relating to horse reproduction and has been author or editor of three textbooks on equine reproduction. He has received Theriogenologist of the Year and Bartlett Lifetime Achievement awards from the American College of Theriogenologists.

**Andrew Waller**

**BSc PhD**

Andrew was awarded his DPhil by the University of York and then worked in the pharmaceutical industry for 6 years. He joined the Animal Health Trust 14 years ago, where he is now head of bacteriology, and has utilised genome sequencing technologies to learn more about how strains of Streptococcus equi and Streptococcus zooepidemicus cause disease in horses and other animals. Using this information, he and his team have developed new diagnostic tests for the identification of horses exposed to or infected with S. equi which are now used around the world. This knowledge is being used to develop new vaccines that protect against S. equi and S. zooepidemicus.

**Renate Weller**

**DrMedVet PhD MRCVS FHEA**

Renate is currently professor for comparative biomechanics and imaging at the Royal Veterinary College in London and the current BEVA vice president. She splits her time between clinical work, teaching and research. She has a special interest in how locomotor biomechanics relate to performance and risk of injury. She has authored over 100 peer-reviewed articles and has written 10 book chapters in her field of expertise. She is a highly sought-after speaker at national and international meetings and is known for her informative, but also very entertaining lectures. In her spare time, she likes horse-riding, playing table tennis and baking cakes.
Karen Wolfsdorf
DVM DiplACT
Karen received her DVM from the University of Florida in 1992 and completed a residency in theriogenology at the University of Florida in 1995, becoming board certified in theriogenology. She spent time working in Australia with Dr. Pascoe at Oakey Veterinary Hospital. In 1996, she joined Hagyard Equine Medical Institute, Kentucky as an associate and in 2002, became one of the first two female members of the practice. She is currently a reproductive specialist at Hagyard. Her main area of interest is infertility in the mare and problems during pregnancy. She has authored many chapters on equine reproduction as well as having lectured worldwide and published research regarding progesterone, retained endometrial cups and equine twin reduction with cranio cervical dislocation. Karen and her husband are involved as owners and breeders in the Thoroughbred industry as well as running their hunter jumper business, De Sousa Stables.

Ian M. Wright
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Ian is senior surgeon and hospital director at Newmarket Equine Hospital. He holds the Royal College of Veterinary Surgeons diploma in equine orthopaedics and is a diplomat of the European College of Veterinary Surgeons. He has published over 60 peer-reviewed papers in equine surgery and orthopaedics, written five book chapters and edited two textbooks including the third and fourth editions of Diagnostic and Surgical Arthroscopy in the Horse. Awards include the Equine Veterinary Journal clinical prize in 1994 and 1999 and the open award in 2013. He has also made over 250 national and international scientific presentations and teaches post-graduate courses in arthroscopy and fracture management. In 2016 Ian was awarded honorary fellowship of the Royal College of Veterinary Surgeons in recognition of his contribution to equine surgery.

Marieke Zimmerman
DVM
Marieke graduated in 2008 from the Faculty of Veterinary Medicine at Ghent University. She then completed a 1-year rotating internship at the Ecole Nationale Vétérinaire de Maisons-Alfort and at CIRALE, supervised by Prof. Jean-Marie Denoix. Afterwards, she undertook a second internship, focused on orthopaedics and diagnostic imaging in horses, at the Animal Health Trust in Newmarket, supervised by Dr. Sue Dyson. From 2010 to 2013, she worked at Dr. Suls’ practice in The Netherlands, where she has focused on orthopaedics and diagnostic imaging. In 2013 and 2014, Marieke further specialised in MRI, CT, and scintigraphy in horses by visiting the University of California, Davis, Washington State University, Colorado State University, and the Ecole Nationale Vétérinaire de Lyon. Since 2014, she has been working at the Equitom Equine Diagnostic Centre, where she is responsible for MRI, CT, and nuclear scintigraphy. In April 2018 she decided to pursue her dream of doing a residency in large animal diagnostic imaging which she is undertaking at the Ecole Nationale Vétérinaire de Lyon in France. Marieke has published in international journals and has presented at several international conferences on diagnostic imaging in horses.
Proximal phalanx (P1) fractures are very common in horses of all ages and uses. These fractures are difficult to detect when only a small part of the bone is affected, or they can be very complicated with many fragments. A unique feature of P1 fractures is the multitude of possible configurations. Classification is usually based on the results of radiography; however, this does not always provide sufficient detail about the full extent of the fracture. Short incomplete sagittal fractures (SISF) of P1 have a length of less than 30 mm and arise from the midsagittal groove of the proximal articular surface of P1 [1]. This fracture configuration is typically seen in horses used for athletic activities such as racing [1] but also in other disciplines such as showjumping and dressage [2]. The fracture configuration corresponds to the common form of propagation, which is from the sagittal groove of the proximal P1 as a result of compressive and torsional forces. Pain after fracture initiation is typically moderate and of relatively short duration. This may be the reason why some horses are presented in the subacute or chronic stage when periostal new bone formation at P1 is already visible. The mild or moderate degree of lameness and lack of abnormal findings on palpation can make SISF of P1 a diagnostic challenge. As results of clinical examination are often not suggestive of a fracture, diagnostic local anaesthesia is performed for the diagnostic work-up in many of these horses. Fracture lines in some patients are very short and subtle and multiple and repeated high-quality radiographs may be necessary to demonstrate the fracture. A recent study in nonracehorses found that these fractures do not usually extend through both the dorsal and palmar/plantar cortices, and are located more dorsally in forelimbs and more plantarly in hindlimbs [3]. The precise fracture configuration can only be detected using magnetic resonance imaging or computed tomography (CT) [3,4]. Mean fracture length as determined by CT is 5.1 mm (range 1.7–13.8 mm) and degenerative joint disease of the fetlock joint is noted rarely. Nowadays, CT is the imaging modality of choice to provide exact information on the three-dimensional configuration of fractures.

Conservative and surgical approaches have both been suggested for SISF of P1 [15–7]. Too often conservative treatment is instituted for short proximal P1 fissures (Fig 1), which markedly increases the time required for healing and the risk of complications. Surgical fixation of this type of fracture is always indicated; otherwise, arthrosis, nonunion, cyst formation and complete fracture are very common sequels [8]. A case series in nonracehorses showed that conservative therapy can be associated with catastrophic fracture propagation [2]. Inadequate stabilisation and the compressive and torsional forces transmitted via the articular surface are the most likely factors impairing bone healing in fractures not stabilised by internal fixation.

Internal fixation using a lag screw technique is the best treatment option for achieving optimal bone healing and minimising the risks of nonunion or progression to a more severe or catastrophic fracture. The planned location of the proximal screw is in the dorsopalmar/dorsoplantar centre of the fracture line, maximally 5 mm distal to the sagittal groove and parallel to the joint space. The use of cross-sectional imaging modalities such as CT to determine the exact position and extent of the fracture can help in precise localisation of the screw. Results of follow-up examinations showed that patients treated by internal fixation had a better clinical and radiographic outcome than conservatively managed horses [2]. Fracture propagation occurred in two horses not treated by internal fixation in this study. Formation of subchondral cystic lesions (SCL) can be the result of a failure of endochondral ossification but they can also develop secondary to damage of articular cartilage or bone. There is experimental evidence that full-thickness cartilage defects can lead to SCL and that subchondral defects in communication with the joint cavity do not heal spontaneously. The study of Bryner et al. shows that lag screw fixation of SISF of P1 is associated with good long-term results and a high probability of the horse returning to its intended use [9]. The study population comprised mainly Warmblood horses used for showjumping but very good results have also been published in racehorses, with a 71% rate of return to racing [7]. However, the high rate of incomplete radiographic healing was surprising. Prior to this study, nonunion of these fractures was only reported in cases treated conservatively [2]. The majority of fractures were very short, and it can be questioned whether fissure fractures that are mainly restricted to the sagittal groove can be fully stabilised and compressed with lag screws with regard to the biomechanical forces acting on this area [9,10], and the fact that it is hardly possible to place a screw that close to the articular surface. The conclusion to be drawn from these studies is that the surgical fixation of SISF of P1 is strongly recommended.

Fig 1: a) Short fissure. b) Short fissure with characteristic dorsal reaction. c) Short fissure seen during arthroscopy
References


NOTES
Sagittal groove osseous trauma of the proximal phalanx - a distinct injury in the sport horse?

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Since magnetic resonance imaging (MRI) has become a more common diagnostic imaging modality, osseous trauma of the proximal sagittal groove of the proximal phalanx (P1) has been noted [1-3], albeit infrequently (<0.1%). Debate remains regarding the pathophysiology of this problem, similar to the debate regarding the pathophysiology of sagittal fractures of P1. The proposed aetiologies are either an acute one-off event or an accumulation of repetitive stress injury. Although osseous trauma of P1 in sport horses appears somewhat different from short incomplete fractures, P1 fractures in the racing and sport horse, the similar anatomical location of the abnormality suggests a common underlying biomechanical basis for both conditions.

The biomechanical features of metacarpal/larsophalangeal joint (MCPJ/MTJ) movement must be considered to facilitate understanding of osseous damage to the proximal sagittal groove of P1. The MCPJ moves primarily in the sagittal plane; however, collateromotion and axial rotation occur to a lesser degree and are limited by the anatomical congruence of the sagittal ridge of the distal third metacarpal bone (MCIII) with the sagittal groove of the proximal P1, as well as by the collateral ligaments and the suspensory apparatus. Contact pressure and von Mises stress appear to increase along the sagittal groove as load increases across the joint in vitro studies. In addition, at mid-stance with maximal load on the MCPJ, the strain on dorsoproximal P1 increases exponentially as collateromotion and axial rotation increase. These findings indicate that with MCPJ hyperextension, the forces on proximal P1 and within the sagittal groove probably increase substantially; however, the rate of loading or the degree of foot slip (surface) may affect the exact location of maximum articular loading. Within any equestrian discipline, repetitive hyperextension of the MCPJ occurs; however, the exact biomechanical features associated with loading may vary with the type of work performed (or the limb affected) which could explain the different manifestations of sagittal groove trauma between different disciplines. For example, a dressage horse working at submaximal canter may create maximum load at a slightly different area of the sagittal groove compared to a racehorse galloping at speed.

A diagnostic challenge

Clinical signs of osseous trauma of the sagittal groove are not pathognomonic, so careful lameness evaluation is required to reach this diagnosis [1-4]. The degree and duration of lameness at presentation is variable. Rarely is effusion of the MCPJ/MTJ present as a localising sign. Occasionally, pain on palpation of the dorsoproximal margin of P1 can be detected. Diagnostic anaesthetic techniques can also be misleading, with some cases responding positively to blocking of the palmar digital nerves at the level of the abaxial sesamoid bones or the collateral cartilages, rather than only when the low palmar block is performed. Intrarticular anaesthesia of the fetlock joint is usually negative.

In addition, radiographic examination is often unrewarding, with either subtle or no abnormalities detected. The definitive diagnosis relies on MRI imaging of the region.

Radiographic abnormalities, if present, consist of areas of osteolysis within the subchondral or trabecular bone distal to the sagittal groove. Occasionally, small radiolucent lines or subtle alterations in bone density are observed, the authenticity of these becoming clear only after the MRI findings are revealed. In some cases, new bone at the dorsoproximal aspect of P1 is noted.

MRI findings

The MRI findings are generally confined to the sagittal groove region; however, the width, depth and dorsopalmar length of the abnormalities are variable. In general, the MRI images (T1, T2, T2 GRE, STIR and proton density) have a high signal intensity in the affected area. There is often a hypointense rim surrounding the hyperintense area on T1 and T2 GRE images, demonstrating a fat-water cancellation artefact [1-4]. A debate exists as to whether the hyperintense signal should be referred to as a high fluid or water signal. Rarely, a clear fracture line is visible. To date, there is no evidence for a correlation between width, depth or dorsopalmar length of the abnormality and degree of lameness or prognosis. Densification of the sagittal ridge of MCIII has been noted in some cases. Similar to the computed tomographic evaluation of short incomplete P1 fractures, the length and position of the sagittal groove abnormalities is variable [5].

At present, there is no evidence to link the prognosis for the condition to the apparent severity of the MRI abnormalities. Repeat MRI examinations have demonstrated improvement in some cases; however, the alterations in MRI appearance do not appear linked to the ultimate outcome for the horse.

Treatment

The best treatment modality for these lesions has not been elucidated, with an overall fair to poor prognosis noted following conservative and surgical management, although results vary between reports. The prognosis appears more favourable when the lesions are noted at an early stage in the racing horse as opposed to a more dorsal position along the sagittal groove. To date, surgical management has consisted of screws placed in lag fashion across the area in an effort to facilitate healing of the bone. A recent retrospective study did not demonstrate a significant difference in outcome between conservative and surgical therapy [4]. The likely loss of articular cartilage and/or subchondral bone support for overlying articular cartilage may be the determinant of the poor prognosis.

References

Prevention and screening of metacarpal condylar injuries in racing Thoroughbreds

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Introduction

The fetlock joint is the most common site of musculoskeletal disease that results in euthanasia of Thoroughbred racehorses worldwide [1,2]. A 15-year summary of Thoroughbred racehorses submitted to a US necropsy programme revealed that 57% of all submissions involved the fetlock joint [3]. Recently it was identified that 55% of horse spills injure the jockey [4]. When the fatal injury rate is 1.9 horses per 1000 starts, 1000 starts are attained when 10 horses per race compete in 10 races per day. In this hypothetical example, two may be destroyed at least one human injured every 10 days, demonstrating the urgent need to develop additional surveillance strategies for the fetlock.

Catastrophic injuries of the fetlock are created when the proximal sesamoid bones (PSB) oppose the downward movement of the third metacarpal/metatarsal bone (McIII/ MtIII) during the stance phase of the gallop [5–17]. At weights of 500 kilograms and speeds of 60 kilometres per hour, the repetitive cycle of the gallop has each limb supporting this entire load unassisted at some point during the four beats of this gait. Cyclic fatigue [5,6] of the subchondral bone (SCB) creates failure of the McIII/MtIII condyle and first phalangeal (PI) bones (herein McIII), palmar osteochondral disease (POD) and biaxial PSB respectively in the fetlock [6–16].

Identifying the signs of cyclic fatigue in the SCB of the fetlock, pre-fracture, has the potential to significantly reduce injuries to jockeys and Thoroughbred racehorses. We hypothesised that standing magnetic resonance imaging (MRI) (a) would identify significantly more severe (i.e., higher grades) bone changes in Thoroughbred racehorses with catastrophic fracture of the fetlock when compared to Thoroughbred racehorses without fetlock fracture (controls) and (b) these MRI signs could be used, pre-fracture, to identify the at-risk horse so that training and racing schedules can be altered pre-injury.

McIII condylar fracture

A catastrophic condylar fracture is the final event of a bone stress injury (BSI) that began in the SCB of McIII [5–23]. Bone can fail monotonically by a maximal load that exceeds the failure stress of bone, or gradually by a repetitive submaximal load that creates fatigue [5,6]. Overuse injury to bone occurs in the absence of a radiographically apparent fracture because lower strain (submaximal) creates microscopic damage and microcracks [17–19]. Fatigue is dangerous because the single lower strain (submaximal) creates microscopic damage and ultimate failure to the SCB plate of the McIII [20]. Bone marrow oedema is significantly faster when fractured limbs were compared to nonfractured limbs in horses with condylar fracture, and when the fractured limb of case horses was compared to the forelimb fetlock of controls. Density in either the medial or lateral condyles was not significantly different when comparing fractured limbs with nonfractured limbs in horses with condylar fracture [14].

Density was significantly greater when fractured limbs were compared to nonfractured limbs in horses with condylar fracture, and when the fractured limb of case horses was compared to the forelimb fetlock of controls. Density in either the medial or lateral condyles was not significantly different when comparing fractured limbs with nonfractured limbs in horses with condylar fracture [14].

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Biaxial proximal sesamoid bone fracture and palmar osteochondral disease

Biaxial PSB fracture [20,21] and POD [7,8,10–13,15,21–23] are the final event of cyclic fatigue in the SCB of the PSB and McIII condyle, respectively. In the PSBs, histomorphometric analysis identified that the bony material is more compacted in horses with biaxial PSB fracture when compared to horses without biaxial PSB fracture [20]. The authors concluded that the early identification of these structural changes could provide an opportunity for prevention of PSB fractures [20]. In severe POD lesions, Bani Hassan evaluated racing Thoroughbred horses using high-resolution CT and identified articular surface collapse [24]. It was suggested that articular cartilage collapse was a sequel to fatigue injury of SCB, that focal SCB resorption appears to contribute to the collapse of the calcified articular cartilage layer and that articular surface collapse with intact overlying cartilage is a feature of advanced POD [23].

The sMRI was used to compare 21 horses with biaxial PSB fracture (fractured and nonfractured limb) and 53 horses without biaxial PSB fracture (controls) [21]. Specifically, the progressive densification of the PSBs and the progressive damage and ultimate failure to the SCB plate of the McIII condyle as an indication of POD was evaluated [21]. Horses with marked densification of the PSB in the ipsilateral (fractured) limb were 10.4 times more likely to have a biaxial PSB fracture vs. horses without marked PSB densification [21]. Horses with severe POD (Fig 1) of the contralateral (not PSB fractured) limb were 20.8 times more likely to have a biaxial PSB fracture in the ipsilateral limb vs. horses without severe POD (controls) in the contralateral limb [21].
Fig 1: Representative T1W standing MRI images obtained in the sagittal plane from six different equine forelimb fetlocks is provided to describe the POD MRI grading system developed for a study of bony changes in the forelimbs of Thoroughbred racehorses with and without catastrophic biaxial proximal sesamoid bone (PSB) fracture [21]. This grading system is focused on the integrity of the subchondral bone (SCB) plate in the contact area of the PSB with the palmar aspect of the condyles of McIII (grey arrows in panel A). The SCB plate (white arrows in panel A) curves from the dorsal to the palmar aspect of McIII and is a continuation of the dense cortical bone of the distal portion of McIII. It creates a symmetric linear hypointense (black) signal that is sandwiched superficially between the symmetric linear hyperintense (white) signal of the articular cartilage and the deeper symmetric linear medullary trabecular bone and fatty marrow. The specifics of each panel are described below.

A: POD grade 0: The SCB plate is normal and there are no signal abnormalities in the SCB deep to the SCB plate. This is an example of an untrained (normal) horse.

B: POD grade 1. The SCB plate has normal signal intensity and remains symmetrical and intact. There is an area of superficial hypersignal intensity immediately beneath the SCB plate (white arrow) and an increase in densification of the medullary bone marrow (grey arrows) towards the periphery of the lesion (vs. panel A). Joint fluid does not extend into the SCB plate, which implies that the overlying articular cartilage of McIII is intact.

C: POD grade 2. The SCB plate has a normal signal intensity and a contour deformity (grey arrow) that is suggestive of focal depression or fracturing of the SCB plate or resorption or fracturing of the deeper trabecular bone. There is a progression from panel B with a larger area of superficial hyperintensity immediately beneath the SCB plate and a larger area of increase in densification of the medullary bone marrow towards the periphery of the lesion (vs. panel A and B). Joint fluid does not extend into the SCB plate, which implies that the overlying articular cartilage is intact.

D: POD grade 3. There is full-thickness defect in the SCB plate (grey arrow) with a signal intensity similar to that of joint fluid, which implies that the overlying articular cartilage is not intact, and an increase in the densification of the subjacent SCB marrow. There is a progression from panel C with an increase in hyperintense superficial signal near the SCB plate and an increase in densification towards the periphery of the lesion.

E: POD grade 4. There is a partial or complete detachment of an osteochondral fragment that is not displaced (grey arrows), an increase in superficial hyperintense signal and an increase in the densification of the deeper SCB marrow. In this image, the signal intensity around the fragment is not as hyperintense as that of joint fluid, which implies that the overlying articular cartilage is still intact.

F: POD grade 5. Notice that an osteochondral fragment from panel E is displaced from the original defect in this panel F, which has left a large area of exposed SCB of McIII (grey arrows), and there is an increase in the densification of the subjacent SCB marrow.

References


Surgical management of marginal tears of the suspensory ligament branches in Thoroughbred racehorses

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Introduction
Desmits of the suspensory ligament branches (SLB) is a common injury in all types of sport horses [1]. Aside from a description of avulsion injuries of the dorsal (articular) surface of the SLB [2], most injuries of the SLB are grouped together and considered as a single pathological entity. A plethora of nonspecific treatment modalities similar to those employed for desmits of the suspensory ligament body are recorded in the literature [1,3–5]. Despite current concepts associated with regenerative therapies, it is generally accepted that horses cannot recreate the exact structure of the insertion of the SLB following injury [6]. Healing consists of scar tissue and it is improbable that any type of scar tissue will be able to function in a similar fashion to the undamaged SLB [6]. Associated prognoses have been poorly documented in the literature and are mostly anecdotal. In general injuries of the SLB have a guarded prognosis [7] and when accompanied by periligamentous fibrosis this has been described as poor [1,3]. The prognosis for SLB injuries in both fore- and hindlimbs for dressage and showjumping is reported to be fair [3]; however, the long-term prognosis for racehorses has been considered poor [8]. In one report a degree of objectivity was introduced for juvenile injuries in Thoroughbreds. This study demonstrated that horses with juvenile insertion suspensory branch lesions race significantly less as 2- and 3-year-olds (27% and 62%, respectively) compared to unaffected horses (58% and 82%) [9]. The current paper reports a subgroup of SLB injuries with a consistent, marginal location and treatment by surgical removal of the disrupted tissue. This is based on the hypothesis that intrinsic removal of torn collagenous tissue is limited, while persistence results in a chronic inflammatory response and inhibits second intention healing.

Materials and methods
Clinical records of all horses with lesions of the SLB that included the nonarticular margins diagnosed at Newmarket Equine Hospital between 2007 and 2015 were reviewed. Thirty-two horses were identified; of these, 29 horses (32 limbs) that were treated surgically were included within the study. Three cases underwent different management and were excluded. All affected and contralateral metacarpo/metatarsophalangeal joints were evaluated radiographically including, in 28 of 29 cases, lateral 45° proximal-medial distal oblique and medial 45° proximal-lateral distal oblique projections. Affected and contra-axial SLBs were examined ultrasonographically in transverse and longitudinal planes.

Surgery
Surgery was performed under general anaesthesia. Horses were positioned in lateral recumbency with the affected SLB uppermost. SLBs were exposed through a linear incision and, following palmar/plantar reflection of the neurovascular bundle, disrupted SLB fibres were removed by a combination of sharp dissection and use of a motorised synovial resector. The perilesion (periligamentous fascia) was then closed with continuous sutures of polyglactin 910 followed by layering material consistent with fibrosis was present in all cases demonstrated disruption of the palmar/plantar abaxial margin of the SLB with a hypoechoic to anechoic defect. The epidesmon was disrupted with extrusion of herniated fibres in all 32 SLBs. Periligamentous echogenic layering material consistent with fibrosis was present in all limbs which was mild (<0.25 mm) in 14 branches, moderate (>0.25 mm to ≤5.0 mm) in ten branches and marked (>5.0 mm) in eight branches. Thirty-two SLBs has an enlarged cross-sectional area when compared to normal contra-axial branches. The osseous reflection of the PSB was irregular in 28 limbs and there were small hyperechoic foci in 26 legs. Surgery in all cases revealed a defect in the SLB located at a consistent site at the palmar/plantar margin. All lesions appeared to be avulsions from the PSB.

Post-operative care
Skin staples were removed between 11 and 15 days post-surgery, and bandaging with progressively decreasing bulk was maintained for 18–32 days. Horses were kept on box rest for 2–4 weeks followed by a progressively increasing walking exercise of between 4 and 8 weeks. Thereafter exercise was determined by individual case progress.

Results
All 29 horses were Thoroughbreds used for flat racing and were aged between 1 and 8 (mean 3.3; median 2) years. The forelimb was affected in 22 horses, six had hindlimb and one had fore- and hindlimb injuries. A single limb was affected in 26 horses. Three horses had injuries to two branches in separate limbs; two involved lateral SLB in forelimbs and one involved lateral SLBs in a forelimb and a hindlimb. These included 26 lateral and six medial SLBs. Radiographs demonstrated irregular radiopacity, with areas of resorption and disrupted infrastructure involving the abaxial margin of the ipsilateral proximal sesamoid bone (PSB) in 29 of 32 affected limbs. Small radiopacities proximal to the PSB were identified in three limbs. Ultrasonographic evaluation in all cases demonstrated disruption of the palmar/plantar abaxial margin of the SLB with a hypoechoic to anechoic defect. The epidesmon was disrupted with extrusion of herniated fibres in all 32 SLBs. Periligamentous echogenic layering material consistent with fibrosis was present in all limbs which was mild (<0.25 mm) in 14 branches, moderate (>0.25 mm to ≤5.0 mm) in ten branches and marked (>5.0 mm) in eight branches. Thirty-two SLBs has an enlarged cross-sectional area when compared to normal contra-axial branches. The osseous reflection of the PSB was irregular in 28 limbs and there were small hyperechoic foci in 26 legs. Surgery in all cases revealed a defect in the SLB located at a consistent site at the palmar/plantar margin. All lesions appeared to be avulsions from the PSB.

Follow-up information was available for 28; one horse was lost to follow-up but did not appear to race after surgery. Nineteen (65%) horses raced after surgery. These made between 1 and 27 (mean 9) starts. Ten horses won and 14 were placed. Only three horses raced prior to injury/surgery. The time from surgery to first race varied from 6 to 30 (mean 15) months.

Discussion
The above represents a reasonable return to function with the lesions described and has proved superior, in the author’s hands, to noninvasive management. Although anecdotal, this also is in keeping with accounts in the literature. It should be emphasised that, like the dorsal (articular) lesions, this is a specific subgroup of SLB injuries and should not be considered an appropriate or reasonable treatment for all lesions of the same. Preoperative (ultrasonographic) case selection is critical.

References


Challenges and opportunities in equine practice

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As a veterinarian born in the late fifties and trained in the early eighties, practitioner, educator and now administrator, it is difficult to ignore the issues unveiled by Dr. David Bartram about 10 years ago related to mental health problems that veterinary professionals endure. We as a profession are at higher risk of having mental health problems such as anxiety and depression, that if unattended could ultimately lead to devastating and fatal consequences.

There are several studies that would lead us to conclude that some of the most prevalent factors contributing to mental health unwellness would include the very rigorous curriculum, the number of hours expected to study out of the classroom or work in the teaching hospitals, the type and frequency of procedures such as euthanasia that young veterinarians experience without previous exposure to it, clients taking advantage of ‘veterinarian personality’ leading to compassion fatigue and, in the United States, the amount of debt load that students accrue during their education compared to their low starting salaries. A recent study done at the University of Tennessee sponsored by Merck Animal Health indicated that perhaps the major cause of the problems is related to the stress that students feel during vet school.

So it is undeniable that the profession is at a crossroads, evidenced by the high incidence of mental unwellness in veterinary schools, a high rate of young veterinarians leaving the profession and a high number of young veterinarians not recommending the profession. Veterinary schools are trying to address wellness and provide a better environment for students to learn; the response to the unveiling of the problem has been more reactive than proactive. So, from an equine practitioner’s perspective, there are important questions that we need to ask ourselves in order to address the issue from its roots:

• Is this a new problem or has it always been like this and just recently documented or destigmatised?
• If it is a recent problem, what got us to where we are?
• If it is an old problem, why has it gained so much attention recently and why did we not address it?
• What role have we played as equine practitioners?
• Are we willing to make some changes?

I will attempt to describe my perspective on why the profession is at this junction, some of the major challenges that we have and offer my opinion as an equine veterinarian of some of the opportunities that are in front of us.

Mental health in the profession

Psychological distress and elevated suicide mortality within the veterinary profession is not new and has been prevalent for many years. A study of mortality patterns among US veterinarians from 1947 to 1977 by Blair and Hayes indicated that sunlight exposure is responsible for the excess of skin cancer among veterinarians whose practices are not exclusively limited to small animals, and ionizing radiation exposure contributes to the excess of leukaemia among veterinarians practising during the years when diagnostic radiology became widely used [1]. Mortality was also high for motor vehicle accidents and suicides, but low for diseases of the respiratory system. However, in recent years wellbeing has garnered momentum and has been a topic of research, and mental health has had an increased level of awareness and destigmatisation, with veterinarians becoming increasingly confident in acknowledging their distress. It would be tempting to say that the current generational expectations for improved working conditions and better work–life balance are relatively new, but mental ill-health and suicide risk is not.

So what got us where we are?

As with most complex problems, there is not a single reason and, due to the multifactorial nature, it becomes more difficult to address. I would suggest that, among others, some of the most important factors that contribute to that state of the profession and that of equine practice reside in generational cohort differences with different ideas and expectations working at the same time, the significant generational shift that occurred in the late eighties, the explosion of research, medical specialties and medical information, the selection of candidates and admissions process, the experience and expectations that students receive during their veterinary curriculum, and the starting salaries for young entry-level equine practitioners.

Equine practice

‘I love horses and would like to work with them, but the working hours and the starting salary make it very difficult, so I took a job at a small animal practice’.

That was the answer that a student gave me when I asked: What will you do after graduation? Does this resonate with any of you?

I am almost positive that no one, regardless of age or generation, is expecting to get overpaid for doing little work. But if we analyze this answer in depth, it addresses generational issues, gender issues, work–life balance and starting salaries. In addition, it touches on other less tangible areas, such as the implicit concept that there is a compulsory requirement for any new graduate that wants to do general equine practice to enter a low paying internship prior to securing a full-time job.

Data gathered from AAEP and BEVA membership would suggest that we are not attracting new graduates into the profession at the rate that we should; consequently the average age of the working veterinarian is increasing. We need to start making some bold decisions in order to attract young veterinarians. Failure to do that will result in a similar phenomenon to what has happened in small animal practice, which includes the explosion of corporate ownership and which is a decision that we as a discipline will have to make.

We need to ask ourselves if we will be proactive and embrace the explosion of new data generating technologies such as imaging, clinical and population informatics. The production of terabytes and petabytes of information from a single cell or tissue known as Big-DATA generated from genomics, epigenomics, transcriptomics, microRNAomics, proteomics, metabolomics (lipidomics) and metagenomics (microbiome) will likely change the way medicine is practised. These technologies will drive preventive techniques as well as diagnostic and therapeutic procedures at the metabolic, protein, genetic, cellular, tissue or animal level including the effects of the environment also known as the exposome. It is likely that the pressure from
science, clients and our patients will lead to us practising evidence-based medicine and likely ‘precision medicine’.

To stay at the vanguard, we will have to do an in-depth and honest self-reflection in order to develop good ‘discipline awareness’. If we as a discipline (equine practitioners) do not become proactive, embrace the changes in technology and research, but most importantly embrace the changes in the population of our profession, our patients, our clients and ourselves will suffer the consequences. We know that every challenge brings new opportunities and, if we have an open mind and take advantage of the situation, we will end up in a better place as a discipline and as a profession. LET’S TAKE ADVANTAGE OF THIS OPPORTUNITY!

References

Further reading
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BEVA Membership Services 2018
Intra-articular corticosteroids were first used in the treatment of musculoskeletal conditions in horses in 1955 [1]. Corticosteroids are still considered the gold standard of intra-articular therapy for tackling inflammatory disorders such as osteoarthritis (OA), synovitis or capsulitis. They are used both to modify clinical signs and to treat disease in sport horse disciplines. As potent anti-inflammatory and analgesic agents, they inhibit the inflammatory process at all levels through reduction of inflammatory dilution and margination, migration and accumulation of inflammatory cells, as well as inhibition of synthesis and release of several soluble mediators (prostaglandin cascade, IL-1) and the arachidonic cascade [2]. Their clinically beneficial effect and their inexpensiveness make them the most popular choice of intra-articular treatment in the equine industry, superseding other products that are less efficacious and more expensive.

In the study, Triamcinolone acetonide (TA) (intermediate-acting), methylprednisolone acetate (MPA) (long-acting) and betamethasone sodium phosphate-betamethasone acetate (BM) (intermediate to long-acting) are the three most commonly used. Their efficacy and effect on the synovium and articular cartilage has been established via the osteochondral fragment model of OA developed at Colorado State University [2]. BM has no deleterious effects on articular cartilage (based on histology, histochemistry and uronic acid content). TA has favourable effects on lameness grade and synovial fluid, synovial membrane and articular cartilage morphology and synovial membrane area and articular cartilage morphological parameters [3,4]. Additionally, intra-articular TA has no deleterious effects on subchondral bone [5]. MPA does alter the mechanical integrity of articular cartilage (42 days following second injection). A single dose does not cause long-term detrimental effects in repair quality of full thickness cartilage defects in exercising horses [5]. Lower concentrations of MPA do not have the same therapeutic effect, with therapeutic doses resulting in cartilage damage [6]. As potent anti-inflammatories, intra-articular corticosteroids are indicated for the treatment of traumatic synovitis and capsulitis – two significant conditions that result in significant pain and joint restriction. They inhibit the release of IL-1, MMPs, aggrecanases, PGE2 and free radicals that lead to degradation of articular cartilage and subsequent OA [2]. Combining hyaluronan (HA) with MPA does not mitigate the deleterious effect of the MPA on articular cartilage, but HA combined with TA or BM is appropriate, combining the anti-inflammatory effects of the steroids with the chondroprotective effects of the HA [7]. A recent study of 80 horses realised a greater reduction of lameness with TA alone vs. TA and HA combined [8].

In comparison with other intra-articular medications, the duration of effect of corticosteroids is impressive, with significant clinical benefit seen at 56 days in one clinical study, and supported by controlled clinical studies in the horse fragment model that document persistent clinical effects at 70 days after intra-articular therapy administered at 14 and 28 days (doses: TA 6–9 mg; MPA 120 mg) [9].

While a period of rest is recommended following intra-articular corticosteroid to maximise the therapeutic potency and longevity, exercise itself does not have any harmful effects, nor does it promote increased risk of catastrophic injury in the presence of corticosteroids [9].

Corticosteroid-induced laminitis remains controversial. The UK legal case in which a total intra-articular dose of 160 mg of TA (80 mg each tarsus) and systemic dose of 20 mg of dexamethasone resulted in laminitis in the horse prompted an extensive literature review which highlighted that good evidence linking laminitis to corticosteroid use is lacking [10]. In addition, no association was found with intra-articular use of TA in a majority Thoroughbred population [11] and a prevalence of laminitis of 3/2000 horses (0.15%) was noted in a retrospective study (total dose 20 to 45 mg) [12]. Corticosteroids should be safe if used at appropriate total body doses in horses that are not under metabolic insults.

There are concerns that corticosteroids provide a competitive advantage over disease-free horses. Suitable protocols that enable horses to be treated and compete without an unfair advantage have been established [13]. Serum concentrations fell below the 100 pg/mL Racing Commissioners International (ARCI) regulatory threshold for both TA (2–40 mg dose) and isoflupredone acetate (4–30 mg dose) by Day 7. MPA (20–600 mg dose), being a lipid-based adjuvant, fell below ARCI threshold (100 pg/mL) by Day 21, and BM by day 10, in all horses treated intra-articularly independent of the volume or combination of corticosteroids used [13]. It should be noted that regulatory threshold limits are based on serum and not urine. Current Fédération Equestre Internationale (FEI) guidelines following intra-articular use are therefore appropriate for TA (7 days) and MPA (28 days) but not for BM (7 days) [13]. Current British Horseracing Authority (BHA) guidelines prohibit the use of any corticosteroids 14 days prior to the day of racing but do not publish detection times for intra-articular corticosteroids and, therefore, practitioners should be cautious to ensure that additional time is given between injection and race day if using MPA (https://www.britishhorseracing.com/faqs/detection-times-withdrawal-times/).

Septic arthritis is an uncommon complication of intra-articular corticosteroid medication but in horses the risk is substantially greater than in man (1/1279 compared with 1/10,000 to 1/77,300) [14]. The type of corticosteroid and the veterinarian injecting were identified as risk factors. Over 45 months, a total of 16,624 injections were given to 1103 horses at 6695 horse visits. A mean number of six repeated injections per joint, with a mean of 2.48 joints injected per visit and 15.1 injections per horse, led to the reported septic risk. BM had a lower risk of septic arthritis than dexamethasone, but dexamethasone vials were used multiple times for the same horse in the same visit, whereas a new vial of BM was used for each joint injected. Of the 5% joints medicated with corticosteroid and amikacin, none became septic, but this was not statistically significant [14]. Corticosteroids can potentiate the ability of low numbers of bacteria to establish infection, as evidenced with polysulfated glycosaminoglycan (PSGAG) in a horse model [9] and while a healthy joint is able to eliminate low numbers of bacteria, an inflamed joint may have reduced defensive capabilities and thus be more prone to corticosteroid facilitated sepsis [9].

In conclusion, corticosteroids should still be considered a mainstay of treatment of intra-articular inflammation of whatever cause. There is no evidence of a link between their use and catastrophic injury, laminitis or subchondral bone degeneration. Other products that are less efficacious and more expensive.
There is good evidence of a chondroprotective effect of TA and the use of MPA should be cautioned against, given its consistently proven deleterious effects on articular cartilage. Multiple joints can be injected multiple times within safe limits and sepsis should not be an expected complication if appropriated injection practices are adopted. Their effect should be long-lasting and result in good clinical improvement in lameness and effusion, based on the osteochondral fragment model of osteoarthritis.

References
Alternatives to IA corticosteroids in high motion joints

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Strategies for the management of osteoarthritis (OA) in horses focus on decreasing pain, improving joint function and minimising continued deterioration of joint tissues [1].

The most commonly used intra-articular medications are corticosteroids, hyaluronates and to a lesser extent pentosan polysulfate [2]. Intra-articular therapy with biological agents such as autologous conditioned serum, platelet rich plasma and mesenchymal stem cells have not only been in the focus of many researchers over the past two decades, but are also commonly used in practice [3]. Relatively new substances for intra-articular treatment of OA in horses are polyacrylamide hydrogel and stanozolol.

Polyacrylamide hydrogel (PAAG) consists of polyacrylamide polymer (2.5%) and water (97.5%). In human medicine it is used for the treatment of stress incontinence in women [4] and to reinforce facial subcutaneous tissues [5]. It is not degraded but rather integrated into soft tissues through vessel ingrowth and molecular water exchange [6,7]. First clinical reports on refractory OA cases showed promising results [8] and in a multicentre prospective study on 43 horses with OA, 82.5% of treated horses were lameness-free 2 years after treatment with PAAG [9].

Two of the proposed modes of action for PAAG are to decrease joint capsule stiffness after being integrated into the synovium, and visscosupplementation [10].

Stanozolol is a synthetic derivative of testosterone. As are other anabolic steroids, it is abused in human and equine athletes as a performance-enhancing drug [https://www.usada.org/what-is-stanozolol/], [11].

In vitro studies demonstrated that stanozolol can upregulate insulin-like growth factor 1 and reduce the production of nitric oxide [12]. It was also shown to reduce osteophyte formation and to promote articular cartilage regeneration in an ovine model of OA [13] and to improve lameness in acute and chronic cases of naturally occurring OA in horses [14,15]. At least two injections in acute and four in chronic cases with at least 5 mg of stanozolol were necessary to show improvement. The longest follow-up was 60 days. ‘Antidystrophic’ and anabolic effects of the stanozolol were thought to explain the clinical improvement in the latter two studies.

The fact that intra-articular application of stanozolol for the treatment of joint disease (“controlled medication”) cannot be securely differentiated from the i.m. application as a performance-enhancing drug (“doping”) remains an issue.

OA does not simply affect the cartilage but also other articular tissues which have to be addressed in the management of degenerative joint disease. Polyacrylamide hydrogel and stanozolol offer relatively new modes of action in the management of OA.

References
Alcohol facilitated ankylosis in the distal tarsal and pastern joints

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Introduction
The exact definition of a ‘low-motion joint’ is unclear but it is generally accepted that the equine distal limb possesses three joints that fit this definition: the proximal interphalangeal (PIP) joint and the two small distal tarsal joints (centrodistal [CDT] and the tarsometatarsal [TMT] joints). Other joints have a reduced range of motion but, either because they have complex anatomical features, or because the synovial space consistently communicates with an adjacent ‘high motion joint’, they are more complex than the latter; examples of these are the carpometacarpal and the proximal intertarsal joints.

True low-motion joints, from an evolutionary perspective, should be evolving to fusion of the adjacent bones as the joint becomes mechanically obsolete. However, the mechanical importance of two cartilage covered surfaces to the damping of impact through the limb must not be underestimated and should be taken into clinical consideration when performing arthrodesis procedures.

The reduced range of motion, along with evidence of naturally occurring ankylosis of the TMT-CDT and the PIP joints, has led surgeons to seek methods to achieve fusion of these joints, either by internal fixation techniques (arthrodesis) or by facilitating the ankylosis process. These methods have been applied in both the management of intractable osteoarthritis (OA) or following traumatic events which leave these joints unstable or severely damaged.

Proximal interphalangeal joint

Joint kinematics
The kinematics of the proximal interphalangeal joint are not as simple as they appear intuitively: a variation between flexion and extension at different time stages of a trotting stride has been nicely shown in vivo [1].

Using XROMM (x-ray reconstruction of moving morphology) we have demonstrated in a cadaver limb that this joint changes from flexion to extension when high loads (1–2 times bodyweight) are applied. We have used this to construct a subject specific musculoskeletal model (SIMM: software for interactive musculoskeletal modelling) and with it, the use of inverse dynamics calculations, we have obtained highly accurate characterisation of joint loads in the distal limb which we have used to test two different constructs used in surgical arthrodesis of the PIP joint.

Computerised modelling of internal fixation: finite element method
Several biomechanical studies have investigated different implant combinations to achieve a stable arthrodesis of the PIP joint [2–8]. These studies have used either clinical data (retrospective studies) or ex vivo loading of cadaveric limbs with different construct combinations. Mechanically, while ex vivo studies provide useful information, they use simple and nonphysiological loading conditions in their testing (e.g. three-point bending and axial compression) but provide limited information on the mechanical limitations and critical sites of each construct (e.g. stress concentration points).

Due to their limitations this form of mechanical testing is being superseded by advanced computerised models using the finite element method (FEA). FEA permits complex structural evaluation of constructs providing information on critical points which influence their assembly. The advantages of these state-of-the-art techniques and their clinical applicability will be demonstrated by applying them to study two different construct types commonly used in surgical arthrodesis of the PIP joint of horses:

1. Three 5.5 mm transarticular screws.
2. One three-hole locking compression plate (LCP) and two transarticular 5.5 mm cortical screws.

Chemical ankylosis
Chemical ankyloses of the PIP joint using ethanol has been described by Caston et al. [1] in 34 cases with a 50% success rate (return to previous levels of work). The procedure involves a single or multiple injections under radiographic guidance into the joint. It appears that, unlike the distal tarsal joints, the degree of post treatment comfort is more variable and the use of multiple injections (up to five) may be necessary. The author has treated six cases with PIP joint OA using ethanol and has experienced similar results, with only two of them returning to work. The degree of motion and volume of the joint are likely to be the reason for these differences between joints.

The distal tarsal joints: TMT-CDT
OA of the small tarsal joints is still a common condition in many types of horse. Management and treatment options available can be divided into nonsurgical and surgical. Nonsurgical treatments involve systemic and local medication which, combined with exercise management, attempt to reduce inflammation and pain [9]. Surgical options include procedures aiming to facilitate ankylosis with chemicals [3,5,10,11], surgical arthrodesis [12–14], aiming to denervate the area by tibial neurectomy [15] or by reducing pressure on the tarsus by cunean tenectomy [9].

Monoloidoacetate (MIA)
MIA causes rapid cell death and although one study has found that its use did not cause significant pain in the post-treatment period [16], others [10,17,18], as well as the author, have seen significant discomfort following its use.

Table 1: Results from peer-reviewed papers and free communications on the outcomes and complications of the use of MIA to facilitate ankylosis

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of horses</th>
<th>Success</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sammut et al. [17]</td>
<td>5</td>
<td>2</td>
<td>Post-treatment pain and medium-term discomfort</td>
</tr>
<tr>
<td>Dowling et al. [19]</td>
<td>50</td>
<td>41</td>
<td>Mild discomfort</td>
</tr>
<tr>
<td>Zubrod et al. [18]</td>
<td>6</td>
<td>4</td>
<td>Minimally weightbearing for 24 h post-treatment</td>
</tr>
<tr>
<td>Schramm et al. [20]</td>
<td>23</td>
<td>5</td>
<td>Skin necrosis. One deterioration</td>
</tr>
<tr>
<td>Bohanon et al. [21]</td>
<td>39</td>
<td>29</td>
<td>Significant swelling. Long-term tibiotalocalcaneal OA</td>
</tr>
<tr>
<td>Dyson [22]</td>
<td>25</td>
<td>21</td>
<td>Fusion of the talocalcaneal joint. Significant discomfort post-treatment</td>
</tr>
</tbody>
</table>

TOTAL 148 69% (102)
MIA, however, does seem to induce significant new bone formation and a stable ankylosis. Results of published studies of MIA use are summarised in Table 1.

Advantages: Easy to perform, cost, standing procedure, good ankylosis.
Disadvantages: Post-procedure discomfort, risk of periarticular damage, contrast radiography is needed.

Ethanol

Recently, Shoemaker et al. [23], described the effects of intra-articular infiltration of ethanol into the tarsometatarsal joints of sound horses. Importantly, this report described histological evidence of ankylosis 12 months post-injection and reported no associated significant complications or discomfort post-injection.

Since then, two publications [11,24] have evaluated the effects of this approach in clinical cases. The results of these studies have shown that facilitated ankylosis with ethanol is a valid option to manage pain caused by OA of the distal tarsal joints.

Although the success of this treatment in these two studies (11,24) are consistent with the data from their paper:
- Treatment with ethanol appears generally safe, with problems occurring in only two cases in one study [24].
- A radiographic contrast study of the injected tarsal joints is highly recommended, in order to prevent injection into the proximal intertarsal-tibiotarsal joint.
- Radiographic evidence of ankylosis is either minimal or difficult to assess.
- Authors of both studies recommended caution in the use ethanol as first line treatment in cases of OA of the distal tarsal joints.

Results also appear to be more encouraging in the early stages of the process compared with horses where the condition was considered chronic and unresponsive to intra-articular steroids [24]. The explanations for this are speculative but are likely to be associated with the presence or development of multiple pathologies involving other structures in the region; ankylosis is not achieved in some cases and only a neurolytic effect might be responsible for the reduction in lameness.

The technique involves a single needle approach with a two or three-way tap. The radiographic contrast (iohexol) is injected first, and radiographs evaluated for presence of contrast within the proximal intertarsal (PIT) joint and tibiotarsal (TBT) joint. The contrast is allowed to drip out of the joint and then 70% ethanol is injected until there is resistance (2-3 mL). For more details consult references [24,25].

No discomfort is expected post-injection but a mild subcutaneous swelling at the injection site might occur due to leakage around the needle or the joint entry site, which should disappear within days. To minimise this, a minimal number of attempts should be made to enter the joint.

Of greater concern is the fact that a small percentage of horses might develop PIT joint OA and associated significant lameness in the long term (approximately 6 months post-treatment) in one study [2]. This complication has also been reported after MIA treatment [10,17] and could be due to: a change in tarsal biomechanics, with distal ankylosis increasing stress in the proximal joints; or possible contamination of the proximal joint with ethanol at the time of treatment. Regardless of its cause, this should be seen as a potential complication and explained to owners.

The author supports the use of 70% ethanol solution for management of distal tarsal joint OA pain in cases which do not respond to corticosteroid medication. Careful case selection and accurate contrast-facilitated injection technique are mandatory to minimise potential complications of this treatment. Results of published studies of ethanol use are summarised in Table 2.

Advantages: Easy to perform, few side effects, cost, rapid clinical effects, standing procedure.
Disadvantages: Might not lead to ankylosis. Contrast radiography is recommended, long-term PIT OA

Recent caseload of alcohol facilitated ankyloses of the distal intertarsal joints (unpublished)
The author now has information on a further 27 cases which have shown a long-term success rate of 67% under the same conditions as those described in our 2012 paper. Case selection and small changes to the technique are likely to explain these better results.

Surgical drilling

Drilling of the distal tarsal joints was first reported by Adams in 1970 [26]. Surgical drilling involving a three drill-tract technique with a 3.2 mm or 4.5 mm drill bit has been the best described and overall accepted technique for surgical arthrodesis. Results of published studies of surgical arthrodesis are summarised in Table 3.

Advantages: Good outcomes, stable ankylosis, long-standing technique.
Disadvantages: Cost, post-operative recovery time is long, post-operative discomfort and complications can have serious consequences.

Laser facilitated ankylosis

The use of laser surgery for destruction of the articular cartilage of the distal tarsal joint has been investigated; although clinical results from this technique are lacking in the literature, it appears a promising technique.

Advantages: Less morbidity, stable ankylosis, minimally invasive in most cases (through needles).
Disadvantages: Cost, risk of subchondral bone necrosis (probably not significant).

References


Bursoscopy

Navicular bursoscopy was first described in a seminal publication [1], for the treatment of septic bursitis. The same team then adapted the technique to the diagnosis and treatment of ‘navicular disease’, culminating in the largest series so far [2]. During this time MRI has become established as the imaging modality of choice for ‘navicular disease’ or palmar foot pain, yet few studies have really compared surgical and MRI findings.

Sepsis of the navicular bursa

Following the initial description of bursoscopy for contaminated or septic navicular bursitis in 1999, the technique rapidly became the accepted standard of surgical treatment for penetrating injuries of the navicular bursa. This was based largely on the documented poor results with open bursotomy, commonly known as the ‘streetnail procedure’. Wright reported a success rate of 63% following bursoscopy, with a further 19% of horses salvaged for breeding, while in contrast Richardson reported only 32% with a ‘satisfactory’ outcome, which included 16% broodmares.

The procedure was not reviewed further until 2014. These authors reported a multicentre study, which showed 56% of horses survived to discharge, although only 36% of horses returned to pre-injury athletic function. Interestingly, multivariate analysis showed the hospital involved was a significant risk factor both for euthanasia and for failure to return to athletic use [3]. Increasing time prior to presentation was also a significant risk factor for euthanasia and for failure to return to athletic exercise, emphasising the need for prompt and accurate diagnosis.

Considering diagnosis, it is worth mentioning how often clients are let down by their veterinary surgeons when presented with a foot with a nail in it. Some clients will pull the nail out straight away, and we cannot legislate for inability to watch medical soap operas on television. But veterinary surgeons will also pull the nail out. Do not do this. Half a tonne of horse has stood on it. It is not going any further, the damage is already done. It is a cheap, convenient and effective positive contrast radiographic marker of where the nail has gone. Either take an x-ray machine out to the horse, or bandage the foot up so the nail is not on the weightbearing surface, and transport the horse to a clinic for radiography.

Most recently, remarkable results have been published following navicular bursotomy, or the old streetnail procedure [4]. Of 19 horses, 100% survived, and 85% returned to previous levels of performance [5]. Of 11 horses, 100% survived, and 85% returned to previous levels of athletic function [6]. Subsequently, of 84 horses with follow-up, 53% returned to exercise, and 44% returned to previous levels of athletic activity [2]. Large tears of the deep digital flexor tendon (compared with small) and injuries of the navicular bone were statistically associated with reduced chances of return to soundness and to athletic activity.

A key question always remains with any surgical series: did the horses need surgery? Obviously, the best way to get good results is to operate on horses which are going to get better. This probably holds true of palmar foot pain more than any other condition. Investigation with MRI scans has suggested that there are several types of deep digital flexor tendon lesion, and lesions involving the dorsal border appear to have a better prognosis [8]. Dorsal lesions are the lesions which would be most accessible for endoscopic assessment and debridement.

Technique of navicular bursoscopy

The technique of navicular bursoscopy has also evolved. The initial description was what has become known as the direct approach. An arthroscope cannula is introduced just proximal to the cartilage of the foot and directed distally along the dorsal margin of the deep digital flexor tendon. This could result in accidental penetration of the palmar coffin joint or scoring of the fibrocartilage of the navicular bone. A more controlled technique, the transthecal technique, was first described at the European College of Veterinary Surgeons conference, and subsequently by Smith et al. [7]. This involves sharp dissection of the distal wall of the digital flexor tendon sheath immediately dorsal to the deep digital flexor tendon. The visibility of differing techniques has been compared, which confirmed better visibility of the navicular bone and deep digital flexor tendon using a transthecal approach. There was also significantly less iatrogenic damage to both the fibrocartilage of the navicular bone and the deep digital flexor tendon using a transthecal approach [9]. We find that visibility of the abaxial margins of the navicular bursa is still best from a direct approach. The two are easily combined by using a transthecal approach, and then guiding the ‘direct’ approach using a 2 inch needle and subsequent sharp incision under arthroscopic visualisation. It is helpful to have two arthroscopy cannulae, so the second cannula can be placed under endoscopic visualisation.

Correlation with MRI findings

Correlation with MRI images has been described [2]. There was poor correlation of MRI and endoscopy for lesions of the fibrocartilage, confirming similar findings with articular

What’s the evidence for navicular bursoscopy in the treatment of deep digital flexor tendon injuries?

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Navicular bursoscopy was first described in a seminal publication [1], for the treatment of septic bursitis. The same team then adapted the technique to the diagnosis and treatment of ‘navicular disease’, culminating in the largest series so far [2]. During this time MRI has become established as the imaging modality of choice for ‘navicular disease’ or palmar foot pain, yet few studies have really compared surgical and MRI findings.

Sepsis of the navicular bursa

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Palmar foot pain – navicular disease

Subsequent to the description of bursoscopy for treatment of sepsis, a post-mortem study confirmed good endoscopic visibility of the bursa [5], and a second study again confirmed that the bursa could be reliably visualised in the live horse [6]. The first series describing findings in lame horses was then published, from the same team who initially described bursoscopy for sepsis [7]. These horses were subsequently included in a second publication [2], which remains the largest case series of navicular bursoscopy to date. These authors reported on 114 horses which underwent bursoscopy for the investigation of lameness other than contamination or sepsis. Only 92 horses had identified abnormalities within the navicular bursa. Thirty-nine of these horses also underwent MRI in a Hallmarq® scanner. As is often the case, the results deteriorated with greater numbers and longer follow-up. Originally the authors reported on 15 cases with 6 months follow-up and 73% were sound and 60% returned to previous levels of performance [7]. Subsequently, of 84 horses with follow-up, 53% returned to exercise, and 44% returned to previous levels of athletic activity [2]. Large tears of the deep digital flexor tendon (compared with small) and injuries of the navicular bone were statistically associated with reduced chances of return to soundness and to athletic activity.

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cartilage, and for adhesions, which were often falsely predicted. There was some correlation of dorsal border tendon lesions, with 38 of 56 (68%) lesions identified endoscopically that were correctly predicted by low field MRI [2]. In addition, a further 10 lesions were predicted but could not be corroborated endoscopically.

One of the reported findings from bursoscopy is collagenous clumps of tissue extruded into the bursa. Magnetic resonance imaging may show tendon lesions which involve the dorsal border of the tendon associated with a hyperintense mass dorsal to the tendon in the suprassesamoidean region. We hypothesised that these hyperintense masses on MRI scan were the collagenous clumps identified at surgery. Furthermore, we hypothesised that an ideal candidate for surgery would be a horse with a large synovial mass, but no underlying abnormality of the deep digital flexor tendon.

We undertook a retrospective study of horses which had undergone an MRI scan of at least one foot and subsequent navicular bursoscopy. MRI images were reviewed and the size of any synovial mass was subjectively graded. Associated abnormalities of the deep digital flexor tendon were also graded. Surgery findings were reviewed, and 51 horses were identified that had undergone surgery on 73 navicular bursae, of which 40 had one year of follow-up.

The prognosis following surgery was guarded, with 12 horses (30%) returning to their previous level of exercise, 10 (25%) returning to some exercise, and 18 (45%) remaining lame. There was no evident effect on prognosis of any of the criteria assessed.

Hyperintense masses adjacent to the dorsal border of the deep digital flexor tendon on MRI scan were predictive of masses of collagenous tissue identified at surgery. However, these masses did not appear to influence the prognosis. The relatively poor correlation of MRI and surgical findings concerning tendon lesions was due to 19 horses which were predicted to have minimal tendon lesion on MRI scan, but were identified to have a surface erosion of the deep digital flexor tendon at bursoscopy. We suggest that the presence of a synovial mass on MRI scan may be an indicator of this tendon erosion, and the erosion may be the more significant pathological abnormality.

References

Diagnosis and management of blackthorn penetrations

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Objectives
To describe the presentation, diagnosis, treatment techniques, and outcome of blackthorn (*Prunus spinosa*) injury and synovitis in the horse, based on the results of a prospective clinical study. To present practical methods to deal with these challenging cases successfully.

Study methods
All cases were presented with blackthorn injury and synovitis. Surgical treatment was performed within 24 h, using a two-stage procedure: 1 - Perisynovial technique using ultrasound-guided electrosurgical dissection. 2 - Endoscopic technique. The diagnosis was confirmed by retrieval of black plant material from, or close to, the affected synovial structure.

Study results
Mean lameness score on presentation was 4/5 (range 1–5). The most commonly affected structures were extensor tendon sheaths (12/35) and fetlock joints (11/35). All cases had thorn material removed; 80% had thorn material removed at surgery and in 49% it was intra-synovial. On presentation, the mean synovial fluid total protein level (TP) was 47.6 g/L (range 18–66) and mean total nucleated cell count (TNCC) was 176 x10⁹ cells/L (range 12–312). Two days post-surgery, mean TP levels were 33 g/L (range 16–52) and mean TNCC was 13 x10⁹ cells/L (range 1–35). At 5 days post-surgery the mean TP was 23 g/L (range 12–28) and TNCC was 5 x10⁹ cells/L (range 1–12). All synovial fluid cultures were negative. Twenty-eight (80%) horses were sound 5 days post-operatively and seven (20%) were not lame in walk; they all returned to full work in an average time of 8 weeks (range 3–48 weeks).

Study conclusions
Surgery by the techniques described achieved accurate identification and removal of thorn material. In contrast to previous studies of synovial sepsis, these cases had a positive outcome despite high pre- and post-operative synovial fluid TP and TNCC. These findings suggest that blackthorn synovitis has a different aetiology to synovitis originating from sepsis or other types of contamination.

Practical conclusions
Blackthorn injury can be rewarding to treat, with excellent outcomes when using the techniques described. It is unlikely that blackthorn reactions are the result of bacterial infection, suggesting limited use of antimicrobials is appropriate.
The Newshour session is back and promises to be an absolute belter. For those of you familiar with the Kester News Hour at the American Association of Equine Practitioners Congress, this session is run along similar lines. We have assembled true experts in the fields of surgery, medicine, reproduction and lameness. There will truly be something for everyone. These dedicated specialists and wonderful presenters have spent many hours sifting through recently published papers in their field. Each have then selected four or five which they believe to be of most interest to equine practitioners. In the available time, they will highlight the salient and practical messages from each of the selected papers. This will ensure a rapidly moving journey through all that is new and relevant across the field of equine veterinary medicine in the last twelve months. A session not to be missed that is for sure.

15.50
Surgery
Bruce Bladon

16.15
Medicine
Celia Marr

16.40
Reproduction
Madeleine Campbell

17.05
Lameness
Michael Schramme
Managing mares for natural cover

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Thoroughbred mares being managed for natural cover require pre-season screening (after January 1) to identify any venereal infections that may be transmitted to the stallion during mating. The HBLB Codes of Practice now overseen by BEVA outline the necessary laboratory samples to be submitted prior to any natural cover (https://codes.hblb.org.uk/). For UK-domiciled mares, considered to be ‘low risk’, the requirement is for a clitoral swab that is tested for CEMO, Pseudomonas aeruginosa and Klebsiella pneumonia (venereal capsule types). Either PCR or bacteriological culture at an approved laboratory is acceptable. Blood tests indicating a negative status for equine viral arteritis and equine infectious anaemia are also needed. A cervical swab taken during oestrus and cultured overnight aerobically is then the minimum necessary before the mare may be mated; a new cervical swab is required for every subsequent oestrus period if the mare is not pregnant. The Codes are an essential guide to the samples needed from mares that have arrived in the UK from overseas or have had a venereal infection detected in previous breeding seasons; additional testing will be required in these mares.

For Thoroughbred mares being mated to flat-racing stallions, the economic requirements of the industry are for mares to be mated early before the start of the natural breeding season and therefore barren and maiden mares should be managed under lights (increasing day length) to ensure they are cycling normally by the middle of February. Progesterone treatment with altrenogest may be helpful to synchronise mares to be ready for mating at the start of the breeding season.

As mares must be capable of standing to be mated naturally. Good teasing management is important to ensure the process will go smoothly and with the least likelihood of injuries to the mare, stallion or personnel involved in handling the horses.

Gynaecological management of mares is very similar to those being bred by artificial insemination, with rectal palpation and ultrasound examination of the genital tract to identify any underlying endometritis, both from clinical findings and the results of cervical swabs and smears. Determination of the stage of the oestrus cycle and of follicular development is important to determine the best time for the mare to be mated. Flat and National Hunt Thoroughbred stallions are often very popular, and the likelihood is that there will only be one opportunity for the mare to be mated during any oestrus period. Ideally mares should ovulate within 24 h of being mated and, therefore, careful assessment to determine the best time for the mare to be mated is important if the highest reproductive efficiency is to be achieved. Depending on circumstances it is likely that frequent daily examination may be needed to ensure the stallion stud is kept informed of the mare’s progress if she is ‘walking in’, which is the most common practice today. It is also not uncommon for mares to travel long distances from the home boarding stud to visit the stallion and, therefore, ovulatory agents are frequently used, most commonly deslorelin as an implant or injection. This should, in most circumstances, be given the day before natural mating to ensure timely ovulation.

The practice of ‘walking in’ has resulted in the mare’s attending vet often having little knowledge of the expected per-cycle fertility of the stallion being used; this is in contrast to studs farms where the mares are predominantly being mated to stallions on the farm where the resident vet will have detailed knowledge of the stallion’s fertility statistics. For this reason, making no assumption about the stallion’s fertility is important until one has become experienced in sending mares to any individual stallion. If a stallion with known subfertility is being used it may be necessary to time mating to be very close to ovulation, combined with the use of pre- or post-mating semen extender or even mating the mare more than once such as in consecutive covering sessions. Often this may be done most efficiently if the mares board at the stallion stud and are managed by one individual vet. Some reproductive specialists also advocate the technique of reinforcement to increase fertility results.

Once mated, checking the mare the day afterwards for ovulation is ideal and then any appropriate treatments can be performed and the mare’s vulva sutured if necessary. If the mare has not ovulated then determining the time of a ‘cross cover’ or second mating can be decided, depending on the availability of the stallion.

Further reading

NOTES
Stimulating early season cyclicity

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Introduction
The start of the breeding season is the first ovulation of the year. The average date in horses is April 7th +/- 9 days and in ponies, May 7th +/- 21 days [1].

Early season cyclicity is desirable in the equine stud industry. Commercial pressures create a requirement for birthdates close to January in the Northern Hemisphere, particularly in the Thoroughbred industry. Annual earnings are higher for horses born in January and February compared to those born between April and June [2]. Delay in the onset of cyclicity results in breeding inefficiency.

Vernal transition
Vernal transition is the period between winter anoestrus and the first ovulation of the year. The transitional stage is characterised by the onset of follicular development, which occurs in waves and can result in large anovulatory follicles. The process that begins vernal transition is not fully understood, but it begins soon after the winter solstice. Table 1 summarises the critical events and basic hormonal changes associated with vernal transition [3].

Factors affecting onset of cyclicity

Daylight length
The onset of the equine breeding season is triggered by increasing day length. Melatonin is a pineal hormone produced during hours of darkness. During long days, the inhibitory action of melatonin on the mare’s reproductive axis is lifted and increased gonadotrophin-releasing hormone (GnRH) pulse frequency stimulates the anterior pituitary to release follicle-stimulating hormone (FSH) and luteinising hormone (LH) which act together to promote growth, development and ovulation of ovarian follicles.

Age
Less follicular activity has been demonstrated in older mares compared to young mares during the transitional period [4].

Pasture
Mares pastured on green grass ovulated sooner in the spring than mares housed and fed hay [4].

Other factors
It is likely that many factors including local weather conditions, nutrition, body condition and disease can affect vernal transition and the onset of cyclicity in mares.

Table 1: Critical events of vernal transition in the Northern Hemisphere [3]. GnRH: gonadotrophin-releasing hormone; FSH: follicle-stimulating hormone; LH: luteinising hormone

<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortly after the winter</td>
<td>Increased hypothalamic GnRH</td>
</tr>
<tr>
<td>solstice</td>
<td></td>
</tr>
<tr>
<td>Early January</td>
<td>Increased FSH secretion</td>
</tr>
<tr>
<td>Late January–early</td>
<td>Onset of follicular development</td>
</tr>
<tr>
<td>February</td>
<td></td>
</tr>
<tr>
<td>Throughout early spring</td>
<td>Approximately 3.7 sequential anovulatory follicles at 10-12-day intervals. Equates to approximately 45 days of follicular waves prior to first ovulation</td>
</tr>
<tr>
<td>time</td>
<td></td>
</tr>
<tr>
<td>Throughout early spring</td>
<td>Failure of LH secretion</td>
</tr>
<tr>
<td>time</td>
<td></td>
</tr>
<tr>
<td>Approximately 5 days</td>
<td>Failure of follicular steroidogenesis</td>
</tr>
<tr>
<td>prior to first ovulation</td>
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<td>of the year</td>
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<tr>
<td>Termination of transition</td>
<td>First ovulation of the year</td>
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Artificial lighting
Artificial photoperiod is currently the best method to hasten the first ovulation of the breeding season in winter anoestrus mares. Day length is extended for at least 8–10 weeks by exposing mares to artificial light, producing an artificial photoperiod of 16 hours of light and 8 hours of darkness. In order to have mares cycling for the beginning of the Thoroughbred breeding season in the Northern Hemisphere these artificial photoperiods should be initiated at the beginning of the preceding December. Burkhardt [5] showed that a 100W light bulb in a 3.6 m x 3.6 m stall is effective at advancing the onset of cyclicity in mares. The light produced by this method is on average 107 lux. Light within the short wavelength spectrum or blue light (465–485 nm) has been shown to be most effective at inhibiting melatonin [6]. Timed low level blue light to one eye provided by a head-worn mask is as effective as indoor barn lighting at advancing the equine breeding season [7]. Therefore, blue light masks offer an alternative method to provide light therapy.

Hormonal therapies
Progestogens
Progesterone and synthetic progestogens are often used to manage the transition period in mares. Delivery is either by daily or weekly depo injections, orally or by intravaginal devices (PRID/CIDR). Intravaginal devices releasing low dose progesterone offer a convenient, cost-effective method of inducing oestrus and ovulation in transitional mares [8–10]. For inducing early ovulation, exogenous progesterone administered via a intravaginal device should be administered for 10–12 days during mid to late transition with follicles greater than 1 cm in diameter [9]. If an ovulation is detected following removal of the intravaginal device, prostaglandin may be administered at the time of removal. Additional treatments ensuring ovulation (with Ovuplant or hCG) are needed [9].

GnRH
Several GnRH treatment regimens have been shown to hasten the first ovulation in the majority of mares that are undergoing or nearing spring transition. Cost and administration rates make this option impractical.

Stimulating early season cyclicity
Dopamine antagonists

Commonly used dopamine antagonists include domperidone, sulpiride and fluphenazine. Research has demonstrated that these compounds can stimulate follicular growth and/or ovulation in seasonally anovulatory mares to some extent; however, results are variable [11].

• Domperidone – administration of 11 mg/kg bwt orally once daily to seasonally anoestrus mares maintained under natural photoperiod from January 15 stimulated follicular development within 14 days of treatment and brought forward the mean date of ovulation by 78 days [12]. Other studies have shown no benefit, including its use during artificial light therapy.

• Sulpiride – dose rate 1.0 mg/kg bwt once a day [13]. Beginning sulpiride treatment when follicles were 25 mm in diameter resulted in a significant advancement of cyclicity in non-photo-stimulated mares [14].

Conclusion

Artificial lighting remains the most reliable method of inducing early cyclicity in mares. Hormonal therapies may assist success and efficiency when breeding on early season follicles. Many factors should be considered when initiating early season cyclicity, including management and nutrition, together with lighting and hormonal therapies. The timing of combinations of therapies is important in achieving successful early cyclicity.

References


NOTES
Seasonal/lactational anoestrus

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Introduction
Mares are seasonally polyoestrus animals with a gestation of 330–345 days; this ensures that in the natural situation foals are born between March and August when there is good weather and sufficient nutrition available for lactation and the rearing of the foal. This is achieved by the mare having a period of seasonal anoestrus during the winter where the reproductive tract is quiescent; she then undergoes a ‘spring transition’ where, in response to an increasing day length, the hypothalamus-pituitary-ovarian pathway awakens and ovarian activity is initiated leading to cyclical seasonal activity. An ‘autumn transition’ then occurs leading back into ‘winter anoestrus’. In the northern hemisphere mares will naturally cycle between April and September, resulting in foals being born between March and August. It should be noted that some mares will omit the ‘winter anoestrus’ and cycle all year round; there can be variation in individual mares over the years, and between mares, as to when ovarian activity begins. This variation is multifactorial, involving photoperiod, nutrition, environmental temperature and body condition, amongst others. It is these factors that can interfere with cyclical activity during the normal physiological breeding season meaning that mares that are expected to be cycling are not; these factors can be used by the horse breeder to advance the breeding season for commercial or management purposes. Anoestrous mares are a significant problem as they have a financial and emotional effect on the commercial and nonprofessional horse breeder alike.

Anoestrus is defined as an absence of oestrus/ovulation and can be due to a wide variety of causes, both physiological and pathological. The investigation of an anoestrous mare involves a good clinical history, knowledge of previous breeding patterns, manual and ultrasound examination of the reproductive tract (ovaries, uterus, cervix) and hormone analysis. Here we will discuss seasonal and lactational anoestrous states in which the mare has no ovarian activity and does not display normal oestrous behaviour.

Seasonal anoestrus
Mares that have no ovarian activity during the breeding season are termed ‘seasonally anoestrous’; interestingly, such mares can display weak oestrous behaviour but have no ovarian activity and no ovulation [1]. This often occurs in young, maiden mares who, despite being anatomically ‘normal’, fail to cycle; in the majority of cases such mares need time to respond to light stimulation and do eventually cycle later in the season or in subsequent seasons in cases of sexual immaturity. There may be pressure from owners to treat cases; options include progestagens (Altreton® 0.044 mg/kg bwt once a day orally or PRID delta), domperidone (11 mg/kg bwt orally once a day) or gonadotrophin releasing hormone (GnRH) analogues (goserelin implant 1.8 mg s.c.; buserelin 20 µg i.m. twice a day). Cases should be carefully selected as treatment failure is not uncommon; mares should have a minimum follicle size of 25 mm and any treatment continued for 10 days with regular ultrasound monitoring. In mares that remain anoestrous, further investigation is warranted using hormone assays (progesterone, follicle stimulating hormone, luteinising hormone) and possible karyotyping to identify any chromosomal abnormalities.

Lactational anoestrus
A particular form of seasonal anoestrus occurs in post-foaling mares and is termed ‘lactational anoestrus’. This can have a significant impact on the mare’s foal production over her lifetime; some mares will be repeat offenders and not cycle when they have a foal at foot (every-other-year breeder). It is important that all mares are examined by manual palpation and ultrasound at foal heat (7–14 days post-partum) to assess uterine recovery and monitor ovarian activity; particularly the foal heat ovulation. Most mares will then continue a normal cyclical pattern every 20–21 days. Lactational anoestrous cases present in two ways: either with minimal/absent ovarian activity at foal heat, or with a normal foal heat ovulation followed by minimal/absent ovarian activity. This interruption in the normal process is an effect of lactation; in some mares which foal early in the year (prior to the physiological breeding season) the situation may be complicated by seasonal anoestrus. Lactation has a major impact on the mare’s metabolism, so a physiological effect would be expected. The incidence of lactational anoestrus in the horse is reported as 4% [2]; however, in lactating women, the incidence can be above 98% and last for over 6 months, the duration apparently being dependent on night-time sucking in particular [3]. The management of mares in lactational anoestrus can be difficult as often they are identified late; treatment of any musculoskeletal or reproductive tract pain is important, as is increasing light exposure, particularly for those mares foaling early in the year, using an appropriate stable/barn lighting system or a head-collar light mask (Equilume). Treatment options include: progestagens (as above); GnRH analogues (implants should be used with caution as they may lead the mare to stop cycling temporarily; daily buserelin injections can be helpful but the necessary length of treatment can be expensive); domperidone (increase in milk production is a side effect); or prostaglandin (usually no beneficial effect). Reducing the mare’s nutritional outgoings can be attempted but this involves the early weaning of the foal or the partial removal of the foal from the mare; there is increased stress associated with this, and the need to supplement the foal nutritionally, but in some cases and especially in high value broodmares, the option to foster the foal might allow her to breed each year. In many cases, mares in lactational anoestrus can cycle naturally in spite of treatment and in their own time, which may be 2–3 months later; the key is to identify them early, institute treatment if necessary but use the information in the subsequent years to minimise recurrence.

References
Managing mares for chilled and frozen semen

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Introduction
When managing mares for artificial insemination (AI), the aim is to introduce sufficient ‘fertile’ spermatozoa into the uterus close enough to ovulation to offer an optimal chance of fertilisation, without compromising subsequent pregnancy maintenance, e.g. by provoking a persistent breeding-induced endometritis (PBLE). The strategy will take account not only of semen type (fresh, chilled or frozen), but also quality (number of ‘normal’ sperm), availability (e.g. certain days of the week; number of straws) and mare reproductive history. The major practical differences between chilled and frozen semen are the preferred timing of AI with respect to ovulation, and that chilled semen is usually ordered shortly prior to use, whereas frozen semen is usually stored on site. While it is assumed that chilled semen retains fertilising capacity for approximately 24 h after AI, compared with 12 h for frozen-thawed semen, there is considerable between-stallion variation both in sperm longevity and in sperm number required for reasonable fertility.

Inducing ovulation
Accurately predicting when ovulation will occur is an important aspect of AI management, particularly if semen is limited in amount, irregularly available or has to be ordered long in advance. Inducing ovulation is an invaluable aid to planning, notwithstanding that no agent is 100% reliable, and mares presented very close to ovulation will not ‘wait’ for the effects of induction. The major ovulation-inducing agents available are human chorionic gonadotrophin (hCG) and gonadotrophin-releasing hormone ( GnRH) analogues. Ovulation induction is typically performed when a mare is in heat (e.g. obvious uterine oedema) with a large preovulatory follicle (>35 mm). Approximately 80% of mares ovulate 36±4 h after hCG administration [1] and failure to respond is more common in older mares and mares treated too early in oestrus and respond predictably to ovulation induction. It becomes challenging when chilled semen has to be ordered far in advance of proposed AI, or when only a single straw of frozen semen is available. For optimal frozen semen results, the dogma has long been that AI should be performed between 1 h prior to and 8 h after ovulation. This is labour intensive, since it can only be guaranteed by checking mares at 8-hourly intervals and inseminating post-ovulation. Fortunately, there appears to be more room for manoeuvre. Sieme et al. [2] reported similar pregnancy rates for mares inseminated once with frozen-thawed semen anywhere between 12 h prior to and 12 h after ovulation, and Newcombe et al. [3] found no differences in pregnancy rates or subsequent embryonic loss rates for mares inseminated on a single occasion post-ovulation following examination intervals ranging from 0–3 h to 12–15 h. Based on these findings, our current protocol for mares to be inseminated with a single straw of frozen-thawed semen involves inducing ovulation at 20.00–22.00, checking for ovulation twice the following day (8.00 and 17.00) to rule out ‘unexpectedly early’ ovulation. Unless imminent ovulation is predicted at the last examination, the next check is at 8.00 the next day (i.e. 33–34 h after ovulation induction) when only a small percentage will have ovulated (and are inseminated immediately). At 12.00, the vast majority of mares will have ovulated and will be inseminated. Where multiple straws are available, we prefer to split the dose and inseminate twice, once prior to and once after ovulation; in our hands, this improves pregnancy rates (approx. 50% vs. 35% per cycle for single straw AI). When the split-dose protocol is used, ovulation is induced in the morning (8.00), and half of the dose is inseminated the following afternoon (16.00; i.e., 32 h later). The other half of the dose is inseminated the following morning, assuming ovulation has taken place. If the mare fails to ovulate when expected, half of the semen is retained for a single post-ovulation AI.

Chilled semen
When chilled semen is available daily at short notice, AI management involves simply inducing ovulation and ordering semen for the following day. For mares that appear very close to ovulation at first presentation, same day AI is preferable. However, if that is not possible and the mare has ovulated by the following morning, it is probably still worth performing AI that afternoon; pregnancy rates do not seem to be seriously compromised. There are also situations (e.g. subfertile stallion) when is preferable to plan two AIs in an oestrus (at a 24–48 h interval), although the owner of a busy stallion may take some convincing. Two AIs can also be achieved by splitting a chilled semen dose over two consecutive days (keeping half in the fridge overnight). The rationale is provided by the increasing number of surveys reporting higher pregnancy rates when mares are inseminated more than once per oestrus [2].

Frozen semen
For optimal frozen semen results, the dogma has long been that AI should be performed between 1 h prior to and 8 h after ovulation. This is labour intensive, since it can only be guaranteed by checking mares at 8-hourly intervals and inseminating post-ovulation. Fortunately, there appears to be more room for manoeuvre. Sieme et al. [2] reported similar pregnancy rates for mares inseminated once with frozen-thawed semen anywhere between 12 h prior to and 12 h after ovulation, and Newcombe et al. [3] found no differences in pregnancy rates or subsequent embryonic loss rates for mares inseminated on a single occasion post-ovulation following examination intervals ranging from 0–3 h to 12–15 h. Based on these findings, our current protocol for mares to be inseminated with a single straw of frozen-thawed semen involves inducing ovulation at 20.00–22.00, checking for ovulation twice the following day (8.00 and 17.00) to rule out ‘unexpectedly early’ ovulation. Unless imminent ovulation is predicted at the last examination, the next check is at 8.00 the next day (i.e. 33–34 h after ovulation induction) when only a small percentage will have ovulated (and are inseminated immediately). At 12.00, the vast majority of mares will have ovulated and will be inseminated. Where multiple straws are available, we prefer to split the dose and inseminate twice, once prior to and once after ovulation; in our hands, this improves pregnancy rates (approx. 50% vs. 35% per cycle for single straw AI). When the split-dose protocol is used, ovulation is induced in the morning (8.00), and half of the dose is inseminated the following afternoon (16.00; i.e., 32 h later). The other half of the dose is inseminated the following morning, assuming ovulation has taken place. If the mare fails to ovulate when expected, half of the semen is retained for a single post-ovulation AI.

Conclusions
Management of mares for AI with chilled or frozen semen can be straightforward, if sufficient semen is available, mares are presented early in oestrus and respond predictably to ovulation induction. It becomes challenging when chilled semen has to be ordered far in advance of proposed AI, or when only a single straw of frozen semen is available. In such situations, ovulation induction is invaluable, and strategic timing of induction can make the process much less labour intensive. In the author’s opinion, there is more scope for improving results by establishing individual stallion requirements for minimum sperm number and maximum AI-ovulation interval, than examining mares more often in the hope of determining the ‘exact moment of ovulation’.

References
Prefixation management of twins

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Except for embryo transfer programmes, twins are an undesirable outcome, since most multiple pregnancies will result in fetal loss. Effective twin management involves:

- detection of multiple ovulation, and
- early intervention prior to embryonic fixation by 16 days post-ovulation.

Overwhelmingly, multiple pregnancies are the result of multiple ovulations. Breed plays an important role, with Thoroughbreds and Warmbloods having a higher incidence. Ovulatory inducing hormones, such as deslorelin, can increase multiple ovulations. Prebreeding ultrasonographic examination of the ovaries during oestrus, so as to identify all large follicles (>30-35 mm), should be performed, and followed until ovulation. Post-breeding ultrasonographic examination will identify the absence of follicles indicating recent ovulations and often the presence of one or several corpora lutea. Occasionally, a late-developing follicle can continue to grow and ovulate days after the initial ovulation.

Twin reduction

Embryo transfer

If multiple ovulations are diagnosed, the potential embryos of the bred mare, in breeds that allow this procedure, may be retrieved around 7 or 8 days post-ovulation and transferred to synchronised recipients. Alternatively, embryo(s) may be transported to a recipient herd facility for transfer. Finally, young, small, healthy embryos at approximately 6.5–7 days post-ovulation could be vitrified and stored in liquid nitrogen for future transfer. These procedures will incur more expense to mare owners.

Pregnancy diagnosis

Commonly, initial pregnancy diagnosis is performed at approximately 13–15 days post-ovulation. The uterine horns, body and cervix must be slowly and systematically examined in their entirety. Prior to the examination for pregnancy, if the mare has endometrial cysts, record the location, number, and size of these structures, so that they are not mistaken for pregnancy. The ovaries should be examined to confirm the location and number of corpora lutea, as asynchronous ovulations may not have been readily apparent at breeding. Two or more corpora lutea should alert for the possibility of twinning.

Manual reduction

When twins are identified at the initial prefixation examination between 13 and 15 days, manual reduction ‘vesicle crushing’ is the preferred method, regardless of whether twins are adjacent or separate. In doubt about the presence of twins or of confounding cyst(s), delay the procedure 12 to 24 h and re-examine for growth or position of the structures. Cysts remain essentially unchanged at the same location, while embryonic vesicles grow daily, change location constantly, and can be moved manually within the uterus. The decision of which embryonic vesicle to ‘crush’ is made based on factors such as size, position, and ease of access and manipulation by hand. A very small vesicle of 15 mm or less, can be more difficult to reduce, requiring more force, whereas vesicles larger than 15 mm are more fragile. Reduction can be performed in a number of ways. Identifying the vesicle by ultrasonography, manually moving it toward a horn tip, then crushing it, is common. Alternatively, the transducer can be used to separate vesicles or to squeeze the area of the uterus containing the vesicle against the pelvis. Alternatively, downward pressure may be applied on the vesicle with the transducer until the vesicle has an oblong shape, then a quick flick of the wrist with the transducer is made without releasing the pressure to rupture the vesicle. The veterinarian must see the dispersed fluid within the endometrial folds (and/or feel the ‘pop’) to confirm that the vesicle has ruptured.

Adjacent vesicles

Vesicles in the mobile stage may be identified that are adjacent. How aggressive one can be to separate the vesicles, risking harm to both, has to be considered. Generally, vesicles prior to 16 or 17 days post-ovulation can be moved, either through spontaneous uterine contractions or by transrectal manipulation, aided by the use of sedative or an antispasmodic drug. If the mare has gone further than 17 days and fixation of the vesicles has occurred, it is not recommended to rupture unilaterally fixed vesicles. If fixation has occurred bilaterally, reduction can be done up to 20 days post-ovulation. Rarely, triplet or quadruplet pregnancy occurs. In these cases, examine early at approximately 13 days and crush vesicles at 12–24-h intervals.

Spontaneous reduction

Mares carrying unilaterally fixed twin pregnancies past the post-fixation period have a high incidence (75–80%) of spontaneously reducing to a singleton. However, it is not recommended to take this chance. When twins are fixed bilaterally, spontaneous reduction generally does not occur.

Therapies post-reduction

Post-reduction therapies are often anecdotal and empirical. Sheerin (2010), in a retrospective analysis of a large data set, indicated that mares that were treated with flunixin meglumine as well as progesterone/progestagens after the procedure, had a significantly higher foaling rate than those that had either no treatment or other treatments not involving progesterone therapy and flunixin meglumine [1].

Success rate

Prefixation twin reduction results in a close to 90% foaling rate. According to Sheerin (2010), there was no difference in live foal rates in mares that underwent a twin reduction on days 13–16 and 17–20 days of gestation [1]. However, the individual performing the procedure was a significant factor determining the successful outcome. Therefore, re-examine mares undergoing twin manual reduction for singleton status at 5–7 days post-reduction and again prior to the formation, at 35 days, of endometrial cups.

Reference

Further reading


NOTES
Occasionally veterinarians are faced with the situation where a mare is first diagnosed with twins after embryo fixation has occurred, i.e. after day 16 post-ovulation. Such cases most commonly arise because clients do not present their mare for pregnancy diagnosis at the optimum time after artificial insemination or natural service, i.e. 14–16 days later. In other cases, a pregnancy may have been misdiagnosed as a uterine cyst at an earlier examination, and therefore it is not until an embryo proper (with a heartbeat) is seen that it is confirmed that the mare has twins. The focus of this presentation is to discuss options and approaches for mares diagnosed with twins between days 17 and 65 of gestation. Techniques for managing twins prior to day 17 and after day 65 will be covered elsewhere.

Deciding whether to attempt manual twin reduction after day 16 depends upon several factors, namely:

**Size difference between two unilaterally fixed embryonic vesicles**

Ginther [1] was the first to describe the phenomenon of ‘natural twin reduction’, which is the natural elimination of one member of a unilaterally fixed twin set by the end of the embryo stage (day 40). Embryo reduction occurs when a major portion of the vascularised wall of the yolk sac is in apposition with the wall of the adjacent vesicle rather than with the endometrium; the vesicle is therefore deprived of adequate embryonal–maternal exchange and regression occurs. The greater the size difference between embryos, the more likely this is to occur. In unilaterally fixed twins with a size difference of greater than 4 mm, natural twin reduction occurred in 100% of mares [1].

**Positioning of the embryos**

Twins are more likely (85% of the time) to become fixed unilaterally when there is a size difference between the two embryos that is equivalent to an asynchronous ovulation of at least 1 day apart (≥4mm) [1]. In all cases of bilaterally located twins (i.e. one embryo in each uterine horn), manual rupture of one twin should be attempted as soon as possible, as natural twin reduction does not occur in bilaterally fixed twins.

**Experience of the veterinarian**

In a study involving 1493 manual twin reductions performed by 14 different veterinarians in Kentucky, Sheerin et al. [2] showed that there was a significant effect of operator on the live foal rate following twin reduction performed between days 13 and 20 of gestation. Interestingly, experience was not a factor in this study, indicating that some people are clearly more proficient at the technique than others.

**Time in the season when the twins are first diagnosed**

If twins are diagnosed early in the season, and relatively early in gestation, a simple and effective option is to abort both pregnancies with prostaglandin. The value and availability of the stallion and/or his semen may also be a consideration.

**Stage of gestation when twins are first detected**

From a practical point of view, the period between days 17 and 65 of gestation involves three physiological stages: day 17–21 – the period immediately after fixation, but prior to the detection of a fetal heartbeat; day 21–34 – the period after detection of a heartbeat and prior to the formation of the endometrial cups; day 35–65 – the period during which eCG production from the endometrial cups results in the production of accessory corpora lutea, even in mares that have lost their pregnancy.

Recommended approaches to manual reduction of unilaterally fixed twins during the three different stages between days 17 and 65 of gestation are:

**Day 17–21**

If there is a size difference of greater than 4 mm between the two vesicles, it is not unreasonable to leave them alone and allow natural twin reduction to potentially occur. If they are of a similar size (less than 4 mm diameter difference) and both twins have retained their spherical shape, it is possible to separate them and crush one as per the usual method for twin reduction. Bowman reported a success rate of 96% on day 18–19 and 62% on day 20–21 with manual reduction [3]. If the vesicles are losing their turgidity, it is very difficult to isolate one vesicle from the other, and an attempt at manually crushing one twin is very likely to result in the loss of both. In these cases, it is probably best to leave them until around day 30–34, as approximately 75% of them will reduce to a singleton through the process of natural twin reduction [1].

**Day 21–34**

A decision on how to manage a set of twins is best made before day 34, prior to formation of the endometrial cups. During this period, it is difficult, if not impossible, to separate unilateral twins and there is a high risk of damage to both embryos when manual rupture is attempted. Manual reduction is best attempted as early as possible in this period, as the success of manual reduction between day 22 and 24 is around 50%, compared with 20% between days 25 and 30 [3]. Between days 30 and 34 it is possible to ‘pinch’ one embryonic vesicle with the ultrasound probe, the goal being to cause membrane damage rather than complete ablation. This involves putting downward pressure on the edge of the vesicle rather than in the centre. Think of it like popping a grape by pushing down vertically on one end. A successful result is seen by observing the ‘snowflake effect’, which is cellular debris from damaged fetal membranes floating within the amniotic and/or allantoic cavity. Vigorous attempts to destroy the embryonic vesicle are likely to result in the loss of both pregnancies.

**Day 35–65**

Between days 35 and 45, manual rupture using the ‘pinching’ technique is effective in approximately 50% of cases [4]. Another technique that can be attempted at this stage is repeated (every 24 h) ‘worrying’ of one fetus with the ultrasound probe until the ‘snowflake’ effect is seen. This can take up to 7–10 days and is reported to be effective in approximately 65% of cases [4]. A technique of repeated oscillation and dislocation of the fetus from the umbilicus between 45–50 days has been described; however, its
effectiveness has not been widely reported. A very recently described technique implemented at around days 50–65 involves putting pressure on the neck of the fetus with the ultrasound probe until the heart stops. This technique appears to be very effective in a limited number of cases [5].

References
Ultrasound-guided twin reduction

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Introduction
The introduction of transrectal ultrasound for pregnancy evaluation has revolutionised the identification and management of twin pregnancies in mares. The rate of abortion due to twin pregnancies has dropped from an average of 20% [1] to 6% [2]. While improvements in management of twins are certainly notable, pregnancy loss as a result of missed twins is costly. As a consequence, management of twin pregnancies to ensure delivery of a viable singleton is essential. Several methods are available for managing twins, depending on the stage of gestation at which they are detected as well as cost.

Twin management using manual crushing during mobility phase
Twin pregnancies are optimally detected between days 13 and 15 of gestation. During this time period, the embryonic vesicles are mobile within the uterus [3]. Twin pregnancies that are detected during the mobility phase (up to day 16 or 17) are best managed by manual crush of one embryonic vesicle [4]. Survival rates of the remaining vesicle after the crush procedure exceed 90% in experienced hands [5].

Transvaginal ultrasound-guided twin reduction
Selective reduction of pregnancy using transvaginal ultrasonography has been advocated for mares with twins between 25 and 50 days of gestation, when manual crush is less effective for twin management [6–8]. Advantages of using a transvaginal ultrasound-guided approach for twin reduction in mares include twin reduction prior to placentaion, minimal trauma to the mare, and that it is a standing, outpatient procedure. Disadvantages of this approach include expense, need for specialty equipment and variability in success rates between operators.

The technique involves a 5 or 7.5 MHz transvaginal ultrasound transducer designed for use in large animals. Prior to the procedure, mares are often administered prophylactic antimicrobials, anti-inflammatory agents and progesterone to promote uterine tone. An operator carries the transducer into the anterior vagina, replaces the hand in the rectum and secures the pregnancy. The transducer is manipulated (transvaginally) until the pregnancy is imaged on the ultrasound screen. An assistant passes a sterile, 16 to 18 gauge, 60 cm needle through a needle channel in the transducer casing. The needle is passed through the vaginal wall and uterine lumen into the yolk or allantoic space using a sharp jab. Fluid is aspirated and/or fetal trauma is induced with the needle.

The success rate of transvaginal ultrasound-guided twin reduction has been highly variable [7, 9–12]. Operator experience, parity, day of gestation and bilateral vs. unilateral position of pregnancies are all factors impacting success. Data from a prospective study described live foal delivery rates after transvaginal twin aspiration was performed in mares between 25 and 62 days gestation [12]. One skilled operator performed all twin reduction procedures and nearly half (20/41; 49%) of treated mares delivered live foals. The live foal rate was highest in mares that underwent the procedure during days 31-35 gestation (9/14; 64%) and was lowest (0/5) in mares that had the procedure after day 42 of gestation. One could argue that unilateral twins prior to day 40 might reduce naturally and intervention was not necessary [13]; however, similarly sized unilateral twins at day 25-30 frequently continue to thrive and aggressive management is warranted. Poor uterine tone and dependent position in mares with twins >35 days gestation limit success of the procedure.

Transcutaneous ultrasound-guided twin reduction
Transcutaneous ultrasound-guided twin reduction in the mare was pioneered by Rantanen and Kincaid [14]. The technique has been widely used and offers the advantage of consistent live foal rates (260%) when performed by experienced individuals [14,15]. This technique is often used when the window for early twin reduction, by either manual crush or transvaginal ultrasound-guided procedures, has passed. Performing twin reduction at a later date may prove advantageous for unilateral twins that have undergone placental development and have greater stability. Conversely, twins with a significant shared placental interface will not regain endometrial contact after the procedure is performed; thus placental insufficiency may result in premature termination of pregnancy or delivery of small, unthrifty foals [16]. The original suggested time to perform this procedure was between 115 and 130 days gestation [17]; however, a range of days has been described [16]. As with other described procedures, mares are often treated prophylactically with broad-spectrum antimicrobials, anti-inflammatory agents, and exogenous progestins. The procedure is performed in the standing, heavily sedated mare. Sedation promotes movement of the fetuses into the cranial abdomen allowing for easier accessibility and to minimise fetal movement during the procedure. The fetuses are identified with a 2.5-3.5 MHz curvilinear transducer to determine fetal positioning and size. The most accessible fetus is targeted for reduction. The mare’s abdominal area adjacent to the fetuses is clipped and surgically prepared prior to the procedure. Typically, a 6 inch, 18-gauge spinal needle is used to perform the procedure. The needle is passed through the skin and abdomen in one motion. Once the needle is advanced into the peritoneal space, the needle tip is located on the ultrasound image. Using a quick, thrusting motion, the needed is advanced through the uterine wall and into the uterine lumen. A fetal heart is identified and the needle is advanced, rapidly, into the fetal thorax/heart. Penetration of the fetal thorax and heart can be challenging as the fetus frequently moves away from the needle. Free flow of blood from the needle after removal of the stylet indicates needle placement within the fetal heart. Potassium chloride (KCl, 2 mEq/mL, up to 32 mEq KCl) or procaine penicillin (10–20 mL) [18] are injected into the fetal heart, thorax or abdomen. Potassium chloride generally results in rapid fetal death, particularly with intracardiac needle placement. Cardiac activity of the treated fetus is monitored immediately after the procedure. The fetus does not always die immediately in which case the mare is monitored over subsequent days to assess the status of both the treated and untreated fetuses. Generally, mares are administered flunixin meglumine at the time of the procedure and for up to 4 additional days (twice daily). Progestin therapy and prophylactic antimicrobials are also prescribed for a period of 5 days.

Success rate of fetal cardiac puncture for twin reduction exceeds 50% in most cases. Factors that contribute to success of the procedure include proximity of the fetus to the adjacent twin (and placentaion involved), operator experience and conditions for performing the procedure. The terminated fetus is mummified and delivered in a small placental sac along with the live fetus.
Conclusions
Manual reduction of twin embryonic vesicles to a singleton is the most viable option for managing twin pregnancies in mares. If twins are not identified during the period when manual reduction is optimal, several other procedures are available to the mare owner. Pros and cons of all procedures, including success rates and stage of gestation, should be considered prior to selecting a method of management for late embryonic or fetal twins.

References
Cranio-cervical dislocation (CCD) is described as the dislocation of the first cervical vertebra from the cranium, disrupting the ligamentous attachments and severing the spinal cord. This procedure can be performed via colpotomy, transrectal or transabdominal techniques between 60 and 110 days of gestation to produce a single foal [1]. The basis for this procedure is to eliminate one twin before placental formation is complete, allowing the remaining fetus to utilise the entire endometrial surface for nutrient and oxygen exchange and to grow to its full potential.

Transrectal manipulations have been performed between 60 and 90 days of gestation. The mare is restrained in stocks or twitched in the doorway. Sedation can be administered using detomidine (10–20 mg/kg bwt i.v.); however, after sedation the uterus may relax and the fetuses may move cranially in the abdomen and out of reach. Relaxation of the smooth muscle in the uterus and rectum can be achieved by the administration of buscopan (2–5 mL i.v.); this will allow easier identification and manipulation of the fetuses. To help inhibit prostaglandin release, flunixin meglumine (1 mg/kg bwt) is administered prior to the procedure. The smaller fetus or the fetus that has less contact with the endometrium and minimal space to grow is preferentially reduced. This fetus is usually identified in the more cranial aspect of the uterine horn in unilateral twins. Once the identified fetus is located, the head must be isolated by finding the dome-shaped head and the mandible or locating the cervical vertebrae. CCD is performed by stabilising the head between the thumb and forefinger and bending the head from side to side. This will damage the ligaments attaching the head and neck. Dislocation is then created by placing the thumb at the base of the cranium and applying pressure proximally and dorsally. A distinctive pop is felt when dislocation is achieved, and the thumb and forefinger can be placed in the space created between the head and neck. Mares should be prescribed detomidine (Regumate) (0.088 mg/kg bwt once daily for 3–4 weeks). After CCD, death with loss of the fetal heartbeat is usually evident within 24 h to 1 week. Fetal viability should be evaluated 1 week later and every 2 weeks for 1 month to confirm normal growth of the continuing fetus and demise of the other.

If transrectal reduction cannot be achieved, an intra-abdominal or colpotomy approach may be tried between 58 and 150 days of gestation. Transabdominal ultrasound is used to identify the horn in which the most viable fetus is located, and that both fetuses are viable. Preoperative medications include flunixin meglumine (1 mg/kg bwt i.v.), procaine penicillin G (22,000 IU/kg bwt i.m.) twice daily and gentamicin (6.6 mg/kg bwt i.v. once a day). Buscopan (0.1 mL i.v.) is administered at the time of incision and is essential for uterine relaxation by preventing uterine contractions while finding and manipulating the fetus. A standing flank laparotomy is performed on the right side of the abdomen to eliminate the potential for splenic interference or damage. The uterus is located within the abdominal cavity with one arm, and the twin is isolated as described for transrectal dislocations. CCD is performed by manipulating the fetus through the uterine wall, without incising or invading the uterine lumen. The flank incision is then routinely closed. Mares should be prescribed flunixin meglumine (1 mg/kg bwt i.v.), procaine penicillin (20–50 IU/kg bwt i.m. every 12–24 h) and gentamicin (6.6 mg/kg bwt i.v. or i.m. every 24 h) for the next 2 days, then trimethoprim sulmamethoxazole (24 mg/kg bwt orally twice daily for 1 week) and altenogest (0.088 mg/kg bwt orally once daily for the next month).

The success of the transrectal procedure has been 63% with delivery of a single normal-sized foal [2]. Due to technical difficulties with the transrectal procedure, only colpotomy and transabdominal approaches have continued to be performed to date. CCD via the intra-abdominal approach produced a single normal healthy foal in 63% of mares. With this technique, death of the manipulated twin was evident from 24 h to 8 weeks post-procedure. One fetus did not die and abortion was induced at 7 months in order not to affect the mare’s present or future fertility. Re-evaluation of fetal viability is performed with transrectal or transabdominal ultrasonography every 2 weeks until demise of one twin is observed.

Recently, CCD has been performed via colpotomy. Fourteen mares had the procedure performed between 65 and 90 days. Sixty-four per cent had a single normal-sized foal (Dr Reed Holyoak, unpublished data).

Signs of impending death of a fetus include: loss of thoracic shape, becoming more convex; loss of definition of abdominal organs; and irregular, weak heartbeat. The placenta shows the nonviable fetus marsupialised, forming a pedunculated pouch off the allantoic surface. Examination of the chorionic surface reveals minimal evidence that a twin was present.

The advantages of CCD over other procedures for reducing post-fixation twins include: a better outcome than transvaginal or transcutaneous ultrasound-guided reductions; transcutaneous reductions are done later in gestation than CCD, when placental function and growth may be limited; transvaginal ultrasound-guided aspirations puncture the uterus and vesicle releasing fluid from the reduced conceptus and potentially disrupting the fetal membranes of the remaining conceptus [2,3,4]. Additionally, not traversing the abdomen and entering the lumen of the uterus reduces the chance of bacterial contamination.

The disadvantages of CCD mostly pertain to isolation of the fetus. It is difficult to identify the correct fetus within the uterus. Uterine relaxation is imperative for identification of fetal anatomy. The extent of trauma or prostaglandin release that occurs with manipulation of the fetus through the uterus is unknown, although previous studies have demonstrated 20 minutes is necessary for significant prostaglandin release [5]. The procedure is relatively rapid; therefore, severe inflammation should not result, but proficiency and duration of manipulations may affect the outcome. The incision site of the flank laparotomy may develop a seroma or cellulitis; however, the incision can be opened and drained. Scarring is minimal, with the occasional white hair. The duration of time that the manipulated fetus survives is inconsistent, the explanation for which is unknown [1].

References
There is a paucity of information regarding drug metabolism and transport in equine pregnancy. Safety data for drug use in pregnancy are equally lacking, not only in horses, but also in humans. Most of the data available regarding drug metabolism and safety have been obtained in rodent or nonhuman primate species. Because placenta tion varies between species, extrapolation of information about drugs between species is limited. Several general principles apply to the pharmacokinetics (what the body does to a drug) and pharmacodynamics (what the drug does to the body) of a given drug, including physiological changes during pregnancy (absorption, distribution, metabolism and elimination) and placental transfer of drugs [1]. Understanding these processes is the most direct path for informed decision making regarding drug use in pregnancy.

Pharmacology in pregnancy
There is little published information about the physiological changes that occur in equine pregnancy. In women, several body systems are affected by pregnancy, which in turn can affect the pharmacology of drugs [1,2,3]. Some specific changes that occur in human pregnancy include:

- Gastric pH increases can affect drug absorption.
- Increased progesterone concentrations lead to slowed gastric emptying and gastrointestinal motility which can delay peak drug concentrations after oral drug administration.
- Drug distribution is altered by significant changes to the cardiovascular system; cardiac output increases by over 50% during gestation which can speed the distribution of drugs within the body.
- Significant increases in both total body water (20%) and plasma volume (50%) result in an expanded volume of distribution which can alter peak and steady state serum concentrations, particularly for water soluble drugs.
- Similarly, an increase in maternal fat mass and stores causes an increase in volume of distribution for lipophilic drugs.

These changes can affect initial and maintenance doses necessary to obtain therapeutic drug concentrations. A reduction in plasma albumin and decreased binding affinity affect the total concentration of albumin-bound drugs, such as nonsteroidal anti-inflammatory drugs (NSAIDs). Under these conditions, the concentration of free drug is increased while the total plasma drug concentration is decreased, thus affecting interpretation of plasma concentrations with the possible consequence of over-dosing a drug.

Drug metabolism and excretion further cloud the picture of drug administration in pregnancy and, therefore, drug safety [3]. The liver is the primary clearing house for most commonly administered therapeutic agents. Not only is hepatic blood flow increased in pregnancy, but drug metabolism is affected by numerous enzymatic pathways in the liver. Among the most notable systems is cytochrome P450 (CYP); isoenzymes within the P450 system are increased or decreased during human pregnancy. For example, CYP2C9 expression and function is increased during pregnancy. This isoenzyme controls metabolism of NSAIDs; increased CYP2C9 function leads to more rapid metabolism of NSAIDS. Conversely, the CYP1A2 isoenzyme decreases the metabolism of caffeine during pregnancy. Metabolism of some drugs is driven by multiple cytochrome P450 isoenzymes which can render accurate prediction of drug activity impossible. Rate of excretion of drug further exacerbates prediction of drug activity. Many drugs, both in humans and horses, are primarily excreted via the kidneys. The glomerular filtration rate in pregnant women is increased by 40–65%, thus enhancing the clearance of commonly used drugs such as penicillin. Not knowing similar physiological changes in horses limits accurate prediction of drug activity during pregnancy, as well as proper drug dosing intervals.

Placental transfer of drugs
Placental transfer of drugs and fetal metabolism add yet another factor to consider when identifying effective, safe therapies in pregnancy. Existing studies about placent al mechanisms controlling drug activity have largely been performed in rodents and nonhuman primate species [4]. Placental differences between species significantly limit extrapolation of information between species, particularly when comparing invasive placentation (haemochorial: rodents, humans) to noninvasive placentation (epitheliochorial: horses, ruminants). In general, it has long been suggested that all drugs pass the placenta; however, an increasing body of information suggests that placental transfer of substances is far from simple.

Historically, passive diffusion has been identified as the primary source of placental transfer [5]. Several molecular properties affect passive placental diffusion, including molecular weight and polarity, lipid solubility and plasma protein binding. Low molecular weight, highly lipid soluble, unionised drugs are favoured in passive placental diffusion. Molecules less than 500 g/mol are thought to diffuse across placental membranes while molecules greater than 1000 g/mol are too big for placental passage [6]. Molecules in the 500 to 1000 g/mol range exhibit partial placental diffusion. However, these criteria do not necessarily define passive transfer of all compounds. For example, desfuroylceftiofur (DCA), the active metabolite of ceftiofur drugs, has a molecular weight of 429 g/mol (http://pubchem.ncbi.nlm.nih.gov/compound/Ceftiofur_sodium). Based on this mid-range molecular weight, one would expect detection of low to moderate concentrations of DCA in fetal compartments after administration to pregnant mares. Instead, concentrations of DCA were undetectable or well below therapeutic concentrations in fetal fluids and tissues after administration of both ceftiofur crystalline free acid and ceftiofur sodium to pregnant mares [7,8]. The weight profile of DCA does not substantiate poor detection in pregnant mares; therefore, one must assume that molecular size alone is not the reason for poor placental drug passage.

Protein binding affinity can also affect transplacental passage of drugs. The unbound drug fraction diffuses across the membrane gradient to establish equilibrium. While many drugs are highly protein bound, the concentration of unbound drug in the circulation is often high enough to
facilitate passage of the drug over a membrane gradient, such as the placenta, which minimises the impact of protein binding on drug metabolism in pregnancy. An example where high protein binding might interfere with transplacental passage is ceftiofur sodium, an antimicrobial commonly used in equines. After ceftiofur administration to pregnant mares, the DCA metabolite was undetectable in fetal fluids or foal serum. A relatively normal plasma pharmacokinetic profile of DCA was identified in the same mares. While a high degree of protein binding does not logically explain negligible concentrations of DCA in fetal fluids, drug protein binding is one of many possible explanations for poor transplacental drug passage. Lipid solubility and pH may also play a role in placental diffusion of drugs. Lipophilic compounds (such as trimethoprim and phenylbutazone) are favoured in diffusion across a lipid-dense membrane like the placenta. Yet many drugs used in equine veterinary medicine are hydrophilic rather than lipophilic, which should limit transplacental passage. Surprisingly, penicillin, which has poor lipid solubility and is administered parenterally to horses, readily penetrated the equine placenta and was detected in fetal fluids. These are only a few examples of how complex drug activities are in pregnant females, including mares.

More recently, active transport mechanisms have been validated as drug transporters across placental membranes [5]. Interestingly, the same hepatic metabolic enzymes and membrane transporters that affect drug metabolism in pregnant females have also been shown to actively participate in drug passage across the placenta. For example, the cytochrome P450 (CYP) and enzymatic system has been identified in the human placenta [9]. Probe studies using marker drugs relevant to CYP have demonstrated the role of placental active transport systems in vitro [10]. Caffeine clearance was increased via CYP1A2, while dextromorphan clearance was decreased (CYP2D6), at all stages of pregnancy. Again, enzymatic pathways along a common system (CYP) had dramatically different outcomes for drug transport across the placenta. Active transport of drugs across the placenta is poorly understood, yet the implications that drug transporters have for metabolic effects, and proper dosing, of drugs in pregnancy is staggering.

What we know about therapeutics in equine pregnancy

As stated, there is a paucity of information about drug metabolism and safety in pregnant mares. Most drug dosing and safety studies for horses have been conducted in geldings. A growing body of work has been published in recent years regarding drugs that are commonly used to treat mares with placentitis [7,8,11–13]. As a part of these trials, placental transfer data for antimicrobial and anti-inflammatory drugs have been established (Table 1).

Safety data for commonly used equine therapeutic drugs (antimicrobials, anti-inflammatory drugs, sedatives etc.) are virtually nonexistent. The concerns when administering a drug to a pregnant mare are the risks to the developing fetus, and risks to the mare. The fetus is particularly at risk given its poor ability to metabolise and eliminate most foreign compounds. Too little is known about placental metabolism of drugs to expect that the placenta provides a barrier to the developing fetus. On the contrary, the presence of placental transport systems suggests that the gateway for molecules to access the fetus is greater than once thought.

Administration of therapeutic drugs to pregnant mares must be considered carefully and judiciously. As stated by Yates and Thomas [14], ‘prescribing in pregnancy should take into account the risk to the mother and fetus of inadequate maternal treatment, as well as the known theoretical risks to the fetus from use of medicine.’ Often, the equine veterinarian faces the dilemma of a mare that suffers a life-threatening condition which, ultimately, will threaten the life of the fetus/foal. However, caution must prevail when the teratogenic and fetal risks of administering drugs to pregnant mares is unknown. Treatment plans for mares requiring pharmacological intervention should be formulated with good sense and sound judgement. When possible, medications with few to no known adverse effects on a developing fetus should be used. The United States Food and Drug Administration (FDA) provides guidelines for drug use in pregnant women through categorisation of drugs into risk categories. An adaptation of the FDA guidelines, with some equine drugs included, is provided in Table 2. Furthermore, minimum treatment times that effectively address the condition affecting the mare should be adhered to.

Table 1: Distribution of commonly used equine therapeutics after administration at recommended doses and intervals to pregnant mares

<table>
<thead>
<tr>
<th>Drug</th>
<th>Drug type</th>
<th>Dose/route of administration</th>
<th>[plasma]</th>
<th>[placental fluids]</th>
<th>[fetus]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium penicillin</td>
<td>Antimicrobial</td>
<td>22,000 IU/kg bwt i.v. q. 6 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Not tested</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>Antimicrobial</td>
<td>6.6 mg/kg bwt i.v. q. 24 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Not tested</td>
</tr>
<tr>
<td>Trimethoprim</td>
<td>Antimicrobial</td>
<td>50 mg/kg bwt orally q. 12 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Yes</td>
</tr>
<tr>
<td>Ceftiofur sodium</td>
<td>Antimicrobial</td>
<td>4.4 mg/kg bwt i.m. q. 24 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Not detected or very low levels (allantocentesis)</td>
<td>No</td>
</tr>
<tr>
<td>Ceftiofur crystalline acid</td>
<td>Antimicrobial</td>
<td>6.6 mg/kg bwt i.m. q. 96 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Not detected or very low levels (allantocentesis)</td>
<td>No</td>
</tr>
<tr>
<td>Pentoxifylline</td>
<td>Anticytokine, vasoactive, xanthine deriv</td>
<td>8.5 mg/kg bwt orally q. 12 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Yes</td>
</tr>
<tr>
<td>Flunixin meglumine</td>
<td>Nonsteroidal anti-inflammatory</td>
<td>11 mg/kg bwt i.v. q. 12 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Not detected (microdialysis)</td>
<td>Not tested but unlikely</td>
</tr>
<tr>
<td>Firocoxib</td>
<td>Nonsteroidal anti-inflammatory</td>
<td>0.1 mg/kg bwt orally q. 24 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Not tested</td>
</tr>
<tr>
<td>Phenylbutazone</td>
<td>Nonsteroidal anti-inflammatory</td>
<td>4.4 mg/kg bwt orally q. 12 h</td>
<td>Equivalent to nonpregnant horses</td>
<td>Therapeutic concentrations</td>
<td>Not tested</td>
</tr>
</tbody>
</table>
Table 2: FDA pregnancy risk categories with selected examples of drugs commonly used in horses (Reprinted and adapted, S. Giguère, ACVIM 2014 Proceedings) [15]

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Examples of equine drugs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category A</td>
<td>Adequate and well-controlled studies have failed to demonstrate risk to the fetus in the first trimester of pregnancy (and there is no evidence of risk in later trimesters)</td>
<td>Azithromycin, erythromycin, penicillins, cephalosporins, metronidazole, amphotericin B, omeprazole, diclofenac, ranitidine</td>
</tr>
<tr>
<td>Category B</td>
<td>Animal reproduction studies have failed to demonstrate a risk to the fetus and there are no adequate and well-controlled studies in pregnant women</td>
<td>Clarithromycin, imipenem, gentamicin, fluoroquinolones, TMS, rifampin, fluconazole, itraconazole, ketoconazole, some NSAIDs, butorphanol, dexamethasone, prednisolone, fluticasone, albuterol</td>
</tr>
<tr>
<td>Category C</td>
<td>Animal reproduction studies have shown an adverse effect on the fetus and there are no adequate and well-controlled studies in humans, but potential benefits may warrant the use of the drug in pregnant women despite potential risks</td>
<td>Tetracyclines, aminoglycosides (except gentamicin), some NSAIDs, ACE inhibitors, diazepam, pentoxyfylline, phenobarbital</td>
</tr>
<tr>
<td>Category D</td>
<td>There is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience or studies in animals, but potential benefits may warrant the use of the drug in pregnant women despite potential risks</td>
<td>Misoprostol</td>
</tr>
<tr>
<td>Category E</td>
<td>Studies in animals or humans have demonstrated fetal abnormalities and/or there is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience, and the risks involved in use of the drug in pregnant women clearly outweigh potential benefits</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion

Equine veterinarians are challenged with choosing safe, effective medications to treat mares during pregnancy. Data supporting, or refuting, use of specific drugs in equine pregnancy are scarce. Collating information regarding the medical condition of the mare, known information about equine specific drugs, known information about pharmacology and drug transport of drugs in other species and known safety data of drugs can guide the equine veterinarian toward making sound choices for ensuring the health and welfare of the pregnant mare and developing fetus.

References


NOTES
The successful induction of lactation in non-maiden mares was first reported in 2002. The original treatment protocol consisted of the administration of estradiol, progesterone (or altrenogest) and a dopamine-D2 antagonist (sulpiride or prolactin) to stimulate prolactin secretion. Since the original report, hundreds, perhaps thousands, of mares have been successfully induced to produce milk, adopt an orphan foal and raise it to weaning age.

The most important conclusions of the research and clinical reports are summarised below:

- The milk that is produced by hormonal induction has the same composition as milk from naturally lactating mares; foals of mares with induced lactation appear healthy and have a similar growth curve as naturally raised foals.
- The induced lactation does not start with colostrum production, as occurs in foaling mares, but rather starts with the production of normal milk, similar to a mare at a week or more post-partum. Attempts to induce colostrum production have not been successful to date.
- Once lactation has been set in motion (after 7–10 days of hormonal treatment), milk production continues without sustained hormonal treatment on condition that mares are milked frequently (probably more than 7–8 milkings/day) or are nursed frequently by an adopted foal.
- If a foal is grafted to a mare with induced lactation, the regular suckling of the foal stimulates sufficient milk production (with no requirement for hormonal treatment) until the foal reaches weaning age. The amount of milk produced appears to result in the same growth as in naturally raised foals.
- Estradiol is an essential ingredient in the induction of lactation. It is not possible to induce lactation using only dopamine antagonists (sulpiride or domperidone) in mares without an endogenous source of oestrogen (ovariectomised and anestrous mares). It has been demonstrated that estradiol has a synergistic or priming effect on prolactin secretion if given prior to, or during, the dopamine-D2 antagonist treatment. However, estradiol administration to mares is not possible in most European countries. Experimental and clinical evidence demonstrate that lactation can only be achieved in mares with sufficient endogenous estradiol production provided by growing follicles. Without access to estradiol, it is advised that only normal cyclic mares with follicular activity are used for induction of lactation.
- Clinical experience tells us that lactation can be successfully induced in about 90% of cyclic mares.
- The induction protocol can be stopped at any stage without an increased risk of mastitis if a lactating mare is no longer required.

Previous treatment protocols consisted of the administration of a luteolytic dose of PGF2α on day 1 of the treatment followed by daily administration of estradiol, progesterone/altrenogest and a dopamine-D2 antagonist (sulpiride or domperidone). The logic behind this treatment was to simulate the prepartum endocrine environment. The main reason for progesterone administration was to suppress (exaggerated) oestrous behaviour that occurs subsequent to PGF2α and estradiol administration; it very likely does not play a role in the stimulation of lactation. Later, the protocol was modified to accommodate the fact that we could no longer administer estradiol to mares in Europe. The new protocol is limited to mares that have cyclic ovarian activity (anestrus mares are not good candidates). The PGF2α was first reported in 2002. The original treatment protocol as there did not seem to be any advantage to its inclusion. The dopamine-D2 antagonist is administered twice daily for 7–10 days to stimulate prolactin secretion. It is recommended to start milking around day 5 of treatment. Clinical observations indicated that this treatment protocol is as efficient as the original protocol and it has been used in several adoption centres for over a decade.

Treatment protocol

- **Day 1:** Make sure the mare has foaled in the past and has regular cyclic ovarian activity. The presence of a corpus luteum and the interval since the last ovulation are irrelevant (including if the mare has recently ovulated and is unlikely to respond to the PGF2α treatment). Administer a normal luteolytic dose of PGF2α and start dopamine-D2 antagonist treatment (sulpiride 300–400 mg i.m. every 12 h or domperidone 1.1 mg/kg bwt orally every 12 h). Sulpiride is available as a human drug in most European countries under the trade name Dogmatil®. In most countries it is available as an injectable formulation in 100 mg/2 mL ampoules. When oral medication is used, one should use this at three times the i.m. dose every 12 h. Domperidone, commonly known under the brand name Motilium® in human medicine, is also available as an oral paste for horses under the brand name Equidone® and is only of limited availability in Europe.
- **Continue dopamine antagonist treatment for 7–10 days.**
- **Around day 4–7,** one should notice swelling of the mammary gland and normal milk present in the teats. Since mares have a very limited storage capacity (foals nurse very frequently), it is advised to start milking the mares 5–8 times per day starting around day 5. If no milk secretion is observed by day 7–10 of treatment, it is advised to stop the treatment as it is unlikely that the mare will start lactation. In practice, we observe about 10% of mares that fail to make milk.
- **In most mares,** sufficient milk is produced to adopt a foal by day 5–10.
- **After 10–14 days** the treatment should be stopped as it has been reported that with prolonged treatment the effect on prolactin secretion decreases. In the majority of cases, the frequent nursing of the foal and interaction between mare and foal will quickly result in a further increase in milk production. When in doubt, we recommend to stop treatment for 1 week and then resume treatment for 1 week. This has proven to further increase milk production in mares with induced lactation that were machine-milked.
Induction of parturition
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Although it is normal practice to attend parturition in the mare to avoid foaling complications and despite the fact that mares generally foal undisturbed during the middle of the night when it is not especially convenient to those attending the foaling, because of the risks associated with induction it is not common to induce parturition as an aid to management. However, it can allow for timely intervention and be lifesaving for the mare and foal when used with careful assessment of the potential risks to benefits.

The most important assessment prior to induction of foaling is to determine that the fetus is fully mature and able to survive without maladjustment problems after delivery. The equine fetus is relatively unique in that adrenocortical maturation, and the cortisol surge that is a prerequisite, occur very late in gestation, only about 24-48 h prior to full-term delivery. If the fetus is not fully mature, complications due to prematurity or dysmaturity are very likely to occur, resulting in a poor outcome.

Deciding when to induce a mare to foal has a significant potential for error and the following factors that should be considered together (and not in isolation) are gestational age, mammary development and milk electrolyte values, and cervical softening.

Gestational age on its own is not a reliable indicator of foal maturity, although most mares are over 330 days at term and many mares have similar gestational lengths from year to year. Milk secretion electrolytes, namely calcium, sodium and potassium, can be measured using bench-side water hardness kits or, more accurately, a laboratory biochemistry analyser. The bench-side kits are most reliable with regular use and when the user is familiar with the testing procedure. Milk electrolytes are generally most reliable in multiparous mares, compared with maiden foaling mares; however, caution must be taken if placentitis is present because the electrolyte changes may occur precociously and are not likely to be predictive of full term. Cervical softening and dilation is a good indicator of closeness to foaling and thus more likely to be associated with a favourable outcome.

Glucocorticoids, prostaglandin and oxytocin can be used to induce parturition. Glucocorticoids require high doses to be given over several days and are reserved for use in high-risk mares to induce fetal maturation prior to full term, when maternal disease such as colic or severe laminitis demands that gestation be shortened. Prostaglandin is less desirable as an agent to induce parturition, as it is associated with more complications and the time from injection to foaling is longer than with oxytocin. Oxytocin is the most popular choice of induction agent with a variety of different doses, routes and protocols used. The expected time from injection to foaling is reported to be between 15 and 90 minutes. A very low-dose regime has also been reported which perhaps mimics the natural physiological changes leading to delivery in mares that are ready to foal. A single dose of 2.5 iu oxytocin is given i.v. in mares that have been determined to be suitable for induction; the injection is repeated once daily in mares that do not respond, until delivery occurs. In one study, 14/17 foaled within an hour of the first injection, 1/17 after injection on the second day and 2/17 after injection on the third day.

In conclusion, with careful assessment of the suitability of the mare and having determined that the fetus is highly likely to be sufficiently mature, induction of parturition, especially using a very low-dose oxytocin protocol, is a practical and safe technique when it is important to be present at foaling.

Further reading
Examination of the post-partum mare and foal

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For a mare to be reproductively efficient, she has to produce a foal every year. With mean gestational length in the equine being 335–340 days, the goal to produce one foal/mare/year is achievable only if foaling mares conceive by 25–30 days post-partum. There are numerous factors to consider when trying to determine what is the best management of a mare post-partum. One of the most important pieces of information is her periparturient history. Periparturient problems, including dystocia or retained placenta, have been shown to slow the rate of uterine involution and delay the first post-partum ovulation [1]. Trauma to the uterus, cervix or caudal reproductive tract are more commonly associated with dystocia. A mare that has evidence of trauma/dystocia or retained placenta should be examined within 24 h, depending on the situation, to determine the severity and initiate treatment. Another criterion for immediate examination is evidence of a vaginal discharge or the presence of a fever. These clinical signs warrant exploration as to a cause, i.e. retained placenta, metritis, uterine tear, bruising, haemorrhage or urine pooling, so prompt treatment can be initiated. This could include uterine lavage, oxytocin, acupuncture, intrauterine/systemic antimicrobial treatment and surgery.

The author will usually examine mares that have foaled normally 7–8 days post-partum or when the mare shows signs of oestrus. The pendulous nature of the uterus makes it difficult to examine per rectum prior to that time period. Post-foaling/foal heat examination of the reproductive tract can include: perineal conformation evaluation; rectal palpation and ultrasound to determine follicular activity, uterine involution/size and the presence of intraluminal fluid; vestibular, vaginal, and cervical examination with a speculum to identify bruising, hyperaemia, lacerations, exudate or urine; and endometrial culture and cytology, depending on the previous results. Mares experiencing periparturient abnormalities have significantly reduced pregnancy rates and therefore warrant a delay in breeding until the uterus and, in the authors opinion, the cervix have returned to normal [2]. Uterine therapy should not be necessary in the normal post-foaling mare with access to turnout and the presence of a suckling foal [2]. However, mares that are aged, those that are kept in a stall due to their newborn foal having problems, or mares with abnormal retention of uterine fluid in the post-partum period may benefit from pre- or post-breeding treatment [2]. Oxytocin aids uterine clearance by initiating progressive uterine contractions, moving intraluminal fluid out through the dilated cervix [3]. It is therefore suggested that these mares may benefit from oxytocin treatment (6–20 mg) 2–6 times daily, depending on the situation. This can be a preventive measure or a treatment for intrauterine fluid. Uterine lavage effectively reduces bacterial contamination and persistent inflammation in cycling mares that are susceptible to uterine infections [4]. Because of this, the procedure has become common practice both post-foaling and post-breeding. Different protocols are used depending on the post-partum period. Within the first 5 days, most veterinarians will utilise a large volume lavage with a solution of 1% betadine and salt in water to produce an isotonic solution. After that period a sterile uterine lavage with either lactated Ringer’s solution or normal saline would be recommended. It is, however, important to recognise that there is no evidence showing that uterine lavage enhances pregnancy rates in normal post-partum mares without intrauterine fluid accumulation [2]. Antimicrobials should not be necessary in the post-partum period unless some of the above abnormalities have been identified. Good perineal conformation prevents contamination of the vestibule, vagina and uterus from inflammation and infection; therefore a Caslick procedure should be performed either 4–5 days post-foaling or post-ovulation if necessary.

Complete examination of the newborn foal should occur preferably within the first 12 h of life. This allows identification of physical and physiological abnormalities, including an abnormal haemogram, failure of passive transfer, neonatal isoerythrolysis, and the early initiation of treatment. Ocular lesions can include cataracts and entropion. Rib fractures most commonly occur an inch above the costochondral junction, where the elbow resides during parturition. Location, number and mobility of the fracture/fractures will dictate treatment options [5,6]. Protocols can include stall rest for 7–10 days until mobility at the fracture site ceases and a callus forms, or fracture fixation if the presence of haemorrhage or trauma indicates that laceration of underlying structures is occurring [6]. Auscultation and ultrasound of the lungs and heart can be used to identify abnormalities such as heart murmurs or aspiration pneumonia, and of the abdomen can identify borborygmi, gas and retained meconium [7]. Examination of the umbilicus identifies intestinal herniation, enlargement due to haemorrhage, abscessation, or enlarged urachus. Ability to stand within 2 h and nurse appropriately, as well as pass meconium, should also be monitored. Dipping of the umbilicus helps to prevent infection and potentially impending joint ill. A complete blood count should be obtained and immunoglobulin G measured at least 6 h after initiation of nursing. This allows identification of failure of passive transfer, which should be treated by administration of tested (high gamma and neonatal isoerythrolysis [NI] negative) colostrum and/or high gamma plasma transfusion, neonatal isoerythrolysis, and the early initiation plasma administration. Identification of leukopenia or anaemia is imperative for early treatment.

Finally, a window into the mare’s uterine environment and exposure of the foal to pathogens can be obtained by examination of the placenta. Completeness and pathological abnormalities identified early can help prevent complications in the future. A retained placenta or evidence of placentitis will necessitate further investigation of both mare and foal.

References
Fostering of foals

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When faced with an orphan foal, due to the death of the mare or her unwillingness to accept her foal, it is critical to quickly find an alternative way to feed the foal and create a suitable social environment for its upbringing. One can use a mare that has recently lost her own foal as foster mare; however, when a suitable adoption mare cannot be found or when the mare does not want to adopt the new (unknown) orphan foal, other options must be considered including feeding a replacement formula or using a mare with induced lactation. Today, there are excellent milk replacements that enable us to feed an orphan foal for a limited time or even up to weaning age with excellent body development. However, prolonged bottle feeding often results in poor social skills towards other horses and abnormal/dangerous behaviour towards humans. With simple and relatively safe methods available for inducing lactation and fostering foals to mares, it seems advisable to recommend the use of this type of foster mare to owners. Induction of lactation is described in another abstract presented at this meeting.

Initially, our method for adoption consisted of a system whereby the foal was presented to the adopting mare while the anterior vagina and cervix of the mare were vigorously massaged, triggering oxytocin release through the Fergusson reflex which in turn triggers maternal behaviour in the brain. The administration of large doses of oxytocin does not trigger maternal behaviour because oxytocin does not cross the blood-brain barrier; in contrast, a large dose of PGF2α does initiate maternal behaviour, presumably through the stimulation of central oxytocin release within the brain. Careful observation of behaviour in normal mare-foal combinations and in adopted combinations demonstrate that the bonding and interaction between mare and foal are identical.

Adoption technique

The mare must have raised a foal in the past but must not have foaled and/or been weaned in the current breeding season. Lactation will have been successfully induced using the methods described elsewhere in these proceedings and the mare is ready for adoption when the milk production has reached at least 2–3 L per day (usually after 5–7 days of treatment).

Preferably, the mare has been housed in a calm, rather isolated location for the past days or weeks so that she feels safe in her box. It is also advised that she has no direct contact with neighbouring horses that may be seen as a threat to the foal during the adoption process. Some veterinarians have suggested that the foal should be in an adjacent stall in the days prior to the adoption so that both can become familiar with each other. However, we have not added this to our protocol and have not seen a need to do this.

On the day of the adoption, the foal is not fed during the 1–2 h prior to the adoption to ensure that it is hungry and motivated to seek the udder of the mare. Immediately before the foal and mare are brought together for the adoption, maternal behaviour needs to be triggered; this is no longer induced by vaginal massage, but by a single injection of PGF2α. We routinely use cloprostenol injected i.m. at 3–4 times the normal luteolytic dose (750–1000 µg cloprostenol or 3–4 mL Estrumate®). About 15–20 min after PGF2α injection, the mare is starting to sweat and show other PGF2α-induced side effects (restlessness and signs of colic), the foal is moved to the mare’s stall, carefully introduced to the mare and gradually allowed to nurse. Usually when the foal is introduced, the mare will immediately start to lick and nuzzle the foal and will often vocalise in a similar way to a mare that has just delivered and is making first contact with the newborn foal. The foal should be encouraged to nurse during the phase of PGF2α-induced side effects, while the mare is restrained sufficiently to allow the foal to nurse, but not to the extent that it would limit her licking and smelling the foal. Maternal behaviour is considered to be activated when the mare follows the foal around the stall, vocalises to communicate with it and licks it. Once maternal behaviour is established, both mare and foal can circulate freely in the stall and continue the bonding process. Complete adoption of the foal by the mare is usually accomplished within 20–30 min after introduction of the foal.

In fewer than 5% of attempts, maternal behaviour is not initiated and the mare refuses the foal. This becomes apparent within 5–10 min of introduction of the foal and the foal should then be removed as the mare may become increasingly aggressive. In our experience, mares that fail to adopt should be retired 12 h later using exactly the same protocol (including PGF2α treatment) as this is nearly always successful in our hands.

In our clinical setting, the lactation is induced by twice-daily administration of sulpiride, a dopamine antagonist. The detailed description of the hormonal treatment for induction of lactation is the subject of another abstract in these proceedings. We recommend that the treatment for induction of the lactation is continued for 7–10 days after adoption. All client-owned foals are supplemented with artificial milk 3–5 times per day (1–2 L each time) for 3–15 days after adoption. Bottle feeding is continued until the foal refuses the artificial milk or when it is judged that the mare is producing sufficient milk. Although we have never been able to quantify weight gain in these foals nor to evaluate the impact of these interventions objectively, we have noted a very high client satisfaction rate.

Videos shown during the presentation can be viewed on YouTube:
https://youtu.be/YohQmxwajgk
https://youtu.be/s7dOhWbkMno
https://youtu.be/cePBVf4EPRU
https://youtu.be/KoAW05GItsU
Diagnosing PPID: art or science?

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Pituitary pars intermedia dysfunction (PPID) is a common ageing-related endocrinopathy estimated to affect 15–30% of aged horses. Measurement of adrenocorticotropic hormone (ACTH) concentration is the most popular means of diagnosing PPID and has reasonable accuracy; however, increasing evidence and consensus of expert opinion indicates a need for revision of how ACTH test results are interpreted and a need for replacement of basal ACTH concentration with measurement of ACTH concentration following the administration of thyrotropin releasing hormone (TRH) in all horses that do not have obvious clinical signs [1]. Assessment of insulin dysregulation should be routine in the diagnosis and monitoring of PPID but is frequently overlooked.

Adrenocorticotropic hormone

Estimates of sensitivity and specificity for diagnosing PPID by measurement of ACTH concentration vary between studies and with different inclusion criteria. When comparisons are made between horses with advanced histological changes and horses with no histological changes, the test performs very well, with sensitivities and specificities in excess of 80% and 90% respectively. In clinical practice the challenges for this diagnostic test are greater, as the test is typically applied to cases that may or may not have early disease, rather than being used in cases that are clearly healthy or clearly diseased. Large numbers of borderline results therefore occur with some false positive and false negative results being inevitable. When the test is applied to a population with a lower incidence of disease (i.e. it is used speculatively as a screening test or is used in horses with vague clinical signs, rather than for confirmation of disease in horses with clinical signs), the positive predictive value of the test drops and the number of false positive diagnoses increases. Recent recommendations are for horses that do not have obvious clinical signs of PPID to be tested with a dichotomous classification on a disease that is highly variable and progressive in nature. Any ACTH value should be considered as an indication of the likelihood of the horse having PPID and should be considered alongside clinical findings and signalment.

Thyrotropin releasing hormone stimulation test (TRHST)

The TRHST is currently considered to be the most reliable means of diagnosing PPID. The concentration of ACTH is measured 10 minutes after the i.v. injection of 1 mg of TRH to maximally stimulate production from the pars intermedia. In ponies weighing <250 kg, 0.5 mg can be used. The TRHST should be used for the diagnosis of PPID unless there are obvious clinical signs. It should be used in younger horses in which the prevalence of PPID in the population is lower and it should be used to follow-up cases where ACTH concentration has been measured but is equivocal. The TRHST is inexpensive, quick and safe. Performing a TRH stimulation test at the first visit is less expensive and less onerous than having to perform it on a second visit after an equivocal ACTH result has been returned. Prior to administering TRH, owners should be warned that the horse may cough, yawn, exhibit flehmen, chew or have muscle fasciculations immediately following administration; however, these signs are short-lived. The author is unaware of any serious side effects of TRH administration having ever been reported.

The TRHST used to be difficult to perform because of the expense and availability of TRH. However, a recent investigation demonstrated that TRH is stable and efficacious after freezing and thawing and remains stable and efficacious for at least 18 days if stored at room temperature. This makes it possible for TRH to be reconstituted and frozen in the practice and then to be removed from the freezer within 18 days of administration. Although TRH will remain stable, sterility should also be considered when vials are being stored at room temperature.

Seasonal variations in TRH responses have been characterised recently but until more data become available, there is a reluctance to utilise the test during the autumn

| Table 1: Recommendations for interpretation of diagnostic tests for PPID [1] |
|-----------------------------|-----------------------------|-----------------------------|
| ACTH (mid-November to mid-July) | <30 | 30–50 | >50 |
| ACTH (mid-July to mid-November) | <50 | 50–100 | >100 |
| ACTH 10 minutes following 1 mg TRH (mid-November to mid-July) | <110 | 110–200 | >200 |

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ENDOCRINOLOGY

Chair: John Keen
Sponsor: BEVA Journals

8.30–8.50
Assessing insulin dysregulation in horses with PPID

Insulin dysregulation ought to be assessed and monitored in all horses with PPID to assess laminitis risk and to enable feeding to be tailored to individuals. Performing an oral sugar test (OST) (also known as a Karo challenge test) does not affect the subsequent basal ACTH concentration so these two tests can be combined, and samples collected for ACTH, insulin and glucose 60–90 minutes after the administration of Karo sugar. Performing an OST was shown to reduce the subsequent ACTH response to TRH by a mean of 25 pg/mL in one study, so these two tests should be combined with caution. Discussion of the diagnosis of insulin dysregulation is covered elsewhere in these proceedings.

Reference
Introduction
Equine metabolic syndrome (EMS) is a collection of metabolic and endocrine abnormalities associated with an increased risk of laminitis. There is often, but not always, general or regional obesity. Conventionally, a diagnosis of EMS was investigated in response to an episode of laminitis. The focus now is increasingly on detection of horses with EMS before the onset of laminitis, allowing preventative strategies to be implemented.

Insulin dysregulation
The key feature of EMS and laminitis risk is insulin dysregulation (ID). This term was first introduced by Frank and Tadros (2014) [1], and refers to any combination of three abnormalities:
- Tissue insulin resistance (the inability of tissues to respond appropriately to insulin).
- Fasting hyperinsulinaemia.
- Postprandial hyperinsulinaemia.

Several experimental and clinical studies have demonstrated an association between ID and laminitis, and for this reason ID remains the focus of diagnostic testing. When choosing and interpreting a diagnostic test, it is useful to consider which of the three abnormalities above is being tested, as they can occur to varying degrees in different horses. A suggested protocol for testing for ID is shown in Fig 1.

Appropriate cut-offs for EMS are difficult to define, especially as the onset of EMS is gradual and cases sit on a spectrum of severity, rather than simply being positive or negative. Appropriate reference intervals for each diagnostic test should be discussed with the diagnostic laboratory.

Selecting horses to test
Further diagnostic testing should be considered in horses which have risk factors for EMS. These include any evidence of clinical or subclinical laminitis, regional or generalised adiposity, PPID, low levels of exercise and an ‘easy keeper’ phenotype.

Basal insulin concentration
This is a simple and convenient test and can often be done at a visit with no advance preparation. The previously-recommended 6-h fast prior to sampling and cut-off of 20 µIU/mL for diagnosis of EMS results in a very low sensitivity and is no longer recommended.

1. Feed only poor quality, low nonstructural carbohydrate (NSC) hay (soak if necessary) for a minimum of 4 h prior to the test. If grazing is unavoidable it should be restricted/poor quality.
2. Collect blood into serum/EDTA tube (check with laboratory).

For all negative and borderline results, dynamic testing is recommended.

Dynamic tests
These measure response to orally or intravenously administered glucose +/- exogenous insulin. They are more sensitive for detection of ID compared to basal insulin concentration.

Oral tests are generally simpler to perform than i.v. tests and include the contribution of the enteroinsular axis to ID. As they reflect the insulinaemic response to ingested carbohydrate, they probably have a greater relevance to pasture-associated laminitis.

For the assessment of tissue insulin resistance, i.v. tests are more standardised and repeatable than oral tests but are of no use for assessing the enteroinsular axis.

Oral sugar (Karo) test (OST)
Karo Light (not Lite) corn syrup is available from online supermarkets. The advantage of the OST over the oral glucose test (OGT) is that it does not rely on the horse eating it and there is a more consistently timed peak glucose peak.

1. Ideally fast for a minimum of 6 h prior to the test.
2. Owner administers 0.45 mL/kg bwt (225 mL/500 kg bwt) Karo Light by dosing syringe.
3. Measure serum insulin concentrations after 75 and 90 min.

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**Fig 1: Proposed algorithm for diagnosis of EMS**
**Oral glucose test (OGT)**

This was recently shown to predict laminitis risk in ponies fed a high NSC diet [3].

1. Feed a single slice of hay the evening prior to the test.
2. The following morning the owner feeds 1 g/kg powdered glucose/dextrose, mixed with 1 g/kg low-sugar chaff and 1 g/kg water.
3. If the feed is not finished, weigh the residual feed and inform the lab.
4. Measure insulin and glucose 2 h after the feed was given.

**Combined intravenous glucose–insulin tolerance test (CGIT)**

CGIT assesses tissue insulin sensitivity. It is more time-consuming and less convenient than oral tests. It is useful for borderline cases, or those in which ID is suspected but which are negative with oral tests. A standard CGIT protocol is described [4]; however, a shortened version is more practical, with glucose and insulin being measured at 0, 45 and 75 min.

**Intravenous insulin tolerance test**

This assesses tissue insulin resistance. A simplified, two-step version of the full insulin response test is recommended [4].

**Adipokine concentration**

Leptin and adiponectin have been investigated as markers of EMS. Given the well-established role of hyperinsulinaemia and insulin dysregulation in the pathogenesis of laminitis, direct tests of ID are still recommended over adipokines for the diagnosis of EMS and assessment of laminitis risk. Adiponectin remains an interesting area of research, however, and may have a role for diagnosis of EMS and monitoring weight loss in the future.

**Conclusions**

Diagnostic testing for ID should be performed in all suspected cases of EMS. If only one test is possible then a dynamic oral test (OGT or OST) is recommended. Basal insulin can be used for convenience, or i.v. tests may be used to test specifically for tissue insulin resistance.

**References**

Tackling the obesity epidemic

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Background
In the UK, the proportion of recreational horses exceeds 60%, numerically dominating our equine industry. This shift towards companion animal status distances owners from traditional advice and is matched by an increased incidence of management-associated conditions, the most common of which are equine obesity, laminitis and insulin dysregulation (ID). While there are commonalities in the aetiologypathology of these co-morbidities, they are not inextricably linked (equine metabolic syndrome: EMS). Many obese animals are neither laminitis-prone nor affected by ID. The direct, negative health impacts of obesity are significant, including mechanical/thermal stress, poor athletic/reproductive performance, obstructive/strangulating colic and dyslipidaemia [1].

Identifying and ameliorating obesity risk is essential to welfare [2]. Expansion of the leisure sector, with decreased workloads, feedstuff overprovision and thermal protection (rugs/shelter), is at variance with the animal’s ‘thrifty’ physiology. Risk factors include genetic (host genotype, epigenetics, gastrointestinal microbiome), environmental (season, management, exercise) and nutritional (pasture, feedstuffs) components. Breed impacts on weight-gain propensity and insulinaemic responses to carbohydrate meals, ‘less-selected’ ponies being at greatest risk [3]. Fitness, and muscle type/mass are contributors to insulin:carbohydrate dynamics and energy balance (EB) [4]. Hindgut microflora dictate the efficiency of nutrient assimilation. Pasture access, forage and feed provision are important [2]. Obesity, attained by consuming low glycaemic diets, is less likely to be associated with the development of ID than when animals ‘fatten’ on carbohydrate-dense feeds [3].

Pasture is a common theme in the pathophysiology of obesity and related co-morbidities. Modern, sugar-rich swards, engineered for high-yielding dairy cattle with relatively modest appetites of approximately 3.5% body mass (BM) as daily dry matter intake (dDMI) but extensive metabolic energy requirements (MER) around 5.5 × maintenance, are increasingly used for horses. By contrast, ponies can consume 5.6% of BM as dDMI, yet at most (sustained exercise), require twice maintenance. The extent of pasture overprovision has not been appreciated for equines.

Recognising the obese horse or pony
Bodyweight management is essential to prevent obesity [5]. Owners should monitor body condition score (BCS), ideally to maintain BCS between 5/9 and 6/9. The association between body fat and BCS is curvilinear. Obesity is assumed when BCS is >7/9; however, when above 7/9, BCS is not a reliable indicator of absolute ‘fatness’ [6]. In the absence of weight loss, measures of belly girth provide responsive measures of weight change [7]. Ultrasound measures of rump fat are not useful.

Controlled weight loss programmes
The imposition of negative EB to promote weight loss is most readily accomplished by removing the animal from pasture [7]. There is little justification for feedstuffs other than forages and vitamin/mineral balancers. Moderate quality grass hay should be fed in preference to haylage to limit water-soluble carbohydrate (WSC) intakes and enhanced insulinaemic responses to haylage. Analysis of hay is warranted and WSC contents of <12% as hay DM are recommended [2]. Water-soaked hays have been advocated to further decrease WSC [9]. This practice is not without concern. Soaking leaches minerals and unpredictable quantities of protein, WSC and DM, increasing the severity of nutritional restriction. Soaked hay must be accompanied by vitamin/mineral balancers [9].

Obese animals have reduced appetites (−2% BM as dDMI) [1]. Weight reduction begins by offering fresh hay DM, at 1.25% BM daily. Responsiveness to dietary restriction is highly variable [5]. Weekly weight losses of 0.5-1% BM are targeted. For weight loss resistant animals (<1% BM decrease, first 4 weeks), hay DM provision can be reduced to 1% of BM under veterinary supervision [5]. More radical planes of negative EB incur greater weight regains post-diet [10]. So slow! Divide forage allowances between frequent meals. Discourage bedding consumption. Moderate exercise is a useful adjunct to dietary restriction, promoting insulin sensitivity and the preferential anabolism of fat. Insulin sensitivity may initially decrease (~6 weeks) before improvements are evident.

If grazing is the primary forage, restrict pasture intakes using anti-grazing muzzles or strip-grazing systems. Correct muzzle use can be onerous. Confirm the animal’s ability to drink while muzzled, inspect regularly and remove periodically to permit social grooming. Where animals are paddocked individually, faecal output can be a useful proxy for consumption.

References


When nutritional management of obesity fails...

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Introduction

Obesity is a leading health concern for horses in the 21st century and leads to significant comorbidities including the development of laminitis, insulin dysregulation and equine metabolic syndrome (EMS). It exacerbates osteoarthritis when present and may have other less well understood implications including that it is pro-inflammatory, can lead to infertility, causes preputial oedema, predisposes to the development of pedunculated lipomas and may impact on the immune response to vaccination and disease. Despite these impacts, obesity is a human induced condition that is not seen in undomesticated animals.

A failure of weight loss in an established weight reduction programme is almost entirely down to a lack of compliance, either due to human factors resulting in a failure to restrict food intake, or due to an inability to promote exercise due to concurrent disease, in particular laminitis. Improving owner compliance is beyond the scope of this session; however, incentivisation is undoubtedly useful in promoting weight loss in such animals. As veterinary surgeons, we can only influence to a small extent improving compliance, although strategies that could be adapted by the industry as a whole could include:

- Risk-based insurance premiums: based on annual health checks and confirmation of body condition score.
- Financial rewards for animals maintained in optimal body condition scores.
- Prizes at national showing competitions for animals in BCS 2.5–3.5.
- Elimination of animals from competitions where BCS >4.
- Rewarding weight loss, through prizes, discounts etc.

Measurement or quantification of obesity can be a very motivating tool to promote ongoing weight loss and therefore laboratory assessment of obesity is commonly used to show a reduction in insulin insensitivity, although changes in weight and body condition score are probably more useful measures of obesity per se. However, changes in heart girth or body condition, commonly used tools in clinical practice, change slowly in response to weight loss, so may not always provide the necessary motivation.

Equine metabolic syndrome

EMS is characterised by obesity with weight loss resistance and therefore should be considered likely in animals that fail to respond to routine weight loss reduction programmes. EMS can be seen in animals without generalised obesity, especially those with ‘lean EMS’, as defined as animals with a predisposition for obesity managed in a restricted environment, or animals with pituitary pars intermedia dysfunction (PPID) and EMS, which may develop insulin dysregulation secondary to PPID.

Exercise in obesity

Increasing energy use while decreasing energy intake is the mainstay of management of obesity. Where exercise can be undertaken this should include long periods of moderate intensity exercise. Exercise increases insulin sensitivity and glucose transport molecule expression and can be highly effective in cases that can be exercised.

Medication

Medication is routinely employed in animals in which exercise is limited, especially due to concurrent laminitis, but can be very effective in promoting compliance through early and rapid weight loss. Such protocols in our clinic have seen weight loss reductions of up to 5% per week, well in excess of the normal 1% aim for dietary management alone.

Levothyroxine

Levothyroxine has been used in the USA for many years for horses with EMS, even before EMS was properly characterised. Recently it has been shown to increase glucose transport molecule expression in cell membranes, thereby mimicking the effects of exercise. It can be highly effective but should not be considered as lifelong therapy. Animals should be weaned off levothyroxine slowly. The following doses are recommended:

- 0.025 mg/kg bwt for 2 weeks
- 0.05 mg/kg bwt for 2 weeks, followed by
- 0.1 mg/kg bwt orally once a day for 3–6 months, followed by
- 0.025 mg/kg bwt for 2 weeks

Cascade implications: Canine levothyroxine is a meat-flavoured palatable tablet that may not be appropriate in the horse. As such, human tablets or special formulations may be appropriate depending on the animal and dosing considerations. Proper justification should be recorded whenever using medicines under the prescribing cascade.

Metformin

Despite initial successes, numerous reports of poor clinical responses have been reported, possibly reflecting its poor oral bioavailability. Recently it has been proposed to reduce glucose uptake in the gastrointestinal tract through hepatic and/or intestinal actions, although these are unproven. As such, it is most likely to be useful as a mechanism to facilitate early turnout or with noncompliant owners who do not heed calorific restriction advice.

Cascade implications: Metformin cannot be used in food producing animals. A human formulation is available that can be justified in appropriate patients; however, in some cases alternative formulations may be necessary given the limited feed these animals receive. In such cases special formulations may be essential to dose these animals appropriately.
Distant direct ophthalmoscopy
Your '30 second' ophthalmic assessment tool. This technique does not rely on the direct ophthalmoscope (DO) although the focused light source and coaxial illumination provided by the DO make this the preferred instrument. Any light source which can be placed close to the observer’s visual axis can be used, e.g. a pen torch, head torch, auroscope or DO set to ‘0’.

At arm’s length the patient is encouraged to direct their gaze towards the observer, who aims to observe reflected light from the retina – the ‘tapetal’ or ‘fundic reflex’ or reflection.

Using this technique one can observe and assess:
• Pupil size, shape, symmetry and response to light.
• Changes in tapetal and fundic reflectivity.
• Opacities both in and out of the visual axis; localisation of lesions can be estimated by assessing movement of opacities relative to the pupil.

Localising lens lesions
The use of Purkinje reflexes, parallax and an obliquely directed focused light can further allow localisation of lens lesions.

Imaging the eye with your smartphone
Distant direct ophthalmoscopy and direct visualisation of the retina using close direct ophthalmoscope can be readily mimicked using most smartphones with the correct camera application. More information is available at www.theeyephone.com and www.equineeyeclinic.co.uk.

Using a phone camera with a wide-angle lens allows us to directly image a wider retinal area than is achievable using a conventional direct ophthalmoscope. In many cases a direct view of the retina, comparable to that previously only obtained using indirect ophthalmoscope, is possible.

The ideal camera phone for imaging the retina will have:
• A small light to lens (LL) distance (Fig 1).
• The lens positioned near the corner of the phone.
• A light whose illumination can be varied.
• A lens with a wide angle.

With the addition of readily available macro lens adaptors, magnified views of the lids, ocular surface, iris and lens can be obtained.

Direct phoneoscopy – a step by step guide
1. Mydriasis is helpful but not always essential, especially if using a phone with a short LL distance.
2. Open camera app – see the ‘Which App’ section on www.theeyephone.com if you don’t already have a suitable app installed.
3. Turn the LED on continuously - if you do not have a suitable app installed use your embedded video app and turn the light on.
4. Reduce the LED illumination - if this cannot be done within the app then apply multiple (three) layers of Micropore tape or similar to the LED.
5. Image the tapetal reflection from arm’s length - the distant direct ophthalmoscopy technique can be mimicked in this fashion. Zoom in until the tapetal reflection fills the screen.
6. Zoom out again prior to imaging the retina.
7. Move the camera towards the eye - when the eye is closer than the camera’s minimum focal distance the retina will start to be imaged.
8. Position the camera close to the cornea (2–5 mm) in the same was you would position a direct ophthalmoscope when performing close direct ophthalmoscopy. Removing your camera case will make this easier (Fig 2).
9. Tap the screen to focus on the optic nerve head.
10. If your app allows separate focus and exposure (e.g. Camera +) then tap the tapetal fundus to avoid ‘white out’ due to the highly reflective tapetum.
11. Reposition the exposure on the nontapetal fundus to image (Fig 3).

Examples of phoneoscopy images of various ocular conditions are shown in Figs 4–6.

Fig 1: iPhone 4 and 4s: LED light is positioned 5 mm from the lens allowing near co-axial illumination of the fundus.

Fig 2: The LED is covered in two or three layers of Micropore tape, the pupil dilated and the phone camera positioned close to the cornea.
Fig 3: Equine fundus showing pigmentary retinopathy. Single fundic image captured with iPhone4S.

Fig 4: Post-laser coagulation of cyst. Retro-illumination of linear band keratopathy using distant direct phoneoscopy.

Fig 5: Macro phone image: Iris melanoma.

Fig 6: Macro phone image: drainage angle.

NOTES
Decision making in nonulcerative corneal disease

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A methodical approach to managing nonulcerative corneal disease (NUCD) is predicated on initial differential diagnosis and consequent definitive diagnosis, based upon careful clinical examination and ancillary investigation where required.

Is NUCD present?

Cardinal presenting signs of NUCD
- Corneal opacity is present to some degree.
- There is an absence of geographic area of stromal fluorescein retention (i.e. an ulcer). Note, however, that some cases of NUCD will show intraepithelial fluorescein retention.
- Ocular pain is variable and may be absent, depending on cause.

Is NUCD primary or is it a secondary manifestation of disease elsewhere in the eye or adnexa?

Primary causes of NUCD
- Immune-mediated keratitis (IMMK), including some forms of eosinophilic keratitis.
- Primary epithelial disease.
- Acute blunt trauma; embedded foreign bodies may be (rarely) present.
- Chronic (long-standing) blunt trauma: stromal scarring, linear keratopathy, Descemet’s membrane detachment.
- Stromal abscess.
- Corneal ‘dystrophies’ including idiopathic primary oedema.
- Neoplasia: squamous cell carcinoma (SCC), lymphoma.

Secondary causes of NUCD
- Uveitis: traumatic, endogenous (including equine recurrent uveitis [ERU]), infectious, metastatic neoplasia. Note that reflex uveitis will be present in any instance of painful primary NUCD.
- Glaucoma.
- Eyelid pathology: mebomianitis, chronic blepharitis, distichiasis, anatomical discontinuity.
- Intraocular space-occupying lesion impinging on corneal endothelium: melanoma, iris cyst, anteriorly luxated lens.
- Congenital anterior segment dysplasia.
- Tear film deficiencies e.g. keratoconjunctivitis sicca.

How do I diagnose primary NUCD?

Careful clinical examination
- Assess depth, extent and nature (fibrosis, cellular, oedema) of corneal opacity/opacities; slit lamp biomicroscopy is very helpful.
- Assess presence, configuration and depth of any corneal blood vessels.
- Assess whether primary uveitis or any other anterior chamber abnormality is present.
- Stain with fluorescein to eliminate geographic ulceration.
- Stain with rose bengal (if available) to assess integrity of epithelium/tear film interface.
- Perform a Schirmer tear test to assess quantitative tear production.

Ancillary examination
- Assess intraocular pressure to eliminate possible glaucoma.
- Cytology may be helpful in superficial disease.
- Keratectomy (biopsy) can be diagnostic, but be aware that, by default, NUCD will be converted to ulcerative disease in a physiologically compromised cornea, which can create its own problems.

If you are no longer in your comfort zone, refer the case!

How do I manage primary NUCD?

Effective treatment and confident prognosis depends on accurate diagnosis, where possible. If you are no longer in your comfort zone, refer the case!

IMMK
- IMMK is a generic term for a group of nonulcerative corneal inflammatory diseases presumed to have an immune-mediated origin. It is not a specific diagnosis.
- These diseases are largely classified according to the depth of the inflammatory pathology (i.e. opacity, neovascularisation). There is no uveitis.
- Typically, ‘staircase’ topical therapy using anti-inflammatory and immunomodulatory agents, singly or in combination, is used in the first instance. Agents include corticosteroids, cyclosporine A (CsA), rapamycin, doxycycline.
- Guidance on initial selection of therapy is available: see ‘Further Reading’.

Acute blunt trauma
- Typically, there is acute onset of a densely oedematous cornea. Hyphaema (blood in anterior chamber) is common.
Performing an ultrasound scan of the eye is useful prognostically.

Watch for corneal perforation (Seidel’s test).

Aggressive topical and systemic corticosteroids are indicated (where no ulceration).

Blood in anterior chamber resolves very rapidly in the horse (4–7 days). Intracocular tissue plasminogen activator speeds this up but is probably unnecessarily heroic in most cases.

Corneal fibrosis, capsular cataracts and peripapillary butterfly lesions are common sequelae.

**Chronic blunt trauma**

- Geographic scarring and linear opacities with or without anterior chamber synechiae are the hallmarks of historical blunt trauma.
- There is no treatment.
- Fibrosis will typically improve or resolve over several years.

**Stromal abscesses**

- Typically painful, though some quiescent abscesses may be comfortable.
- They look like abscesses! They are dense yellow/white foci with typically aggressive local neovascularisation. Reflex uveitis is almost invariably present.
- Be very suspicious if a ‘spot’ gets better with topical corticosteroids but returns once treatment is withdrawn.
- In the UK, many abscesses are bacterial and will respond to aggressive topical antimicrobial therapy (use chloramphenicol or fluoroquinolones to penetrate overlying epithelium). If perilimbal, systemic antimicrobials will be of benefit.
- Fungal abscesses are a problem.
- Superficial fungal abscesses may respond to debridement and topical antifungals (especially voriconazole).
- Deep fungal abscesses are best referred. They frequently require surgery involving a high level of experience, skill and financial commitment.

**Corneal dystrophies**

- These are rare; they usually present as an oedematous cornea with no or limited neovascularisation.
- Watch out for Friesian horses (specific perilimbal, focal dystrophic lesions occur in this breed). See ‘Further Reading’.
- Diagnosis and treatment are not easy: consider referral.

**Neoplasia**

- Primary corneal neoplasia is rare.
- SSC is most common.
- Lymphoma may be a sequela of IMMK.
- Diagnosis is by biopsy.
- Treatment usually debridement and adjunctive therapy (see ‘Further Reading’).

**Further reading**

Advances in equine ophthalmic surgery

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Ophthalmic surgery is a rapidly changing field both in man and in veterinary species.

Many of the advances in technique and surgical equipment in human ophthalmology are transferable to our equine patients, providing more treatment options with better outcomes.

What’s new in standing surgery?
The use of head-mounted operating microscopes, regional anaesthesia, multimodal sedative techniques and constant rate infusion sedative protocols allows complex ophthalmic procedures to be performed by experienced ophthalmic surgeons, including complex corneal reconstruction and placement of intraocular medication devices for the treatment of recurrent uveitis.

Appropriate blocks and sedation allow more routine surgeries to be performed in the standing horse by experienced general surgeons, including enucleation, third eyelid surgeries, lid laceration repair as well as indolent ulcer treatment and superficial keratectomy.

What’s new in adnexal surgery?
Tissue expanders and canthal tendon releasing techniques allow the removal and repair of larger lid lesions.

Photodynamic therapy allows a targeted chemotherapeutic option for previously untreatable ocular tumours.

Controversy exists in the veterinary ophthalmology community regarding the use of orbital implants following enucleation. In the authors clinic, combining the use of orbital implants with a modification of the transpalpebral enucleation technique to spare the eye lashes and periocular cilia results in the post-operative appearance of a closed rather than missing eye, as well as improving facial sensation, following removal of the globe (Fig 1).

What’s new in corneal surgery?
Restricted depth corneal knives and corneal lamellar dissectors allow superficial keratectomy to be performed more safely in the standing patient even where the surgeon doesn’t have extensive microsurgical experience. These instruments make corneal biopsy a safer diagnostic and treatment option for many equine patients.

The diamond burr (AlgerBrush) provides a safer option for indolent ulcers than the anterior grid and punctate keratotomy. Care should be taken to clean the instrument properly to reduce the risk of iatrogenic corneal melting and/or infection.

Conjunctival grafting techniques
Conjunctival grafting techniques have been widely used for many years; while these are still very useful, corneal grafting techniques (e.g. corneonoconjunctival transposition (Fig 2) and donor corneal grafting) are now a routine part of the veterinary ophthalmologist’s armoury. The availability of a number of biografts (e.g. amnion and ‘collagen’ grafting materials) further increases corneal repair options.

Fig 1: Modified lid split transpalpebral enucleation with placement of silicon orbital implant.

Fig 2: Sliding corneal graft (or corneonoconjunctival transposition) for treatment of axial corneal rupture.

Fig 3: Prosthetic intraocular lens placed following phacoemulsification of a lacerated lens.
What’s new in surgical implants for chronic medication?
Suprachoroidal implantation of slow release cyclosporine implants for the treatment of the equine recurrent uveitis syndrome has been available for over a decade. Cyclosporine-impregnated biodegradable silicone implants have been more recently developed for surgical implantation in the episcleral space, which can be of help in the management of some immune-mediated superficial corneal diseases.

What’s new in intraocular surgery?
Cataract surgery by phacoemulsification is now offered at several sites across Europe. Advances in cataract machine technology, increasing surgeon experience, an appreciation of the importance of intensive post-operative medication and the more widespread use of prosthetic intraocular lenses is leading to increased visual rehabilitation rates in elective cataract surgery and in traumatic lens laceration cases (Fig 3).
While vitrectomy is still widely used for the treatment of leptospiral vitritis, particularly in mainland Europe, intravitreal low dose gentamicin (2–4 mg) has been used as an alternative treatment with apparent success in UK cases with laboratory evidence of intraocular leptospiral infection.
Equine recurrent uveitis (ERU) is a spontaneous disease characterised by repeated episodes of intraocular inflammation. In the long term it can lead to chronic ocular pain, loss of vision and can decrease the monetary value of affected horses.

**Immunology**

It is generally accepted that ERU is an autoimmune disease, and this is supported by its recurrent nature, the positive effect of immunomodulatory medications and the inconsistent success of antimicrobials. However, the initiating events of this disease remain unclear. ERU is characterised by recurrent inflammatory bouts caused by activation of leukocytes in the eye, separated by variable periods of quiescence. Most of these lymphocytes are helper T lymphocytes, and demonstrate a Th1 response characterised by increased expression of interleukin (IL)-2 and interferon (IFN): However, a novel IL-17 secreting T cell denominated Th17 has been identified in uveitis-affected horses. It is now believed that Th1 cells may initiate the immune response while the Th17 cells are responsible for the chronic activity. In contrast to the increased numbers of helper T cells, the numbers of regulatory or suppressor T cells, which have a role in the prevention of autoimmunity, are reduced in patients with uveitis.

In addition, a number of retinal autoantigens capable of inducing uveitis in horses have been identified, including interphotoreceptor retinoid-binding protein (IRBP), S-antigen (S-Ag or arrestin), recoverin and cellular retinaldehyde-binding protein (CRALBP). For unknown reasons, these autoantigens are expressed throughout the retinaldehyde-binding protein (CRALBP).

**Genetics**

A relationship between horse breed and the risk of developing uveitis has been established, with previous studies indicating a much higher risk in Appaloosas compared to thoroughbreds, and also showing that Appaloosas are at an increased risk of becoming blind compared to other breeds. Recently, genetic analysis of Appaloosa horses has identified three markers significantly associated with insidious ERU. More recent work has helped to identify two more regions associated with ERU, one of which has been associated with the regulation of IL-17, and another that may be indicative for cataract formation in the course of ERU.

**Leptospira**

A large number of micro-organisms have been implicated in the pathogenesis of uveitis, but the most important pathogen implicated in the pathogenesis of ERU is Leptospira. The mechanisms by which Leptospira may trigger the disease are not completely clear. One explanation may be that the bacteria penetrate the eye and are deposited in the ocular tissue causing persistent infection, inflammation and exposing the immune system to an immune privileged site. A second explanation could be that the organism mimics a native antigen, triggering an immune response (molecular mimicry). According to this model Leptospira may help initiate the disease in some, but not all, horses, but its continuous presence is not necessary in the pathogenesis of recurrent disease. The most common species associated with ERU in North America is Leptospira interrogans serovar pomona whereas Leptospira kerscheni serovar grippotyphosa is most commonly implicated in the ERU cases in Europe. The prevalence of Leptospira-associated ERU cases in the UK is believed to be much lower compared with North America or mainland Europe (approximately 6.7% of ERU cases), with other serovars being involved in these cases.

**Therapy**

The two main objectives of therapy are to reduce pain and control the inflammation. Topical triamcinolone is commonly administered to effect in order to relieve ciliary muscle spasm and achieve mydriasis. Corticosteroids are the most important drug used to decrease the inflammation. These can be administered topically, periocularly (most frequently triamcinolone subconjunctivally), intraocularly and/or systemically. Another option is the use of cyclosporine A (CsA), a potent immunosuppressive drug. Systemic CsA is commonly used in human uveitis patients but cost makes this approach prohibitive in ERU cases. A topical preparation exists but studies have shown no intraocular penetration following corneal application. A suprachoroidal slow-release CsA implant was subsequently developed. Long-term studies following implantation of these suprachoroidal implants in horses have shown a reduction in the number and severity of uveitis episodes with minimal complications, making them a promising alternative. Other drugs such as tacrolimus and rapamycin have a similar mechanism of action to CsA, but increased potency, and may provide an alternative treatment option in the future. Another surgical option in the treatment of ERU is pars plana vitrectomy (PPV). The main goals of this procedure are the clearance of the ocular media and removal of cells and inflammatory mediators from the posterior segment. Case selection is essential because of the potential for serious complications following PPV. The technique has proved to be particularly effective in Leptospira-associated ERU cases, while Leptospira-negative patients appear to be poorer candidates. Recently good results have been reported with intravitreal injections of low-dose gentamicin and intrachoroidal injections of triamcinolone.

**Further reading**


Epidemiology and risk factors

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No equine practitioner is immune from the effects of equine gastric disease (EGD) in their patients and consequently probably in themselves. We now recognise that EGD, which must now be viewed as two distinct pathological presentations, equine squamous gastric disease (ESGD) and equine glandular gastric disease (EGGD) affects all types of equids working in all disciplines. While many of us diagnose and manage cases of EGGD in all types of horse, most commonly sport and leisure horses on a daily basis, our knowledge of the epidemiology and risk factors of EGGD remains limited due to a paucity of large scale studies. Post-mortem studies have shown that EGD is significantly associated with breed, being more common in Thoroughbreds and Standardbreds. However, of more interest to most practitioners, were the findings of a study of EGD in sport and leisure horses in the UK in which no effect of age, sex or month of presentation on the prevalence of EGGD was reported [1]. Again, the only significant breed association was in Thoroughbreds with ESGD. Warmblood horses in Denmark were found to have a higher prevalence of EGGD in comparison to other breeds [2,3]. Thus environmental and management factors (nature, frequency and intensity of exercise, nutrition, intercurrent disease, handling, social interaction, social cohort management) are likely to predominate. Straw feeding and lack of water in paddocks has been associated with EGD in general [4].

While our understanding of the pathogenesis of EGGD, the natural history of the designated lesion types and, not least, prediction of their clinical significance to the horses that carry them remains poor, a true assessment of risk factors for EGGD from the perspective of managing a career athlete, even those competing in low level or leisure pursuits, is difficult, if not impossible. However, the recognition of the potentially profound effects of EGGD alone on performance and temperament of horses working in sport and leisure disciplines has, over the last 5 years, produced some interesting data on risk factors for the presence of EGGD.

In Thoroughbreds, trainer alone [5] and exercising more than 4 or 5 days/week in both Thoroughbreds [5] and showjumpers [6] were found to be significant risk factors for EGGD but the intensity of that exercise was not a significant factor. However, in elite endurance horses the prevalence of EGGD doubles during the competition season in comparison with the off season [7]. Of particular interest to practitioners dealing with EGGD in young sport horses as they enter training were findings that EGGD prevalence was inversely correlated to the level of ‘experience’ of both polo ponies and showjumpers [6,8] suggesting either adaptation to the ‘stresses’ of work over time or changes in management of those more ‘experienced’ animals or selection for animals that do not succumb to EGGD as they rise through the ranks.

In man, the risk of gastric disease also increases with the total amount of exercise and frequency rather than intensity, and reduction of splanchic and especially gastric mucosal blood flow during exercise has been implicated. The physiological stresses of hypotension and ischaemia have also been implicated in the pathogenesis of EGGD in foals [9].

Stress is an important risk factor for peptic ulcer disease in man [10] and this links in with the negative effects of ‘experience’ on EGGD prevalence [6,8]. A trend towards a higher EGGD prevalence was found with an increase in the number of people living at high altitude [5]. Indeed, horses with severe EGGD showed a greater cortisol response to both novel stimuli [11] and exogenous ACTH [12]. While objective assessment of ‘stress’ in an individual animal may remain elusive, application of the developing field of visual assessment of horse behaviour and appearance to develop an equine ethogram may provide some interesting data for the study of EGGD.

While there is currently no evidence to implicate diet in the development of EGGD, unpublished data suggest that access to pasture is protective [13] but whether this is a nutritional effect or an effect of enhancing general wellbeing through ‘natural’ grazing behaviour, possibly in a herd situation, is far from understood.

While many practitioners have noted an association between EGGD and intercurrent musculoskeletal pain, especially in sport horses, given the high prevalence of low grade and/or undiagnosed lameness in this population and the absence of an association between orthopaedic disease and EGGD in Thoroughbreds [5], this association requires much more study in different athletic disciplines.

Nonsteroidal anti-inflammatory drug (NSAID) use has often been considered a risk factor for EGGD, yet the lesions that result from NSAID-induced glandular injury are quite different from naturally occurring EGGD, such that NSAIDs used at licensed doses should not raise concern and indeed this mirrors experience from practice.

We continue to have much of interest to learn, not least about how we train and manage sport and leisure horses, which will have significant implications for prevention of EGGD and, no doubt, wider benefits to animal welfare.

References


Further reading
What do we know about the pathogenesis of glandular disease?

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Introduction
There is minimal experimental information regarding the pathogenesis of equine glandular gastric disease (EGGD) [11]. None of the squamous experimental protocols induce EGGD, so it is unlikely that increased acid exposure alone is the cause of EGGD. In man, peptic ulcer disease (PUD) is considered the end result of an imbalance between aggressive gastric luminal factors and defensive mucosal barrier function [2,3]; in horses, it is most likely that weakened mucosal barrier function is the primary cause of EGGD and that acid injury may perpetuate mucosal damage, inhibit epithelial restitution and is required to cause clinical signs [1].

EGGD is an erosive gastritis
Histologically, three EGGD lesions are identified: haemophaemia, shallow erosion, and deep erosion [4,5]. An inflammatory component is always present; hence EGGD is erosive gastritis [6]. Haemophaemia represents superficial capillary congestion, mild mononuclear inflammatory infiltrate and an intact epithelium. Shallow and deep erosions have epithelial disruption (denudation and erosion leading to ulceration), fibrinosuppurative exudation, haemorrhage and a variable inflammatory cell infiltration. Four types of mucosal architectural change accompany the epithelial disease: atrophy, dysplasia, metaplasia and hyperplasia. Post-mortem and clinical studies show the majority of EGGD occurs within the antrum and the pylorus [7,8]. In man, erosive gastritis is associated with chemical dissolution of the mucus barrier by alcohol and nonsteroidal anti-inflammatory drugs (NSAIDs) [2], or by underlying inflammation which can be part of inflammatory bowel syndrome [9].

Equine gastric glandular bacteria
There is no evidence that bacteria are the primary cause of EGGD in the way that Helicobacter pylori is in PUD [2,4,7]. Bacteria may colonise EGGD lesions, rather than create them. Relevance is likely to be individual, as no difference has been found between the microbiota of EGGD horses and those without [10]. Bacterial mucolytic enzymes, used to transit across the glandular juxtamucosal layer, may reduce mucus barrier integrity.

NSAIDs
Phenylbutazone and flunixin meglumine can induce ulceration at elevated doses, but no effect occurs after top-dressing at the recommended dose rate [11,12]. The use of NSAIDs in young racehorses is not a risk factor for EGGD [13].

Mucosal stress
‘Stress is the sum of the biological reactions to any adverse stimulus, physical, mental, or emotional, internal or external, that tends to disturb the homeostasis of an organism’ [14]. The aetiology of stress-related ulceration reflects splanchnic hypoperfusion, loss of host defenses and acid injury. As gastrointestinal blood flow is reduced in fasted splanchnic hypoperfusion, loss of host defenses and acid [14]. The aetiology of stress-related ulceration reflects that tends to disturb the homeostasis of an organism’ [14]. The aetiology of stress-related ulceration reflects

EGGD show greater cortisol responses to novel stimuli and to exogenous ACTH; however, the direction of this association is unknown [17,18]. The blood supply to different regions of the glandular mucosa is anatomically different and so may be unevenly affected by exercise, potentially leading to localised development of ‘exercise ischaemia-recovery reperfusion’ injury or heat-related injury [19].

Diet
There is currently no experimental or epidemiological evidence to suggest that EGGD is caused by specific feeding practices, or by starvation [1].

References
Clinical signs and clinical significance

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Introduction
Equine gastric ulcer syndrome (EGUS) has been associated with a variety of clinical signs in adult horses. Unfortunately, most of the information is anecdotal, with very little robust scientific evidence to support an association between perceived clinical signs of EGUS and the presence or absence of a specific type of lesion seen on gastroscopy. Reporting clinical signs of EGUS and trying to establish clinical significance is complicated. Most of the clinical signs associated with EGUS are nonspecific and are often subjective and owner-perceived. This is complicated further by the fact that a large proportion of horses with EGUS will not demonstrate clinical signs. In addition, horses with equine glandular gastric disease (EGGD) and equine squamous gastric disease (ESGD) will often manifest with different clinical signs, and to date there has been no attempt to differentiate between EGGD and ESGD when reporting clinical signs.

Clinical signs and significance of EGGD
Clinical signs characteristic of EGGD [1] include:
- Changes in temperament (including nervousness and aggression).
- Acute or recurrent colic (often manifested as postprandial abdominal discomfort).
- Reduced appetite, altered eating patterns and unexplained weight loss.
- Poor performance and changes in rideability (including reduced willingness to work and reluctance to go forward).
- Cutaneous sensitivity (manifested as biting of the flanks or resentment of girthing, grooming, leg aids or rugging).

Changes in temperament
Changes in temperament may be a manifestation of stress, and it has recently been shown that horses with EGGD exhibit greater increases in cortisol in response to novel stimuli and in response to exogenous ACTH, suggesting that they may be more sensitive to stress [1]. Changes in temperament in these horses are therefore likely to be a cause rather than an effect of EGGD, as is the case with peptic ulcer disease (PUD) in man.

Colic
Epigastric pain is well described in people, and is defined as pain localised to an area below the sternum and above the umbilicus. The pain is thought to be caused by gastric acid, and the nature of the pain varies depending upon the underlying cause (e.g. gastro-oesophageal reflux disease, gastritis or PUD). It is likely that horses with EGGD experience a similar form of pain, and there is a wealth of anecdotal evidence to suggest that these colic signs resolve rapidly following treatment, often within 24 hours. Alternatively, colic caused by other gastrointestinal diseases may increase the risk of EGGD in horses. Likely mechanisms in such cases include increased acidity secondary to intermittent feed deprivation, delayed gastric emptying and bile reflux.

Reduced appetite, altered eating patterns and weight loss
Inapetence, ‘fussy’ eating and poor body condition have all been associated with EGUS. Unfortunately, there are no data to suggest that horses with EGGD are more likely to be present with this clinical sign, despite anecdotal reports to the contrary. Again, the cause-and-effect relationship is unclear. Postprandial epigastric pain is well described in people with PUD and may cause weight loss precipitated by fear of food intake. It would seem logical that a similar mechanism may explain altered eating patterns and loss of condition seen in horses with EGGD and it is not unusual for these horses to begin eating normally within a few days after initiating treatment. Alternatively, it has been suggested that some EGGD lesions may be a manifestation of inflammatory bowel disease, in which case weight loss may be a consequence of a more generalised gastrointestinal disease.

Poor performance
Decreased performance has long been associated with EGUS in horses, and a number of supportive studies have been published. Excluding other factors that might influence poor performance is a challenge, however, as is determining which type of lesion impacts on performance and how. In the case of EGGD, poor performance appears to be manifested specifically by changes in rideability, with riders complaining that affected horses are unwilling to work and are reluctant to go forward. The exact mechanism by which EGUS may affect performance has not been elucidated, but again, it is likely to be a direct consequence of epigastric pain. Gastro-oesophageal reflux disease (GERD) is common in human athletes, with many athletes complaining of pain during exercise that is proportional to increasing exercise intensity. Acid reflux on to the sensitive squamous epithelium of the oesophagus during exercise causes a ‘burning sensation’ that has been shown to affect performance. Horses with ESGD have similar lesions to those causing GERD in human athletes, and the problem is likely to be compounded by the fact that the squamous epithelium extends into the proximal one-third of the stomach and is not protected by an oesophageal sphincter. Unfortunately, GERD is a less plausible explanation for horses affected by EGGD, however, as they rarely manifest with lesions characteristic of GERD, and it is likely that other, as yet undetermined factors play a role.

Cutaneous sensitivity
Perhaps the most intriguing clinical sign recognised almost exclusively in horses with EGGD is cutaneous sensitivity. Owners report that affected horses resent girthing, grooming, leg aids or rugging; and in some cases, horses may even be seen to bite at their flanks. The most likely explanation is that of a viscerosomatic reflex (referred pain), in which localised visceral stimuli in the stomach produce patterns of reflex activity and hyperaesthesia in segmentally related somatic structures such as the skin [2]. Alternatively, afferent signals originating from the skin via the sixth to ninth thoracic spinal nerves may be affected by input from visceral afferents in the stomach and misinterpreted within the brain as pain – a phenomenon best explained by the ‘common pool theory’ [1].

References
Recently, a number of factors that may affect the efficacy of oral omeprazole have been highlighted. The purpose of this talk is to review the factors that affect oral omeprazole efficacy, with the goal of maximising therapeutic response.

**Diet**

Until recently recommendations for the management of equine gastric ulcer syndrome (EGUS) included ad libitum roughage [1]; however, feeding has been shown to impact the absorption of omeprazole in horses and other species. Furthermore, feeding has been shown to negatively impact on the ability of omeprazole to induce acid suppression in the horse [2]. As such, recommendations that do not distinguish between feeding management during treatment with proton pump inhibitors (PPIs) and dietary prevention strategies are incomplete. Instead, where possible, omeprazole should be administered after an overnight fast during the therapeutic phase of case management. Ad libitum roughage as part of prevention management is inappropriate, as long as concurrent oral omeprazole therapy is not required.

**Timing of feeding**

To date, treatment recommendations have not considered the timing of feeding in relation to dosing. PPIs are prodrugs and to be converted to their active form they require gastric acid secretion [3]. Horses are constant acid secretors, and the consistently low pH in the ventral stomach reflects this [2,4], but meal feeding increases plasma gastrin concentrations [5]. Maximal plasma omeprazole concentration occurs at around 45-90 minutes [6–9] and it is important that maximal stimulation occurs within this period to recruit, and subsequently inactivate, as many proton pumps as possible with each dose. Meal type may also be important, as larger amounts of gastrin are released more rapidly in response to voluminous, roughage-based meals [5]. The author recommends withholding of feed overnight, followed by the feeding of a large, roughage-based meal 60–90 minutes after administration of oral omeprazole, then any required supplemental feeding.

**Dose and individual variation**


**References**


**NOTES**
Introduction
Given the poor response of oral omeprazole monotherapy in the treatment of equine glandular gastric disease (EGGD), other medical therapies have been given considerable attention in the management of this complicated condition. Many of these therapies are based on the hypothesis that acid is not the predominant mechanism of epithelial injury, although it may perpetuate disease in affected animals.

Misoprostol
Misoprostol is a prostaglandin analogue and an increasingly popular treatment for EGGD which has multiple mechanisms of action that may be of benefit. Misoprostol suppresses acid production and inhibits neutrophilic inflammation, is mild and self-limiting. Misoprostol may compromise the acid suppressive effect of proton pump inhibitors and the acid is not the predominant mechanism of epithelial injury, and is therefore a logical treatment for EGGD. In a study of 63 horses with EGGD, clinical healing (normal epithelial) was reported in 75% of cases receiving misoprostol (5 µg/kg bwt orally twice a day). Diarrhoea has been reported in association with high doses of misoprostol but is rare at standard clinical doses and, in the author’s experience, does not interfere with binding of active omeprazole to proton pumps.

Sucralfate
Sucralfate adheres to damaged mucosa within the gastrointestinal tract, providing a physical barrier while also stimulating mucus secretion, both of which actions reduce the potential exposure of the epithelium to gastric acid. It is also thought to promote epithelial healing through a number of cytokines including epidermal and insulin like growth factors and prostaglandins, the latter thought to improve mucus secretion, both of which actions reduce acid production and inhibits neutrophilic inflammation. Sucralfate is commonly used for the treatment of EGGD and its effects on gastric pH are published data on the efficacy of sucralfate monotherapy and what direct effects occur in this condition. There are no adheres to the mucosa of nonulcerative glandular lesions and is mild and self-limiting. Sucralfate may compromise the acid suppressive effect of proton pump inhibitors and the acid is not the predominant mechanism of epithelial injury, although it may perpetuate disease in affected animals.

Antimicrobials
The role of bacteria in EGGD is unknown, but they are found occasionally colonising some chronic lesions (Hepburn, unpublished data). Antimicrobials should not be used for the routine management of EGGD and do not improve healing when used as a first-line therapy [4]; their use should only be considered in refractory cases where there is evidence of neutrophilic inflammation and relevant bacterial species identified from gastric biopsies.

Corticosteroids
Given the inflammatory nature of EGGD, corticosteroids may be useful in refractory cases, but are not currently considered as first-line therapies. They may be useful in a small subset of cases, especially those where lymphocytic infiltrates are evident on biopsy specimens.

Nutraceuticals and diet
There are a multitude of dietary supplements claiming efficacy in gastric disease. There are limited data to support any specific recommendations for therapy, although the addition of oil and mucosal protectants may be of benefit alongside therapy, and for long-term management of cases. Maize oil may be added to feed at 0.1 mL/kg bwt or at higher doses if additional caloric intake is not contraindicated. Rapeseed oil is a cheaper alternative that is likely to be equally effective. Supplemental pectin and lecithin complexes have been shown to be of benefit in small numbers of horses. Sugar beet is high in pectin and may be fed as a less expensive alternative to proprietary pectin and lecithin products, although no data exist to support its use in this setting.

The cascade and medical treatment of EGGD
While omeprazole is licensed for the management of ulcerative disease in the stomach, no medicines are currently licensed for the management of gastritis of the equine stomach. As such, it is appropriate to consider alternative medicines in accordance with the prescribing cascade. There is currently no evidence to suggest any other veterinary medicine (from either the UK or the EU) would be suitable and therefore under the prescribing cascade vets should consider (in order):
• Suitable human medicines e.g. misoprostol.
• Special veterinary medicines (extemporaneous preparations) e.g. sucralfate/alternative proton pump inhibitors discussed elsewhere in this session.

The current veterinary medicines regulations allow for the importation of medicinal (e.g. human or veterinary) products from outside the EU in exceptional circumstances on a named horse basis with appropriate documentation. Given the availability of specials containing sucralfate, it is not clear how practitioners would justify this use currently.

References
Starting a new equine practice: will it work for me?

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Are you at a point in your career where you would like to have more control over your own work and income? This can be a highly rewarding task to undertake but it is not without hard work, risk and commitment. You become an entrepreneur in the making and inspired to learn so much more about yourself and the whole business environment.

One consideration when thinking about establishing your own practice is that you are responsible for all financial decisions. This can be in relation to buying and hiring decisions, clinical decisions, how to manage complaints - the list goes on. It is wise to remember you are no longer just a vet once you have your own practice, but the rewards when accepting these risks and challenges can be massive.

Certain personality traits are a definite bonus when making this type of venture work. Do you have the resilience to take risks and follow them through? For some the risks are too high, even after lots of research and investigation. For others, risk is not a problem and they are keen to leap into business and become self-employed. Risk is multifaceted: financial and personal, but also are you prepared to accept the possibility of failure?

Being in charge of your own destiny is extremely fulfilling. Drive and determination are required to start the business process, but commitment and patience are needed to see it through. Reward is a very personal thing and for many it is not always about financial reward. Whatever your reward trigger is, it needs to be strong enough to take the risks associated with your own practice. Making decisions on how to improve the business or researching what equipment to buy are rewarding tasks in themselves. Working in quieter times to decide what will keep your practice healthy and sustainable will become the norm.

One question that you should ask yourself when considering your own practice is ‘what do I want to achieve’? Most people, including myself, want to build a business that they can be proud of and makes money. It is essential to plan and set immediate goals but also set longer term goals for the future (10 to 20 years). This helps to keep you fresh and maintains your desire to achieve these goals. Review and adjust your goals regularly to make sure they are realistic.

As we all know, being a vet is not a nine-to-five career and being entirely responsible for your own veterinary practice is completely different from working within a practice. Learning about cash flow, business planning, health and safety, employment law and much more, are all parts of the exciting information you have to analyse and interpret. This can be a challenge too far for some people, but others relish it.

Another factor to consider is that 24-hour cover has to be provided. This is a massive undertaking and cannot be underestimated. Initially while the business is small, the out-of-hours work will be minimal, but being available every day and night still has an effect. Work-life balance is a frequently used term and being constantly on call can have a considerable effect on this. It is very hard to achieve a balance without a good support network and being disciplined to take time off. A high emphasis should be placed on where you wish to position your new business so that you might be able to employ other practices to occasionally assist with the out-of-hours rota. While other practices are your competitors, building good, sound relationships with each other and collaborating can be beneficial to all concerned. Out-of-hours cover is also less of a problem if you have business partners that can also share the rota.

Being a vet was my aim from a very early age, but also being in control of how I live life as a vet is so rewarding. Personal sacrifice, commitment and overcoming challenges has not been easy. I did a lot of research and it took a long time to decide if this was the right decision for me. Endless lists of pros and cons were written. I also spoke to a lot of people for their thoughts and ideas.

Once I had decided to take a leap of faith, I made a plan that I committed to, no matter how hard it would be. My aim was to build a business that was well-respected, something to be proud of and that would make me enough money to make it all worthwhile. Part of this plan was a very clear vision of what I wanted to do in my veterinary practice, and one of my first goals was to employ an assistant within 2 years. If I could not achieve this goal the business would not be sustainable. I actually achieved this goal at the end of the first year.

I repeatedly reset my goals to keep me focused and keep the business on track. Planning is key for me. While this venture has had significant challenges along the way, it has been very rewarding and, despite the changes affecting the profession, there are still opportunities for veterinary surgeons with the right motivation and determination.
Clinical needs and outcomes driving financial performance, and not the other way round, is something that is increasingly talked about. Maybe your practice is fully on board with this and you are striving to offer the gold standard to clients. You receive your accounts or management accounts and are hoping that all is going great financially. How do you know, however? This is where benchmarking, both internally within the practice and externally against other practices, can be invaluable. How do you know what to look at? In this session, we explore what areas of financial performance can be easily benchmarked. We will explain in plain English what we mean by key performance indicators (KPIs) and look at how technology can be used to produce KPI information for you. Benchmarking can be looked upon as a marker in the sand and aids discussion surrounding practice development. It can be useful in helping you to set goals for the future and in developing an action plan to try to achieve those goals.
Raising capital – funding that new project

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What is the business plan?
A business plan should be as detailed as you can make it, starting with the vision for the project and justification of the requirements. Be as specific as you can with the specifications. For a new build, spend as long as is necessary getting the design right before submitting it for planning permission. The funding will depend on having a solid business plan, demonstrating a need and an ability to generate profit.

It is very hard to predict how much your business will grow by, but you will need to demonstrate a range of growth to cover the costs of loan repayments.

Should we borrow at all?
There is a choice – borrow the money, or fund using profit retained in the business; alternatively, you could choose a combination of both strategies.

To best understand this, start with your cash flow statement. It is the cash flow that will service the loan repayments. A cash flow statement summarises your cash position according to cash inflows from your sales, inflows from borrowing money and outflows from investment activities. Preserving cash for day-to-day activities is fundamental. You may need to produce cash flow forecasts to justify the loan.

Attitude to risk and borrowing is important – some business owners will be more comfortable with borrowing than others. Consider interest rates and the cost of the capital in fees. If both these are low and you need to retain cash within the business, borrowing may arguably be the best option.

How much can we afford to borrow?
Liquidity ratios measure a business’s ability to repay debt, and the associated margin of safety. They determine whether you have sufficient cash and cash equivalents. They can be easily calculated from year-end accounts: these ratios are taken from the balance sheet, which is just one snapshot in time at the year end.

- Current ratio = Current assets (cash at bank, stock, debtors) divided by current liabilities. This is a test of short-term liquidity. A ratio around 1.5 indicates sufficient working capital; less than 1 might indicate cash flow problems, whereas too high a ratio might indicate cash reserves not effectively utilised.
- Acid test (Quick ratio) = Current assets minus stock divided by current liabilities. This is a good ratio for businesses that hold a lot of stock. It measures the capability of a business to pay off short-term liabilities. Less than 1 might mean lack of cash flow and inability to service further loans.
- Gearing ratio = Long-term liabilities divided by capital employed. Gearing is a measure of financial leverage as it compares how much of a firm’s activities and assets are funded by the business’s owners, rather than borrowed capital. Higher ratios have higher debt to equity, hence higher debt to service.

Budgeting
Budgeting is a complex process, but it is worth considering not only the fixed costs of the build, but also how the build will change the work flow of the business.

- Decide how much you want to spend!
- Estimate how much the business will grow by.
- Estimate efficiency savings – veterinary surgeons’ time.
- Think about how people will move around a new building – how it might affect their roles and responsibilities.
- Think about whether you will need more people, either as fee earners or administrative assistants, stablehands or managers.

How to get funding
Banks will offer a range of options depending on the size of the loan and the risks associated with the venture. A well-established business may pay less. Loans will need to be secured; with partnerships, this may be around personal guarantees. They will also consider taking a charge on any property you might own, but lending might only be on 70% of the full market value.

It takes a lot longer to arrange funding than you might think. During this time, you need to watch your cash flow/overdraft limits carefully as banks are looking for secure cash flow for evidence that you can afford loan repayments.

Be prepared to negotiate with several banks at once – you might get a better deal and you might get a faster drawdown. Also, be prepared to continue to share management information on a quarterly or six-monthly basis. The length of loan should correspond to the length of the lease, and this might be a requirement of the loan. Banks prefer longer leases for larger loans as it gives more security.

Contingencies
You will spend more than you think on items such as fire doors, fire alarms and internet cabling, and these are hard to budget for so you need to have a contingency reserve in case of overspending. Factor in a contingency around 10%. Banks do not like you going over an agreed loan budget.

Get advice from your accountants on tax savings. HMRC deal with fixtures and fittings differently from leasehold improvements, so there are tax implications for different aspects of a building. Additionally, there might be reductions at your quarterly VAT reconciliation, as the VAT on your build will increase the VAT you pay out compared with a normal quarter.
Each veterinary practice is unique and operates in a slightly different way. However, they all have the same requirement to generate a profit. That may be required to fund partners’ drawings, expansion of the practice, or investment in new equipment; profitability is required to in turn provide the cash for those projects.

In this short session we will focus on what figures you should be monitoring on a regular basis and what steps can be taken to help maximise the practice profitability.
In any environment – be that work or outside – inspirational leadership can make the difference in how motivated, energetic, enthusiastic and happy the people around you are. Good leadership has consistently been linked to success of companies – and good leadership that supports the people working there has been linked to long-term, truly sustainable success.

Leadership is not an inborn ability, it is a set of clearly defined and identifiable skills. These are available to all of us when we apply the work, the effort and the discipline to focus on them and develop them fully [1]. Despite what a lot of people may think, leadership is not about personality – it is about consistent behaviours.

So what is it about leaders that makes us think of them as inspirational? And what do we need to focus on in order to inspire our equine team?

As we go through life and look at what other people do and say, a full 82% of the variance in how we perceive social behaviours can be linked to just two values [2];

• Warmth
• Competence

Warmth is processed by the unconscious mind, typically within the first few seconds of meeting someone. Competence is assessed over time and evaluated by the conscious mind. From a leadership perspective, the two values taken together translate as a profound feeling of trust in the individual – and lack of trust is one of the reasons people give when they choose to leave an organisation. A person can be effective as a leader without either of the two values, but will not be able to fully engage people without the two being present in equal measure.

Once we move into research that looks specifically at values in relationship to leadership, what people say they look for in a leader that they would want to follow has been consistent over the last 20 years [1]. It boils down to four key values:

• Honest
• Forward-looking
• Inspiring
• Competent

These four values are consistent across time, cultures, countries and gender.

Honesty is about being worthy of trust. People want to know that the person they are following is truthful, ethical and has integrity. They want to be reassured that the person is honest about what they believe in, what they stand for and what they are doing, and that the leader is confident enough about those beliefs that they will stand their ground when pressured.

Being forward-looking is about having a sense of direction and a concern about the future of the organisation. This translates into a vision, a goal, a dream or a personal calling that comes across as a compelling destination. It is the ability to imagine or discover a desirable destination towards which the practice, community or team should head. It provides a goal for the journey that allows others to plan how they are going to contribute to getting there.

Being inspiring is about passion and positivity. It is about setting the example with enthusiasm and energy every day, everywhere. People expect their leaders to be enthusiastic, energetic and positive about the future and for them to lift the spirit of the people around them and give them hope that the vision/goal/destination is achievable. Inspiring leadership gives people meaning and purpose in their lives. Being upbeat, positive and optimistic about the future gives them hope.

Being competent is all about skills and behaviour. Leaders are expected to have a good track record of experience within the field and the ability to get things done. Leaders do not have to be the experts in their field – people recognise that true leadership requires different skills. They do need to have enough experience in the field to be able to guide the strategy and to be able to actively pitch in everywhere to set the example and demonstrate how important a task is.

These key values add up to a value of credibility. They state that we must be able to believe in our leaders, to believe that their word can be trusted, that they are personally passionate and enthusiastic about the work that they’re doing and that they have the knowledge and the skills to lead.

Finally, it is important to notice that leadership is about people, whereas management is often about tasks or processes. A key skill to focus on when dealing with people, is developing your own emotional intelligence skills.

Research [3,4] has highlighted the moderating effect of emotional intelligence skills on inspirational leadership. Leaders with high levels of emotional intelligence skills are better leaders – and followers with high levels of emotional intelligence skills can operate at a high level even with not so good leaders. Just as with other leadership skills, emotional intelligence skills can be taught and developed.

Some people have been conditioned to believe that emotions are not welcome in the workplace and that work decisions should be based upon cold, logical reason. Unfortunately, human beings are largely governed by their emotions (whether we realise it or not) and leadership research tells us that the lack of interpersonal skills and inability to adapt are the two principal derailment factors in business.

References
Conflict management and mediation

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What is conflict?
Conflict may be defined as ‘a struggle or contest between people with opposing needs, ideas, beliefs, values, or goals’.
Everyone is different, and this is a good thing! It enables the whole team to be stronger and more flexible as everyone brings their own skills, strengths and ideas. Along with these, however, individuals also have their own goals, values, beliefs and needs which need to be met. It’s therefore easy to see how conflict can arise.

What causes it?
There are many potential causes of conflict. These include:
• Personality clashes
• Differences in needs and expectations
• Differing values
• Unresolved problems in the past
• Increased workload
• Change in practice.

Conflict often results from people misunderstanding the behaviour of others, or from poor communication, rather than from genuine intent. If we don’t understand other people’s motives or reasons, then it is easy to be irritated or upset by their behaviour when this was far from their aim.

Why do we need to manage it?
On average, there will be five issues a day within a team and, if these are left to escalate in a negative manner, the outcome will always be a loss of productivity, team breakdown, disconnection and disengagement. On the other hand, dealing with issues constructively helps to foster trust and allows for open and honest debate which can strengthen teams.

Our natural response to conflict
Physiologically we respond to conflict in one of two ways – fight or flight. We either want to get away or we are ready to take on anyone who comes our way. Neither physiological response is good or bad; it is simply our personal response. We are, however, able to override this instinct and choose our response to conflict and turn a reactive situation into a more proactive and controlled response.

Understanding ourselves and others
DISC behavioural profiling is an online behavioural profiling tool that recognises everyone is different, but that we are predictably different. It enables us to understand why people behave in the way they do and identify what motivates and drives them as well as what their fears are. These are all key to understanding the triggers for conflict as well as how to resolve it so that everyone’s needs are met. It enables us to manage our own response to conflict as well as that of our teams.
The four different DISC styles are shown in Fig 1.

Practical steps to addressing conflict

Define the problem
Meet with employees separately at first and question them about the situation. Focus on the facts. Consider different behavioural styles and other factors such as levels of stress.

Manage the environment
Is your environment conducive to proactively managing the conflict? Ask yourself, ‘is this the right time and the right place?’

Manage your emotions and those of others
Manage your own emotions prior to addressing the issue and during any meetings. Allow others to express their emotions and ensure these are acknowledged without allowing them to derail the process.

Acknowledge that a difficult situation exists
Honesty and clear communication play an important role in resolution. Be open about the problem. Deal with it when it first becomes apparent rather than letting it grow.

Establish common ground
Establish a mutual understanding of the basic facts to ensure both parties understand how the conflict has arisen and what beliefs and assumptions may be at play.

Focus on moving forwards
Acknowledge what has happened but don’t dwell on it. Focus on moving forwards to a resolution and agree actions and owners.

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The four different DISC styles are shown in Fig 1.

Fig 1: The four different DISC styles.
Everyone thinks, feels and behaves differently. Understanding your team’s DISC styles as well as your own enables you to modify your language and behaviour to meet the needs of the individual, enabling you to communicate more effectively, proactively manage conflict and take the stress out of working with others.

**Determine underlying need.** The goal of conflict resolution is not to decide which person is right or wrong; the goal is to reach a solution that everyone can work with. Looking first for needs, rather than solutions, is a powerful tool for generating win/win options. Ask individuals what they need to be addressed, and what are the benefits of the solutions they are proposing? This will help you establish where each person is coming from and to identify common needs and potential solutions.

- **Find common areas of agreement, no matter how small:**
  - Agree on the problem
  - Agree on the procedure to follow
  - Agree on worst fears
  - Agree on some small change to give an experience of success

- **Find solutions to satisfy needs:**
  - Problem-solve by generating multiple alternatives.
  - Ask ‘what could you do?’
  - Determine which actions will be taken
  - Make sure involved parties buy into actions. Total silence may be a sign of passive resistance so be sure you get real agreement from everyone. Ask ‘what could stop them moving forwards?’

- **Determine follow-ups to monitor actions.** You may want to schedule a follow-up meeting in 2 weeks to determine how everyone is doing. At this point, ask what’s worked well and where could improvements be made; remember this is a dynamic process.

- **Determine what you’ll do if the conflict goes unresolved.** If the conflict is causing a disruption in the practice and it remains unresolved, you may need to explore other avenues. An outside facilitator may be able to offer other insights on solving the problem. In some cases, the conflict becomes a performance issue, and may become a topic for coaching sessions, performance appraisals, or disciplinary action.
Employee engagement: what is it and how do you know how much you have?

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Over the last 20 years the term ‘employee engagement’ has become increasingly popular and there has been a variety of definitions for what exactly this term means. Within the academic literature, it has been defined as a distinct and unique construct that consists of cognitive, emotional and behavioural components that are associated with individual role performance, and that is different from organisational commitment, organisational citizenship behaviours and job involvement [1]. Various definitions are included within that construct, such as ‘an emotional and intellectual commitment to the organisation’ [2,3,4] and ‘a positive, fulfilling, work-related state of mind that is characterised by vigour, dedication and absorption’ [5]. Most of us will have some idea about what engagement looks like and sounds like – and especially about how disengagement presents itself.

Gallup research conducted over 142 countries found that only 13% of employees are engaged at work [6]. Gallup identified three groups of engagement:

- **Engaged employees** that work with passion and feel a profound connection to their company. They drive innovation and move the organisation forward. In the UK, 17% of employees are engaged, though this number is slightly less among professionals.
- **Not engaged employees** that essentially have ‘checked out’. They are sleepwalking through their workday, putting time – but not energy or passion – into their work. In the UK this number is 57%, though significantly higher among professionals.
- **Actively disengaged employees** that aren’t just unhappy at work – they are busy acting out their unhappiness. Every day, these workers undermine what everybody else accomplishes. Numbers in the UK sit around 26% with professionals scoring lower.

Gallup also quantified the advantages of employee engagement:

- Work units within an organisation that score in the top half in employee engagement (compared to other work units in the organisation) have nearly double the chance of success when compared with those in the bottom half. Those at the top 1% have four times the success rate compared with those at the bottom 1%. (Success is based on a composite of financial, customer, retention, safety, quality, theft and absenteeism metrics.)
- Employee engagement affects multiple performance outcomes. Compared with the bottom 25%, the top 25% have:
  - 37% lower absenteeism
  - 25% lower employee turnover (in high-turnover organisations)
  - 65% lower employee turnover (in low-turnover organisations)
  - 28% less theft
  - 48% fewer accidents
  - 10% higher customer loyalty
  - 21% higher productivity
  - 22% higher profitability

How do I know where we are at?
There are many surveys available commercially that will tell a practice how engaged their team is. The results of the surveys are rarely a surprise to the leaders and managers in the practice and so the main benefits of surveys are the fact that they allow benchmarking within the practice and that they give indications as to what factors are influencing employee engagement – and as such where it is a good idea to start!

What can I do about it?
Specific recommendations on how to increase employee engagement are many and varied depending on what exactly is going on in the practice and therefore beyond the space available in this abstract. In general, people are engaged when they are involved with the strategic and practical decisions in the practice, when they feel listened to and when they feel appreciated. In addition, research has identified three basic psychological needs that, when fulfilled, are likely to drive autonomous motivation [7]:
- Autonomy – having a sense of choice and control.
- Competence/mastery – being able to improve and grow skills.
- Relatedness – feeling connected to others including the wider community, especially with a shared purpose.

Psychological needs are defined as universal necessities: their satisfaction promotes psychological health and, importantly, their thwarting undermines psychological health. So, when the needs are met, we feel better; when they are not met, we feel worse. Making sure that employees have those three needs met are essential to even starting to think about employee engagement.

A final value that is essential to driving employee engagement is the feeling of trust. Trust is very much about honesty, integrity and respect. Employees that perceive that their management lacks in any of the three areas are likely to feel actively disengaged and are more likely to leave the practice. Exit interviews are a good way to identify whether there are challenges in these three areas. Often the challenges are not about who the leaders are, but about specific behaviours that do not come across in the way they are intended. This provides a focus for development that is likely to be a good return on investment.

References
Do you want to make sustainable changes in your practice? Does the thought fill you with a slight sense of dread? Would you like to make the process less stressful for everyone concerned?

If you’ve answered yes to the above questions, then you’re not alone! Making even the simplest changes in practice can seem like an uphill struggle with people moaning, finding all the possible problems, refusing to do things the new way or running off in their own direction. Changes often don’t stick and when they do, they may never realise their long-term benefits for the business.

Key reasons that changes fail

Lack of motivation

It's normal human nature to resist change unless there’s a clear reason for it. To get commitment from your team, you need to convince them that the change is both important and urgent by identifying the reasons for it and the impact of not doing it. The message may need to be tailored for different groups within the practice; you need to create a compelling reason for people to move out of their comfort zone and do something different.

Unclear vision

You need a clear vision of the outcome that the change will achieve: the end state. This allows you to identify progress points to keep you on course and to know when you've achieved your aim. It also allows you to be flexible to achieve that outcome as you know your end goal. This is the vision that needs to be communicated to your stakeholders; think about the end state from their perspective and answer the ‘what’s in it for me?’ question.

Poor communication

Without good communication, the vision and the motivation are lost. Communication needs to be two-way to enable you to achieve feedback, ideas and input. It needs to be planned and tailored to the people receiving it. Identify all your stakeholders (this can include suppliers and clients for some changes).

For larger changes, develop a communications plan which keeps the tempo up on communication, keeps people involved and allows you to get feedback and deal with problems early.

The change isn’t planned

Without a plan, the change won’t succeed, and the right people need to be involved in the planning process. Have you considered the impact on people, not just on finances and operations? What reward systems (bonuses, recognition, feedback, scorecards) can you use to support the change? How flexible are you, and what are your contingency plans?

Success takes too long to arrive

Success can motivate, so build some ‘quick wins’ into the implementation plan. These also allow you to assess the change process, audit compliance and gather feedback early on as well as showing that you are committed to the change and building momentum. Celebrate all the successes and reinforce the change.

There’s too little follow-through

Change projects usually get lots of attention early on, but they can fizzle out well before completion. Don’t let this happen! Keep track of targets, implement corrective actions and follow through to the end to make sure your change

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**Fig 1: Cotter's eight-step change model.**
Delivering effective and sustainable change

John Kotter’s model (Fig 1) describes eight steps to effectively plan, communicate and implement change and is a useful process to work through when implementing changes in practice.

**Step 1: Create urgency**
Develop a sense of urgency around the need for change and spark the initial motivation to get things moving. Why is the change necessary? Why now?

**Step 2: Form a powerful coalition**
Convince people that change is necessary through strong leadership and visible support from key people within your practice and potentially externally.

**Step 3: Create a vision for change**
A clear vision will help everyone understand why you’re asking them to do something and what you’re trying to achieve.

**Step 4: Communicate the vision**
Communicate your vision frequently and powerfully, embedding it within everything that you do. Talk about it at every chance you get and use it every day to make decisions and solve problems, so that it’s always on everyone’s mind. Lead by example; if you are asking others to change make sure you follow through with the changes too!

**Step 5: Remove obstacles and focus on solutions**
Put in place a structure for the change and continually check for barriers to it. By removing obstacles, you’ll empower people to implement your vision and move the change forwards. When communicating the change to the team, ask what could stop them implementing it? What else do they need to know, what can you expect from them, how will you measure success? Keep them focused on solutions rather than problems.

**Step 6: Create short-term wins**
Give your practice a taste of victory early in the change process by building some obvious quick wins. Create short-term targets, not just one long-term goal, with each target being easily achievable.

**Step 7: Build on the change**
Many change projects fail because victory is declared too early. Quick wins are only the beginning of what needs to be done to achieve long-term change. Each success provides an opportunity to build on what went right and identify what you can improve.

Have a common way of debriefing with your team, asking:
- “What’s working”
- “What’s not working?”
- “What do we need to do more of?”
- “What needs to be changed?”

**Step 8: Anchor the changes in your practice culture**
To make any change stick, it must become part of the core of your practice. Reflect on and communicate the progress you are making, helping your team focus on the positives.

**Conclusion**
Change is necessary for continuous improvement within practice. Whether you are planning a large or a small change in your practice, being clear what you are trying to achieve and communicating this well are essential. Involve your team early and keep them and their needs at the heart of the process. Time spent at each phase of the change process will help to maintain your team’s engagement and their productivity, delivering sustainable benefits for you and your practice.
The marketing mix was defined in the 20th century by a marketing professor called E. Jerome McCarthy. He created a set of tools called ‘the four Ps’, and these are still widely used today as the basis to create marketing strategies. The four Ps are:

1. **Product** (what you sell)
2. **Price** (what price you sell it at)
3. **Place** (where you sell it)
4. **Promotion** (how you create demand)

The four Ps have since been further developed, mainly for the service industries, into the seven Ps:

5. **People** (who sells the product or service?)
6. **Process** (how is the product or service received? e.g. via an ambulatory visit)
7. **Physical Evidence** (what the customer receives, e.g. the horse’s diagnosis and/or treatment)

This practical module will cover these key ingredients when applied to veterinary marketing. In particular, we will look at the seven Ps in context with the business’ strategy and goals, and the role that marketing will play in achieving these goals. At first glance some of the seven Ps may appear to be outwith of what usually defines ‘marketing’. However, most marketers will argue that much of what we do in business is in fact related to marketing in some way! Marketing itself can be as simple or as complex as we make it. In any case it’s important to start simply and build from there. While it can be tempting to try juggling several elements, the best route is always to focus on one or two key areas, and do them well. Better to have successes with simple campaigns than overstretch resources, confuse your audiences or dilute results by trying to take on or achieve too much. Another important element to consider is the business’ available marketing resources. As well as time, this includes individual and team capabilities and financial marketing budgets (including any budget for outsourcing expertise). So the first decision is who is going to run your marketing campaigns? Once you know your available resources, this person, or team, can begin to plan a campaign that can be successfully implemented. We will also discuss the four Cs of what successful marketing looks like: clarity, consistency, credibility and competitiveness. And finally, the promotional mix tools: advertising, PR, sponsorship, e-marketing (social media, digital marketing), point of sale, personal selling, direct marketing/CRM (customer relationship management). Arguably the most important relationship we have is with our existing customers; creating loyalty through well targeted engagement is an essential part of any marketing programme, but is particularly so with service-led businesses such as veterinary practices.
At its most fundamental, buyers in B2B markets are motivated by the desire to meet a business need, while those buying in a B2C market are meeting a personal need or want. To understand the difference between B2B and B2C markets is to understand clients’ perception of value in each market. Value judgements are central to decision making because clients want to make sound purchasing decisions. However, value is difficult to pin down and is psychologically complicated. In economic terms, value consists of two major aspects: benefits and sacrifice, with clients perceiving value as a trade-off between relative quality and relative price [1].

**Defining value**
Kotler’s value equation [2] is based on the concept of trade-off or ‘give and get’:

\[
\text{Value} = \frac{\text{Benefits} (\text{functional benefits} + \text{emotional benefits})}{\text{Costs} (\text{monetary costs} + \text{time costs} + \text{energy costs} + \text{psychological costs})}
\]

The elements of value in B2B and B2C markets
Research has tried to decode the conundrum of ‘value’ by identifying its constituent elements. This research [3] has identified 30 elements of value applicable to B2C buying decisions and divided them into four categories as shown in Table 1. The elements of value model has its conceptual roots in Maslow’s hierarchy of needs, in which the most powerful forms of value live at the top (Fig 1).

The research has recently been extended [4] to explore the elements of value in B2B markets and identified 40 elements of value divided into five categories as shown in Fig 2 and Table 2.

**Which elements matter most?**
It’s unrealistic to attempt to inject all elements into a product or service; however, the analysis confirmed how excelling at multiple elements paid off. The research also demonstrated that to deliver on the higher order elements, a business must successfully provide some of the lower order elements required by the customer.

**B2C**
In 2016, US research spanning more than 10,000 consumers and 50 companies, identified that service quality affected customer advocacy more than any other element. All services must attain a certain minimum level, and no other elements can make up for a significant shortfall in this one. The most successful companies managed a high score (8+ on a scale of 0-10) on four or more elements of value.

**B2B**
In 2018, B2B research was carried out among 2300 corporate buyers in IT and commercial insurance. Three elements emerged as the strongest predictors of customer loyalty: service quality, expertise and responsiveness. Seven of the top 10 elements resided in the pyramid’s ease of doing business segment, and cost reduction wasn’t among the top 10. The most successful companies managed a high score (8+ on a scale of 0-10) on six or more elements.

**A note about service quality**
Service quality is identified as an important element of value for both B2B and B2C markets and, is in itself, a multifaceted concept. For those requiring further information, the SERVQUAL model [5] proposes five key ingredients of service quality.

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**Table 1: Examples of the elements of value in B2C purchasing**

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social impact</td>
<td>Helping other people or society</td>
</tr>
<tr>
<td>Life-changing</td>
<td>Provides hope, affiliation, personal accomplishment, motivation</td>
</tr>
<tr>
<td>Emotional</td>
<td>Reduces anxiety, promotes wellness, delivers therapeutic value, provides access</td>
</tr>
<tr>
<td>Functional</td>
<td>Service quality, saves time, simplifies, reduces risk, avoids hassle, reduces cost</td>
</tr>
</tbody>
</table>

**Table 2: Examples of the elements of value in B2B purchasing**

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiring</td>
<td>Vision, social responsibility, hope</td>
</tr>
<tr>
<td>Individual</td>
<td>Reduces anxiety, reputational assurance, fun and perks</td>
</tr>
<tr>
<td>Ease of doing business</td>
<td>Availability, responsiveness, expertise, variety, risk reduction, flexibility</td>
</tr>
<tr>
<td>Functional</td>
<td>Service quality, improves revenues, reduces costs, innovative capabilities</td>
</tr>
<tr>
<td>Table stakes</td>
<td>Capability, acceptable price, ethics, regulatory compliance</td>
</tr>
</tbody>
</table>
Some implications for marketing to equine clients

Client relationships
B2C markets have more numerous customers who make their decisions emotionally, while B2B customers will be fewer in number and more rational in their decision making. Relationships are more important with B2B customers as they seek veterinary expertise on an on-going basis to support their business. Work with B2B clients should focus on maximising the value in the relationship, while B2C relationships focus on maximising the value in the service.

Communications
B2B clientele value education, so more detailed communications are appropriate. B2C clients are more likely seeking enjoyment and simply need their information to be useful and nowadays, humorous and shareable.

Segmentation
Most practices will have a formal or informal methodology for segmenting their clients; e.g. leisure, professionals, hunters, livery yards, racing yards etc. The elements of value provide the opportunity to better understand what each segment values and provide the appropriate service.

Pricing
Pricing can change the value equation so any discussion about price changes should be accompanied by a consideration of the value elements. Implementing an intentional change in one or more value elements can be used to facilitate price increases.

References
What is a marketing plan and how do I write one?

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The working and practical aim of a marketing plan is to create a timelined campaign that can be picked up and actioned by anyone working in marketing within the business. It really doesn’t have to be – nor should it be – anything more complicated than that. However, as we will have covered in an earlier session, there is quite a lot of work to get to that point, but it will pay dividends to invest in developing a well thought through campaign that is simple to execute.

Both marketing and business goals should be SMART (specific, measurable, achievable, relevant and time-bound). With a clear vision, your marketing campaign will work in harmony with the business goals.

A successful marketing plan starts with the research. Understanding where your business is currently, and where you want it to be in 1, 2 and 5 years from now (your goals); understanding who your clients are and what you want to do with them; grow (numerically or geographically), add another sector, or even drop some! Once you know and understand (a) where you and your customers are now and (b) your goals and when you want to reach them, you will have your overall objective(s). You may also have a set of further objectives you want to achieve en route.

Now you can start to plan your marketing journey; the strategy. This is where your king ingredients come in, and the seven Ps we discussed earlier. What communication vehicles best suit your objectives? These will depend on whether the campaign is awareness-based, educational or loyalty building for example.

You first need to specifically identify and ideally segment your target audience(s). Whose behaviour do you need to change in order to meet your goals? This may include your internal audience (colleagues). What are the key messages that you want to get across throughout your campaign? Setting your key messages is important in order to provide consistency which will help cement and drive the campaign. Who are your competitors? What do they offer and why would your clients buy from them instead of you? What are your unique selling propositions?

We will also briefly discuss completing a SWOT analysis (strengths, weaknesses, opportunities and threats).

Once you know what you want to say, to whom, and how you’re going to reach them, it’s time to create the tactics (the specific initiatives). These are the initiatives that you will use to execute the campaign. And finally, when this is all going to happen; you will need to timeline the campaign, and if there are several campaigns, then create one master campaign planner so you can see how they all interact. A timelined campaign plan will not just ensure you keep things on track, it will also enable you to work out how the campaign will be both delivered and received.

Summary
One of the keys to successful marketing is to keep it simple and not try to do everything! One well run campaign focusing on a specific topic (e.g. dentistry) can be more successful than several campaigns which might overstretch resources or confuse your audience. And finally, the four Cs discussed earlier – what does success look like?

NOTES
In the UK 42 million people (37% of the population) are active users of social media. The use of social media is growing every year, with younger generations choosing to use social media rather than email to communicate.

In the UK, 91% of retail brands use two or more social media channels, while 81% of all small and medium businesses use some kind of social media platform.

Should we engage with our clients via social media, as a ‘free’ way to interact and to advertise our services to them and potential new customers? How can we best engage with them? Can we target our audience?

There is always concern that with social media comes the potential of bad publicity, for example from a disgruntled client, and bad news travels fast! How can we turn such a threat into a positive opportunity?

In our businesses, how should we actively engage with social media when we are all busy doing our daily work? How can we control and plan social media within our veterinary practices?

’We don’t have a choice on whether we do social media, the question is how well we do it.’ – Erik Qualman
Epidemiology

Chair: Tim Mair
Sponsor: HBLB

8.30
UK horse-owners: factors associated with choice of practice and qualities of individual vets
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Background: There is limited information about factors UK horse-owners consider important when choosing veterinary care. Objectives: To investigate UK horse-owner opinions about choice of veterinary practice and attributes they look for in a vet. Study design: An online questionnaire was promoted via social media/internet forums in March 2017. Results: Questionnaires were completed by 704 respondents. Most (78.0%) had their horse(s) registered with one practice, 20% were registered with two and 2% were registered with three or more practices. Essential factors when choosing a practice were: reputation of the whole practice (38%), reputation of a specific vet (25%) and having specific equipment (18%). Factors considered ‘not important’ were the practice used by the yard (72%) and charges being less than other practices (52%). Essential qualities owners expected from a vet were asking their opinion when making decisions about treating their horse (44%) and a nice personality was considered very important by 38%. Having additional qualifications was ‘somewhat important’ (53%) and particular areas of expertise by 44%. Owners rated it ‘not important’ that the vet was male or female (97%), that they owned their own horse (69%) and that they competed on horses (88%). When asked about new graduates (<1 year qualified) treating their horse in an emergency situation, 61% had some concerns, 17% had no concerns, 17% had major concerns and 5% would not let them treat their horse. When asked about risk of injury when vets treated horses, 41% of respondents considered vets to be at ‘some risk’, 38% ‘high risk’, 18% ‘possibly at risk’ and 1% considered there to be no risk of injury. Main limitations: Potential bias towards respondents who utilise the internet and social media. Ethical animal research: The study was approved by the University of Liverpool Veterinary Ethics Committee. Source of funding: None. Competing interests: None declared.

8.40
Using veterinary electronic health records to estimate disorder prevalence in UK equine practice
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Background: Accurate prevalence data are needed to support the diagnostic process and prioritise equine clinical research. Reliable disorder frequency measures are scarce due to a lack of comprehensive disease monitoring in first-opinion equine practice. Veterinary electronic health records (EHRs) are a potentially valuable source of prevalence data. Objectives: To describe the prevalence and types of disorders presented to UK first-opinion equine vets. Study design: Cross-sectional. Methods: Anonymousised EHRs from five UK equine practices were collected via a bespoke data-capture system and stored in a secure central database. Records from a random sample of all horses attended between 14 October 2016 and 13 October 2017 were reviewed in detail. Information on presenting complaint and diagnosis was extracted and 18 broad disorder groups created. Records pertaining to racing Thoroughbreds, external referrals or lacking sufficient detail to categorise were excluded. Disorder group prevalence and prevalence estimates and 95% confidence intervals (CI) for common specific diagnoses were calculated. Results: Over the study period, 29,229 horses were attended. Within the random sample of 3025 horses, 1527 (50.5%) presented with at least one disorder. The total number of disorder events was 3071. The most prevalent disorder groups related to the limb (n = 811, 26.8%), integument (n = 583, 19.3%) and gastrointestinal system (n = 237, 7.8%). Foot abscesses was the most common diagnosis in the limb disorder group (n = 77, 2.6%, 95% CI: 2.1–3.2%) although a specific diagnosis was not recorded for 425 (52.4%) limb events. Wounds (n = 183, 6.0%, 95% CI: 5.3–7.0%) and pituitary pars intermedia dysfunctions (n = 100, 3.3%, 95% CI: 2.7–4.0%) were the most prevalent specific diagnoses overall. Main limitations: Diagnosis was as recorded within the EHR and may be presumptive. Conclusions: This study highlights the importance of limb disorders, which account for over a quarter of disorders seen. Veterinary EHRs can be used to generate robust measures of disease frequency. Ethical animal research: This study was approved by the Royal Veterinary College’s Clinical Research and Ethical Review Board. Sources of funding: Royal Veterinary College Mellon Fund for Equine Research and RCVS Knowledge. Competing interests: None declared.

8.50
Outcome of critical cases seen ‘out-of-hours’ in first-opinion equine practice
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Background: Provision of out-of-hours care is an obligatory service of the veterinary profession. There are limited data on the incidence and outcome of critical cases seen out-of-hours in primary equine practice. Objectives: To describe the signalment, presenting conditions and outcomes of critical cases seen out-of-hours. Study design: Retrospective case series. Methods: Clinical records of the primary assessment of critical cases presenting out-of-hours between 2011 and 2013 at two equine veterinary practices were reviewed. Critical cases were defined as animals that required intensive treatment (hospitalised for medical or surgical treatment), were euthanased or died. Univariable logistic regression was used to determine which aspects of signalment and
presentation were associated with a critical outcome compared with the total population of 'out-of-hours' cases. Variables showing evidence of association (P<0.02) were used in a stepwise forward multivariable model. Results: There were 2602 cases attended out-of-hours at the two practices; 18.4% of these cases were categorised as critical. The most common critical conditions recorded were colic of unknown cause (42.8%), simple limb wounds (9.5%) and lameness (7.6%). Increased heart rate was significantly associated (P<0.001) with a 'critical' outcome. The majority of critical cases (62.5%) were euthanased without any intensive treatment, 3.5% died without intensive treatment, and 33.9% had intensive treatment; 73.6% of cases which received intensive treatment survived. The overall mortality rate of critical cases was 75% (n = 360/480). There was variation in the data recorded in critical cases; euthanased cases frequently had limited information recorded. Main limitations: Retrospective study of clinical records from two veterinary practices. Information recorded varied. Conclusions: Almost one in five out-of-hours cases were critical, and 75% of these had a fatal outcome. Critical cases have a significant association with high heart rate. The study outcomes were used to develop a recording protocol for cases requiring euthanasia. Ethical animal research: The study was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham. Informed consent not stated. Sources of funding: Adelle Bowden’s studentship was funded by the School of Veterinary Medicine and Science, University of Nottingham. Competing interests: None declared.

9.00 Impact of an educational campaign on owner knowledge and approach to equine colic

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Background: There are currently no published studies on the effectiveness of equine health campaigns. Objectives: To assess the impact of educational resources for horse-owners. Study design: Online survey. Methods: An educational campaign, ‘REACT to beat colic’, was developed based on evidence reviews, surveys and multi-stakeholder workshops. Free resources were distributed by The British Horse Society (BHS) from September 2016 through various media. One year post campaign release, an online survey evaluated horse-owners’ awareness of the campaign and its potential impact upon behaviour. Survey participants were recruited using a snowball sampling strategy; descriptive analysis of the data was performed. Results: Campaign materials were emailed to 93,000 BHS members and posted to all equine veterinary practices. Over 20,000 hard copy resources were distributed at equine events, information evenings, scientific meetings or direct requests. There were over 100,000 ‘hits’ on educational videos and 400,000 social media reaches over 12 months. A total of 1286 horse-owners participated in the survey; 37% (450/1205) were aware of the ‘REACT’ campaign, mainly through social media (21%). The most recognised resource by those aware of the campaign was the ‘REACT’ quick reference guide (78%) which was launched 2 months prior to the survey; 12.9% of owners were actively using this guide in decision-making. Campaign effect on owner behaviour was noted in several areas including monitoring health parameters: 11% of owners now measure these regularly since being aware of the campaign and a further 27% intend to start. Main limitations: Survey may be subject to response bias, and sample size was small. Conclusions: The campaign used a large scale dissemination strategy with social media being the main source of campaign awareness. However, this study shows that educational campaigns require regular reflection and provision of stakeholder support to successfully elicit the desired behaviour change in the target population. Ethical animal research: The study was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham. Sources of funding: Katie Lightfoot’s studentship was funded by World Horse Welfare and University of Nottingham School of Veterinary Medicine and Science. Competing interests: None declared.

9.10 Investigation into the telephone triage of colic cases within UK veterinary practice

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Background: It is essential that all those responsible for answering telephone calls within veterinary practice are able to identify and prioritise cases that require immediate emergency attention (www.rvc.org.uk/setting-standards/practice-standards-scheme). Objectives: To investigate telephone triage of colic cases within practice and develop resources to support decision-making. Study design: Mixed-methods interviews and survey. Methods: Interviews were conducted with four equine reception teams (n = 14) on current approaches to telephone triage of colic. Pilot resources, including an information pack, decision flow chart and call recording form, were discussed during these sessions. Interview responses were recorded and categorised. An online survey investigating telephone triage by all those within an equine practice was developed and distributed. Results: The majority of interview participants felt confident they could recognise signs of colic during a telephone conversation with an owner. The most common indicators of ‘critical’ colic identified by participants were sweating and recumbency. Pilot resources received positive feedback; the decision flow chart and information on critical indicators were identified as most useful. The online survey had 116 participants, with both nonclinical (reception and management) and clinical (veterinary surgeons and nurses) teams represented. Nonclinical personnel (53/116) felt less confident giving owner advice (P<0.01) and recognising critical indicators (P = 0.03) when compared with clinical personnel (63/116). Insurance status and access to equine transportation would only be discussed in 21% and 24% of telephone calls. Thematic analysis of survey data identified 13 themes relating to owner advice, with the most frequent being reference to exercise and owner safety; however, conflicting guidance was noted on several occasions. Main limitations: Direct access and engagement of those primarily managing telephone calls was difficult. Conclusions: This study describes current approaches to telephone triage and identified variations in advice given. The outcomes were used to develop targeted open access resources to aid decision making (www.react.vet/triage.pdf). Ethical animal research: The study was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham. Sources of funding: Katie Lightfoot’s studentship was funded by World Horse Welfare and University of Nottingham School of Veterinary Medicine and Science. Competing interests: None declared.
9.20 Implementation of biosecurity on equestrian premises in Great Britain
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Background: Equine infectious diseases represent a major welfare concern. Biosecurity is relevant to the entire equestrian community, yet the extent to which existing guidelines are utilised in the nonracing equine population is unknown. Objectives: To describe the implementation of biosecurity practices and facilities available on a cross-section of nonracing equine premises. Study design: Cross-sectional. Methods: Postal questionnaires were administered to a random sample of horse-owners, requesting information on owners’ involvement with horses, equestrian premises, biosecurity practices undertaken and facilities available at the premises. Results: Useable response rate was 65% (n = 708/1091). 59% of respondents were leisure owners/riders (n = 415/708), with 92% (n = 638/696) having >10 years of equine experience. Handwashing facilities were available on 86% (n = 606/708) of premises. Regardless of availability, 59% (n = 414/707) of respondents reported rarely/never washing their hands prior to equine contact, with an association between lack of pre-handwashing and nonprofessional owners (P = 0.007), and 34% (n = 240/708) rarely/never washed their hands after contact. 42% of premises had a biosecurity plan (n = 248/594); this was positively associated with commercial premises (P<0.001). Dedicated isolation facilities were present on 54% (n = 364/679) of premises; most frequently a separate stable (52%) or field/paddock (43%). Presence of an isolation facility was associated with commercial premises (P<0.001). Most respondents vaccinated for influenza (89%; n = 627/705); however, professional owner status was associated with lower levels of influenza vaccination (P = 0.02). 58% of respondents (n = 412/706) owned/managed their premises, of which 77% (n = 296/387) reported having a protocol for new arrivals, with passport check and anthelmintic treatment undertaken during the study period. Anonymised scores of various types of CAM with owners. Ethical animal research: The project was approved by the University of Liverpool Veterinary Research Ethics Committee (астерisk VREC73). Source of funding: None. Competing interests: None declared.

9.40 Improving equine surgical safety through clinical checklists; identifying barriers to adoption
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Background: Safety culture is embedded in organisational culture and can be a predictive indicator of safety outcomes in human healthcare. The use of safety checklists has been given little focus in equine surgery as a method of improving clinical safety. Objectives: The aim of this pilot study was to study safety culture in a single equine hospital, to establish barriers to the introduction of a surgery checklist and identify barriers to implementation. Study design: Prospective survey of clinical staff. Methods: A validated veterinary safety culture questionnaire (Veterinary Clinical Checklists Evaluation: VREC73) was distributed to 13 (consenting) staff in the surgical suite of an equine hospital. The questionnaire focused on four main domains that can be used to assess safety culture: production pressures, staff perception of management, communication and technical skills. Subsequently an anaesthesia checklist intervention was adopted for 60 elective anaesthetics undertaken during the study period. Anonymised scores of respondents and consensus meetings were used to tailor the checklist. Results: The audit was undertaken during the study period. Anonymised scores of respondents and consensus meetings were used to tailor the checklist.
for each of the four domains were compared for individuals and between groups of staff using Mann–Whitney U test. **Results:** Clinical error was not identified as problem within the hospital. Differences between veterinarians and nurses were evident in communication and leadership domains (P = 0.003 and P = 0.04 respectively) with nursing staff being more negative about these aspects of safety culture. Areas contributing to potential errors included communication, handover, questioning hierarchy, and the role of audit. The results were used to implement change in the safety checklist. **Main limitations:** Sample size, survey-based meaning respondents may provide answers to hypothetical scenarios that differ from how they interact in real-life. **Conclusions:** Acceptance and adoption of a safety intervention was poor. Changes were made to the standard operating procedures following the study to embed aspects of the safety checklist into daily clinical practice. **Ethical animal research:** This study was approved by the ethical review committee of the School of Veterinary Medicine, University of Nottingham. **Source of funding:** Not applicable. **Competing interests:** None declared.


**9.50**

**Objective pain assessment in donkeys – scale construction**

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**Background:** Objective recognition of pain in horses has been studied extensively; however, studies on objective pain assessment in donkeys are limited, and the available scales are not validated. **Objectives:** This study describes scale construction and clinical applicability of a Composite Pain Scale (do-CPS) and a Facial Assessment of Pain scale (do-FAP) for acute pain in donkeys. **Study design:** Observational. **Methods:** The study included 159 adult donkeys (n = 44 patients, n = 115 control donkeys) which were directly observed at The Donkey Sanctuary. Patients were presented with lameness (n = 24), colic (n = 7), head related pain (n = 7) or post-operative pain (n = 6). Based on equine scales, specific potential elements and scores for donkeys were developed in a pilot study. The observers were not involved in donkeys’ clinical management. For each animal, the score of each element in both scales was assessed by two groups of independent observers. When applicable the patients were followed over time, once or twice daily. Patients and control groups were compared by Mann–Whitney U tests. **Results:** The inter-observer reliability was strong for do-CPS (R2 = 0.95, P<0.001) and good for do-FAP (R2 = 0.77, P<0.001). Patients had significantly higher pain scores, compared with control donkeys (P<0.001 for both do-CPS and do-FAP) and specificity overall for the do-CPS (73%), do-FAP (68%), and specificity do-CPS (99%), do-FAP (75%) were good. Sensitivity and specificity for ‘lameness’ were strong in do-CPS (92% and 100%, respectively). Sensitivity and specificity for ‘colic’ were strong for both do-CPS (71% and 100%, respectively), do-CPS (75% and 79%, respectively). **Main limitations:** Observers could not be masked to the patients’ condition. More patients are needed with painful conditions other than lameness. These scales will be validated in planned follow-up research. **Conclusions:** Objective pain assessment in donkeys is possible and may support objective evaluation of treatment of donkeys with acute pain. **Ethical animal research:** The study protocol was approved by The Donkey Sanctuary and their representatives gave consent for animals’ inclusion. **Source of funding:** The Donkey Studbook of the Netherlands and The Donkey Sanctuary provided support and facilities. **Competing interests:** None declared.


**13.30**

**The use of equine faecal volatile organic compounds as an indicator of risk for development of laminitis in pastured animals**

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**Background:** Metabolomics shows potential in clinical settings as a tool for screening for disease. It is widely recognised that exposure to pasture is a risk factor for laminitis, a significant cause of morbidity/mortality in horses. Noninvasive markers for risk of laminitis would improve welfare of pastured horses. **Objectives:** To describe volatile organic compounds (VOC) from faeces of pastured horses, with/without laminitis, to identify potential biomarkers for laminitis. **Study design:** Prospective case-control study. **Methods:** Horses presented to clinic for investigation of laminitis (diagnosed by vet) or health plan check were examined by a vet. Faecal samples were collected noninvasively from laminitic (L) and controls (C). Blood samples were collected for investigation of endocrinopathic status. VOCs were characterised using selected-ion flow-tube mass spectrometry (SIFT-MS) and gas-chromatography mass spectrometry (GC-MS) in conjunction with multivariate data analysis to distinguish between C and L. **Results:** There were no significant differences between L and C for age, sex, time at pasture or diagnosis of PPID. Laminitic horses had significantly higher body condition score, cresty neck score, serum [insulin] and plasma [glucose] than controls. SIFT-MS revealed no clear separation of L and C. GC-MS showed no clear separation of groups. However, five metabolites showed higher concentration in L compared with C, of which sphinganine showed the largest fold change. **Main limitations:** Included use of owner-managed, clinical cases at single time point, blood analysis during episodes of laminitis and use of...
faeces as biological sample. **Conclusions:** This study is the first to report faecal volatile metabolite from pastured horses with laminitis. A key finding was significant elevation in sphinganine, a marker of fumonisin B1 toxicity, measured by VOCs in faeces. Further studies are needed to assess this as a potential biomarker for laminitis. **Ethical animal research:** Sampling and metadata collection were carried out under University of Surrey ethics approval, with the informed consent of owners. **Source of funding:** The project was funded by a grant from the Animal Welfare Foundation. **Competing interests:** None declared.

### 13.40 Frequency and clinical signs of owner-reported laminitis in a cohort of horses and ponies in Great Britain

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**Background:** Previous robust epidemiological studies of equine laminitis have utilised only veterinary-diagnosed episodes of disease, potentially underestimating true disease frequency. **Objectives:** To estimate the frequency of, and describe clinical signs associated with, owner-reported active laminitis in horses/ponies, using both owner-recognised and/or veterinary-diagnosed episodes. **Study design:** Prospective cohort. **Methods:** Data were collected from horse/pony owners in Great Britain between August 2014 and December 2016. The incidence of owner-reported laminitis was estimated using both first incident and repeat episodes reported during the study period via a previously-validated laminitis reporting form. Owner-reported clinical signs present in these episodes were recorded. **Results:** A total of 1070 horses/ponies contributed 1066 horse-years at risk (HYAR), with 97 reported to have at least one active laminitis episode while enrolled. Nineteen horses/ponies had repeat episodes, resulting in a total of 123 active laminitis episodes reported, of which 50.4% (CI 41.6–59.2%; n = 62) were veterinary-diagnosed. Of the horses/ponies with owner-reported laminitis, 75.3% (95% Confidence Interval [CI] 66.7–83.8%; n = 73) had a laminitis history. The incidence of owner-reported active laminitis was 11.5 episodes/100 HYAR (CI 9.7–13.8). Episodes were reported across seasons with the combined monthly incidence being highest in May and lowest in March. Incidence was highest in Connemara and New Forest and lowest in Thoroughbred and Cob breed categories. The most prevalent owner-reported clinical signs (≥20%) included difficulty turning and a short/stilted or lame walk. Laminitis was reported in all limbs, with bilateral forelimb lameness being most common (62.9%, CI 54.1–71.7%). **Main limitations:** Self-selection enrolment resulted in an over-representation of pony breeds and horses/ponies with a previous history of laminitis. **Conclusions:** Laminitis remains a considerable year-round welfare issue affecting a number of breeds, with frequency estimates utilising owner-reported data being more representative of the true impact of the disease. Owner-reported prevalence of clinical signs was in keeping with previous veterinary-reported estimates. **Ethical animal research:** This study was granted institutional ethical approval from the Animal Health Trust (AHT01-2014) and the Royal Veterinary College (2014 0105H). Self-enrolment in the study was taken as informed owner consent. **Sources of funding:** Both the project and D. Pollard were funded by World Horse Welfare. C. E. Wylie was funded by The Margaret Giffen Charitable Trust. J. R. Newton was supported through a combined contribution to the Animal Health Trust’s Equine Infectious Disease Service from the Horserace Betting Levy Board (HBLB), Racehorse Owners Association (ROA) and Thoroughbred Breeders’ Association (TBA). **Competing interests:** None declared. **Acknowledgements:** The authors acknowledge the funders and all participating horse/pony owners.
14.00
How do owners perceive body condition and weight management of UK leisure horses?


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Background: Obesity is one of the leading welfare problems for UK leisure horses. However, there has been a lack of research regarding horse-owners’ perceptions of condition and weight management; research around these issues could highlight new ways of helping owners to monitor and manage their horse’s weight. Objectives: This study aimed to understand how horse-owners conceptualise the body condition of their horses, and the strategies used to manage their horse’s weight. Study design: Grounded theory analysis, a qualitative methodology. Methods: Semi-structured interviews were conducted with a diverse group of horse-owners (n = 26), exploring owners’ perceptions of their horse’s condition and their experience of weight management strategies. Results: Owners experienced great confusion around ideal equine condition; many owners felt unable to recognise when their own horse was overweight. Several owners used the horse’s abdomen as their main signifier of overweight. Owners who reported regularly monitoring weight became interested in observing change over time; regular measuring could therefore help owners to be more aware of equine weight changes. Weight management strategies ranged from strip-grazing to weight loss ‘boot camps’ for horses. Importantly, individuals had to consider which strategies would suit their personal circumstances as well as their horse’s wellbeing; weight loss strategies which took these factors into account appeared to be most sustainable for owners. Main limitations: Qualitative interviewing focuses on what people say they do; it would be useful to work alongside owners to observe whether there are differences in what they actually practice. Conclusions: Horse-owners described significant problems in assessing their horse’s weight, and in subsequently making changes in order to restrict weight. Understanding the owners’ perceptions, and particularly the need to construct individualised weight management plans, will provide useful insights for professionals who wish to assist owners in making changes.

Ethical animal research: This study was approved by the University of Liverpool ethics committee, and owners gave individual consent to participate. Source of funding: Horse Trust. Competing interests: None declared.

14.10
Lost in translation: examining communication between horse-owners and professionals about equine weight management


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Background: As one of the biggest welfare problems for UK leisure horses today, obese horses are seen regularly by equine professionals; however, no research has yet examined communication between owners and professionals about equine weight. In other fields, the use of behaviour change principles and communication skills have been shown to improve compliance with health-related behaviour change in human and veterinary medicine. Objectives: This study examined the reported experiences of discussion around equine obesity between equine professionals and horse-owners, to determine key components contributing to successful communications. Study design: Qualitative analysis. Methods: In-depth interviews were conducted with 26 horse-owners and 15 equine professionals (vets, nutritionists, farriers etc), and analysed qualitatively to determine common themes. Results: Owner priorities often appeared to be at odds with the concerns of professionals; owners perceived weight management to be embedded within their management of multiple, often conflicting, aspects such as the horse’s emotional and physical wellbeing, yard restrictions, and their own lifestyle, and hence behaviour change was complex. Conversely, many professionals perceived themselves as purveyors of information and felt that a ‘directive’ approach to weight management should encourage the owner to make changes. Professionals who were able to communicate effectively about obesity were those who employed a collaborative approach, building a relationship with the individual and taking time to discuss proposed strategies for change. Main limitations: This study utilised interviews which were retrospective in nature; it would be valuable to compare the language used in real-life conversations through observation. Conclusions: Time spent by professionals building relationships with owners and the application of communication skills consistent with the principles of behaviour change were received positively by horse-owners and assisted them in changing their behaviour; this information could be useful for equine professionals who wish to consult with owners on complex management issues.

Ethical animal research: This study was given approval by the University of Liverpool ethics committee, and owners gave individual consent to participate. Source of funding: Horse Trust. Competing interests: None declared.

14.20
Validity and repeatability of accelerometer activity tracking in horses and the effect of pasture management on time budget

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Background: Accelerometry is an accepted means of quantifying human physical activity. Quantitative physical activity tracking in horses and the effect of pasture management on time budget. Study design: Proof of concept. Methods: Accelerometers (ActiGraph) were positioned at the poll. Horses underwent 5 min of observed activity in three categories: standing, grazing and ambulating. Additionally, a 20-day study was undertaken on six horses at pasture. Receiver operating characteristic curve analysis, used on 10 second data epochs, calculated cut-off points between the activities. At pasture, time in each category (per day) was deduced; a Mann-Whitney U test was performed to compare standard vs. strip grazing and day vs. night grazing. Results: Cut-off values with the optimum sensitivity (94.7–97.7%) and specificity (94.7–96.8%) were found to be: +127.6 counts for standing, 127.7–702.7 counts for grazing, and +702.8 counts for ambulating. At pasture, time in each category was significantly different between standard and strip grazing. Conclusion: This study was given approval by the University of Liverpool ethics committee, and owners gave individual consent to participate. Source of funding: Horse Trust. Competing interests: None declared.
and night: standing: 32.95% vs. 50.97% (P<0.0001), grazing: 60.81% vs. 46.77% (P<0.0001), and ambulating: 4.57% vs. 2.40% (P<0.0001). **Main limitations:** Small sample size and lack of cut-off points of cut-off points on independent, “unseen” data. **Conclusions:** Accelerometry can distinguish activities in grazing horses repeatedly. Our proof-of-concept study demonstrates modifying pasture management influences activity, opening avenues for studies into obesity management.

**Ethical animal research:** The Clinical Research and Ethics Review Board at the Royal Veterinary College granted ethics approval for this study (URN: 2017 U109); all horse-owners gave written informed consent. **Sources of funding:** The Horse-racing Betting and Levy Board (HBLB) partially funded the activity trackers and electric fencing equipment in this project. **Competing interests:** None declared.

### 14.30 Efficacy of a novel palatable pergolide paste formulation for the treatment of pituitary pars intermedia dysfunction (PPID) in ponies

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**Background:** The licensed treatment for PPID is a pergolide mesylate paste. Palatability of the tablet is poor and accuracy of dosing the drug is limited when tablets have to be split. Alternatives are needed but pergolide is an unstable molecule and formulations need to be evaluated critically.

**Objectives:** To assess efficacy of a palatable pergolide paste in clinical cases. **Study design:** Retrospective review of clinical cases. **Methods:** Clinical records of 19 ponies that had been refractory to treatment with the licensed pergolide tablet and were subsequently treated with a palatable pergolide paste (BOVA UK) were reviewed and clinical and endocrinological data were analyzed. PPID was diagnosed if there were clinical signs and adrenocorticotropic hormone (ACTH) concentration was >50 pg/mL in July (10 ponies, NAUT group) or >100 pg/mL from August to October (9 ponies, AUT group). All ponies were re-examined after 1 month of treatment. In October, November and after 6 months of treatment, clinical and endocrinological data were analyzed. PPID was diagnosed if there were clinical signs and adrenocorticotropic hormone (ACTH) concentration was >50 pg/mL in July (10 ponies, NAUT group) or >100 pg/mL from August to October (9 ponies, AUT group). All ponies were re-examined after 1 month of treatment. In October, November and after 6 months of treatment, clinical and endocrinological data were analyzed.

**Results:** ACTH concentrations improved significantly with treatment and returned to within reference range in 14/19 cases (74%). Median ACTH concentration improved from 110 to 37 pg/mL (NAUT group) and from 206 to 25 pg/mL (AUT group). There was no significant difference in insulin concentration in association with treatment in either group. Clinical signs (44 signs in 19 ponies) improved markedly, mildly, did not improve or deteriorated in 31%, 12%, 43%, 4% and 10%, respectively. There were no clinically relevant changes on haematological or clinical chemical examinations following treatment. One pony developed laminitis on treatment, two became inappetant (which resolved with dose reduction) and one pony refused to eat the paste. **Main limitations:** Small numbers. **Conclusions:** The palatable pergolide paste preparation was effective and safe in ponies with PPID. **Ethical animal research:** Informed consent was obtained from all owners to use an unlicensed product and to publish clinical data. The study was approved by The University of Nottingham Animal Welfare and Ethical Review Body. **Sources of funding:** The cost of the treatment was subsidised by BOVA UK and the cost of laboratory fees was subsidised by Rainbow Equine Lab. **Competing interests:** D. Rendle has received payment for consultancy services provided to BOVA UK.

### 14.40 Aminoglycoside antibiotics: still essential in equine practice?

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**Background:** Legislative restriction on the use of aminoglycoside antibiotics and cascade use of antimicrobials has been proposed, either of which may impact on equine clinical practice. **Objectives:** To describe aminoglycoside use in clinical practice. **Study design:** Prospective survey of veterinary surgeons. **Methods:** An electronic survey was developed, trialled, and distributed through email distribution lists; consent was implied through active participation. Data are presented as median scores. Differences between responses were compared using chi-squared analysis. **Results:** 166 respondents completed the survey. The majority of respondents (66.9%) use gentamicin, with specialists using it more frequently than non-specialists (P<0.0001). Amikacin was used by 59.6% of respondents; frequency of use was less than for gentamicin (P<0.0001). Gentamicin was used intravenously, by inhalation and IVRA (65.1%, 18.6% and 28.3%, respectively), more frequently than amikacin by these routes (30.1%, 3.4% and 19.3%). Amikacin was used more than gentamicin intra-arterially (51.8% vs. 24.1%). Bacterial sensitivity was used prior to use of gentamicin for 35.9% of responses to 20 clinical scenarios across the scores. First line empirical use was selected for 74.2% of responses that did not include lower airway infection. Majority of respondents used gentamicin at a dose of 6.6 mg/kg bwt, with higher doses being described by 13.7% of respondents for use in the otherwise healthy adult, 18.5% when treating the adult with sepsis, 65% when treating the otherwise healthy foal and 48.5% when treating the foal with sepsis. **Main limitations:** Survey responses may not accurately reflect behaviour in clinical practice. **Conclusions:** Aminoglycosides remain widely used, especially in specialist clinical practice. They are commonly used for indications outside the UK marketing authorisation without the use of culture and sensitivity. Restrictions on aminoglycoside use would have significant impact on clinical practice. Opportunities exist to enhance stewardship relating to aminoglycoside antibiotic use including development of a guideline on prudent use. **Ethical animal research:** This study was undertaken on behalf of, and approved by, the Medicines Working Group of the Federation of European Equine Veterinary Associations. **Sources of funding:** None. **Competing interests:** None declared.

### 14.50 Influences of age and disease on peak and trough plasma gentamicin concentrations in horses

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**Background:** Gentamicin is used commonly in the treatment of Gram-negative bacterial infections of equids. Adequate peak and trough gentamicin concentrations are crucial for effective therapeutic use and to prevent toxicity. **Objectives:** To determine if peak and trough
plasma gentamicin concentrations alter with patient age and disease state. **Study design:** Retrospective case series. **Methods:** Records were reviewed to identify all horses and ponies admitted to a single equine hospital between 2005 and 2016 that underwent therapeutic drug monitoring of plasma gentamicin concentration. Clinical records were reviewed to obtain patients’ age, sex, breed, date of admission, date of gentamicin assay, peak plasma gentamicin concentration, trough plasma gentamicin concentration, serum urea concentration, serum creatinine concentration and current diagnosis. A linear mixed effects model was produced to consider the influences of age, sex, breed and current diagnosis on peak plasma gentamicin concentration. **Results:** Peak and trough plasma gentamicin concentrations were available for 229 patients. Horses aged less than 1 year old and horses with respiratory disease had lower peak plasma gentamicin concentrations than all other groups (P<0.01 and P<0.01). All extrapolated 24-h trough plasma gentamicin concentrations were less than 0.5–2 µg/mL. **Main limitations:** Serum urea and creatinine concentrations after gentamicin treatment were not included in the separate disease groups.

**Conclusions:** Patient age and disease status should be considered when calculating initial gentamicin dose. Therapeutic drug monitoring allows for gentamicin dose adjustment, which may be particularly important in young horses and those with respiratory disease. **Ethical animal research:** Research ethics committee oversight not required by this journal: *Researcher has no conflicting interests.*

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**15.00**

**High carriage of multi-drug resistant ESBL-producing *E. coli* isolated from horses at five equine hospitals in the UK**

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**Background:** Antimicrobial resistance (AMR) threatens the efficacy of antimicrobials in equine patients. Extended-spectrum β-lactamases (ESBL) confer resistance to third generation cephalosporins (3GC) and are often associated with multi-drug resistance (MDR, resistance to ≥3 antimicrobial classes) in *Escherichia coli*. **Objectives:** To determine the prevalence, patterns and risk factors of ESBL-producing faecal *E. coli* carried by horses at five UK equine hospitals. **Study design:** Prospective multicentre cross-sectional study. **Methods:** Each hospital was sampled for 3 weeks: faecal samples and data were collected daily from inpatients. Samples were inoculated on to Harlequin agar+cefotaxime (3GC), incubated overnight at 37°C and were confirmed as ESBL-producers by double-disc diffusion test, with susceptibility performed against clinically relevant antibiotics. Additional ESBL-producing *E. coli* were screened by PCR assay for relevant ESBL genes. **Results:** 753 faecal samples were collected from 217 horses. ESBL-producing *E. coli* were detected in 46.1% samples (n = 347) (range 22.6–88.2% between hospitals). AMR was detected to cefotaxime (93.4% n = 325), gentamicin (91.4% n = 317), trimethoprim/sulfamethoxazole (85.9% n = 298), doxycycline (85.0% n = 295) and enrofloxacin (27.1% n = 94), with MDR detected in the majority (94.2%) of samples with ESBL-producing *E. coli*. The blaCTX-M gene responsible for ESBL-phenotype was detected in 91.4% of samples. Ongoing analysis aims to identify other genes responsible for the resistance phenotypes. **Main limitations:** The high prevalence of multidrug resistant bacteria cultured from these horses represents faecal carriage rather than clinical infections and their role in the spread of hospital-acquired infections needs further investigation. **Conclusions:** This study demonstrated a high prevalence of ESBL-producing *E. coli* from faeces of hospitalised horses with a high proportion of MDR isolates; however, there was wide variation between hospitals. Strategies aimed at identifying and limiting risk factors associated with carriage are important to reduce AMR in hospitalised patients. **Ethical animal research:** Approval by University of Liverpool’s Ethical Review Committee. Owner informed consent not stated. **Source of funding:** C.M. Isgren’s PhD is funded by the Horse Trust and E. Winward’s summer project was funded by the Wellcome Trust. **Competing interests:** None declared.

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**15.10**

**Efficacy of long-acting injectable omeprazole (LAIOMEP) in the management of equine glandular gastric disease (EGGD) and equine squamous gastric disease (ESGD)**

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**Background:** ESGD and EGGD are common causes of morbidity; more efficacious treatments would improve animal welfare. **Objectives:** To further evaluate long-acting injectable omeprazole (LAIOMEP) in clinical cases in the UK. **Study design:** Retrospective review. **Methods:** Clinical records of horses treated with LAIOMEP (BOVA UK) at Rainbow Equine Hospital were reviewed. Horses with EGGD or ESGD received IM injections of LAIOMEP on Days 1 and 7 and had repeat endoscopy performed on Days 11–19. If lesions had not resolved, then one or two further injections were administered at 7-day intervals and endoscopy was repeated around 7 days thereafter. Recommendations for diet and management were standardised. Clinical signs were assessed by owners. Endoscopy images were anonymised and reviewed by DR who was blinded to the identity of the patient and the stage of treatment. **Results:** 31 cases of EGGD and 29 cases of ESGD were identified in 36 horses. Clinical signs were resolved or improved in 48% and 87% of EGGD cases and 52% and 90% of ESGD cases at 2 weeks. Clinical signs resolved in a further 13% and 3% of EGGD and ESGD cases by 4 weeks. Gastric lesions resolved or improved in endoscopic appearance in 58% and 86% of EGGD cases and 86% and 96% of ESGD cases at 2 weeks. By 4 weeks lesions had resolved in 81% of EGGD cases and 100% of ESGD cases. Six localised injection site reactions were observed in four horses from a total of 116 injections (5%); they were not associated with pain, did not require treatment and did not result in long-term complications. **Main limitations:** Small numbers and absence of a control population. **Conclusions:** LAIOMEP is a safe and effective treatment for EGGD and ESGD and resulted in more rapid healing in the study population than has been reported previously. **Ethical animal research:** Information of client consent was obtained from all owners to use an unlicensed product and to publish clinical data. The study was approved by The University of Nottingham Animal Welfare and Ethical Review Body. **Sources of funding:** None. **Competing interests:** D. Rendle has received payment for consultancy services provided to BOVA UK but received no payment for involvement in this study.
Owner satisfaction and outcomes following diode laser excision of sarcoids

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Background: There are few previous studies on the surgical success following diode laser excision of sarcoids with minimal detailed assessment of owner satisfaction.

Objectives: To describe the surgical outcomes and owner satisfaction following 980 nm laser excision of sarcoids.

Study design: Retrospective case series. Methods: All cases which underwent laser excision of skin tumours believed to be sarcoids between January 2013 and July 2017 at Chine House Veterinary Hospital were included in the study. An owner questionnaire regarding outcomes and complications of laser surgery was completed either online or by telephone interview. Contact was made at least 6 months after surgery.

Results: In total 84 horses were eligible for inclusion. Fourteen owners could not be contacted and five owners were unwilling to participate in the data collection. The mean age at which sarcoids were noted by the owner was 5.2 years; the mean age for surgical treatment was 6.7 years. Previous treatment had been performed in 23.1% (15/65) of cases. Following surgery, recurrence of sarcoids at a surgical site occurred in 24.6% of horses (16/65) with half (8/16) occurring within 3 months. New sarcoids developed in 16.9% of cases (11/65). Overall, 64.6% (42/65) had no regrowth or new sarcoid formation by 6 months; however, in horses with fewer than six sarcoids the success rate was 79.2% (42/53). Owners were happy with the cosmetic outcome in 87.7% (57/65) of cases and 90.7% (59/65) would use laser excision again in the future. In nineteen (n = 65) cases owners reported the overall length to complete healing to be greater than 8 weeks. Main limitations: Retrospective study of clinical records from single veterinary practice. Conclusions: Overall owner satisfaction was excellent. The main concerns of owners were the size of the wound following surgery and an expectation of more rapid healing of surgical sites.

Ethical animal research: The project has been approved by the School of Veterinary Medicine and Science, University of Nottingham Ethics Committee. Owner informed consent for inclusion of animals in this study was not stated.

Source of funding: None.

Competing interests: None declared.

Orthopaedics

Chair: Andrew Fiske-Jackson

Sponsor: HBLB

Voorjaarsdagen Award Winner 2018

Chair: Andrew Fiske-Jackson

Sponsor: HBLB

Clinical, ultrasonographic and histopathological findings in six horses with Descemet’s membrane detachment


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Background: Descemet’s membrane detachment (DMD) is infrequently reported in horses. Objectives: To describe the clinical features, diagnostic findings and histopathologic results in a series of six horses with DMD. Study design: Retrospective case series. Methods: Case records of horses diagnosed with DMD on histopathology were reviewed. Results: Six horses were included in the study. Breeds included two Dutch Warmblood horses, two Icelandic horses, one Appaloosa and one Welsh pony. Median age at presentation was 13.5 years (range 11–24). Clinical signs were unilateral in all horses and included; blepharospasm and epiphora (5/6), moderate to severe focal or diffuse corneal oedema (5/6), corneal stromal bullae (4/6), corneal neovascularisation (4/6), buphthalmos (4/6), Haab’s striae (2/6), corneal endothelial precipitates (1/6), fibrin in the anterior eye chamber (1/6), and pigment deposits on the anterior lens capsule (1/6). During transpalpebral ultrasonography, a marked linear echogenic structure was noted in the anterior eye chamber parallel to the posterior lining of the cornea. It converged with the posterior cornea in the periphery. In all cases the cornea was severely thickened and echogenic, consistent with the corneal oedema, and DMD was suspected. In all horses, clinical signs progressed and the affected eye was eventually enucleated. All eyes were examined histopathologically, and DMD was confirmed in all six. Main limitations: Small number of cases. Conclusions: In our case series, ultrasonography was a valuable tool for evaluation of the posterior cornea for DMD in horses with moderate to severe corneal oedema. Concurrent eye diseases included uveitis and glaucoma; however, the exact cause of DMD remains unknown. Prognosis for globe retention in eyes with DMD was poor in our study. Ethical animal research: Research ethics committee oversight not required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated. Source of funding: None. Competing interests: None declared.
Background: There is a need to improve therapies for osteoarthritis in horses. Objectives: To assess the efficacy of chondrogenic induced mesenchymal stem cells combined with equine allogeneic plasma (the investigational veterinary product [IVP] Arti-Cell® Forte) in 12 healthy horses using an ostechondral fragment-groove model. Five weeks after surgery, horses were treated intra-articularly with either the IVP or with a placebo control product (CP). Horses underwent a weekly assessment of joint effusion and lameness (visually and using inertial sensor measurements) from surgery until the study end (11 weeks). Before surgery and at Week 5, Week 5+1day, Week 7, Week 9, and Week 11, synovial fluid was collected for cytology and biomarker analysis. At the study end, all horses were euthanased to allow macroscopic and histologic examination of the osteochondral fragment-groove model.

Results: Visual lameness scores and vector sums were significantly reduced in the IVP vs. the CP group. Additionally, joint effusion was significantly ameliorated in the IVP group. Significantly higher viscosity of the synovial fluid was noted in the IVP group, while the CP group presented a higher glycosaminoglycan concentration. On necropsy, significantly less synovial hyperaemia and wear lines were present in the IVP group. Additionally, a significantly higher area percentage of cartilage oligomeric matrix protein, collagen type II and glycosaminoglycans was seen in the articular cartilage of the IVP group.

Main limitations: This study assessed the short-term effect of the IVP on a limited number of horses, using an osteoarthritis model. Conclusions: Equine allogeneic chondrogenic induced mesenchymal stem cells combined with equine allogeneic plasma seems a promising treatment for osteoarthritis in horses.

Ethical animal research: The study protocol was approved by the local ethics committee of Global Stem cell technology (approval number EC_2015_002; Permit Number: LA1700607). Sources of funding: Flemish Agency for Innovation and Entrepreneurship (Vlaio, grant number 130543) and Global Stem cell Technology NV.


16.20

The influence of rider weight on exercise-induced changes in thoracolumbar dimensions and epaxial muscle tension and pain

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Background: There is increasing debate concerning the optimal rider:horse bodyweight ratio. Objectives: To investigate the effect of rider:horse bodyweight ratio on thoracolumbar dimensions and epaxial muscle tension and pain. Study design: Prospective, randomised, cross-over pilot. Methods: Six horses in regular work were ridden by four riders of comparable ability, but differing rider:horse bodyweight ratios (>10±2%M = Light), >12±15%M (>Moderate), >15±18%H (H = Heavy) and >20%H (>Very Heavy)). A 30 min exercise test, predominantly in trot and canter, was performed. Test abandonment criteria relating to lameness or behaviour were predetermined. Horse thoracolumbar width at predetermined sites and epaxial muscle tension and pain were assessed before and after ridden exercise. Saddle-fit for horse and rider was assessed.

Results: All tests for riders H and VH were abandoned (after mean = 16.6 and 8.3 min, respectively). The mean change in thoracolumbar width after exercise was significantly different between rider L and riders H and VH (P = 0.02). Mean thoracolumbar width increased with riders L and M (3.9% and 1.9%, respectively) and decreased with riders H and VH (-3.4% and -2.8%, respectively). There was no significant increase in tension or pain scores for rider L; tension scores increased significantly for riders M and H (P<0.05) and there was a trend for increased pain score for rider VH (P = 0.08). Main limitations: The saddles were too small for riders H and VH; saddle-fit was not ideal for each horse. Although potential confounders, this represents a ‘real life’ scenario, such as that at a riding school.

Conclusions: High rider:horsebodyweight ratios negatively influenced thoracolumbar width changes with exercise and positively influenced development of tension and pain. Excessive rider weight may accentuate the negative effects of an ill-fitting saddle.

Ethical animal research: The study was approved by the Animal Health Trust Clinical Ethical Review Committee (AHT 28-2016). Sources of funding: World Horse Welfare, the Saddlle Research Trust, Frank Dyson, British Equestrian Federation, British Horse Society, Pony Club, UK Polocrosse Association, The Showing Council, The Showing Register, The Society of Master Saddlers, Riding for the Disabled, British Eventing, British Dressage, the British Horse Foundation, the Worshipful Company of Saddlers and Endurance GB.

Competing interests: None.

16.30

The influence of rider bodyweight on salivary cortisol concentrations and spontaneous blink rate for horses performing a standardised exercise test

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Background: Judgements concerning optimal rider weight for horse size are rarely inferred by objective science, despite the potential welfare ramifications of a heavy rider on a mismatched horse. Objectives: To measure the equine stress response to riders of differing weight. Study design: Prospective, cross-over, randomised trial. Methods: Six horses in regular work, 500–600 kg bodyweight, were ridden by four riders (rider:horse bodyweight ratio 10–12%M = Light), >12±15%M (>Moderate), >15±18%H (H = Heavy) and >20%H (>Very Heavy)), in a standardised dressage test lasting 30 min. The test was abandoned for grade 3 lameness or demonstration of ≥10 behavioural
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Background: Little is known about the effect of training on muscle morphology because of a lack of standardised equine studies. Objectives: (1) comparing muscle morphometric changes induced by dry treadmill training (DT) vs. aquatraining (AT), (2) comparing metabolic profiles of the pectoralis profundus (PP) muscle and vastus lateralis of the quadriceps femoris (QF) muscle trained Friedman (DT) in untrained Friesians (DTBefore) and untrained Warmblood horses. Study design: Prospective clinical study. Methods: Twelve untrained Friesians were subjected to two different training programmes: seven horses completed 8 weeks of AT, five horses a DT training programme. Morphometric assessment of 15 muscles was performed at start, after 4 weeks and at finish using ultrasound. Muscle biopsies were harvested from the DTBefore and DTAfter group at start and finish from the PP and the QF. Metabolomic profiling was performed by (RP) UPLC-MS/MS and HILIC/UPLC-MS/MS. Results: (1) AT increased muscle diameter of the cervical and thoracic part of the trapezius muscle, brachiocephalicus, QF, semitendinosus, semimembranosus and the thoracic part of the erector spinae (2) DT significantly increased long chain and decreased medium chain acylcarnitines in PP and QF. Early and late stage glycolytic intermediates and pentose-phosphate pathway intermediates were significantly increased in the QF. A significant increase in oxidised glutathione and intermediates of the glutamate/glutamin metabolism and decrease in glycine and acetyl-glycine was found in the PP (P<0.05). Main limitations: The effect of AT on muscle metabolomics was not studied. Conclusions: AT causes hypertrophy of muscles in the forelimb, back, and hindlimb, particularly muscles involved in forelimb elevation and forward movement, flexion of the hindlimb and muscles used for spine extension. Following 8 weeks of DT, an upregulation of fat oxidation and glycolysis in QF muscle was shown, while the muscle PP showed an upregulation of a fat oxidation and amino acid metabolism. Competing interests: None declared.

16.50
The effect of sole padding and packing materials on impact vibration in a group of military horses
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Background: Sole-padding and packing materials may affect foot-surface impact vibration. They warrant further investigation due to the diversity of products and their potential to affect horse soundness and performance. Objectives: To determine the effect of three experimental shoeing conditions on impact vibrations. Study design: Experimental, quantitative analysis of impact vibration. Methods: Seventeen military horses were allocated to one of three experimental shoeing groups: ‘firm’ sole-padding, ‘soft’ sole-packer and ‘leather pad’. Horses were equipped with a single forelimb, high-range accelerometer (1000x gravity, 5000 samples/s) and trotted in-hand under a ‘steel shoe’ baseline condition followed by the experimental shoeing condition of their group. Foot-surface impacts were extracted from the accelerometer output and a Fast Fourier Transform applied from impact for 30 ms. Impact vibrations were characterised in terms of total (TOTAL) and maximum signal power (MAX). Frequency at MAX (fqMAX) was expressed as low (centre frequency ≤315 Hz), low-middle (314–625 Hz), middle-high (626–938 Hz) and high (≥939 Hz). A linear mixed effect model (TOTAL, MAX) and a generalised linear model (fqMAX) categories (‘firm’, ‘soft’ and ‘leather pad’) were used to test for differences between shoeing conditions. Results: In the ‘firm’ group (n = 6), proximodistal TOTAL and MAX were significantly greater under the experimental condition compared with the baseline (both P<0.0001). The proportion of foot-surface impacts in the ‘middle-high’ and ‘high’ fqMAX categories increased significantly between baseline and experimental shoeing conditions (P<0.001). No significant differences between the baseline condition and the other two experimental shoeing conditions were detected. Main limitations: To reduce hoof damage it was only possible to assess one experimental shoe condition per horse, which always followed the assessment of the baseline condition. Conclusions: In this study a firm sole-packer increased impact vibration power.
and fqMAX. This differs from previous work. Horse type and surface properties may influence the effect of sole-packers on impact vibration. Further work is needed to fully understand the shoe-surface interaction. Ethical animal research: Informed owner consent was obtained and the study was approved by the Royal Veterinary College’s Ethics and Welfare Committee. A representative of the Household Cavalry Mounted Regiment gave informed consent for the horses’ inclusion in this study. Sources of funding: Royal Veterinary College and Singapore Turf Club ethical committees. Informed consent for their animals’ inclusion in the study was given. Sources of funding: Horserace Betting Levy Board (HBLB). Competing interests: None declared.

17.00

Location specific bone strains in dorsal McIII and dorsoproximal P1

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Background: Knowledge of strain magnitudes and directions at injury prone sites of the equine third metacarpal (McIII) and phalangeal (P1) bones will improve our understanding of injury pathogenesis. Objectives: We hypothesised that principal and shear strain (SS) patterns, magnitudes and directions would differ among dorsosphyseal McIII, dorsodistal McIII and dorsoproximal P1 regions and would relate to McIII and P1 fracture patterns. Study design: An in vitro biomechanical study of equine cadaver limbs. Methods: Bone surface strains were measured on McIII and P1 during sinusoidal limb loading (0.25 Hz, displacement control) to 10,500 N using nine cadaver forelimbs. Rosette strain gauge data from seven sites (dorsosphyseal McIII, dorsodistal McIII [medial, middle, lateral] and dorsoproximal P1 [medial, middle, lateral]) were reduced to principal and SS magnitudes and directions. The effects of bone and gauge positions on strain magnitudes and directions were assessed using a mixed-model ANOVA for repeated measures (P<0.05). Results: The magnitude of principal compressive and SS at dorsosphyseal McIII had multiple fluctuations during the loading cycle, whereas strain in dorsodistal McIII and dorsoproximal P1 increased smoothly. For dorsodistal McIII locations, only medial-vs.-lateral principal compressive and SS were significantly different. On dorsoproximal P1 more differences were noted, primarily between medial-vs.-lateral and medial-vs.-middle sites, for principal strain magnitude and direction. Mean tensile and compressive principal strain directions were: -15° and 75° for dorsodistal McIII and 13° and 103° for dorsoproximal P1, respectively. Main limitations: In vitro experimental system using the equine limb. Conclusions: Strain patterns were distinct for each anatomical location reflecting different temporal loading patterns between distal McIII and dorsoproximal P1. Principal compressive and tensile strain of distal McIII and proximal P1 demonstrated different directions, consistent with different loading mechanics for each bone. These data should be useful for further understanding of equine distal limb fracture biomechanics and related in vitro and in silico work. Ethical animal research: informed consent was obtained for use of post-mortem material. Source of funding: Internal funding. Competing interests: None declared.

17.10

Effect of surface type on head and trunk movement asymmetry in racing Thoroughbreds during in-hand trot-ups

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Background: Different surfaces are used for exercise and lameness detection. Musculoskeletal injury occurs in racing Thoroughbreds. Inertial measurement unit (IMU) data has not previously been compared between surfaces in racing Thoroughbreds. The different biomechanical constraints imposed by different surfaces may aid detection of injuries. Objectives: To compare the effect of surface on IMU derived movement asymmetry during in-hand trot-ups. Study design: Cross-sectional experimental study with quantitative gait analysis. Methods: 18 flat racing Thoroughbreds were asked to trot in-hand over different surfaces: concrete, hard rubber, polytrack, tapeta and turf at the Singapore Turf Club whilst equipped with a wireless IMU gait analysis system. Movement asymmetry parameters were calculated from vertical displacement of head, withers, tubers sacrale and coxae. Linear mixed models with movement asymmetry parameter as dependent variable, horse as random factor, surface as fixed factor and stride time as covariate tested for differences between surfaces (P<0.05, Bonferroni post-hoc test). Results: Movement asymmetry parameters ranged from -31.50 mm to 27.69 mm indicating the level of asymmetry in the population. Differences between displacement minima (P = 0.012) and maxima (P = 0.045) of the tuber sacrale movement were found to be significantly different between surfaces. Post-hoc tests revealed a significant difference between rubber (estimated marginal mean minima -8.38, maxima -6.86) and tapeta (estimated marginal mean minima -3.69, maxima -2.40). Main limitations: Sources of limitations included variation of the number of strides over which the data were evaluated and that due to the temperament of the horses, they required to be trotted by two handlers, which may have led to an alteration in head nod. There are no sources of bias to declare. Conclusions: This study has shown a difference in pelvic movement asymmetry between surfaces in Thoroughbreds, highlighting the potential for assessment on different surfaces to influence the detectability of asymmetries below the reported visual threshold. Ethical animal research: Approved by the Royal Veterinary College and Singapore Turf Club ethical committees. Informed consent for their animals’ inclusion in the study was given. Sources of funding: Horserace Betting Levy Board. Competing interests: None declared.

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Effect of tree width on kinematics of the thirteenth thoracic vertebra, thoracolumbar dimensions, saddle pressures and limb kinematics

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Background: The cranial portion of the saddle (twist) is at its narrowest in the region of the thirteenth thoracic vertebra (T13). Objectives: To evaluate the effect of saddle width on T13 kinematics, dimensions, saddle pressures and locomotion. Study design: Intervention study. Methods: 13 horses considered non-lame by a veterinarian (mean ± s.d. age 12 ± 8.77 years, height 1.65 ± 0.94 m) were ridden by...
the same rider. Correctly fitted saddles (assessed by five qualified saddle fitters) were altered to narrow and wide fit. Horses were equipped with: skin markers at 24 anatomical locations, inertial measurement unit positioned at T13 and a Pliance pressure mat beneath the saddle. Data were collected in trot, on left and right rein, and thoracolumbar dimensions (flexicurve) taken pre and post each condition. Left and right rein data were pooled and limb, thoracic spine range of motion (ROM), saddle pressures and thoracolumbar dimensions were compared between saddle widths using a general linear model with repeated measures and Bonferroni post hoc correction (P≤0.05). Results: Compared with the correct and narrow fitted saddle, in trot with the wide saddle showed: increased peak pressures either side of T13 (P = 0.004); reduced thoracolumbar dimension at T13 (P = 0.03); a decrease in T13 latero-lateral ROM (P = 0.001); decrease in vertical ROM of T13 (P<0.0001). With the narrow saddle compared with the correct and wide fitted saddle: increased pressures at the rear of the saddle (P = 0.01); increase in carpal (P = 0.0001) and tarsal (P = 0.01) flexion; increase in ROM of T13 in a latero-lateral direction (P = 0.004); decrease in vertical ROM of T13 (P = 0.003). Main limitations: Only trot was studied. Conclusions: Saddle width has an effect on limb, T13 ROM, saddle pressures at T13 and thoracolumbar dimensions, likely as a result of the instability caused by a narrow/wide saddle. Further work is needed to understand the mechanics behind these changes. Ethical animal research: Informed client consent was obtained for all animals used in the study. Source of funding: Society of Master Saddlers. Competing interests: None declared.
The role of ridden lameness evaluation

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The lameness diagnostician relies on the ability to recognise symmetrical (sound) and asymmetrical (lame) gaits. Historically, gait assessment (i.e. the lameness examination) is performed while the horse is walking and trotting with its handler. This method of lameness evaluation dominates the equine veterinary literature and is the basis for nearly all lameness grading systems. It is the best way to assess a ‘head nod’ and/or ‘pelvic hike’ upon which lameness is localised to a limb or limbs. Despite its inherent value, the horse’s gait in-hand may not accurately represent the gait in the ridden horse. This is particularly true in sport horses when specific movements, sport-specific gaits, and/or changes of pace such as canter-to-trot transitions are not only training but competition elements of the horse’s performance. For these athletes, the role of the ridden lameness evaluation becomes an important diagnostic tool for the lameness detective.

Poorly performing riding horses can exhibit a wide array of abnormal gait characteristics such as overt limping, reluctance to go forward, resistance in the bridle, hopping-type gait, loss of rhythm, bucking and/or rearing [1]. Many of these pain-related performance abnormalities are only apparent or exacerbated with a rider [2]. Traditionally, most of these ridden abnormalities have been attributed to back pain. Although the addition of a saddle and weight changes the mechanics of the back resulting in increased back extension [3], lame horses similarly adapt their gaits by stiffening the thoracolumbar–sacral region [4]. The addition of a rider’s weight also causes increased limb loading [5] whereby mild pain-related lameness may worsen, causing the horse to be lame when ridden despite being sound in-hand. Posting (rising) trot causes uneven loading of limbs, with peak forces higher on the sitting trot diagonal compared with the rising trot diagonal [6]; sitting on the left diagonal increases the forces on the corresponding left front and right hindlimbs. Subsequently, this uneven weight during rising trot, particularly changing diagonals, can be used not only for the detection of lameness but also determining which leg is the lamest; hindlimb lameness is often worse when the rider sits on the diagonal of the lame leg [1]. In addition to uneven stresses on the limbs, rising trot also creates asymmetrical stresses on the back. Maximal back flexion occurs during the unloaded rising trot stride and maximal extension during the loaded sitting trot stride [3]. However, changes in back movement are not strictly limited to rider positions. Limb lameness also results in back hyperextension [4]. This resultant thoracolumbar stiffness is often perceived as back pain by the rider even when the underlying pain and decreased back flexibility is due to limb lameness.

Although the mere presence of a rider can influence the incidence of lameness, rider effects on an individual horse cannot be predicted [7]. Some horses will be lame in-hand and sound with a rider, and vice versa, and the prevalence of lameness may be related to the rider’s skill level [7]. Professional riders may mask underlying gait abnormalities while unbalanced beginners may exaggerate asymmetrical gait conditions. For all riders, accurate identification of lameness and/or localisation of the lame limb is often difficult and a ‘higher-propped-up’ and/or ‘owner-sounded’ horses are lame when assessed comprehensively by a skilled lameness diagnostician [8]. Another rider–horse interaction includes saddle fit. Ill-fitting saddles can cause primary back pain [1] and ridden gait abnormalities. Saddle slip, where the saddle consistently slips to one side of the horse’s back, was traditionally thought to be due to poor saddle fit. However, current research indicates that lameness influences the presence of saddle slip, with most saddles slipped to the side of the lame hindlimb [9].

Similar to in-hand lameness examination, diagnostic analgesia is an essential tool by which the lameness detective can authenticate the underlying source(s) of pain in the ridden horse. Resolution of limb lameness after nerve blocks may also eliminate the saddle slip and the rider’s perception of back pain, illustrating its high diagnostic value in the riding horse. Albeit time-consuming, nerve blocks should be performed in a systematic and thoughtful manner, since ‘best guesses’ frequently result in improper diagnosis and treatment followed by continued poor performance in the athletic horse.

Although ridden evaluation is not a substitute for in-hand lameness assessment, it can enhance the clinician’s ability to detect and localise lameness. Keen observations of the horse moving with and without a rider are paramount for the lameness diagnostician.

References
Evaluation of the ‘sore backed horse’ – is an objective evaluation possible?

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Back pain/dysfunction is commonly implicated by owners as a cause of poor performance, but it is challenging to arrive at a secure diagnosis [1]. As veterinarians, we are frequently tasked with establishing whether a horse truly does have back pain. If there is a clinical suspicion of back pain the next step is to work out whether it is primary, or secondary to another orthopaedic problem such as hindlimb lameness. When looking for an objective measure of back pain the first problem encountered is the lack of a ‘gold standard’ test. Intuitively, pain on palpation and bucking when ridden are the most frequent signs attributed to back pain by practitioners. A number of kinematic studies have been performed which have assessed the response of the back to pain. If lactic acid is injected unilaterally into the longissimus dorsi muscle, increased extension of the caudal back is noted as part of an overall increased flexion/extension [2]. However, in a study of horses adjudged to have natural back pain, diminished flexion/extension movement at or near the thoracic lumbar junction was observed [3].

Optical motion capture (mocap) is the gold standard to assess three-dimensional movement and orientation of back movement with a high degree of accuracy. However, in practice its use is restricted to a gait laboratory and/or a treadmill that requires habituation and is known to cause kinematic changes [4]. An alternative technique for collecting kinematic data is the use of (wireless) inertial sensors. These consist of small, lightweight sensors mounted on the horse allowing data to be collected during unrestricted movement [5–8]. This allows investigation in a routine setting and can be used alongside assessment of lameness [8–10] and horse–rider interaction [11]. When compared to mocap, inertial sensor displacement and symmetry data show acceptable accuracy and good levels of consistency for assessment of back movement [12].

Horses adapt to hindlimb lameness by extending the thoracolumbar region and decreasing the range of motion (ROM) of the lumbosacral junction [13,14]. The asymmetry and reduced ROM improves when the hindlimb lameness is eliminated [15]. If lameness is not present or has resolved, measurable asymmetrical movement may indicate a presence of back pain. The problem with interpretation of these data is making the link between ‘active’, relevant back pain and asymmetrical movement or reduced ROM. The author is collecting data from horses before and after interspinous ligament desmotomy to assess whether this improves alongside a resolution of clinical signs; these will be presented.

A reduction in the ability of lame horses to build epaxial muscle mass has been shown, suggesting that lameness results in reduced ability to use the thoracolumbar epaxial muscles normally [16]. Saddle slip to one side occurs in approximately half of horses with hindlimb lameness [17,18], which is probably due to asymmetrical thoracolumbar movement and/or asymmetrical epaxial muscling. Osseous spinal pathology has been shown to cause measurable left/right asymmetry in multifidus at or close to the level of pathology in Thoroughbred racehorses [19] and in man; this is ipsilateral to symptoms in people with acute/subacute lower back pain [20]. This suggests that measurement of cross-sectional area of multifidus could provide an objective measurement of back pathology; data being collected by the author will be presented.

References
Clinical signs of cervical pain include general neck stiffness, lack of flexibility and abnormal head carriage. Unwillingness to work on the bit and/or resistance to certain head positions when ridden are also common. Affected horses may have previous trauma, such as a fall or a collision with another horse or solid object. Cervical pathology should be considered in horses with unilateral forelimb lameness that cannot be localised to the limb [1]. Subtle hindlimb ataxia, stumbling, or loss of hindlimb propulsion may reflect compression of the cervical spinal cord.

Physical examination begins with assessment of conformation, posture and position of the neck. Patchy sweating areas may reflect local nerve damage. Muscle atrophy and/or sites of pain during palpation should be noted. Neck mobility can be assessed with baited manoeuvres to induce flexion and extension of the neck. After static evaluation, dynamic neck movement and its influence on gait is assessed. The horse should be observed in-hand, while lunging and, if indicated, while ridden. Complaints such as difficulty bending in one direction, a jerky head/neck movement or neck stiffness should be thoroughly investigated. Implementation of various bits, bridles or side reins may also be valuable.

Diagnostic analgesia of the limb should be performed in horses with unilateral forelimb lameness and in horses with abnormal head/neck carriage, since abnormal neck posture and/or gait may reflect a primary lesion elsewhere. Neurological assessment is indicated when ataxia, posture and/or gait may reflect a primary lesion elsewhere. Cervical pathology should be considered in horses with unilateral forelimb lameness or other large-breed horses. Oblique imaging enhances the detection of bone and soft tissue pathology. Lateral radiographic imaging of the entire neck requires large exposures are necessary, especially in Warmblood or other large-breed horses. Oblique imaging enhances diagnostic value [2]. The size of the cervical APJs increases with age [3]; therefore, clinical significance should be confirmed with intra-articular analgesia.

Nuclear scintigraphy is relatively insensitive at detecting neck lesions. In normal horses, increased radiopharmaceutical uptake (IRU) is associated with the C5–C7 and the dorsal aspect of C2. Right and left lateral scintigraphic images are obtained and compared. Conformational abnormalities such as abnormal angulations or enlarged cervical APJs may be noted.

Ultrasonography of the neck is indicated for soft tissue swellings, painful muscles, nuchal ligament abnormalities and nuchal ligament bursitis. Ultrason-guided cervical APJ injections for diagnosis and therapy of joint pain can also be performed.

Large bore computed tomography (CT) and standing robotic CT imaging are currently available, which has enhanced the detection of bone and soft tissue pathology within the cervical region. For example, CT confirms the potential impact of cervical APJ enlargement on spinal cord compression [4]. Fracture detection and comminution are more easily assessed on CT images and may assist with surgical planning.

Clinical conditions and treatment

**Insertional desmopathy of the nuchal ligament**

Affected horses are resistant to rein pressure and unwilling to lower and flex the head. Bony remodelling of the nuchal ligament insertion along the caudal occipital bone is noted. As many as 85% of Warmbloods have bony remodelling [5] and this is likely to be an incidental radiographic finding in these breeds. Nuclear scintigraphy may reveal IRU, but is frequently negative. Diagnosis is confirmed following significant reduction of clinical signs after infiltration of the local anaesthetic. Local corticosteroid injection followed by exercise without poll flexion for 2–3 months can be beneficial. Shockwave therapy may also be helpful.

**Nuchal ligament bursitis**

Affected horses have prominent swelling in the poll and abnormal head carriage. Diagnosis is confirmed by ultrasonography. Fluid distension of the nuchal ligament bursa, synovial thickening, and numerous floating amorphous hyperechoic densities are frequently noted. Soft tissue mineralisation and bony remodelling can be appreciated on radiography and some affected horses have focal IRU during scintigraphy. Nuchal bursectomy is preferred over surgical resection [6]. Intrabursal corticosteroids may be beneficial but often results in short-lived response.

**Osteoarthritis of the cervical APJs**

Cervical APJ osteoarthritis can cause neck pain or stiffness, reluctance to work on the bit, or general poor performance. Unilateral forelimb lameness is an infrequent clinical sign in horses with arthritis between C4 and T1. However, approximately 50% of clinically normal horses have bone remodelling of the caudal cervical APJs [3]; therefore, clinical significance of cervical osteoarthritis should not be determined by radiographic evaluation only. Therapeutic and/or diagnostic intra-articular dorsal cervical facet joint injections followed by resolution or reduction of clinical signs confirms this diagnosis of neck pain.

Numerous ultrasound-guided cervical APJ injection techniques are described; dorsal and craniodorsal approaches have been validated [7]. Improvement of clinical signs after anaesthesia of cervical APJs confirms neck joint pain regardless of radiographic findings. Intra-articular anti-inflammatory therapy can be beneficial [8].

**References**


Introduction
Pain in the region of the sacroiliac (SI) joint is a relevant and frequently discussed topic and is a recognised cause of lameness and poor performance in sport and leisure horses [1]. Due to the anatomy of the SI joint and the mostly nonspecific clinical signs, the evaluation of injury or pain affecting the SI joint remains a diagnostic challenge [2]. Understanding SI joint disease requires good anatomical and biomechanical knowledge of the pelvic region and neighbouring structures. Diagnosis involves the combination of a thorough clinical examination – ideally including a ridden assessment – with diagnostic local anaesthesia and the application of suitable diagnostic imaging modalities such as ultrasonography and/or scintigraphy. Although systematic evaluation for SI injuries can lead to satisfactory results, the majority of the possible diagnostic findings have not yet been measured objectively. In order to achieve scientifically acceptable, evidence-based information, the observations recorded during clinical assessments and imaging findings should be repeatable and measurable. Although experienced clinicians may produce repeatable observations (while accepting a degree of interobserver variability), thus far, a large number of observational points regarding SI joint injuries are still not measurable.

It is, therefore, advisable to have a holistic approach to diagnosis and treatment of potential SI cases. While the ideal would be a definitive diagnosis, the elimination of other differential diagnoses is currently still an important part of reaching the correct diagnosis.

Anatomical considerations
The SI joint is a diarthrosis with a hyaline cartilage articulation between the sacrum and the ilium dorsally and a fibrocartilage surface ventrally [3]. The joint connects the pelvis and the axial skeleton, transmitting propulsion from the hindlimbs to the spine. The joint capsule is tight and, together with the SI ligaments, it restricts the complex movement of the joint [3]. Important neighbouring structures include the lumbosacral junction and disc, the intertransverse joints, and the closely associated nerve route outlets. Furthermore, there are the dorsal and ventral SI joints. On the ventral aspect of the SI joints the cranial gluteal and sciatic nerves are located medially.

Physical examination
Although frequently, findings on the static assessment of the horse may give clues to the presence of SI joint region pain, the physical features and common findings are mostly nonspecific. Furthermore, the complexity of the SI joint region and its deep location makes direct assessment or palpation of the joint impossible. Therefore, the only way to approach to increase objectivity of image interpretation when applied to animal imaging is to use occult phase images of the pelvis. Semiquantitative methods can be applied to increase objectivity of image interpretation when detecting abnormal distribution of radiopharmaceutical uptake associated with the SI joint regions [20]. Careful consideration should be given to possible factors affecting the appearance of the SI joint region, such as muscle asymmetry, radioactive urine artefacts or soft tissue attenuation [20]. Although scintigraphy is considered useful in the clinical diagnosis of problems affecting the SI joint would be solved if meaningful criteria for pain assessment and an objective system of quantifying these were established. Unfortunately, specific clinical signs are lacking.

Gait and performance analysis
Objective gait analysis utilising either inertial sensor units or 3D motion capture has the potential to offer objective and unbiased information about the horse's gait and has been described in a number of publications [4–8]. In recent years, objective gait analysis systems have become more commercially available, resulting in their increased application in routine lameness assessments in equine practice. In cases where SI joint injuries result in an asymmetry of hindlimb action in straight lines or on the lunge, these systems could contribute greatly to objective assessment of gait; unfortunately, some horses only show overt lameness when ridden [9] and there is limited evidence for the usefulness of inertial measurement units for lameness exhibited during ridden exercise [10]. SI pain is more commonly diagnosed together with concurrent lameness than on its own [1]. Frequently horses with SI disease show no overt, unilateral lameness. In these horses, visual observations regarding head carriage, hindlimb impulsion, (canter) gait quality and willingness (on the lunge and/or during ridden exercise) are the most important signs, which have not yet been measured objectively.

Diagnostic local anaesthesia of the SI joint region is a vital part of reaching a correct diagnosis and a number of different injection techniques have been described [11–12]. For diagnostic local anaesthesia, the midline approach [1] is most appropriate in the clinical scenario. Clinical signs of SI joint injury can be significantly reduced following diagnostic local anaesthesia, which is considered a useful, safe, but nonspecific block.

Diagnostic imaging and interpretation
Ultrasoundography of the SI joints is considered a useful technique and can be performed per cutem and per rectum [16–19]. Other structures, such as the lumbosacral joint, the intertransverse joints and the nerve route outlet regions, can be assessed satisfactorily. Although ultrasonography of the SI and lumbosacral regions is readily available to most practitioners, it is limited in that only a small part of the SI joint can be viewed using this technique. It is therefore important to recognise that a negative ultrasound evaluation of the SI joints does not rule out pain and injury coming from this site. In a proportion of cases with SI joint region pain confirmed by diagnostic analgesia, no significant abnormalities can be identified ultrasonographically [1].

The advanced imaging modality gamma scintigraphy allows the assessment of the SI joint when acquired during the phase images of the pelvis. Semiquantitative methods can be applied to increase objectivity of image interpretation when detecting abnormal distribution of radiopharmaceutical uptake associated with the SI joint regions [20]. Careful consideration should be given to possible factors affecting the appearance of the SI joint region, such as muscle asymmetry, radioactive urine artefacts or soft tissue attenuation [20]. Although scintigraphy is considered useful...
to identify SI joint disease, it should be used in conjunction with other diagnostic tools looking for signs supportive of the diagnosis [21]. Horses with and without pain in the region of the SI joint have a degree of overlap and a range of radionuclide uptake associated with the SI joint region should be expected. This makes a definitive diagnosis with scintigraphy alone difficult in the majority of cases.

Conclusion
In most cases the objective evaluation of SI joint injuries is not yet possible. Clinical observations currently considered important in the identification of horses with SI joint region pain have not been measured. There is a large variety of nonspecific clinical signs thought to be associated with SI disease, which often makes definitive diagnosis difficult without applying further diagnostic tests such as diagnostic local anaesthesia. Objective gait analysis and semiquantitative methods for interpretation of scintigraphy images can be considered to increase the degree of objectivity. Ruling out possible differential diagnoses plays an important role in reaching a correct diagnosis.

Although SI injuries continue to represent a diagnostic challenge, increasing evidence and information provided by larger scale studies should be taken into account to ensure a more standardised and systematic approach.

References

What is the current best approach to treatment of subchondral cyst-like injuries

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Subchondral cystic lesions (SCLs), also referred to as subchondral bone cysts or osseous cyst-like lesions (OCLs), have been described in many equine joints. Nowadays, we know that many pathological mechanisms can lead to the development of SCLs. In 1975, Rooney described SCLs of the equine tarsus as a manifestation of the osteochondral (OC) complex as a result of retained, thickened, necrotic cartilage in the epiphyseal physis, that folds into the subchondral bone in the weightbearing areas of the joint. Recent studies have demonstrated that the disturbance in ossification in pigs and horses affected by osteochondrosis is the result of failure of the blood supply to epiphyseal growth cartilage and associated ischaemic chondronecrosis. Another pathological mechanism responsible for the development of SCLs is trauma to the articular cartilage, subchondral bone or both, creating a communication between the subchondral bone and the joint and allowing synovial fluid to flow under pressure in the subchondral region, producing necrosis of the adjacent bone and contributing to cyst formation. In a recent study evaluating the morphology of SCLs in limbs of horses it could be shown that, in almost one-third of the cystic lesions, a concomitant fissure was visible on computed tomography (CT) [1]. Alternatively, trauma can cause subchondral bone damage and bone ischaemia and necrosis, followed by revascularisation and resorption of necrotic bone, leaving a subchondral lesion [2]. Lameness is attributed to increased intracystic or intraosseous pressure, or both [3]. In some cases, the diagnosis of a subchondral cystic lesion is made using radiography [4]. A typical radiographic finding is a dome-shaped or round to oval subchondral lucency with a variable surrounding sclerotic rim. Some SCLs may be difficult to detect on radiography, and several projections may be necessary to see and recognise the extent of the lesions. In a recent study, of 42 SCLs of the equine limb diagnosed by CT, only 33 (79%) were identified radiographically [1].

Nonsurgical management of SCLs involves rest and the use of nonsteroidal anti-inflammatory drugs. This type of treatment is not very successful, with one study reporting a failure rate of 66% [5]. Limited exercise and intra-articular medication has a reported success rate of 64%, with horses less than 3 years of age having a better prognosis for soundness. One author reported that horses resuming athletic activity following conservative management redevelop lesions. Benzopyrone has been used systemically in horses with SCLs, with 12 out of 19 horses returning to normal use [6]. Assuming that pain associated from these lesions originates from increased intraosseous pressure, this drug should decrease the osmotic pressure in the bone that is causing lameness [6]. Tiludronate, a non-nitrogen containing bisphosphonate, inhibits osteoclast-mediated bone resorption and has been used in humans since 2007 [7]. However, although clinical results show that tiludronate can improve lameness in horses with navicular disease or with tarsal pain at 6 months, no long-term results are available [7], and it still is unknown as to whether tiludronate can improve lameness in horses suffering from SCLs. Intra-articular injection of steroids is often the first approach to SCLs and leads to immediate improvement of the lameness; however, the risk of recurrence is very high [8]. The technique of injecting corticosteroids into the lining of the SCL under arthroscopic or ultrasonic guidance is based on earlier work, where inflammatory mediators leading to bone resorption were detected in the cystic contents. Success rates of 90% for unilateral and 67% for bilateral SCLs was reported [9]. Surgical treatment is the therapy of choice for horses that are lame because of a SCL, especially if refractory to conservative treatment. Surgical debridement is performed using either an intra-articular approach by arthroscopy [4] or by a transcortical approach. The arthroscope is introduced into the affected joint using routine technique. The lesion is identified either through the presence of a canal when the SCL has a communication into the joint or by a slight indentation or a ‘Mercedes star’ irregularity. Once the cyst has been identified, a rongeur can be used to remove the articular cartilage overlying the SCL. Once all the cartilage is removed, the contents of the cyst are evacuated with the help of a curette or a shaver. All the contents and lining of the cyst are carefully removed, until the subchondral bone is visible. Most of the SCLs of the distal limb are not accessible through an articular approach and have to be debrided transcortically. The surgery should be performed under digital radiography, fluoroscopy or CT guidance, and careful planning is very important. Although simple debridement and exposure of the subchondral bone promotes some migration of pluripotent stem cells (MSCs), this effect is minimal [9] and more advanced grafting is generally indicated in deeper lesions. Multiple grafting techniques have been developed and evaluated for their ability to accelerate and improve healing of the debrided SCL. Packing the lesion with autogenous grafts also has been recommended. However, a study comparing healing of surgically created subchondral defects filled with compacted cancellous bone grafts compared to empty defects revealed no difference in the healing patterns after 6 months [10]. Mosaic arthroplasty (autologous osteochondral grafting) has been studied as a potential treatment for SCLs. Osteochondral autograft transplantation (mosaic arthroplasty) was performed in a clinical case series, where grafts were harvested from the abaxial border of the medial femoral trochlea of the unaffected limb [11]. Tricalcium phosphate (TCP) granules can be implanted in SCLs following transosseous curettage [12]. Prior to implantation, granules are placed in a syringe, autologous whole blood is added, and a vacuum is applied for several minutes. Good results were reported with this technique; however, the population was small [13]. Therapy with low-dose parathyroid hormone (PTH) analogues has become a popular treatment for severe osteoporosis in man, because, when administered systemically and intermittently, it has a strong anabolic effect on bone. In a clinical case series of 15 horses that were lame because of a SCL at different anatomical locations, I1 became sound after debridement and filling of the lesions with PTHI-34, in a fibrin hydrogel [14]. Autologous chondrocyte implantation (ACI) is the ‘gold standard’ for repair of large cartilaginous...
lesions in man. In a recent study, Ortved et al. (2015) demonstrated improved healing in the short (8 weeks) and long term (8 months) following implantation of autologous chondrocytes transduced ex vivo with a self-complementary adeno-associated virus (AAV) overexpressing IGF-1 in the equine femoral trochlea. More recent studies examined the potential beneficial effects of bone morphogenetic protein (BMP)-2 in the repair of experimental equine osteochondral defects. In one study, the effect of rhBMP-2 in three horses suffering from five SCLs in the pastern joint was investigated: in all the three horses, treatment resulted in increased bone density, decreased cyst size, and an absence of lameness. In a recent study, 20 horses with lameness attributable to a SCL in the medial femoral condyle were treated with a transcondylar 4.5 mm screw inserted in lag fashion without debridement of the lesions. By 120 days, lameness was eliminated in 15 horses and the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the SCL area had decreased ≥50%. In another study, placement of a bone screw in the proximal-medial radius resulted in a substantial reduction in, or elimination of, lameness in seven out of eight horses (88%). Another possible option is the combination of transcortical debridement and filling of the

References


NOTES

Further references available on request.
Decision making with OCD fragments – significance and management

Osteochondrosis/osteochondritis/osteochondritis dissecans

Introduction
Osteochondrosis (OC) occurs in about 25% of Thoroughbreds, Quarter Horses, Standardbreds, Warmbloods and Arabians [1–4]. It is a common reason for veterinarians to evaluate young athletic horses and is the most common reason that arthroscopic surgery is performed on horses [1–4]. Although OC has been identified in all joints, greater than 95% of all OC is localised to the femoropatellar (FP, stifles), the tarsocural (TC, hock), and the metacarpophalangeal/metatarsophalangeal (fetlock) joints [1–7]. These joints will be the focus of the information presented. The generalities described below are to be applied to all joints and specific joints will address variations from these generalities.

Aetiology
During endochondral ossification, a cartilage precursor is replaced by bone in the growing skeleton and this transition occurs in a series of identifiable zones [1–4]. This replacement process fails in the zone of hypertrophy [3] and leaves a section of retained cartilage that results in the formation of OC. As described below, focal failures of ossification occur at very specific sites of predilection depending on the joint in question [1–7].

Cartilaginous and/or osteochondral fragments may remain attached (no synovial effusion) or can detach from the parent bone (producing synovial effusion) and form an intra-articular fragment. If the articular fragment causes inflammation in the joint, it is called osteochondritis [1]; if the fragment contains a dissecting flap, it is called osteochondritis dissecans (OCD) [1]. Although the subject of osteochondrosis typically includes subchondral bone cysts, this subcategory will not be discussed [4].

Clinical signs
The owner typically identifies synovial effusion of the suspected joint. Lameness is possible but not an essential feature of OC. A useful axiom of OC is: synovial distension of a joint in a growing horse (yearling) has OC until proven otherwise.

Diagnosis
Radiographic examination provides the definitive diagnosis because fragments are located at very specific sites of predilection [1–7]. Synovial effusion is often present but is not an absolute requirement. If the patient has the appropriate signalment, then a lameness exam, diagnostic anaesthesia, synovial aspirates and cytology are not necessary to make a definitive diagnosis. If a lesion is identified, the contralateral joint should also be radiographed because bilateral involvement (quadrilateral in the fetlock) is common [1–7].

Radiographs: when?
An axiom of imaging is that radiographs support a diagnosis but do not establish a diagnosis. Lesions without lameness are often radiographically interesting but not clinically significant. Given the repeatable and exact sites of occurrence, OC is a contradiction to the rule. The objectives of the owner dictate the timing and when radiographs are to be taken. Is the horse to be sold at public auction (racehorses)? Does the owner breed to sell or retain the horse for their pleasure and performance?

Radiographs: how?
Radiographs: when?
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Radiographs: how?
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Rarely, weanlings with LTR OC may present with pronounced joint effusion and marked lameness to the point of being recumbent [9], but with no radiographic evidence of disease. These LTR lesions can be identified with ultrasound [10] initially and ultimately with radiographs. In the author’s practice, stall confinement, the judicious use of NSAIDs, periodic assistance to stand and slow increases in spacing for exercise, allow surgery to be avoided in most cases until the horse is greater than 12 months of age.

**Radiography**

**Sites of predilection**

In the authors practice, an LTR (99%) lesion is far more common than a medial trochlear ridge (MTR) lesion (1%). Although OC of the LTR affected 161 of 252 joints, lesions may also be located on the MTR, the trochlear groove, the articular surface of the patella, or in any combination [8].

**Images required (three)**

- Lateral-medial (L10Ca-CrMO): Laterocaudal-cranio medial oblique (L45Ca-CrMO): Caudocranial (Ca-Cr)

A perfect lateral-medial projection can superimpose the LTR on to the intertrochlear groove of the distal femur, causing small LTR lesions to go unidentified. This issue can be avoided if the projection is repeated with the generator positioned 10 degrees caudal of lateral.

**Treatment**

Surgical success rates of 64% to 89% have been reported, without regard to sex, location of the lesions, or bilateral or unilateral involvement [1–5, 8]. Increased size of the lesion is inversely related to success rate for return to intended use, as lesions less than 2 cm, 2–4 cm, and more than 4 cm had success rates of 78%, 63%, and 54%, respectively [8]. The prognosis for athletic activity following arthroscopic surgery for femoropatellar OC is generally excellent. Of a series of 134 horses, only 16% were unsuccessful for reasons related to the OC [8].

**Osteochondrosis of the tarsocrural joint**

Hock arthroscopy is the third most common OC surgery performed at the author’s practice.

**Clinical signs**

Horses with TC OC usually present with synovial effusion (‘boggy’) prior to training and are frequently not lame [11,12], but may also be identified as a coincidental finding on repository/presale radiographs [7–8]. After 5 months of age, TC OC lesions are mature [1]. Bilateral OC lesions occur in 20% to 45% of cases [11,12] so radiographic identification requires close scrutiny of the same location on the opposite joint. The great majority of distal LTR lesions identified in February are small and reattach prior to the fall yearling sales. Rarely, distal LTR lesions are large (50% of the frontal dimension), cause substantial effusion and lameness and require surgery. Even the largest lesions can be removed with a good prognosis.

If OC of the TC joint is suspected clinically but not identified radiographically, or if synovial effusion becomes evident once training has commenced in a previously normal joint, an unidentified OC of the medial malleolus is a frequent explanation [4]. In a perfectly DP radiograph, the medial malleolus is hidden by the proximal aspect of the medial trochlea. Early removal is recommended, because erosive lesions on the medial trochlea of the talus can become severe over time [4].

Distal MTR fragments are typically a normal radiographic finding that does not require treatment [4]. Rarely, smooth depressions in the proximal dorsal surface of MTR are radiographically interesting but clinically insignificant findings that do not produce clinical signs [4].

**Radiography**

**Sites of predilection**

In the author’s practice, the decreasing order of occurrence is as follows:

1. Distal intermediate ridge of the tibia ‘DIRT’
2. Distal LTR (small OC that resolves without surgery)
3. Medial malleolus
4. Distal MRT (but variation of normal)
5. Distal LTR (large OC that requires surgery)

**Images required (three)**

- Lateral-medial, dorsoplantar (DISL-PIMO); DM-PLO (DSSM-PIL0). Medial malleolar OC lesions can be missed because of their axial location. Repeating the DP image by rotating your projection 15 degrees lateral of DP will identify the medial malleolar as a distinct entity medial to the medial trochlea of the talus.

**Treatment**

A study of horses with a mean age of less than 5 years identified no significant difference in money and races won when comparing horses with DIRT OC treated medically or surgically [11]. This is in contrast to a study identifying fibration of articular cartilage in aged horses that did not receive surgery [2]. In an effort to maximise the long-term health of the joint, early surgical intervention is recommended. Arthroscopy for OC of the TC joint is uncomplicated, with minimal soft tissue morbidity, a short recovery and an excellent (>90%) prognosis after surgery because typical lesions are minimally associated with a weightbearing surface [1–4,11,12]. For TC joint arthroscopy, the lateral portal is placed under tension when the patient is resting in sternal recumbency as this portal is positioned in the fold of the lateral aspect of the flexed TC joint. Typically, this author places two sutures in this portal to prevent this joint from becoming open in the post-operative patient.

**Osteochondrosis of the metacarpophalangeal/metatarsophalangeal joint**

Fetlock arthroscopy is the second most common OC surgery performed at the author’s practice. A lucency of the distalmost aspect of the medial sagittal ridge (MSR) of MtII (MtIII less common) identified on the DP and flexed lateral radiograph of the fetlock is a normal finding in the author’s opinion. This radiographic blemish does not cause clinical signs of effusion or lameness, has a dramatic decrease in incidence during serial radiographs taken in weanlings, yearlings, and 2-year-olds, and resolves by a horse’s 2-year-old year in 99% of cases.

The aetiology of palmar/plantar fragments of the proximal phalanx remains controversial [1–4,13–15]. Some consider these fragments to be manifestations of OC because bilateral fragmentation occurred in 21 of 119 (18%) horses; 13% of horses had fragments in the medial and lateral aspect within the same joint, and 13% of horses had concurrent OC on the distal intermediate ridge of the tibia [13]. Others believe these fragments are avulsion injuries from the proximal phalanx because they are consistently attached to the short sesamoidean ligament with an associated defect in the palmar/plantar aspect of the proximal phalanx [4]. Histological evaluation strongly suggested that these fragments are a consequence of fracture formation and not a failure of enchondral ossification [14,15].

**Clinical signs**

Typically, synovial effusion and lameness is rare. OC lesions in the fetlock can be bilateral and rarely quadrilateral.
Radiography

Sites of predilection (in order of occurrence)
1. Distal McIII/MtIII MSR (but variation of normal)
2. Palmar/plantar PI
3. Proximal McIII/MtIII MSR
4. Dorsal condylar or dorsal parasagittal (markedly less common).

Images required (five)
DP (D30Pr-PaDi), DM-PLO (D45M-PLO), DL-PMO (D45L-PMOG; LM, flexed LM,
Keep the machine parallel to the ground and elevate it to the level of the distal McIII/MtIII physis. For the DP projection, a downward angle of 30 degrees elevates the sesamoid bones proximally out of the joint. The MSR is easily imaged if an assistant clasps the radius and holds it proximally and in a parasagittal plane.

Treatment
Proximal sagittal ridge and parasagittal condylar lesions are easily removed under arthroscopic guidance. These lesions can leave a substantial subchondral defect but because of the nonweightbearing location and the joint stability is unaffected, the prognosis is favourable.

Osteochondrosis of the scapulohumeral joint (shoulder)
Osteochondrosis of the shoulder is most frequently diagnosed in weanlings and yearlings 6 to 12 months of age [1–3,16]. Most cases present with a history of mild but it has been reported in foals younger than 5 months up to moderate intermittent forelimb lameness with a distinct reduced cranial phase of stride. Atrophy of the muscles of the shoulder region and a small foot with a contracted heel is typical in chronic cases [1–3,16]. Diagnostic anaesthesia improves the lameness in most cases. Radiographs are used to diagnose the lesion and a contrast arthrogram can be used to outline the extent of the lesion if necessary. The primary cartilage lesion is located in the glenoid, humeral head, or both (most common) and the disease often affects a major part of the joint surface [1–3,16]. Secondary degenerative changes in the joint are prominent features of this disease.

In the author's practice, although shoulder joint OC is significantly less common than the sites mentioned above, the poor prognosis for this condition is in dramatic contrast. Because secondary arthritis develops rapidly in cases of shoulder OC, the prognosis is poor with only 15.4% (4/26) of potential racehorses being able to start a race, and 25% (8/32) of all horses returning to their intended use [16].

References
Management of penetrating injuries to the calcaneal bursa

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Introduction
Penetrating injuries to the calcaneal bursae present the standard challenges of treating synovial sepsis; however, the complex regional anatomy presents special considerations to optimise successful treatment. The special challenges relate to the anatomy of the calcaneal bursae; the associated tendinous and ligamentous structures, the potential involvement of the tuber calcanei (TC) and the high degree of movement which can compromise wound healing.

Anatomy
The calcaneal bursae facilitate smooth movement of the superficial digital flexor tendon (SDFT) and the gastrocnemius tendon in the region of the TC. The three calcaneal bursae include the superficial calcaneal bursa (SCB), the intertendinous calcaneal bursa (ICB) and the gastrocnemius calcaneal bursa (GCB). The ICB and GCB communicate medially (100%) and laterally (50%) [1]. The ICB extends from about 10 cm proximal to 7 cm distal to the point of the hock. The SCB usually extends from the proximal TC distally to the level of the centrodistal joint. Communication between the SCB and the ICB is inconsistent (40%).

Special considerations
A systematic approach to injury evaluation is important due to the complex anatomy of the region. The associated anatomical structures are interrelated; however, to ensure complete evaluation of structures related to the calcaneal bursae, it is useful to divide assessment into categories: soft tissue (SDFT, gastrocnemius tendon, plantar ligament); bony (TC); and adjacent synovial structures (tarsal sheath, tarsocural joint, tendon sheath of medial deep digital flexor tendon (DDFT)). To minimise the effect of gas/air artefact on diagnostic imaging from the initial injury or synoviocentesis, performing ultrasonography and radiography prior to synoviocentesis is recommended.

Radiography
Radiographic evaluation should include four standard views, as well as a flexed lateral-medial and a plantaroproximal–plantarodistal oblique (skyline) projection of the TC. Placement of a marker over the wound is beneficial to determine the relationship of the wound to the underlying bony structures on standard and flexed lateral-medial projections. Removal of the marker may be necessary for some views to avoid obstruction of the area of interest. Additional lesion-oriented oblique projections of the TC can help identify small bony abnormalities. Radiographic evidence of bony involvement in the first instance or at subsequent examinations provides essential information regarding prognosis [2] and continued treatment requirements.

Ultrasonography
The importance of ultrasonography in this region cannot be over-emphasised due to the relevance of soft tissue damage to the horse’s subsequent rehabilitation and long-term prognosis [3]. The use of sterile ultrasound gel is recommended when scanning directly over the wound. The SDFT should be evaluated from the proximal ICB bursa to the level of the distal tarsal sheath distally, including the medial and lateral retinacular attachments. During examination of the SDFT and retinaculum, a clear image of the surface of the TC can be obtained, potentially revealing subtle damage not visible on radiographs. This examination may help determine which calcaneal bursae are involved in the injury. As the SDFT is essential to the stay apparatus of the hindlimb, the presence and degree of damage can be determined to assist in surgical planning and determination of prognosis.

The gastrocnemius tendon is less commonly involved in wounds; however, evaluation of the tendinous portion and the area of insertion on to the TC should be performed. Identification of the medial and lateral margins of the gastrocnemius often results in good visualisation of the potential sites for synoviocentesis, proximal to the retinaculum of the SDFT.

The tarsal sheath is situated medial to the calcaneal bursae and can be involved in penetrating injuries to the area, in particular with larger wounds. Initially, the tarsal sheath and the plantar ligament can be assessed ultrasonographically from the plantar aspect, along with the SDFT starting at the level of the TC. However, should the location of the wound or the ultrasound images suggest tarsal sheath involvement, then ultrasound of the tarsal sheath should be performed along its entire length. The plantar tarsocural joint pouches lie cranial to the ICB; therefore, assessment of these pouches for involvement is also prudent.

Synoviocentesis
Synoviocentesis is performed in the standard manner based on palpation of a synovial effusion or by ultrasound guidance. If a wound or a small penetrating injury is present, then injection of sterile saline into the affected bursa could determine whether the wound communicates with the bursae directly.

Treatment
Treatment of sepsis of the calcaneal bursa is similar to treatment of any potentially infected synovial structure, with arthroscopic lavage and antimicrobial therapy essential elements. Arthroscopic exploration should be complete, with careful evaluation, lavage and mechanical debridement of affected synovium, tendon, retinacular tissue, TC or the fibrocartilaginous covering. Altering the degree of flexion of the limb and using multiple arthroscopic portals for visualisation during surgery can facilitate complete assessment of the ICB.

One of the biggest treatment challenges in this region is the high degree of motion and the high tensile forces on the skin over the prominent TC. Therefore, for most wounds, the quality and rapidity of healing is substantially improved with the use of a bandage cast once the horse has recovered from the arthroscopic procedure. No matter how large, a Robert Jones bandage is unlikely to restrict motion adequately to prevent sliding of the SDFT, movement of the TC and tension on the skin over the TC.

Prognosis
The benefit of arthroscopic lavage for treatment of septic calcaneal bursa has been demonstrated in a recent retrospective study [3] with the success rate (84.4% hospital discharge; 88% long term) similar to sepsis of other synovial structures. The risk factors for a poor prognosis include tendinous or bone involvement [2,3]. Involvement of the SCB alone has an excellent prognosis for survival.

References
Surgery
Equine perioperative mortality is regularly held out to be disgracefully high. In 1995 Johnston published the preliminary results of the confidential enquiry of perioperative equine fatalities (CEPEF), which established the time-honoured figure of 0.9% [1]. Recently Dugdale published an anaesthesia or recovery-associated mortality of 1.1% for all cases, including colics and emergencies, of which 71% were caused by fractures [2].

Surgery checklist
A considerable body of research into human mortality has concluded that approximately half the adverse events in medicine are preventable. In 2008 the World Health Organization introduced a checklist for surgery, inspired by experience of the aviation industry (http://www.who.int/patientsafety/topics/safe-surgery/checklist/en/). A remarkable reduction in complications was documented: the rate of any complication dropped from 11.0% to 7.0% after introduction of the checklist (P<0.001). We introduced it into our surgery protocol in 2011. The checklist is:

- Has written consent been obtained?
- Has the instrument count, swab count, and needle count been carried out?
- What medications are required post-operation?
- Are there any anticipated complications?
- Are there any broken equipment, faulty instruments or stock requiring replenishment?

We have introduced a checklist for standing surgery. The issue with standing procedures is that they do not clearly ‘begin’, as there is no anaesthetic induction. This checklist seeks to clarify individual roles, so that it is established that someone is available to monitor the plane of sedation, or to obtain intraoperative radiographs.

Anaesthetic recovery
The unique problem of equine anaesthesia is fractures during anaesthetic recovery. Hans Wilderjans in Belgium developed the system of rope-assisted recovery [3]. The forces involved are enormous. The bolts in our wall are rated to 1 ton in shear and they have bent. Thus, mechanical assistance is necessary. We use a Spinlock® XTC 0610/2 clutch, designed for yachting. The ropes must run through pulleys. A head collar must be customised, with no buckles, to prevent pressure on the facial nerve. This also needs to be reinforced, and at least two are needed, one for either recumbency. One rope is attached to the horse’s tail using a simple clove hitch. Place the rope over the tail near the base of the dock, then fold the tail over the rope. Wrap the rope around the tail once or twice, then feed a loop of the end of the rope through these first loops. Pull tight and maintain tension. A second rope is secured to the head collar.

We have observed complications with rope-assisted recovery. We have had fractures in anaesthetic recovery, including of the olecranon, palmar carpal fragments and tibia, so it is not a panacea. We also pull the hair out of a horse’s tail about once a year. We have had one tail fracture which left the tail paralysed. We have changed from using sailing rope to using climbing rope, which is much more elastic.

Rope-assisted recovery is simple and cost-effective, and we are convinced it is a better way. Mark Senior from Liverpool University conducted a multicentre study involving four centres, including Donnington Grove Veterinary Surgery. Over 33,000 recoveries were recorded, and there were 35 fractures, an incidence of just under 0.1% [4]. The CEPEF enquiry of the 1990s recorded 115 fractures from 44,220 recoveries, 0.26%, and this difference is statistically significant (P = 0.001).

Standing surgery
Some condylar fractures (usually medial) have proximal propagation of the fracture plane into the diaphysis of the bone, and these fractures are prone to development of a complete and catastrophic fracture, commonly in anaesthetic recovery. Lag screws can be placed in the standing sedated horse to avoid subjecting it to anaesthetic recovery.

We drape the lower limbs by wrapping with sterile Co-Plus® bandages, from the hock or carpus, distally to the coronet. The floor is covered with a disposable paper drape wrapped around the pastern. Anaesthesia can be adequately provided using a four-point block (palmar and palmar metacarpal or plantar and plantar metatarsal nerves at the level of the distal splint bones), augmented with a dorsal ring block at the same level.

The surgical technique of standing fracture repair is surprisingly straightforward. Drilling is easy, possibly because the surgeon is innately familiar with the orientation of the limb; the hole is drilled horizontally. We have also found intraoperative radiography to be much more straightforward.
The plate and plate holder are enclosed in a sterilised plastic bag, and then radiography is performed in the routine way.

The results are good, much the best we have ever achieved. Of 118 racehorses with 6 months follow-up, 85 raced again (72%). The return to racing results were: 29/40 lateral condylar fractures (73%), 13/19 medial condylar fractures (68%), 43/59 P1, split pastern and frontal plane (73%). We have also experienced horses which remained lame, and radiography 6 weeks later confirmed fracture planes spiralling up into the diaphysis that were not visible on radiographs obtained at the time of surgery.

References


In horses, the initial treatment of injuries to skin, muscles, joints, tendons, tendon sheaths, and bones greatly affects the chance of ideal healing. The objective of first aid treatment is to minimise additional damage to the fractured limb. A thorough clinical examination is mandatory for horses with fractures [1]; lacerations or lesions that are overlooked can considerably affect the diagnosis and prognosis. Palpation often reveals the first signs of an acute inflammatory response (principally pain and swelling) and can usually be used to localise the region of injury [2].

A fracture should be suspected whenever there is severe lameness of acute onset. When in doubt, the horse should be treated and handled as a fracture patient. This is particularly true in horses that have been kicked in a region where the bone lies directly beneath the skin; such areas include the scapular spine, the major tubercle of the humerus, the deltoid tuberosity, the cutaneous plane of the radius, the metacarpus, the metatarsus, the tuber coxae, the third trochanter, the sustentaculum of the talus, the calcaneus, and the tibia [3]. Optimal emergency treatment should include the following: sedation, initial wound management, fracture stabilisation, administration of proper analgesia and anti-inflammatory medication, antimicrobial prophylaxis, i.v. fluid therapy, and careful and safe rescue using appropriate transportation aids and vehicle to deliver the patient to a specialist clinic. The use of sedation is dictated by the circumstances; drugs indicated for one horse may be hazardous to another. In most cases, judicious use of a sedative facilitates the examination and emergency treatment of an acutely traumatised horse, especially when the horse is stressed after competing in an event or is in severe pain. Stabilisation of the fractured limb in an anatomically normal position is the most important aspect of initial treatment; this should be applied so as to allow the patient to bear some weight without causing excessive damage to the fracture ends and the soft tissues. The joints above and below the fractured bone should be immobilised using some type of external coaptation, and the support should extend well beyond the fracture line. In no case should the end of the coaptation device be near the fracture line, because it then acts like a lever to further displace the fracture. A cast should not extend at mid-diaphyseal level, and, when possible, it should include the hoof. These requirements severely limit the number of fractures that can be stabilised with external coaptation techniques. For emergency stabilisation of fractures, robust materials must be used. A Robert Jones cannot be used to stabilise a fractured limb for any length of time without the addition of splints. On the other hand, if a splint is applied, the padding does not have to be so thick. A variety of splints are suitable for stabilisation of fractures in horses. The splints must be applied to the cranial or caudal and lateral aspects of the limb and held in place with nonelastic tape. For optimal stabilisation, the splints are applied in orthogonal planes. Polyvinyl chloride (PVC) splints are very stable and inexpensive but difficult to mould unless heated using a propane torch. Splints also can be improvised using metal rods, broom handles, wooden boards, and other sturdy materials. The following splint lengths have been recommended for stabilisation of limb fractures in racehorses: 35–40 cm for a dorsal splint extending to the level of the proximal metacarpus; 70–80 cm for a splint extending to the level of the elbow; 140–150 cm for a lateral splint extending to the level of the scapula; and 55–60 cm for a hindlimb splint extending to the level of the caudal calcaneus [4]. The equine cast, also referred to as a synthetic splint, is made of fibreglass tape impregnated with a polyurethane resin. These materials are well suited for immobilising equine limbs, provided that appropriate limb/joint positions can be obtained. They are very strong, light, easy to apply, cure quickly, and provide good counter pressure. The horse should stand quietly during cast application to prevent the development of microfractures and folds in the cast, which can reduce its strength and cause pressure sores. Fracture stabilisation may be difficult in some situations, especially with markedly unstable fractures, and therefore splints are often the first choice for stabilisation. Good stabilisation should not inflict additional damage to the limb. Swelling of the surrounding tissues is common after an injury, and stabilisation may result in pressure and friction sores as well as tissue strangulation if the splint or cast is not sufficiently padded. Therefore, the padding should be layered, and each layer tightened with nonadhesive gauze. However, layers that are too thick (2–4 cm) allow movement of the bone fragments or slippage of the splint and should be avoided. Ideally, the thickness of each layer of padding should be about 1–2 cm.

Incomplete and complete fractures of the proximal, middle, and distal phalanx, proximal sesamoid bones, and the distal sesamoid bone are easily stabilised with either a cast or a splint [5]. Fractures of the proximal or middle phalanx, and the distal third metacarpal/metatarsal bone (McIII/MtIII) must be stabilised in an almost straight line to prevent movement in the frontal plane at the fracture line. With fractures of McIII/MtIII, a cast or splint is applied from the hoof to the elbow or stifle joint, respectively. Depending on the temperament of the horse and the location of the fracture, the splint or cast may extend only to the top of the calcaneus for fractures of the distal MtIII. Fractures of the radius and tibia present special problems because the large muscle masses usually prevent fixation of the elbow and stifle joints. Furthermore, contraction of the extensor tendons, located cranilaterally on the limb, causes abduction of the limb below the fracture line, which may lead to skin perforation on the medial aspect of the radius or tibia. Therefore, stabilisation up to the elbow or stifle joint is not sufficient and will not prevent abduction. In these fractures, a sturdy splint or cast should first be applied up to the level of the elbow or stifle joint or even higher, if possible. This should subsequently be augmented with an additional splint applied laterally and extending from the hoof to the point of the shoulder or hip. Fractures of the ulna result in failure of the passive stay apparatus of the forelimb (triceps apparatus), which normally allows the horse to stand with little muscular effort for prolonged periods of time. Therefore, the limb should be stabilised with a splint that includes the carpal region so that the horse can bear weight on the limb. The splint should be applied caudally and extend from the metacarpophalangeal region to the level of the elbow joint. Fractures of the humerus
and femur do not require a bandage or a splint because they cannot be adequately immobilised and there is enough muscle mass to protect the bone. Complete fractures of the neck and body of the scapula commonly displace and override. The injured horse must be transported carefully and humanely, according to animal welfare legislation [5–8]. It is advantageous to have a specialised large-animal trailer or van and the support of an experienced veterinarian or assistant [5,8]. However, there are those who think that this kind of transportation can be accomplished with normal horse trailers that are minimally adapted [9]. In the author’s experience, horses with a fracture should be transported in a specialised large-animal trailer built for transportation of injured horses.

References
Complete fractures of the diaphysis of the third metacarpal and metatarsal bones occur in all types of horses. They account for approximately one-third of all long bone fractures in the horse. Open reduction and internal fixation (ORIF) involving anatomical reconstruction of the bone with two plates at 90 degrees currently represents the most common treatment method.

In a report of 21 animals (10 mature horses and 11 foals), bone healing was achieved in 62% (three mature horses, 30% and ten foals, 90%) [1]. The main fracture types were simple transverse (33.3%) or simple oblique (28.6%), and 71.4% of the fractures were open. The preoperative assessment revealed inadequate emergency treatment in five horses (five mature and five foals; 47.6%). Survival rate of horses with open fractures was 12.5% (1/8) in mature and 85.7% (6/7) in foals. Post-operative incisional infection (four mature horses, three foals) was only managed successfully in two foals. Fracture instability related to inadequate fracture fixation technique occurred in four horses (all mature) and was always associated with an unsuccessful outcome. In the majority of these cases, a dynamic compression plate technique was used.

Ten years after this report, technical improvements are available to equine surgeons that may improve our chance of success in repairing diaphyseal fractures in foals and especially in adult horses.

Despite these advances, there are well known facts that remain as important for a successful outcome as are the new implants and their application methods:

- Firstly, the timely and effective emergency management of horses with cannon bone fractures, especially if they are open. The most important aspect is a stable external coaptation of the limb using a full limb cast to prevent further damage to bone and soft tissue during transportation of the horse to the clinic.
- Secondly, careful handling of soft tissue and adequate surgical management of open fractures, including effective debridement of the contaminated tissue and effective local delivery of antimicrobials during and after surgery [2].
- Thirdly, the precise anatomical alignment and reconstruction of the bony column, especially opposite the plates, to allow load sharing of the construct is paramount for successful repair.

**Locking compression plates**

In an in vitro biomechanical comparison of locking compression plate (LCP) fixation and limited-contact dynamic compression plate (LC-DCP) fixation of osteomised equine third metacarpal bones, the 4.5 mm LCP was superior to the 4.5 mm LC-DCP in resisting the static overload forces (palmarodorsal four-point bending and torsional) and resisting cyclic fatigue under palmarodorsal four-point bending [3]. This biomechanical advent of fixed angle constructs (LCP) increases stability and allows fractures to heal even when open and infected [4].

**Minimal invasive plate application**

The strength and stability of locking plates has allowed surgeons to try minimally invasive long bone repair of some seriously comminuted fractures in the distal limb of foals and smaller large animals (llamas, alpacas, and so forth). It is still premature to claim that most foal metacarpal and metatarsal fractures might be treated this way, but the complications with aggressive open exposures in such fractures is high enough that further efforts seem warranted. The metacarpus/metatarsus is particularly well suited to minimally invasive plate placement because of the minimum overlying soft tissue and relatively straight bone. If the periosteo sleeve and its contained comminuted fragments and fracture haematoma are undisturbed by two extraperiosteal bone plates, it seems highly probable that the normal progression of fracture healing will be unimpared [5].

**T-plate**

Recently, a 4.5/5.0 LCP T-plate has become available in different lengths. This implant fits perfectly to the dorsal aspect of the third metacarpal and metatarsal bones of foals and New World camelids (alpacas, llamas) and is very useful in distal or proximal diaphyseal/metaphyseal fractures.

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Management of comminuted phalangeal fractures

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Comminuted fractures of the middle phalanx

Incidence and causation
Fractures of the middle phalanx are usually associated with work that entails speed in conjunction with quick turns and abrupt stopping. They are most common in western performance horses but can occur during all activities, including simple turnout in a paddock or arena.

Fracture type
Comminuted fractures are typically highly fragmented at the proximal articular surface, with the palmar or plantar eminences fractured in two or more fragments separated from the parent midline phalanx. In many cases they have at least one fracture line extending to the distal articular surface. With weightbearing, the pattern is unstable in the plantar direction and the proximal phalanx displaces distally into the fracture lines between the parent middle phalanx and the palmar/plantar eminences.

Acute fracture management
If surgery cannot be done immediately, the limb should be protected in a cast or an appropriate dorsally positioned splint. A prefabricated Kimzey splint is useful for temporary management. If a dorsal splint is used, it is important not to pad the bandage excessively because this will significantly decrease the efficacy of the splint. Phenylbutazone or flunixin should be given; although this will not result in significantly improved weightbearing it will provide considerable relief to the horse.

Treatment options and recommendations
Comminuted and displaced fractures of the middle phalanx should be treated surgically by internal fixation. The osteosynthesis construct uses the first phalanx to fix the fractured fragments of the second phalanx by performing a proximal interphalangeal (PIP) arthrodesis using double plating, usually locking compression plates (LCP). Fusing the PIP joint also prevents delayed pain when the fracture has healed, caused by PIP arthrosis that is almost inevitable after cartilage damage and multiple fragmentations.

Results
Prognosis for survival is good if no complication occurs. Prognosis for return to previous activity is mainly related to reduction and healing at the distal interphalangeal joint (DIP). Potential complications are post-surgical infection and support limb laminitis.

Other options
A transfixation pin cast has been proposed as an acceptable method for managing comminuted fractures of the middle phalanx. Transfixation allows the horse to immediately put weight on the fractured limb and reduces the occurrence of early support limb laminitis. However, delayed pain and discomfort due to pin loosening and/or degenerative joint disease of PIP and DIP joint are common complications.

In non- or slightly displaced comminuted fractures of the middle phalanx, there are some anecdotal descriptions of management using long-term casting, especially in light horses.

Comminuted fractures of the proximal phalanx

Incidence and causation
Although it is most common to see these fractures in racehorses, comminuted proximal phalanx fractures can occur in all breeds and during all activities including simple turnout in a paddock or arena.

Imaging
A clear idea of the fracture configuration is essential even if an aggressive surgical exposure is elected. We usually move around the leg with the x-ray generator performing 10–12 incidences to understand the configuration of the fracture. If computed tomography is available, this is an ideal situation to use it.

Treatment options and recommendations
Case selection is a pivotal issue with comminuted proximal phalanx fractures. The most critical decision is whether or not to attempt to reconstruct the bone with lag screws or to use some form of external fixation. In general, no attempt should be made to reconstruct a comminuted proximal phalanx unless there is at least one bone fragment that extends from joint to joint. This intact strut of bone serves as the foundation for the reconstruction.

Lag screw fixation using a minimally invasive surgical approach
It is definitely feasible to reconstruct the simpler 3–5 fragment comminuted fractures if the fragments are not too badly displaced. Closed reduction is also much easier if the repair is undertaken as quickly as possible after the injury. The fracture is repaired step by step with a standard lag screw technique proceeding from the deepest and most palmar fragments.

Results
Such fractures carry an excellent prognosis for survival and a fair to good prognosis for racing, depending on the cartilage status at arthroscopy.

‘Maximally invasive’ surgical approach
If the fragments are highly displaced, with many fragmentations at the proximal surface, an open approach is preferred to accurately reconstruct the proximal joint surface.

Lag screw fixation combined with transfixation cast
If a fracture is clearly too comminuted to allow reconstruction, some form of transfixation is necessary to prevent collapse of the fragments that would occur within a simple cast. For closed fractures with minimally damaged soft tissues, transfixation casts are technically simple and inexpensive. Transfixation pins are drilled through the mid and distal metacarpus/metatarsus using copious lubrication and sharp bits. There is general agreement that the risk is lessened by placing the pins as distally as possible in the cannon bone. It is also critical to apply the cast close to the bone, in order to prevent pin bending or breakage.

Double arthrodesis using a distal femoral plate
We have recently developed another strategy to stabilise comminuted fractures of the first phalanx. The technique is very similar to the biological fracture fixation used in humans and small animals and consists of proper axial and rotational alignment of the fractured proximal phalanx, followed by fixation of the fracture with a longer plate fixed into the metacarpal bone and second phalanx. The horse is placed in lateral recumbency, the fracture is reduced using traction, both the fetlock and PIP joints are drilled, and as much cartilage as possible is removed. An eleven-hole 5.5 mm distal femoral locking plate is then tunnelled under the digital extensor tendon and fixed by strategically positioned locking head screws via stab incision.

Results
Most mildly comminuted fractures with minimal displacement have a fair to good prognosis for return to racing. Severely comminuted fractures requiring transfixation remain very challenging cases. Despite the problems, it is reasonable to expect fracture healing in at least 50% of such cases.
Fractures of the distal phalanx consist of an interesting variety of configurations including some that are nearly trivial to those that often result in euthanasia. The majority of these fractures can be managed nonsurgically using temporary measures to restrict the hoof mechanism. When the distal interphalangeal joint is involved (types II, III and IV), there are surgical management options to consider that include fixation with cortical lag screws.

**Fractures of the extensor process (type IV)**

Small fragments will not cause clinical problems in many horses, but in some they do. It is a clinical impression that size matters and that larger fragments will more often become clinical problems, but this is certainly not proven. Larger fragments of the extensor process are often traumatic and occur in older horses that show lameness. They can be very large and most of them are surprisingly chronic when they are diagnosed. The Friesian horse seems to be particularly predisposed to this lesion. Very large fragments can be successfully removed arthroscopically without destabilising the joint [1]. It is feasible to repair large extensor process fragments with internal fixation, usually with 3.5 mm lag screw(s), but most are better treated by fragment removal.

**Sagittal/parasagittal (type III) and large articular wing (type II) fractures**

These fractures may be managed surgically or nonsurgically, but there is an ongoing debate whether internal fixation with lag screws is superior to cast application, orthopaedic shoeing and extended box rest. A retrospective study of 96 type II and III fractures revealed similar results for conservative and surgical treatment using lag screw fixation [2]. However, in this study many surgeries were included that were done without the assistance of proper intraoperative imaging techniques.

In principle, it is accepted that in a simple fracture best healing is achieved when the fracture is stabilised and compressed by lag screw fixation. While conceptually simple, internal fixation of the distal phalanx remains challenging because of deep encapsulation by the hoof wall and an extremely narrow anatomical margin for error. Internal fixation of equine fractures has advanced over the last few decades primarily because of the improving expertise of practising surgeons and correct application of implants. Arthroscopy and fluoroscopy/digital radiography are already routine adjuncts to many internal fixation procedures, but intraoperative computed tomography has enormous potential to minimise the errors that are inherently more likely with minimally invasive techniques [3].

The location of the lag screw is crucial because it must not penetrate the joint, nor should it comprise the canalis solearis or the insertion of the deep digital flexor tendon. Mechanical testing on cadaver limbs revealed that screw size and screw positioning had an influence on stability: 5.5 mm cortical screws were more effective than 4.5 mm screws in reducing type III distal phalanx fractures and restricting distal fracture gap expansion under load [4]. Compared with the conventionally recommended screw position for internal fixation of type III distal phalangeal fractures, a more distal screw position allowed placement of a longer screw and resulted in a more rigid fracture fixation but carried a higher risk of penetration of the solear canal [5].

Lag screw fixation of the pedal bone offers several advantages regarding fracture healing, such as improved fracture reduction and fracture stabilisation, which increases post-operative comfort, accelerates fracture healing and probably reduces development of osteoarthritis in the coffin joint. Complications include post-operative infection and abscess formation around the screw head, which can occur months or years after fracture repair.

**References**


Noninfected tenosynovitis of the digital flexor tendon sheath (DFTS) is a cause of both forelimb and hindlimb lameness in all breeds of horse [1-4]. Pathology of the DFTS is usually accompanied by distension, which is usually relatively straightforward to identify. However, in cob breeds, where thick skin and feathering is a feature, the distension may not be as obvious. Careful examination, including palpation of the limb, and diagnostic anaesthesia is performed to localise the lameness to the DFTS. Many causes of tenosynovitis have been described, with the most commonly reported lesion types being marginal tears of the deep digital flexor tendon (DDFT) and tears of the manica flexoria [1,4,5]. There also appear to be clear predilection sites, with 79% of DDFT tears occurring in forelimbs, 75% of which occur in the lateral margin [1,4]; in contrast, 79-82% of manica flexoria tears are diagnosed in hindlimbs [1,5].

It can be argued that once lameness has been localised to the DFTS, tenoscopic evaluation should be performed, therefore negating the interest in obtaining a definitive diagnosis of the structure involved. In the author’s opinion, a definitive diagnosis is always desirable to give the client information on expected prognosis; tears of the manica flexoria have a prognosis of 79% for return to previous use compared with 38-42% for horses with DDFT tears [1,5]. This may influence the enthusiasm for surgery, especially if other factors are at play, e.g. limited funds. A further reason for pursuing a definitive diagnosis is for information on surgical positioning. Most tenoscopies are performed with the horse in lateral recumbency using tenoscopic portals on the uppermost side of the leg. Marginal tears of the DDFT on the lowermost side of the leg are difficult to visualise and access from the opposite side of the DFTS. If identified during surgery, further portals must be created on the underside of the limb that are more challenging to operate through. Alternatively, the horse can be switched into the opposite recumbency with the associated increase in surgery time and anaesthetic risks.

The concurrent administration of an iodinated contrast agent (in a 2:1 ratio of local anaesthetic and contrast agent) into the DFTS, followed by a weightbearing lateromedial radiograph, was found to diagnose manica flexoria tears with 96% sensitivity and 80% specificity [6]. The same test was reported to diagnose DDFT tears with 57% sensitivity and 84% specificity [6]. Given the relatively low numbers in this study, a larger evaluation of 227 DFTS contrast tenograms with known tenoscopic diagnoses is being performed; the findings will be included in the presentation.

Ultrasonography remains an important part of the diagnostic work-up of lameness localised to the DFTS. It has reported sensitivities of 36–71% for diagnosing DDFT tears but only 38% for the diagnosis of manica flexoria tears [1,4]. Work carried out at the author’s hospital has suggested a nonweightbearing view is more sensitive at detecting manica flexoria tears. In particular, a torn manica flexoria will often appear thicker and more clearly delineated in the nonweightbearing leg. Data will be presented illustrating this, and other ultrasonographic techniques, which aim to improve the sensitivity of ultrasonography in detecting both manica flexoria and DDFT tears. Contrast-enhanced ultrasonography has been reported to detect 90–100% of surgically created deep flexor tendon tears [7].

Recently there has been interest in the use of computed tomography (CT) imaging to optimise the identification of these lesions, treatment that may be considered in cases where other factors are at play, e.g. limited funds. A further study was performed in cadaver limbs without pathology, it may represent a more reliable technique to detect DDFT tears in particular. This has particular importance, as stated previously, when determining the appropriate recumbency to place the horse to optimise surgical access to the lesion.

Certainly, the correct identification of lesions in the DFTS remains a challenge, particularly given the propensity for these injuries to occur in cob breeds which makes ultrasonographic examination challenging. However, with an increased array of imaging modalities and techniques to optimise the identification of these lesions, treatment that is more appropriate can be recommended.

References
Computed tomographic myelographic examination of the equine cervical spine
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Until recently, the gold standard for evaluating disorders of the equine cervical spine that result in stenosis of the spinal canal and subsequent spinal cord compression has been the use of radiographic myelography. With a sensitivity of only 53% there remain a large number of equivocal results [1]. A multi-institutional retrospective study revealed that 61% of horses with suspected compression were confirmed at post-mortem examination using plain radiography, while 68% were confirmed using myelography [1]. The difficulty in interpretation of radiographic studies makes the technique a poor tool for diagnosis of spinal cord compression. This allows acquisition of a plain CT scan is performed. The horse’s head and neck are elevated on a premade triangular block maintaining an angle of 45 degrees. An area of the poll and neck 15-20 cm caudal to the ears and 8-10 cm on either side of the mane is clipped and steriley prepared. The head is maintained in a flexed position so that the median axis of the head is at right angles to the median axis of the cervical vertebrae. Following placement of a sterile iodinated self-adhesive drape (lobahn), a sterile 8.9 cm 18 gauge spinal needle with stylet is inserted at the intersection of the cranial borders of the atlas and the external occipital protuberance along the dorsal midline. The needle is placed parallel to the ground, perpendicular to the skin and orientated toward the middle of the mandible of the horse. The needle is gradually advanced until a ‘pop’ is felt with penetration of the atlanto-occipital (AO) membrane and cervical dura. The stylet is removed and free flow of cerebrospinal fluid (CSF) confirms correct needle placement. A 20 cm extension set is placed on the end of the needle and a three-way tap used to withdraw 50 mL of CSF over 2.5 minutes. Immediately following the withdrawal of CSF, 20 mL of nonionic iodinated contrast material (iohexol 300 mg/mL) is injected into the subarachnoid space followed by a 50:50 combination of iohexol:sterile isotonic solution over a timed 3 minute period. The initial nondiluted contrast agent is ‘chased’ by the subsequent diluted contrast agent. A total of 80 mL of injectate is used. After 5 minutes the head is repositioned on the table and images acquired as before.

Following completion of CT myelography, the horse is moved into the recovery box. A series of radiographic views are acquired in a maximally extended and flexed position at the cranial, mid and caudal cervical regions to complete the myelographic study. Digital radiography allows rapid and detailed image acquisition. Once completed, the head and neck are maintained in an elevated position for 10 minutes using a premade triangular block to prevent retrograde flow of contrast around the brainstem and cerebrum.

Conclusion
CT myelography has been performed in horses with ataxia of grades 1-4/5 without complications occurring during the procedure or in the recovery period. The time from induction of anaesthesia to completion of the flexed and extended radiographic views following CT myelogram is routinely less than 1 hour, with images from the head down to T1 consistently obtained. Flexed CT myelographic views can be obtained of the cranial end but radiographic flexed views of the caudal cervical region are required. These are readily repeated as part of the same procedure immediately following CT and in the recovery room. Correlation of specific pathological findings on CT with spinal cord pathology is required.

References


High quality radiographic images are required to assess the musculoskeletal system accurately for pathology. With respect to the tarsus and stifle specifically, the anatomy of small tarsal bones and the associated soft tissue attachments mean that both subtle pathology, i.e. very early onset degenerative joint disease, or potentially small tarsal bone or patella fractures can be challenging to identify even on perfect ‘standard views’. Overriding radiographic principles to optimise image quality of the above regions are the same as for any radiograph obtained of a horse. Factors to be considered include choice of kVp, mAs, distance from the generator to the detector, detector type (CR vs. DR), collimation to reduce unnecessary scatter, correct angulation of the primary beam (differing per projection) and image labelling. Patient movement should be avoided; however, movement blur can also occur secondary to the personnel involved (i.e. hand holding of x-ray generators). As a minimum, all images should be labelled with a limb marker in the correct position.

The tarsus
To assess the three-dimensional anatomy of complex regions, multiple orthogonal projections must be obtained. For the tarsus, the standard radiographic projections include:
- Lateromedial (primary beam angled distally 5-10 degrees)
- Dorso-plantar
- Dorso-lateral-plantaromedial oblique
- Dorso-medial-plantarolateral oblique.

Additional views for the tarsus
- Flexed lateromedial – to evaluate the proximal portions of the trochlear ridges of the talus
- Flexed plantaroproximal-plantarodistal oblique (skyline of the calcaneus) – to evaluate the sustentaculum tali and the calcaneus in particular. Particularly used for horses with suspected calcaneal bursa synovial sepsis
- Dorso3°lateral-plantaromedial oblique – to evaluate the axial aspect of the medial malleolus; osteochondrosis/ osteochondritis dissecans.

One of the most common reasons to obtain radiographs of the tarsus is to assess for the presence of degenerative joint disease affecting the distal tarsal joints. There are a number of subtle radiographic features which can be identified early in this process prior to extensive periarticular bone formation; however, correct positioning and radiographic beam angulation are vital to avoid superimposition and facilitate assessment of the joint surfaces. Angling the primary beam by 5-10 degrees in a proximal-distal orientation for the lateromedial projection aids in this; however, typically this angulation is not required for the other projections.

The stifle
With respect to the stifle, in clinical practice, it would be recommended that a minimum database of the following projections is acquired, with additional views selected based upon clinical suspicion of disease:
- Lateromedial
- Caudal-lateral-cranio medial oblique (60 degrees/45 degrees angulation around the limb axis)
- Caudocranial (i.e. caudo10°proximal-craniodistal, angling the primary beam down).

Additional views for the stifle
- Flexed lateromedial – Improves visibility of the cranial aspect of the intercondylar eminences of the tibia, and portions of the trochlear ridges of the distal femur and patella.
- Caudolateral-cranio lateral oblique.
- Flexed cranio proximal-craniodistal oblique (skyline of the patella) – critical to evaluate the body of the patella and the respective poles, especially important to assess patella fractures.

For the standard projections of the stifle, a horizontal beam is preferred for the lateromedial and caudolateral-craniodistal projections, whereas, for the caudocranial, it is necessary to angle distally. The exact angulation required varies by the limb position: a caudally located limb will require progressively more distal angulation for the primary beam to project clearly through the joint spaces. Poor technique should not be confused with joint space collapse, which is more often seen in end-stage joint disease.

Horses with trauma to the cranial aspect of the stifle can often sustain fractures to the tibial tuberosity and patella given their superficial location, which can be difficult or impossible to see on standard projections. Obtaining additional images at varying degrees of obliquity, and flexed skyline projections of the patella for example, are often required.

In all scenarios, if obtaining images with which a clinician is not familiar, it is potentially helpful to obtain images of the contralateral limb. While some common tarsus and stifle pathologies are often seen bilaterally (OCD for example), other lesions would far less commonly occur bilaterally (i.e. fractures); therefore, this can be used as a potentially useful indicator of abnormality.

Stressed radiographs
In cases where a clinical suspicion of a collateral ligament avulsion or rupture exists, obtaining stressed radiographic images can be diagnostic for both the tarsus and stifle. Both abduction and adduction of the limb, using even manual pressure while a radiograph is obtained, can be performed with care. This can result in radiographically visible joint space widening or collapse on the contralateral aspect of the limb, confirming this finding.

Lesion-orientated radiographs can be obtained and optimised in general practice without need for complicated equipment. However, to do this, the pathological lesions either must be suspected and thus searched for, or identified and additional projections sought. Clinicians should not be afraid of deviating from the ‘standard’ images, and would be encouraged to safely (conforming with the ALARA/ALARP principles) seek out projections which would highlight the pathology suspected or identified. In some cases, acquisition of additional projections may highlight findings which provide information that may either alter the course of treatment (i.e. detection of a fracture plane requiring surgical stabilisation) or the prognosis (i.e. osteolysis seen in the calcaneus associated with calcaneal bursa sepsis).

While there is the potential for lesion-orientated radiographs to facilitate accurate diagnosis, it is stressed that the ability to detect pathology is only maximised when images of diagnostic quality are obtained. Therefore, image quality and an understanding of radiology principles is vital and should be actively considered in the process of acquiring the projections.
Are MRI and CT helpful in the diagnosis of injuries of the carpal region?

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Introduction
Lameness localised to the carpal area is a common cause of lameness in racehorses [1,2] and is also increasingly diagnosed in sports horses [3]. The anatomy of the carpus is complex which limits the usefulness of conventional imaging techniques. There is significant superimposition of the carpal bones on radiography and not all structures are accessible to ultrasound investigation.

Magnetic resonance imaging (MRI) and computed tomography (CT) provide us with three-dimensional images and therefore give us detailed information about the bone and soft tissue structures of the carpal region. MRI and CT scanners are becoming increasingly available for horses, MRI can be performed standing or under general anaesthesia, and in high-field or low-field systems. CT is mostly performed under general anaesthesia, although standing systems are becoming available on the market.

Bone lesions
MRI and CT provide us with detailed images of the carpal bones. Both techniques allow us to identify bone mineral densification and/or bone resorption of the subchondral and cancellous bone [4], as well as peristeal and endosteal irregularity [5]. MRI is the only modality that allows us to identify bone marrow lesions, which are characterised by hyperintense STIR and T2* signal, in combination with hypointense T1W signal. Increased radiopharmaceutical uptake on nuclear scintigraphy correlates well with bone marrow lesions on MRI in humans [6]; however, scintigraphy is much less detailed compared to MRI.

MRI and CT allow us to detect fractures with much greater detail compared to radiography [7], and to get detailed information on the extent of the fracture and its configuration. Abnormalities of the articulation between the second and third carpal bones and second and third metacarpal bones are often not visible on radiographs [8] but are easily detected on MRI and CT. Fragments at the axial aspect of the ulnar carpal bone are relatively frequently identified on MRI [5] and CT, often without evidence of pathological fractures or avulsions of the lateral palmar intercarpal ligament.

Soft tissue lesions
MRI allows us to image soft tissue structures that cannot be imaged with conventional imaging techniques, such as the transverse intercarpal ligaments, the radiocarpal ligament, the short palmar carpal ligaments and the carpometacarpal ligaments [5].

Desmopathy of the lateral carpometacarpal ligament diagnosed on high-field MRI was described in one case [9]. Due to the small size, location and fibre orientation (oblique in multiple directions) of this ligament; it is difficult to evaluate, even on high-field MRI, and low-field images provide even more limited information [10].

Transverse intercarpal ligament injury is best seen on high-field MRI images; however, osseous reactions at the insertions can also be seen on low-field images [8] and CT.

CT arthrography allows visualisation of the medial and lateral palmar intercarpal ligaments, radiocarpal and transverse intercarpal ligaments, and palmar carpal ligament [11]. MRI arthrography of the middle carpal joint [12] has been described to increase visualisation of the structures within the palmar lateral outpouching of the middle carpal joint, including portions of the ulnar carpal bone, fourth carpal bone, fourth metacarpal bone, lateral palmar intercarpal ligament, and lateral collateral ligament.

Intra-articular contrast-enhanced CT permits us to visualise areas with increased vascularity or increased vascular permeability within the soft tissues [13]. In my experience, lesions of the superficial digital flexor tendon within the carpal sheath are easily identified using this technique and are often more severe than expected from ultrasound examination.

Conclusion
MRI and CT of the carpal region provide us with a detailed image of this complex anatomical region and allow us to visualise bone and soft tissue lesions that cannot be seen using conventional imaging techniques. Therefore, MRI and CT are helpful techniques in horses with lameness that is localised to the carpal area, especially in cases with no significant radiographic or ultrasonographic findings, or in horses with fractures.

References
The breeding soundness examination of the stallion comprises a series of steps aimed at determining the suitability of the animal for breeding; it includes a basic physical examination, evaluation of the fitness to breed, detailed evaluation of the external genitalia and a rigorous semen evaluation. By performing these procedures systematically, a practitioner is able to ascertain with a high degree of confidence the stallion’s suitability for breeding.

Often during one of these steps one can find abnormalities that need further investigation with different imaging modalities. Problems associated with the reproductive tract of the stallion can be further examined using endoscopy, laparoscopy or ultrasonography. The purpose of this paper will be to describe some of the problems for which ultrasonographic examination is recommended.

Cryptorchidism
Transabdominal or transrectal ultrasonography can provide evidence of the location of a retained testicle. Abdominal, inguinal and subcutaneous locations have been reported. Identification of the location of the testicle would provide a guide for the selection of the best surgical approach for removal [1,2].

Scrotal enlargement
The scrotal skin should be smooth and free from evidence of trauma, inflammation or dermatological lesions, and the median raphe should be obvious covering both testicles. Abnormalities of the scrotum could be limited to the skin; however, when the scrotum is rounded or pendulous, an ultrasonic examination is suggested to determine the presence of adhesions and/or fluid accumulation in conditions such as hydrocoele, haematocoele and varicoceles, or the presence of omentum or small intestinal contents, which would suggest an inguinal hernia.

Testicular size
Testicular volume is an important measure that should be estimated in all breeding stallions. Daily sperm production (DSP) and output (DSO) are highly correlated with parenchymal weight, which is calculated by measuring the height (h) width (w) and length (l) of each testicle. The volume of each testicle (TV) is calculated using the formula: TV=0.5×w×h×l, and the combined testicular volume can then be calculated [3]. Sperm production is highly correlated with testicular volume, with stallions producing between 16 and 20 million sperm/gram of testicle. Lower total sperm output than expected for the testicular volume could be suggestive of total or partial ampullary blockage, while larger than expected sperm output suggests ejaculation of accumulated sperm.

Testicular irregularities
Testicular palpation should reveal symmetrical and turgid structures with no evidence of irregularities. Asymmetrical, smaller, softer, or firmer than normal testes should be imaged with ultrasound and could provide evidence of degenerative, neoplastic, or traumatic conditions. The vascularity and testicular blood perfusion can also be examined with Doppler ultrasonography. Low blood flow to the testis has been implicated in lower stallion fertility [4,5]. The appearance of the testicular parenchyma should be homogeneous, grey, and slightly granular throughout. Changes in widespread echohogenicity or focal hypop- or hyperechoic areas are indicative of pathological conditions such as tumours, haematomas or abscesses that should be further investigated. The testicular artery and central vein of the testis can be imaged and this is useful in evaluating blood supply to the testicular parenchyma.

Spermatic cords
The spermatic cord should have a heterogeneous appearance with anechoic circular areas surrounded by more hyperechoic regions in cross-section. The size of the vessels and their pulsatility can be easily evaluated using Doppler ultrasonography which can be used to evaluate blood flow to the testis. Distension of vessels (varicoceles) are often correlated with scrotal accumulations of fluid (hydrocoele). Changes in vascularity can be the result of inguinal hernia repair without hemicastration, or testicular torsion or chronic testicular rotations [5].

Epididymis
The appearance of the epididymis is that of a ‘Swiss cheese’ pattern owing to the fact that the epididymis is a single, highly convoluted, sperm- and fluid-filled duct. The lumen is narrowest in the head and widest in the tail, making the epididymal tail easier to visualise. Although rare, prominent dilation of the epididymal duct can be due to chronic accumulation of sperm or may indicate a disease process such as epididymitis [6]. The presence of cysts can also be detected.

Accessory sex glands
The stallion’s accessory sex glands include the paired ampullae, seminal vesicles, bulbourethral glands and the prostate. Ultrasonographic evaluation is recommended in stallions with anejaculation, azoospermia, oligospermia (blocked ampullae) or when white blood cells are detected in the ejaculate (seminal vesiculitis). Verminous arteritis can also be suspected when stallions have difficulty mounting or supporting their bodyweight during breeding. In these cases, ultrasonography of the caudal aorta, external and internal iliac arteries is recommended.

The urethra and penis
Ultrasonographic evaluation of the pelvic and penile urethra can be useful when urethral uroliths are suspected. Ultrasound of the penis is performed in conditions of paraphimosis, priapism or trauma, to identify a haematoma in the subcutaneous tissues or in the corpus cavernosum. In addition, rents or communications between the corpus cavernosum and corpus spongiosum caused by trauma can be visualised, which aids in surgical evacuation of the haematoma [6].

Summary
Although ultrasonographic evaluation is not a routine procedure performed during a breeding soundness evaluation, it is a very useful imaging technique when certain conditions are suspected. In addition, other lesions or conditions that may be innocuous, such as epididymal or urethral cysts,
can be found and recorded. It is recommended that, when possible, an ultrasonographic examination of the reproductive tract of the stallion be done when a full breeding soundness exam is performed.

References
Anatomy of the prepuce

The prepuce shields the detumescent penis. Unlike that of other domestic species, the prepuce of the stallion telescopes around the nonerect penis to form two distinct folds, creating both an external and internal prepuce. The external prepuce consists of external and internal laminae that meet at the preputial orifice. Only the external lamina of the external prepuce (sheath) is exposed when the penis is not retracted.

The external prepuce of the stallion is similar to the entire prepuce of other domestic species; however, its internal lamina does not attach directly to the penis of the stallion, but continues as the internal prepuce, also with external and internal laminae that meet at a second orifice, the preputial ring. The internal prepuce separates the preputial cavity into two separate compartments, the external and internal preputial cavities. The internal lamina of the internal prepuce reflects on to the body of the penis at the fornix of the internal preputial cavity.

NOTES

Managing penile and preputial injuries and abnormalities

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Anatomy of the penis

This erectile copulatory organ is well developed in stallions. It consists of a root (radix penis), body (corpus penis) and glans penis. The root of the penis is securely attached to the ischial arch by two strong ligamentous crura containing erectile lumina. These crura fuse in the root of the penis and extend distally to occupy the body of the penis as the expansive corpus cavernosum penis. The sizeable glans penis is located distal to the body, capping the free end of the penis. The cranial surface of the glans has a deep depression, the fossa glandis, from which the urethral process protrudes. The fossa glandis contains two ventrolateral recesses and a large dorsal diverticulum (urethral sinus).

The penis of the stallion is of the musculocavernous type, because the erectile tissue is made up predominantly of cavernous spaces rather than trabeculae of connective tissue. This is in contrast to the fibroelastic penis of male ruminants. The penis is composed of three cavernous bodies: the corpus cavernosum penis, corpus spongiosum penis and corpus spongiosum glandis. The corpus cavernosum penis spans the entire length of the penile body and is covered by a thick tunica albuginea. Precopulatory erection in the stallion is achieved through engorgement of the corpus cavernosum penis. A longitudinal groove on the ventral surface of the corpus cavernosum penis shields the penile urethra. The corpus spongiosum penis surrounds the penile urethra along its entire length. This cavernous tissue is an extension of the stratum cavernosum surrounding the pelvic urethra. The corpus spongiosum penis enlarges at its proximal end at the ischial arch as the bulb of the penis. Also continuous with the cavernous spaces of the corpus spongiosum penis is the corpus spongiosum glandis, located in the glans penis. It is capable of great expansion and is responsible for the marked ‘belling’ or ‘flowering’ of the glans penis during coitus.

Examination of the penis and prepuce

The nonerect penis has a soft compressible texture because of its musculocavernous construction. Typically, it is retracted fully into the prepuce because of the collapsed cavernous spaces of the penis coupled with contraction of the paired retractor penis muscles. Sexual excitement initiates a series of haemodynamic and neuromuscular events that transform the penis into a rigid copulatory organ. Exposure of a stallion to a mare in oestrus or other stimulatory element causes the flaccid penis to drop from the prepuce through relaxation of the retractor penis muscles, thereby allowing its inspection. The extent of the examination is dependent on the type of medical problem presented. This procedure also permits assessment of sexual behaviour, including erection capability. Manual extraction of the penis from the prepuce for examination is difficult and usually met with resistance from the stallion. The penis can be examined while the horse urinates. Urination can sometimes be stimulated by placing the horse in a freshly bedded stall; shaking or piling the bedding may increase a horse’s urge to urinate. Intravenous administration of a diuretic should result in urination within 10–15 minutes. Tranquilisation (acepromazine, xylazine) elicits penile prolapse, making the penis accessible; however, tranquillisers, especially phenothiazine-derivative tranquilisers (e.g. acepromazine), can result in penile paralysis or priapism in stallions and, therefore, should not be used indiscriminately.

The penis may require cleansing prior to inspection, as epithelial debris mixed with secretions from the preputial glands tends to accumulate in the preputial cavity and on the exterior of the penis. The root and proximal body of the penis are buried in tissue, thereby limiting the examination to the exposed body and glans. The penis should be examined thoroughly, and any palpable or visual lesions recorded. Because the fossa glands and urethral process are partially concealed, particular attention should be given to these areas. Common penile lesions include those of traumatic origin (such as trauma to the urethral process) as well as vesicles/pustules of coital exanthema, habronema granulomas, squamous cell carcinomas and papillomas.

During penile tumescence, the prepuce also is readily available for examination. The skin of the prepuce should be thin and pliable, with no evidence of inflammatory or proliferative lesions. Developmental abnormalities of the penis and prepuce are rare. Lesions of coital exanthema, squamous cell carcinomas and papillomas often coexist on the penile and preputial integuments. While the word limit of this abstract prevents elucidation of various abnormalities of the penis and prepuce, this presentation will address the diagnosis of the various penile/preputial lesions, as well as possible therapeutic strategies and potential pitfalls.

I emphasise anatomy of the penis and prepuce in this abstract, as familiarity of anatomy is important to evaluation of various forms of penile and preputial abnormalities.
Post-mortem epididymal sperm extraction

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Introduction

The loss of a breeding stallion can not only be a distressing and emotional time for a stallion owner, it can, furthermore, have devastating financial implications. Customarily the breeding potential of a stallion is lost with death; nevertheless, advances in cryopreservation techniques have meant that stallions can now have genetic material collected and stored indefinitely.

In normal circumstances, valuable breeding stallions have semen collected and cryopreserved routinely during periods of competing rest, or when fresh semen breeding programmes have concluded. Epididymal sperm harvesting, which is removal of semen from the epididymis, is an option where there are abnormal circumstances – such as when the stallion has either been through an elective or emergency castration procedure, or where death of the stallion is sudden and unanticipated.

This procedure enables us to salvage valuable genetics which would otherwise have been lost at a time when there is simply no option to use conventional collection and freezing techniques.

Methodology

For this procedure, the stallion has one or both testes removed using standard castration techniques, leaving as much of the ductus deferens as possible intact to prevent any loss of sperm. The success of this procedure is very much dependent on the speed at which the testes are transported to the centre, from the time the animal was castrated or the time of death. In most instances, spermatozoa will survive and maintain capacity for fertilisation for up to 24 hours following castration and, in some instances, even up to 48 hours. It is recommended, however, that the sperm be harvested and cryopreserved as soon as possible following death, euthanasia, or elective castration of a stallion. Ideally the samples should arrive at the centre within 12 hours of castration, to allow for ample processing time of the testes.

Although this procedure is normally carried out at short notice and often under difficult circumstances for the stallion owner, it is essential that biosecurity is not overlooked, in order to prevent future disease outbreak. Therefore, the donor stallion should undergo a full pre-entry health testing programme; this includes a blood sample tested for equine infectious anaemia (EIA), equine viral arteritis (EVA) and a set of swabs for contagious equine metritis (CEM), Klebsiella and Pseudomonas. These tests may be done at the point of castration.

Results

The number of breeding doses collected can vary enormously from harvest to harvest depending on the age of the stallion, the size of the testicles and the density of the semen sample collected, but typically anything from 10 to 60 doses can be achieved. While it has already been proven that pregnancies can be achieved via this technique, unfortunately there is not as much pregnancy data available as we would like. Pregnancy data is readily available for stallions where the supply of semen is in abundance, but maybe semen obtained in this manner is perceived to be too precious to use, due to its limited availability. We hope that available data will improve as this method is adopted on a more frequent basis.

For the future, intracytoplasmic sperm injection (ICSI) may be the preferred method of use for epididymal sperm. This procedure requires only one sperm cell to be injected into an oocyte and therefore would help to conserve spermatozoa banks.

As the developments in assisted reproductive techniques continue, it is doubtless that there will be a higher instance of viable pregnancies obtained from cryopreserved epididymal sperm from valuable stallions. However, the most effective way of cryopreserving a stallion’s genetics is still through conventional collection and freezing techniques and therefore epididymal sperm harvesting is best adopted as a last resort, as there is no guarantee that it will be successful.

Alternative conservation method to epididymal sperm extraction

Genetic preservation is a must if we do not want to see rare-breed equines, such as the Suffolk Punch, and even endangered species such as rhino, become extinct. Today science provides us with another viable technique for genetic preservation and that is cloning.

Cloning is becoming more efficient and therefore affordable in countries such as the USA, Italy and China. In the UK, with the exception of Dolly the sheep, it is not practised due to ethical considerations.

The process of cloning begins with taking a biopsy of the animal and extracting the DNA. A cell line is then grown from the cells in the biopsy. Cryopreservation can take place at either the initial biopsy stage or after the cell line has been grown. The DNA present within the cell line can then be inserted into an unfertilised enucleated oocyte, which is shocked in order to start cell division. The embryo is then implanted into a recipient mare. After this, normal gestation and birth occurs resulting in a genetically identical/cloned foal of the original horse.

Surprisingly, many cloned animals do not look like their original, or do not possess the same characteristics. Therefore, while cloning will help prevent extinction of certain breeds, it does not ensure the production of an identical looking or performing animal.

Of course, carrying out the cryopreservation of either the biopsy or the cell line does not imply that the cloning of that animal will ever take place; it does, however, allow for the possibility in the future. This technique is therefore potentially invaluable as a means of rare breed preservation.

Summary

In summary, both of the aforementioned techniques, while being very different, have strong merits with regards to genetic preservation of recently deceased animals.

With epididymal sperm extraction, this method can be used more easily for regeneration and is more cost-effective. However, it will only help to sustain the male genetic line, so when it comes to rare breeds where you want to preserve the female lines as well, taking tissue samples for the possibility of future cloning could be preferable. Although the cost of cloning may currently be prohibitive for many, it has halved in the last 5 years to approximately £60,000 for equines. If this continues to decrease, then it could be a viable option for regeneration projects in the future.

NOTES
International trade of equine semen

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The equine industry is reliant upon the free movement of horses, semen and germinal products globally. The UK is privileged, with relatively few restrictions internationally thanks to its high health status and geographical location; keeping this is fundamental to maintaining and growing future trade.

Within the UK, the importation and exportation of semen is primarily undertaken by few providers. The majority of the frozen semen that is imported from and exported to the UK is via Stallion AI Services. The majority of the chilled semen imported into the UK is via Elite Stallions. The remaining consignments are via smaller providers, private mare and stallion owners and veterinary surgeons. The responsibility for the health status of the shipment of semen (frozen and chilled) is with the importer/exporter. Once imported/exported, the semen can be disseminated within the UK without further health restrictions, at the discretion and satisfaction of the mare owner and their veterinary surgeon.

The market for international trade in semen is strong and has demonstrated growth over the past 3 years. From 2014 to 2016, the number of countries the UK exports to has remained largely constant at 16 or 17. However, the number of frozen exports has risen significantly from 36 to 76 doses, equating to 3500–5500 straws. If each straw is given a value of £500 then this suggests an annual value of £1.8m in 2013, rising to £3.2m in 2016. Similarly, the number of chilled exports has increased from 19 in 2013 to 76 in 2016.

The industry estimates that the combined sector has grown from £0.5m in 2012 to £4.1m in 2018.

The trade in importing chilled semen has also demonstrated significant growth. Elite Stallions estimate they handled 80–90% of imports to the UK in 2017. During this trading year an estimated 1300 mares received imported chilled semen, equating to approximately 2400 shipments.

The legislation regarding the movement of semen across international borders is governed by UK law. It currently states that all consignments must be accompanied by specific internationally recognised and original documentation. Within the industry this causes significant difficulty with respect to compliance at the point of insemination. The Royal College of Veterinary Surgeons is duty bound to monitor that veterinary surgeons are practising within the law in every aspect of their professional conduct and this area is no exception. Stallion AI Services estimate that the frequency of documentation error is worryingly high, but progress has been made in recent years, falling from 60–70% in 2016 to 30% in 2018. Errors in documentation are more prevalent in the frozen sector, despite there being more time to request correct certification prior to insemination in comparison with the importation of chilled semen.

Some European countries now accept digital documentation, but this remains prohibited in the UK. Accepting digital documentation should be urgently considered by the UK governing bodies to avoid it becoming an obstacle to international trade. Currently there is significant discussion with regard to the interpretation of this law to accommodate digital documentation to avoid wholesale re-writing.

Brexit may also affect trade flows and result in changes to rules applying to the importation and exportation of equine semen. We must keep abreast of the changes and react quickly to their relevance to this trade.

As veterinary surgeons, our responsibility is to uphold and improve the health and welfare of the equidae under our care. Within these parameters, the appropriate preparation, screening and certification of each shipment sent or received is paramount. Failure to adhere to these principles could lead to a significant outbreak of disease, a reduced health status and movement restrictions that would retard the sector in a potentially catastrophic manner. We are fortunate in having robust, capable establishments and individuals that ensure these gold standards are being and will continue to be maintained.

Disclaimer
Data presented is based on best estimates rather than fact. Exact published figures for the entire sector without exception do not currently exist.

Acknowledgements
Sincere thanks to Tullis Matson, Lorna Wilson and Jan Rogers for their assistance with the data presented.

NOTES
General principles of semen evaluation

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Introduction

Laboratory-based evaluations of stallion breeding potential have been conducted for many decades, but the results of such evaluations do not have an exact correlation with actual fertility. The reasons for this disparity are varied, but mare and management factors can certainly confound one’s interpretation of the actual intrinsic fertility of a stallion. In other instances, the fertility cannot be explained by standard tests of semen quality. As an example, we conducted a fertility trial with a subfertile stallion whose semen was subjected to density-gradient centrifugation in an effort to improve semen quality prior to insemination. Values for sperm motility before and after semen processing for the subfertile stallion and a fertile control stallion are listed in Table 1.

Table 1: Effects of semen processing on enhancement of sperm motility parameters

<table>
<thead>
<tr>
<th>Stallion</th>
<th>Semen treatment</th>
<th>Total motility</th>
<th>Progressive motility</th>
<th>Curvilinear velocity (µm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertile</td>
<td>Before</td>
<td>80</td>
<td>63</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>91</td>
<td>78</td>
<td>209</td>
</tr>
<tr>
<td>Subfertile</td>
<td>Before</td>
<td>63</td>
<td>48</td>
<td>251</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>90</td>
<td>79</td>
<td>259</td>
</tr>
</tbody>
</table>

Based on these results, it would appear that semen treatment for the subfertile stallion yielded a sperm population with quality similar to, or exceeding (based on velocity values), that of the fertile control stallion. Nonetheless, when fertile mares were inseminated hysteroscopically with 20 × 10^6 progressively motile sperm (100 µL volume), the resulting pregnancy rates were 15/20 (75%) for the fertile stallion, as compared to 7/20 (35%) for the subfertile stallion (P = 0.01). This demonstrates that sperm motility does not provide absolute discriminating power, again emphasising that sperm attributes other than motility play critical roles in their fertilising ability. Despite these limitations, laboratory-based prognostication of stallion fertility remains a mainstay of veterinary practice and various features of sperm quality following cooled or frozen storage. Many other assays have been developed for assessing various compartments or molecular features of sperm from a variety of species; however, the prognostic value of these assays remains largely unknown in relation to stallion fertility.

Procedural considerations

Conventional laboratory tests for assessment of sperm quality have included light microscopic evaluation of sperm morphological characteristics and estimation of sperm motility (including percentages of motile and progressively motile sperm, velocity of sperm movement, and longevity of sperm motility following in vitro storage). Other ancillary tests shown to be of diagnostic value are incorporated into the examination process within some reference laboratories today. As an example, one of these ancillary tests is the sperm chromatin structure assay (SCSA). This assay, introduced by Donald Evenson, has been applied to sperm from a number of species, including horses. The SCSA tests a compartment of spermatozoa that is not monitored by conventional methods, i.e., nuclear chromatin. The SCSA is a flow cytometric procedure that utilises the metachromatic fluorochrome, acridine orange, and tests the denaturability of sperm chromatin challenged with acid treatment. The assay determines the amount of double-stranded and single-stranded DNA in each sperm. The literature provides variable results regarding the relationship of stallion sperm chromatin denaturation to the extent of disulfide bonding within and between protamine molecules; however, chromatin susceptibility to denaturation has been correlated with the level of actual DNA strand breaks. The DNA strand breaks can be associated with a myriad of factors, including idiopathic apoptosis, oxidative stress, heat stress, radiation injury, or protamine deficiency, and may involve double-stranded or single-stranded DNA fragmentation or oxidised nucleosides. Sperm affected by such damage may appear to be normal, based on laboratory parameters such as sperm motility and membrane integrity, but may induce post-fertilisation embryonic failure. Owing to the highly condensed nature of the sperm chromatin, mature sperm are known to be transcriptionally inactive, so it is logical that DNA damage might not be expressed until mitosis occurs at the time of sperm-oocyte fusion. This becomes quite important clinically as it represents a potential noncompensable defect.
i.e., affected sperm in an ejaculate may not be impaired for fertilisation, so increasing the insemination number will not increase pregnancy rate. Assays other than the SCSA are available to measure sperm DNA fragmentation/ chromatin disruption, including a TdT-mediated-dUTP nick end labelling (TUNEL) assay, a sperm chromatin dispersion (SCD) assay, and an electrophoresis-based comet assay. While these assays have not been used to the same extent as the SCSA in the equine arena, they are commonly applied in the human field. We have identified a subfertile stallion with significant sperm DNA strand breaks, as determined by TUNEL assay, which responded normally to the SCSA.

Other commonly used procedures in our laboratory include examination of sperm plasma membrane integrity, assessment for seminal plasma toxicity, and an acrosomal responsiveness assay in stallions with subfertility and from a particular lineage. These will be discussed in the presentation.
Which semen extender?

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Introduction
After collection, semen is diluted with an extender to maintain sperm viability until use for artificial insemination (AI). Extenders protect sperm against temperature fluctuations, accumulation of oxidative damage, inhibit microbial growth during storage, and contain nutrients for metabolising and retaining motility.

Semen handling
For diluting raw semen an appropriate extender should be selected, which should be added directly after collection and initial evaluation of the gel-free volume and sperm concentration. Preferably, for immediate use for AI, minimally an equal volume of pre-warmed (37°C) extender should be added (1:1, extender to semen). If stored at refrigerated temperatures (5°C), or frozen-thawed, presence of high seminal plasma content is detrimental to sperm. Then, a higher dilution ratio (4:1, 25–50 million sperm per mL) should be used, resulting in less than 20% seminal plasma. Alternatively, for removal of seminal plasma and increasing the sperm concentration, semen can be centrifuged (600 g for 10 minutes) and the sperm pellet can be resuspended with fresh extender.

Semen extenders for processing and cooled storage
Semen extenders contain protective compounds that allow for sperm survival outside the reproductive tract. Typically, they contain skimmed milk and glucose, and have a pH of 6.5–7.2 and osmolality of 300–360 mOsm. Other sugars added include sucrose, raffinose and lactose. Extenders are buffered using sodium bicarbonate, citrate, and/or HEPES. Antimicrobials (e.g. penicillin and gentamicin) are added to minimise bacterial growth. Here, the antimicrobial type (bacteriostatic, bactericidal) should be taken into account, as well as the storage temperature and duration (below/above 15°C), and the doses mares are exposed to when inseminated. If storage temperatures exceed 10°C, antifungal drugs may be needed to control fungal growth. Lipoproteins, as present in milk (and egg yolk) have been described to have several protective roles; however, they are of animal origin. Such compounds can be substituted with defined compounds like phosphocaseinate isolated from milk, and/or lipids. Accumulation of reactive oxygen species (ROS) may damage sperm during storage, which can be counteracted by addition of antioxidants (e.g. vitamin E, ascorbic acid).

Semen extenders for sperm cryopreservation
Stallion sperm cryopreservation is typically done using a two-step dilution procedure. This involves dilution in a primary (skimmed milk–glucose) extender for centrifugation and concentration of spermatozoa, followed by dilution with a extender containing cryoprotective agents (CPAs). CPAs that are typically used include egg yolk (2.5%) and glycerol (2.5%). Also (combinations of) other permeating CPAs may be used, including ethylene glycol and dimethyl formamide, and antioxidants can be added. For freezing, the interplay between the CPA concentration (1−10%) and cooling rate (10−60°C/min) has to be taken into account. Dependent on the CPA chosen, a narrower or wider range of concentrations and/or cooling rates can be used.

Commercial semen extenders
Nowadays, semen extenders are commercially available (and patent protected). Such extenders are convenient, sterile, quality tested and standardised. Moreover, different extenders exist for specific uses, including extenders for semen processing such as (density gradient) centrifugation, extenders for fresh use as well as cooled and frozen storage, and different compositions for testing with semen from different stallions. It is important to note that for testing efficacy of different extenders and processing procedures, a split ejaculate approach should be used.
Introduction

Stallions become sires based principally on three basic qualities: pedigree, performance record and conformation. Even though stallions represent 50% of the breeding equation, the decision to retire a stallion to stud duty is made with little consideration to breeding capability or reproductive health. As such, the equine breeding industry abounds with stallions whose level of fertility is less than optimal.

Undesirable fertility can emanate from physical, mental or environmental aberrations that result in disruption of mating ability, and inefficient semen transfer from the stallion to the reproductive tract of the mare. More often, subfertility results from disturbances in testicular, epididymal, or deferent duct function. Some forms of subfertility may have a genetic basis, but subfertility is often associated with ageing in stallions and the attendant effects of age on testicular and epididymal function. Effects of long-term medications, such as prostogestogens or anabolic steroids, on testicular health and fertility of sires must also be considered. Other effects, such as hot environmental temperature, fever, or genital trauma can also induce a subfertile state in an otherwise fertile stallion.

Taken together, these scenarios rationalise the need for veterinary intervention as a means to maximise the fertility of stallions. While ethics should be considered before applying assisted reproductive techniques that could propagate genetic forms of subfertility in stallions, it is difficult at present, except in isolated circumstances, to differentiate between heritable and nonheritable causes of reduced fertility. This presentation addresses some semen management strategies that can be applied in an effort to maximise the fertility of breeding stallions, either in natural cover or artificial insemination programmes.

Natural cover breeding programmes

While stallions subjected to only natural cover conditions cannot benefit from many laboratory techniques that would be likely to improve their breeding performance, one can implement methods to critically assess a stallion’s fertility, and devise officially authorised strategies to enhance its reproductive success. Assessment of breeding records will allow one to uncover some management factors that also impact reproductive performance of stallions. For instance, some stallions exhibit improved fertility when bred more frequently, whereas other stallions experience a decrease in pregnancy rate when breeding frequency is increased (Table 1). Close examination of breeding records will allow demarcation of these differences. In Table 1, Stallion 1 experienced an apparent improvement in fertility as breeding frequency increased from one to three times daily, and pregnancy rate also tended to improve from Session 1 to Session 3 on days when three mares were covered. Conversely, pregnancy rate declined precipitously when the stallion was allowed 1 or 2 days of sexual rest between covers. Stallions like this are commonly encountered when evaluating breeding records. Such stallions typically have large testes and tend to develop stagnant stores of sperm in the extragonadal ducts when not breeding frequently. Some also appear to possess an unhealthy milieu for sperm within the cauda epididymal luminae (i.e. have unidentified toxicants to sperm in the epididymal plasma). Sperm number in ejaculates are generally not the limiting factor for establishment of pregnancies. Maximising reproductive efficiency in these types of stallion may involve covering of non-commercial mares to avoid periods of sexual abstinence that will negatively impact breeding performance. In stallions with stagnant sperm reserves, this breeding strategy becomes especially important in the days and weeks prior to the onset of the commercial breeding season, as these stallions are generally quite susceptible to a condition termed ‘plugged ampullae’ following extended periods of sexual rest. On the contrary, Stallion 2 in Table 1 demonstrates that fertility of some stallions is lowered as breeding frequency increases, something that we typically see as stallions have a drop in sperm output and semen quality. As is evidenced with this stallion, pregnancy rates are often improved in the last covering session of the day when such stallions cover multiple mares in a day. This may be attributed to the fact that mares are probably being covered nearer to the time of ovulation. Stallions with this breeding scenario may be managed most effectively by limiting the number of mares that are covered per day so that the stallion can ejaculate the threshold number of normal sperm necessary to achieve an acceptable pregnancy rate. This table demonstrates that the fertility of Stallion 1 could be improved by actually covering more mares, whereas the opposite is the case for Stallion 2. I term these forms of breeding management to be “in vivo semen processing.” Another way to improve the fertility of some stallions is with the use of “reinforcement” breeding.

| Table 1: Effect of breeding frequency on pregnancy rate for two Thoroughbred stallions |
|---------------------------------|-----------------|-----------------|
| Number of mares covered         | Stallion 1      | Stallion 2      |
| Per-cycle pregnancy rate on days when one mare covered | 39%            | 46%            |
| Per-cycle pregnancy rate on days when two mares covered | 48%            | 55%            |
| Per-cycle pregnancy rate on days when three mares covered | 52%            | 22%            |
| Per-cycle pregnancy rate on Session 1 when three mares covered | 40%            | 18%            |
| Per-cycle pregnancy rate on Session 2 when three mares covered | 50%            | 9%             |
| Per-cycle pregnancy rate on Session 3 when three mares covered | 67%            | 40%            |
| Per-cycle pregnancy rate following 1 day of abstinence | 25%            | 71%            |
| Per-cycle pregnancy rate following 2 days of abstinence | 18%            | 67%            |
Artificial insemination programmes
Approval of artificial insemination by most horse registries has resulted in commercial application of a multitude of assisted reproductive technologies to maximise the reproductive efficiency of stallions. Two relatively new strategies that are becoming more commonplace in equine breeding programmes involve advancements in centrifugation of semen (cushioned centrifugation and gradient centrifugation) and application of deep-horn low-dose insemination. While the limitations in abstract size prevent elucidation of these techniques, all have application to stallions in artificial insemination programmes that have deficiencies in sperm quality, sperm output, or that have evidence of toxic factors in seminal plasma.
Sperm selection and concentration techniques

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Introduction
In the horse world, sperm quality is not the most important characteristic used for stallion selection; rather, these animals are selected based on sporting ability and the high value of their progeny, thus increasing the number of stallions with no proven fertility and poor semen quality. Additionally, there is considerable variation between stallions in fresh semen and in coolability and freezability of semen. Removal of seminal plasma may increase semen quality in some cases, as well as improving the viability of cooled or frozen semen. Several techniques have been developed to improve the quality of semen from stallions with poor semen and also to enhance sperm parameters after the cooling or freezing process [1]. The goal of this paper is to review strategies that may be used in field situations to increase sperm quality and stallion fertility.

Sperm concentration techniques
The most useful technique for sperm concentration is centrifugation. For this, several protocols have been reported that use different centrifugation forces, semen extenders or procedures to minimise the possible damaging effects of centrifugation [2]. Usually, centrifugation is performed at 600 g for 10 min to remove seminal plasma, and a skimmed milk-based extender must then be added to the semen at a 1:1 ratio prior to cooling or freezing. However, some studies reported a negative effect of centrifugation on sperm cells, including damage to the sperm membrane and motility, as well as loss of cells during this process (10–15%) [3].

One method of reducing these negative effects is to use a cushion solution (Cushion Fluid, Minitube, Brazil; Red Cushion, Botupharma, Brazil). Cushion centrifugation may be used to maximise sperm recovery from centrifugation and reduce the damage to sperm cells [4]. Using this technique, high centrifugation forces (1000 g for 20 min) may be performed, improving sperm recovery rates and minimising damage to semen cells. Semen preparation is the same as is used for conventional centrifugation; however, after placing the semen in a 50 mL or 15 mL falcon tube, 1–3 mL of cushion solution is carefully deposited at the bottom of the tube using a straw or a catheter attached a syringe.

Another sperm concentration method that can be used is the SpermFilter® (Botupharma, Brazil), which consists of a filter with a synthetic hydrophilic membrane (containing 2 µm pores) for sperm retention and plasma discharge [5]. The semen should be diluted as for centrifugation and then deposited on the filter, which should be manipulated gently on a 15 cm Petri dish; alternatively, the dish may be placed on a surface inclined at an angle of about 30 degrees to allow seminal plasma to flow through the filter membrane. Filtration is finished when a very low volume of fluid is observed on the filter; a pre-determined quantity of extender should be added to the filter immediately, to resuspend the sperm cells and flush the filter allowing the retained semen to be retrieved.

We in our laboratory, and some Brazilian veterinarians, have used the SpermFilter® added to BotuCrio® to improve poor-quality cooled semen. In this procedure, the seminal plasma and extender are removed from the cooled semen using SpermFilter® and the cells are resuspended with BotuCrio®. Using this manipulation, improvements in sperm kinetics and in fertility rates of stallions with low fertility have been observed. Additionally, in a recent study we observed that in very poor quality semen after the cooling process (<25% total motility), the removal of seminal plasma and extender using SpermFilter®, with resuspension in BotuCrio® or in a skimmed milk-based extender with pentoxyfiline (BotuTurbo®, Botupharma, Brazil), besides the improvement on sperm kinetics, also improved the mitochondrial potential of these sperm cells.

Sperm selection techniques
A technique that can be used to improve semen quality is sperm selection by EquiPure™ (Nidacon) or Androcoll-E™ (Minitube) [6]. This technique is based on a selection gradient of microparticles of silica that select sperm cells with good progressive motility, cell integrity and normal morphology, increasing the percentage of viable cells.

This procedure can be used to select fresh semen prior to the cooling or freezing process, as well as for cooled semen or thawed frozen semen to improve the quality of sperm for insemination [1]. The protocol for sperm selection from thawed frozen semen uses four straws (2.0 mL) of thawed semen placed on the EquiPure column (2.0 mL) and centrifuged at 400 g for 20 min. The number of recovered sperm cells was, on average, 18% of the initial cell count. The resulting pellet is aspirated and resuspended in 1 mL of BotuCrio® (Botupharma, Brasil), maximising the fertility rates even with a low sperm dose (50–100 x 10⁶ total sperm).

References
Endometritis in the mare is commonly categorised into acute infectious, chronic infectious or post-mating-induced endometritis [1]. While these definitions are appropriate, in clinical practice we are mostly dealing with mares that present with either clinical or subclinical endometritis. Clinical endometritis, by definition, is relatively easy to diagnose as the presence of intruterine fluid on ultrasound, with or without a vaginal discharge, is readily apparent [2]. Historically, the diagnosis of endometritis was based on a positive culture from a uterine sample obtained with an unguarded swab. The standard practice of ‘routine swabbing’ from the uterus and/or clitoris has been a key component in avoiding the transmission of equine venereal diseases [3]. In contrast to clinical endometritis, subclinical endometritis is more difficult to diagnose. The prevalence of subclinical endometritis in barren mares ranges from 10–65%, depending upon the population studied and the method of diagnosis [4]. Subclinical endometritis is the most common finding in mares referred to our clinic with a history of infertility. Although uterine culture is known to lead to false positive and false negative results [15,6], endometrial culture is still the most common method used by practitioners to diagnose subclinical endometritis [7]. However, the detection of subclinical endometritis is improved significantly by utilising cytology (with culture) to detect the presence of neutrophils in an endometrial sample [4].

The options for collection of an endometrial sample for both cytology and culture include uterine biopsy, guarded cotton swab, guarded cytobrush and low volume lavage (LVL). Each of these techniques have their limitations, and case selection is important in deciding which is most appropriate for a particular mare.

Uterine biopsy

The histological presence of polymorphonuclear neutrophils (PMNs) in the endometrium is regarded as the ‘gold standard’ method of diagnosing subclinical endometritis [2,4]. However, as a routine diagnostic test, histological examination of an endometrial biopsy is an invasive technique which lacks practicality due to the tissue processing required and a time delay in obtaining the results. It does provide very valuable information on endometrial health, however, and can be used as a prognostic indicator for future fertility potential [8]. Therefore, a uterine biopsy is always performed on mares referred to our practice for investigation of infertility. Performing bacterial culture and cytology on a uterine biopsy sample is also possible and this provides rapid and useful information [6].

Guarded cotton swab

Currently, the most common method used to obtain an endometrial sample for cytology and culture is the use of a guarded cotton-tipped swab. While this method is cheap and easy to perform, the technique is associated with a high number of false negative results [5]. Cell numbers are reduced compared with other techniques [9], although this can be improved by wetting the tip with sterile saline prior to use. Contact time also improves cellularity, with a minimum of 30 seconds recommended. LeBlanc [1] showed that cotton swabs have lower sensitivity in identifying Gram-negative organisms than culture of small volume uterine flushings or endometrial biopsy. A limiting factor with the cotton swab is the fact that the sample is obtained from a very small area of the endometrium and therefore may not be representative of the entire uterus [10].

Cytobrush

In both humans and cattle, the cytobrush technique has been determined to be superior to other methods for the collection of cervical and endometrial cells [11]. In mares, the cytobrush provides superior recovery of cells and a higher proportion of intact cells compared with both the cotton swab and LVL [4,9]. The technique is quick and easy to perform. In one study, the combination of culture and cytology using the cytobrush significantly improved the identification of mares with subclinical endometritis compared with the use of a cotton swab [4], and in another study, the cytobrush technique had similar diagnostic value as LVL [9].

Low volume lavage

LVL facilitates contact with the entire uterine lumen and therefore provides a more representative sample of the endometrium compared with swabs, cytobrushes or biopsies [1]. LeBlanc reported a sensitivity of 0.8 for flush cytology when compared with endometrial biopsy for the diagnosis of subclinical endometritis. LVL is time-consuming and requires at least two people to perform. False positives (contaminants) are not uncommon when performing LVL, and a double-guarded LVL technique has been described to avoid this [12].

In summary, several methods are available for collecting an endometrial sample to identify mares with subclinical endometritis. No single technique by itself is foolproof. Diagnostic accuracy is increased by using a combination of the different techniques.

References


Uterine lavage is commonly performed by equine reproductive veterinary surgeons. The goal is to improve the environment within the uterus – e.g. to clear post foaling debris, maximise potential for spermatozoa to reach the oviduct, or to provide a suitably clean environment so that when the embryo enters the uterus it has maximal chance of survival.

Indications for uterine lavage are diverse but are usually related to reducing inflammation within the uterus. It may be used diagnostically and has been found to be twice as sensitive as uterine swab culture for detecting endometritis [1].

What to use

Uterine lavage is performed with 0.9% sterile saline or Hartmann’s solution. The author prefers Hartmann’s solution and finds it to be less irritant to the endometrium, perhaps as it usually has a higher pH than saline. The volume used per lavage infusion (1–2 L) will depend on the size and parity of the mare. The aim is to distend the uterus fully just to the point where the mare becomes uncomfortable, stimulating myometrial contractions and therefore aiding fluid return. Lavage is repeated until the fluid returns clear – being able to read the writing on the opposite side of the fluid bag through the efflux is a useful practical guide.

Additives for specific indications

Endometritis, particularly when chronic in nature, causes increased mucus production within the uterine lumen. This mucus can render intrauterine treatments such as antimicrobials (particularly aminoglycosides) ineffective. When visible on ultrasound, mucus appears as a hyperechoic linear echodensity in the lumen, often without accompanying fluid. Biofilms are produced by some Gram-negative bacteria (notably *Pseudomonas aeruginosa* and *Escherichia coli*) and fungi, and can similarly reduce the efficacy of intrauterine treatment. Mucolytics can be added to uterine lavage fluid to attempt to clear mucous/biofilm.

Dimethyl sulfoxide (DMSO) has been shown to improve the histopathological grade of the uterus in 18/27 mares treated with a 30% solution; the treated mares were also found to have a higher pregnancy rate vs. controls [2]. While this concentration may have a chemical curettage effect, a 10% solution in Hartmann’s is preferred therapeutically by the author and is the mucolytic of choice. Acetyl cysteine is used to reduce the viscosity of mucus and thus aid clearance. It has been shown to be nonharmful to the endometrium at concentrations of 3.3% (30 mL of 20% acetyl cysteine added to 150 mL Hartmann’s solution) [3] and resulted in higher than expected pregnancy rates when used at a concentration of 0.6% as an infusion prior to breeding [4]. Buffered chelating agents such as Tris-EDTA have been used specifically when a biofilm is suspected, but these are not yet readily available in the UK.

When to lavage

**Pre-breeding**

If fluid is detected on ultrasound prior to breeding there is likely to be inflammation within the uterus, which will reduce sperm motility and fertility. Work has shown that there is no reduction in pregnancy rates in mares in which the uterus is lavaged with Hartmann’s solution immediately prior to insemination with chilled semen [5]. This study found that even when fluid was left in the uterus post-lavage (up to 39 mm detected by ultrasound), mares still became pregnant. The author would lavage a known problem mare one hour prior to breeding and has achieved pregnancies using deep horn insemination of low doses of frozen semen using this method.

**Post-breeding**

The indication for post-breeding lavage is widely accepted as the presence of >2 cm intrauterine fluid detected on ultrasound. The author prefers to lavage mares with any detectable fluid in the uterus, except for <1 cm in the uterine body, and routinelylavages all mares inseminated with frozen semen 4–8 hours post insemination using 1–3 litres of Hartmann’s solution. This has led to increased pregnancy rates. Lavage performed too soon post-breeding negatively affects pregnancy rates, as shown in a study using saline or povidone iodine 30 or 120 minutes post-breeding [6]. Lavage with the same solutions at 4 hours post-breeding led to a similar pregnancy rate to controls [7]. This is supported by work suggesting that some spermatozoa reach the oviduct by 2 hours post insemination, but that significantly more will have reached the oviduct by 4 hours [8]. Any post-breeding lavage should be timed with regard to breeding, not ovulation, and lavage is best performed early while the cervix is relaxed; it can be manually dilated if necessary to aid fluid evacuation. Ultrasound followed by transrectal uterine massage may aid in fluid return; as does administration of oxytocin.

**Conclusion**

Uterine lavage is an important tool in maximising pregnancy rates in mares. The likely cause of inflammation must be considered but if in doubt, using Hartmann’s solution up to 1 hour prior to breeding and at 4 hours post-breeding, combined with specific intrauterine treatments, oxytocin and exercise will help many problem mares.

**References**


Use of cellular therapies in reproductive problems of mares

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Introduction

Most reproductive problems in mares are related to old age, with uterine fibrosis and persistent post-breeding inflammation considered to be the main causes of subfertility in these animals [1]. Currently, the therapies that are used in these animals are supportive, rather than acting directly on the pathological process.

Cellular therapies have been used in human and veterinary regenerative medicine. Some studies have already demonstrated the establishment of stem cells in the endometrium [2] and the anti-inflammatory effect when stem cells were infused into the uterus [3]. Also, platelet-rich plasma (PRP) that contains growth factors and interleukins with anti-inflammatory effects has been shown to be effective in the downregulation of endometrial inflammatory markers in mares [4]. Thus, several experiments using cell therapy were developed in our laboratory, aiming to treat mares with endometritis.

Abstract

In the first experiment, 15 Quarter Horse mares, aged from 14 to 23 years and with severe uterine fibrosis (endometrium classified as grade III) previously confirmed by histological examination, were used. These mares were treated with stem cells (12 × 10^6 cells diluted in 6 mL of plasma (PRP) that contains growth factors and interleukins) directly on the pathological process.

In the second experiment, PRP was used to treat mares in 13 mares classified as susceptible to persistent mating-induced endometritis (PMIE) [3]. Each mare was followed over three cycles in a cross-over study: in the control cycle, mares had no intrauterine infusion, and in the two treatment cycles (one pre-AI and the other post-AI), 20 mL of PRP (minimum of 250 × 10^6 platelets/mL) was infused into the uterine body, without activation. The pre-AI treatment was administered 24 h prior to AI at the same time as ovulation was induced; the post-AI infusion was administered 4 h after AI. Intrauterine fluid, amount of PMNs and COX-2 protein levels were assessed by ultrasound evaluation, endometrial exfoliative cytology and immunohistochemistry of the biopsy endometrial samples respectively, 24 h after AI, and conception rates was determined within 14 days after ovulation. We could observe that both PRP treatments were able to decrease PMNs and COX-2 expression; however, no difference was observed in the amount of uterine fluid between control and treated cycles. Additionally, conception rates were significantly higher in mares treated with PRP (control – 31%; pre-AI – 69%; post-AI – 58%). We concluded that PRP treatment decreases the inflammatory reaction in PMIE mares, improving the conception rates.

References

In practice a small number of mares are encountered which appear to be unable to conceive when inseminated, naturally or artificially, with semen from stallions of proven fertility. These mares are often middle-aged/old and their poor breeding record may persist in the absence of any identifiable abnormality of their reproductive tract and with intensive veterinary management. The potential for compromised oviduct function has been proposed as a contributory factor.

Evaluation of the oviduct and recognition of abnormalities which may compromise function is challenging. The small size and location of the organ prevent examination by normal diagnostic procedures. The only part of the oviduct that can be visualised is the uterotubule junction (UTJ) during hysterectomy.

The oviduct is the smallest component of the tubular genital tract but it is not a passive conduit linking the ovaries and uterus. It has distinct anatomical regions which perform a range of complex physiological functions essential for conception and early pregnancy development. Gametes must be transported in the opposite direction, sperm require binding sites to complete their potential for fertilisation and following conception there is a prolonged period of tubal pregnancy development (5.5 days).

The oviduct lies on the lateral surface of the ovary and has three distinct parts: the infundibulum is the funnel-shaped opening of delicate membranous tissue which glides across the ovulation fossa to capture the ovum; the ampulla forms the proximal half of the tubular duct (diameter 5 mm) and is lined with ciliated epithelium; the ampulla blends into the narrower (diameter 3 mm) isthmus which has fewer ciliated cells but more muscular walls. The ampullary-isthmic junction is considered to be the site of fertilisation and unfertilised ova do not pass this point. The distal limit of the isthmus is the UTJ.

The events occurring around the time of conception are similar to those in other domestic species but, arguably, there are a number of unique characteristics of the mare which both predispose to dysfunction and render investigation more difficult; i.e. development of very large pre-ovulatory follicles which contain protein-rich fluid, the prolonged tubal period of early pregnancy development with consequent large diameter of transit stage pregnancy and the valve-like UTJ which prevents retrograde flow.

Greater clarity and understanding of oviduct function was achieved by Weber et al. (1991) who proposed that transport of the early pregnancy from the ampullary-isthmic junction to the uterus was initiated by the release of a prostaglandin E₂ (PGE₂) signal from the conceptus [1]. Reports of oviduct pathology in the literature are few. Infundibular cysts, adhesions, rare adenomas and hydrosalpinx have been reported. More significantly, gelatinous masses within the oviduct lumen at post-mortem examination of older mares were reported [2]. These masses appeared to become lodged within the tortuous bends of the oviduct and at the ampullary-isthmic junction.

Unfortunately, the techniques which have been used successfully to evaluate oviduct patency in other species are not applicable in the mare because of the efficiency of the utero-tubule junction preventing retrograde fluid flow. In the research environment, starch grains, dyes and radio-labelled microspheres have been injected on to the surface of the ovary (transvaginally or via the flank) and have subsequently been retrieved from the uterine lumen. However, the small size of these particles (50 micron) does not equate to that of the transit stage conceptus (120-170 micron) and so may not provide a true test of patency. Currently there are no techniques which can be regarded to characterise equine oviduct function accurately.

Historically, in mares which were considered to have clinical indications of possible oviduct obstruction, attempts have been made to cannulate and physically flush the oviducts. These procedures were carried out at laparotomy and cannulation has been attempted via the infundibulum and UTJ via hysteroscopy. These invasive approaches risk oviduct tissue damage.

Following the recognition of PGE as the chemical signal which naturally stimulates oviductal transport, a study which applied synthetic PGE₂ to the oviducts by a laparoscopic approach showed that not only was early oviduct transport triggered, but also that unfertilised oocytes and oviductal protein masses could subsequently be obtained from uterine flushes [3].

This laparoscopic technique was subsequently applied to a group of mares which fulfilled criteria that were considered to be consistent with the potential for a clinical syndrome of oviduct obstruction as a cause of their infertility [4]. Each mare had received breeding management from an experienced clinician and a comprehensive reproductive evaluation including endoscopy and uterine biopsy sampling. Fifteen mares, aged between 10 and 21 years, were included. These mares had a combined total of 114 barren mating attempts prior to treatment. Following treatment 14 mares (93%) had conceived on a group total of 19 matings.

The conclusions drawn from this study suggest that oviductal obstruction with proteinaceous masses is a potential cause of infertility in older mares and can be treated by the application of PGE₂ to the oviducts. However, it must be recognised that this procedure does not constitute a definitive test of oviduct patency. Case selection for the procedure must be carried out carefully and it is likely, bearing in mind the age group involved, that some suitable candidates may also be developing degenerative endometrial changes.

Further experience of the technique in practice confirms its value as a treatment option for suitable mares. Potentially pathological changes associated with the oviduct are recognised at surgery and require further investigation (distension, overlying fibrosis, inflammatory changes and adhesions). In selected mares, treatment has been performed at 5 days (range 4–6 days) post-ovulation on an inseminated oestrus.

References
15.30

**Specials manufacturing in the UK will adversely affect equine welfare in the long-term**

**Proposing:** Linda Horspool and Shaun McKane  
**Opposing:** Bruce Bladon and Mark Bowen  
**Witnesses:** Nick Bova, Andrew Harrison, David Renney and Michael Stanford

The Moral Maze will explore the issues surrounding the use of “specials” in equine practice in the UK. Is equine welfare and equine health compromised or improved by their availability? Do “specials” empower vets with more treatment options or do they simply undermine the industry and those who take licensed medicines through the conventional registration process. Do specials encourage innovation or stifle investment? Specially compounded medicines have been used widely in other parts of the world; is their increased use in the UK a step forwards or a lowering of standards? Hear the arguments from leaders of the profession, from those working in the pharmaceutical industry and take the opportunity to have your say.

**NOTES**
Radiotherapy has long been considered the ‘gold standard’ for the treatment of periocular sarcoids, with occasional case reports in the literature of the use of various forms of radiotherapy in other locations [1–5]. Low dose rate brachytherapy is no longer available in the UK because of the high cost of implants, the impracticality of treatments requiring isolation of the horse, alongside concerns for operator safety during the implantation and removal of radioactive sources from the horse. High dose rate brachytherapy (HDRB) has been successfully used in horses under routine standing sedation [6], although the technique is expensive and in the UK is currently only available at the Animal Health Trust, Newmarket.

In HDRB, catheters are implanted into the lesion and, following imaging and 3D planning, a bespoke radiation treatment can be administered using a remote afterloader. This involves a high dose rate source which is welded on to a wire and machine driven into the catheters according to the pre-defined plan. The horses are sedated and restrained in stocks throughout the treatment, and are monitored using high definition CCTV cameras and ECG monitoring (Fig 1). The treatment itself takes only a few minutes (usually 2–7 minutes, depending on the size of the lesion in question), there is no risk of operator exposure, and there is no need for isolation of the horse between or after treatments. The cosmetic results are excellent, and the treatment appears to be successful, with a 90% complete resolution rate still achieved in horses 2 years after their HDRB treatment (Figs 2–5).

Strontium plesiotherapy has also been used successfully in the treatment of selected sarcoid lesions [4]. Strontium is a beta emitter that has limited penetration, and is only suitable for small lesions or those that have been surgically debulked prior to treatment. With appropriate case selection, there has been a 100% resolution rate in horses treated with strontium plesiotherapy for sarcoid lesions. In the UK, this treatment is currently only available at the Animal Health Trust, Newmarket.

References
Equine sarcoids are the most common form of skin neoplasia reported in the horse and account for up to a third of all reported neoplasia. The age, breed and sex of the animal are important factors in the risk of the development of the disease [1]. Bovine papilloma virus has been implicated in the aetiology of the development of equine sarcoids [2]. They most often occur in thin skinned areas that are prone to biting flies and can become ulcerated and infected leading to pain and significant morbidity. The location of certain sarcoids, particularly periocular lesions, can be problematic, especially when considering treating lesions with topical medications.

There is a plethora of reported treatment options available with variable success rates, including iridium wires, immunotherapy, topical therapies such as AW4-ludes, imiquimod, blood root extract, aciclovir, photodynamic therapy, laser surgery, SMART surgery and cryosurgery [3]. Various methods of treating sarcoids with intralesional chemotherapeutic agents have been described including, cisplatin in almond oil [4], cisplatin in bioabsorbable beads [5] and intralesional mitomicin [6].

Electrochemotherapy (ECT) has been used in human medicine since 2006. A meta-analysis in 2012 reported a response rate of 84.1% in 1894 tumours, with a higher response rate than using bleomycin or cisplatin alone. A higher response rate was reported when the chemotherapeutic agent was administered intratumourally compared to intravenously [7].

ECT can be used multiple times to achieve resolution of the tumour and can be used in cases where other treatment options have failed. The technique also allows treatment of the tumour margin to reduce the risk of lesion recurrence. ECT does not result in protein denaturation so there may be an immune response following treatment. The reported response rate following ECT in equine sarcoids is 97.9% at 4 years [8].

The chemotherapeutic agent is injected intratumourally under general anaesthesia; the volume of drug injected is calculated based on the volume of tissue to be injected. Once the tumour has been injected, the ECT probe is applied at intervals and at 90 degrees to completely treat the affected area. Reassessment of the treated area is performed at 2- to 3-week intervals until resolution of the lesion. On average three treatments are required to achieve resolution of the lesion. Although the technique is currently performed under general anaesthesia, recent research has shown that recovery from general anaesthesia in horses improves with multiple anaesthetic episodes [9]. ECT adds another useful tool in the management of equine sarcoids, which can be challenging to treat and can result in significant equine morbidity.

References
Laser therapy
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Introduction
With an estimated prevalence of 2-11.5% [1], sarcoids are the most common neoplasm of horses. They may represent a welfare problem for the affected animal, an economic problem to the owner and a therapeutic and litigious problem to the veterinary surgeon when encountered at prepurchase examination. The array of treatments available is testament to the challenge of therapy where no single therapy fits all lesions. Sarcoids are often found in anatomical areas that are difficult to access and recurrence is a significant problem.

In this presentation we will focus on the use of laser surgery to excise sarcoids, which is an area that has shown significant development in recent years.

Laser surgery was first used at the author’s hospital during the 1990s, but it wasn’t until the early 2000s that it was used as the sole means of sarcoid treatment on selected cases. The short-wave energy of a coherent laser beam is absorbed by water within the neoplastic cells and converted into heat [2]. This results in cellular vaporisation and formation of an irreversible zone of coagulative necrosis around the main surgical site [3]. With the laser’s ability to not only cut tissue, but also provide haemostasis, it has the potential to be a simple and yet highly effective technique for skin surgery.

Laser types
Early laser therapies utilised medical CO₂ and ND-YAG lasers. CO₂ lasers transmit infrared wavelength light which is readily absorbed by water in the neoplastic cells to make an effective tissue cut [2]. However, due to the relatively superficial penetration of a CO₂ laser [4], cords of sarcoid cells, which often extend deep into the surrounding tissues (invisible to the naked eye), may not be effectively removed which increases the risk of recurrence [2]. Indeed, Carstanjen et al. found a 38% recurrence rate of sarcoids following treatment with a CO₂ laser [2].

The ND-YAG laser beam is primarily absorbed by haemoglobin and melanin and as such, provides better coagulation than the CO₂ laser, with increased thermal damage to the surrounding tissues [3]. This ‘penumbral effect’ results in a zone of irreversible coagulative necrosis, which helps to minimise the risk of sarcoïd recurrence. Compston et al. found that following laser excision of a sarcoïd, 83% of horses had no recurrence at the surgical site [3]. Advantages of laser surgery over traditional surgical excision include precision of control, sterilisation of the surgical site, reduced haemorrhage, creation of a bloodless surgical field, reduced post-operative swelling and pain, and shortened hospitalisation times [3]. The ability of laser surgery to minimise seeding of neoplastic cells during excision is invaluable [3]. Disadvantages of laser surgery can include potentially large open wounds. With patience and careful management these wounds will heal, so long as they are sarcoïd free. Warning signs of possible recurrence include unexpectedly slow healing, or wounds that appear to granulate and contract normally, but subsequently fail to heal and then proliferate.

In the past decade portable diode lasers have become freely available, and these have proved to be highly effective in the treatment of sarcoids. Despite the increasing popularity of laser surgery, case selection remains critical if favourable outcomes are to be achieved. It is also important remember that a significant variety of treatment options exist, and that ‘no one treatment fits all’.

Diagnosis
Although sarcoids are invariably diagnosed by visual inspection, the accuracy of diagnosis should always be questioned, as other lesions (e.g. squamous cell carcinomas, melanomas and eosinophilic granulomas) may have a similar appearance. In general biopsy should be avoided due to the risk of stimulating further tumour growth, but excised tissues should be submitted for histology.

Summary
Laser surgery is gaining popularity for sarcoïd removal. It is a convenient cost effective technique which shows great promise for the future, and so far there are few reported side effects. Further studies are needed to fully identify its benefits and limitations.

References
Cisplatin and bleomycin are two chemotherapeutic agents that in horses are most commonly used as a local chemotherapeutic treatment for sarcoids. They can also be used against other tumours, such as squamous cell carcinomas.

Cisplatin is one of the platinum-based family of antineoplastic drugs. Its mechanism of action is by interfering with DNA replication, which theoretically should kill the quickly replicating cells. Bleomycin is made by the bacterium Streptomyces verticillus and also interferes with DNA, although the exact mechanism is still unclear. Both drugs undergo renal excretion, although cisplatin is nonenzymatically degraded to protein-bound metabolites that are renally excreted, so its clearance is much longer than that of bleomycin.

Cisplatin has been extensively studied as a treatment for sarcoids. There are several large published studies in which cisplatin was used locally as an intratumoural injection, either alone or in combination with surgery; injections were performed at 2-week intervals until resolution of the sarcoid, with relatively high reported success rates. One of the larger studies, in which 409 sarcoids were treated with cisplatin, the cure rate was 96% [1]. More recently cisplatin has been studied in combination with electrochemotherapy (ECT); ECT is used to open the pores in cells and make them more susceptible to the chemotherapy. It can be argued that the majority of positive reports regarding intratumoural administration of cisplatin for sarcoid treatment come from one place, which can affect the application of the results to a wider field of users. Haspeslagh et al. reported a significantly less good outcome with intratumoural chemotherapy using cisplatin compared with that obtained using electro surgical excision, with only a 52% success rate at 6 months for cisplatin injection and 67% when cisplatin bead placement was combined with surgery [4]; the success rate for electro surgical excision in this study was 87%.

Bleomycin is less well studied. A study of squamous cell carcinomas around the eye (not sarcoids), comparing intratumoural administration of cisplatin and bleomycin, showed that cisplatin had an improved 1-year control rate (93%) compared with bleomycin (78%), although there was no difference in the 2-year control rate [5]. Bleomycin has also been studied in vivo in combination with ECT and shown to be cytotoxic to sarcoid cell lines in an enhanced manner when used with ECT [6]. There are few other studies showing efficacy against equine sarcoids.

In human medicine it is generally accepted that chemotherapy is more effective when tumour burden is low. However, the timing of chemotherapy in relation to surgical excision or debulking is still under debate. Theon et al. looked at intratumoural injection of cisplatin both at the time of surgical excision and 2 weeks post-surgery for both sarcoids and squamous cell carcinomas and reported no apparent difference in complications [7]. However, the majority of perioperative treatments were those in which primary closure was not performed. Tumours that returned rapidly after surgery could not be treated as effectively as those treated immediately, which may argue for perioperative treatment. As chemotherapy affects rapidly dividing cells there is potential for wound healing to be affected and thus good communication with owners is necessary to warn owners of potential healing complications.

There is literature to guide treatment of equine sarcoids with cisplatin in a variety of forms. However, there are no large clinical studies with bleomycin to guide the treatment choice. Initial research suggests that bleomycin may be less effective than cisplatin and clinical experience would tend to agree with this. However, insufficient data exist to enable a decision to be made based on evidence, and practitioners must remain guided by their own experience and the many different sizes, locations, and types of sarcoids, as well as by which treatment is available to them.

References
Antiviral drugs

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Bovine papillomavirus (BPV) types 1 and 2 have been detected in up to 100% of sarcoids and have been implicated as a major factor in their pathogenesis [1]. This has led to the use of topical antiviral agents for the treatment of sarcoids, most commonly as sole therapy but in some cases as an adjunct to surgical excision.

Acyclovir

Acyclovir is an antiviral drug developed for the treatment of herpes simplex virus (HSV) in people and is available as a 5% topical cream. To exert its antiviral effects, acyclovir requires phosphorylation by a thymidine kinase which is specific to HSV. Papillomaviruses lack the gene coding for this enzyme [2], suggesting that acyclovir is unlikely to have efficacy against BPV. A possible explanation for its apparent clinical efficacy is that some phosphorylation to the active form can occur in the absence of HSV-specific thymidine kinase, and viruses other than HSV might be sensitive to lower concentrations of phosphorylated acyclovir. Following topical application, acyclovir diffuses to the dermis of normal and sarcoïd-affected skin in sufficient concentrations to be efficacious against HSV. It is unknown whether this concentration exerts antiviral effects on BPV [3].

Clinical trials of acyclovir for the treatment of sarcoids have produced conflicting results. All have been performed on occult or verrucose lesions, or mixed/nodular lesions after surgical ablation. Full resolution with no recurrence after ≥2 months was obtained in 68% of sarcoids treated once daily for 2–6 months [4]. Thicker lesions were less likely to resolve. When acyclovir was applied twice daily in another study [5], 53% of sarcoids resolved with no recurrence for 26 months; however, successfully treated cases required a median duration of acyclovir application of 50 weeks and the success rate was lower than for most of the other treatments in the study. More recently, in a double-blinded, placebo-controlled trial there was no difference in clinical outcome between 6 months of acyclovir and placebo [6]. Furthermore, acyclovir-treated sarcoids had higher rates of BPV PCR detection than those treated with placebo.

Use: direct topical application once or twice daily. Prolonged treatment (several months) might be required for a response. Skin irritation/inflammation is minimal.

Imiquimod

Imiquimod has antiviral and antineoplastic activity, mediated via direct and indirect immune-modifying effects. In people it is used topically for treating genital warts, actinic keratosis and basal cell carcinoma. The first reported use in horses was a small pilot study in which a variety of types of sarcoïd were treated with 5% cream (Aldara), applied three times a week for a maximum of 32 weeks [7]. After 8–32 weeks complete resolution was achieved in 60% of lesions and a further 20% of lesions reduced in size by >75%. There was no recurrence for a mean of 22 weeks follow-up. Full regression without recurrence for 26 months occurred in 72% of occult or verrucose sarcoïds treated three times a week for a median of 6 weeks [5]. In both studies there was moderately severe skin irritation around the treatment site.

Use: apply three times a week (e.g. Mon, Wed, Fri.), usually for a prolonged period (often 2–3 months) until resolution. Clean the lesion before applying imiquimod using gloves/cotton bud. Significant skin reactions occur, including below the lesion. If required, a treatment break can be taken, and nonsteroidal anti-inflammatory drugs used for analgesia. Loss or whitening of hair can occur.

Others

Cidofovir is an antiviral agent with some anti-human papillomavirus activity. A cidofovir and sucralfat combination gel applied topically was used successfully to treat two sarcoïds, as reported in a letter to the Veterinary Record in 2012.

Podophyllotoxin is derived from Podophyllum species, has antiviral and antimitotic actions and is available as a cream for topical treatment of papillomavirus warts in people. Some success with treatment of sarcoïds is reported anecdotally, but no specific dose regimens have been published.

Xanthate was combined with potassium laurate and TNF-α in one study and injected sublesionally every 3 weeks. A satisfactory response was shown in 10/15 sarcoïds after follow-up periods of 13–18 months [8].

Conclusion

Topical antiviral therapies are most appropriate for superficial occult, verrucose, or small nodular lesions, as penetration is probably insufficient for deeper lesions. With careful application they can be used for periorcular lesions. Although evidence is lacking, imiquimod appears to be a reasonably effective treatment, but is associated with significant local skin reaction. Data on the mechanism of action and clinical efficacy of acyclovir provide weak evidence to support its use.

References

NOTES

Acyclovir

Podophyllotoxin

Imiquimod

Others

Xanthate

Cidofovir

Prolonged treatment (several months) might be required for a response. Skin irritation/inflammation is minimal.

References
Mitomycin C (MMC)

MMC is an antitumoural antimicrobial isolated from *Streptomyces caespitosus*. The drug is an alkylating agent with cytotoxic effects on cells.

MMC has been used for the treatment of periocular sarcoids with very favourable results (100% success rate reported) for nodular and fibroblastic lesions. Two courses of injections 1 week apart were administered, with each course consisting of five intraleisional injections of 0.04% MMC carried out every other day [1]. A second protocol has been described consisting of intraleisional injections being administered every 8 weeks until resolution is achieved, with an overall success rate of 100% for periocular sarco- ids and 94% for sarco-ids in other locations [2].

5-Fluorouracil (5-FU)

5-FU is an antimetabolite drug that has also been used for the treatment of sarco-ids in horses.

The drug can be applied topically as a 5% cream, with good results reported in 6/9 verrucose or occult sarco-ids [3]. 5-FU can also be applied intraleisio-nally. In a study comprising 14 sarco-ids, 50 mg/cm³ were injected every 2 weeks for a maximum of seven treatments. The authors reported a success rate of 61.5% (3-year relapse free) with significantly better responses seen in smaller sarco-ids (less than 13.5 cm³) [4].

AW cream

AW cream consists of a combination of 5-FU, thiouracil, heavy metals and rosemary oil, although its complete formulation has not been disclosed. Different strengths and protocols are applied according to lesion type, size and location. Despite its extensive use, there are limited scientific studies to determine its efficacy. Overall a success rate of approximately 80% has been reported for AW-3. For periocular lesions, its success rate drops to 35% but this is likely due to the difficulties associated with the application of topical chemotherapeutic agents close to the eye [3].

Other ‘nasties’

**Tazarotene**

Tazarotene is a third-generation retinoid available as a 0.05 and 0.1% topical cream. It is used in human dermatology for the treatment of psoriasis, acne and photodamage. There are anecdotal reports of its use in equine sarco-id, with a study reporting its use in combination with imiquimod. In this study the tazarotene was applied twice a day for 2 weeks prior to commencing the treatment with imiquimod, with good long-term results [5].

**Silver nitrate (caustic pencil)**

This has a direct tissue destructive effect in very small localised lesions. It has been used anecdotally but there are no written reports of clinical trials.

**Formalin-based gels**

These have been used anecdotally in small, superficial sarco-ids. Due to the cytotoxic properties of most of these drugs, safety precautions have to be taken during their preparation and handling. The drugs should only be prepared (when required) in an exhaust safety cabinet and personal protection devices should be worn when handling or applying them. In addition, they should be disposed of only in an appropriate container for chemotherapeutic agents.

References

Immunotherapies are techniques that alter the relationship between a host’s immune system and the tumour, and therefore utilise the immune system to specifically identify and destroy tumour cells [1]. As tumour antigens are self-antigens, overcoming the immune system’s innate self-tolerance has been the primary challenge in immunotherapy. There are two major pathways to accomplish this: (1) activate the cell-mediated immune system through administration of cytokines or bacterial antigens that cause nonspecific activation of cytotoxic T cells, and (2) expose antigen-presenting cells to tumour antigens in the hope that this will overcome self-tolerance [2].

**BCG**

Periocular sarcomas can be difficult to treat due to the risk of damaging the eyelids. Radiation treatment is the ideal option but can be prohibitively expensive. Intralesional BCG has proved effective for both nodular and fibroblastic sarcomas at this site. Verrucose/occult sarcomas responded much less favourably. BCG is thought to stimulate a local cell-mediated immune response when injected intratumourally, inducing cytotoxic T cell and natural killer cell activity against tumour cells [3,4]. Success rates from 83–100% have been reported. For sarcomas found elsewhere on the body, it is far less effective, with success rates of approximately 50% reported. BCG is injected directly into the sarcoma with a pressure syringe and this procedure is repeated at 1–4-week intervals until the lesion has resolved [4,5]. Side effects include severe local inflammation. There is also a small but potentially fatal risk of anaphylaxis during treatment and appropriate precautions should be taken, including pre-treatment administration of dexamethasone (0.05–0.1 mg/kg bwt i.v.) and/or flunixin meglumine (1 mg/kg bwt i.v.). The risk of anaphylaxis is higher if a repeat treatment is administered months to years later [3]. Sadly, it is incredibly difficult to get hold of this treatment now.

**Sanguinaria canadensis**

Bloodroot (Sanguinaria canadensis) is a North American plant extract that has an alkaloid in its sap, sanguinaria, which has both cytotoxic and immune-modulatory effects. It has been used in the treatment of skin cancers in people since the 19th century due to its apoptotic (programmed cell death) and anti-proliferative action.

In the UK, the easiest available formulation is Newmarket bloodroot ointment (Newmarket Premixes). The ointment is applied twice daily to the sarcoma by the owner for 3–6 weeks. It is relatively inexpensive, has mild side effects (hair loss and soreness) and a reasonable efficacy for sarcomas under 2 cm in size, with 90% improving and about 66% completely regressing. Like most treatments, it is less effective on previously treated sarcomas [6].

**Imiquimod**

Imiquimod (Aldara) has immune-modifying, anti-viral and anti-tumour properties and is used to treat genital warts in people. For equine sarcomas, treatment is applied every other day by the owner until the lesion has resolved (usually about 6 months) [7]. Daily pre-treatment for 2 weeks with a retinoid cream containing tazarotene (0.1% Zorac gel; Allergan) to reduce the superficial keratinisation significantly improves efficacy of treatment. Imiquimod therapy is most suited to superficial occult and verrucose sarcomas. It can be used in sensitive areas such as over joints, periorbital and genital regions [3]. In a small pilot study of previously untreated sarcomas, 60% of tumours completely regressed after treatment with imiquimod 5% cream. In addition, 80% of tumours showed more than a 75% reduction in size. Complications include alopecia, erythema, erosions and depigmentation of the tumour and periphery. More studies are required to corroborate these findings [3,7].

**Vaccination**

Recently, therapeutic vaccines composed of chimeric virus-like particles have resulted in tumour regression in approximately half of treated equids [8,9]. Further research is needed in this field and attempts to circumvent virus-mediated immunosuppression are ongoing.

Most recently, a Genome Wide Association study on a cohort of horses with confirmed sarcoma and controls was performed to detect an association between susceptibility to sarcoma and allelic variants in the major histocompatibility complex of the horse. This study identified a region on ECA22 associated with equine sarcoma tumours. Genes within the candidate region on ECA22 have functions associated with immune response, tumour growth and progression. Further investigation of these regions could aid in the development of novel methods for prevention and treatment via early screening for highly susceptible individuals [10].

**References**

Photodynamic therapy
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Introduction
Photodynamic therapy (PDT) is a fast-evolving, cost-effective and relatively simple method to treat a variety of both pre-cancerous and cancerous cutaneous lesions. Although widely used in the treatment of human cutaneous neoplasia, such as basal cell carcinoma and squamous cell carcinoma (SCC), PDT is a relatively novel approach in veterinary oncology. The technique utilises photosensitising chemical substances, known as photosensitisers. In the UK, one of the most widely available photosensitisers is methyl aminolevulinate (MAL), marketed as Metvix by Galderma (UK) Ltd; Metvix is licensed for use in humans for the treatment of a number of cancers and is used under the Veterinary Medicine Directorate’s Cascade in equids.

Although in other species photosensitisers may be administered orally, intravenously and topically, in equids they are applied topically (or injected into the surgical bed, if used as an adjunct to surgery), due to the large volumes that would otherwise be necessitated by the patient’s size. After application to the lesion, both target tumour cells and microvascular endothelial cells take up and retain the drug selectively. The photosensitiser is then activated by light of a specific wavelength to produce radical oxygen species (ROS), resulting in necrosis and apoptosis of the targeted tumour cells and damage to their supporting microvasculature. In humans, additional local inflammation resulting from the PDT occasions the stimulation of an immune response against the tumour. The cellular biology of tumour cells makes them highly sensitive to the effects of PDT and this selectivity can be further enhanced both by the precise application of the photosensitiser topically and careful positioning of the light source to reduce exposure of non-neoplastic tissue.

Practical application in equine oncology
The use of PDT has been described in the treatment of equine sarcoid, squamous cell carcinoma and melanoma, with high rates of efficacy and with minimal complications. One of the restrictions of PDT is the relatively limited penetration of both the photosensitiser and the light source (some 10 mm; or less) and so, although the technique can be used as a sole therapy for more superficial lesions, it is often used as an adjunct after debulking surgery (for example, using a carbon dioxide [CO₂] laser) when full excision may be precluded by the anatomical site of the tumour; most typically therefore, the technique is utilised for either periorbital lesions or lesions overlaying joints.

After application of the photosensitiser, including any margin deemed appropriate given the lesion’s appearance and history; the site must be covered with a light-occlusive dressing during the incubation period of 3 hours; alternatively, the patient can be stabilised in a dark stable. At the end of this period, the dressing is removed, any excess photosensitiser is wiped away and the site illuminated with a specific light source for just over 8 minutes. Any adjacent tissue that does not require treatment should be shielded to minimise any unwanted, collateral damage. This part of the procedure may produce signs of discomfort in the patient and so the use of both sedation and either topical or regional local anaesthesia should be considered. This discomfort may continue for some hours after the treatment and so it may be advisable to discharge the patient with some topical local anaesthetic. In human oncology, MAL PDT consists of two treatments 1 week apart and so this same protocol is observed with equine patients.

After a few days, the tissue that has been treated becomes necrotic and sloughing may subsequently occur over a period of some days or even weeks. However, this seldom results in any clinical issues and patients generally recover quickly and unproblematically after PDT.

Outcomes and complications
Excellent efficacy rates are reported for a range of periorbital tumours, including both SCC and sarcoid when PDT is used as an adjunct to debulking surgery. The treatment is well tolerated and cosmesis following treatment is often very good. Complications reported in a minority of patients after the use of PDT to treat periorbital sarcoids were confined to transient oedema and/or transient keratitis; the latter may have been due to either the light-occlusive dressing traumatising the cornea inadvertently or the unintentional contamination of the corneal surface with excess MAL. Care should therefore be exercised to try to minimise such complications.

New developments
Techniques to enhance the penetration of photosensitisers and also inhibit the intrinsic antioxidant defences of tumour cells are being developed. In addition, developments in light source technology will probably result in greater tissue penetration in the future, enabling larger tumours to be treated without recourse to initial surgical debulking.

References
Flower power! Can natural plant-based extracts treat sarcoid tumours?

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The cry of ‘Flower Power’ echoes through the land. We shall not wilt. Let a thousand flowers bloom.’ – Abbie Hoffman, Workshop in Nonviolence, May 1967

‘My mare had Thuja tablets in an apple for 2 weeks and it was the only thing to get rid of the sarcoid, even cream from the vet didn’t work. You can get it from chemist, they also do a cream that costs £7 that you apply to area, for best results you can use both xxx’ – Verbatim Internet comment on a sarcoid blog

Plant-based materials have been advertised over many years in a desperate attempt to ‘naturalise’ the management of sarcoid in the wish to avoid veterinary charges at any cost, or are used by charlatans and quacks to exploit the gullible, the vulnerable and the disillusioned. The science behind almost all of these is nebulous at best and almost all are based simply on anecdote. Since ‘two anecdotes don’t make data’ the various studies have not been tested on their own in any form of efficacy against other equine tumours. Combination of a number of immunological effectors cell. No further studies have developed from this.

• Blood root (Sanguinaria canadensis): Sanguinaria canadensis, also known as bloodroot, is a traditional medicine used by Native Americans to treat a diverse range of clinical conditions. The rhizome contains several alkaloids, including sanguinarine, that individually target multiple molecular processes. Commercially available ‘blood root ointments’, which include variable concentrations of ‘blood root’ invariably also contain 10–25% zinc chloride; this is of course an escharotic. Various commercial preparations containing different concentrations are available as treatments for sarcoid, including XXTERRA™ with 93% success and minimal side effects [3]. Subsequently, a Swedish retrospective postal owner study with Newmarket Bloodroot™ found significant efficacy was reported by owners; significantly, very small tumours were more likely to be resolved [4]. Alarmingly, the material has also been associated with clinical toxicities in humans. In equine practice the effects of the commercial preparations appear to be more related to the escharotic effects of the zinc chloride than the ‘mysterious’ effects of the plant extract. Nevertheless, there is much anecdotal ‘evidence’ that these preparations are potentially useful.

• Tea tree oil (Melaleuca alternifolia): This oil is extracted from the Australian melaleuca plant and is known to have significant antiseptic properties against bacterial and fungal skin infections; it is rarely used in human medicine. It also appears to have amazing household uses such antimicrobial laundry fresher, insect repellent, natural deodorant, acne face wash and general household cleaner. It is truly a multipurpose medication but whatever else it does, it has no proven effect on tumour cell biology! It is, however, potentially toxic and is listed as a toxic plant. It has nevertheless gained wide owner support in sarcoid treatment. It is seldom if ever prescribed by veterinarians. Again, there are no reports of its efficacy in any sort of trial in proper medical or veterinary journals. Anecdote rules!

• Turmeric: Although curcumin has been used historically, its potential for medicinal properties remains unproven as a therapy when used orally. In vitro, curcumin exhibits numerous interference properties which may lead to misinterpretation of results. Although curcumin has been assessed in numerous laboratory and clinical studies, it has no properly established medical use. Indeed, according to a 2017 review of over 120 studies, curcumin has not been successful in any clinical trial, leading the authors to conclude that ‘curcumin is an unstable, reactive, nonbioavailable compound and, therefore, a highly improbable lead’ [5]. Cancer studies using curcumin were deemed fraudulent and subsequently retracted and the US government-sponsored research into curcumin found no medical use for curcumin; however, its ‘value’ remains embedded in the mind of owners. In spite of the ‘public perception’ of the efficacy of turmeric applied topically or ingested in the treatment of sarcoid (amongst a list of over 40 different conditions) there is no scientific publication relating to its use for sarcoid or any of the other equine tumours. A recent anecdotal study (if that is not a contradiction in terms), however, identified that a large proportion of cases had resolved or were significantly benefited by its use. If it is so good, why are there no placebo blinded trials on its use? Since horses only have a proxy (owner) placebo effect it should be possible to conduct a proper trial of its use.

• Thuja (Thuja occidentalis): A review of 61 published papers relating to the medical use of thuja and its extracts failed to reveal any claimed effects on cancer cells [6]. The only purported effects are on human viruses including the common cold and HIV apparently! The ‘tree of life’ (Arbor vitae) has no place in sarcoid treatment.
Various other topical herbs and less well-defined concoctions, including combinations, are marketed for sarcoid treatment and prevention with reported ‘science’ that is simply ‘unique and amazing’ based on a mixture of tumour cell terminology and mediator acronyms coupled with vague and incomprehensible jargon! It all sounds very good; ‘boosting the immune system’ is a common theme. On the basis that a fool and their money are soon parted, these materials sustain a great lifestyle for the sellers. This is not even homeopathy – it is probably even worse since many of the materials used are toxic. Questions should at least be asked about the scientific basis for the treatments. In spite of the justifiable scepticism, however, there are cases that appear to resolve and if these circumstances were subjected to a sensible scientific study we might establish reasons for them and indeed we might find phytotherapies that are both logical and understandable. The makers need to put their money where their adverts are!

Internet ‘consultations’ with ‘therapists’ and other charlatans do not help the cause of plant-based medicine. Anecdote should drive scientific study. There is an ‘element of truth in every lie’ and it is likely that this applies to many phytotherapies; perhaps there is something in it.

Phytotherapy has been used historically of course and we are all grateful for that, but it is now used hysterically; there are few of these so-called therapies that have any place in modern evidence-based cancer medicine. Large scale trials compared to current gold standard treatments need to be carried out to establish categorically whether they have an exploitable benefit or not.

References
10.40–11.00

A view from the House of Commons
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No abstract submitted.

NOTES
A view from BEVA

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Introduction
Adaptations help organisms survive in their ecological niche or habitat. BEVA has its own natural habitat but the challenges it faces are shifting; young members have new expectations and aspirations, the commercial environment is changing, the world is shrinking and technological evolution is presenting exciting new opportunities (and risks). If BEVA is to thrive in the coming decades, it will need to continue to adapt to the world around it.

Membership
BEVA is its members; it is run by its members for its members. However, with the gender pendulum swinging firmly in a new direction, with societal attitudes to the work/home balance shifting, and with membership decisions becoming much more transactional in nature, BEVA is changing.

Once upon a time subscribing to BEVA was ‘the done thing’ for all equine vets; it was seen as a way of supporting the profession and joining the club. Now, although many vets will still see great value in feeling part of a wider group of peers, many will make the decision to join BEVA based, in part, on the value that is being offered. BEVA therefore has to work hard, and make some tough commercial decisions, to ensure both that members feel engaged with the association and that the perceived (financial) value of membership outweighs the cost. This is a challenge being faced by membership associations in all sectors.

Geography
Despite the political isolationism evident in some parts of the globe, technology and communication are making the world a smaller place. BEVA has always been an international organisation and we have recognised that many of our digital services are useful to equine vets across the planet. We are trying to use this opportunity to develop a virtuous circle; by creating closer and more commercial relationships with equine veterinary associations from other countries (and their members) we can generate more income, reinvest in more and better member services, and create further relationships.

Industry
The corporates have finally entered the equine marketplace; something that has caused approval and irritation in equal measure. As an association, BEVA must choose to either adapt or ignore the tide of change. We have the benefit of being able to look at what’s happening in the UK’s small animal market and note the effects on other professional associations. From a business perspective, BEVA is looking to capitalise on the opportunities that corporatisation might offer and to mitigate against some identified threats. Burying our collective heads in the sand would be naïve.

Education
While some of us fondly remember snoozing through pharmacology lectures, copying handwritten notes and the challenges of getting slide reels organised, those days are long gone. Online education is already a necessary part of BEVA’s CPD programme. Hands-on practical teaching and face-to-face discussions will, for the foreseeable future, remain at the heart of what we do but there are ways in which online learning can help to improve even that. We have recently trialled pre-course confidence-based multiple choice quizzes; these highlight areas of known weakness, misplaced confidence, and clear understanding prior to the course, thereby enabling the course tutors to focus their face-to-face teaching on the areas where it is most needed.

Representation
Over the last decade or two there has been a clear shift in how Government and other bodies interact with their stakeholders, how they expect their stakeholders to be represented and the speed with which they expect responses. Brexit has only increased the demand for opinions. These changes have seen the development of a British Horse Industry Confederation, an Equine Health and Welfare Sector Council and, latterly, a British Horse Council (formed by a merger of the first two bodies). BEVA has had significant roles in these organisations and, while the relationship with the BVA remains important for pan-species issues, BEVA now has a more direct line of communication with Government on equine industry matters.

Communication
The rate of change in communication technology shows no signs of abating and all organisations, commercial and not-for-profit, continuously face the challenge of when to adapt (and invest). We see a mindboggling array of opportunities that could improve communication to and between BEVA members. We are trying to select those technologies that will enable us to provide members with the news and information that they want and enable members to easily engage with what the association is planning and doing.

Legislation
Boring but important, like all businesses and charities we are dealing with new legislation on a regular basis. The General Data Protection Regulation (GDPR) has been top of most people’s action lists in 2018. This legislation is an attempt to adapt to the world of Big Data and, although it has forced us to change some of our working practices, it will ensure that we manage data more effectively, internally and externally. It is also ‘the right thing’ to do with our members’ information.

The future
Like all organisations, BEVA must adapt to thrive. Our habitat is changing and, while some fluctuations are predictable and the necessary modifications obvious, other changes will appear from left-field and may require shrewd and sometimes painful or unpopular adaptations. These challenges should be welcomed not shirked. Einstein said ‘The measure of intelligence is the ability to change’ – we don’t want to look stupid.
A view from the RCVS
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At a time when the pace of change is ever increasing, the profession has to rapidly adapt to ensure that it is best able to continue providing animal health and welfare for society. The Vet Futures project identified a number of areas where we could be proactive in developing the profession, equipping it for its role well into the future. The Royal College of Veterinary Surgeons has led on several of the initiatives emerging from that project.

ViVet
ViVet is an ambitious and wide-ranging programme designed to ensure veterinary professionals are at the centre of innovation in the animal health sector. ViVet is driven by the mission of ‘enabling creative veterinary solutions for the good of animal health and welfare’. Through a biennial seminar, blogs, case studies and events, ViVet will ensure that the profession is at the forefront of innovation in the sector. The RCVS will also keep ahead of the emerging technologies and business models to ensure that its regulation enables, rather than hinders, innovation that enhances the profession’s ability to deliver animal health and welfare.

RCVS Leadership Initiative
The initiative is focused around three areas of work:
• **Leadership for everyone:** promoting the importance of self-reflection and the development of leadership skills as key aspects of veterinary professionals’ continuing education and providing the resources to help support such development.
• **Leading the profession:** ensuring that, as an organisation, the RCVS is an exemplar of leadership development and is fit to lead the professions.

• **Tomorrow’s leaders:** highlighting the diverse range of leadership development opportunities for veterinary surgeons and veterinary nurses, the roles and positions these could lead to, and the impact they could have on the future of the professions.

In autumn 2018 the RCVS will be launching the Edward Jenner Leadership Programme – a free-to-access online course for veterinary surgeons and veterinary nurses. The programme has been developed in conjunction with the NHS Leadership Academy to encourage and support the development of everyday leadership skills for veterinary professionals, and is based on a version used in human medicine that over 55,000 people across the globe have accessed.

Graduate Outcomes
The Graduate Outcomes project is considering the skills and competences of future veterinary professionals, including the viability and desirability of limited licensure, the behaviours and skills required of veterinary graduates and how the undergraduate course might be structured in the future. This project is likely to report in 2019.

Legislation
The RCVS Legislation Working Party has been examining the veterinary legislation in preparation for opportunities for it to be modified in Parliament. It is likely in future that veterinary legislation will incorporate the whole veterinary team.
‘It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than a new system...’ Niccolò Machiavelli

Change is constant and reacting to the challenge of a changing environment is a necessity, whether that be the policies needed for emerging industry trends or diseases, using the opportunities provided by new technology, or recognising areas where there can be improvement. Government has a responsibility to react to both sudden and evolving change, to bring people together to work through the solutions and, where necessary, to co-ordinate, protect, guide and deliver.

The UK leaving the European Union in March 2019 is a sudden national change which has major implications for Defra generally, and with so much having been framed by EU policy, for food, farming and biosecurity in particular. For example:

- The UK trades heavily in food, animals and plants with the EU and is part of existing free trade agreements (FTAs). In the equine area, much has been in the context of those EU frameworks;
- The UK participates in the Common Agriculture Policy (CAP), with £2bn going to English farmers alone each year;
- The UK shares common services and systems, including early warning systems in a range of areas, including food safety, animal diseases and biosecurity issues, and provides expertise, laboratories and services on behalf of the EU.

Never has there been so much change taking place at Defra in terms of restructuring, increases of staff (a planned 65% uplift), scenario planning and the opening up of new areas of policymaking. Never have there been so many opportunities to bring new benefits to industry. At the time of writing this abstract some months prior to the BEVA Congress, and with negotiations still to be finalised, there are many potential outcomes in many areas that could touch the equine industry. Examples are the possible cessation of the 50-year-old Tripartite Agreement (TPA) that permits registered horses to have expedited travel without health certification; the approach to the identification of horses and the delivery of the EU based central equine database and veterinary surveillance concept; the licensing of medicines and the degree to which planned EU Animal Health legislation will be adopted.

This is not a once in a generation event - it is a once in several generations event.

For most, the UK being part of the EU has been part of the lives. There are both major challenges, and unrivalled opportunities for change depending on what is implemented. In many areas and depending on the final settlement, the absolute building blocks of policy could be re-examined and a new food, farming and biosecurity landscape could be recreated. Across Government, including Defra, there are three key groups of activity:

- Legislating – ensuring that all current EU law is incorporated into UK law, and updated to ensure that it works after the UK has left the EU. For example, where the law refers to the European Commission, it needs to be updated to name an alternative UK institution. Where an Animal Health certificate is in compliance with EU Regulations, in future it would likely operate under UK legislation.
- Negotiate - agreeing the terms of the UK’s departure, including finances.
- Build – ensuring that the UK has the capacity to deliver the services required after exit – including the people, the processes and the technology needed.

In the equine sector, proposed ways to enable horses to travel post EU exit are being examined, as well as ensuring that our legislation and certificates are up to date and enable people to keep on moving bloodstock (whatever replaces the TPA) to sell, breed or compete.

Defra is also working closely with key industry groups and delivery colleagues to manage EU exit needs, and their input is essential. As we move into longer-term reforms, the work of delivery bodies is likely to change, which will mean that they will have different roles for people working, in them that may require new skills. Industry groups can identify areas for improvement and act as links to wider industry networks.

In a wider context, the possible approaches to future versions of CAP have been put out for discussion with the ambition of incentivising methods of farming that create new habitats for wildlife, increase biodiversity, reduce flood risk, better mitigate climate change and improve air quality by reducing agricultural emissions. The effects on equine businesses are not clear yet, but a move away from land-based subsidy may have a consequential effect for the equine sector. See Consultation document at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684003/future-farming-environment-consult-document.pdf

Wider evolving changes to be met remain, such as global changes in social, business and demographic shifts. An increasingly rapid movement of people and products risks rapid geographical leaps in disease. Changes in industry or human practices and climate change can also have substantial effects. The Secretary of State has made it clear though that it is the firm intention of government to maintain our current high standards, and if thought necessary to enhance them.

Our veterinary surveillance systems, for example, must continually reassure trading partners, are essential to disease eradication plans, and provide early warning of new and emerging diseases. That and good veterinary stewardship are vital in the fight to avert a global catastrophe of antimicrobial resistance (AMR). At its core, however, surveillance requires the right people and frameworks. Changes in the structure of veterinary practices in the UK to more corporate models provide both concerns and also great opportunities for unified efforts to collect, analyse, interpret and provide the blended insight that leads to having foresight, which in turn supports better decision making by all.

One of the greatest challenges to overcome amongst all this change is how we all achieve change in ourselves and our way of thinking and see what can be done, both in the short and long term; what are the priorities and what are the links?

Importantly – the key to doing this all successfully, is people working together through this very exciting time.
A view from the NGOs

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Summary
Adapting to a changing environment is an integral element of management and the pace of current change makes it even more imperative for everyone involved in the equine sector – including veterinarians and others responsible for overseeing welfare and disease surveillance – to regularly consider the future opportunities and threats to the sector.

Threats and opportunities in 2018
World Horse Welfare has identified five key health and welfare opportunities and threats currently facing the UK equine sector.

Brexit: movements and biosecurity
The biggest impacts of Brexit on equines are likely to be around biosecurity and their movement, with 24,757 equidae registered on the Trade Control and Export System (TRACES) moving between the UK and the other EU countries in 2016 [1]. This does not include movement between the UK and the Republic of Ireland, which currently has an ‘open’ border. If the UK does not have future access to EU systems, such as TRACES and the Animal Disease Notification System, then this could threaten both biosecurity and the ease of equine movement between the UK and the EU. Whatever the future relationship with the EU, veterinarians will continue to have a key role to play, especially through the certification of equine movements.

Fitness for transport
Veterinarians have an important role in ensuring equines that are being moved are healthy and fit-for-transport for the intended journey. The UK Government is currently considering the effectiveness of the welfare during transport regime and completed a call for evidence on this issue. It is recognised that the main dangers of long-distance transportation are compromised due to noncompliance or minimum standards being set too low. This can be further compounded by inappropriate handling facilities and techniques at the point of loading and unloading, as well as during lairage [3,4].

Horses at risk
A real challenge for all equine welfare organisations is the ongoing ‘horse crisis,’ which is now the ‘new normal’ as illustrated by the RSPCA’s 2017 figures that show a rise in equine welfare concerns and prosecutions. (http://www.bbc.co.uk/news/uk-43813364). This is putting pressure on organisations such as World Horse Welfare as there are not the facilities to take in every equine whose needs are not being met. At the root of the challenge is a need to encourage a behaviour change among equine owners to reduce the number of animals being indiscriminately bred, neglected and abandoned. This includes proactively working with owners to improve the welfare of ‘at risk’ equines and raising awareness among the wider equine sector – especially veterinarians to help them educate clients to comply with equine ID legislation and lead by example.

Education: responsible ownership
World Horse Welfare has commissioned research and developed educational materials, in collaboration with experts and other organisations, on issues such as responsible breeding, laminitis, weight management and equine end of life. It is recognised that different education and communication strategies and tools are needed, depending on the audience. A particular focus at present is how to effectively communicate with ‘hard to reach’ communities and individuals, such as Gypsy, Roma and Traveller groups and those with disorders/illnesses including hoarders, to help address the systemic and growing number of equine welfare concerns being reported and managed. Veterinarians have a vital role to play here as they are at the coalface and have a good understanding of the priority welfare issues facing equines and where the real problems lie. With many horses ‘invisible’ in yards or in private homes. Incorporating specialist veterinary knowledge is also vital to ensuring there is a sound basis for evaluating the impact of any intervention, and veterinarians also have an important role in disseminating credible information as they often have a significant bond of trust with these owners.

Social media and public perception
One of the greatest opportunities and threats to equine welfare today is social media. These online channels can be a powerful force for good, drawing attention to vulnerable horses, creating momentum behind campaigns and allowing people to share tips on horse care. Equally, it can also spread ‘fake news’ and misinformed advice, foment vigilante action against horse-owners and create online storms around images taken out of context.

Increasingly, public perception of cruelty to horses extends beyond conventional welfare concerns and into their use in sport and racing, where more people are questioning whether any use of horses is abuse. Sharing imagery over social media of horse falls, bloody noses or hyperflexion paints a picture of horses cruelly exploited for entertainment, when often these images show a snapshot in time and do not necessarily reflect poor treatment. Meanwhile, other more subtle practices in sport, such as overtraining and inappropriate turnout, can pose threats to welfare. Increasingly, horse sport needs a social licence to operate [5].

Conclusion
The five areas outlined demonstrate that there are significant opportunities and threats facing the equine sector and it is critical that everyone involved – including veterinarians, welfare organisations, enforcement bodies, the public and Government – understand their roles in addressing these issues.

References

NOTES
Veterinary courses used to provide certainty for universities: certainty over the number of students that were funded each year, certainty that each place would be oversubscribed multiple times over, certainty that research income would be mediocre and certainty that equine teaching hospitals would be loss-making, both being offset by student income. This has all changed so that now (at least in England):

- Universities set their student numbers, with tuition fees being essential for survival.
- Increasingly international students (and international accreditation) have become essential for boosting budgets with international students paying more.
- Research excellence dictates government funding and impacts on the ability to attract more funding.
- The National Student Survey suddenly means something to the veterinary schools (with Nottingham coming top every year since it opened).
- Teaching excellence is finally being recognised with small financial incentives, but will become an important measure for students selecting schools.
- Clinical income has become important with hospitals run as separate business entities in some universities or even by outside companies.
- Universities are competing for students for the first time; this year one school elected not to interview any of its applicants on the basis that the number of applicants met the number of offers that they would make.

Many hold their hands up in horror every time a new veterinary school comes along; indeed, in 2004 the British Veterinary Association (BVA) warned that there was likely to be an oversupply of graduates in the profession by 2008. Clearly, they could not have been more mistaken and the demand for veterinary graduates has continued to exceed supply. New veterinary schools have driven innovation and, although biased, many believe that the Nottingham curriculum is delivering a different breed of veterinary graduate. It is possible that its reputation for clinically informed and practical teaching is selecting the more practically able students. It is hoped that the next time you employ a European graduate whether that is the way the profession has moved, yet the schools are forced to continue to train students with the concept of omnicompetency. For the majority this is wasted competency, with students developing skills that they will never use in species groups that they will never work with. Animal husbandry extra-mural studies (EMS) amount to 12 weeks of additional training, based mainly in farm work, and is largely simply unpaid labour, no longer balanced to the majority employment in 100% small animal practice. Clinical EMS adds another 26 weeks of clinical training, again with an expectation that students will study species that they never intend to treat. Perhaps this provides the barrier to entry for students that want to be more clinically focused. For the majority this is wasted effort.

Teaching excellence is finally being recognised with small financial incentives, but will become an important measure for students selecting schools.

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**NOTES**
13.25–13.45
Alternative succession plan: would a Trust work for us?
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Overview
This presentation is a summary of a project I undertook in 2017 examining the success of the Trust model of business ownership and how it may apply to veterinary practice. At the time of the project, there were four veterinary practices in the UK which operated under this model. One of the most familiar nonveterinary brands associated with this ownership structure is the John Lewis Partnership, which also incorporates Waitrose. The John Lewis Partnership was studied and advantages over similar businesses in the same sector were clearly identified and measured. This presentation may provoke thought on how we can select appropriate and relevant advantages from this ownership model and apply them to veterinary practice.

What is a Trust?
A Trust is a form of employee ownership; specifically, indirect ownership. In its simplest sense, a Trust is formed when ‘Party A’ sells a business to ‘Party B’ for the future benefit of ‘Party C’.

A Trust preserves what is unique and special about the business and ensures that the company is run by people who share the vision and values of the outgoing owner. Employees have a vested interest in consolidating and expanding the business they helped build up.

How does a practice become a Trust?
Many businesses that convert to employee ownership do so with the assistance of the Employee Ownership Association (EOA). This organisation, in the early stages of investigation into employee ownership, will help individual businesses find the most appropriate model for them.

There are three steps to Trust ownership:
1) An independent valuation is carried out. This is based on past performance and future prospects.
2) The practice funding structure is examined and sources of finance identified; capital is needed to buy out owners, service debt and for day-to-day working capital. Baxendale’s is an organisation that can offer a capital fund and consultancy service to support and encourage employee ownership.
3) The business works with professional advisors to ensure all structures and legal formalities are in place. Businesses must check their conversion is acceptable to Her Majesty’s Revenue and Customs (HMRC).

What are the benefits of conversion and Trust ownership?
• Businesses owned by Trusts enjoy
  o Increased productivity
  o Increased resilience to difficult economic conditions
  o Improved employee engagement.
• Employees do not need to over-burden themselves with debt.
• Absenteeism is lower.
• Staff turnover is lower.
• Benefits of success are shared more equally.
• The exiting owners do not pay capital gains tax or inheritance tax (conditions apply) on the proceeds of the sale.
• Beneficiaries can receive a tax-free bonus.

Conclusions
The practising arm of the veterinary profession is currently struggling with recruitment and retention of staff. The causes of this are probably multifactorial. As the ownership structure of veterinary business changes and alternative succession models are examined, the Trust model provides an insight into the culture and productivity of employee-owned businesses.

Further reading
Preparing your practice for sale

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Selling your business is one of the biggest financial steps you will take in your life. This may be a partial sale to your fellow shareholders or partners (although strictly incorrect, I will use these terms interchangeably) or a complete sale of the business to a third party.

At the outset, one has to consider the life stages of the various sellers. A board member in their fifties is likely to have a different perspective from one in their thirties. Although employment may continue with the new owner, the level of salary may be less than under private ownership. More importantly, if one still has 20 or 30 years of earnings left with the business, a considerable level of profit will be foregone after the sale, together with the opportunity cost of a more valuable business. This has to be balanced against the level of debt that a practice may have to carry if several owners leave within a short time. Are there younger people in the business who wish to take on the risks of ownership and devote the time necessary to running a practice?

If the sale of the whole business is being considered, it is wise to try and achieve unanimity round the board table before negotiating with a buyer. A simple majority may be required in the partnership or shareholders’ agreement, but this may strain relationships post-sale if some members feel that the business has been sold over their heads.

When considering the sale of a practice, finance is inevitably at the top of the agenda. This usually encompasses the term EBITDA, or cash profits. EBITDA stands for earnings before interest, tax, depreciation and amortisation. This effectively strips out accounting adjustments which are non-cash items and allows comparability between businesses. One usually hears of practices being sold for multiples of EBITDA. Caution is needed here. Less profitable businesses tend to be sold at higher multiples than more profitable ones. However, the multiple comes down at a slower rate than the profitability goes up.

One needs to appreciate that the purchaser will talk about enterprise value. This refers to the value of equipment within the business as well as the intangible assets such as goodwill. This may well include anaesthetic machines, endoscopy equipment and surgical instruments, for example. If there has been a significant upgrade to the practice, such as the purchase of stainless steel kennels which have not been leased, then the value of these should be agreed separately. Almost invariably property is excluded, and if it does form part of the sale its value must be considered individually.

It is probably sensible to take a 3- to 5-year view leading up to a sale. During this time, one should consider maximising the profit of the business and it is important to think very carefully whether to take on straight leases or buy goods and equipment on hire purchase.

Similarly, if a major refurbishment is being considered, it should be possible to negotiate with the buying entity to take on the full liability for this, otherwise the sellers may not realise its full value.

Preparing a business for sale also requires the sellers to prepare themselves. It is easy intellectually to understand that once shares have changed hands, the new owner calls the tune. It is therefore essential, if ex-owners are staying on in the business, for them to consider how they might feel taking instruction from a new boss. Whatever any purchaser says, there will inevitably be change. It is likely that the purchasing company will have its own finance, human resources and marketing departments. This may mean that there are redundancies and staff/ex-owner relations may be strained for a while. Change can be painful if only one or two individuals on the board are closely involved with the sale process. It is very important that colleagues are kept as fully informed about the details of the sale process as possible, and detailed minutes of meetings relating to the sale should be kept. It is an uncomfortable position to be told at a later date that a particular issue was not discussed.

It is wise to consult with the practice accountants and lawyers at an early stage so that they can give detailed advice. If either of these are not familiar with the sale or purchase of veterinary practices, then it would be wise to seek advice from ones who are. Professional fees associated with the sale of a practice can be truly eye-watering. It is helpful to agree these at the outset and make sure they are fixed. The scope of the fees should also be considered; for example, it is likely that significant personal tax advice will be required and this should be included.

It is sometimes difficult to know who to approach regarding a potential purchase and how much information to release initially. It is wise to agree a non-disclosure agreement. If the practice accountant is negotiating the deal, it likely that the firm will have one of these in place as a matter of course. Some purchasers are interested only in small animal practices, others are looking at buying mixed, equine or farm practices. It is worth investing a little time researching the purchasing habits of individual groups.

For large practices, especially where the buyer is a plc, the purchase may have the potential to be market-sensitive and it is vital to maintain secrecy around the sale process to the last possible moment. In particular, no seller, nor any member of their family or friends, should be buying shares in the bidding company.

In summary, allow plenty of time to maximise profitability prior to sale and ensure that all shareholders have been able to express their opinions fully and that unanimity of purpose is achieved where possible.
Practice valuations and sales: crunching numbers or picking numbers?

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Practice valuations are often veiled in mystery. It is a topic that is often talked about: 'Is there a definitive way to value a veterinary practice?'; you may have asked yourself. In this session we will dispel the myths and look at how practices are valued. We will also explore the historic trends, what is happening in the marketplace with regard to valuation and sales at the moment, and where the market might go in the future. We will also pose the question, ‘Should one sell now or in the future?’
Corporatisation: the director’s perspective

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During this presentation I will outline the personal and professional reasons that we chose to take the route of corporate ownership of our practice. B&W Equine Vets was sold to CVS Group in September 2017 and as such we are still new to the corporate world. However, I will also discuss the peaks and troughs post-acquisition from the point of view of a now ex-director. I will review some of the plans moving forward and discuss the challenges of implementing them and the changes that our practice has undergone. By the time of the presentation we will have doubled the time under corporate ownership (from the time of abstract submission) so we will have more experiences to report.
Corporatisation: the assistant’s perspective

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With corporatisation of veterinary profession continuing at pace in recent years and new moves being made in the equine side of the profession, much has been made of the benefits of corporatisation for business owners and shareholders. One only has to look at the programme in this session at BEVA Congress 2018 to realise who and what is setting the agenda [1]. But one can argue little consideration has been given to the wider impact on the profession and its relationship with its clients.

Looking at the stock exchange [2] and recent national press coverage [3], we can see that the shine of veterinary corporatisation is starting to wear off. Large decreases in the share price of veterinary corporates have been seen in the past year, and directors have begun cashing in share options underlying their lack of confidence in their own businesses. Once the bubble bursts, what state will the profession be left in, and who really benefits in the long run?

The reality is the profession is in a precarious position at the current time; retention rates of experienced veterinary surgeons and nurses in clinical practice are at an all-time low and CEOs of large corporates have taken to writing pleading articles in the Veterinary Record to get staff [4], while at the same time failing to realise the negative impact of their own actions [5].

As corporatisation is being pushed by a small number of individuals and businesses, we ask if corporate greed has any place in veterinary medicine [6] and whether the minority should be allowed to destroy the profession for their own personal gratification? We also ask what are the alternatives, and whether, ultimately, money will decide our destiny as a profession-turned-industry?

References
3. https://www.thetimes.co.uk/article/cvs-vet-group-loses-gloss-with-60m-cash-call-3vlpphr0r
Is corporatisation the worst thing to happen to the veterinary profession? Can being part of a larger group be good? The world has examples of great corporate groups, full of employees who are happy and fulfilled. We all know about the economies of scale that come from being part of a larger group (or buying group). What about camaraderie, having a shared vision? Is that possible as part of a larger group?

We have started hearing good things about being part of a corporate group; maybe it is not so bad after all. In fact, could corporatisation be a wonderful thing for our profession? Can we provide a bright future for the younger generation of vets and excellent care for our clients and our patients, as well as ensuring our profession has a voice at the highest levels?

Let’s assume we believe corporatisation can be a good thing, something you want to consider. What do we look for in a practice? What can you do to ensure you choose the right group, and how can you ensure you maximise the position you are in?

Honesty and openness is important from the start. Find out as much as you can about the various groups. Reference them. Using an advisor can depersonalise the negotiations on price. However, if you have a clear preference make that clear to them.

The diligence process can be challenging. Ensure you keep a close dialogue with the acquirer during the process. Changes in numbers/staffing will come out during the diligence process; the sooner there is a discussion about potential issues the quicker they can be resolved.

We are all aware that recruitment and retention of vets is hard. I genuinely believe a larger group can help that. However, acquiring a practice with existing people problems, or staff shortages, can be very challenging. To secure the practice in the long term, it is important to air any potential people problems early on.

To maximise your choices and the offer you are made, give the acquiring group as much information as possible. Be honest, open and expect the same from them.
What do I want from my boss?

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The overriding theme and take-home message of this is alliterative as an aide-memoire: What do I want from my boss? BALANCE.

Support
Support can be subdivided into three main categories: clients, procedures and the diary.

Clients
It is crucial to success that your boss ‘sets you up for a win’, especially if you are unfamiliar with the client. By this, they should brief you on the situation and task they are dispatching you on beforehand. Knowing the situation you are about to arrive at before you do will help you immeasurably in dealing with it. Examples of this may be: known high input client, gold standard diagnostics and treatment will be requested, vs. budget client – don’t suggest an MRI in the second sentence. Or, the dog will bark but probably not bite. Your boss should also prepare the client, as a minimum by telling them your name.

The other aspect of support with regards to clients is sticking up for you when things go wrong. A good boss will take time to actively listen to your perspective on a situation when dealing with a complaint from a client.

Procedures
No matter whether a new graduate or a boarded surgeon, we all require help on occasion. To advance your skills, a boss should assist you when necessary and to the level that is required. This could range from doing everything for you when the task is completely new or you are fatigued, to just being present with you and maybe assisting with only one part of an operation that you are struggling with.Bosses who are especially good at this will recognise the input required, or instigate a conversation with you to ascertain. Sometimes they will push you out of your comfort zone and tell you to go alone.

Diary
You want to be neither overworked nor under stimulated. Bosses should oversee your workload to prevent these, so don’t be offended if they ask where you are, what you’ve done, what you’re doing next; this will allow your boss to be your troubleshooter. Your boss should recognise flaws in your plan before they happen. Occasionally, things will go wrong. These may be of your making or not; nobody can help if three colics in opposite directions phone in at once. Either way, you want a boss that will help you as best they can. This may be only phone advice, it may be physical assistance, or an empathetic post-mortem of the debacle, that could avoid repetition.

Expectations
From the author’s personal experience, it is fundamental that your boss accurately communicates exactly what they want from you. Once this has been established, you both have a clear standard to work to. These expectations may not be set out at interview, on the first day, or even in full by the first month; but the quicker the better. Expectations will touch all aspects of your work including (non-exhaustively):
• punctuality (for work and for appointments within).
• standards of dress, etiquette and demeanour with clients and behaviour towards animals.
• management of other staff.
• care and cleanliness of vehicles and equipment.
• response times to correspondence.

If these aren’t forthcoming; seek them out, ideally before you are found to have fallen short of them. If you do, use that as a catalyst for open and honest dialogue. Such expectations are easier to meet when they are aspired to by the whole team; you, your colleagues, and by your boss – leading by example.

Feedback and recognition
Prompt, regular, and above all judicious feedback on all aspects of your employment is critical to a long and harmonious relationship. A good boss will not constantly badger you with pedantic details of each and every task you complete; micro-managing you to the point you become like a beaten dog. Nor will they tell you everything is fine, when it isn’t. This communication is critical to maintaining the ‘psychological contract’ [1], a set of unwritten promises, that by this nature, need to be adhered to and regularly discussed if they are to be maintained. This will be far easier if your boss has a high level of social intelligence. Social intelligence and not an extreme personality will mean your boss is far more likely to be empathetic to a situation. To take an example of an expectation from above, you might be expected to have finished your notes and invoices from work on occasion, provided you complete the task swiftly after. Being able to meet with your boss informally, either in or out of work time, will facilitate this. Someone who is a brilliant clinician, or researcher, whom you may have selected as your boss because you aspire to be like them, may not be the best person to get you there. Perfectionists won’t let you have a go as you inherently won’t be as good as them. You want a boss who is interested in you, and your development, personally, and professionally. In recognition of hard work from you they should not just pay your wages each month, they should give you their time now and then, for whatever you may need it for. Forbes magazine [2], in addressing the same question as this presentation, says your boss should be willing to give you a ‘seat at the table’. In an equine veterinary context this may be more like a stand in the pouring rain at the local point-to-point, where they’ve asked you to come as ‘third vet’.

References
What do I expect?
It’s obvious, isn’t it? Straightforward, old-fashioned clichés such as good work ethic, team player, flexible with a good sense of humour, combined with a willingness to take on increasing levels of responsibility with advancing years post-qualification. However, as always, it’s not quite that simple and establishing clear, fair targets, creating the correct environment for the individual to flourish and instigating timely unbiased methods of assessing progress requires significant effort from both the business owner and the associate.

To get the best out of individuals the correct working environment is vital. If an individual is going to be asked to work hard, attain targets and conform to certain behavioural patterns, they need to feel supported and respected.

Getting it right has important implications to the smooth running of the practice and has a direct effect on two current hot topics: 1) the recruitment and retention of staff and 2) job satisfaction and mental wellbeing.

The Royal College of Veterinary Surgeons Day One Competences (DC1) set out in broad terms what is required of a new graduate and helps prepare for ‘day one’. Although they form the cornerstone of university veterinary curricula, they are not the sole measure against which students are assessed. In the same way attainment of the recommended competence levels and specified skills outlined in the document will go a long way to fulfilling the majority of goals in practice assessment, however, it is not the only measure.

As well as the clinical competences there is an expectation that the associate will possess certain core values. These are set out in the RCVS Code of Professional Conduct [1] and are similar to the seven principles of public life [2], which underpin the long path of professional and career development. These principles of selflessness, integrity, objectivity, accountability, openness, honesty and leadership provide an ideal foundation for progression through one’s career.

Are my expectations fair?
There is a potential mismatch between the manager or business owner and associates with regard to acceptable expectations. Some of this may be due to a generational difference of Baby boomers/Generation X vs. Millennials [3] and good leadership is required to understand, motivate and fairly assess the associate.

Unbiased assessment is required and the implementation of S.M.A.R.T (Specific, Measurable, Achievable, Relevant, Timely) targets is essential.

How are the expectations managed and measured?
What is the best environment for the new graduate or associate to flourish: independent or corporate? There is no easy answer as it is the culture of the individual business and the support of the immediate team that will ultimately determine the best place to work. There are good and bad examples in both sectors.

Within Fellowes Farm, assessment of targets is constantly monitored by numerous means. Formal assessments via annual performance reviews, 6-monthly reviews and monthly HAI GO meetings with the practice manager which include discussions of key performance indicators (KPIs). Less formal assessments occur monthly at clinical clubs and vets’ meetings. However, constant feedback is gained from day-to-day interaction at hospital rounds, communication via email and social media, feedback from nurses, support staff and clients.

Clinical skills are assessed and monitored via a ‘traffic light’ system, and appropriate training given as required. As a member of the XLEquine community we are also able to offer a bespoke graduate development programme for equine vets, as well as focused CPD, together with all the other benefits of being part of XLVets – sharing of experiences, mentoring, charity work, etc.

How can you influence the process?
If behaviours, standards and targets are to be met they need to be clearly articulated and understood. The job description/role information should give clear guidance to prospective employees as to what’s expected of them; the interview gives an opportunity for clarification and also involvement in the setting of targets. There should be no surprises once in the role.

Managers can fall victim of the ‘horns and halo’ effect especially during appraisal time. This is a type of cognitive bias where a person’s impression of another can substantially influence thoughts and feelings about that individual; in an attempt to avoid this, managers must take notes on all aspects of performances throughout the year; otherwise evaluations can unfairly be based around a single event or only memory of recent events. It is sensible for the associate to document progress and be prepared to share these notes during the performance review.

References
Soft skills. What are they? Why do I need them?

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Hard skills are teachable abilities or skill sets that are easy to quantify. They are typically taught in the classroom, or on the job. Veterinary skills are hard skills – you are trained to do them or learn them from reading books and practising the tasks.

Soft skills, on the other hand are harder to quantify. They are more subjective and correlate with the way you relate to, and interact with, other people. They are generally not taught in the undergraduate veterinary curriculum in any great detail.

Task vs. people orientation

Our personalities can be divided into two orientation types: either task- or relationship-focused, with a spectrum in between. There are no rights or wrongs here - we need a balance of both orientations in society. People-orientated personalities build relationships and community, while task-orientated people get things done. Our businesses need both.

Task-orientated people focus on their to-do list and getting things done, have concrete goals and are concerned with productivity. This is a very typical veterinary personality trait. Those who are people-orientated lean towards a focus on the people around them, running happy teams, building relationships and placing a greater importance on happiness.

Soft skills

The types of skills referred to as soft include communication, flexibility, patience, problem solving and leadership. Time management, dealing with difficult clients and resilience are three key skills a newly graduating colleague should try to prioritise. Leadership, communicating your vision and enabling staff to fulfill their potential are three key skills a principal might aspire to achieve.

Soft skills are vitally important to allow us to thrive within the veterinary industry. We work as part of teams; we need to communicate and build rapport with clients, understand and communicate with our bosses, provide feedback for our employees and deal with the daily dramas of practice. To understand if you need more soft skills in your life ask yourself the following three questions:

1. Does how well I work with other people affect my success and job satisfaction?
2. Do I see some people within my workplace thriving more than others?
3. Does my ability to control my temperament and my stress levels at work affect my performance?

If you answered yes to these questions, you may find that improving your soft skills can improve your relationship with colleagues and your job satisfaction.

The drama triangle

Drama is pervasive throughout our lives, and the drama triangle is a great way to understand how these behaviours are damaging to our everyday lives. In the triangle, people fall into one of three positions - the victim, the persecutor and the rescuer. The triangle starts with someone taking the role of victim of a situation, or persecutor who is controlling or blaming another person. The rescuer comes to the aid of the victim, but does not allow the victim to solve his own problems. Recognising we are in drama, or staying out of the triangle, are vital soft skills to understand. Solving interpersonal problems becomes easier when we recognise the dysfunctional nature of these interactions.

Listening is a good place to start

Listening to other people is a key soft skill. There are several levels of listening. The Coaches Training Institute recognises three levels:
• Listen to the speaker, not your inner voice.
• Listen to understand where the speaker is coming from.
• Listen to what is not being said.

Practical applications

For the business owner: taking a coaching approach to employees’ issues, better appraisals and more enabling of staff all lead to better engagement and better team performance.

For the young graduate: more resilience, less stress, being part of a team, focusing on positive outcomes, less drama, more job satisfaction.
Mindset theory has been linked to a wide range of behaviours that are less than ideal:

- Arrogance or lack of confidence [1]
- Performing less well than predicted [2]
- Low levels of resilience and a negative impact on self-esteem [3,4,5]
- Blaming, making excuses, cheating and misrepresenting things [6,7]
- Lack of utilising coping mechanisms with mental health problems [8]
- Prevalence of stereotyping and judgemental evaluations [9]
- Defensive reaction to feedback instead of action [10]
- Gender bias - quicker to choose male leaders and resisting women in authority [11]
- Quickly assigns hostile or aggressive intent [12]
- Uncomfortable about aversive situations and experiences [13]
- Translating transgressions and traumas into a negative view of identity [14]
- Overall experiencing more negative emotions and exhibiting lower emotional intelligence [15]

All of the above behaviours are linked to what is known as entity mindset.

Where does mindset come from?

Mindset theory comes from intelligence theory and is directly linked to whether someone perceives intelligence according to entity theory or incremental (malleable) theory. People who hold an entity theory of intelligence view it as a fixed quantity that cannot be changed very much by effort and learning, whereas people who hold an incremental theory believe intelligence is malleable and expandable [16,17].

Across many different studies with diverse populations, research has repeatedly shown that:

- Most individuals generally endorse either an entity theory or an incremental theory and each theory occurs with equal frequency [18].
- People can hold different theories in different context (e.g. intelligence vs. personality, in different areas of life).
- No one theory is consistently linked to people’s ability level, education or cognitive complexity.

When studies look at long-term implications of different theories for people’s regulation of their self-esteem when facing repeated struggles, the following was found [19]:

- Implicit self-theories (entity vs. incremental) are stable, psychologically meaningful constructs that persist over time and become increasingly stable as age increases.
- Entity theorists were far more likely to adopt performance goals whereas incremental theorists were more likely to adopt learning goals.
- Entity theorists showed a generally helpless pattern rather than the mastery-orientated pattern shown by incremental theorists. Entity theorists blamed their failure on low ability yet explained away their success by attributing it to luck. Emotionally they felt more distressed about their academic performance and were less likely to feel determined and inspired, despite performing as well as incremental theorists.

- Entity theorists generally had lower self-esteem than incremental theorists and this disparity widened over 4 years of college.

A thorough understanding of mindset theory is the start to learning how to influence yourself and others into a more incremental mindset. At the end of the day, it is not about whether someone is an incremental or entity theorist - it is about how willing they are to change and how quickly they do it.

Did you know?

Alfred Binet invented the IQ test to identify children who weren’t thriving in the Paris public schools. He wanted to devise programmes that would get them back on track and help them to blossom intellectually. Far from assuming that these children were irrevocably deficient, he held the view that their intelligence could be nurtured through the proper educational programmes.

References

Updates in echocardiography

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Introduction
Ultrasoundographic image quality continues to improve and ultrasound machines continue to get less costly and more portable. Does carrying out cardiac ultrasound today, however, offer any additional information to that obtained by the pioneers of equine echocardiography in the early 1990s? As technology has improved, there are many technical hardware and software features that have improved image quality and frame rates for a given volume of data, which makes good quality ultrasound more accessible to the practitioner. This presentation will briefly discuss some of the newer technologies that have increased the range of tools available to study cardiac form and function.

Real-time three-dimensional echocardiography
Three-dimensional echocardiography (3DE) uses sophisticated ultrasound probes with matrix array technology that, when used in ‘full volume’ mode, enable the acquisition of pyramid-shaped ultrasound datasets [1,2]. These probes, however, also allow significant flexibility since they can be used for imaging in one plane (i.e. in standard 2D mode) as well as allowing the imaging of (currently) up to three orthogonal planes simultaneously. Computer processing capabilities and 3D ultrasound technology have progressed sufficiently in the last 10–20 years to allow real-time viewing and acquisition, rather than previously available technology which reconstructed still images. In concert, the accompanying 3D software packages allow flexible manipulation of these datasets to select, view and measure structures or chambers, from many different and often unusual viewpoints.

The accurate assessment of valvular regurgitation and its effects is a common goal of many echocardiographic examinations. In theory, real-time 3D imaging may offer:
- Better assessment of valve architecture and motion.
- Better assessment of regurgitant orifices.
- Better assessment of cardiac chamber volume.

Studies are underway to validate the use of this technology in horses, although the lack of a gold standard technique for estimating chamber volume in horses (i.e. cardiac MRI) creates some difficulties.

In our clinic we now use a 3D probe routinely for echocardiography, targeting specific areas of interest (e.g. chambers, valves) after our standard 2D examination. Initial experience suggests that the ability to assess structures from innumerable aspects is useful for assessing valves, valve lesions and congenital abnormalities. While this new technique is clinically appealing and visually impressive, whether it offers distinct advantages over standard 2DE is still to be ascertained.

Studying cardiac function by assessing tissue strain
Assessment of cardiac function in horses is currently fairly rudimentary. Assessment of left ventricular function has been limited to subjective evaluation of motion, combined with measuring the (one-dimensional) fractional shortening of the ventricle. While pulsed wave Doppler assessment of cardiac output (assessing blood flow) can be reproducible in experienced hands, the problems associated with poor alignment with flow are well known in horses and this often leads to underestimation of this important indicator of cardiac function. More recently there has been interest in assessment of (cardiac muscle) tissue strain using technologies that assess tissue movement. Indices of strain can be calculated from either the displacement (speckle tracking echocardiography [STE]) or the velocity (pulse waved tissue Doppler imaging [TDI]) associated with tissue movement. Each of these two new techniques has advantages and disadvantages, but STE is probably the most easily clinically applicable, with fewer disadvantages and will be described in more detail.

Speckle tracking echocardiography
Speckle tracking is a novel software technology that uses high quality B-mode echocardiographic images to depict and quantify myocardial deformation, providing indices of strain and strain rate in longitudinal, circumferential and radial planes [3]. Older techniques for measuring myocardial deformation, such as left ventricular fractional shortening, are crude and not reflective of global ventricular function, while some newer technologies such as TDI, based on Doppler technology, are subject to significant errors due to angle, heart rate and load dependency. STE provides a more comprehensive assessment of cardiac function; is less heart rate and load dependent; and has been shown to provide novel information about cardiac mechanics in response to training and exercise in humans [4]. STE is rapidly gaining credence in clinical medicine for detecting subtle changes in cardiac muscle function with disease [1]. It has also been used to determine the difference between cardiac hypertrophy associated with athleticism vs. that associated with cardiac disease [4,5].

STE has already been validated in a research setting in horses for assessing left ventricular and right ventricular systolic function, and has shown generally low measurement variability [6,7,8]. It has also been shown to reliably demonstrate myocardial dysfunction in ionophore toxicity and atypical myopathy [9,10] and to demonstrate improvements in myocardial contractility associated with recovery from asthma [11]. Many centres are now starting to use this technology, but is it useful in equine clinical practice where we rarely see obvious myocardial disease? The greatest potential advantage of such a technology could be in detecting early signs of myocardial dysfunction in horses with significant valvular regurgitation.

Summary
To a certain extent we have become stuck on our standard 2D echocardiographic examination in horses and watched from the sidelines as echocardiography has developed in other species, merely updating our machines to ensure we get nicer images. Perhaps this reflects the inevitably lower caseload in horses along with some of the logistical difficulties of scanning horses. However, equine cardiology groups are starting to study new views for addressing specific problems or answer specific questions, with both standard technologies and the newer ones. The future is exciting for equine echocardiography.
References


Recording diagnostic ECG
A variety of types of ECG are suitable for the equine practitioner to provide instantaneous or ambulatory ECG recordings in the horse. The traditional paper-trace ECGs can still provide useful clinical information but have largely been replaced by newer electronic devices providing permanent digital recordings without the use of thermal paper that fades over time. Base-apex electrocardiograms remain the standard lead placement in the resting horse and this standardisation of lead placement allows for consistency between recordings which is particularly useful when assessing drug-induced changes in the ECG during treatment for atrial fibrillation. Smartphone enabled devices (Kardia/AliveCor) provide often useful patient-side recordings in the field and are particularly appropriate to the competition environment, although suboptimal recordings and movement artefact are particularly common. In a study of 835 ECG recordings from 333 polo and polocrosse horses, only 2% of recordings were considered nondiagnostic, although occasional artefacts were common. The diagnostic quality of these recordings improved following exercise, presumably as a result of sweating resulting in improved skin contact (Walker et al. 2016). Multi-purpose Holter/telemetry ECG devices are now widely available in equine practice and make the diagnosis and assessment of cardiac dysrhythmias accessible and reliable. Lead placement and attachment remain opportunities for artefact, which often increases significantly during exercise due to the presence of muscle activity.

ECG interpretation
Irrespective of the type of recording used, the standard approach to assessing the ECG remains the same and should include evaluation and assessment to address the following questions:

1. Is the ECG of diagnostic quality?
   • Is the baseline consistent, is it free from obvious movement artefact, is it contained within the limits of the paper (only applicable for paper-trace recordings) and is the amplitude set appropriately to maximise the size of the complexes?

2. What is the cardiac rate?
   • Is it normal, fast (tachycardic) or slow (bradycardic)?

3. What is the cardiac rhythm?
   • Is it regular?
   • Is it irregular? Regular irregular, irregularly irregular, paroxysmal, intermittent or sustained?

4. Is there a P for every QRS (and are they evenly and consistently related)?

5. Is there a QRS for every P (and are they evenly and consistently related)?

Based on these descriptions it should be possible to document whether any abnormalities are derived from the atrium (supraventricular), the atrioventricular (AV) node (junctional), or the ventricles. Ventricular complexes are wide and often larger (bizarre) than normal complexes, but this difference is often less marked than in other species. Junctional abnormalities, aberrant conduction pathways and bundle branch blocks are uncommon in the horse but should be evaluated in horses with specific abnormalities.

Assessing ambulatory ECG recordings
Assessment of ambulatory ECG recordings is more time-consuming than the assessment of resting recordings, either due to length of recording or because of movement artefact that can occur during ridden exercise. Semi-automated analysis based on RR intervals can help to identify ectopic (premature beats), although shape-based algorithms used for automated analysis of human and small animal ECGs are not reliable in the horse.

Reference available on request.
Endocarditis and pericarditis

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Endocarditis

Pathogenesis and presentation

Infective endocarditis is usually a bacterial, or rarely fungal, infection of the valvular or mural endocardium. The most common site of infection is the mitral valve, closely followed by the aortic valve. The tricuspid valve is affected most frequently in horses with septic jugular vein thrombophlebitis. Horses of all ages can be affected but the condition is more common in younger animals. The condition has been reported in males more often than females.

Clinical signs depend on site and severity of the intracardiac infection, embolisation of vegetations to any organ, the presence of bacteraemia, and the development of immune-complex disease. Signs can vary in severity from a relatively mild febrile condition to severe systemic signs and heart failure. Presenting signs frequently include fever, shifting leg lameness and synovial distension.

Large vegetative lesions may obstruct the outflow of blood from the chamber, resulting in a murmur of valvular stenosis. More often, vegetations lead to valvular incompetence and a murmur of valvular regurgitation. It is important to be aware that with tricuspid regurgitation, there may be no murmur. Rupture of associated chordeae tendineae will exacerbate regurgitation. There may also be concurrent myocarditis with dysrhythmias.

Diagnosis

Definitive diagnosis of infective endocarditis is established with echocardiography by identifying irregular, hypoechoic to echoic oscillating masses associated with the valve leaflet, chordeae tendineae, or mural endocardium. Small lesions can be difficult to identify so echocardiography should not be relied on to definitively rule out the condition. Echocardiography is also used to assess the impact of the lesions by assessing the degree of regurgitation and chamber enlargement. In early cases, there may be minimal chamber enlargement but repeated echocardiographic examinations may identify this.

Where concurrent arrhythmias are suspected, ambulatory ECG is helpful.

Ideally, three serial blood cultures at 1-hour intervals should be obtained before treatment with antimicrobials. Assay of cardiac troponin I can be helpful to identify myocardial disease. Typically, there is neutrophilic leucocytosis with hyperfibrinogenaemia, hyperglobulinaemia and anaemia of chronic disease. Azotaemia may be detected in horses with renal embolii or may be prerenal in horses with low cardiac output.

Treatment

Bacterial infections of the valvular or mural endocardium most frequently involve streptococci, Pasturella/Actinobacillus, and Pseudomonas spp., but a wide range of bacterial species have been implicated, and fungal endocarditis has been reported rarely. As a result, selection of antimicrobials should be broad-spectrum and with good tissue penetration.

This is a life-threatening condition and therefore, treatment with fluoroquinolones, macrolides and cephalosporins is warranted. Additional medications which may be helpful include aspirin and antidysrhythmics.

Prognosis

This is primarily determined by the valve(s) affected and the severity of valvular damage that develops and is also likely to be influenced by the organism(s) involved and the response to antimicrobial treatment. Cases with involvement of the mitral valve have a particularly grave prognosis. Even when bacteriological cure is achieved, severe valvular regurgitation can ultimately lead to heart failure.

Pericarditis

Pathogenesis and presentation

Pericarditis occurs occasionally in horses. The best documented form is the effusive, fibrinous form but a noneffusive form is seen occasionally. Like endocarditis, younger animals appear to be over-represented in reports of equine pericarditis. The aetiology is less clear. In some cases, bacterial infection is documented; there is much discussion but little evidence that viral infection can result in pericarditis; and finally, pericardial effusion may be immune-mediated (or idiopathic) or traumatic in origin.

Regardless of the aetiology, the pathogenesis revolves around cardiac tamponade. As pressure within the pericardial sac rises, the right heart can become compressed. Jugal distension and marked ventral oedema develop as a result. There is tachycardia and heart sounds are usually muffled.

Pericardial friction rubs are typically triphasic in nature and are generally only detected in cases with minimal effusion. Other signs are nonspecific and include fever, lethargy and depression.

Diagnosis

Echocardiography is used to identify pericardial thickening and effusion, characterise its nature, and to document the degree of cardiac tamponade. Where concurrent arrhythmias are suspected, ambulatory ECG is helpful. Pericardial fluid can be submitted for bacterial culture, viral isolation and PCR, and cytology. Assay of cardiac troponin I can be helpful to identify myocardial disease. Haematology and inflammatory biomarkers can be useful, mainly in monitoring progress, and it is important to assess renal function, which is often compromised due to low cardiac output.

Treatment

In the presence of cardiac tamponade, pericardial drainage is critical. Lavage of the pericardial sac is advocated by some authors. Generally, broad-spectrum antimicrobials are selected and where an immune-mediated pathogenesis is suspected, corticosteroids are a rational choice.

Prognosis

The prognosis is variable. There are reports of horses returning to racing following treatment but in others, fibrous pericarditis can progress to constrictive pericarditis and permanent restriction of cardiac function.

Further reading

New frontiers in equine cardiology

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Introduction

Nowadays, echocardiography and ECG recording are routine procedures. Arrhythmias are very common both at rest and during exercise but for some arrhythmias, exact diagnosis and treatment remains challenging.

Advanced techniques, such as cardiac biopsy or pacemaker implantation, have become available but equine cardiology still lags behind, especially regarding techniques for cardiac imaging, invasive cardiology and advanced (invasive) arrhythmia diagnosis and treatment. In human and small animal medicine, invasive procedures strongly depend on visualising catheters by fluoroscopy, computed tomography (CT) or magnetic resonance imaging (MRI). These techniques are disappointing in adult horses, which hampers further development of catheter-based cardiological procedures.

New ways to image the heart

Cardiac imaging is almost entirely based upon ultrasonography because other techniques fail. Advanced ultrasound imaging techniques, such as two-dimensional speckle tracking and tissue Doppler imaging have been explored and provide ways to better quantify atrial and ventricular function and contribute to the assessment of valve regurgitation. Recent studies using 3D-ultrasound are also very promising.

The author uses CT images of casted hearts [1] or CT images of small-sized animals (pony or foal), and also virtual reality images, to better understand 3D cardiac anatomy and improve cardiac ultrasound interpretation.

New left- and right-sided transthoracic echocardiographic views for visualisation of atria-related structures and vessels dorsal to the heart have recently been described (Fig 1) [1]. Both venae cavae, right atrial appendage, intervenous tubercle, terminal crest and the region of the sinus node, oval fossa with the limbus, pulmonary artery bifurcation, left atrial appendage, the pulmonary veins and the aorta to brachiocephalic trunk bifurcation could all be visualised ultrasonographically in adult horses. These structures are important to guide intracardiac procedures and place catheters at specific locations in the heart or surrounding vessels.

The author uses intracardiac echo (ICE) (Fig 2) in horses to guide intracardiac procedures, whereby a steerable, catheter-based ultrasound probe of 4.5-11.5 MHz is introduced in a vessel and manoeuvred inside the heart to provide more detailed visualisation of specific structures. Both left and right heart can be evaluated by this technique and all above-mentioned anatomical structures, important for invasive procedures and electrophysiological studies, have been identified with more detail compared to transthoracic ultrasound.

Invasive cardiac procedures (e.g. electrophysiology, occluder implantation)

For all invasive cardiac procedures, good visualisation of catheters or other material is essential. Catheters can be selectively navigated through vessels and valves to be positioned at specific sites. In order to visualise a catheter, it is important to obtain longitudinal images through the catheter tip because cross-sectional images do not allow the precise catheter location to be determined [2]. In the beating heart the operator should continuously apply minimal probe adjustments in all directions in order to pick up such longitudinal views of the catheter. For transvenous catheterisation, the catheter is identified from a right parasternal view, along the long axis of the cranial vena cava (cranial displayed right on screen). During insertion in the right atrium, when the catheter is pushed over the intervenous tubercle, the transducer is gradually rotated counter clockwise towards the four-chamber view to follow the catheter entering the right ventricle. Subsequently, further insertion of the catheter into the pulmonary artery is guided from the right ventricular outflow tract view. For left heart catheterisation via a carotid artery access, the bifurcation between aorta and brachiocephalic trunk is visualised from a right parasternal view to ensure that the catheter is directed towards the aortic valves and left ventricle, and does not slip downstream into the aorta. Subsequently, the catheter or guide-wire should be gently passed through the aortic valves, not entering the coronary arteries and not damaging the valve leaflets. In order to introduce a catheter into the left atrium and even the pulmonary veins, it should be supported by a long steerable sheath placed in the left ventricle. With the sheath remaining in curved position in the left ventricle, the exploring catheter can be pushed dorsally into the left atrium and pulmonary veins.

Fig 1: Right parasternal view of the dorsal right atrium (RA) (right on screen is cranial, imaging depth 30 cm) which shows the intervenous tubercle (IT) between the right atrial appendage (RAA) and the caval vena cava (CrVC). The oval fossa (OF) separates the right atrium (RA) from the base of the pulmonary vein (PV). Medial to the right atrium the aorta (Ao) and brachiocephalic trunk (BT) are visible.

Fig 2: Intracardiac echogram (ICE) (right on screen is caudal, imaging depth 15 cm) taken from within the cranial vena cava (CrVC) at the level of the terminal crest (TC) showing the right atrium (RA) and atrial appendage (RAA), tricuspid valve leaflets (TV) and the right ventricle (RV).
Implantation of an occluder to close an aortocardiac fistula or a ventricular septal defect can be guided by ultrasound as these devices can be clearly identified on ultrasound (Fig 3).

Arrhythmias: new catheter-based diagnosis and treatment

Diagnosis of arrhythmias is still mainly based upon a surface ECG, usually with one or sometimes three leads while antiarrhythmic treatment is mainly based upon medication, except for pacemaker implantation (bradycardia) and transvenous electrical cardioversion (atrial fibrillation). This is in sharp contrast to human cardiology, where invasive cardiac procedures with multiple multi-electrode catheters allow the operator to perform electrophysiological studies and ‘map’ arrhythmias, i.e. identify their mechanism (focus vs. re-entry) and anatomical origin. Intracardiac pacing (electrical stimulation of the myocardium) and sensing (recording myocardial electrical activity) from multiple, well-defined regions are needed for such electrophysiological studies and for mapping.

In combination with the above-mentioned ultrasound imaging techniques, high-density, 3D electroanatomical mapping has been successfully performed in adult horses at Ghent University [3]. This technique is based upon a catheter with 64 high-resolution electrodes in the heart and an electromagnetic field generator placed externally over the cardiac region. While the catheter is manoeuvred through the heart, the 64 electrodes continuously register all electrical activity and at the same time the electromagnetic field generator determines the exact 3D position of the catheter tip. Combining this information produces a colour-coded 3D replica of the heart with all electrical potentials at any time and at any site. Using a stable electrode from within the heart as time reference (e.g. the coronary sinus electrode), the electrical activation pattern of the myocardium can be visualised in slow motion. This technique can unravel the normal and abnormal activation patterns of atria or ventricles, which is necessary for diagnosis of complex arrhythmias. The 3D electroanatomical mapping technique can identify the exact origin of, for example, a focal tachycardia. When the origin of such an arrhythmia is found, a steerable ablation catheter can subsequently be positioned against the spot where the tachycardia originates from, using the electromagnetic field for precise navigation. Once myocardial contact has been made, the ectopic focus is ablated by radiofrequency energy delivery. This technique has recently been successfully performed at Ghent University in an adult horse with focal atrial tachycardia. Ablation of the ectopic focus not only restored sinus rhythm, it also resulted in drastic reduction of the recurrence risk. The fact that both mapping and ablation techniques are technically feasible in horses, opens broad perspectives to develop new diagnostic and therapeutic strategies in horses.

Conclusion

Good visualisation and perfect knowledge of 3D cardiac anatomy are mandatory to develop advanced, invasive procedures in equine cardiology. Techniques such as electroanatomical mapping and even ablation of arrhythmias have been successfully applied in adult horses and will improve diagnosis and treatment of arrhythmias in future.

References


NOTES
Pleuropneumonia - advances in treatment and prognosis

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Introduction
Bacterial pleuropneumonia is a common condition of horses that is an important cause of morbidity and mortality. For horses with pleuropneumonia, outcomes have varied considerably between studies, with survival rates of 44–96% reported. Conventional strategies for treatment of pleuropneumonia include systemic administration of antimicrobial and nonsteroidal anti-inflammatory drugs, fluid and nutritional support and drainage of pleural effusions. While antimicrobial drug regimens may be empirical, selection is best directed by cytological examination and bacterial culture of tracheal aspirate and pleural fluid samples. Pleural drainage is important when septic parapneumonic effusion is suspected or confirmed, based on cytology/bacteriology findings, gross appearance, biochemical examination and/or ultrasonographic findings. Despite these approaches, poor responses to treatment, progression of parenchymal and/or pleural effusion and development of complications can occur. In these ‘complicated’ pleuropneumonia cases, additional treatment options may be warranted in an effort to improve outcomes, and careful case assessment is required to best determine prognosis.

Prognosis
While the clinical course of horses with pleuropneumonia can be unpredictable, certain factors have been associated with prognosis. Negative prognostic indicators include markers of systemic and/or pulmonary dysfunction (e.g. increased blood concentrations of creatinine, systemic inflammatory response syndrome, necrotising pneumonia, foul odour to breath, pulmonary haemorrhage), bacterial isolates (e.g. Klebsiella spp., anaerobes, Actinobacillus spp.), increased volume of pleural effusion and accumulation of fibrin, sharp thoracic radiographic demarcation between marked alveolar infiltration and normal lung, and development of complications (e.g. laminitis, thrombophlebitis, colitis, bronchopleural fistula) [1-3].

Pleural drainage – advances in management
Horses with pleuropneumonia frequently require drainage of pleural effusions via intermittent or indwelling chest drains. However, fibrinous effusions are associated with decreased efficacy of drainage. In one study, fibrinous parapneumonic effusions developed in 85% of horses with pleuropneumonia and the fibrin accumulation was associated with a greater number of drains required for treatment and decreased survival [3]. Given the propensity for accumulation of fibrin within the pleural cavities and development of loculated effusions, there is increasing interest in the use of local fibrinolytic treatment to facilitate more effective pleural drainage and clinical outcomes. There are several reports of the successful use of recombinant tissue plasminogen activators (rTPA) for local fibrinolytic therapy in horses with pleuropneumonia [4,5]. Uncertainty remains regarding dose, frequency and timing of rTPA treatment; however, in one study, earlier onset of treatment was associated with increased odds of survival [4]. Newer generation rTPA drugs (e.g. tenecteplase) have a longer half-life, greater fibrin specificity and are more resistant to the inhibitory effects of plasminogen activator inhibitor-1 than earlier recombinant and natural plasminogen activators. The concurrent use of alfadornase (recombinant DNase) with rTPA may be superior to rTPA alone in improving pleural drainage by liquefying empyema pleural material [5].

Lateral thoracotomy
Thoracotomy has often been considered a salvage procedure in horses with refractory pleuropneumonia and fibrinous parapneumonic effusions that don’t respond to conventional management. However, standing lateral thoracotomy may be used earlier in the treatment of pleuropneumonia to facilitate pleural drainage, management of pleural abscesses and resection of necrotic lung. Lateral thoracotomy can be performed by rib resection, although intercostal muscle myectomy or myotomy may provide adequate surgical visualisation and lower morbidity and shorter healing times [6]. The often chronic nature of disease and the use of ultrasonographic examination to identify diseased tissue margins in relation to the thoracic wall prior to surgery reduces the likelihood of bilateral pneumothorax [6]. Preoperative placement of a chest drain adjacent to the intended thoracotomy site for equilibration with atmospheric pressure can also be used to assess for a perforate mediastinum. Standing lateral thoracotomy is well tolerated by most horses with minimal short-term complications and is associated with good clinical outcomes [6] and increased odds of survival in horses with pleuropneumonia [1].

References
Introduction
Interstitial pulmonary disease includes a heterogeneous group of disorders characterised by damage to the alveolar walls and loss of functional alveolar capillary units. Interstitial pneumonia (IP) is a morphological characterisation of lung diseases, which may be attributed to toxic or infectious agents or to allergens. Traditionally, IP is considered a chronic disorder, although acute inflammatory responses have been reported.

Clinical presentation
The presenting signs of horses with IP vary depending on the stage of the pneumonia and the causative agent. In the acute phase, horses may be presented for respiratory distress, tachypnoea and fever. With chronic disease, horses may exhibit exercise intolerance, persistent tachypnoea, weight loss, fever, anorexia, coughing and nasal discharge.

Diagnostic work-up
A thorough work-up focusing on the lower respiratory tract is essential to determine the exact cause. The diagnosis of IP is generally based on clinical signs, history, radiographs, analysis of pulmonary fluid, isolation of a causative agent and lung biopsy.

The minimal data base, including a complete blood count and biochemical panel, may be normal or may demonstrate leucocytosis and elevation of acute phase proteins (fibrinogen, serum amyloid A). Arterial hypoxaemia may be evident on blood gas analysis. Nasal swabbing should be considered for acute cases, where an infectious viral pathogen may be suspected. Chest radiographs are often suggestive of an interstitial disease process and may demonstrate a focal or diffuse increase in interstitial patterns (miliary to nodular infiltrates). Thoracic ultrasound complements thoracic radiography and allows determination of superficial pleural or parenchymal abnormalities. Pulmonary fluid collection is always indicated in horses with suspected bronchial or parenchymal pulmonary disease. While it is not always clear cut as to which procedure to choose, one may want to consider performing both a tracheal wash (TW) followed by a bronchoalveolar lavage (BAL), since many of these horses experience a secondary bacterial infection due to decreased pulmonary clearance function. Antigen detection in fluid from a TW and/or BAL may also be important to rule in or rule out specific viral, bacterial or fungal infections. Percutaneous lung biopsy in the horse is indicated when a histological diagnosis is required for management or therapy of a patient with diffuse lung disease of undetermined aetiology and after other less invasive diagnostic methods have failed to provide a definitive diagnosis. The procedure should be restricted to horses that are not in respiratory distress. The diagnostic accuracy of the biopsy specimen depends mainly on the nature and extent of the underlying disease.

### Table 1: Various hallmarks for selected equine interstitial pulmonary diseases

<table>
<thead>
<tr>
<th></th>
<th>Idiopathic granulomatous pneumonia</th>
<th>Equine multinodular pulmonary fibrosis</th>
<th>Equine idiopathic chronic eosinophilic pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>8–21 years</td>
<td>2–24 years</td>
<td>8–20 years</td>
</tr>
<tr>
<td><strong>Clinical signs</strong></td>
<td>Lethargy, anorexia, weight loss,</td>
<td>Lethargy, anorexia, weight loss,</td>
<td>Tachypnoea, moderate mucoid nasal discharge,</td>
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<tr>
<td></td>
<td>tachypnoea and abnormal lung</td>
<td>exercise intolerance, tachypnoea,</td>
<td>increased expiratory effort,</td>
</tr>
<tr>
<td></td>
<td>sounds</td>
<td>tachycardia, increased respiratory</td>
<td>tachycardia and abnormal lung sounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>effort, fever, coughing and nasal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>discharge</td>
<td></td>
</tr>
<tr>
<td><strong>Blood work</strong></td>
<td>Chronic inflammation</td>
<td>Chronic inflammation</td>
<td>Eosinophilia</td>
</tr>
<tr>
<td><strong>Radiographs</strong></td>
<td>Miliary to nodular masses</td>
<td>Solitary or coalescing masses</td>
<td>Miliary masses</td>
</tr>
<tr>
<td><strong>BAL cytology</strong></td>
<td>Suppurative inflammation</td>
<td>Suppurative inflammation</td>
<td>Eosinophilia</td>
</tr>
<tr>
<td><strong>Pathogen</strong></td>
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<td>EHV-5</td>
<td>None identified</td>
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<td><strong>Histology</strong></td>
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<td>Pneumocyte type II hyperplasia,</td>
<td>Eosinophilic nodules</td>
</tr>
<tr>
<td></td>
<td>multinucleated giant cells</td>
<td>intraluminal inflammatory infiltrates</td>
<td></td>
</tr>
<tr>
<td><strong>Prognosis</strong></td>
<td>Guarded</td>
<td>Guarded</td>
<td>Fair</td>
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<tr>
<td><strong>Treatment</strong></td>
<td>Corticosteroids, antimicrobials,</td>
<td>Corticosteroids, antimicrobials,</td>
<td>Corticosteroids, antimicrobials,</td>
</tr>
<tr>
<td></td>
<td>NSAIDs</td>
<td>NSAIDs, valacyclovir</td>
<td>NSAIDs, anthelmintics</td>
</tr>
</tbody>
</table>
Selected causes of interstitial pulmonary disease

These are summarised in Table 1.

**Idiopathic granulomatous pneumonia**

Idiopathic granulomatous pneumonia (IGP) is also known as sarcoidosis and is considered a sporadic lung disease presumed to be an abnormal host response to the persistent presence of an unidentified antigen. IGP affects adult horses, often presenting with lethargy, low body condition score, partial anorexia, tachypnoea and abnormal lung sounds. Consistent blood work abnormalities include mild anaemia, neutrophilia, hyperglobulinaemia and hyperfibrinogenaemia. Radiographic evaluation of the chest often reveals a mild to severe structured interstitial pulmonary pattern with miliary to nodular masses. Cytological analysis of TW and BAL is generally consistent with mild suppurative inflammation. Histological changes in lung biopsy specimens include characteristic noncaseating granulomas composed of epithelioid macrophages, multinuclear giant cells mixed with lymphocytes, plasma cells, and neutrophils. Macrophages and fibroblasts commonly surround the granuloma. Unfortunately, the symptomatic treatment of such horses with high doses of corticosteroids, NSAIDs and antimicrobials is rarely successful and horses are generally euthanased due to progression of clinical signs.

**Equine multinodular pulmonary fibrosis**

Equine multinodular pulmonary fibrosis (EMPF) is a recently described condition of adult horses that has been associated with equine herpesvirus-5 (EHV-5) infection. The clinical signs include a combination of lethargy, partial anorexia, weight loss, exercise intolerance, tachypnoea, tachycardia, increased respiratory effort, fever, coughing and nasal discharge. Animals are generally sick for weeks (3–6 weeks) prior to presentation, but acute onset of respiratory distress has also been reported. Blood work is nonspecific and reflects a chronic inflammatory condition. Chest radiographs generally display numerous discrete to coalescing nodular densities with a focal to diffuse distribution. The ultrasound examination often reveals discrete to well-defined 1–2 cm nodular lesions on the surface of the lungs. Cytological analysis of TW or BAL fluid commonly reveals a sterile, mild to severe suppurative inflammation, characterised by increased nucleated cell count, including an increased number of non- to mildly-degenerated neutrophils with the remaining cells being mononuclear cells. EMPF should be suspected based on the characteristic radiographic, ultrasonographic and histopathological findings (presence of interstitial fibrosis, mixed inflammatory cells in the interstitium, pneumocyte type II hyperplasia). The detection of EHV-5 in either BAL or lung tissue by qPCR is highly supportive of EMPF. The exact pathogenic role EHV-5 plays in EMPF is unknown (i.e. whether it is a true aetiological agent or cofactor in the development of EMPF). The prognosis in advanced cases is generally grave and treatment consists of the administration of corticosteroids, NSAIDs, antimicrobials and valacyclovir.

**Equine idiopathic chronic eosinophilic pneumonia**

Equine idiopathic chronic eosinophilic pneumonia is a disease associated with eosinophilic tissue infiltrates. Clinical signs on presentation often include tachypnoea, moderate mucoid nasal discharge, increased expiratory effort, tachycardia and abnormal lung sounds (crackles and harsh lung sounds). Interestingly, peripheral eosinophilia is often observed in affected horses. Thoracic radiographs reveal a severe diffuse interstitial pattern of increased pulmonary density, sometimes described as miliary or granular. Cytological evaluation of BAL consistently shows eosinophilic inflammation. The diagnosis is based on clinical appearance, eosinophilia in peripheral blood and BAL and eosinophilic infiltrates of a lung biopsy. Treatment recommendations generally include corticosteroids, NSAIDs, bronchodilators and prophylactic use of anthelmintics.
To answer the question, ‘when does LRT inflammation affect performance?’, it is important to consider the following factors.

What does LRT inflammation include?
Lower respiratory tract (LRT) inflammation may be defined as mild to moderate equine asthma (mEA) (previously termed inflammatory airway disease, IAD). This syndrome is a common disease in sport and racehorses and constitutes a common cause of poor performance in horses [1].

Which variables may be used for LRT inflammation diagnosis?
Diagnosis of EA is based on (a) clinical signs and (b) tracheal mucus. Bronchoalveolar lavage fluid (BALF) cytology or pulmonary function tests [1]. mEA has been defined as a neutrophilic and/or mastocytic and/or eosinophilic lower airway inflammation, characterised by occasional poor performance and coughing, but without increased respiratory effort at rest [12]. The diagnostic variables are measured at rest; however, some studies give some of their results with measurements performed after exercise and it is important to be aware of this in order not to draw incorrect conclusions.

Which variables may be used to define performance?
A recent publication has reviewed 217 studies describing racing performance and using 117 different performance measures [3]; of these, 17 variables were used 1 or more times, with the top five comprising: ‘return to racing’, ‘number of starts’, ‘days to first start’, ‘earnings per period of time’ and ‘earnings per start’. However, the great variety of variables make it difficult to compare different studies.

Some studies have evaluated the relationship between physiological variables such as V4 (velocity inducing 4 mmol/L of blood lactate concentration) and V200 (velocity inducing a heart rate of 200 beats/min) and performance in racehorses. Leleu et al. (2005) studied the relationships between these variables and the performance indices of 223 healthy French trotters and showed that V4 and V200 were highly correlated with the horses’ age and level of performance [4]. Thus, V4 may be a valid indicator of performance level.

What type of horse are we talking about?
It is important to define whether we are talking about sport or racehorses and, if sport horses, whether we mean endurance, eventing, showjumping or dressage horses, for example. As the physiological demand of the different disciplines may vary greatly, a mild to moderate inflammation of the LRT may lead to completely different consequences on performance.

So, when does LRT inflammation affect performance?
Some studies were performed with clinically healthy horses involved in competitions or races; others have focused on poorly performing horses.

Gerber et al. (2003) performed a study on 26 dressage horses which had no historical or clinical evidence of lower airway disease, were performing well and were housed permanently in a conventional stable environment. Mucus quantity and quality and differential cytology of BALF were assessed. This study showed that, although clinically healthy and performing well, all of the examined horses showed evidence of mEA [5]. This finding prompts the question, is there a degree of airway inflammation which does affect performance?

Holcombe et al. (2006) performed a study on Thoroughbred horses at a racetrack in order to determine the effect of tracheal mucus and cytological indices of tracheal aspiration on racing performance. The authors found that a moderate to severe tracheal mucus score (2 to 4), and not increased tracheal neutrophils, was a risk factor for poor racing performance [6]. Salz et al. (2016) performed a study on 135 Thoroughbred horses in which measurements were made after a gallop. They showed that there was no significant association between tracheal mucus score or tracheal aspirate cytology and subsequent racing performance.

Depecker et al. (2014) performed a study in 135 Standardbred racehorses to determine whether tracheal mucus and BALF cytology from both lungs was associated with racing performance [8]. Multiple logistic regression was used to determine whether increased proportions of neutrophils (>5%, >10% or >25% in at least one lung), metachromatic cells (>2%, >5%), eosinophils (>2%, >5%) and tracheal mucus accumulation (22) were associated with various race records including total earnings, mean earnings per race and finishing position. In this study, horses with >10% neutrophils from at least one lung had 4.33 times more chance (CI 1.40–13.35; P = 0.011) of being in the 75th percentile or higher for mean race earnings. No significant influence on performance was found for other cell types or tracheal mucus score. This study showed that pulmonary neutrophilia, based on a 10% cut-off value for at least one lung, was significantly associated with poor performance in Standardbred racehorses [8].

References
Introduction
Equine herpesvirus-1 (EHV-1), EHV-4 and equine influenza virus (EIV) are among the most common viruses recognised in infectious upper respiratory tract disease (IURD). All these viruses spread rapidly due their short incubation time and transmission occurs via fomites, droplets and aerosols. The morbidity of these viruses can reach 100% in a population of susceptible horses, while the mortality is generally low.

The diagnosis of IURD relies on the combination of historical information, physical findings, blood work and antigen detection in respiratory secretions. Quantitative real-time polymerase chain reaction (qPCR) has supplanted conventional culture-based detection methods for the diagnosis of IURD. qPCR is fast, reliable, cost-effective and more sensitive than conventional detection methods. However, molecular diagnostic improvements are needed in order to expand the field of respiratory viruses and also further define virulence and viability for selected viruses. Molecular diagnostic methods for selected respiratory viruses are summarised in Table 1.

Parallel testing by qPCR
Parallel testing of multiple infectious agents in standardised platforms is a central component of qPCR; it essentially allows several detections to happen simultaneously on a single platform. This strategy allows an efficient work-up of complex clinical syndromes with clinical signs in common. Even though veterinarians tend to make a single pathogen diagnosis, it has become more evident that syndromes can be caused by co-infections.

Equine rhinitis viruses (ERVs) have been given little attention by practitioners compared with other respiratory viruses, mainly because of the lack of diagnostic modalities. These viruses are common in horse populations but knowledge of their epidemiology, pathogenesis and association with disease is poor. There are two ERVs, namely ERAV (formerly known as equine rhinovirus 1) and ERBV (formerly known as equine rhinovirus 2). These important pathogens are capable of infecting both the lower and the upper airways. Both natural and experimental infection of seronegative horses with ERAV has been associated with fever, anorexia, seromucoid nasal discharge, coughing, lymphadenopathy and occasionally, lower limb swelling. The diagnosis has remained a true challenge for ERVs until recently. The infection may be diagnosed by virus isolation, detection of viruses by qPCR or demonstration of rising antibody titres to ERVs through virus neutralisation using acute and convalescent serum samples.

Equine herpesvirus (EHV)-2 and EHV-5 are widespread in horse populations; therefore, the detection of any of these viruses can occur in healthy but also in sick animals. Two viruses are optimally adapted to their host, which means that significant clinical expression of infection is rarely encountered. Another characteristic of the herpesviruses is their ability to immunomodulate the immune system, potentially increasing the susceptibility of horses to various infectious pathogens. However, due to their high detection rate in healthy horses and in order to avoid dilemmas with the interpretation of qPCR results, testing of EHV-2 and EHV-5 in horses with upper respiratory tract disease is not recommended at this time.

Assess viability of selected viruses
EHV-1 and EHV-4 are α-herpesviruses that affect the equine respiratory tract and can establish lifelong latent infection following exposure. The diagnostic sample of choice is a nasal or nasopharyngeal swab which should be taken early in the febrile phase of the disease. Due to the lymphotropism of EHV-1, detection can also be attempted from whole blood. qPCR assays used in the diagnostic field are based on the detection of viral genomic DNA and are therefore unable to distinguish between lytic and nonlytic virus. Discrimination between the different viral states is now possible by:

- targeting several genes (e.g., glycoprotein, latency-associated transcripts)
- detecting viral genomic DNA and transcriptional activity of the target genes at the messenger RNA (mRNA) level
- using absolute virus quantification.

This molecular strategy is used diagnostically for EHV-1 or EHV-4-infected horses in order to discriminate between lytic and nonreplicating virus, to determine their infectious risk based on viral load in nasal secretions and to monitor their response to treatment.

Assess genotype of selected viruses
Equine herpesvirus-1 myeloencephalopathy (EHM), a relatively uncommon manifestation of EHV-1 infection, can cause devastating losses. In general, EHM is supported by historical and clinical findings, the presence of xanthochromia and elevated total protein concentration in cerebrospinal fluid, and laboratory detection of EHV-1 in blood and/or nasal secretions by qPCR. Because affected horses can shed the virus in nasal secretions, and thus represent a risk of infection for unaffected, in-contact horses, it is imperative to determine the risk of shedding in a suspected horse in order to institute an appropriate infectious disease control protocol. A recently identified single nucleotide polymorphism (SNP) at position 2254 in the DNA polymerase gene (ORF 30) correlates with

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Table 1: Molecular diagnostic strategies used to detect selected respiratory viruses in respiratory secretions

<table>
<thead>
<tr>
<th>Virus</th>
<th>qPCR testing</th>
<th>Absolute quantitation</th>
<th>Genotyping</th>
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<tr>
<td>EHV-1</td>
<td>Blood and nasal swab</td>
<td>Lytic vs. nonlytic</td>
<td>Neurotropic vs. non-neurotropic</td>
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<tr>
<td>EHV-2</td>
<td>Routine testing not advised</td>
<td></td>
<td></td>
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<tr>
<td>EHV-4</td>
<td>Nasal swab</td>
<td>Lytic vs. nonlytic</td>
<td></td>
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<tr>
<td>EHV-5</td>
<td>Routine testing not advised</td>
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<tr>
<td>EIV</td>
<td>Nasopharyngeal swab</td>
<td></td>
<td>H3N8 clade 1 vs. clade 2 Florida sublineage</td>
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<tr>
<td>ERVs</td>
<td>Nasal swab</td>
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neurological disease. This SNP is responsible for a single amino acid residue at position 752 of the DNA polymerase with EHV-1 strains associated with neurological outbreaks involving a D752 genotype (also referred as G2254), whereas most non-neurological outbreaks involve a N752 genotype (also referred as A2254). However, the genotyping of field isolates needs to be interpreted carefully as 14% to 24% of EHV-1 isolates from horses with EHM do not have this neuropathogenic marker. Strain characterisation may be important given that the potential of EHM development is greater in horses infected with a neuropathogenic genotype (D752). Furthermore, detection of a neurotropic EHV-1 strain may influence therapy, especially in the use of antiviral drugs such as valacyclovir, used to decrease viraemia and prevent the development of neurological sequelae.

Contemporary EIV strains circulating worldwide all belong to the H3N8 Florida sublineage. Recent EIV surveillance data has shown that Florida sublineage viruses from both clade 1 and 2 circulate in Europe, while clade 1 viruses have been primarily reported from North America. With the increased national and international transportation of equids, it is very important to monitor the spread of EIV using timely, fast and reliable molecular diagnostic platforms. In past years, clade affiliation of EIV strains has been monitored using conventional nucleic acid sequencing techniques and more recently pyrosequencing, both of which are time and labour-intensive. Recent advances in genomic analysis have identified various SNPs of the hemagglutinin A1 (HA1) gene of EIV virus able to determine clade affiliation of EIV field isolates. Contemporary information on EIV clade affiliation is important not only from an epidemiological standpoint but also to monitor and understand EIV outbreaks and update EIV vaccine strains in order to improve protection against clinical disease.
The cascade and equine practice

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Introduction
The prescribing cascade is a risk-based algorithm for the selection of medicines that should be used whenever using medicines outside of their marketing authorisation. It is a part of the current Veterinary Medicines Regulations (2013) and may see some minor changes in the next EU Veterinary Medicines Regulations; these changes are likely to be minor, although could include restrictions on how the cascade is applied to certain classes of antimicrobials. Medicine selection under the cascade is totally the responsibility of the prescribing vet. Advice from the Veterinary Medicines Directorate (VMD) is that ‘the use of a medicine under the cascade is legal provided the veterinary surgeon follows the cascade decision tree and is able to justify the choice of treatment based on animal welfare.’

Obligations when using the prescribing cascade

When using medicines outside their marketing authorisation, either for a different condition, at a different dose, or outside the advice and warnings in the SPC (datasheet), veterinary surgeons may be open to litigation in the event of an adverse event. The RCVS code of professional conduct reminds us that such decisions should not be taken lightly or without justification, and that in such cases clients should be made aware of the intended use of unauthorised medicines and given a clear indication of potential side effects. They also stipulate that consent should be given IN WRITING.

In order to help veterinary surgeons comply with these requirements, BEVA has made the following tools and resources available at www.beva.org.uk/cascade:

- **Client information leaflets** - these facilitate collection of INFORMED consent and ensure that potential side effects are highlighted. These are beneficial in complying with the RCVS practice standards scheme.
- **Consent form** - a consent form that records justifications based on dynamic responses given during form completion.
- **Specials** - additional information for clients when using special veterinary medicines.
- **Food animal medicines** - links to relevant regulations for medicines allowed in food-producing horses.

Steps in the prescribing cascade
The steps in the prescribing cascade are summarised in Fig 1. In the event that there is no suitable medicine licensed for the treatment of a given condition in a given species, then it is appropriate to consider alternative steps, and these include (in order):

1. **Other veterinary medicines**: either licensed in the horse for a different condition or in another species (irrespective of condition). Note that these steps are considered equal in the Veterinary Medicines Regulations.
2. **Human medicines or veterinary medicines from the EU** (irrespective of licensed species). Note that a special import certificate is required when using medicines imported from the EU.
3. **Extemporaneous preparation** (special medicine). These can be formulated in-house or by a specials manufacturer; however, the RCVS guidance is that where possible these should be formulated by a specials manufacturer since they ensure quality assurance of these products.

As a derogation from EU law, the veterinary medicines regulations allow for the importation of medicinal products (i.e. human or veterinary) from third countries (i.e. outside the EU) in exceptional circumstances. This is the only mechanism by which human medicines can be imported into the UK for use in veterinary species. The VMD interpret this to allow importation of human medicines from within the EU. When using such medicines, a special treatment certificate is required for the named horse being treated and the product cannot be held in stock.

The prescribing cascade and food-producing animals
When applying the prescribing cascade to food-producing animals the same steps apply; however, the active ingredient must be permitted for use in food-producing animals (i.e. listed in EU 37/2010) or must be listed as an ‘essential medicine for the treatment of equidae’ (i.e. listed in EU 122/2013). Relevant withdrawal periods need to be set by the treating veterinary surgeon (6 months for essential medicines) and passports or medicines records updated appropriately.

Common misconceptions and oversights when applying the cascade
There are multiple times that, as veterinary surgeons, we use medicines under the prescribing cascade without being aware of this (e.g. using phenylbutazone in horses for management of colic) and others where perceptions about the cascade appear to limit clinical decision making in horses. This session will explore these examples.

Fig 1: Summary of the prescribing cascade as it applies to veterinary medicines.
All equine practitioners are well aware of the impact that the introduction of ivermectin had on the predominant equine large strongyle populations in the mid-20th century. This led to a sea change in the equine parasite species of concern, with the small strongyle or cyathostomin species coming to dominate our lives. Introduction of new anthelmintic compounds and reliance on rotational worming strategies with the timing of administration determined by the anticipated duration of efficacy of the anthelmintic in question appeared effective in limiting disease, but no doubt contributed to our current plight where the spectrum of anthelmintic resistance (AHR) should loom large in all our minds. We should also not forget the significance of anthelmintics in young stock, where industry reliance on ivermectin has blindly created resistance on many premises. Evidence of resistance to all available anthelmintic compounds in some cyathostomin populations suggested that a more forward-thinking strategy was needed. The focus on anthelmintic sales, price comparisons and widespread training of paraprofessionals to provide anthelmintic advice led to the disengagement of veterinary practitioners from their critical role of providing strategic parasite control consultancy, which we now know should centre on disease prevention and control of parasite populations rather than their elimination, which is unachievable. Parasite control in small groups of privately owned mature horses is relatively straightforward but we have been slow to learn lessons from our colleagues working with food animals, who deal with large populations of immature animals with developing gastrointestinal immunity. While pharmaceutical companies should be lauded for their efforts to encourage responsible anthelmintic use, unfortunately, it is often only when parasite-related gastrointestinal disease threatens or appears on a premises that owners and/or managers begin to take the issue seriously and recognise the value of veterinary involvement.

A move to strategic worming in response to seasonal risks (e.g. Anoplocephala perfoliata and cyathostomins) and faecal worm egg counts (cyathostomins) with accurate liveweight-based dosing were initial attempts to mitigate the risk of inappropriate drug exposure to parasite populations. These steps remain the cornerstone of control and in fact are relatively easy to achieve in healthy mature horses on well-managed premises where the 80:20 rule appears to apply, with 80% of the parasites being present in 20% of the horses. Indeed, in many larger private and livery yards, ‘repeat offender’ animals that are particularly susceptible to re-infection are often well known to owner, manager and vet in requiring more frequent treatment with this only rarely being due to AHR. ‘Poo picking’, preferably manually, quarantine of new animals that might be carrying resistant parasites, housing of animals after anthelmintic treatment, regular use of FWEC and FWECRT data, as well as any perceived or real, parasite-related disease data.

It is critical that the consulting veterinary surgeon obtains a clear and detailed history and understanding of the farm, including the use, layout and management of paddocks, yards and stables, the age demographic of the herd, the numbers and frequency of movements both of resident stock and of incoming and transient animals, historical and current anthelmintic strategies, any FWEC and FWECRT data, as well as any perceived or real, parasite-related disease data. Furthermore, the actual drugs used in the anthelmintic administration process should be explored in detail, including accuracy of weight measurement/assessment, competence of staff and management of animals post-dosing. If necessary, these activities should be observed.

The three key data sets required are:
- FWECs - can they be considered reliable? Threshold counts that trigger anthelmintic treatment must be decided in advance. On some farms the threshold may vary with parasite species, age cohort and season.
- FWECRT - calculated from pre- and 14-day post-treatment FWEC data (fenbendazole and pyrantel >90%, and ivermectin and moxidectin >95% reductions are expected).
- ERPT - this may be useful to flag up impending AHR and may require monthly FWECs (fenbendazole and pyrantel 6 weeks, ivermectin 8 weeks and moxidectin 13 weeks are expected).

Accurate records are critical to facilitate analysis. The best way to avoid AHR is to minimise or avoid use of anthelmintics while closely monitoring FWECs, but this may not be feasible in dealing with young stock. Careful monitoring of FWECs, accurate dosing, housing after treatment, regular use of FWECRTs in animals with high FWECs, monitoring ERPTs, introducing other products (e.g. pyrantel and even fenbendazole) and monitoring their efficacy, raising the FWEC threshold for treatment especially in the summer and early autumn to reduce treatment frequency, and paddock quarantine of animals carrying resistant parasites with scrupulous pasture cleaning are all important components of an AHR resolution strategy.

Management of AHR scenarios from practice will be discussed.
Antimicrobial resistance – priority or political interference?

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‘Antimicrobial resistance... within a wide range of infectious agents is a growing public health threat of broad concern to countries and multiple sectors. Increasingly, governments around the world are beginning to pay attention to a problem so serious that it threatens the achievements of modern medicine. A post-antibiotic era – in which common infections and minor injuries can kill – far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century’, or so say the World Health Organization [1]. But does the evidence support this view and should we be concerned in veterinary practice? Does what we do and do the choices we make really have an impact on human health? The answer to all of these questions is obviously a resounding ‘yes’.

The association between the use of antimicrobials and the development of resistant bacteria is well established in both human and animal populations and was reviewed at the request of David Cameron’s government in the O’Neill report which was published in May 2016 [2]. The O’Neill report concluded that globally, 700,000 human fatalities annually were attributable to an inability to treat and control microbial infections with six human pathogens with antimicrobial resistance (AMR). This figure was predicted to rise to 10 million per annum unless there was a dramatic change in antimicrobial use.

Animal sources of AMR are likely to make a minor contribution to this massive burden of disease and, currently at least, mortality and morbidity in companion animals as a result of AMR appears to be relatively uncommon. This observation is anecdotal as there is no means in place to record disease associated with AMR and defining such disease would present challenges. While they may not yet be an everyday concern, there is an increasing body of evidence that cases of AMR are becoming more frequent. There is manifold evidence that AMR determinants can travel between the bacteria of animals and human subjects by close contact, through the food chain, or indirectly via the environment [3].

The use of antimicrobials in agriculture is a well-publicised driver of resistance in bacteria [3]. Regrettably, there are no comprehensive and reliable data on the use of antimicrobials in companion animals, particularly horses [3], which is a failing on the part of the veterinary profession. It is reasonable to assume that antimicrobial use in companion animals is considerably less than use in the livestock sector. However, the antimicrobial agents used are often more closely related to those used in human medicine, and the close physical contact between companion animals and human subjects presents an opportunity for the two-way transfer of bacteria (commensal and pathogen) or genetic determinants of resistance. Exogenous exchange of genetic material enables rapid dissemination of resistance mechanisms in previously susceptible species and may take place between differing strains of the same species of pathogen or across genera, either by incorporation of exogenous DNA released from bacteria (transformation), transfer of plasmids (conjugation) or via transfer of resistance genes by bacteriophages (transduction). Owners and their dogs routinely share microbiota and experimental studies have confirmed that transient carriage of animal-derived commensals can result in transfer of resistance genes to bacteria likely to be better adapted to, and more likely to cause disease in, human hosts. The constant increase in international movement of companion animals, including horses, provides further opportunity for global dissemination of multidrug resistant (MDR) pathogens.

There are now numerous reports of the colonisation of horses with bacteria that are resistant to all registered veterinary drugs and pose a serious threat to human health [3]. The MDR organisms that present the greatest threat to human population and companion animal health are meticillin-resistant Staphylococcus aureus (MRSA) and Staphylococcus pseudintermedius (MRSP), extended spectrum b-lactamase (ESBL)-producing Escherichia coli and other coliforms, carbapenemase-producing E. coli, and MDR Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii and Enterococcus faecium/ faealis. Multiple drug resistance also appears to be increasing in Salmonella species and Clostridium difficile, which are important zoonotic diseases.

In the face of increasing evidence of the threat to human health posed by MDR bacteria from horses, it is paramount that all veterinary surgeons embrace the principles of antimicrobial stewardship. Equine veterinary surgeons have a responsibility to promote public and political confidence by demonstrating leadership through responsible use of antimicrobials, monitoring of AMR, and implementation of evidence-based practice. AMR is not somebody else’s problem; those of us who have the power to prescribe are on the front line and have been equipped with the tools we need to attack the problem of increasing AMR. While attacking the problem, we also need to defend ourselves, our families and our pets, all of whom we inadvertently place at increased risk of carrying MDR pathogens that have the potential to cause disease.

A more in depth review of this topic was published in Equine Veterinary Journal (2018) [4].

References

NOTES
There is little doubt we would all like to reduce antimicrobial use in our routine practice. The hitch is that, on a day-to-day and case-by-case basis, it can be hard to identify opportunities. Change is difficult and the temptation to use antimicrobials ‘just in case’ is strong. Pressure from owners and the need to ‘do something’ compound the problem.

**Smarter use of antimicrobials?**

The ‘ten commandments’ for the appropriate use of antimicrobials in human outpatient clinics are [1]:

1. Use antimicrobials only when needed; teach the patient how to manage clinical signs of nonbacterial infections.
2. Select the adequate antimicrobials; precise targeting is better than shotgun therapy.
3. Consider pharmacokinetics and pharmacodynamics when selecting an antimicrobial; use the shortest antimicrobial course that has proven clinical efficacy.
4. Encourage patients’ compliance.
5. Use antimicrobial combinations only in specific situations.
6. Avoid low quality and substandard drugs; prevent prescription changes at the drugstore.
7. Discourage self-prescription.
8. Follow only evidence-based guidelines; beware those sponsored by drug companies.
9. Rely upon the clinical microbiology lab.
10. Prescribe antimicrobials empirically – but intelligently; know local susceptibility trends, and also surveillance limitations.

A 2013 survey of antimicrobial prescribing practice in UK equine vets [2] revealed that fewer than 1% of practices had antimicrobial use guidelines, 5% of prescriptions for licensed antimicrobials were under the recommended dose and only 15% of respondents reported that they weighed horses routinely. When asked to rank the importance of a number of factors when deciding to treat an animal with antimicrobials, clinical signs were ranked as important by 93.2%, ease of antimicrobial administration by 64.5%, bacterial culture by 39.0%, financial constraints by 35.1%, client expectation by 27.5% and cytology by 15.9%. Trimethoprim sulfadiazine, despite a relatively high level of resistance, was the most common choice. Clearly, we have some way to go to fulfill the ten commandments.

**Respiratory disease**

Ultrasonographic monitoring, rather than antimicrobials, is recommended for foals with subclinical, pulmonary abscesses due to *Rhodococcus equi* infection [3]. But we do not have the same evidence to support decision making in other respiratory infections. In the recently revised ACVIM consensus statement on equine inflammatory airway disease (IAD), it was stated that evidence of systemic signs of infection (anorexia, lethargy, fever, haematological abnormalities compatible with infection) should be considered exclusion criteria for IAD [4]. IAD and recurrent airway obstruction can be considered a spectrum under the umbrella of equine asthma. Environment and airway hyperreactivity are key components of the pathogenesis. There is considerable merit in being more precise in reaching a diagnosis of IAD [5] or its differentials, since precise diagnosis should lead to more appropriate therapy. Major differentials for IAD include viral infection (where again antimicrobials are not indicated) and bacterial bronchitis/bronchopneumonia. It is in conflating the latter category with IAD that we set up the thought processes that lead to antimicrobial treatment for cases which are perhaps more appropriately managed with anti-inflammatory agents.

**Diarrhoea**

While there is perhaps a rationale for using narrow-spectrum drugs such as metronidazole, there is very little evidence to justify the use of broad-spectrum antimicrobials in adult horses with diarrhoea. Again, better use of diagnostic tests is preferable to antimicrobials in the first instance.

**Field surgery**

There are numerous studies emerging from veterinary referral hospitals on antimicrobial resistance [6,7]. For clean, elective procedures minimal or no antimicrobials are required. Surgical site infection is a concern in contaminated and clean-contaminated procedures, but measures such as hand hygiene, avoiding surgery in patients with existing infection, optimal surgical technique and facilities all reduce risk and antimicrobials are not the key component of infection control.

It is, of course, more difficult to optimise conditions in field surgery. Depending on the precise definitions used, it has been reported that 10–60% of horses will develop a complication after castration [8–10]. Closed techniques reduce the risk of complication. However, open castration in the standing horse has some cost advantages, even taking into account the additional costs of treatment of complications [9]. In that setting, it is difficult to avoid the use of antimicrobials over several days.

**Conclusions**

We need smarter use of antimicrobials in equine practice. More detailed investigations and less antimicrobial use will not only promote antimicrobial stewardship but also likely provide more appropriate patient care.

**References**


This workshop will bring together speakers from around the world to discuss the challenges facing practitioners dealing with the barren mare. The panel will present and discuss their own cases, illustrating their approach to the barren mare, promoting debate of current contentious areas. These presentations will illustrate and explore the potential causes of failure of establishment of pregnancy and/or pregnancy failure. The workshop will encourage discussion from the audience and welcome observations from the participants own experiences.

NOTES
The goal of this presentation is to present current and future sepsis diagnosis concepts.

The struggle to define sepsis
The study of sepsis and attempts to advance knowledge have been hampered by a lack of standardisation of definition, the result of continual changes in understanding of sepsis pathophysiology. The modern definition arises from the criteria for the systemic inflammatory response syndrome (SIRS). This syndrome involves organ dysfunction; association with infection (suspected or documented) is separate. Components included poor perfusion leading to organ dysfunction, tachycardia, tachypnoea, and hypo- or hyperthermia. Later, SIRS was acknowledged as a ‘systemic activation of the innate immune response, regardless of the cause’ and therefore not specific to sepsis. The most recent consensus definition for sepsis and septic shock largely redefined sepsis and associated syndromes. Currently, uncomplicated infection with signs compatible with an inflammatory response, but without organ dysfunction, is defined as infection (formerly sepsis). The term sepsis is now defined as infection with organ dysfunction (indicated by a sequential organ failure assessment [SOFA] score >2), this formerly being the definition of severe sepsis (this term is now withdrawn). Septic shock refers to patients with infection who have hypotension, are receiving vasopressors, and are hyperlactataemic.

In veterinary medicine, the definition of sepsis has been similarly difficult to crystallise. While detection of bacteraemia is pivotal in diagnosis, identification of sepsis and treatment is necessary in the early stages long before microbiological confirmation. Current definitions for SIRS and sepsis are derived from those originally published in human medicine. The diagnosis of SIRS is made clinically based on abnormalities in vital signs and white blood cell count (as above). There is currently no consensus, with definitions varying between publications. Sepsis is defined as infection plus two or more SIRS criteria. The foal sepsis score definitions varying between publications. Sepsis is defined as infection plus two or more SIRS criteria. The foal sepsis score calculation has been attempted to make the technique practical to apply more widely in clinical practice situations.

Currently deployed techniques in the diagnosis of sepsis
Sepsis scoring
In neonatal foals, sepsis diagnosis is assisted by sepsis scoring, this being considered more reliable than any individual parameter. A positive blood culture has been shown to be associated with nonsurvival; however, low numbers of circulating bacteria may give false negative results.

Haematological and clinical chemistry values are integral to many prognostic models. A low segmented neutrophil count, degenerative left shift, neutrophil toxicity, low total erythrocyte count, and elevated fibrinogen concentration were significant indicators of mortality in many studies. Leucocytosis, leucopenia, or elevations in band cell percentage are significant. Immunoglobulin G concentration affected survival and avoidance of infection. Lactate is considered a marker of circulatory competence, with the rate of clearance predicting survival. Serial blood lactate measurements can predict development of multiple organ failure following human sepsis, and in sick neonates, blood lactate elevations were associated with increased mortality, with increasing levels preceding clinical markers of deterioration. Arterial blood lactate in neonatal foals at the time of admission has been shown to be associated with survival and occurrence of SIRS. Venous blood lactate elevation, and persistent hyperlactataemia, has been shown to be associated with survival and severity of illness. The highest admission lactate concentrations were present in haemorrhagic shock, sepsis and complicated perinatal asphyxia. Regardless of initial diagnosis, lactate is significantly increased in nonsurvivors vs. survivors. Anion gap elevation and decreased venous PO₂, were also associated significantly with nonsurvival.

Clinical observations
While commonly measured, fever has been found to be an inconsistent finding in septic foals; however, hypo- or hyperthermia is associated with SIRS diagnosis. Tachycardia, tachypnoea, and altered mentation are also indicative. Physical examination identifying a septic focus (umbilical remnants, lungs, decubital ulceration, gastrointestinal inflammation, urinary tract infection, joint infection, meningitis) should alert the clinician to sepsis as a cause for any deterioration in patient condition.

Future diagnostics researched for clinical application
Ideally, a diagnostic biomarker would exhibit high sensitivity, high specificity and positive predictive value. Levels would change during disease course to allow not only early diagnosis, but also monitoring of progress. Regrettably, while important in human medicine, deployment in equine medicine is limited. Serum amyloid A (SAA) levels are the result of IL-1, IL-6 and TNFα activity, and are raised in response to both injury and infection. C-reactive protein (CRP) is a liver-derived acute phase protein. It is a specific but late marker of infection. Normal levels of CRP indicate the absence of sepsis. Procalcitonin (PCT), widely studied and implemented in human sepsis guidelines, is a prohormone of calcitonin and is another acute phase mediator affecting immunomodulation of SIRS and vascular responses. It is produced by hepatocytes and monocytes. Lipopolysaccharide-binding protein (LPB) is a soluble pattern recognition molecule that is synthesised by epithelial cells (including hepatocytes and myocytes). Protein biomarkers (fibronectin, α1 antitrypsin, lactoferrin, haptoglobin) can also be used for sepsis diagnosis. Unfortunately, many of these markers have proven nonspecific for sepsis. Cytokines are highly labile during neonatal sepsis, rendering measurement similarly difficult to interpret.

The response to sepsis shows alterations in the RNA transcriptome of peripheral white blood cells between affected and healthy individuals. The advantage of RNA molecules as biomarkers is they can be easily incorporated into PCR-based tests available in clinical practice. Measuring multiple RNA biomarkers concurrently should improve sensitivity and specificity.

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Where are we then?
Early diagnosis and timely (often pre-emptive) treatment are essential to the successful management of sepsis; however, initial signs are subtle and nonspecific, and confirmation is hampered by the low predictive value of many biomarkers and clinical parameters.

Further reading
Monitoring the critical neonate
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What are some of the reasons a newborn foal would be admitted?
1. History of difficult delivery or abnormal placenta
2. Failure to properly progress postpartum (modified APGAR score)
3. Weak, unable to stand
4. Alert, unable to stand (contracted tendons)
5. Unresponsive foal
6. Shock
7. Seizures
8. Coma/somnolence
9. Colic
10. Difficulty breathing, respiratory stertor or stridor

Each set of presenting signs would suggest certain things to check for; for example, if there is a history of difficult delivery/dystocia, make sure you check for fractured ribs.

A checklist for both history and physical examination is sometimes helpful to make sure important items are not missed.

Physical examination
1. Observation – able to sit sternal or not?
2. TPR:
   - Most sick foals will have a low temperature – usually due to low blood pressure.
   - Heart rates can vary from very high to very low in sick foals. Very low (<40) suggests advanced illness with prolonged low oxygen levels.
   - Respiratory rates are often very elevated in sick foals (trying to compensate for poor lung function) but sometimes you will see slow or irregular respirations in foals with neurological problems. It is also important to observe the character of respirations in sick foals. Normal character should be good chest movements, but some foals with serious lung problems will have predominantly abdominal movements with breathing.
3. Mucous membranes (mouth, conjunctiva, vulva): pale could suggest internal bleeding; muddy suggests possible infection (bacterial sepsis or shock); yellow (icteric or jaundiced) may indicate red blood cell breakdown with neonatal isoerythrolysis; petechiae (small red spots – 1–2 mm haemorrhages) can be seen with bacterial sepsis or low platelet counts (seen rarely but maybe 4–6 foals each year have immune-mediated low platelet counts).
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6. Shock
7. Seizures
8. Coma/somnolence
9. Colic
10. Difficulty breathing, respiratory stertor or stridor

Clinical laboratory
Sick foals tend to look the same. So, lab work is needed just about all the time to obtain more specific information about the metabolic status and response to disease.

** Blood glucose levels can be quickly obtained using hand held glucometers in the NICU. It is important that everyone be familiar with these machines, including how to do the daily maintenance of controls to make sure they remain accurate. Neonates of all species have very little glycogen storage in their bodies and illness, struggling, low oxygen levels, etc., (especially during prolonged deliveries), can deplete what little glucose precursor (glycogen) is present. Low blood glucose levels often play a role in sleepy sick foals. After a period of time with low glucose levels, injury begins to occur to brain cells and this could result in seizures immediately or hours later.

Ancillary diagnostic equipment
Many times, more information is rapidly needed to see what things look like inside the chest or abdomen. Ultrasound is the first tool of choice after palpation (so it is usually handy to already have the machine at least in the ICU at the time of arrival to save time going back-and-forth).

First things first – what do you need to live and breathe?
On arrival, down foals... Need to determine:
• Are they breathing?
• Do they have a heartbeat?
• How strong are the pulses?

A lot of foals might show up that still have a heartbeat but are not breathing. Number one step is to breathe them: mouth-to-nose or placement of an endotracheal tube and ventilation with Ambu bag. Placement of an endotracheal tube is for trained, experienced people. It is sometimes very difficult to get into the trachea and you can cause harm by inflating the stomach if the tube is in the oesophagus, not to mention the failure to really ventilate the foal when it is critically needed.

This may need to be done for a prolonged period of time, so a team approach is needed. Someone will be assigned this duty while someone else does other tasks.

The next step will be determining if there is a heartbeat. In some foals, the heart will still be beating but so weakly that it is not palpable (but still detectable on ECG). In these cases, chest compressions and ventilation may allow enough improved circulation and oxygen delivery to resuscitate/revive the foal. If no heartbeat is palpable, someone can perform the ECG while another is doing chest compressions.

The process of i.v. catheter placement needs to be rapid in a lot of cases, so again, the team approach and prior preparation before the foal arrives will make all these things fall into place in a smooth, organised fashion. Time wasted in getting a catheter in place is sometimes enough time for the patient to die. After provision of i.v. fluid volume, the next use of the catheter is for rapid i.v. access and administration of medications.

Okay, you have taken some history on the telephone, prepared the admission cart, set up the stall, admitted the foal and done the initial stabilisation. Now, it is good to take a second look over the foal to make sure nothing is missed. After that, your hands-on monitoring of the foal’s response will make the difference in its survival. A lot of times, disease processes will continue to progress in spite of the initial treatment programme. Foals that had significant birth asphyxia may begin to have progressive loss of consciousness or begin to have mild seizures (sometimes seen as mild facial twitches, stretching, or abnormal breathing patterns) before they begin to show the classic severe convulsions. Foals with bacterial infections (sepsis, septic shock, pneumonia, etc.) may also show signs of deterioration as progressive weakness or listlessness before they ‘suddenly crash’. The challenge is always to detect some subtle change before they do. The best rule is to ask if you are not sure of what you are observing or if you think there has been a trend downward.
Rhodococcus equi: an update

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Disease caused by Rhodococcus equi infection continues to be an important cause of morbidity and mortality in foals.

Epidemiology

R. equi is a soil organism found worldwide. Replication of the organism in the soil can occur in certain conditions but environmental contamination is greatly increased by faecal excretion from foals. Infected foals also swallow the bacteria in sputum, with further faecal excretion. Inhalation of dust particles is the major route of infection and airborne concentrations of R. equi have an association with disease. Host response is critical, as exposure is widespread but only a proportion of foals develop disease. Immunity to R. equi is complex and multifactorial.

A recent study shows that R. equi does not form part of the normal flora of the nasal cavity in adult horses [1].

Pathophysiology

R. equi strains that cause clinical disease have a virulence plasmid that encodes a virulence-associated surface-expressed protein (VapA). This plasmid is essential to allow the organism to escape the host immune response and replicate within and destroy macrophages.

Clinical disease

Pyogranulomatous pneumonia in foals between 3 and 6 months of age is the most common clinical manifestation. Subclinical disease is very common. Extrapulmonary infection can occur with enterocolitis, abdominal abscessation, septic arthritis or osteomyelitis.

Immune-mediated complications include polysynovitis, uveitis and haemolytic anaemia. However, a recent study [2] suggests that these complications may occur as a direct result of sepsis.

Diagnosis

The gold standard of diagnosis remains the identification of the organism from a tracheal sample via culture or PCR in a foal with clinical evidence of disease. The use of serial faecal qPCR as a possible screening test has been further investigated, but the test lacks diagnostic accuracy [3].

Treatment

The combination of a macrolide (usually clarithromycin or azithromycin) and rifampin is the currently recommended treatment; however, there remains some controversy over this recommendation due to drug interactions between these drug classes. Newer generation macrolides such as gamithromycin and tulathromycin have also been used. Hyperthermia during macrolide treatment is a recognised complication. Stieler et al. have shown that this response is caused by drug-induced anhidrosis [4].

Co-administration of clarithromycin with rifampin reduces the bioavailability of both these drugs. Splitting the dosing of the drugs by 4 hours leads to a small but probably clinically insignificant relative increase in clarithromycin concentration [5]. In contrast, co-medication of gamithromycin with rifampin leads to increased plasma concentrations of gamithromycin and decreased concentrations of rifampin [6].

Rifampin is commonly dosed at 10 mg/kg bwt orally twice a day. Berlin et al. [7] suggest that once daily dosing can achieve adequate plasma and cellular concentrations.

The combination of azithromycin and rifampin may be slightly superior to tulathromycin in terms of recovery rates and speed of disease resolution [8].

Gamithromycin has previously been found to be effective for the treatment of R. equi pneumonia but is associated with a high rate of drug reactions following i.m. injection. Administration of the drug intravenously may be a viable alternative [9].

Prevention

This challenging but current recommendations include trying to reduce exposure to high levels of airborne R. equi, and the use of hyperimmune plasma; the use of hyperimmune plasma has been shown to reduce the rate of clinical disease in experimentally challenged foals [10]. Chemoprophylaxis is not recommended and a vaccine is not currently available.

References

The aim of the neurological examination is to determine if a neurological disorder exists and if so, where the lesion or lesions are located. Horses, as a precocious species, are born with a more developed brain and fully functional vision and hearing compared with altricial species such as humans. Although brain development continues after birth, the cerebellar layers in prey animals such as the neonatal foal are already distinct histologically at birth compared with predators’ brains. Cerebellar development and myelination in various parts of the nervous system explain the ‘bouncy’ gait in neonatal foals. Neonatal foals are not little adult horses, and major physiological and neurological differences exist compared to older foals and adult horses. 

During the first few hours of extra-uterine life, important milestones must occur for successful functioning and survival of the neonatal foal. Horses, as prey animals, must develop a menace response relatively quickly after birth (within 7-10 days) compared with predators (several weeks). 

Lesion location determines the differential diagnoses and allows formulation of a diagnostic plan. Several important components of the neurological examination such as behaviour, mental status, head posture, vision, pupillary light reflexes and inspection for muscular symmetry can be noted in the general physical examination which should precede the detailed neurological examination. A thorough physical examination is important as disease of other systems or organs may account for the neurological signs that are seen (e.g. hyperammonaemia) or may take precedence for diagnosis or treatment (e.g. shock). Do not forget signalment (breed, sex, age) since there are disorders that can be seen in specific breeds (i.e. juvenile epilepsy in Egyptian Arabian foals).

The neurological examination should be performed as a systematic search for defects and asymmetries. The exact order of the examination is not important but a common principle is to start at the head and progress caudally to the tail to avoid omissions. The sequence of the neurological examination is as follows:

1. Head
   - behaviour
   - mental status
   - head posture and co-ordination
   - cranial nerves
2. Gait and posture
3. Neck and forelimbs
4. Back and hindlimbs
5. Tail and anus

Behaviour

The owner should be questioned about the patient’s behaviour and response patterns and whether there has been progression of the syndrome over time. Most congenital disorders are evident early in life and are progressive, whereas those related to physical injury have a sudden onset and may stabilise or improve. The patient’s age, breed or sex may influence its behaviour. Close observation may be required to detect seizures. A seizure is a manifestation of cerebral cortex dysfunction characterised by loss of consciousness or involuntary motor activities. A seizure may be generalised, focal, or focal with secondary generalisation. Generalised seizures are characterised by complete loss of consciousness and variable degrees of involuntary motor activity including flailing of limbs, passage of urine and faeces, nystagmus and vocalisation. Focal seizures can take two forms; the first is characterised by localised involuntary movements and may not be accompanied by an obvious alteration of consciousness. The second may result in momentary lapses of consciousness without collapse or significant motor activity. A focal seizure with secondary generalisation has a focal onset but subsequently seizure activity spreads throughout the cerebral cortex resulting in generalised signs. 

Bizarre and inappropriate behaviour such as head pressing, licking objects or compulsive wandering may be associated with cerebral disease and is easy to recognise. Animals with cerebral lesions that circle have a tendency to circle towards the side of the lesion.

Mental status

Mental status is assessed based on the patient’s level of consciousness or awareness. The animal’s responsiveness to the internal and external environments is affected by the cerebral cortex and the ascending reticular activating system (ARAS). These can be affected by stimuli from the sensory nervous system and thus responses to sensory stimuli should be considered; e.g. visual, tactile, auditory and painful stimuli. Loss of awareness can be described as depression, lethargy, somnolence, obtundation and stupor. The most profound loss of awareness is described as coma. This is a state of complete unresponsiveness to noxious stimuli. The deepest comas are usually related to brainstem, particularly midbrain, lesions.

Head posture and co-ordination

Normal animals maintain their heads in a certain posture and are capable of quick and smooth head movement. The most obvious abnormality of head posture is head tilt or turn. Unilateral, mild central and peripheral vestibular lesions frequently result in a head tilt that is characterised by a laterally deviated poll with the caudal neck and muzzle remaining on the midline. The head tilt in this case is described by the direction of the poll deviation. A horse with a cerebral lesion that continually turns in circles often has the head and neck deviated to one side, but the head itself is not tilted. A severe unilateral vestibular lesion can result in a marked head tilt, in addition to a head and neck turn, both usually towards the side of the lesion. 

The cerebellum acts to modulate movements of the head and limbs. Fine control of head positioning and movements is often lost with cerebellar disease resulting in awkward jerky movements and head tremor that is seen at rest. Neonatal foals have a hypermetric gait which becomes more co-ordinated by 3 days of age. Therefore, for the first few days of life it may be difficult to determine if the foal has cerebellar issues.

Further reading


10.30–12.35
Panel: Bettina Dunkel, Emily Haggett, Peter Morresey and Nathan Slovis

The panel will discuss new advances in the assessment and management of sick neonates, current controversies and their approaches to problematic neonate cases.
13.40–15.10
Panel: Elizabeth Davidson, Sue Dyson, Andrew Fiske-Jackson, Carolin Gerdes, Ellen Singer and Roger Smith

In this Lameness Workshop five of the world’s leading clinicians will challenge delegates with the diagnosis of a difficult lameness case with the help of videos and images. The delegates will be divided into five groups and rotate around each case for 12 minutes to reach a diagnosis. Cases of sufficient complexity will be selected to be of an appropriate level for the general practitioner or Cert AVP/specialist stream. At the end of the session, each tutor will have 6 minutes to present the final diagnosis and outcome of their case, followed by time for questions from the delegates.

NOTES
15.30–15.50

Transfusion medicine
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Plasma products
‘Fresh’ vs. ‘fresh frozen’ plasma
Fresh frozen plasma is required when the integrity of all of the clotting factors is needed. Plasma that is frozen to -18°C (or lower) within 8 hours of collection without being refrigerated preserves the labile clotting factors for up to 12 months. Plasma that is not handled with these specifications would be considered ‘frozen’ and will not contain the labile factors [1]. ‘Frozen’ plasma is stable for 2–3 years.
- Labile factors include factors V, VII, (and von Willebrand factor) and X, whereas stable factors are II, VII, IX, X and XIII.
- All plasma should be screened for anti-erythrocyte antibodies and blood-borne diseases but are not routinely screened for anti-platelet antibody.

Indications for fresh frozen plasma transfusions

Failure of passive transfer (FPT)
Plasma transfusions may be indicated in foals that are >12 hours of age which have complete or partial FPT. In the author’s experience most foals require between 20 and 60 mL/kg bw of plasma to obtain an IgG concentration >800 mg/dL. Healthy foals with partial failure may require only 1 L. Sick foals may require very high doses due to catabolism or consumption of IgG during sepsis or loss of IgG through protein-losing enteropathies.

Treatment of coagulopathies
Most frozen plasma products are considered ‘fresh frozen’ and therefore will contain the full complement of clotting factors, antithrombin and protein C.

Colloid therapy
Albumin is the primary determinant of plasma colloidal osmotic pressure (COP). In equine neonates 1–3 L can have a significant effect on the albumin concentration and their COP. In adults, the author’s experience is that 1 L of commercial plasma will only increase albumin levels by 0.1–0.2 g/dL. For colloidal replacement, the author prefers to have a significant effect on the albumin concentration and osmotic pressure (COP). In equine neonates 1–3 L can have a significant effect on the albumin concentration and osmotic pressure (COP). In equine neonates 1–3 L can have a significant effect on the albumin concentration and osmotic pressure (COP).

Anti-endotoxin or sepsis [2]
This is a controversial area of plasma use. Veterinarians tend to use plasma to target lipopolysaccharide (LPS) in patients with sepsis. Plasma that has been obtained from donors hyperimmunised with a core mutant Gram-negative E. coli isolate resulted in plasma with a much higher concentration of anti-lipopolysaccharide (anti-LPS) antibody. In one study administration of plasma rich in antiendotoxin antibodies was associated with greater survival in septic foals.

Immunoprophylaxis
Hyperimmune plasma has been utilised for treatment of infectious diseases caused by organisms such as E. coli, Clostridium botulinum, C. difficile, C. perfringens, R. equi, Salmonella, Streptococcus equi ssp. equi, West Nile virus and rotavirus.

Whole blood transfusion
Whole blood transfusions are indicated when there are concomitant deficits of oxygen-carrying capacity, blood volume and coagulation factors. Compensatory mechanisms for augmenting oxygen delivery to tissues allow patients to tolerate modest degrees of anaemia. These mechanisms include increasing cardiac output by raising stroke volume or heart rate; redistributing blood to areas requiring more oxygen; enhancing oxygen extractions by tissues; increasing coronary artery blood flow, ventilatory volume and respiratory rates.

In the absence of cardiopulmonary dysfunction, otherwise healthy patients usually do not have signs or clinical signs of anaemia at rest when the haemoglobin concentration is greater than 7–8 g/dL. However, dyspnoea on exertion occurred at this level. Weakness occurs at a haemoglobin of 6 g/dL, dyspnoea at rest occurs when the haemoglobin concentration falls to 3 g/dL, and the risk of heart failure is significant when the haemoglobin is less than 2.5 g/dL [3].

The objective of whole blood transfusion is to help improve the oxygen delivery to the tissues during anaemia; however, it is considered only a temporary life-saving procedure that should be used only as needed. The majority of transfused erythrocytes remain in the circulation for an average of 5 days (after crossmatch), which is why the bone marrow response to the anaemic crisis is very important to the overall recovery [4]. Over 30 different erythrocyte antigens (alloantigens) constituting seven blood groups have been identified in horses, accounting for more than 400,000 phenotypes. The possibility of identifying a completely compatible recipient is nearly impossible, but crossmatching can help prevent severe transfusion reactions.

An important decision in the management of anaemia, blood loss and coagulopathies in the patient is determining whether a blood transfusion is indicated. Blood transfusions should be considered in patients with a PCV <12% and who are considered unstable; those with haemoglobin concentrations less than 8 g/dL; when there is acute loss of 30–40% of the blood volume; when blood loss is associated with collapse or ongoing haemorrhage is present.

Donors
All horses kept specifically as donors should have blood typing performed. Alloantigens Aa of the A system and Qa of the Q system are the most immunogenic of the equine alloantigens and are highly prevalent among light breed horses. Transfusion of blood from a donor positive with these alloantigens will result in the development of a high alloantibody titre in the recipient that can cause severe haemolysis upon subsequent exposure. Donors lacking those alloantigens are considered safe blood donors. Suitable donors can be found among Standardbreds and Quarter Horses since both breeds have a low prevalence of Aa, and Standardbreds rarely possess Qa.

Crossmatching should be performed before any blood transfusion administration. Crossmatch stimulates, in vitro, the response of a recipient to a transfusion of type-specific donor red cells plus some donor plasma. The full crossmatch consists of a major and minor part. The major part is the crossmatching of donor red cells with the recipient serum (plasma). The minor part is the crossmatching of recipient red blood cells with the donor serum (or plasma). If an immediate transfusion is needed to sustain life, then administer without
delay. Initial transfusions rarely are associated with adverse reactions because horses infrequently produce strongly reactive natural erythrocyte alloantibodies.

**References**


The goal of this presentation is to differentiate fluid types and rationalise clinical choices.

Replacement or maintenance

Replacement fluids rapidly distribute to the compartments of the extracellular fluid (ECF). They are isotonic and should be used to replace deficits in hypovolaemic and dehydrated animals. Maintenance fluids provide free water that distributes to both the intracellular fluid (ICF) and ECF. They should be used to maintain fluid balance following rehydration in horses that need ongoing i.v. support. As continued use of replacement fluids may cause hypernatraemia and hypokalaemia, maintenance fluids contain a lower sodium concentration and a higher potassium concentration. Being made isotonic with dextrose. Increased levels of calcium and magnesium are also present. However, an appropriate fluid can be made by adding 5% dextrose and potassium to either isotonic saline or one of the replacement type fluids.

Crystalloids

**Replacement fluids**

These are polyionic isotonic fluids that are formulated to have similar electrolyte concentrations compared with plasma.

**Lactated Ringer’s solution (LRS)**

LRS is useful in situations where a rapid restoration of fluid volume is required. Although its concentration is low, potassium is present so LRS should be avoided in situations where fluid volume is required. Although its concentration is low, potassium is present so LRS should be avoided in situations involving hepatic dysfunction. Calcium may precipitate with citrate and bicarbonate.

**Plasmalyte 148® and Normosol-R®**

These are similar to LRS, but contain magnesium rather than calcium and can be used where precipitation with anticoagulants may occur. Alkalinising agents are acetate and gluconate respectively.

**Normal saline (0.9% NaCl)**

This is an isotonic fluid containing Na and Cl only, with concentrations higher than in plasma. Mildly acidifying, usage in hypokalaemia and metabolic alkalosis is indicated. Correction of hypernatraemia with this fluid should be gradual.

**Bicarbonate solution (isotonic)**

Isotonic bicarbonate is indicated in the correction of metabolic acidosis and hyperkalaemia; rapid administration must be avoided.

**Hypertonic saline (7% NaCl)**

Hypertonic saline is useful as an adjunct to crystallloid fluids in restoration of intravascular fluid (IVF) volume. Administration results in a rapid transient plasma volume expansion by osmotically drawing fluid from the interstitial fluid (ISF), improving cardiac performance and tissue perfusion. The positive effects last between 30 and 60 minutes. In hypovolaemic shock, concurrent administration with isotonic replacement fluids is beneficial.

**Plasmalyte 56® and Normosol-M®**

These are both hypotonic solutions that are lower in sodium and higher in potassium than replacement solutions, with magnesium substituting for calcium. They are also available commercially as isotonic solutions with the addition of dextrose.

**Half-strength dextrose saline (0.45% NaCl and 2.5% dextrose)**

This is an isotonic fluid that provides free water once the dextrose has been metabolised. It is useful for long-term management of hyperkalaemia.

**Colloids**

Colloids contain large molecular weight particles allowing rapid IVF expansion over a short time. As colloid particles are too large to diffuse across cellular barriers, colloid oncotic pressure is maintained, resulting in more effective volume expansion over a longer period than that possible with crystalloids alone. Small-volume colloid infusion can draw fluid from the ECF in the early stages of IVF volume restoration.

**Plasma**

Plasma is a source of essential proteins as well as osmotically active albumin. However, plasma may contribute to oedema if lost from the vascular space in situations of increased capillary permeability.

**Synthetic colloids**

Synthetic colloids are a more cost-effective colloid replacement than plasma. Clotting system function may be disturbed.

**Usage in combination**

Concurrent or sequential administration of both crystalloids and colloids is advantageous. Crystalloids distribute to the ECF space, with approximately 75% distributing to the ISF space, allowing interstitial rehydration. Expanding IVF volume with crystalloids in hypovolaemic patients decreases plasma protein concentrations, reducing colloid oncotic pressure. Colloids are restricted to the intravascular space; therefore, they are useful in hypovolaemic shock for rapid IVF expansion and increase retention of crystallloid fluids within the IVF compartment.

**Goals of fluid therapy**

- To correct hypovolaemia
- To manage dehydration
- Normalisation of electrolyte and acid-base status
- Restoration of oxygen transportation/oncotic pressure
- Provision of ongoing fluid requirements

**Clinical situations: rational fluid choices to best help the patient**

Choice of fluid will be made following assessment of the biochemical profile and clinical appearance of the patient. The initial replacement fluid is usually an isotonic crystalloid fluid such as LRS or an equivalent solution with a bicarbonate precursor.

**Haemorrhage**

Whole blood is the fluid of choice in cases of haemorrhagic shock. However, when blood is not available, isotonic polyionic solutions can be administered to maintain circulating volume, with consideration of their relatively
short time within the vascular space. Administration of up to three times the estimated blood volume lost has been recommended. Care should be exercised with the concurrent use of synthetic colloids (e.g. hetastarch, due to perturbation of clotting function) and hypertonic saline (rapid plasma volume expansion, causing increased arterial pressure).

**Gastrointestinal disorders**

Regardless of the causative disease process, whether diarrhoea, intestinal accident or impaction, disorders of water, electrolyte, oncotic, and acid-base homeostasis are present. Metabolic acidosis usually occurs due to intestinal loss of bicarbonate, and decreased IVF leads to inadequate tissue perfusion. Large volume gastric reflux, duodenitis-proximal jejunitis and proximal obstructions cause significant loss of chloride and hydrogen ions, leading to metabolic alkalosis. Impactions tend to not cause abnormalities in themselves, but secondarily through systemic dehydration. In the absence of severe electrolyte derangements, isotonic polyionic fluids are indicated. Addition of potassium, calcium and bicarbonate may be necessary. Sodium-rich fluids are indicated in cases of hyponatraemia.

**The exhausted horse**

Isotonic NaCl is the fluid of choice for dehydration associated with exhaustion or hyperthermia in endurance horses. Considerable loss of chloride ions is likely to have occurred due to sweating, leading to retention of bicarbonate and metabolic alkalosis. However, acid-base status is variable and metabolic acidosis also occurs. A markedly elevated heart rate, respiratory rate and rectal temperature following strenuous exercise require prompt treatment. Therefore, the need for volume expansion and cooling outweighs the risk of worsening a metabolic disturbance, should isotonic NaCl not be available.
Colitis – maximising diagnostic success
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Introduction
Colitis represents one of the most challenging disorders encountered by equine practitioners, both in determining the cause and in therapeutically managing the case. The detection of equine gastrointestinal pathogens using conventional microbiological tests can be very challenging because these pathogens are either difficult or impossible to grow, or can be present in pathogenic or nonpathogenic forms, making interpretation of positive results difficult. The introduction of molecular assays for the detection of common enteric pathogens has in recent years markedly improved the diagnostic success rate in colitis cases. However, the use of faecal material for molecular diagnostics has been associated with false negative results due to the presence of inhibitory substances (salts, proteases) in the faeces that can interfere with nucleic acid extraction or amplification. It is therefore imperative that molecular diagnostic laboratories comply with good laboratory practice by incorporating controls (internal or external) to mitigate the effect of faecal inhibition on PCR. The sensitivity and specificity of quantitative real-time PCR (qPCR) assays vary for different enteric pathogens. This mainly depends on the relative prevalence of detection of the pathogens in healthy vs. sick animals and the fact that the detection of toxins or toxin genes is generally more accurate in supporting a diagnosis. Furthermore, parallel testing of multiple enteric infectious agents in highly standardised platforms is a central component of molecular assays; it essentially allows several detections to happen simultaneously on a single sample for both DNA and RNA pathogen targets. Diagnostic methods for selected colitis-causing pathogens are summarised in Table 1.

Enteric pathogens
Salmonella enterica
Infection with Salmonella enterica is an important cause of enteric disease and death in horses. However, Salmonella can also be associated with subclinical shedding, representing a source of infection for other animals. In recent years, qPCR assays for the detection of Salmonella in faecal samples from horses admitted to veterinary hospitals have been evaluated. Collectively, these studies have shown an unquestioned higher analytical sensitivity for the detection of Salmonella by qPCR when compared with conventional microbiological culture. The use of novel virulence target genes for the molecular detection of Salmonella has considerably improved the performance and accuracy of such assays. It is imperative that qPCR for Salmonella be performed on faecal samples following a 24-h selective enrichment step in order to increase diagnostic sensitivity. The use of qPCR has the potential to reduce contamination risks and turnaround time, with results being available within 22–28 h from sample collection (18–24 h enrichment time, 4 h for DNA purification and amplification). One must keep in mind, however, that a positive qPCR result should be confirmed by culture so that serotyping of the Salmonella isolate and antimicrobial susceptibility can be determined.

Clostridium difficile
Clostridium difficile is a fastidious anaerobe considered an important cause of colitis, although it can also be found in the intestinal tract of healthy horses. While the dynamics of colonisation are unknown, it is likely that horses can carry C. difficile for long periods without ever developing disease. Carrier status is generally higher in foals and in adult horses treated with antimicrobials. The diagnosis of C. difficile infection is generally based on the detection of toxin A or B, or both, in faeces, gastric reflux or colonic content, ideally using a test that has been validated in horses. A variety of immunoassays are available; however, only one assay has been validated in horses (Clostridium difficile TOX A/B II ELISA, Techlab, Blacksburg, VA). This test, which detects toxin A and B, has a reported sensitivity of 84% and specificity of 96% compared to the gold standard (cell cytotoxicity assay). qPCR assays targeting toxin A and B genes of C. difficile have been shown to be highly sensitive with the advantage of a short turnaround time. qPCR is considered an acceptable screening tool to rule in or rule out C. difficile infection, allowing proper management and isolation of qPCR-positive patients.

Equine coronavirus
Historically, the detection of equine coronavirus (ECoV) has relied on either electron microscopy, antigen-capture ELISA or viral isolation from the faeces. All of these detection modalities lack sensitivity, especially if viral particles are not present in sufficient numbers. qPCR for the detection of coronaviruses has supplanted many conventional virological assays, mainly due to its short turnaround time, high throughput capability and increased analytical sensitivity and specificity. The detection of ECoV by qPCR in the faeces of foals with fever and diarrhoea is difficult to interpret because ECoV has also been detected in the faeces of healthy foals. Healthy foals have been found to be infected mostly by ECoV in a single infection without any other co-infecting agents, whereas ECoV was found exclusively in association with other co-infecting agents in sick foals. This is in sharp contrast to the detection of ECoV by qPCR in adult horses, where the virus has been shown to be responsible for a self-limiting disease characterised by lethargy, anorexia, fever and, less frequently, changes in faecal character and colic.

Table 1: Diagnostic strategies used to detect selected enteric pathogens in faeces from horses with colitis

<table>
<thead>
<tr>
<th>Disease</th>
<th>Blood work</th>
<th>Faecal testing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonellosis (Salmonella spp.)</td>
<td>Neutropaenia, left shift, toxic changes, electrolyte abnormalities, metabolic acidosis</td>
<td>Culture, qPCR</td>
<td>Pre-incubation of faeces in enrichment broth is recommended</td>
</tr>
<tr>
<td>Clostridium difficile</td>
<td>Neutropaenia, left shift, toxic changes, electrolyte abnormalities, hypoproteinaemia, metabolic acidosis</td>
<td>Culture, ELISA, qPCR</td>
<td>Can be found in the faeces of healthy foals</td>
</tr>
<tr>
<td>Equine coronavirus</td>
<td>Leucopaenia due to lymphopaenia and neutropaenia</td>
<td>EM, ELISA, qPCR</td>
<td>Considered a true enteric pathogen in adult horses</td>
</tr>
<tr>
<td>Lawsonia intracellularis</td>
<td>Hypoproteinaemia/hypoalbuminaemia</td>
<td>qPCR, serology</td>
<td>Important to combine both antigen and antibody detection</td>
</tr>
</tbody>
</table>

qPCR=quantitative PCR; EM = electron microscopy; ELISA = enzyme-linked immunosorbent assay
Lawsonia intracellularis

Lawsonia intracellularis, agent of equine proliferative enteropathy (EPE), is a gastrointestinal pathogen of young horses. Because culture of L. intracellularis from faeces is currently not possible, the ante-mortem diagnosis relies on serology and qPCR. The combination of both tests will increase the chance of diagnosing EPE. qPCR has the advantage of being fast and can yield positive results in the early stage of disease, when antibodies are not yet measurable. Prior use of antimicrobials can negatively affect the molecular detection of L. intracellularis in faeces. Therefore, in a suspected case, faecal collection for qPCR testing should be performed prior to institution of any antimicrobial treatment.
Colitis in adult horses is a multifactorial disease of frequently undetermined origin. In general terms the therapeutic approach should be designed to:

- Eliminate the cause where possible.
- Provide analgesia.
- Reduce inflammation.
- Adsorb enterotoxins.
- Support and augment the mucosal barrier.
- Support the circulation in terms of volume, colloid and electrolytes.

This presentation will focus on the evidence for three commonly used therapeutic approaches: metronidazole, diosmectite and larvicides.

**Metronidazole**

Metronidazole is a nitroimidazole antimicrobial that inhibits nucleic acid synthesis in an anaerobic environment. Although metronidazole resistance has been recognised in one US study of equine *Clostridium difficile* isolates, it was concluded that these were specific nosocomial strains [1], and no metronidazole resistance was found in later equine studies from Sweden and Australia [2,3]. A single toxigenic isolate of *C. difficile* with unstable metronidazole resistance was also isolated from a clinically normal zebra in a zoo in Madrid [4].

Many studies in non-equine species have demonstrated immunomodulatory effects of metronidazole including suppression of cytokine production, neutrophil migration and macrophage function [5]. Although no specific evidence exists in equids, a putative anti-inflammatory effect of metronidazole might be of benefit in both enteric colitis and in other forms of colitis.

**Diosmectite**

Diosmectite is a natural clay-like material formed from aluminium and magnesium silicates. It has been used as an intestinal adsorbent both in veterinary species and humans. Interest in its use in equine species first arose following a study of lincomycin-induced colitis in which all horses treated with diosmectite survived, whereas untreated controls did not [6]. Subsequently in vitro studies indicated effective binding by diosmectite of *Bacteroides fragilis* enterotoxins, *C. difficile* toxins A and B, and *C. perfringens* exotoxins including enterotoxin and beta-toxin [7-9]. Clostridial growth appeared unaffected by diosmectite and the activity of metronidazole and clostridial antibodies were similarly unaffected [7,8]. Diosmectite was found to be associated with a significantly lower incidence of post-operative diarrhoea (41% vs. 11%, P = 0.003) in a randomised clinical study of horses subject to large intestinal surgery [10].

**Larvicides**

Parasitic colitis associated with mass cyathostomin larval emergence is a common cause of acute weight loss and diarrhoea, especially in young horses in the winter. Based on label claims, the two main selected approaches for both treatment and prevention of this disease in practice appear to be either a single oral dose of 0.4 mg/kg bwt moxidectin (MOX) or five consecutive daily treatments of 7.5-10 mg/kg bwt fenbendazole (FBS). Several studies compared the adulticidal efficacy of FBS vs. MOX and found high prevalence of resistance of adult worms to FBS but not MOX [11]. Given the poor efficacy against luminal adults, it becomes hard to envisage good activity against encysted larvae. Two studies indicated a milder inflammatory response to dying larvae following MOX than FBS [12,13], although this was not confirmed by a third study [14]. Finally, studies designed to estimate the larvicidal activity of MOX and FBS clearly demonstrate poor efficacy of FBS, although it should also be realised that treatment with MOX is not absolutely effective in killing all encysted larvae [15].

**References**


Does the clinical examination of the foot help determine where it hurts?

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Hurt (pain) is one of the clinical signs of injury in the well-known ‘calor, rubor, tumor, dolor and functio laesa’ series. Pain in the foot leads to altered function in the form of lameness, but altered (locomotor) function is not always accompanied by pain, as in the case of old injuries which have healed with consequently reduced range of motion in the foot’s joints.

Lesions to the foot can be divided into hoof injuries and diseases of the bones, tendons, ligaments and joints.

Bruises, abscesses, thrust, canker, keratomas, hoof wounds, onychomycosis, hoof cracks and laminitis are examples of the first and are usually fairly straightforward to diagnose by visual examination, palpation, measurement of heat, taking the pulse, the use of hoof testers, percussion, probing and x-rays (Figs 1 and 2).

Palpation in the case of (suspected) laminitis should include the coronary band for the presence of a ‘trough’ instead of its normal bulge (Fig 3) [1]. Palpation of the free margin of the ungular cartilages proximal to the ipsilateral hoof wall is important in the case of quarter cracks (Fig 4) [2].

Clinical examination of non-hoof injuries may require additional means: diagnostic anaesthesia, flexion tests, more elaborate imaging, and more visual examination in movement.

An additional clinical aid that is especially useful in lameness due to joint, tendon, and ligament disease is the use of a graduated digital extension and elevation test with a digital extension device (DED).

In this test the horse’s tolerance to dorsal extension and lateral, medial and palmar/plantar elevation of its digit are measured precisely. By standing the horse’s foot (with the opposite foot held up by an assistant) on a plate attached to a long handle where a spirit level on a needle will give the degrees, the maximal inclination of the foot the horse can accommodate in four directions is established (Figs 5–7).

What this test does is measure the ‘functio laesa’ part of the lameness puzzle. To be able to compare individual results with the normal range of values, the dorsal extension, lateral and medial elevation was established in 250 sound horses, giving the following results:

- Dorsal extension (mean 43.18 ± 0.93 degrees; 95% CL), lateral elevation (mean 18.83 ± 0.26 degrees) and medial elevation (mean 19.79 ± 0.32 degrees).

The standard deviations were 7.46 degrees, 2.12 degrees and 2.53 degrees respectively [3].

Only once the initial study was completed did the author start using this device to establish tolerance to palmar and plantar elevation; based on observation in clinically sound horses, the minimal tolerance to palmar elevation seems to be 25 degrees, and to plantar elevation, 35 degrees (Figs 8 and 9). Dorsal extension of the hind foot seems to vary between 16 degrees and 25 degrees. The normal range of values for the forefoot are summarised in Fig 10; an example of notations made for a clinical case is shown in Fig 11.
This clinical test does not tell where it hurts but how much, or better put, by which degree and in which direction normal function is affected. It is therefore not a specific test but an objective and precise one. Of course, it does offer general clues to the type of lesion to be expected, and more importantly, what sort of remedial/therapeutic farriery will be needed to treat the horse successfully [4].

An injury to the inferior check ligament on a forelimb, for instance, will severely reduce dorsal extension tolerance of the affected foot – as a navicular lesion could – whereas an injury to the origin of the suspensory ligament can be expected to reduce tolerance to palmar elevation. In the author’s practice this test is the ideal interface between imaging results and therapeutic shoeing: magnetic resonance imaging will tell you, in sometimes abundant detail, what is wrong, the DED test by how much this affects the normal range of motion in each direction and how much you have to compensate for this in the design of your shoeing. It is also useful for monitoring functional recovery (or worsening!) by keeping notes and repeating the test over time.

References
Epidemiology of foot lameness
The foot remains the most common source of forelimb lameness in the horse. The anatomy within the foot is complex and, to minimise the risk of misdiagnosis, it is important to accurately localise the source of lameness prior to diagnostic imaging. Along with clinical examination, specifically palpation, assessment of the response to diagnostic intrasynovial anaesthesia of the foot has a pivotal role.

Perineural anaesthesia
Unless clinical examination identifies a localising sign, such as synovial distension or hoof tester sensitivity, perineural anaesthesia remains the starting point for localising lameness. It is highly recommended that the lameness investigation begins with anaesthesia of the palmar digital nerves at the level of the collateral cartilages. Although from a practical perspective, anaesthesia of the palmar nerves at the level of the proximal sesamoid bone can be useful to block the entire foot, this block lacks specificity, having a variable and unpredictable effect on the fetlock and tendon sheath and does not rule out the pastern as a source of lameness.

As has been demonstrated, anaesthesia of the palmar digital nerves desensitises the entire sole [1] and almost the entire distal interphalangeal joint (DIP) [2]. There is evidence that pain originating from the dorsal extent of the DIP may not be fully anaesthetised and, therefore, although there may be marked improvement in lameness, complete soundness is only achieved following anaesthesia of the palmar nerves at the level of the proximal sesamoid bones. In addition, the dorsal hoof wall is also considered not to be desensitised following anaesthesia of the palmar nerves at the level of the collateral cartilages. One can also not rule out proximal interphalangeal joint pathology when lameness is abolished following anaesthesia of the palmar digital nerves, as mild proximal diffusion of local anaesthetic can result in proximal interphalangeal joint anaesthesia. The effectiveness of anaesthesia of the palmar nerves is confirmed by abolition of heel bulb sensation. Due to dorsal nerve supply, cutaneous sensation will remain at the dorsal coronary band.

Intrasynovial anaesthesia
With the lameness localised to the foot, intrasynovial anaesthesia is recommended in the majority of cases. The response to intrasynovial anaesthesia of the foot is complex.

Distal interphalangeal joint anaesthesia
Anaesthesia of the DIP joint is not specific to the joint alone; it will also desensitise the navicular bursa and sole of the foot [1,3]. The horse should be re-evaluated at both 5 and 40 minutes post-injection of the DIP joint. At 5 minutes post-injection it is theorised that the effect of the block is specific to the DIP joint, but the author has seen cases with navicular bursa pathology that have improved at 10 minutes post-anaesthesia of the DIP joint. It is therefore important to re-evaluate horses promptly following injection and compare the response to DIP joint anaesthesia with that of the navicular bursa. The proposed explanation for this is that the palmar/plantar digital nerves pass close to the palmar/plantar pouch of the DIP joint. After 30 minutes, maximal diffusion to surrounding structures (navicular bursa, deep digital flexor tendon (DDFT) and sole) will have occurred and any further improvement is unlikely. The volume of local anaesthetic has been shown to influence the specificity of the block, with 5 mL shown to be optimal [4].

Navicular bursa anaesthesia
The navicular bursa is a fluid-filled pocket bordered distally by the impar ligament and palmar/plantar aspect of the pedal bone, palmarly by the DDFT, dorsally by the navicular bone and proximally by the ‘T’ ligament. It provides lubrication and cushioning to the DDFT as it passes around the navicular bone to insert on the palmar/plantar aspect of the distal phalanx. Inflammation and pain resulting from damage to any of these structures that make up the navicular bursa will respond quickly (5 minutes) to intrathecal anaesthesia. As with the DIP joint, the horse should be re-evaluated promptly following injection (within 10 minutes), when the block has the highest specificity to the bursa only. After 10 minutes, loss of sensation to the toe region of the foot occurs and after 20 minutes, anaesthesia spreads to the DIP joint [5].

In summary, incomplete diagnostic anaesthesia runs the risk of misinterpretation of diagnostic imaging techniques, particularly with increasing use of highly sensitive imaging techniques such as magnetic resonance imaging or computed tomography.

References

NOTES
What imaging algorithm is most suitable when examining a horse with foot lameness?

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The last two decades have seen tremendous advancement in equine diagnostic imaging. Technical improvements associated with digital radiography and ultrasound, and the increased availability of magnetic resonance imaging (MRI), computed tomography (CT) and nuclear scintigraphy, give the equine clinician a vast array of diagnostic tools to help determine the cause of lameness. These advances in imaging have improved our understanding of foot lameness in the horse, allowing clinicians to improve treatments and rehabilitation programmes and to provide clients with more accurate prognoses. Determining which imaging modalities are most appropriate requires a good understanding of likely pathologies and the merits and limitations of each modality. The client’s expectations and budget will also be determinants. A suggested algorithm for selecting imaging modalities for horses with foot lameness is shown in Figure 1.

Fig 1: An algorithm for imaging of horses with foot lameness.
Localisation of pain to the foot is based on clinical history, physical examination, gait analysis and diagnostic analgesia. Accurate localisation of lameness with diagnostic analgesia is important in determining which imaging modality is most appropriate. It is important that clinicians understand which areas may be desensitised by each analgesic technique so that imaging of appropriate areas is performed. It should be considered that lameness arising from the fetlock may also be alleviated by a palmar digital nerve block.

Following localisation of lameness to the foot, radiography is the initial imaging modality of choice. Increased availability of digital and computed radiography means that acquisition of good quality radiographs should be achievable. Radiography provides excellent visualisation of osseous structures, is readily available, cost-effective and can rule out numerous differential diagnoses. The downside is its inability to detect lesions unless a significant amount of pathological change is present, and it is poor for detection of soft tissue injuries. In horses with an acute-onset, moderate-to-severe lameness, oblique projections of P3 should be taken, as fractures of the palmar processes may otherwise be overlooked. These fractures may be hard to appreciate in the first few days after injury and so further radiographs should be taken after 10–14 days if fracture is considered possible. Sequential foot radiographs may be useful in horses with suspected laminitis to assess for signs of rotation or sinking of the distal phalanx. Radiographs of the foot are still important, even if MRI is available, as enthophytes and osteophytes may be difficult to appreciate on MR scans and assessment of foot balance is easier on radiographs than on MR scans.

In those horses with foot lameness in which radiographic findings do not account for the severity of lameness, MRI is indicated. Over the last decade there has been a huge increase in the number of equine MRI units available, especially of low field magnets which allow MR scanning of the distal limbs in standing horses. Advances in software mean that good quality, diagnostic MR scans are obtainable in most horses except those that are particularly uncooperative or have very large feet. MR scans of the feet will allow diagnosis of soft tissue injury (e.g. deep digital flexor tendinopathy or desmitis of a collateral ligament of the distal interphalangeal joint) and demonstrate effusions of synovial structures, as well as some osseous pathologies that are not evident on radiographs. MRI has poor sensitivity for detection of pathology of the hoof capsule and for detection of mild-to-moderate articular cartilage loss. MR scans of the fetlock should be performed in those horses in which findings on MR scans of the foot/pastern do not account for the lameness. Osseous injuries may not be evident on scans taken within a few weeks of onset of lameness. Repeat MR scans 4–8 weeks later may sometimes reveal pathology not evident at the time of the first scan. When horses with foot pain have no detectable radiological abnormalities, soft tissue assessment remains a diagnostic challenge without MRI. Ultrasonography can provide an alternative to MR imaging when that modality is not available. Ultrasound is readily available and can be used in a field setting. Obtaining diagnostic images is very operator-dependent and ensuring the sonographer has adequate training and skill is essential. Although ultrasound is generally considered to provide excellent soft tissue images, it is also sensitive to small, superficial osseous abnormalities. However, as most of the foot is encapsulated in the hoof it has limited use in horses with foot lameness. Detection of lesions in the deep digital flexor tendon in the pastern region or desmitis of the proximal part of a collateral ligament of the distal interphalangeal joint is relatively easy and ultrasound can be used to detect or monitor healing of such lesions identified on MR scan. Detection of lesions on the flexor surface of the navicular bone, effusion of the navicular bursa or desmitis of collateral ligaments of the navicular bone is technically more challenging. Ultrasonography of the insertion of the deep digital flexor tendon by scanning through the frog has been described but it requires excessive trimming and preparation of the frog and therefore MRI must be considered the better option.

Nuclear scintigraphic scanning following injection of Tc99m-labelled methylene diphosphonate provides physiological information about the turnover of bone and the blood flow to an area. The spatial resolution is poor compared to other imaging modalities. Scintigraphic examination may be useful as a screening tool in horses with multiple sites of lameness, those demonstrating poor performance or if fracture is suspected. However, if lameness has already been localised to the foot by regional analgesia then other imaging modalities are more appropriate.

The use of CT for detection of pathology in the foot has been reported. CT can provide excellent detail about the osseous structures but is less useful for detection of soft tissue abnormalities. In most systems, the horse has to be in lateral recumbency under general anaesthesia to position the limb within the CT machine. The risks and costs associated with general anaesthesia and a reluctance to anaesthetise horses in training, together with the poor depiction of soft tissue structures means that CT is difficult to recommend if MRI is available. CT may be useful for detailed imaging of fractures of the distal or second phalanx or navicular bone if internal fixation is considered or for guided injection of deep digital flexor tendon lesions.
Diagnostic imaging provides at least two different types of information relevant to therapeutic shoeing. First, it provides information about the relationship between the distal phalanx and the hoof capsule, and the relationship between the phalanges, navicular bone, and metacarpus/metatarsus. Second, it provides diagnostic information that can identify which structure is injured and the nature of the injury. This discussion will focus on the latter. Additionally, radiography is a valuable aid for placement of a shoe in relation to the position of the distal phalanx.

Every therapeutic shoe uses just a few biomechanical principles:
- Changing the distribution of force across the ground surface of the foot, either symmetrically or asymmetrically
- Changing the centre of pressure
- Changing the moments about the distal interphalangeal joint
- Changing the rate of deceleration as the foot lands.

Symmetrical distribution of load on the ground surface of the foot can be used to either decrease or increase pressure on any given area of the foot. For example, pour-in pads distribute the ground reaction force broadly across the ground surface of the foot whereas using a shoe with a narrow web will concentrate the ground reaction force on the distal surface of the wall. Asymmetrical distribution of the ground reaction force on the ground surface of the foot will cause the centre of pressure to change and is likely to have a variety of effects depending on the structure under consideration. For example, placing a wedge on one side of the foot will move the centre of pressure towards the side that is elevated. The moments about the distal interphalangeal joint in the sagittal plane can be changed by elevating the toe or heels, a manoeuvre that is effective both at rest and at exercise. The moments about the distal interphalangeal joint during the breakover phase of the stride are affected by the position of breakover on the shoe. Also, the distal interphalangeal joint exhibits limited movement in the frontal plane (a combination of slight sideways and rotational movement), so there are also moments about the joint in the frontal plane. Changing the rate of deceleration as the foot lands is primarily directed at decreasing maximum deceleration, which may be achieved by incorporating a material between the foot and the shoe that compresses during impact. It should be noted that changing any one of these is likely to change at least one other. Additionally, it should be noted that while there are only a few principles to follow, they are many ways to implement them.

In determining a therapeutic shoeing strategy, there are several sequential questions that should be addressed:
- What is the structure affected?
- Is the structure stressed under tension or compression?
- Is the tension or compression affected by weightbearing at rest and/or by movement?
- What biomechanical principles should be applied to decrease the tension/compression in the affected structure?
- What shoeing (or other appliance) manipulations will achieve the desired result?

The affected tissue is identified by a combination of the physical exam, diagnostic imaging and diagnostic analgesia. Ligaments and tendons are stressed under tension while bone and joints are primarily stressed under compression. Additionally, the lamellae are stressed under tension and the tissues of the sole are stressed under compression. The application of biomechanical principles and shoeing manipulations is best demonstrated by examples.

Desmitis of the collateral ligament of the distal interphalangeal joint is not an infrequent diagnosis made on magnetic resonance imaging (MRI). As a ligament, it is stressed under tension; that is, anything that tends to lengthen the ligament will increase the tension in it. Therefore, the therapeutic goal is to shorten the ligament/limit how much it can be stretched. At rest this is accomplished by moving the centre of pressure towards the side of the ligament, which will minimise the opening of the joint on that side and thus minimise lengthening the ligament. The joint on the affected side will also tend to open and the ligament lengthen when a horse is turning away from that side. To minimise lengthening the ligament as the horse turns, the associated moment in the frontal plane can be decreased. The simplest way to move the centre of pressure to the affected side if the horse is standing on a deformable surface is to make the branch of the shoe on the affected side wider than the contralateral branch. To ease movement away from the affected side, the opposite branch of the shoe is rounded.

Asymmetrical subchondral bone bruising and/or loss of cartilage that are identified on MRI should logically be treated in the opposite manner to collateral ligament injury. That is, the structures are stressed under compression and therefore, the centre of pressure should be moved away from the affected side and breakover eased on the affected side.

Deep digital flexor tendon injury within the foot is also a relatively common MRI diagnosis. As a tendon, decreasing its length decreases its tension (force). Therefore, the goal is to shorten the tendon when standing at rest and the middle of the stance phase of the stride, and limit its tension at breakover. The tendon can be shortened at rest by applying a wedge to the heels and at breakover by reducing the lever arm as breakover begins by moving the point of breakover in a palmar direction.

There are several reasons why therapeutic shoeing might be ineffective or fail:
- The disease is too severe for any therapeutic shoeing to be effective
- The wrong principles have been applied
- The correct principles have been applied, but to an insufficient degree to be effective
- The correct principles have been applied, but so severely that other structures are damaged.

Additionally, there are occasions when an injury is present, but the severity of the disease/severity of the clinical signs are sufficiently mild that the injury is likely to heal regardless.
Bisphosphonates (BPs) were first created in the 1960s; they are thought to be the most potent inhibitor of bone resorption and, therefore, are used in the treatment of people with Paget's disease, osteoporosis and osteolytic bone metastasis [1,2]. They reduce bone resorption by causing osteoclastic apoptosis, either via accumulation of cytotoxic ATP (non-nitrogen-containing or 'simple' BPs like etidronate, clodronate, tiludronate) or via altering the mevalonate pathway (nitrogen-containing BPs like alendronate, pamidronate, zoledronate) [3,4].

Besides their antiresorptive effect on bone via killing osteoclasts, recent review articles considered BP effects in animals and people to be antiresorptive, chondroprotective, analgesic, anti-inflammatory, anti-angiogenic and adverse [2,3,5,6].

Tiludronate and clodronate are currently licensed for use in horses in several countries. Tiludronate was found to have beneficial clinical effects in horses with navicular disease [7], osteoarthritic lesions of the thoracolumbar vertebral column [8] and bone spavin [9]. Pamidronate was not found effective in a preliminary clinical trial on horses with navicular disease [10]. Results for clodronate on horses with navicular syndrome were comparable to those for tiludronate in the freedom of informations summary of both drugs [11,12]. Overall, the success rate for horses with navicular disease after treatment with tiludronate or clodronate was up to 67% after 6 months, with best results at 2–6 months post-treatment, but with no follow-up longer than 6 months [7,11,12].

Navicular disease is one of the most common chronic causes of lameness originating from the equine foot and is characterised by degenerative changes of the podotrochlear apparatus, which is composed of the navicular bone, deep digital flexor tendon, navicular bursa and supporting ligaments [13].

Considering merely the antiresorptive effect on bone, only cases of navicular disease with osteolytic lesions would benefit from BPs. Depending on the study, the navicular bone is involved in 18–86% of cases with palmar foot pain and is the primary lesion in 5–35%, with not all lesions being osteolytic. For comparison, the deep digital flexor tendon is involved in 44–83% of cases and is the primary lesion in 18–33% [14,15,16].

In a 60-day randomised trial using standard dose and administration schedules, tiludronate and clodronate did not alter bone structure or remodelling in healthy horses and after an induced bone defect [17]. Many cases of navicular disease may not be appropriate for treatment with an antiresorptive bone product and the antiresorptive effect of licensed BPs when used at standard dose and administration schedules seems to be questionable. The anti-inflammatory [5,6] and analgesic properties [18] of BPs may be of benefit in horses with navicular disease. However, these effects appear to be short-term.

References
Managing foot pain with intrabursal medications

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Intrabursal corticosteroids

Lameness arising from injury to the podotrochlear apparatus has been treated by injection of therapeutic agents into the navicular bursa for many years [1,2,3,4]. Verschooten et al. evaluated the effect of navicular bursa treatment with 40 mg methylprednisolone or triamcinolone acetonide, in 161 horses with a positive palmar digital nerve block that had no, or mild, radiological abnormalities [1]. Following navicular bursa injection, 80% of horses were sound at 2 weeks, 66% were sound at 1 month, 60% were sound at 2 months, 30% were sound at 6 months, and 12% were still sound at 12 months. Babareiner et al. described similar results in a group of 25 horses, with 80% was required with a mean duration of stances of 4.6 months [2]. Therapeutic injection of the navicular bursa with corticosteroids results in more horses becoming sound for a longer period of time than similar treatment of the distal interphalangeal joint. In a review of 253 horses with navicular syndrome treated with either intrabursal or intra-articular corticosteroids, 60% of horses in the intrabursally treated group were sound for 2 months or more compared with only 34% of the horses in the intra-articularly treated group [5].

Case selection

Gutierrez-Nibeyro et al. suggested that horses fared no better if intrasynovial medication was given in addition to rest, controlled exercise and corrective shoeing, irrespective of the structures injured, in palmar foot lameness [6]. This observation is in contrast to two other studies that reported the efficacy of bursal medication, especially in horses with foot lameness caused by injury of the deep digital flexor tendon (DDFT), and pointed out that the duration of remission of lameness was highly dependent on the disease identified with magnetic resonance imaging and the duration of lameness prior to injection [3,4]. Additionally, the duration of remission of lameness after injection was significantly greater if intrabursal injection of corticosteroids and hyaluronic acid was combined with a 6-month rest-and-rehabilitation programme, when compared with horses that returned to work immediately following injections [3,4]. In another study, remission of lameness was significantly longer in horses with a diagnosis of navicular bursitis when compared with other diseases of the podotrochlear apparatus, while horses with erosive lesions of the flexor surface of the navicular bone were reported to have the poorest outcome [7].

Distension of the navicular bursa with 6 mL of a therapeutic mixture of corticosteroids and hyaluronic acid under general anaesthesia has been reported to help break down adhesions between the DDFT and adjacent structures in the navicular bursa, even though the exact role of adhesions as a cause of lameness is unique with [8] improved case selection and modification of the post-injection convalescence regime based on results of magnetic resonance imaging are likely to increase the efficacy of intrabursal medications.

Complications

Medication of the navicular bursa is not without risk. Strict asepsis is required to avoid iatrogenic septic bursitis. Post-injection exacerbation of the primary lesion is also possible. According to Verschooten [1], the duration of remission of lameness decreases each time after the second, third and fourth injections, until horses become unresponsive to bursal medication with corticosteroids. Babareiner et al. reported four horses that became severely lame 6-8 weeks after injection of the bursa due to developing severe tendinopathy of the DDFT in the eastern region [2]. All four horses had been injected at least three times at 3-monthly intervals and were likely to have exacerbated existing tendon pathology due to increased loading of the tendon following resolution of lameness. The navicular bursa should probably not be injected more frequently than once every 6-12 months to minimise the incidence of complications.

Injection techniques

Palmar needle approaches to the navicular bursa with needle introduction between the heel bulbs are generally favoured in the literature but penetrate the DDFT [12,3,4]. Some authors have questioned the potentially detrimental effects of penetrating the DDFT with a spinal needle, such as causing additional trauma with repeated needle positioning, especially in the presence of existing tendinopathy lesions [9]. Both a radiographically guided and an ultrasound-guided technique have been described to avoid iatrogenic damage to the tendon [10,11]. The radiographic technique uses multiple redirections of the needle guided by controlled radiographs while injecting small amounts of contrast medium until needle placement in the navicular bursa is confirmed [10]. The ultrasound-guided technique is performed with the foot held steady in flexion in a Hickman block, and a 5-8 MHz microconvex ultrasound transducer positioned against the palmar aspect of the DDFT in the distal aspect of the affected limb. A spinal needle (75 mm, 20 gauge) is inserted and advanced at an angle of approximately 45 degrees to the solar plane of the foot in the frontal plane of the limb, while maintaining visualisation of the needle and the proximal border of the navicular bone, the lateral lobe of the DDFT and the lateral collateral sesamoidean ligament (CSL). This technique has resulted in successful injection of the navicular bursa of 91% of all limbs attempted [11].

References

Therapeutic shoeing for orthopaedic injuries. Part 1: biomechanical basics and Part 2: what is the evidence?

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Introduction
Given the link between the external shape of the hoof capsule and its internal function, trimming and shoeing should optimise functionality and ultimately reduce stress, both to prevent injury and to treat established pathology. For centuries, farriery has been a craft relying merely on tradition, personal experience and empirical evidence [1]. Over the last decades, an increasing number of studies have provided key information on the biomechanics of hoof shoeing [2]. Unfortunately, there is still a lack of high-quality evidence-based research on trimming and shoeing for specific orthopaedic pathologies. However, the technological evolution may ultimately provide objective and quantitative tools to employ routinely in the assessment of equine locomotion and farriery [2]. Nowadays, optical motion capture and inertial sensor technology have become available for clinical use, and although still limited to experimental settings, pressure plates offer unique opportunities for evaluating limb loading symmetry [3], hoof contact area [4], the pressure distribution underneath the hoof [5], and the toe–heel and mediolateral hoof balance of the vertical ground reaction force on hard and soft surfaces [6,7] and in horses with conformational deficits [8]. This paper will summarise relevant biomechanical principles of therapeutic farriery and potential clinical applications.

Biomechanical key-points for farriery

Optimising hoof balance
Mediolateral hoof imbalance results in excessive compression on one side of the joint [9], which may cause progressive cartilage degradation. Moreover, imbalance can lead to progressive distortion of the hoof capsule, including flares, sheared heels and quarter cracks, and to increased stress on the soft tissue structures of the distal limb. In the treatment of these pathologies, correction of hoof imbalance is crucial [10]. If a hoof is visibly observed to be landing on the lateral wall first, a careful assessment of hoof wall heights is a prerequisite. Usually, the side assumed to be longer should be trimmed shorter to allow a visually flat landing. Major imbalances should be corrected gradually over time. In some angular limb deformities, medial or lateral extensions (in case of valgus or varus deformity, respectively) may augment corrective trimming, although excessive modifications should be avoided. There is a significant increase in the moment about the distal interphalangeal joint even during one shoeing interval [11]. Corrective trimming (reducing leverage and restoring optimal mediolateral and craniocaudal balance) is critical before any shoeing technique is applied; shoeing without proper attention to trimming is a missed opportunity [10]. The widest part of the solar surface of the hoof approximates the centre of rotation of the coffin joint, and guidelines for trimming and shoeing have been formulated based on this external landmark [12].

Shock dampening during initial impact phase
The hoof has inherent dampening characteristics, resulting in little or no vibrations extending above the fetlock. Shoeing decreases this natural dampening effect. However, shoes of different materials present differences in shock absorption (steel < aluminium < synthetic), while viscoelastic pads with or without sole filling may further enhance this effect [13,14]. This may be particularly relevant in the treatment of subchondral bone injury or other forms of osteoarthritis.

Appropriate slip/braking during the secondary impact phase
Hoof slip is a normal phenomenon during the secondary impact phase, and is heavily dependent on the track surface, speed and many other variables. The lateral component of horizontal movement during braking allows some energy dissipation and modulation of the magnitude and rate of loading. However, there is a narrow safety margin: too much slip results in instability and risk of falling; too little slip increases the risk of catastrophic injuries. Therefore, toe-grabs or studs/heel calks (and their number and exact localisation) must only be used judiciously and should be avoided when dealing with, for example, collateral ligament injuries. It may be worth considering other modifications like tungsten pins, a fullered and/or concave shoe, etc.

Optimal pressure distribution during the support phase
The application of a wedge creates a shift of the centre of pressure towards the side of the elevation [15], allowing an egg-bar shoe moves the centre of pressure palmarly [16]. Moreover, hoof wedges and egg-bar shoes alter distal limb joint angles [17-20] and forces acting on the flexor tendons: a heel wedge and a toe wedge result in a decrease and an increase, respectively, of the strain in the deep digital flexor tendon, whereas opposite effects are seen in the superficial digital flexor tendon and the suspensory ligament [21]. This may be useful in the treatment of tendinopathies as well as flexural deformities. Similar effects can be achieved by altering the width of the shoe at any point about its perimeter in relation to the rest of the shoe [10], at least when the horse is moving on a deformable surface. For example, egg-bar shoes prevent sinking of the heels into the ground on a sand track [19] and as such resemble the biomechanical effect of a heel wedge on a hard surface. Similarly, shoes with a wide toe prevent sinking of the toe in a soft surface and decrease strain in the superficial digital flexor tendon and the suspensory ligament. Optimal hoof balance results in the most even contact area between the joint surfaces of the coffin joint and, hence, the lowest pressure per unit area [22]. Using dedicated diagnostic imaging, the specific sites of cartilage degeneration/subchondral bone injury and/or ligamentous injury may be revealed. In case of cartilage/bone injury, the compression on the affected side may be relieved by promoting sinking of that side of the shoe in a deformable surface. Anecdotally, a wider lateral branch or a lateral heel wedge combined with rolling or rocking the medial side of the toe may be beneficial as part of the treatment of bone spavin and upward fixation of the patella. In case of collateral ligament desmitis, providing a wider base of support at the affected side can decrease tension. In the treatment of laminitis, styrofoam pads increase the weightbearing surface, decrease the overall pressure, and shift the pressure distribution palmarly [23]. Empirically, a wooden shoe with a bevelled perimeter has similar advantages while decreasing stress associated with breakover, allowing realignment of the distal phalanx and heel elevation as needed [24].
Optimising breakover
Stress associated with breakover may be a therapeutic target for osteoarthritis, navicular syndrome, laminitis and a variety of tendon and ligament injuries. A wedge shoe decreases breakover duration compared with a normal, plain shoe and with an egg-bar shoe [16]. Moreover, a wedge shoe causes a 24% reduction of the maximal force on the navicular bone [25]. The choice between a square toe, a set-back shoe, a reverse shoe, a rolled toe, a rocker-toed shoe, a natural balance shoe etc. is largely dependent on personal preferences and characteristics of the individual case. Different opinions exist regarding the use of a rolled toe [26]. Overall, shoes aiming at promoting breakover reduce the moment arm of the vertical force on the coffin joint [25]. However, this occurs only at heel-off, when the total vertical force has already reduced considerably. As the maximal distal interphalangeal joint moment is reached before heel-off occurs, these adaptations do not affect the maximal load on the deep digital flexor tendon [27,28], although hoof-unrollment has been shown to be smoother, thereby lowering the stress on the distal limb during breakover, at least on a hard surface [29–30]. Interestingly, unshod horses experience 14% lower forces on the navicular bone than horses shod with standard, flat shoes, which may have therapeutic implications [25].

Optimising hoof mechanism
Shoeing restricts the horizontal movement of the heels [31], which may affect shock absorption as well as the blood circulation in the hoof. However, glue-on shoes did not result in decreased expansion of the heels compared with nailed horseshoes, albeit only in the forelimbs. In contrast, contraction of the heels decreased significantly with glue-on shoes compared with nailed horseshoes [32]. Recently, a horseshoe consisting of two independently moving halves ("Moerman shoe") has been shown to allow a similar amount of heel expansion as in a barefoot situation, whereas a conventional single-clipped shoe significantly restricted heel movement [33]. In some cases, (temporarily) restricting the hoof mechanism may be desirable (e.g. in the treatment of fractures of the distal phalanx), using a straight-bar shoe with additional clips beyond the third nailhole [34], often combined with sole packing, or a rim shoe, or fibreglass cast applied directly underneath the hoof capsule. A 5 degree heel elevation has also been shown to significantly decrease hoof deformation [35].

Conclusion
Biomechanical studies provide useful information for evidence-based application of farriery techniques. However, randomised controlled clinical trials are rarely available, and therefore, individual assessment and clinical judgement remain of fundamental importance. The effect of track composition and its maintenance on shock dampening and hoof slip [36] may be at least equally important in the treatment of orthopaedic pathologies and affects the selection of horseshoe modifications (e.g. wedges vs. extensions). Any trimming or shoeing should be tailored to the individual case and should be based on a thorough static and dynamic evaluation of hoof balance, a full diagnostic work-up of any pathology, and adapted to the specific requirements for the chosen sport discipline. Based on the biomechanical aspects of the hoof-ground interaction, farriery can be focused on: (1) optimising hoof balance; (2) shock dampening; (3) appropriate hoof slip; (4) optimal pressure distribution; (5) optimising breakover; and (6) optimising the hoof mechanism. Ideally, several of these principles are already applied in the prevention of injury. The goal should always be to find the simplest solution that meets the objectives [10].

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11. Moleman, M., van Heel, M.C.V., van Weeren, P.R. and Back, W. (2006) Hoof growth. Biomechanical studies provide useful information for evidence-based application of farriery techniques. However, randomised controlled clinical trials are rarely available, and therefore, individual assessment and clinical judgement remain of fundamental importance. The effect of track composition and its maintenance on shock dampening and hoof slip [36] may be at least equally important in the treatment of orthopaedic pathologies and affects the selection of horseshoe modifications (e.g. wedges vs. extensions). Any trimming or shoeing should be tailored to the individual case and should be based on a thorough static and dynamic evaluation of hoof balance, a full diagnostic work-up of any pathology, and adapted to the specific requirements for the chosen sport discipline. Based on the biomechanical aspects of the hoof-ground interaction, farriery can be focused on: (1) optimising hoof balance; (2) shock dampening; (3) appropriate hoof slip; (4) optimal pressure distribution; (5) optimising breakover; and (6) optimising the hoof mechanism. Ideally, several of these principles are already applied in the prevention of injury. The goal should always be to find the simplest solution that meets the objectives [10].

References


Is the proposed effect of kinetherapeutic shoes in hind feet measurable?

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For millennia, horses have been shod to protect the foot against excessive wear, to influence the gait and for orthopaedic rehabilitation. In the farriery industry, there are many types of shoe which are suggested to have specific kinetherapeutic effects. The aim of this lecture is to describe the scientific data available for the clinical effects of specific shoeing, especially of the hind feet.

For the forelimb, there are consensus rules derived from many ex vivo and in vivo studies regarding the influence of the palmar angle on the digit on hard ground. An increased palmar angle induces more flexion of the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints, and more extension of the fetlock, in walk and trot during the stance phase. In walk on soft ground, an egg-bar shoe increases the flexion of the DIP and PIP joints and only tends to increase the extension of the fetlock [1]. A study looking at the effect of a wide-toe shoe on the forelimb, performed on a force plate in walk and trot, demonstrated a caudal shift of the centre of pressure in the direction of the heel during the late stance phase [2]. The authors presumed that this observed caudal shift could increase heel penetration on soft ground and consequently reduce fetlock extension; however, to our knowledge, there is no study that measures the influence of a covered-toe shoe on deformable ground, and direct measurements are necessary to verify this assumption. Studies of the rolling effect were also performed on hard ground, with the conclusions that rolling must be extremely exacerbated to induce a measurable effect on the late stance phase kinematic parameters, but it could induce a more fluent break over.

In the hindlimb, one previous study, performed on hard ground at walk and trot, showed that increasing plantar angle using 8 to 16-degree plastic wedges reduced the extension of the fetlock and the hock [3]. With co-workers, we performed a kinematic clinical study on six horses, in walk and trot, using side-on videos; on hard ground, we studied the effect of plantar angle manipulation using 3-degree plastic wedges. On soft ground, we measured the effects on the hindlimb of an aluminium egg-bar shoe, an aluminium covered-toe shoe and an aluminium reverse shoe, in comparison with a reference shoe. The reference shoe was an association of a classic flat aluminium shoe (AC CONCEPT product, 230–250 g) and of a hind race steel shoe (KERCKAERT product, 220 g). On soft ground, the three hind-shoeing conditions tested were used in combination with the same aluminium flat shoe. On hard ground, we tested the plantar manipulation effect using the reference shoe and with a plastic wedge placed under the hind steel race shoe, with the thicker side under the heel or the toe. Our results on hard ground confirmed the results of Peham et al. [3]: an increased plantar angle on hard ground reduces extension of the hind fetlock and hock. A 6-degree variation in plantar angle is necessary to observe a significant effect on the fetlock, while only a 3-degree variation in plantar angle induces a significant effect on the hock. On soft ground, hind egg-bar shoes significantly increase extension of the stifle and hip during the stance phase and induce more hind fetlock extension at late stance phase in trot only. The hind covered-toe shoe induces a minor effect. The hind reverse shoe increases hind fetlock extension at landing, and increases elbow extension, shoulder extension and forelimb protraction. Another important finding is a greater influence of the shoeing conditions on the proximal joint than on the distal joint. The influence of rolling in the hindlimb is similar to the forelimb: rolling induces a more fluent break over [4].

In conclusion, it is important not to consider the hindlimb to be the same as the forelimb and vice versa, due to their evident anatomical and biomechanical differences [5]. It is also prudent to be cautious about the presumed kinetherapeutic effects of certain types of shoes because of the paucity of knowledge about their measurable effects. It is important when using specific shoes to consider their influence on the centre of pressure, and consequently on the induced hoof balance. Increasing the height or enlarging the surface of the shoe in a particular area increases the pressure locally and could be deleterious to the foot’s health. And lastly, hind shoes should be considered to have minimal kinetherapeutic effects on the distal limb but probably have greater effects on gait conditioning.

Acknowledgements

The company AC CONCEPT which provided all the aluminium shoes for our study. Co-workers, Dr Faustine Blanville, Dr Renate Weller, Dr Marielle Carro, Dr Perrine Mortagne, Diana Salazar, Denis Levillard, Luc Leroy, Patrick Doffemont, Jean-Yves Cosnefroy

References

Managing hoof balance and hoof capsule distortion

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Hoof balance means different things to different clinicians. Hoof balance is classically divided into static balance and dynamic balance. Static balance typically refers to conformation, i.e. the shape of the hoof and its relationship to the limb, and is assessed with the foot both on and off the ground. Dynamic balance refers to the way the hoof contacts the ground during the landing phase of the stride and is determined by observing a horse in motion. Neither are totally satisfactory and the author prefers to consider hoof balance as a concept that relates the hoof both to the rest of the limb and to the ground, therefore making the concept both anatomical and functional in nature. Far more is known about the function of the forelimb than the hindlimb, so the forelimb is the focus of this abstract.

The centre of pressure in the stationary horse is located centrally, typically slightly dorsal and medial to the geometrical centre of the foot. Therefore, force is distributed relatively evenly around the healthy foot at rest. When a horse is exercising, initial contact is at the lateral heel/quarter, but rapidly moves to the centre of the foot before moving towards the toe at breakover, so that for the majority of the stride, the force is distributed relatively evenly over the ground surface of the foot. Both at rest and during the stance phase of the stride, the pressure at any point is dependent on the shoeing and the type of surface on which the horse is housed/exercised.

Hoof capsule distortions commonly associated with imbalance are underrun heels, club feet, sheared heels, and bull-nosed feet. Hoof deformation revolves around movement of the distribution of force in both the sagittal and frontal planes, or a combination of the two. The distribution of force in the frontal plane is largely determined by the horse’s conformation but may also be influenced by the manner in which it is shod. The distribution of force in the sagittal plane is related to the balance between the extensor and flexor moments about the interphalangeal joint. The flexor moment is the product of the force in the deep digital flexor tendon and the shortest distance from the tendon to the centre of rotation about the joint. The extensor moment is the product of the ground reaction force (equal to weight on the resting horse) and the shortest distance from the line of action of that force and the centre of rotation.

The hoof responds to an abnormal distribution of stress in at least three ways: displacement of the capsule proximally or distally; change in growth rate; and deformation (e.g. flaring or underrunning). The relative contributions of weightbearing at rest and during exercise to the development of these deformities are unknown. Limb conformation clearly influences the position of the foot in relation to the rest of the limb, as well as the way the foot moves during the flight phase of the stride, and how the foot loads, bears weight and breaks over during the stance phase of the stride.

Assessment of the deformity involves visual inspection which is often combined with horizontal dorsopalmar and lateral radiographs. The images are taken to examine the alignment of the phalanges and the relationship between the distal phalanx and the hoof capsule. Visual inspection should determine at least the relative positions of the coronary band, hoof growth rate around the circumference of the foot, and deformation of the hoof wall. Palpation of the hoof can often identify more subtle changes in the surface contour better than visual inspection. It is this author’s opinion that horizontal dorsopalmar radiographs are not particularly helpful for evaluating deformities primarily in the frontal plane, though they may be helpful assessing the alignment of the phalanges in the sagittal plane.

Club foot
Club feet occur when the flexor moment exceeds the extensor moment so that the centre of pressure moves dorsally. As the centre of pressure moves dorsally, the dorsal wall grows more slowly and the heels grow more rapidly giving rise to the divergent growth rings seen. Additionally, the dorsal wall deforms under the increased stress and becomes concave. Treatment involves either increasing the extensor moment by adding a toe extension, or decreasing the flexor moment, typically by performing a desmotomy of the distal accessory ligament of the deep digital flexor tendon.

Underrun heels
Underrun heels should be thought of as the opposite of a club foot. That is, the centre of pressure has moved in a palmar direction because the flexor moment is no longer equal to the extensor moment. The cause is not always apparent, but certainly, any injury or stretching that reduces the tension in the deep flexor tendon/distal accessory ligament can cause this to happen, as can certain shoeing manoeuvres, for example, heel elevation. Theoretically, the treatment is to restore the balance between the two moments. However, if the supporting structures within the palmar half of the foot are compromised and the deep digital tendon functionally is lengthened, this may be impossible. Therefore, management rather than resolution is the practical solution, which involves removing damaged heels, shortening the moment arm at breakover and providing slight heel elevation when possible.

Sheared heels
In the author’s experience, sheared heels occur most commonly in horses with angular or rotational ‘deformities’, or a combination of both such that the one heel, almost invariably the medial heel, is closer to the axis of the metacarpus than the other. These horses typically land markedly on the outside of their foot. The displaced coronary band with any associated decrease in growth or underrunning of the heels indicates increased load bearing on that side of the foot; that is, the centre of pressure is too close to the displaced heel. Therefore, the logical treatment is to move the centre of pressure back towards the centre of the foot, typically by trimming/floatting the heel and stabilising the palmar aspect of the foot with a bar shoe or heel plate.
Are there durable farriery solutions for the low-heeled horse? 

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Introduction
The low-heeled foot, also known as underrun or collapsed heels, has been recognised as a cause of lameness for decades [1,2]. Unsoundness from collapsed heels has a mechanical effect upon the deep digital flexor tendon and other supportive structures and also crushes the volar sensitive tissues. Temporary relief from the effects of collapsed heels can be achieved but in the long term these are frequently detrimental [3]. Durable solutions can only spring from comprehensive understanding, rational remedies and initial treatment solutions. This paper defines the condition, offers immediate therapy and suggests long-term farriery therapy.

Low-heeled collapsed or underrun?
There is a constant confusion of the terms 'low-heeled' and 'underrun heels', which need better definition and differentiation. A low-heeled horse is one where the digit has a low angle but aligned hoof pastern axis (HPA) and the caudal hoof wall is not bent. Underrun heels are associated with a negative HPA and are long and folded under the volar hoof capsule (Fig 1). The shape of the dorsum may be convex or concave and the palmar border angle of the distal phalanx is horizontal or negative (Fig 2).

Aetiology
Causes are multifactorial and include: breed; digit conformation, being prone to low HPA; weak hoof wall; negligence from owners, allowing too great a gap between shoeing, poor trimming and shoeing technique, not dressing the hoof correctly; and inappropriate shoe fit. Shoes fitted too long may create additional leverage and shoes that are fitted too tight allow the hoof to over-grow the perimeter of the shoe. A negative HPA causes excessive loading to the caudal hoof causing compression and bending of the epidermal heel. This in turn exacerbates the negative HPA, thus creating a deteriorating cycle where epidermal hoof growth is continually exposed to increased loading.

Trimming
Rebalancing the hoof is aimed at moving the bearing border caudally. Although a long dorsal hoof requires shortening, excessive removal of the abaxial stratum medium can be counterproductive as this diminishes the structural integrity of the hoof wall and often leads to collapse. Biomechanical shortening of the dorsum can be achieved by the shoe design (Fig 3). The heels should be trimmed so that the bearing surface is lengthened to its most caudal safe extent. This should achieve the aim of loading weight through the
hoof wall in the direction of the tubular structure, therefore not creating a bending force. In achieving an extended caudal loading area, the HPA may become negative with the consequent side effects. It is possible to overcome this by shoeing with elevated pads, described in the next paragraph. In recent years it has been suggested that a farrier should trim the heels to the ‘widest part of the frog’: this is dangerous nonsense as it is only possible to fulfil this formula by trimming into the sensitive tissue.

**Shoeing**

Shoe selection involves size, type of section, toe and heel type. If the heel fit is overly long, then additional leverage will increase loading of the caudal hoof. Digital support can be achieved by use of a heart-bar shoe to unload the hoof wall and in conjunction, the caudal hoof wall can be further unloaded by ‘floating’ the heels (Fig 4). This involves creating gaps between the heels and the shoe. Digital support can also be achieved by the use of frog support pads with an underfill, thereby better connecting the foot with the ground. Heel elevation has gained a poor reputation because it increases loading to the caudal region [3]. However, used in conjunction with digital support as a temporary measure it can be beneficial (Fig 5) [4].

### Treatments

1. The hoof should be trimmed to the proportions shown in Fig 3: the foot shod with an elevated pad with a synthetic frog, under-filled with dental impression material. The shoeing cycle should be no greater than 6 weeks, when the treatment is repeated. At the next shoeing a flat pad with synthetic frog should replace the elevated version and used for two shoeings. Where possible, a return to an open shoe without a pad should be attempted after 6 months.

2. After foot preparation, a heart-bar shoe is fitted with neutral pressure from the frog-plate to the frog and prior to attachment by nailing, the heels are rasped to create a gap. This treatment should only be undertaken during periods of low exercise. Three to six months of treatment are required for best results.

### Conclusion

The treatment of collapsed or underrun heels can be successful over a relatively short period (3–6 months). However, the causes often remain for life and therefore a durable solution involves a permanent farriery plan. This may mean shortening the shoeing cycle and close attention to trimming and shoe fit and at times, permanent use of digital support.

### Materials

- PM pads, Stromsholm Ltd., Wood Court, Chesney Wold, Bleak House, Milton Keynes, MK6 1NE, UK.
- PM Hoof Packing, Stromsholm Ltd., Wood Court, Chesney Wold, Bleak House, Milton Keynes, MK6 1NE, UK.

### References

The distal phalanx is suspended within the hoof capsule by the lamellae on three sides and the deep digital flexor tendon on its palmar side. In horses with laminitis, injury to the lamellae weakens the attachment of the wall to the distal phalanx, and if the injury is severe, then the lamellae are no longer able to suspend the distal phalanx in its normal position and the distal phalanx displaces. However, it is more complicated because the distal phalanx does not always displace in the same manner. Specifically, three different patterns of displacement are recognized: rotation (more specifically, dorsal rotation); distal displacement (sinking); or asymmetrical distal displacement (rotation in the frontal plane). In reality, displacement is frequently a combination of the above, but one pattern generally dominates.

Why distal phalanx displacement occurs in different ways is unknown. As most of the lamellar attachment to the distal phalanx is dorsal to the centre of rotation, damage to the dorsal lamellae would be expected to be the dominant effect. From a biomechanical perspective, there are some assertions that can be made. Because rotation is accompanied by divergence of the distal phalanx from the dorsal hoof wall accompanied by flexion of the distal interphalangeal joint, the flexor moment must exceed the extensor moment about the distal interphalangeal joint. When distal displacement occurs, the phalanges remain in their normal alignment but the dorsal distal phalanx displaces away from the dorsal wall without diverging; therefore, the flexor and extensor moments must be balanced when this occurs. Asymmetrical or unilateral displacement is the result of uneven weightbearing capacity, uneven damage, or uneven loading of either the medial or lateral wall compared to the other. In the forelimb, it is generally the medial side that displaces, but reportedly, lateral asymmetrical displacement is more likely to occur in the hindlimbs. Understanding the different patterns of displacement and why they occur is important in managing failure of the suspensory apparatus of the distal phalanx.

If a horse is displaying clinical signs of laminitis but the distal phalanx has not displaced, it is difficult to determine if and how it is going to do so. Distribution of pain detected with hoof testers or the way the animal stands or moves may suggest which type of displacement may occur.

Overall goals for attempting to prevent/treat displacement of the distal phalanx are to remove inciting cause(s), limit pain, stabilise the distal phalanx, and encourage new hoof to grow as normally as possible. These are frequently attempted by redirects weight-bearing, moving the sole to avoid focal pressure and a rounded ground surface on the ground surface of the foot from damaged areas to less damaged areas, altering the moments about the distal interphalangeal joint, and decreasing the maximal forces associated with impact/loading of the limb during movement. Additionally, limiting expansion of the foot with casts appears to be somewhat protective and improve comfort. The different patterns of displacement require different approaches, except that all derive from enhancing breakover at the toe and quarters.

For horses experiencing rotation of the distal phalanx, decreasing the flexor moment both at rest and during movement is important. At rest, elevating the heels is the most efficient way to accomplish this, but packing the palmar half of the foot to increase the surface area may also accomplish it, though to a lesser extent. Moving the breakover point at the dorsal margin of the shoe shortens the moment arm at breakover, but it is also beneficial to do the same from the toe around the quarters of the shoe. Early in the disease a combination of wedges attached to a cuff with enhanced breakover incorporated may be highly effective. Later, as the feet become more stable, the horse is transitioned to wooden shoes (or any shoe with comparable mechanical benefits), with or without a heel wedge. If necessary, deep digital flexor tenotomy is the most effective way to reduce the flexor moment.

Symmetrical distal displacement is significantly more difficult to limit/treat than rotation because the damage is widely distributed around the periphery of the foot and the distal phalanx is descending on the sole symmetrically. Therefore, there is limited ability to redirect the forces associated with weightbearing on the ground surface of the foot, although standing the horse on sand may improve comfort. Additionally, there is little to be gained by elevating the heels. Early in the course of the disease, placing a combined plywood/EVA combination ‘shoe’ on the foot does improve comfort in some horses. The plywood platform against the foot prevents the EVA from pushing directly on the sole; if the sole has dropped, the surface of the plywood must be recessed to prevent sole pressure. The EVA material diminishes concussion associated with movement. Additionally, casting the combined plywood/ethylene vinyl acetate (EVA) on to the foot may also enhance comfort. If these measures fail to improve comfort or stabilise the distal phalanx within the hoof capsule, then a phalangeal cast that incorporates felt padding under the sole to avoid focal pressure and a rounded ground surface on the cast to enhance breakover in every direction should be considered [1].

Attempting to stabilise the distal phalanx in a horse with asymmetrical distal displacement is best accomplished by moving the centre of pressure away from the affected side (this may initially seem counter-intuitive). There are numerous ways to do this, but the simplest is to use either an EVA/plywood shoe or a wooden shoe depending on the animal’s comfort level and setting it wide on the unaffected side. As before, enhancing breakover is beneficial. Other types of shoes can be used in this way if they are tolerated; the author has used the four-point rail shoe in this manner.

**Materials**

a. EVA Wood Therapeutic Shoe: Equicast, Inc., 575 SE Broad Street, Suite 14, Southern Pines, North Carolina, 28387, USA.

b. NAIRIC Ultimate: NAIRIC, 153 S Main St, 131 S Main St, Lawrenceburg, Kentucky, 40342, USA.

**Reference**

15.45–17.30
Panel: Hans Castelijns, Sébastien Caure, Simon Curtis, Maarten Oosterlinck and Andrew Parks

This session hosts some of the leading lights of farriery, Maarten Oosterlinck, Simon Curtis, Sébastian Caure, Hans Castelijns and Andy Parks. The different approaches to the management of the farriery side of orthopaedic cases will be discussed in a typically lively fashion, stoked or otherwise by the effervescent Professor Renate Weller! In an area where scientific evidence is scarce we aim to allow delegates to benefit from hearing the views of such experienced protagonists.

NOTES
Unusual tendon injuries in sport horses

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Introduction
By far the most common tendon injuries occur in the digital flexor tendons of the forelimbs due to either over-strain injury (because they are the highly loaded weightbearing tendons), or percutaneous trauma (because they are superficial and unprotected by other tissues). Therefore, unusual tendon injuries are those that affect either these tendons at unusual sites, other tendons, or where the nature of the pathology is unusual. Each of these categories will be discussed separately.

Uncommon sites of injury in the digital flexor tendons

Intrasynovial injuries of the superficial digital flexor tendon (SDFT)
The SDFT is most commonly injured extrathecally in the mid-metacarpal region and is most rarely injured where it is compressed at the back of the fetlock. However, secondary sites of injury are seen distally in the pastern region, where the branches are most commonly affected, and proximally within the carpal sheath. The latter is truly an intrathecal injury while the former is only partially intrasynovial as the branches are within the wall of the digital sheath. Oblique ultrasound views are essential to identify these branch injuries and care must be taken to avoid mistaking the normal appearance of the musculotendinous junction as pathology for the proximal lesions. These injuries heal less reliably and more slowly than the more common extrathecral lesions, most likely because of the lack of a paratenon, which provides vasculature and cells for repair, in this location.

Extrasynovial injuries of the deep digital flexor tendon (DDFT)
Injuries to the extrathecal metacarpal/metatarsal region of the DDFT are extremely rare and are usually identified in conjunction with the more common injury of desmopathy of the accessory ligament of the DDFT (ALDDFT). As the fibres of the ALDDFT remain separate from the DDFT fibres for a significant length distally after the two structures join, it is the author’s opinion that most of these DDFT injuries are actually tearing of the ALDDFT fibres within the DDFT. However, this may be secondarily responsible for adjacent damage to fibres of DDFT origin.

Hindlimb superficial digital flexor tendon injuries
The hindlimb SDFT is much more rarely injured than its forelimb counterpart but the location is similar; injury occurs most commonly in the metatarsal region, although lesions can extend proximally over the calcaneus. Management is similar, and while numbers are low, the rate of healing is uncommonly affected tendons

Extensor tendon injuries
The digital extensor tendons of the dorsal aspect of the fore- and hindlimbs are commonly injured by external trauma but do rarely also suffer over-strain injury. The aetiology of these injuries in these relatively low-loaded tendons is not clear. The prognosis is favourable because of the limited need for these tendons for locomotion in the horse.

Bicipital tendon
Injuries to this tendon are rare but results in a characteristic reduced cranial phase of the stride and bicipital bursal distension. The swelling of the tendon and bursa can be difficult to appreciate clinically, but pathology is readily seen ultrasonographically where mid-substance pathology and border tears have been identified. Treatment is usually conservative although one recalcitrant case has been managed successfully by surgical transection of the tendon.

Gastrocnemius tendinopathy
Although this is a common injury in humans, injury to this tendon in horses is rare. If present, it usually results in calcaneal bursal distension. Only a very limited case series has been published (3) which suggested a poor prognosis but positive outcomes have been seen (Dyson and Smith, unpublished observations).

Popliteal tendon
The popliteal tendon is readily identified ultrasonographically interposed between the lateral meniscus and the lateral collateral ligament of the stifle. There are no published reports of injury to this tendon but this author has seen two cases of convincing pathology, one which appeared to be an over-strain injury involving the mid-substance of the tendon and a second associated with a septic process at its origin on the distal lateral femoral epicondylar fossa.

Tendon of origin of ulnaris lateralis
Avulsion of the tendon of origin of the ulnaris lateralis muscle has been identified in a horse with lateral antebrachial swelling after a fall. The main differential is avulsion of the lateral collateral ligament of the elbow, as these structures lie immediately adjacent to one another.
Uncommon types of pathology in the digital flexor tendons

Degenerative rupture of the superficial digital flexor tendon

While still relatively rare, this injury is not uncommon in older horses not undertaking strenuous exercise [4]. The pathology is often dramatic and can affect the mid-metacarpal or proximal regions of the tendons. In spite of the severity of the tendon pathology, many of these horses can do well with conservative treatment alone.

Tendon mineralisation

Dystrophic mineralisation is the end result of ‘failed’ healing in tendons but most commonly affects the DDFT and suspensory ligament branches. It can occur rarely in other tendons, such as the SDFT, bicipital tendon, as well as in distal sesamoidean, palmar/plantar annular [5], and collateral ligaments [6]. However, mineralisation, while abnormal, is not always a cause of lameness.

References

It is generally considered better to prevent injuries rather than to treat them once they occur. In order to do this, we must understand the aetiology of the disease and associated risk factors. Tendinopathy is one of those conditions where there is still some debate about the exact aetiology; however, several of the current theoretical models have many similarities. The most accepted human model is the ‘continuum model’ [1], although others exist [2,3]. The common feature of these models is that loading is excessive compared with that which allows the maintenance of tissue homeostasis [4]. This effectively leads to an active process of degenerative change involving pathways associated with inflammation [5,6]. This ‘cell-mediated reaction’ is a biochemical cascade that leads to alterations in various chemicals such as substance P, glutamate, cytokines and numerous protein molecules including glycosaminoglycans (GAGs) and proteoglycans. Several of these chemicals have been associated with pain in tendinopathy and, most recently, GAG content was found to correspond to pain and function in patellar tendons [7]. Ultimately, the tendon’s structure and material properties change and the tendon becomes less resilient; during normal biological loads the tendon can then catastrophically fail. The main process of tendinopathy can be considered an imbalance in the rate of wear and repair [8,9] with training loads identified as the key component in the ‘wear’. In elite sports training and competition, loads are routinely monitored using GPS data and various other variables, some extrinsic and some intrinsic. Recent work by Tim Gabbett has identified a particularly important aspect of load monitoring and this has altered the face of elite sport; it is called the acute:chronic workload ratio [10]. The acute workload is the current week’s average load as measured by a variable of interest, while the chronic workload is measured by determining the weekly average based on the previous 4 weeks’ load. A 1:1 ratio would reflect no change in training, while a ratio of 1.5 would reflect a 50% increase in training mileage. Large increases in training are known to influence injury risk for both overload disorders and acute injuries (sprains and strains), but so are reductions in training load followed by a subsequent return to normal activities; this is particularly true of tendinopathy. Several of the tools used in human performance monitoring may be transferable to the equine athlete.

Seth’s work on Achilles tendinopathy has highlighted the important role of the muscles in controlling tendon loads, in particular, the soleus muscle in humans [11,12]. Other work has identified that changes in neuromuscular performance are likely to explain improvements in patients’ symptoms with typical conservative treatments like eccentric exercise [13]. It is likely that these findings apply to equine tendinopathy; but the previous focus of both research and clinical care has been on the tendon. It may be time to reconsider the muscle and the role of strength and conditioning in equine athletes [14]. This approach has successfully been piloted in equine athletes and shows some promise. In both human and equine sporting athletes, there are some training and recovery methods that may be triggering a higher incidence of tendinopathy or preventing successful intervention, in particular, cryotherapy. Seth will discuss the evidence for this and highlight management strategies that may need to be stopped and new ones that may need to be started.

References
LASER (light amplification by stimulated emission of radiation) produces coherent electromagnetic radiation that differs from ordinary light in its unique properties of monochromacity, coherence and collimation. This results in the ability to deliver a large amount of energy to a small region over a short period of time [1].

Low level laser therapy (<500 mW; LLLT) is a popular modality in the management of pain, wound healing and soft tissue injury in people and animals [2]. Both in vitro and in vivo studies report biological effects of LLLT, such as increased fibroblast proliferation and collagen production [3], improvement of collagen fibre alignment [4], increase in tendon tensile strength [5], and decreased levels of proinflammatory mediators [6].

The depth of penetration of LLLT is deemed to be insufficient to treat deeper structures in horses [7] and various pathologies in human medicine such as tendinopathies [8], whiplash injuries [9], and other syndromes of back and neck pain [10] are treated with high-power laser (>500 mW; HPLT). In an in vitro study evaluating the effect of a Nd:YAG laser on equine mesenchymal stem cells (MSC), HPLT was shown to increase the expression of IL-10 and vascular endothelial growth factor (VEGF) [11]. It was concluded that the photobiomodulation of MSC could enhance their therapeutic properties.

Protocols and results obtained with one particular laser device, be it LLLT or HPLT, cannot be transferred to another one with different technical specifications.

Based on personal communication with human sports medicine physicians, we started using HPLT on soft tissue injuries in horses in 2013. The laser device we use is a 15 W diode laser that emits light of four different wavelengths simultaneously (635 nm, 660 nm, 810 nm, 980 nm) (FP4 SYSTEM, Therapy Laser X, Lugano, Switzerland). It is equipped with sensors that register local temperature and micro-impedance at the irradiated area and is controlled by a feedback loop regulated by an internal encrypted algorithm. This algorithm is based on a mathematical model which produces approximations of the diffusion of laser light through different biological tissues which accounts for the sensor output [9].

A first group of 150 sport horses (the majority used for high level dressage and showjumping) with superficial digital flexor tendonitis or suspensory desmitis (proximal suspensory or suspensory branches) was evaluated. The median times for return to low-level exercise and to previous performance level was 6 weeks and 6 months, respectively and it appeared that rehabilitation programmes could be built up more rapidly than after other treatments for comparable injuries. Re-injury rates were 17%, 20% and 18% at 6, 12 and 24 months and there were no complications observed [12].

Encouraged by these results we have treated more than 1000 horses with orthopaedic soft tissue lesions since 2014 with this particular device.

A placebo-controlled experimental study on 12 horses with surgically created suspensory branch lesions was performed in co-operation with Ghent University, to evaluate the same HPLT device. Clinical and ultrasonographic evaluations were performed on a regular basis throughout the study period. Magnetic resonance imaging, histopathology and biochemistry evaluations were performed post-mortem after 4 weeks for short-term and after 6 months for long-term results. The study is complete and the results are currently being analysed. It appears that the use of HPLT shows promising results.

In conclusion, HPLT with this particular device appears to be a safe and efficient treatment modality for orthopaedic soft tissue lesions in horses. However, there is more research needed to establish tailor-made treatment protocols for specific lesions.

References
Suspensory ligament branch (SLB) injuries are common in sports horses and racehorses. In a weightbearing position, the dorsal and palmar margins of the SLBs should be parallel and equidistant from proximal to distal. Loss of parallel margins reflects injury. However, palpation can give false negative results [1-3]. There was a significant difference in the ability to detect palpable enlargement of an SLB compared with enlargement detected ultrasonographically [2]. Axial swelling cannot be detected. The SLBs are subsynovial with respect to the palmar/plantar pouches of the metacarpal/metatarsal bone. There are also related ligamentous attachments to the distal aspect of the second and fourth metacarpal bones and the palmar/plantar aspect of the third metacarpal/metatarsal bone at the junction of the proximal two-thirds and distal one-third, so osseous changes may occur in association with SLB injuries.

With acute injuries there may pain on palpation of the injured branch with the limb nonweightbearing, but false negative results also occur. There may be pain on passive manipulation of the fetlock. With more chronic injuries there is often no response to palpation despite moderate lameness, which in some horses is only apparent ridden. Distal limb flexion may result in marked exacerbation of lameness, disproportionate to the severity of injury in some horses, whereas in other horses there is no response. Assessment of distal limb conformation is important. Foot imbalance may be a predisposing factor for injury. The degree of extension of the fetlock joint may reflect the integrity of the SLBs.

Ultrasonographic surveys in small populations of flat-racing Thoroughbreds [1,4] and National Hunt racehorses [3] revealed a frequency of occurrence of grade 2 ultrasonographic abnormalities (on a scale of 0-3) in approximately 30% of symptomless horses. The coexistence of SLB lesions and radiological evidence of sesamoiditis in approximately 30% of symptomless horses. The coexistence of SLB lesions and radiological evidence of sesamoiditis in approximately 30% of symptomless horses. The coexistence of SLB lesions and radiological evidence of sesamoiditis in approximately 30% of symptomless horses. The coexistence of SLB lesions and radiological evidence of sesamoiditis in approximately 30% of symptomless horses.

There is a poor correlation between a clinically significant SLB injury and the presence or absence of lameness and its severity. With a primary SLB injury, lameness is sometimes improved or abolished by palmar nerve blocks performed at the base of the proximal sesamoid bones (PSBs) [2,5]. Intrarticular analgesia of the metacarpal/metatarsophalangeal joints can also alleviate pain associated with a SLB injury. However, in association with extensive periligamentous fibrosis, especially that which extends between the medial and lateral SLBs, lameness may only partially improve after perineural analgesia of the palmar/plantar and palmar metacarpal/plantar metatarsal(“low four-point block”) nerves. Horses with proximal suspensory desmopathy and large concurrent SLB injuries determined ultrasonographically may show no detectable response to a ‘low four-point block’.

Ultrasonographic examination should include the entire suspensory apparatus with comparison with the contralateral limb, comparing the cross-sectional areas of the medial vs. medial and lateral vs. lateral SLBs. The medial and lateral SLBs may differ in size [3]. Some lesions may be more obvious in an unloaded limb compared with a loaded limb. Comparison of on-incidence and off-incidence images may help to distinguish fibrosis. Colour Doppler may show neovascularisation. Dystrophic mineralisation, entheseseal new bone or fracture may be present. Post-mortem examination of horses has indicated that ultrasonography often underestimates the extent of periligamentous fibrosis on the axial aspect of the SLBs, the presence of adhesions to the metacarpal bones and adhesions in the proximal palmar (plantar) recess of the metacarpal/metatarsophalangeal joint (unpublished data). With stretching of the SLBs there is a generalised mild diffuse decrease in echogenicity.

There have been no controlled comparisons of ultrasonography vs. magnetic resonance imaging (MRI) for lesion identification. SLB injuries have been identified using MRI that had not been suspected based on prior clinical assessment [5-7]. MRI may reflect inadequate examination, rather than an inherent limitation of ultrasonography.

Radiographic assessment of the fetlock joint and the distal aspect of the second and fourth metacarpal bones may be indicated to identify concurrent osseous pathology. However, there are no long-term studies in sports horses which have related the presence of sesamoiditis in association with SLB injury and longer-term prognosis. There is a dearth of evidence-based information about the response to treatment of SLB injuries in sports horses [2,8]. In a study of Thoroughbred racehorses, the ability of horses with SLB injuries (cases) to start a race was compared with their cohorts [9]. Mild cases perform similarly to controls by their 3-year-old season, but more severe cases had reduced success as a 3-year-old, with an increased likelihood of re-injury. Ultrasound-guided autologous bone marrow transfer was assessed in 13 Standardbred and 17 Thoroughbred racehorses [10].

References
The equine oral examination

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Summary

The equine oral examination is an important first step in any dental appointment, from a routine maintenance visit to an advanced consultation. Performing the examination in a repeatable, methodical and clinical way will ensure nothing is missed. The goals of an oral examination are:

- To identify dental and oral pathology
- To observe occlusion and functional anatomy
- To enable selection of further diagnostic procedures if required
- To formulate a treatment plan

Summary of procedure for equine oral examination:

- Record signalment, history, previous dental care
- General physical and brief clinical examination; cardiac auscultation
- Observe mastication if considered necessary; e.g. referral case, dysmastication reported
- External head examination, including smell from nostrils
- Incisor examination including assessment of lateral mandibular excursion
- Buccal retraction and ‘line of sight’ to assess cheek tooth occlusion
- Administer sedation
- Soft tissue manual palpation of interdental space, lips, bars of mouth
- Place speculum, rinse mouth (3–4 large volume syringe flushes, collect mouthwash in bucket)
- Intraoral visual inspection and manual palpation; consider:
  - Soft tissues
  - Dentition – number of teeth, overgrowths and malocclusions, fractures, endodontic status, periodontic status, infundibular assessment
- Oroscopic examination
- Record findings – video, dental chart

Overview

Oral and dental diseases are common in horses, as evidenced by results of various incidence studies [1–4]. Signs of dental disease are often not apparent to the owner until the disease is well advanced. Horses are expert at concealing signs of dental pain and can adjust mastication patterns to avoid the poor contrast provided by working outside in bright sunlight. Sedation should be considered mandatory for a complete oral and dental clinical examination. An α₁ agonist and opioid combination is very suitable for oral examinations and procedures. Before sedation is administered, it can be useful to observe the horse eating a variety of foodstuffs including biting a carrot to assess the incisors; e.g. many horses with equine odontoclastic tooth resorption and hypercementosis (EOTRH) will be unable to bite hard on a carrot. The equine oral examination should start by recording the clinical history and signalment on a dental chart. This is followed by an external examination of the head, noting symmetry, soft tissue swelling, bony masses or depressions that could suggest previous sinus surgery. Manual palpation of the interdental space and the bars of the mouth may also be performed at this stage.

Examination of the incisor teeth is commonly overlooked but should always be performed before placing the speculum for intraoral examination. In addition to assessing the presence or absence of teeth, approximate age of the horse and any pathology, the lateral excursion to molar contact test (LMC) may be used to assess for masticatory symmetry and suspected oral or dental pain.

Direct intraoral examination using a bright head torch, speculum, mouthwash and manual retraction of the tongue will yield useful information regarding pathology in many cases; e.g. food material may be seen protruding from interproximal spaces, suggesting a diastema. However, because of the limited opening of the equine mouth and the rostral arrangement of the lip commissures, much of the oral cavity, especially the buccal and lingual aspects of the dental arcades, are not visible directly from a rostral position. The only way to visually inspect the otherwise inaccessible areas of the mouth is by using a dental mirror or a dental endoscope. All areas of the mouth and teeth should be visualised, noting any initial observations such as increased food staining on one side or other, digitally palpated, noting any smell from any area; this is followed by a systematic examination using a dental mirror noting soft tissue and then dental pathology including a general, periodontal, endodontic and infundibular assessment of every tooth and interproximal space.

Dental endoscopes can provide very detailed and highly magnified images of the oral cavity and are especially useful for small defects in the occlusal surfaces. Any aspect of the mouth or teeth can be imaged using an endoscope, with the magnified image enabling more sensitive detection of dental pathology such as dentinal fissures, pulp defects, periodontal disease, caries lesions and any soft tissue lesions. Most endoscopes using a chip to grab the image will display the image on a screen, which is a great advantage when explaining and demonstrating pathology to clients.

Dental charting

Recording of findings from the oral examination is important for good clinical practice and to keep a record for owners and help them understand the pathology presented [5]. For this reason, the author prefers dental charts with the outline...
of a head and teeth that are easily recognisable. Whatever style of chart is chosen, it is imperative that there are anatomically accurate and detailed occlusal surface images for recording occlusal pathology using a common pulp numbering system [6].

References

Management of common dental overgrowths

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Development of overgrowths

Horses’ teeth are prone to developing sharp enamel points and overgrowths, as a result of the hypsodont nature of the teeth and the anatomy of the occlusal contact. Continued occlusal wear and simultaneous eruption of the teeth, and a symmetrical masticatory action result in a fine balance to maintain normal even wear. Any disruption in this normal occlusal anatomy or masticatory action will result in uneven wear and the development of focal overgrowths of the occlusal surface. Dental pathologies such as displaced teeth, missing teeth or fractured teeth will result in the opposing teeth not being worn occlusally and becoming overgrown. Anatomical variations such as mandibular or maxillary prognathism might result in the opposing cheek teeth rows being rostrocaudally misaligned. Asymmetrical mastication with horses avoiding lateral excursions to one side, such as temporomandibular joint (TMJ) arthritis or a painful dental lesion limited to one side (e.g. diastema, fractured tooth), will likely lead to the development of an increased occlusal angle (shear mouth) on the side that the horses is not chewing.

Even in cases where horses have no dental disease or good symmetrical mastication, they will develop sharp enamel points on the buccal aspect of the maxillary cheek teeth and lingual aspect of the mandibular cheek teeth. This is due to the anatomical anisognathia with the maxillary arcade being slightly wider than the mandibular arcade. Early detection of any wear abnormalities and causative dental disease will prevent the overgrowths from becoming excessive and altering normal mastication. Once dental overgrowths have developed, they will impede normal mastication and further promote reduced chewing on the occlusal surface, becoming a self-perpetuating cycle. It is for this reason that routine oral and dental examination in all horses is recommended.

Treatment of overgrowths

It is very important to identify the aetiology of the dental overgrowths, as treatment of the inciting cause where possible will help to restore normal balanced mastication and prevent redevelopment of the overgrowths. Examples of treatable primary causes include resolving periodontal disease associated with painful diastema or medicating arthritic TMJ. In other cases, the primary cause may not be identifiable, but reduction of the focal overgrowths will aid more symmetrical chewing and long-term resolution of the overgrowths. Examples of this are slight bilateral overgrowths of the mandibular 08s often seen in young horses (5–8 years of age) and this is believed to be due to nonsynchronised eruption of mandibular and maxillary cheek teeth, with the permanent mandibular 08s erupting a few weeks prior to the maxillary 08s. In some young horses, uneven crowns can be seen in many cheek teeth and if no other dental pathology is identified, these are also believed to be due to asynchronous cheek teeth eruption. These cases only require one to two dental treatments/ reductions to resolve the overgrowths.

In cases of type 2 malocclusion, i.e. maxillary prognathism/ mandibular brachygnaethism (parrot mouth), there may be a similar disparity in cheek teeth row occlusion with the maxillary 06 cheek teeth partially, or in extreme cases completely, rostral to the mandibular 06s. This results in focal overgrowths on the mesial part of the crown or the whole crown, that is not in wear with the mandibular 06s. At the same time the mandibular 11s will not be in wear with the maxillary 11s and will develop focal overgrowths distally. The opposite will be true in cases of maxillary brachygnaethism/mandibular prognathism (sow mouth; type 3 malocclusion) [1].

Extensive studies have shown that there is great variation in the depth of the secondary dentine overlying the pulp horns on the occlusal surface of the teeth [2]. This may vary from as little as 2 mm to as much as 33 mm. It is for this reason that careful reduction of all focal overgrowths is essential to ensure that the sensitive dentinal tubules or, even more importantly, the pulp horns are not exposed. This may result in painful pulpitis and ultimately infection and death of a tooth. A guideline of 3–4 mm of focal overgrowth reduction with a 2–3-month interval before further reduction is recommended. The 2–3-month interval will allow the pulp to lay down more secondary dentine occlusally, thus minimising the risk of causing pulp exposure.

As motorised dentistry has become more popular and widely used, there has been concern over the potential for heat damage to the teeth [3]. The use of cooled motorised instruments will help to prevent this but is not essential if motorised instruments are used carefully. It is important not to keep constant contact with a focal overgrowth for more than 10 seconds prior to some water-cooling and a period of ‘rest’. It is also important to clean the rotating discs of any tooth dust at these intervals to ensure that they remain ‘sharp’ and minimise their heat production. When rasping the enamel points, constant steady movement along the row of teeth will also help to prevent heat damage.

It is very important to have good visibility of all the teeth while using motorised instruments, as this will allow careful rasping of only the overgrowths and sharp enamel points that require it. This will also prevent damage to surrounding soft tissue structures. In most cases this is only achievable in sedated horse.

References
When considering the purchase of dental kit, one must consider the cost–benefit ratio in a similar way to when buying other pieces of equipment. Luckily for those just getting into equine dentistry the essential kit tends to cost less, whereas the more advanced kit tends to become more expensive. Luckily some pieces of diagnostic kit, such as radiography, are already likely to be present in most equine practices.

**Initial examination equipment (everyday dental bucket)**

The essential list of oral examination equipment includes a speculum, light source, mirror, pulpar explorer, periodontal probe, diastema forceps and cap forceps. These are essential bits of kit so they are heavily used and it pays to invest in quality rather than look at price. The speculum is the best example and the most common types are a Hausmann or a Millennium speculum. When considering a light source, there are dedicated speculum lights which are excellent, but a bright headtorch with the light lowered to between the eyes suffices well and can be used for other purposes too. Diastema forceps can be used to remove food from between the teeth but this should be followed up with lavage of periodontal pockets. Right-angled water picks are available, both in a sprayer format or with a battery-powered pump. The sprayer type are inexpensive and reliable and good for those seeing these cases on an infrequent basis, whereas the costs of a battery-operated flusher can only be justified for those seeing a significant dental caseload.

**Oral endoscopy**

As oral endoscopy is becoming recognised as the gold standard method of detailed occlusal examination, more systems are becoming available at reduced cost. When looking at a system, one should consider the situation that it is being used in, i.e. field vs. clinic, and the expertise available to interpret and treat the abnormalities detected. Recording of the images makes interpretation easier. There are inexpensive options available in both wired and wireless forms, but the author’s opinion is to buy the best possible system that you can afford, particularly when it comes to the optics. Oral endoscopy should be considered essential for those clinics seeing a significant dental caseload.

**Motorised dental equipment**

The quality of motorised dental equipment has never been better, with battery-powered units now the most commonplace. For any practices doing more than occasional dentistry these pieces of equipment are good investments. The majority are now waist-mounted with a drive cable to which you can attach a rotating disc or apple core attachment, though some remain handheld and trigger-operated. Water cooling is likely to become an industry standard in the future, but there are few systems with functioning water cooling at present. Most companies will now allow you to ‘try before you buy’ and the author would encourage this. When doing significant motorised work, a headstand soon becomes an essential piece of equipment.

**Extraction equipment**

It is well known in the dental world that the ideal number of extraction forceps is n+1 so everyone’s collection keeps growing. A complete extraction kit will include gingival elevators, a range of molar spreaders, a range of extraction forceps (both serrated jaw and claw type and fragment forceps), fulcrums and a pick set of interchangeable heads. For those doing a significant number of extractions these are a good investment, but for the equine practice removing only geriatric teeth it is excessive. For this type of caseload, gingival elevators, a basic dental pick set, fulcrums, general purpose molar forceps (suitable for maxillary and mandibular teeth) and four-pronged extractors will probably suffice.

**Advanced extraction equipment**

Equipment for minimally invasive transbuccal extraction (MTE) and minimally invasive pin repulsion (MIPR) is available but should only be considered by those with further training in these techniques.
Dental radiography: when and how?
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When?
Dental radiography is indicated whenever a condition involving the unerupted portion of the tooth is suspected.
• Fractures extending beyond the gingival margin
• Severe periodontal disease
• Sinusitis
• Infundibular caries
• Incisor issues – require specific intraoral views
• Diastemata – open-mouthed oblique views

How?
A series of radiographs of the cheek teeth should include a lateral view, a dorsoventral view and lesion-orientated oblique views. The affected side should be closest to the plate. A lateral view of the sinuses should also be obtained.

Preparation
The horse should be well sedated, stood squarely with its head on a support and a rope head collar in place. The assistant holding the horse should wear lead gloves, or ensure that they are holding the horse well away from the primary beam, in order to minimise exposure of the extremities to scatter. A generator stand should be used as this will help eliminate movement of the generator, which is a common problem when the generator is hand-held. This also minimises x-ray exposure to the operator.

Acquisition

Laterolateral view
These should be acquired with the side of interest closest to the plate. For the incisors, the beam should be centred on the rostral maxillary cheek tooth, and the collimation extended to include the end of the nose. For the maxillary cheek teeth, the beam should be centred at the level of the facial crest over the 09 tooth. To obtain a lateral view of the sinuses, the beam should be centred further dorsally and the exposure lowered.

Latero30° dorso-lateroventral oblique
This view is to assess the roots of the mandibular cheek teeth closest to the plate. To acquire this view, set up as for a laterolateral view. Angle the x-ray machine 30 degrees dorsally, while centring on the same point. The plate should remain vertical and adjacent to the horse’s head. The exposure is similar to that for the laterolateral view of the cheek teeth. I would advise that this view be obtained on both sides of the horse, in order to compare the affected and unaffected arcades.

Dorsoventral
This view can be tricky to obtain; a well sedated horse, a head support and a generator stand will make this easier. The horse’s head needs to be extended out to allow the plate to fit underneath. The generator should be angled such that the front of the light beam diaphragm is parallel with the frontal bone. For the maxillary teeth, centre on the midline of the head, at the level of the 09 cheek teeth. For the incisors, centring at the level of the bars of the mouth is adequate. Ensure that the collimation extends to the lateral aspects of the head, as it can be useful to compare the opacity of the maxillary sinuses if sinusitis is suspected.

Intraoral views (incisors)
These views allow assessment of the roots of the incisors without superimposition of the opposing arcade. The corner of the imaging plate is placed in the mouth and advanced as far as possible. To obtain an image of the upper arcade, the generator is positioned as for a dorsoventral view of the incisors. To obtain an image of the mandibular incisors, the generator is positioned ventrally and the beam angled ventral to dorsal.

Conclusions
Dental radiographs are easily obtainable with portable radiography equipment and little additional kit. Good diagnostic radiographs are easy to obtain in the field and the procedure is usually well tolerated by the horse.

Further reading
Promoting dentistry in your practice

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Dentistry has been a growth segment in equine veterinary practice, especially in the last 10 years. There are many advantages to both the health of your patients and your practice from improving the veterinary dental services offered to clients. Dentistry does not come with an increase in emergency calls and after-hours work and allows a great deal of flexibility in scheduling appointments. The service can be offered to an already existing client patient base with very little advertising or promotion. Basic dental examinations and floating should be offered as part of an annual wellness program. Some specialised equipment and staff training is required to provide modern comprehensive dental care but there is a good rate of return if dental services are provided.

Practitioners should take opportunities during normal work to promote dentistry and incorporate a dental examination into wellness check-ups, prepurchase examinations, insurance examinations, lameness work-ups, poor performance evaluations, and any medical or colic work-up. Dental disease is often missed due to failure to look in the mouth.

When providing dental care, it is important to allow enough time to properly examine the mouth and then perform other diagnostics and/or corrective procedures. This is not possible if you have an overbooked schedule for vaccinations and other routine work. Don't crowd dental work into an already busy schedule. Dental work needs to be charged at a rate that is competitive but compensates the veterinarian for time, training and effort.

If you have a passion for dentistry, encourage other veterinarians in your practice area to properly perform oral examinations and refer cases they are not equipped to handle. This will allow professional care for the horse and keep the client happy. It also adds good colleague communication when referrals are made. These cases must be handled in a professional manner and horses returned to referring veterinarians with a discharge report of findings and/or treatment for their records and follow-up.

A written or digital dental record is necessary to document findings from the examination and to record treatments. This record should have any follow-up information and a date for the horse's recheck. Good record keeping promotes your practice and dental services, as they often stay with the horse in its permanent medical records even if the horse changes owners.

If you are interested in developing and promoting the dental segment of your practice, the number one factor is to provide good service in a professional manner. This accomplished, your good services will be promoted by word of mouth among satisfied clients and trainers. It is also helpful to let clients know that you provide dental services, through client newsletters, speaking to local horse groups and riding clubs, and performing an oral examination as part of your regular physical examination protocol. Remember, a complete dental examination requires a full mouth speculum and a sedated patient. Based on findings, you can advise of a possible problem or the need for a more detailed examination. However, you can never state that the horse's mouth is healthy and in no need of care without a thorough examination. It is also beneficial, when possible, to allow the owner or trainer to look in the mouth and see the teeth and any dental problems that are visible. A digital camera or oral endoscope is helpful for allowing a client to better appreciate intraoral findings. Owners are often not present during the examination process and digital photographs shared via email help them understand what took place and any findings. Many times, the conditions detected on initial examination require more time to properly diagnose and plan treatment than is available during the scheduled visit. It is essential not to disregard a problem because you don't have time, equipment or expertise to diagnose. A more complete detailed examination in a clinical setting with advanced diagnostics is often required to diagnose a dental abnormality. These cases should be rescheduled or referred for further work-up.

Equine dentistry today is not the same as that provided even 10 years ago. The equine veterinary profession has made so many advances in the understanding and diagnosis of dentition, both in health and disease. Dentistry is an important segment of equine health care with many welfare considerations for the horse. Diseased teeth can also have a major emotional and economic impact on an owner as many of these problems are not diagnosed early and chronic disease has many secondary adverse effects on the horse's health and wellbeing.

Further reading
When presented with the dysmasticating (quidding) horse, one should not immediately focus on the head of the horse but, as with all problems, look at the horse as whole and proceed logically through the investigation.

**History**
A full clinical history should be obtained from the owner including the recent and historical dental care of the horse (if known). The current diet, including supplements, that the horse is receiving should be ascertained. Questions regarding the quidding should include the type of food that is being quidded, the duration of the problem, whether it is constant or intermittent, whether the horse holds its head to either side and whether it seems to eat from both sides; also establish if it has halitosis and whether it is maintaining its weight.

**Clinical examination**
The initial portion of this should be performed without the aid of sedation as watching the horse eat will be beneficial, as will observing pain responses to manipulation or palpation. One should examine the symmetry of the masseter and temporalis muscles, along with pain on manipulation and palpation of the temporomandibular joints. The author will also place pressure on the basihyoid bone in the intermandibular space to assess for temporohyoid pain, as well as palpating the submandibular lymph nodes. The cheeks should be palpated for areas of sensitivity and food pocketing. In cases that have begun quidding suddenly, the mandibles should be carefully palpated for swelling that may indicate a fracture. Sensitivity of the incisors can be assessed by feeding a carrot to the horse.

**Oral examination**
This should begin at the incisors and be performed under sedation. The type of bite should be evaluated with the lateral excursion to molar contact. Each incisor should be palpated for mobility.

The cheek teeth should be visually examined and palpated. The visual examination should be done with a mirror as a minimum standard, but preferably using an oral endoscope. Each tooth should be fully evaluated. The most common dental causes of quidding are sharp enamel points, dental fracture causing soft tissue damage, diastema and periodontal disease or mobile teeth.

The intraoral soft tissues such as the cheeks, palate and tongue should be fully examined for areas of ulceration, trauma or neoplasia.

If there is nothing on oral examination explaining the quidding then investigations should concentrate on the potential extraoral causes of quidding such as temporomandibular disease or temporohyoid disease.
Periodontal disease was recognised by the early veterinary authors and was described as the ‘scourge of the working horse’ [1]. Despite this, much remains unknown about the aetiopathogenesis of the disease, and management of the syndrome continues to frustrate. Some light has been shed by recent studies into the histopathology and microbiology of the disease but evidence-based data about efficacy of treatments remain scarce. It is known that the prevalence of periodontal diseases increases with age in horses and donkeys, reaching almost 90% in late-teenaged horses and those of 20 years of age or more [2]. Risk factors are multifactorial and include dental conformation, food type,ivery management systems and the presence of other dental diseases. Other data such as breed and geographical location have not been shown to be risk factors. Primary periodontal disease was described as rare by Colyer, but in the vast majority of equine cases periodontal disease is associated with the degradation of food material entrapped between the teeth. This is usually coincident with the presence of diastemata, which vary in morphology, and progress with age and masticatory wear patterns. Diastemata referred to as ‘valve-type’, where there is occlusal contact but a diastema at the gingival reflection, appear to be most vulnerable to food entrapment and are associated with an acute periodontitis. This type of diastema appears to be particularly painful in young horses. When interproximal food entrapment occurs, putrefaction is accompanied by release of inflammatory mediators that stimulate a periodontitis featuring neutrophilic inflammation, at variable depth depending on the severity of the inflammation [3]. A number of bacteria, including spirochaetes, have been isolated from periodontal pockets in afflicted horses, but their role is unclear [4]. Neutrophilic inflammation deep into the gingiva has been shown histologically and in chronic deep cases, destruction of Sharpey’s fibres and periodontal collagen degradation feature [5]. Chronic cases also show peripheral dental caries, alveolar bone sclerosis and a biofilm. The role of the biofilm, in conjunction with chronic contact with sequestered food substrates and salivary alterations, remains unclear, in contrast to its importance in pathophysiology of the disease in humans. Clinically, periodontal disease is associated with gingival hyperaemta, inflammation and increased depth of the gingival sulcus as a consequence of periodontal collagen lysis. In the face of the inflammation, gingival immune defence appears to be compromised, and affected animals experience pain especially when masticating, which results in alterations in chewing behaviour that over time causes altered occlusal wear patterns. The disease is progressive and ultimately can lead to permanent changes in the occlusal alignment, misalignments, alveolar bone sclerosis, reduction in masticatory stability, tissue ulceration and weight loss. Diagnostic imaging, including open mouth radiographs and computed tomography, is very helpful to demonstrate chronic or irreversible changes that can inform treatment plans. Currently there are few studies demonstrating efficacy of many current treatments. A series involving treatment using odontoplasty amongst other therapies demonstrated marked improvement in clinical benefit in a retrospective case series [6]. Most treatment protocols aim to reduce pain, reverse periodontal inflammation, restore occlusal conformation and improve masticatory efficiency. Ongoing management is almost invariably necessary. The principal goal is to remove entrapped food (without which all other components of therapy fail to make impact). This facilitates debridement of the gingival ulcer, removal of inflammatory mediators and the possibility of gingival healing. In some cases, widening of the diastemata (interproximal odontoplasty) using a narrow 2-4 mm conical or cylindrical rotating burr has shown efficacy. This can also be performed under visual guidance using a dental unit. Diastema widening is less effective in aged horses with open-type diastemata. Food, biofilm and bacteria are also debrided using manual clearance with picks and forceps, water lavage under pressure and air abrasion. The periodontal lesion can be treated with topical antimicrobials, gelatin sponges, and temporarily protected with PVS material extruded into the diastema as a stent or more permanent bridging material bonded to one interproximal surface after debridement. Anecdotally, combinations of these treatments show promise but systematic validation is lacking [7]. There is a study with multifactorial treatments that showed no significant treatment between the various protocols although there was some selection bias. One study showed some cytotoxicity of depot PVS in vitro although this may not be as important in a clinical setting. Horses can resent treatment due to the pain, and optimal results are achieved with the horse sedated and judicious use of local anaesthesia; post-treatment, the use of anti-inflammatory therapy is indicated. Odontoplasty is invasive, requires precision and can result in iatrogenic pulp exposure if performed inaccurately, and therefore a clinic situation incorporating oroscopic control enables more precise treatment. However, treatment to a limited degree involving periodontal pocket evacuation and lavage is widely possible in an ambulatory set-up. The appropriate treatment of associated periodontal caries remains debatable. Debridement of diseased peripheral cementum to reduce food adhesion, and possible superficial restoration of deep carious lesions, appears logical. Dietary management, including avoiding low pH diets, compiling diets devoid of coarse fibre forage and maximum grazing time is a component of the overall strategy. The benefit of systemic antimicrobials or periocuticals is unclear although these may accelerate the subsidence of inflammation in severe cases. Treatment frequency depends on severity but intensive weekly therapy results in the rapid reduction in inflammation, although this is impractical in many cases and 3 or 4-monthly examinations are often utilised. Following effective treatment, improvement in appetite, chewing action and bodyweight are also observed and periodontal inflammation can be seen to recede with reduced periodontal pocket depth and eventual obliteration.

References

HALL 5
SATURDAY 15 SEPTEMBER
14.10-14.30

Bitting problem or behaviour?

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Introduction
A horse that is ridden with a bit and is performing below the expected standard, or is showing signs of oral or head discomfort, should warrant an investigation into the potential role of the bit and its contribution to the problem. However, many horses are presented for poor performance when ridden and these cases can be a particular challenge to owners, trainers and veterinarians. As well as those that are clearly displaying head aversion, head-shaking, and other signs that may suggest a potential bitting problem, many are presented with unusual gaits and abnormalities of head carriage when ridden ‘on the bit’ and these have been shown to be multifactorial [1]. Other factors could also be involved, such as dynamic laryngeal abnormalities only present during exercise, which could potentially be mis-diagnosed as a bitting problem.

Horses and bits
Horses are thought to have first been domesticated around five to six thousand years ago by nomadic tribes living on the Steppes of Eurasia [2]. Bit use was first recorded around 1360 BC and since then the design of bridle and bits has changed due to fashion, materials available and partly from research. Modern competitive ridden disciplines invariably demand the use of the bit (e.g. British Dressage 2018), with the bridle and bit being accepted as a method of reliable physical contact between horse and rider, and well-trained communication with this contact being linked to success in dressage [3].

Does the bit cause performance problems?
There is little research documenting the bit directly causing performance problems. Studies have demonstrated the position of the bit in the mouth both ridden and unreidden [4,5], identified problems with poorly fitting bits [6] and it has been shown that there is an increased prevalence of mandibular exostosis (‘bone spurs’) and abrasive wears of the 06 teeth [7] and soft tissue ulceration [8] in horses ridden with bridles and bits. Racehorses appear to have a high level of lip and bar injuries [9]. There has been a suggestion that head-shaking from trigeminal neuralgia and other conditions such as dynamic airway disorders are directly attributable to bits [10]. One study comparing behaviour in bitted vs. bitless bridles found that abnormal behaviour was mostly present with the bitless bridle [11] but another showed that with continued training, bitless bridles resulted in lower abnormal behaviours [3]. A recent paper shows many bit-related stereotypies and pain reactions were significantly reduced by bitless bridles [12].

Investigation of a suspected bitting problem
Any performance-related problem where an abnormality of head carriage is present in a bitted horse could potentially be bit-related. A first step is to perform a thorough clinical and musculoskeletal examination including full lameness evaluation, preferably with the patient in a halter or bitless bridle. This should exclude many of the common musculoskeletal problems from being bit-related, leaving those horses only exhibiting signs when ridden under saddle and bridle with a bit. It will be possible to exclude some further by test riding in a bitless bridle; however, some horses will not be accustomed to this and results may not be meaningful, at least initially (e.g. may not work to the same ‘routine’ with the same stresses on either the location of the bit, or other musculoskeletal areas). The age of the horse, the stage of training, the discipline and the experience and skill of the rider should also be considered.

Once a performance or behavioural problem has been isolated to ridden performance with a bridle and bit, a full oral and dental examination is warranted, along with an assessment of the tack including the bit. Many dental disorders have been shown to present with ‘bitting problems’ [13], and another study concluded that many dental abnormalities present would potentially have caused bitting issues [14]. The oral and dental examination should be conducted under sedation, with a full mouth speculum, full mouth-wash, bright headlight and mirror or dental endoscope. The examination should include:
• External head examination including palpation and assessment of symmetry.
• Incisor, canine and interdental examination.
• Soft tissues of lips, commissures, interdental space, bars, buccal mucosa and tongue.
• Dental examination including assessment of:
  o Sharp enamel points, focal overgrowths
  o The rostral 06 region including assessment of ‘wolf’ teeth
  o Periodontal status
  o Endodontic and infundibular status.

The teeth should be floated, balanced and addressed as required but not in an aggressive and potentially damaging way. The region of the rostral 06 teeth should be blunt, but not reduced aggressively as has been, and still is, advocated by some practitioners and dental schools. The term ‘bit-seat’ is not appropriate and the term ‘rostral profiling’ is preferred. A conservative profiling of the rostral 06 teeth will prevent potential soft tissue damage but preserve mastication and avoid pulpar exposure of the rostral pulp canals. Wolf teeth may contribute to pain if loose, sharp, displaced or otherwise diseased. Other dental abnormalities identified should be investigated as appropriate. Dental disease in horses is often at an advanced stage before clinical signs are observed by clients and therefore a lack of a dental problem in the history does not rule out more serious dental disorders, e.g. necrotic pulpitis, periodontal disease, fractures etc. [15]. Any such dental problem could logically affect a horse under saddle through stimulation of local nerves, potentially with increased blood flow at exercise.

Assessment of the bit and bridle, and position within the mouth
The assessment of the bit and bridle should include a thorough assessment of the horse’s oral anatomy and the potential for the bit to be ill-fitting or unsuitable. Factors that should be considered include:
• The soft tissues – size and position of the lip commissures.
  o The bars – width, shape and size from left to right.
  o The palate – shape and depth.
  o The chin groove.
  o The poll.

Each bit should be considered in relation to its function, size, shape, action on the tongue, the position in the mouth and how this may relate to the anatomy of the mouth. Articles on methodology are available but each case should be assessed individually. Many modern bit manufacturers have fitting guides and a wealth of information available to view on-line. In some circumstances it may be wise to consider referral to a professional lorriner.
References


Further reading

Managing developmental disorders

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Dental and facial problems seen in the foal can alter the complex development and growth of the equine head. At birth, many congenital defects are in the early stages of development and become evident only with growth over time. Basic knowledge of normal embryology and developmental biology helps the veterinarian better understand dentofacial problems seen in the young, growing horse. Due to the complex nature of tooth formation, jaw growth, and tooth movement into functional occlusion, it is not surprising disturbances in this process occur.

Craniofacial abnormalities involve malocclusions of teeth and skeletal abnormalities. One of these is incisor overjet and overbite, commonly referred to as type 2 malocclusion (parrot mouth). This malocclusion is usually associated with rostral positioning of the upper cheek teeth rows. Another malocclusion is underjet, prognathism or type 3 malocclusion (sow mouth). This condition can be associated with a rostral positioning of the lower cheek tooth rows. Wry nose or campylorrhinus lateralis is a syndrome involving shortening and/or deviation of the maxillary and nasal bone with incisor malocclusion.

Other developmental conditions include changes in tooth number, shape or position: hypodontia or anodontia which refers to a reduction in number of teeth; polydontia or supernumerary dentition which refers to additional teeth; and dental dysplasia which refers to abnormally shaped teeth. Dental displacements are most commonly documented in the incisors but are also seen in the cheek teeth. While they can be developmental, they are often the result of previous trauma.

The genetics of these types of dental disorders have been studied extensively in humans but not much is known about their hereditary nature or their genetic predisposition in the horse. Due to the relative rarity of congenital dental conditions not seen by any one veterinarian in clinical practice, it has been a challenge to collect genetic material from a large enough number of affected horses in order to perform these types of studies and render significant data. This talk will review the present data that have been collected from GWAS studies previously performed and propose an equine dental genetic bank that can be set up to collect samples for testing in the future.

Genetic material can be collected for testing from the mane or tail hairs with the follicular tissue attached. These samples can be preserved in a clean, dry paper envelope for long periods allowing for testing to be done at a later date. Presently, samples can be stored in a central location with a good clinical description of the condition, signalement of the horse, and photos.

Further reading

Nerve blocks for dental procedures – is there anything new?

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Yes

Nerve blocks have been used in equine dentistry for many years and local anaesthetic agents were discovered in the nineteenth century [1]. However, the application of regional anaesthesia to make intrusive painful and noxious dental procedures tolerable to the hapless equine is a new concept to many people. Despite the fact that some horses will tolerate some oral procedures with minimal restraint and analgesia, this does not make it justifiable to subject horses to such potentially painful or frightening procedures without adequate analgesia. This would be the case when undertaking invasive or painful veterinary procedures elsewhere on the horse’s body and some knowledge of analgesic techniques applicable to the dentition is a prerequisite to planning any such intrusions within the oral cavity of the horse or donkey [2–4].

Local anaesthetic agents have variable pharmacokinetic properties and these should be referred to when selecting the appropriate drug for a task. Where possible, licensed drugs should be used but, alternative agents can be used with owner consent according to the cascade if their properties are superior to a licensed product for a specific reason.

For dental procedures, analgesia of the dentition, supporting bones, oral soft tissues and overlying skin may be relevant, in addition to creating the appropriate environmental ambience, patient tolerance, and positioning to expedite the procedure precision. The use of sedative analgesic combinations renders the horse tranquillised, tolerant of the environment, provides muscle relaxation and some analgesia. While this may be sufficient for intrusions that are not painful, specific regional analgesia is often necessary to supplement it.

The innervation to the dentition is supplied by branches of the maxillary and mandibular branches of the trigeminal nerve and blockade of the peripheral cranial nerve at the appropriate point will effect analgesia of the target tissue. In addition, local infiltration techniques are used to achieve desensitisation of gingiva and skin for which a specific nerve block is not identified.

Recent studies have described alternative approaches to block the maxillary nerve at the caudal maxillary foramen and via the infraorbital foramen, using different needle types. More recently ultrasound guidance has been shown to assist with precision of this potentially hazardous nerve block. While different techniques have some minor advantages, effective blockade can be achieved using all methods described with good restraint of the horse, precise and accurate technique, the use of appropriate needles and drug volume with a high level of consistency and minimal complications [5–10].

The mandibular arcade can be desensitised by blocking the inferior alveolar nerve of the mandibular branch of the trigeminal nerve. This large nerve that contains sensory and motor fibres is best blocked at its entry to the mandibular foramen medially on the vertical mandibular ramus. A number of transcutaneous techniques are described [11,12]. Deposition of the local anaesthetic dorsal to the foramen can also desensitise a branch of the lingual nerve that supplies motor and sensory innervation to the caudal third of the tongue. This effect on the tongue can be extremely useful to access the periodontium and the caudal interproximal spaces of the mandibular molars. Conversely, inadvertant self-trauma to the tongue can occur should the horse be allowed to chew before the blockade has expired. Consequently, bilateral blockade of the left and right nerves simultaneously is ill-advised. An intraoral approach described and tested by Henry et al. can be convenient for a simple access to this nerve [11]. While theoretically convenient, unless the tongue is fully relaxed precise placement of the local anaesthetic can be difficult using this method which requires a 40 mm curved needle to inject the drug with precision.

An oral approach to the mental foramen to block the distal mental branch of the mandibular nerve is well tolerated, easily achieved compared with the transcutaneous technique and requires minimal equipment; it is useful for procedures involving the lower incisors. Intraligamental blocks of the periodontium are standard practice in human dentistry but the depth of the periodontium and the poor access to this structure in the horse’s mouth limit this technique in horses. However, adapted human equipment and prilocaine gel is an alternative way of achieving excellent analgesia of the periodontal ligament and gingiva in horses where accessible and is faster acting than regional analgesia in some cases.

For all potential painful dental procedures in horses a rational approach to analgesia should be used and knowledge of the nerve blocks available in a particular situation will facilitate the procedure making it more pleasant and safer for both horse and veterinarian.

References and further reading

infundibula has been gaining popularity and is being performed more frequently across the UK, but is there good justification for this?

Anatomy

Equine maxillary cheek teeth (Triadan 06–11 in the 100 and 200 arcades) each contain two crescent-shaped enamel infoldings (the infundibula), which extend for most of the crown length [1]. These infoldings are thought to have evolved to increase the surface area of occlusal surface enamel ridges for mastication and compensate for the more extensive infoldings of peripheral enamel of mandibular cheek teeth. During development of the infundibula, the enamel is laid down by ameloblasts, then cementum is laid on this enamel from the periphery of the infundibula, proceeding centrally [2,3]. Ideally, cementum should be deposited in the infundibulum until it is completely filled or only a narrow, central, cement-free channel (‘the vascular channel’) remains. The vascular channel originally contains vasculature mainly originating from the dental sac overlying the occlusal aspect of the developing tooth that nourishes the developing cementum. Suske et al. have shown that some blood supply to the infundibulum remains following dental eruption, allowing continued deposition of cementum (when the overlying occlusal dental sac is lost), by a rostral and a caudal accessory vessel which enter the periphery of each infundibulum subocclusally [3].

Pathophysiology

Gross examination of maxillary cheek teeth from 33 cadavers demonstrated that infundibula are rarely (<10%) completely filled with normal cementum [1]. Defects in cementum can be the result of:

- Cemental aplasia, where areas of the infundibulum have no cementum.
- Hypoplastic cementum, where there is porous and often discoloured hypoplastic cementum (sometimes containing food debris).
- Caries of the infundibular calcified tissues that is a sequel to cemental hypoplasia [1–5].

The rostral infundibula have been observed to be more commonly and severely affected with cemental defects than the caudal infundibula [4,6,7], which is thought to be from more prolonged presence of the accessory vasculature to the caudal infundibula than to the rostral [3].

Infundibular caries develops when defects in the infundibular cementum become exposed to the oral environment. This allows cariogenic bacteria and food into these defects, which leads to a local acidic environment that induces caries [5,8,9]. Infundibular cemental caries can progress to affect the infundibular enamel and even surrounding dentine and can lead to pulpar and thus apical infections [5,10]. Infundibular caries also results in structural weakening of the tooth and sometimes subsequent midline sagittal fracture formation [11,12]. Equine infundibular caries is currently classified using the Honma scale as modified by Dacre based on the involvement of cementum (grade 1), enamel (grade 2), dentine (grade 3), and loss of structural integrity of the tooth (grade 4) [13].

Prevalence

A wide range (8–90%) of infundibular caries prevalence have been reported [1,2,4,5,14,15]. Inconsistencies in distinguishing between the apparently normal ‘vascular channels’, infundibular cemental hypoplasia and infundibular caries may partly explain this range. The age of the surveyed populations is also important as there is clear-cut increasing prevalence with age.

Infundibular restoration

Techniques to restore carious infundibula have been recommended to try and prevent the progression of caries and to improve the mechanical strength of affected teeth in order to prevent fracture and/or apical infection [16–20]. Infundibular restoration involves debridement to remove food debris and diseased cementum, followed by disinfection and then filling of the defect with composite restorative materials.

An early infundibular debridement technique involved using high-pressure micro-abrasion with fine aluminium hydroxide particles [17]. However, an ex vivo study showed that this technique alone was ineffective at removing food and cemental debris lying deeper than 15 mm in affected infundibula, with the remaining debris preventing appropriate filling with composite material [12]. The same study also identified challenges in using flowable restoration materials for filling the vertically orientated infundibula, with air bubbles (i.e. incomplete filling) in many restorations [12]. More recently, effective infundibular debridement has been reported using long contra-angled dental drills and Hedstrom files under oral endoscopic control, for both deep infundibular caries [18,19] and patent infundibula [21]. A recent ex vivo study reported that even deep infundibular lesions could be effectively debrided, using dental drills and Hedstrom files [22]. In that study, filling defects in the restorations (i.e. incompletely filled infundibula) were observed in 90% of restorations, although the majority of these (21/30) were small air bubbles within the filling material. Small filling defects in the centre of the filling are unlikely to be of clinical significance, while peripheral defects may weaken the bond between filling and infundibulum and predispose to early filling loss or allow continued caries.

There is limited published information about outcome following infundibular restoration. One author has anecdotally reported good outcomes for treated clinical cases over an 11-year period [18,20].

Conclusions

Infundibular lesions can result in apical infections and/or dental fractures, so techniques to combat this disorder are justified. It is possible to debride even deep infundibula. Complete filling of debrided infundibula can be challenging, but may be improved with careful technique and appropriate filling materials. Limited published follow-up results of cases are available.

References


The enamel of equine incisors is almost fully composed of equine type II enamel, with prisms that run in all three planes, and thus is very crack resistant. Consequently, fractures of incisors seldom occur without high-level direct trauma. This is in contrast to cheek teeth, which contain high levels of fracture-prone, equine type-I enamel and also undergo massive masticatory forces for prolonged periods. Therefore, nontraumatic dental fractures (‘idiopathic fractures’) more commonly occur in cheek teeth. Older horses suffering from equine odontoclastic tooth resorption and hypercementosis (EOTRH) can develop pathological fractures of their damaged incisors and canine teeth. Dental fractures can be classified into:

- Simple or noncomplicated fractures, where only the mineralised dental tissue such as cementum and enamel are fractured, but where the pulp is not exposed.
- Complicated fractures, where the pulp is exposed to the oral environment.

In mature brachydont teeth (such as human or canine teeth), the blood supply to the pulp is supplied by very fine vasculature at the apical region. If a pulp is exposed by a (complicated) fracture, its exposure to a changed pH and to the different molecules in the saliva will cause intense pulp inflammation, even without pulp infection by the many hundreds of different species of oral bacteria present in all equine mouths. Because the pulp is contained within a very rigid container, i.e. the pulp canal, which is composed of rigid dentine, there is no room for expansion, especially with a small traumatic pulp opening. Consequently, this pulp inflammatory will compress its vasculature, especially at the fine apical foraminae. Therefore, traumatically exposed pulps will commonly die from ischaemia rather than from direct infection by the oral microbes. If, however, the pulp vasculature can resist this initial inflammation, later invasion of the pulp by oral bacteria which are pathogenic to the pulp can cause an acute bacterial pulpitis. Additionally, compression of food into the exposed aspect of the pulp will exacerbate the pulpitis and lead to pulp death by causing further pulpar inflammation and ischaemia in addition to the direct action of bacterial toxins.

Because of the prolonged eruption and laying down of secondary dentine of equine incisors over most of the horse’s life, they have a much larger vascular supply than brachydont teeth. Often this allows equine incisors to withstand fracture-related pulp exposure and the subsequent pulpar inflammation described above. Even without any treatment, some young equine teeth can lay down tertiary dentine on the exposed pulpar surface and eventually seal off the pulp fully. However, mature equine teeth have longer and thinner pulps (due to continued secondary dentine deposition on the walls of the pulp horns) and they also have smaller apical vascular openings. Consequently, they are more susceptible to trauma-induced ischaemia and pulp death than young equine incisors.

A high degree of trauma is required to fracture an equine incisor and in most instances the adjacent incisors will suffer a similar level of trauma. In some horses, the clinical crowns of adjacent incisors are intact, but they may have fractured subocclusally. Therefore, it is always worthwhile performing radiography of fractured incisors, and this is especially important if there is any evidence of gingival swelling or retraction of adjacent incisors. In view of the above, it is the author’s opinion that it is always worthwhile attempting to endodontically treat fractured equine incisors. Unlike in brachydont species, this treatment can be performed even weeks after the incisor has been fractured (or the fracture recognised), provided that the underlying pulp remains vital. Pulp vitality can be assessed by first lavaging the occlusal aspect of the fractured tooth with 0.1% (1:1000) chlorhexidine (without detergent), then removing any necrotic exposed pulp with the bent tip of an 18 to 20 gauge hypodermic needle and assessing if haemorrhage of the underlying pulp occurs. If the pulp is found to be vital, the usual treatment is to perform a vital pulpotomy: this involves applying a thin layer of a highly alkaline dressing, such as calcium hydroxide paste or mineral trioxide aggregate (MTA) on to the occlusal aspect of the vital pulp, having first debrided any necrotic exposed pulp and the underlying healthy pulp to a depth 5–10 mm below the fracture site and controlled the subsequent haemorrhage with paper points or lidocaine with added adrenaline. This dressing is followed by an intermediate restorative layer (such as a calcium hydroxide baseliner – usually two-part and possibly UV light-activated; or alternatively, a glass ionomer). The pulp canal wall is then acid-etched and a bonding agent is applied, prior to applying a final restorative layer of a composite restoration material.

If the pulp is found to be necrotic deep into the pulp horn, it is likely that complete pulpar death has occurred and, in this instance, a specialist complete removal of pulp (pulpectomy) and complete endodontic (root canal) restoration is required. Such cases should always be assessed radiographically prior to and during the restoration.
Advances in cheek tooth extraction techniques

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Introduction
Cheek tooth extraction continues to be the most common procedure performed for the treatment of a variety of dental disorders such as apical infection, fracture, developmental displacement, supernumerary polyodontia, ectopic teeth, neoplasia, and problematic diastemata causing periodontal disease. Historically an oral approach using forceps and fulcrum elevation was described [1]; however, following the development of surgery under general anaesthesia, extraction by surgical repulsion and buccotomy [2,3] became standard procedure for cheek tooth extractions during the mid to late 1900s. High surgical complication rates and a developing preference for standing procedures subsequently led to the rediscovery of oral extraction techniques [4] combining improved equipment with development of locoregional anaesthesia, and standing sedation protocols. Further developments in equipment engineering and dental material experimentation from the human field have now resulted in a number of options available to dental practitioners for the extraction of cheek teeth.

Surgical extraction
Traditional techniques of large scale repulsion under general anaesthesia are generally not recommended or practised in modern dentistry; however, improved successes have been documented using alternative approaches, e.g. buccotomy [5]. Surgical techniques under general anaesthesia are currently only generally required for fractious horses unsuitable for standing sedation, or teeth in particularly inaccessible or potentially anatomically dangerous locations, e.g. impacted teeth [6], heterotopic polyodontia [7]. The majority of teeth in horses can now be extracted using variations of standing oral or transbuccal procedures.

Oral extraction and developments of technique
Standing oral extraction is the preferred method for cheek tooth extraction in the majority of teeth where all or even some of the clinical crown is present, and has been well described previously. Improved instrumentation including varieties of molar separators, improved design of extractors, narrow sharp alveolar luxators, good locoregional anaesthesia techniques including intraligamental anaesthesia combined with profound sedation and operator skill can allow even the most challenging of cases to be extracted orally within relatively short procedure times. The oral extraction procedure should not be excessively prolonged. Pre-extraction consideration of anatomical shape of the tooth including potential for divergent root-locking, eruption pathway, pathology, dimensional stability (age, secondary dentine formation) can direct the practitioner towards the particular techniques most likely to succeed and reduces surgical time and the risk of crown or root fracture.

Partial coronectomy [8]
‘Crown interlock’ has been described as one potential problem and risk factor for a failed oral extraction or iatrogenic fracture. Using oral sectioning burs to increase rotational space or allow an unobstructed eruption pathway has been described and may be useful in particular scenarios in teeth with, for example, diverging roots, or enlarged apices or reserve crowns obstructing exit through the existing extraction gap.

Pre-extraction crown restoration
Use of cold-curing materials to crudely restore teeth is useful for mid-saggital infundibular caries-related fractures where both fragments are present [9]. Different from the published method, closing the fragments first and inserting the material to set within the fracture site can stabilise the crown allowing normal placement of extractors. Pre-extraction restoration can also be used to enhance structural stability of diseased teeth, e.g. deep infundibular or pulpar caries resulting in reduced iatrogenic/pathological fracture risk during extraction. A variety of materials may be used for this purpose, including dental restorative resins or cold-curing polymethylmethacrylate, e.g. bone cement.

Oroscopically guided fragment extraction
Advances in optical quality and illumination have resulted in clear bright imaging of the oral cavity and many problematic crown or root fragments can, with practice and training, be extracted successfully and completely using angled luxators of varying length, angle and tip design. The importance of a quality oroscope cannot be overemphasised in this scenario as cheap systems will not provide adequate visual guidance especially in a blooded environment.

Minimally invasive transbuccal surgery (MTE/MTSE)
A standing transbuccal approach has been described [10] and is currently the preferred option for many teeth with fractured clinical crowns precluding grip with oral extraction forceps. This approach may be used to either loosen the tooth prior to oral extraction, to insert a threaded Steinmann pin for retropulsion, or to retrieve crown or root fragments left following oral extraction. The technique is best suited for maxillary or more rostral mandibular teeth. Caution should be exercised using this technique for more caudal mandibular teeth due to the facial crest preventing straight parallel access to the lingual dental margins. The transbuccal equipment may also be used occasionally for rostral, caudal or axially displaced teeth through an oral approach (author, unpublished cases).

Minimally invasive repulsion (MIR)
Once teeth have been loosened either using standard oral forceps or a transbuccal approach, or for difficult to access apical fragments following these procedures, use of transcortical repulsion can be successful if directed accurately using radiographic guidance. Markers such as skin staples can be used for accurate placement of narrow repulsion pins carefully directed following cortical osteotomy. For maxillary teeth, although a risk of sinusitis exists, this is usually only transient and with good alveolar packing post extraction (e.g. polysiloxane) and regular flushing of the socket, normal healing usually occurs within weeks. Repeated puncturing of the sinus or mandible through inaccurate placement or use of large pins or punches will result in higher complication rates.

Conclusion
Selecting the appropriate instrumentation and technique following thorough assessment of the tooth to be extracted and predicting likely problems and complications should allow most teeth to be extracted in a single operation without complication. However, practitioners should also not underestimate the potential difficulty of some procedures and the considerable training and experience required to successfully use these modern techniques and instrumentation.

References


NOTES

Further reading


Are you missing EOTRH?

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Equine odontoclastic tooth resorption and hypercementosis (EOTRH) is a recently described disorder of incisor and canine teeth of older (usually over 15 years old) equids, variably causing resorptive and/or proliferative changes of all the calcified dental tissues and secondary periodontitis. Odontoclasts are multinucleated cells that cause the normal physiological resorption of the roots of the primary (deciduous) dentition prior to their exfoliation, but in this disease, they are abnormally activated and destroy the subclinical aspects of permanent cheek teeth. EOTRH shares some features with similar dental syndromes in cats (feline resorptive syndrome) and a resorptive dental disorder in humans, except that some equids also develop a high degree of peripheral hypercementosis with thickening of affected teeth which can mask and sometimes structurally compensate for the original resorptive lesions. The prevalence of this disease is unknown but possibly affects up to 5% of older horses.

The signs can be insidious and develop over many years. Equids with extensive hypercementosis can be recognised by the subgingival thickening or exaggeration of the convex outline of the incisor alveoli (the alveolar juga). EOTRH-affected teeth with hypercementosis can be very stable and pain-free and so, in the absence of periodontal disease, such cases do not need any treatment at this stage. However, equids that develop more lytic calcified tissue lesions often suffer pathological fractures of affected teeth and if resorptive lesions develop near the gingival border, this will also permit a secondary periodontal disease to develop. The presence of fractured teeth and periodontal disease are clinically obvious and these lesions can cause great pain that can be a serious welfare problem for affected animals. Some equids will develop pulpar and apical infection of affected teeth and have sinus tracts on the gingiva overlying the root apices. Other equids may have painful teeth without evidence of fractures or periodontal disease and may be reluctant to graze, lose weight and have biting problems. Allowing suspected cases to bite a carrot at different sites on their incisors will help identify painful teeth in these animals.

Radiography of suspect teeth (open mouth technique) is essential for complete evaluation of this disorder. Currently, there is no known treatment for EOTRH-affected teeth, and loose, fractured and painful teeth should be extracted using sedation and local anaesthesia. If just one or two incisors remain following exodontia of the worst affected teeth, the remaining teeth, now without any adjacent support from other teeth, may quickly become loose. Consequently, if multiple teeth on an arcade are affected, it may be preferable to surgically extract all remaining incisors in that arcade together, then surgically reduce the height of the alveolar bone (alveolectomy) with rongeurs to allow the gingiva to be fully sutured closed.

Further reading
Treatment options for tumours of the male genital tract

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Introduction
The genital tract may be defined as the organs involved in reproduction. In the male horse this includes the scrotum and testes, the epididymis, deferent ducts, accessory sex glands, urethra, penis and prepuce. The accessory sex glands are the ampullae, seminal vesicles, prostate and bulbourethral glands.

Tumours of the internal genitalia are uncommon and are relatively hard to detect and treat. Knobbe et al. recorded two cases of prostatic adenocarcinoma in geldings [1]. Cases of lymphosarcoma involving the epididymis have also been reported, but again medical and surgical options for treatment are limited.

Tumours of the external genitalia (penis, prepuce and testicles) are more commonly reported and easier to detect: indeed about 6–10% of all neoplasms in the horse affect the external genitalia.

Testicular tumours
Testicular neoplasms are uncommon, which most likely relates to the management practice of castration of most males at a young age [2]. Tumours in entire males, and in particular breeding stallions, may affect fertility and are of important clinical and commercial impact.

Tumours are categorised into those of germ cell origin (seminomas, teratomas, teratocarcinomas, embryonic carcinomas) and those that are nongerminial (Leydig and Sertoli cell tumours) [3,4]. Seminomas are most frequently encountered, usually presenting as rapid testicular enlargement [3]. Apart from teratomas, all testicular tumours have the potential for metastasis. Thorough palpation and examination of the contralateral testicle and spermatic cord, and indeed the entire genital tract, is important prior to treatment. Hernicastration is often the treatment of choice where pathology is unilateral and where continued breeding use is desired.

Teratomas can be found in cryptorchid testicles. Whether cryptorchidism predisposes to teratoma formation, or teratomas prevent normal testicular descent, is the subject of debate. Such cases present a diagnostic and therapeutic challenge. Laparoscopic examination can be a useful technique in such cases.

Tumours of the penis and prepuce
Cutaneous neoplasms frequently affect the penis, prepuce and, less commonly, the scrotum. By far the most common are squamous cell carcinomas (SCC), together with predisposing genital papilloma lesions. Melanomas, sarcomas, fibrosarcomas and haemangiomas may also be encountered. Although usually slow to metastasise, SCCs are locally invasive and commonly result in secondary infection. The discomfort of this and the disturbance of urination often necessitate prompt treatment.

Cryotherapy, local excision and laser surgery
Small penile tumours and those in their early stages can be successfully treated with cryotherapy or local sharp excision [5]. Careful patient selection is critical. Although excision may be curative for focal SCCs, sarcomas and dermal melanomas [6], it carries a higher risk of tumour recurrence [5]. Also, where wide tissue margins are required, soft tissue reconstruction may prove to be impossible. Laser surgery is often an effective technique for local resection of small, well-defined penile and preputial tumours.

Chemotherapy
Topical application of 5-fluorouracil at 7 to 14-day intervals or intratumoural injection of cisplatin has been shown to be effective and even cause regression of preneoplastic lesions [7]. The side effects of local inflammation and epidermal necrosis [8], combined with technical difficulties of application, mean that these treatments are uncommonly used. The use of systemic doxorubicin and piroxicam for SCC has also shown some promise.

Reefing
In reefing (also known as segmental posthioplasty) a cuff of epithelium is removed from the shaft of the penis [7]. This allows extensive penile lesions that do not extend beyond the dermis to be removed while maintaining normal anatomy and function [5]. Although theoretically attractive, use of this procedure is limited by the few cases that fit the selection criteria.

Partial phallectomy
When tumour (typically SCC) has invaded the tunica albuginea and affects the distal glans penis but has not spread to other tissues or lymph nodes, partial phallectomy is indicated [9]. Various surgical techniques for this have been described (Scott, Vinsot, Williams, Frank’s) but none are without risk of complication. Although partial phallectomy may be preferred by owners for practical, economic and aesthetic reasons, the tumour recurrence rate of 25.6% [6] may actually be higher than the 17.9% reported following en-bloc resection.

En-bloc penile and preputial resection +/- penile retroversion
Once tumour (usually SCC) has invaded the corpus spongiosum it can easily undergo lymphovascular spread [5]. Cases identified with distant metastasis usually have a hopeless prognosis, but regional spread can be treated by radical surgery involving resection of the penis and prepuce prior to retroversion of the stump through a perineal urethrotomy. Although potentially curative this is an invasive procedure that can lead to profound complications. Doles et al. [10] and Wylie and Payne [11] have suggested modifications that reduce surgical complexity and maintain a more conventional anatomy by eliminating the need for penile retroversion. Despite these advances en-bloc resection remains a salvage procedure that should only be undertaken after careful consideration, and where thorough examination has taken place to exclude cases with any risk of distant metastasis.

Summary
Tumours of the male genital tract are in many circumstances difficult to treat. A better evidence base of results from randomised treatment trials and information from tumour staging would assist clinicians in making more informed treatment choices.
References

The proportion of geriatric horses in the population is increasing with improved preventive health and nutrition, and it is logical to conclude that the incidence of diagnosis and treatment of oncological conditions will increase correspondingly. The inclusion of examinations for common tumours should start to become part of the yearly preventive health programme for older horses. Tumours of the external female genitalia are more common with increasing age, while tumours of ovaries and the uterus may occur in younger mature mares.

Tumours around the vulva can take the form of the most common skin tumours in horses in general: sarcoïds, squamous cell carcinoma (SCC) and melanoma. There is a wide variety of possible treatments, suggesting that no single treatment has been found to be the most efficacious. Surgical excision alone of sarcoïds or SCC has a relatively high recurrence rate and it is recommended to follow excision with an adjunctive therapy to prevent recurrence. Currently, the best recommendation to reduce the risk of recurrence is to surgically excise or debulk and then follow with either local chemotherapy or radiation. Piroxicam (a nonsteroidal anti-inflammatory drug) has been shown to have beneficial anti-cancer effects and is available as a once daily oral formulation. Combination therapy with surgery, local chemotherapy and systemic oral piroxicam can be used to try to prevent recurrence as much as possible.

Diagnosis of melanomas is generally not a challenge; rather, the challenge lies in when and how to treat. Often melanomas will remain small and unchanged for several years. However, it is necessary to remove the tumours before they become too large and either start to spread or interfere with local functions. Removal is not associated with an increase in aggressiveness but rather that the continued development of other melanomas is inevitable. It is therefore important to educate owners that tumours should be removed surgically when small and to accept that this must be maintained for the life of the horse. Implantation of cisplatin beads and radiation are both very effective with melanomas, either to help control regrowth or as a primary treatment. Cimetine has been used to control melanoma growth but is often impractical and expensive for the length of therapy required, and the efficacy has been questionable. A new melanoma vaccine is available and, while it is based on some good scientific evidence, large clinical trials in horses are lacking.

As with tumours in general, when considering the treatment options for vulvar SCC or melanoma (not sarcoïds) the clinical examination and work-up should include determination of involvement of local lymph nodes and/or distant metastases. Although the risk of metastasis is lower in horses than other species, it does occur and can greatly affect the prognosis and choice of treatment, so should be included in the work-up. Rectal palpation for internal lymph nodes and/or abdominal ultrasound can be performed. Metastases and local spread have been recorded with both SCC and melanoma.

Tumours of the ovaries, mammary gland and uterus can occur, with ovarian tumours being the most commonly diagnosed. Granulosa cell tumour is the most common form of neoplasia in the ovaries. This tumour can be inactive or produce a variety of different hormones which may cause behavioural changes such as stallion-like behaviour, anoestrous, or nymphomania. The other ovary may be small and inactive as a result. Diagnosis is by recognition of abnormal behaviours, palpation per rectum of the ovaries, and ultrasound, as well as a commercially available blood test for levels of anti-Müllerian hormone. Once the diagnosis is obtained, then laparoscopic or open surgical removal is recommended with a good prognosis for return as a broodmare or an athlete. Recurrence is rare. If these tumours become too large they can become painful and life-threatening with the formation of adhesions to other intestinal structures or significant haemorrhage. Tumours of the uterus are uncommon, but a variety of different forms can occur. Diagnosis is by rectal palpation and ultrasound. Laparoscopy can aid in both diagnosis and treatment. Removal of the tumour by either partial or full hysterectomy can be curative. Tumours of the mammary gland are, however, generally much more invasive and tend to metastasise. The most common tumour is adenocarcinoma. Early diagnosis is critical and common clinical signs include serosanguinous discharge from the mammary gland which is commonly mistreated as mastitis. Careful palpation and ultrasound of the mammary gland is indicated whenever there is unusual discharge or swelling. It can occur in both broodmares and sporting mares. A fine needle aspirate or biopsy should be taken of any mass to obtain a diagnosis and the mare should be examined for any signs of metastases (abdominal ultrasound, complete blood work and biochemistry, chest radiographs). Mastectomy is the treatment of choice and is curative only when masses are diagnosed early.

Cancer of the female urogenital tract can occur in a variety of locations, but the majority are readily treatable. Surgical or laparoscopic excision is the most common treatment, but in more invasive forms of cancer this should be combined with adjunctive therapies. Early recognition and diagnosis increases the chance of successful treatment. Client education and communication is critical for owners to understand the treatment options and prognoses.

Further reading
Laparoscopic urogenital surgery. What is possible?

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As the urogenital system is located within the pelvic area, various laparoscopic procedures can be used, either standing, or under general anaesthesia, or a combination of both. Laparoscopy allows assessment and manipulation of structures that are inaccessible by a standard open approach. In horses, however, laparoscopic surgery is often combined with minimal laparotomy, either at the end of the procedure to remove larger organs (e.g. ovarian tumours, bladder stones), or at the beginning of surgery, to manipulate some large or delicate organs under laparoscopic control (kidney). Hand-assisted techniques offer the advantage of permitting manual dissection and retraction. The ability to control haemorrhage is increased as well.

Laparoscopic cryptorchectomy
This is a common and straightforward procedure that can be performed with the horse standing or under general anaesthesia. When the procedure is performed standing, three portals are adopted in the flank area. After haemostasis and section of the spermatic cord using a vessel sealing device (LigaSure®), the testicle is removed through a slightly enlarged instrument portal. If necessary, the opposite testicle is removed via a standard scrotal approach, or by a laparoscopic standing technique.

In difficult and fractious horses, a recumbent technique may be preferable. The laparoscope is introduced through an umbilical portal. The horse is placed in the Trendelenburg position with the head down approximately 30 degrees to displace the viscera cranially. Two other portals are used for instruments, just cranial to each inguinal ring. Haemostasis and sectioning of the cord are performed similarly. We prefer to remove the testicle via the laparoscopic portal. An alternative technique is to use a single ipsilateral instrument portal, and to exteriorise the testicle prior to placing the ligature or emasculator. The opposite testicle is removed via an inguinal approach.

Laparoscopic inguinal hernioplasty
Inguinal hernorrhaphy or hernioplasty is recommended in stallions with a history of strangulated inguinal herniation to prevent recurrence and to preserve testicular function. Reported laparoscopic techniques include mesh placement under a peritoneal flap close to the vaginal ring in the recumbent horse, rolled mesh placement within the vaginal canal in the standing horse, peritoneal flap hernioplasty under general anaesthesia or in the standing horse, and inguinal hernioplasty using cyanoacrylate in the standing horse. Our preferred technique at this time is a combination of cyanoacrylate and direct suturing using a knotless suturing technique and automatic suturing device (V-LocTM Endo StitchTM).

Laparoscopic ovarieotomy
The most common indication for ovarieotomy in the mare is removal of granulosa cell tumours. Dissection and haemostasis of the pedicle is no longer a major problem since the introduction of electrosurgical instruments. However, very large ovarian tumours may adhere to other organs, such as the uterus or bowel, that can also be challenging to dissect laparoscopically. Manual bagging or use of a polypropylene band plastic retrieval bag are the easiest ways to remove a very large ovary through a small 8 cm incision. In the latter technique, an adhesive bag (one section adhesive bag, 48 × 38 cm, Foliodrape® No. 258 322, Hartmann, Heidenheim, Germany) is fixed to a polypropylene band. The latter allows the bag to be opened inside the abdomen without introducing the hand. Once the enlarged ovary has been bagged, the opening of the bag is then pulled back through the incision site, completely isolating the ovary from the abdomen. A combination of stab incisions in the ovary, sectioning of small pieces and aspiration allows the ovary and bag to be removed without contaminating the abdomen.

Another interesting technique that we use to remove a very large ovary is the two-step procedure combining standing laparoscopic dissection and ovarian removal, using a similar bagging technique, through a small 8 cm ventral midline incision with the mare under general anaesthesia.

Laparoscopic ovariohysterectomy
The ovarian pedicles are ligated, and dissection continues through the broad ligament, ligating large vessels in the process. This first step of the procedure can be performed under laparoscopy on the standing mare. The mare is then placed under general anaesthesia in dorsal recumbency and a causal midline laparotomy is performed. The body of the uterus is transected as far caudally as possible, with care taken to avoid contaminating the peritoneal cavity. The uterine stump is closed with a double-inverting suture pattern. The abdomen is closed in routine fashion. A recent report describes the laparoscopic dissection and haemostasis of ovarian and uterine structures followed by inversion of the uterus through the cervix and into the vagina, where the uterus was then resected.

Laparoscopic assisted technique for bladder stone removal
A laparoscopic technique with extra-abdominal extraction of the cystic calculus and closure of the urinary bladder has been described. This technique simplifies bladder closure because prior experience in laparoscopic suturing techniques is not required. It may also decrease the risk of urine leakage into the abdomen. Compared with parainguinal laparocystotomy, the size of the incision is generally smaller.

Laparoscopic nephrectomy by hand-assisted techniques
The surgical technique has been described for the left and right kidney in the standing horse. A 10–12 cm vertical skin incision is made in the paralumbar fossa beginning 5–8 cm below the dorsal border of the internal abdominal oblique muscle. The external abdominal oblique muscle is sharply incised and a modified grid approach is used to gain access to the peritoneal cavity. The peritoneum is sharply incised. A laparoscopic viewing portal is made dorsal to the proximal border of the flank incision. An instrument portal is created cranial and dorsal to the laparoscopic portal. Laparoscopic scissors are used to sharply incise the peritoneum caudal to the kidney. This incision is enlarged by manual dissection to expose the kidney. All the vascular structures entering and leaving the kidney are identified by careful manual dissection. The renal artery and vein are double-ligated separately and transected and the kidney is removed through the flank incision with the ureter intact. The ureter is double-ligated and transected. The renal vessels are inspected for haemorrhage. Closure is routine.
Surgical approaches to the bladder

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The commonest indications for surgery of the urinary bladder are bladder rupture (most commonly seen in newborn/young foals) and cystic calculi (most commonly seen in older geldings). Other indications include persistent (patent) urachus, bladder prolapse or eversion, and neoplasia (such as transitional cell carcinoma).

Bladder rupture
Rupture of the foal’s bladder may occur as a result of a congenital defect or a high intravesicular pressure associated with parturition. Bladder rupture is most common in male foals, and the rupture (usually 2-5 cm in length) typically occurs along the dorsal or dorsocranial aspect of the bladder. Affected foals are usually 1-5 days of age when they develop signs of uroperitonaeum. Foals with uroperitonaeum should be medically stabilised before undergoing surgical repair. Hyperkalaemia and abdominal distension with urine should be addressed. The surgery is typically undertaken via a midline coeliotomy with the foal under general anaesthesia. A fusiform incision is made around the umbilicus to allow excision of the umbilicus. The incision is then continued in the midline cranially and caudally (in male foals the caudal incision is directed paramedially to avoid the prepuce). Once the peritoneal cavity is entered, the bladder is exposed by maintaining traction on the umbilicus. When the tear in the bladder is identified, the wound margins are debrided, and the defect closed in two layers (including an inverting outer layer). The urachus is then resected, and the abdominal wound closed routinely.

Persistent (patent) urachus
Most foals with uncomplicated patent urachus will respond to medical treatment (prophylactic antimicrobials), but if the patent urachus persists despite medical therapy, surgical resection of the urachus and the umbilical vascular elements should be undertaken (cystoplasty). A fusiform incision is made around the umbilicus and extended cranially and caudally as needed. The umbilicus and urachus are dissected free and the umbilical vein double-ligated. The bladder is exposed by traction on the urachus. The umbilical arteries are ligated and divided, and the urachus and the umbilicus are excised by a transverse incision across the apex of the bladder; the bladder wall defect is closed with a double layer inverting suture pattern. The abdominal wound is closed routinely.

Cystic calculi
Cystic calculi are most commonly seen in older horses, and are more frequent in males. The commonest composition of equine calculus is calcium carbonate, and calculi most commonly have a friable, speculated surface that irritates the bladder mucosa resulting in secondary cystitis. Clinical signs include haematuria (especially after exercise), stranguria and, occasionally, urinary incontinence.

A variety of surgical approaches to the bladder are available to remove calculi.

Laparocystotomy
The horse is placed in dorsal recumbency under general anaesthesia, and a urinary catheter is placed. A routine ventral midline incision is made, extending caudally. In males, this will necessitate dissecting deep to the prepuce. The bladder is palpated in the pelvic canal and exteriorised by gentle but firm traction. Allowing the bladder to distend with urine or instilling sterile saline or local anaesthetic solution and then clamping off the urinary catheter prior to surgery may help stretch the bladder wall and make it easier to exteriorise at surgery; the urinary catheter is opened once the bladder is identified at surgery to allow drainage of its contents. Stay sutures are placed in the bladder wall prior to performing a cystotomy. Once the urolith(s) has been removed the bladder is lavaged to remove all debris, and then closed in two layers with synthetic absorbable suture material, using an inverting pattern. The abdomen is lavaged and closed routinely.

A parainguinal approach can also be used as an alternative to a midline coeliotomy.

Laparoscopy
Laparoscopy or laparoscopic-assisted techniques to remove cystic calculi have been described. With the horse under general anaesthesia and in dorsal recumbency, the bladder is visualised via an umbilical portal. A retrieval bag is placed into the abdomen and positioned below the bladder to catch the urolith once a cystotomy is performed. The bladder is closed in two layers using an intracorporeal suturing technique.

Perineal urethrotomy
Small uroliths in male horses can be removed via a pelvic urethrotomy. Trauma to the urethra is a potential complication. Lithotripsy can be employed via a urethrotomy to allow fragmentation of larger uroliths that can then be removed with long-handled forceps piece by piece via the urethrotomy. Alternatively, a laparoscopic retrieval device can be used to facilitate removal of calculi via the urethrotomy. Following removal of all calculus fragments and lavage of the bladder, the urethrotomy is left to heal by secondary intention.

Pararectal cystotomy
Pararectal cystotomy (Gokel’s procedure) can be undertaken in standing sedated horses under epidural anaesthesia.

Further reading
Investigation of the URT: when and how

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• Investigation of the upper portion of the equine upper respiratory tract (URT) can be challenging due to the nonspecific nature of clinical signs and the propensity for some clinical signs to manifest themselves during exercise only.

• Overground endoscopy is now the gold standard for investigation of abnormalities of the equine URT; it is widely available and has major benefits for the health and welfare of performance horses.

• Overground videos are frequently obtained before and after therapy allowing treatment modalities to be critically assessed for efficacy; consequently, it is now clear that several long-standing treatment choices for common disease of the equine URT may be of limited efficacy.

• Using the presence or absence of an abnormal respiratory noise alone in the planning of a therapeutic intervention is likely to result in incorrect therapies being applied in almost half of all animals presented.

• The use of imaging modalities, including ultrasound and computed tomography (CT) have opened a new diagnostic window on the equine URT.

Examination, and subsequent diagnosis, of disease affecting the upper portion of the respiratory tract can be challenging. Clinical signs are often nonspecific, and may only be apparent during exercise or, perhaps, only during a specific type or intensity of exercise. The most frequently reported consequences of obstruction of the URT are poor performance and abnormal respiratory noise [1,2].

Resting endoscopy often has limited value in determining the cause of URT obstruction since it is unable to accurately predict findings that only occur during exercise [3,4,5,6]. Furthermore, endoscopy is not always well tolerated, and the use of sedation may alter the appearance of the airway. The frequency of complex combinations of URT conditions further highlights the importance of evaluation of the respiratory tract during exercise [2,7,8,9]; however, it is now almost exclusively performed using overground endoscopy. The equipment, of which there are a number of versions, allows the acquisition of images of the equine pharynx and larynx under normal exercise conditions [10,11]. With the widespread use of the technique, availability of equipment and the expertise to use it, there has been a giant leap forward in the understanding of the structure and function of the equine upper airway and consequently a paradigm shift in the approach to and therapy for obstructive diseases of the airway in horses.

It is fair to say that the history of therapy for conditions affecting the upper portion of the equine respiratory tract has not always been based on evidence. The pressure on veterinary surgeons from owners and trainers of horses to intervene when presented with a poorly performing horse is often immense. As a profession we have a history of selecting a course of therapy for horses with apparent airway problems based on the presence of airway noise [12], resting endoscopic findings, the age of the horse, or just because that’s what has always been done on a particular premises [13,14]. The scientific basis for therapy has been further damaged by the (sometimes outspoken) opinions of well-known trainers and vets. There is no doubt that the historic approach to the investigation and treatment of the equine airway has not been our profession’s finest hour. Thankfully all this has begun to change. It is now possible for every horse to be examined while it is undertaking the type and intensity of exercise in which it reportedly has a problem. Subsequently no horse should be treated without a diagnosis. In some cases that may even involve examining the horse on a racetrack, with other horses, and performing under race conditions.

A number of studies have been performed recently that have given rise to changes in the approach to investigation and treatment of the equine URT. In a group of 100 racehorses presented due to the presence of abnormal respiratory noise, a comparison of recorded noise and overground endoscopy findings suggested that the use of respiratory noise alone as a diagnostic criterion would result in an incorrect diagnosis in approximately 50% of horses presented [15]. In a significant proportion of horses in this study, abnormal noises were recorded in horses with no evidence of airway disease [16].

A number of longitudinal studies have been performed which suggest that overground endoscopy, when performed in young horses, is able to identify individuals that may subsequently develop significant and career-limiting airway problems [17].

Conservative therapy for problems of the equine airway have never been all that popular; the pressure on vets to ‘do something’ has often led to the use of surgical treatments which are at best ineffective and at worst damaging. This is particularly true for treatment of intermittent dorsal displacement of the soft palate (IDDSP). Due to the ease with which overground endoscopy can be performed, it has been possible to serially examine large groups of horses with this condition. The findings suggest that in the majority of cases in young horses (over 70%) this condition is likely to be self-limiting.

As investigative options for the URT, including overground endoscopy, continue to be developed and refined, the goal will be to correctly diagnose and treat conditions that were previously often diagnosed presumptively, and treated by management methods and/or surgical procedures assumed to be efficacious, but lacking objective evidence.

References


Allen et al. (2011) published the first systematic review of the numerous treatments of intermittent dorsal displacement of the soft palate (DDDSP), and they were not able to determine which procedure is the most appropriate in the management of this condition. There are published reports which suggest that nonsurgical treatments (rest and the use of a tongue-tie) of this condition are associated with a success rate comparable to surgery (in general; not all procedures evaluated) and therefore medical treatment should be seriously considered.

Other changes in horses’ tack are commonly described in the management of palatal instability or DDSSP, usually with other changes (rest or increased training to improve fitness). The use of the figure-of-eight noseband or dropped noseband is claimed to be effective in preventing air entering the oropharynx. Other anecdotal tack changes suggested for managing DDSP are those that decrease head flexion. A bitless bridle has been suggested for sport horses.

Horses with pharyngeal inflammation have been recommended to be treated first with systemic, and perhaps topical, anti-inflammatory agents unless a prior equine protozoal myeloencephalitis (EPM) diagnosis has been made. There is a significant relationship between the occurrence of DDSP and pharyngitis. Holcombe et al. (1998) has shown inflammation of the pharyngeal branch of the vagus nerve as it traverses the medial wall of the gullet pouch can result in DDSP.

Anecdotally, structural abnormalities of the larynx and nasopharynx such as subepiglottic cyst, subepiglottic granuloma and ulcers, palatal cyst, and epiglottitis disturb the laryngopalatal seal and predispose horses to DDSP. Horses with these abnormalities should have targeted treatment to address the condition.

Two-year-old horses with DDSP may have an ‘immature nasopharynx’, so owners should consider waiting a year before pursuing any surgical treatment. Finally, an unfit horse’s fitness level should be raised before considering any surgical treatment.

Surgical treatment

There are many surgical treatments for this condition whose aetiopathogenesis is clearly not fully understood and/or has a different pathogenesis in different horses. With the absence of successful valid meta-analyses to identify the best treatment, the following represent the approach used by the author. Horses diagnosed with DDSP after two or more races where the medical/tack modification has failed to correct the problem, are candidates for surgical treatment. In sport horses, DDSP is far less common, the outcome more subjective, and surgical results reported less often.

Quinlan introduced and popularised the first surgical treatment, staphylectomy. This treatment is still used as part of a composite treatment in general in association with resection of the strap muscles. Aside from the staphylectomy, there are three categories of surgical treatment:

• Those that target correcting the intrinsic nasopharyngeal structures (cyst/granuloma removal)
• Those that seek to increase palatal stiffness (by thermal palatoplasty by cautery, or laser; chemical palatoplasty by injection of sclerosing agents, and tension palatoplasty by suturing)
• Those targeting the position of the larynx and hyoid bone, such as strap muscle resection and laryngeal tie-forward.

The primary benefit of surgery of the intrinsic structure of the nasopharynx relevant to the soft palate is related to removal of granulomas, cysts, and abnormal subepiglottic tissue. One should be aware that the subepiglottic tissue is quite sensitive to surgical trauma (laser, blade, or scissors), and so the veterinary surgeon should be cautious about these areas, especially with repeated surgery. We currently only perform staphylectomy for occasional resection of soft palate cysts, rarely for soft palate ulcer, or as a part of a composite treatment for persistent DDSP after a laryngeal tie-forward has been performed.

The rationale for targeting a procedure that increases palatal stiffness is being questioned, given the results in three studies. In two studies using either injection of a sclerosing agent or laser therapy in the soft palate, the authors did not find evidence of sustained change in stiffness or morphology of the soft palate at up to 6 months post injection.

Strap muscle resections focus on bilateral partial sternothyroidectomy which, with a reported success rate of 58–95%, remains one of the most popular treatments of this condition. With the horse in dorsal recumbency under short-acting or other form of general anaesthesia, a skin incision (5–7 cm in length) is made centred on the ventral aspect of the cricoid cartilage on the midline. After incising the subcutaneous tissue, the sternothyroid muscles are divided using curved scissors. With finger dissection on the lateral aspect of the cricoid cartilage, the sternothyroid muscle is identified on the left and right side, caudal to its tendinous insertion on the lamina of the thyroid cartilage. The tendon is transected 1–2 cm caudal to the thyroid cartilage to avoid trauma to the cricothyroid muscle, which tenses the vocal cord, or to the caudal laryngeal artery. A 3 cm section of each sternothyroid muscle/tendon is then removed. This prevents reattachment of the cut end of the muscle on the cricoid or thyroid cartilage.

The laryngeal tie-forward procedure is also performed with the horse under general anaesthesia in dorsal recumbency. As part of this procedure, a partial sternothyroidectomy is performed as described above and the larynx is elevated dorsally and rostrally using sutures placed from the thyroid cartilage to the basihyoid bone. Because the weak part of this procedure is anchoring the sutures to the thyroid cartilage, a few modifications have been described: four passes of sutures in the thyroid cartilage; and the use of surgical buttons to buttress the thyroid cartilage. In addition, various suture patterns around the basihyoid bone have been described. Mechanically the procedure results in rostral and dorsal movement of the larynx and caudal and dorsal elevation of the basihyoid bone.

There is far less information on the treatment of horses with persistent DDSP. No evidence-based study is available to guide clinicians as to how to manage these cases. In our experience, if there is any tracheal aspiration of feed material, this should be resolved first. Any painful condition that includes epiglottic ulceration or chondritis must also be resolved. Then we use the surgical steps in the order suggested by Ortved et al. (2010): removal of redundant aryepiglottic tissue, laryngeal tie-forward and, if needed, laser staphylectomy.

Further reading


References available on request.
Recurrent laryngeal neuropathy (RLN) is by far the leading cause of arytenoid collapse in the horse. The definitive aetiology of RLN has not been confirmed but both genetic and acquired causes are considered possible. RLN tends to manifest more commonly in large horses, particularly draught horses (Goulden and Anderson, 1981b; Goulden et al. 1985; Archer et al. 1989; Bohanon et al. 1990; Hawe et al. 2001) and is rarely reported in ponies (Dixon et al. 2001). Clinically significant RLN is reported more frequently in males (geldings and stallions) than females (Goulden and Anderson 1981b; Dixon et al. 2001).

RLN, also known as laryngeal hemiplegia or roaring, is a common cause of dynamic upper respiratory tract obstruction and poor performance in the equine athlete (Lane et al. 2006b; Garrett et al. 2010). Distal axonopathy of the recurrent laryngeal nerve is responsible for neurogenic atrophy of the cricoarytenoideus dorsalis (CAD) muscle (clinically affecting the left side) (Duncan et al. 1974, 1978; Cahill and Goulden 1987) and ultimately failure of the arytenoid cartilage to abduct completely (Rakestraw et al. 1991). Inability to abduct the arytenoid cartilage reduces the cross-sectional area of the rima glottidis and this impedes inspiratory air flow (Christley et al. 1997). Since the respiratory system is considered performance-limiting in normal horses, any reduction in inspiratory oxygen content will have a marked detrimental effect on performance—a horse with RLN is at a considerable disadvantage compared with a horse with normal laryngeal function.

In horses, the recurrent laryngeal nerves are the longest peripheral nerves in the body with the left nerve looping around the aorta and the right circling the subclavian artery in the thorax. The total length of the left recurrent laryngeal nerve is up to 250 cm in large horses (up to 40 cm longer than the right recurrent laryngeal nerve) (Cole 1946; Hackett 2000). Distally, the recurrent laryngeal nerves divide into abductor and adductor branches. Each recurrent laryngeal nerve comprises predominantly medium-sized myelinated fibres (Duncan et al. 1991b). Myelinated axons in the recurrent laryngeal nerve segregate initially as fascicles within the vagus nerve; however, the axons for adductor and abductor muscles are mixed within these fascicles throughout the length of the recurrent laryngeal nerve (Dyer and Duncan 1987).

Histopathological changes associated with RLN have been identified in fetuses (Gunn 1973) and in draught horse foals (as young as 2 weeks) (Duncan 1992; Harrison et al. 1992) and therefore supports a congenital and/or hereditary aetiology. A hereditary aetiology seems probable since progeny of RLN-affected stallions are more likely to be affected with RLN than progeny of unaffected stallions (Poncet et al. 1989; Ohnesorge et al. 1993). A recent genome-wide association study (GWAS) of over 500 horses revealed two large loci that appeared protective against RLN, although no disease-associated loci were identified (Dupuis et al. 2011). If RLN is confirmed to be heritable, it is possible that this undesirable trait is the result of either domestication or inbreeding of the horse (Cook 1992). RLN would be a significant disadvantage for a wild, prey animal so it is not surprising that no evidence of RLN has been identified in zebra, another equid species (Hahn and Mayhew 2000).

RLN is characterised by a bilateral distal axonopathy of the recurrent laryngeal nerves (Hahn et al. 2008a) resulting in a progressive loss of large myelinated fibres with the left recurrent laryngeal nerve being more severely affected than the right (Duncan et al. 1978; Cahill and Goulden 1986a, 1986b). Although the reduction in numbers of myelinated fibres and axonal degeneration are greatest in the distal left recurrent laryngeal nerve, similar changes have also been noted proximal and distal to the aorta and within the vagus nerve; abnormalities are also seen on the right side to a lesser extent (Hahn et al. 2008a).

Histopathology may be regarded as a gold standard in assessing muscle morphology (Dubowitz and Sewry 2007). However, the small size and location of the CAD muscle in the horse renders serial muscle biopsy of this muscle technically challenging, and furthermore, may induce injury. Hence, objective, noninvasive methods of evaluating structure and function of the left CAD muscle using advanced imaging techniques are required that will enable monitoring of response to novel muscle-directed treatments, including functional electrical stimulation.

A study by Tulloch (2014) has demonstrated the relationship between intrinsic laryngeal muscle morphology, recurrent laryngeal nerve fibre density and laryngeal function at rest and exercise in horses with naturally occurring RLN and thus endorses the use of standing computed tomography (CT), transoesophageal ultrasound (TEU) and laryngeal endoscopy for the evaluation of RLN severity. The histopathology of RLN is very complex due to the concurrent denervation and reinnervation of the muscle and thus will vary between individuals and disease severity. By summarising the histopathology variables from the left and right CAD muscles, a significant difference was identified between horses with resting grades 2 and 4, and resting grades 3 and 4. This study demonstrated the association between left recurrent laryngeal nerve fibre density, histopathology of the intrinsic laryngeal muscles, CT and ultrasonographic assessment of the intrinsic laryngeal muscles and laryngeal function at rest and exercise in horses with naturally occurring RLN. Standing CT and TEU of the larynx provide useful information on laryngeal muscle morphology and function and are likely to be beneficial in monitoring the effects of muscle/nerve directed treatments.

References available on request.
Airway surgery: standing or GA?

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Standing laryngoplasty

Laryngoplasty is the most commonly used surgical treatment for recurrent laryngeal neuropathy (RLN) in sport and racehorses and is usually performed with the horse anaesthetised in lateral recumbency. The incidence of laryngeal hemiplegia seems to be higher in draught horses and large sport horses. However, complications associated with general anaesthesia and laryngoplasty, such as prolonged recovery and myopathy or neuropathy, are more frequently reported in draught horses than in light horses under similar conditions.

Surgical technique

The horse is sedated with detomidine (0.01 mg/kg bwt) or romifidine (40–80 µg/kg bwt) or a combination of both. Butorphanol tartrate (0.01 mg/kg bwt i.v.) or morphine (0.5–0.8 mg/kg bwt i.v.) is also administered to enhance analgesia. A unilateral or bilateral ventriculocordectomy (VC) is usually performed prior to laryngoplasty with a transendoscopic diode laser. It can also be performed through a laryngotomy performed with the horse standing. The horse is fitted with ear plugs and a hood with blinker over the left eye. The left laryngeal area is then prepared for aseptic surgery. The head is placed in an intermediate extended position using a head stand and is kept stable in a sagittal position by an assistant. A large (200 x 250 cm) impermeable drape is placed over the left laryngeal area and secured with towel clamps on the hood and to a rope fixed on the dorsal neck between the hood and a surcingle. The linguofacial vein is marked with a sterile pen and 2% lidocaine (10–15 mL) is infiltrated up to the incision using an inverted V-shaped line. A standard approach to the caudal aspect of the cricoid cartilage, ventral to the linguofacial vein, is adopted. Either a lidocaine or mepivacaine external flush is used over the larynx or lidocaine-impregnated gauze swabs are placed over the cricoid prior to applying the suture.

All sutures and implantation techniques used in the horse under general anaesthesia can be adopted. We usually use two sutures of braided polyester (No. 5 Fiberwire® and No. 2 Fibertape®) reinforced at the muscular process (MP) with metallic suture buttons (Arthrex or Imex). The endoscope is inserted at the beginning of surgery and fixed to the halter. This strategy allows dissection and passage of the needle through the cricoid cartilage to be controlled and helps the surgeon to check that the tracheal lumen is not penetrated. The surgical wound is lavaged and routinely closed in three layers. A stent bandage is applied.

Exposure of both the cricoid cartilage and the MP are better than with the same procedure performed under general anaesthesia. Tightening the suture in a physiological position on the standing horse is very useful as it enables the most suitable position for the abducted arytenoid cartilage to be determined for each horse. Our unmeasured observation is that less force is needed than in a horse under general anaesthesia to obtain abduction in the majority of horses.

Standing nerve graft

A more physiologically viable treatment option for RLN involves reinnervation of the cricoarytenoideus dorsalis muscle (CAD) with transplantation of the first (C1) or second (C2) cervical nerve. The omohyoideus (OH) muscle is innervated by a nerve formed by the first and second cervical nerve branches, hereafter referred to as the C1/C2 nerve. The recently described nerve-implantation technique is replacing the nerve-pedicle procedure.

Although any horse with RLN is a candidate for laryngeal reinnervation, younger horses and those with grade 3 laryngeal movements are the ideal candidates for this surgical procedure.

Sport horses with grade 3 RLN are excellent patients for reinnervation, as these horses have a long career. Such physiological procedures should provide optimal long-term functional results while preventing complications such as coughing.

Patient preparation and the initial surgical approach are similar to those for laryngoplasty. The procedure was initially performed under general anaesthesia but is now performed in the standing patient in most cases.

The main body of the C1/C2 nerve is identified with the help of a single pulse nerve stimulator (1mA).

The nerve branch that produces the strongest contraction of the OH is selected and gently dissected proximally, as well as one or two other smaller branches. Once they have been sufficiently freed, the distal ends of the nerves are cut.

The thyropharyngeus and cricopharyngeus muscles are bluntly separated. The rostral two-thirds of the cricopharyngeus muscle are sectioned transversely to expose the CAD. The larynx is subsequently rotated laterally. The selected main branch of the nerve is implanted within the CAD tunnel using a Reverdin needle from medial to lateral and secured to the lateral belly of the CAD muscle. Any excess nerve branch is implanted directly in a small slit in the lateral muscle belly of the CAD as described.

We have recently used a caudal approach, by approaching the CAD muscle and MP caudal to the cricopharyngeus muscle. This technique offers improved access to the CAD, does not involve myotomy of the cricopharyngeus muscle, and reduces the risk of post-operative constriction of the nerve by scar tissue.

The horses resume training at 6–12 weeks post-operatively, depending on the remaining post-operative function of the CAD, and the expected improvement after ventriculocordectomy.

Exercising endoscopy and ultrasound-guided percutaneous stimulation of the first cervical nerve at the level of the alar foramen are used to confirm successful reinnervation post-operatively.

The current success rate of this new procedure is comparable to that of prosthetic laryngoplasty. Performing the technique in the standing patient is very well tolerated, improves visualisation, and reduces the risks associated with general anaesthesia and recovery.

For young horses that have never been raced and horses of high value because of their breeding potential, reinnervation can be offered because the restoration of a functional CAD is a more physiologically efficacious method of treating RLN. If the result of laryngeal reinnervation is unsatisfactory, a laryngoplasty may still be performed.
Currently, the standard treatment for recurrent laryngeal neuropathy (RLN) is prosthetic laryngoplasty, with the goal to permanently abduct the left arytenoid. This nonphysiological procedure has been modified during the last decades but still has undeniable adverse effects on upper airway health that can be clinically apparent or subclinical. A recent review of complications after prosthetic laryngoplasty describes complications including dysphagia, chronic coughing, loss of arytenoid abduction and wound inflammation and infection. Another more physiological treatment option for RLN is the reinnervation of the CAD with transplants of the first or second cervical nerve (C1, C2 respectively). This surgery aims to restore physiologically the function of the muscle and avoid major complications, especially dysphagia and coughing. First attempts at reinnervation in horses have been published by Ducharme et al. 1989 more than two decades ago. They described three possibilities for reinnervation:

- Firstly, the nerve–muscle pedicle implantation, where small pieces of the omohyoideus muscle (OH) at the entry of the C1 or C2 branches in the OH were harvested and were implanted in longitudinal incisions in the CAD.
- Secondly, the direct implantation of the C1 or C2 nerve end into the atrophied CAD.
- Thirdly, the anastomosis of the C1 to the abductor branch of the left recurrent laryngeal nerve.

The technique of nerve–muscle pedicle implantation was established by Fulton et al. 2012 and reports positive results with similar success rates, lower morbidity but longer post-operative recovery than prosthetic laryngoplasty. Recently, a direct C1/C2 nerve implantation technique has been described by Rossignol et al. 2018, and the technique will be discussed in this presentation. Functional electrical stimulation (FES) is the application of stimulation devices to rehabilitate neurological deficits, widely used in human medicine to restore motor and sensory deficits (Kern et al. 1999; Grill et al. 2001). Potential therapeutic benefits of a FES approach are to restore muscle mass and muscle force and to improve fatigue resistance. Since the 1970s researchers have been interested on the implantation of pacing systems (neuroprosthesis) as an alternative treatment for human patients suffering from bilateral vocal fold paralysis (BVCP) (Zealear and Dedo, 1977). Laryngeal pacing through neuroprosthetic device has been shown to restore ventilation in patients, both humans and animals, suffering vocal cord paralysis (Otto et al. 1985; Bergmann et al. 1988; Zrunek et al. 1991; Zealear et al. 2002, 2003, 2013). Since 2004 we have been testing the feasibility of FES also in horses, specifically on the equine upper airway tract, to verify its influence on the native function of several muscles and eventually its use to restore naturally occurring deficits. Original studies evaluated pacing of the recurrent laryngeal nerve, but its long-term application was unsuccessful because of nerve cuff technical issues and progression of the neuropathy (Ducharme et al. 2010; Vanschandevijl et al. 2011). A recent study by Cheetham et al. 2011, showed that CAD electrical stimulation through intramuscular electrodes provides an adequate arytenoid abduction both at rest and during strenuous exercise in horses. A summary of these studies will be discussed in this presentation, along with the combination of C1 nerve grafting and FES.

References available on request.
EIA – a genuine threat from the continent?

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Introduction
Equine infectious anaemia (EIA), also referred to as swamp fever, is caused by a lentivirus (EIAV) of the retrovirus family which infects equids. The virus is recognised worldwide and outbreaks have occurred in North and South America, Africa, Asia, Australia and Europe. EIA is a notifiable disease in the UK and is not recognised as a zoonotic risk. The incubation period ranges from as little as 3 days to as long as 3 months, but generally takes 1-3 weeks. Diagnosis is through detection of antibodies against EIAV using either agar gel immunodiffusion (AGID or Coggins test) or enzyme-linked immunosorbent assay (ELISA). It usually takes around 14 days after infection for an animal to develop detectable antibody, but seroconversion can take much longer, which is why repeat testing every 30 days for 3 months after possible exposure is currently recommended in controlling an outbreak. Antibody persistence is then lifelong.

There are three forms of the disease: acute, chronic and subclinical.
• Acute disease is characterised by high fever (40–42°C) lasting a couple of days and may be accompanied by depression, inappetence, petechiation of conjunctiva and mucous membranes, haemorrhagic diarrhoea, skin swelling, anaemia and pallor, jaundice, tachycardia and sometimes death. Such animals are highly viraemic and pose an infectious risk to in-contact horses. Surviving animals may go on to develop the chronic form of disease.
• Chronic disease is associated with recurrent bouts of pyrexia and accompanying increased viraemia and there may be chronic depression, weight loss, anaemia and weakness.
• These bouts become less frequent and less infectious over time until the animal becomes a subclinical case which, although infected, often exhibits no detectable clinical signs at all.

EIAV is transmitted from an infected to a susceptible animal via blood or blood products containing infectious virus. This can be transplacentally from dam to foal, via infected blood products such as hyperimmune plasma or contaminated veterinary equipment, or via insect vectors, notably biting flies which take large blood meals. Infected horses remain infected for life and are a potential source of infection to susceptible in-contact animals, particularly during pyrexic episodes with their correspondingly increased levels of viremia.

EIA occurrence in Europe
In the EU, Italy and Romania are considered endemic for EIA, as historically, infected horses were not always culled but were isolated for the rest of their lives; this is allowed under EU rules, but any in-contact horses must also remain under restrictions. Elsewhere in the EU, EIA outbreaks are sporadic and not considered epidemics. Isolated cases have been reported since 2012 from Belgium, Bulgaria, Croatia, France, Germany, Greece, Hungary, Slovakia, Slovenia and most recently, Spain, Switzerland and the Netherlands.

In 2006 in the Irish Republic and Northern Ireland, over 30 horses across three outbreak foci were detected after initial administration of a nonlicensed contaminated blood product introduced EIAV. The virus was subsequently transmitted via several different routes including aerosols of infected blood, contaminated veterinary equipment and vectors.

Other significant EIA outbreaks have also involved iatrogenic transmission, as evidenced in Germany in 2012 when a series of outbreaks occurred, related to contact with an equine clinic in North Rhine Westphalia and a blood donor horse that had acted as a source of EIAV which had multiple primary and secondary contacts. Several horses tested positive and a large tracing exercise was carried out to determine if there was wider infection present in the German horse population, although no further cases were detected. An example of the impact was that a traced contact in a stable at Cologne racecourse tested positive, leading to nearly 300 other racehorses being restricted for 3 months while clearance testing was conducted.

More recently, in June 2017 subclinical EIA was officially confirmed in 11 polo ponies in four German states leading to multiple in-contact animals being investigated, not only in other German federal states, but also in different EU countries including Austria, Belgium, Denmark, France, Netherlands, Spain and the UK as well as in Argentina. The epidemiological investigations indicated that seropositive animals had previously participated in an official polo tournament in Lower Saxony, Germany. Subsequent outbreaks were officially confirmed on three premises in Germany through these tracings and a further three outbreaks involving five positive horses were identified in Germany in August 2017. From the tracings to other EU member states, a single case of EIA was subsequently confirmed in Utrecht in the Netherlands, two subclinical cases in the province of Avila in the west of Spain and a subclinical case in Mühlingen, Switzerland, all in July 2017. Six polo ponies traced back to the UK from Germany were negative on initial testing and remained negative after a period of restriction. Four clinical EIA cases, not believed to be related to polo, were also reported by Macedonia in July 2017.

Mitigating risk pathways for UK horses
It is evident that movement of even outwardly healthy horses from mainland Europe may carry some risk with respect to EIA, particularly where there may be links to endemic areas, such as Italy or Romania, although these may not always be obvious. Pre-purchase or pre-movement testing by Coggins/AGID test or ELISA is a sensible precaution if feasible. This should be in combination with some form of post-arrival quarantine, preferably in insect-vector-protected housing, depending on the time of year, with basic clinical monitoring such as twice daily recording of rectal temperature. Care should be taken with hygiene and biosecurity with respect to indirect transmission risks via contaminated equipment. Veterinary advice should be sought at all stages and further blood testing prior to exiting quarantine provides the best assurance.
From recent evidence the highest risk pathways for EIA transmission appear to be (in decreasing order of risk):

1. Blood transfusion or other blood products from firstly any clinical EIA case, or secondly, any subclinically infected animal.
2. Iatrogenic or close contact transmission from a clinical case, including sexual contact.
3. Vector transmission by biting insects at certain times of the year from a clinically affected horse or iatrogenic or close contact transmission from a subclinical case, including sexual contact.
4. Vector transmission by biting insects at certain times of the year from a subclinical case.

NOTES
African horse sickness (AHS) is an arboviral disease of Equidae that causes devastating outbreaks of high morbidity and mortality (>90%) in susceptible populations. The disease is endemic in Sub-Saharan Africa but has occurred in periodic outbreaks outside this geographical region throughout the last century. The aetiological agent of AHS is African horse sickness virus (AHSV), an orbivirus very closely related to the agent that causes bluetongue in ruminants. Bluetongue, a disease that was in the past restricted to tropical and subtropical regions of the earth, is today endemic in mainland Europe, causing considerable disruption to the farming industry. This was related to the northerly spread in the last two decades of the insect vectors that transmit bluetongue. Both AHS and bluetongue are transmitted by biting haematophagous insects of the genus Culicoides and for this reason, the perception of an outbreak of AHS occurring again in Europe has justifiably increased.

The impact of AHS in animal welfare, international trade and the economy of affected countries has led to it being a notifiable disease in the UK, one of the top five priority diseases listed in the new EU Animal Health Law, and a World Organisation for Animal Health (OIE) listed disease. It is also the only equine infectious disease for which the OIE certifies disease-free status for specific countries.

The effective control of AHS depends on efficient and co-ordinated implementation by local veterinary authorities of a range of measures based on:

- The use of accurate and rapid diagnostic tests.
- Prevention of insect biting.
- Control of animal movement.
- The use of efficient, safe, protective vaccines.

However, there are justified biosafety concerns over the use of live attenuated AHSV vaccines, which currently are the only AHSV vaccines licensed. This has prompted research efforts on AHSV with the objective of improving the efficacy and safety of AHSV vaccines.

During the last two decades, significant progress has been made in the molecular characterisation of AHSV and improving understanding of the biological properties of the virus, which has served to underpin the development of novel diagnostic tests and vaccines. Today, new improved, rapid and accurate tests are available in AHS diagnostic laboratories. In contrast, while a wide range of novel vaccination strategies have been developed over the years, most of which show very good protective efficacy data in experimental settings, none have yet reached the market. There are a number of factors behind this lack of progress in vaccine commercialisation:

- Considerable scientific challenge in developing novel vaccine technologies.
- Absence of a long-term sustainable funding strategy.
- Lack of co-ordinated efforts between the various stakeholders (equine industry, vaccine industry, scientists, local and international veterinary authorities).
- Commercial barriers based on the small size of the immediate AHS vaccine market.

Recent initiatives addressing these difficulties have been developed by the OIE in association with the Fédération Equestre Internationale (FEI) and International Federation of Horseracing Authorities (IFHAA) and represent the start of bringing a solution to the lack of a reliable, efficacious, safe AHS vaccine for global use. These initiatives have been based on support for the use of OIE validated diagnostic tests (RT-PCR and ELISA) for AHS, the evaluation of the economic impact of AHS, and review of currently available technologies suitable for development of improved AHS vaccines. A brief review of these initiatives will be presented and discussed.
Streptococcus zooepidemicus is often isolated from the respiratory tracts of healthy horses, suggesting that this bacterium is simply a harmless commensal. However, S. zooepidemicus is a genetically diverse pathogen with the potential to cause an array of diseases in a wide range of different animal species, including cattle [1], sheep [2], goats [2], pigs [3], dogs [4] and humans [5,6]. The presence of S. zooepidemicus in horses is associated with respiratory disease [7,8], uterine infections [9,10] and ulcerative keratitis [11]. Furthermore, a biovar of S. zooepidemicus, S. equi, is the causative agent of strangles, one of the most frequently identified infectious diseases of horses worldwide [12].

Identifying disease-causing strains

The analysis of the DNA sequences of seven gene fragments of S. zooepidemicus strains using multilocus sequence typing (MLST) currently resolves 379 different strain types (https://pubmlst.org/szoeeidemicus/ [accessed 22 January 2018]) [13]. MLST can enable the identification of disease-causing strains despite the presence of other strain types. Unlike other techniques, MLST provides a snapshot of the history of infection within an individual animal rather than the assumed identity of harmless bacteria.

Fine mapping epidemics of disease

Modern DNA sequencing techniques provide even higher resolution of different strain types through the comparison of whole genome sequences. We applied genome sequencing to dissect an epidemic of respiratory disease in Iceland, which swept across the country in 2010 leading to a self-imposed quarantine of horses [14]. MLST can enable the identification of disease-causing strains despite the presence of other strain types. Unlike other techniques, MLST provides a snapshot of the history of infection within an individual animal rather than the assumed identity of harmless bacteria.

Preventing new outbreaks

Significant progress has been made towards the development of a new vaccine against strangles [17], directed by data from the S. equi genome sequencing project [18]. The genomes of 47 isolates of S. zooepidemicus that were recovered from the tracheal wash samples of young Thoroughbred racehorses with signs of airway inflammation at 11 different racing yards in the UK have been sequenced. Twenty-nine different strains were identified, with 14 strains being recovered from just one of the yards. Interestingly, 30% of the strains were genetically related, clustering into a clonal complex that may be more likely to infect the trachea of young racehorses. These data concur with an earlier MLST-based study that identified six groups of S. zooepidemicus that were more likely to be recovered from the respiratory tract of horses [13]. The application of modern genetic tools that have been developed in S. equi [19] to identify key determinants of virulence in specific groups of S. zooepidemicus has the potential to facilitate the development of new therapeutics and vaccines with which to prevent disease in horses and other animals. However, at least for now S. zooepidemicus remains one ‘bad guy’ that we should not forget about.

Acknowledgement


References


EHV as a cause of respiratory disease
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Upper respiratory tract disease
Equine herpesvirus-1 (EHV-1) and EHV-4 are double-stranded DNA α-herpesviruses, with EHV-4 being considered one of the leading respiratory viruses associated with upper airway infections. Following a short incubation period, infected horses develop fever, lethargy, anorexia, malarial lymphadenopathy and profuse serous nasal discharge that later becomes mucopurulent. A dry cough secondary to rhinotraheitis is occasionally observed but is not a consistent feature of the disease. Contemporary information on the frequency of EHV-4 detection in 3,028 horses with acute onset of fever and respiratory signs showed that 12.3% of them tested qPCR-positive for EHV-4 [1]. Furthermore, young horses, Thoroughbreds and ranch/farm use were prevalence factors that proved to be significant for horses testing qPCR-positive for EHV-4. Nasal and ocular discharge and fever were more frequently seen in EHV-4 qPCR-positive horses compared to EHV-4 qPCR-negative horses. Comorbidity of EHV-4 with EHV-1 and equine rhinitis viruses (ERVs) was associated with greater and lower frequency, respectively. A similar study recently looked at frequency of detection and prevalence factors in 4,228 equids with acute onset of fever, respiratory signs and/or neurological deficits [2]. In that study, a total of 2.7% equids tested qPCR-positive for EHV-1, with most of the isolates belonging to the non-neuropathogenic genotype (N752). EHV-1 qPCR-positive equids were overrepresented in racing horses. Lethargy, anorexia, nasal discharge and coughing were significantly less frequently reported in the EHV-1 qPCR-positive equids when compared with the EHV-1 qPCR-negative cases. Neurological deficits were more frequently reported in the EHV-1 qPCR-positive cases.

qPCR offers an alternative to virus isolation and has proven to be a sensitive method of detecting EHV-1/EHV-4 in respiratory secretions, peripheral blood lymphocytes and other tissues. Because qPCR assays for EHV-1/EHV-4 routinely used in the diagnostic field are based on the detection of viral genomic DNA, they are unable to distinguish between lytic, nonlytic or latent virus. Alternative molecular approaches have recently been established in order to better define viral states of EHV-1 by targeting several viral genes (e.g. glycoprotein, latency-associated transcripts); detecting viral genomic DNA and transcriptional activity of the target genes at the messenger RNA level; and using absolute virus quantification. This molecular strategy is used diagnostically for EHV-1 and EHV-4 infected horses in order to discriminate between lytic and nonreplicating virus, to determine their infectious risk based on viral load in nasal secretions and to monitor their response to treatment.

It is difficult to determine the exact role the two α-herpesviruses EHV-2 and EHV-5 play in the development of upper respiratory tract infection. EHV-2/EHV-5 are widespread in horse populations; hence the detection of any of these viruses can occur in healthy but also in sick equids. These viruses are optimally adapted to their host, which means that significant clinical expression of infection is rarely encountered. These viruses appear to contribute to various forms of clinical disease in young horses, including upper respiratory tract signs, fever, pharyngitis and enlarged lymph nodes. Another characteristic of EHV-2/EHV-5 is their ability to immunomodulate the immune system. This characteristic makes EHV-2/EHV-5 potential cofactors of infection or disease.

Contemporary information on the frequency of EHV-2/EHV-5 detection in 3,030 horses with acute onset of fever and respiratory signs showed that 11% of horses tested qPCR-positive for EHV-2 alone, 20% of horses tested qPCR-positive for EHV-5 alone and 28% of horses were dually positive by qPCR for EHV-2 and EHV-5. In the same population 10% of horses tested qPCR-positive for EHV-4, 9% of the horses tested qPCR-positive for EIV, 6% of the horses tested qPCR-positive for S. equi subspecies equi, and less than 3% of the horses tested qPCR-positive for EHV-1 and ERVs. The results of this study showed that EHV-2 and EHV-5 infection alone were not associated with severe clinical disease, while dual infection with EHV-2 and EHV-5 was associated with nasal discharge, ocular discharge, cough and fever. This association describes the potential of a dual infection giving rise to pathogenesis compared with infection with EHV-2 or EHV-5 alone.

Lower respiratory tract disease
Equine multinodular pulmonary fibrosis (EMPF) is a recently described condition that has been associated with EHV-5 infection in adult horses. The clinical presentation of EMPF is variable, ranging from exercise intolerance to severe respiratory distress. Consistent clinical signs include coughing, nasal discharge, adventitious breath sounds, tachypnoea, tachycardia, weight loss and exercise intolerance. These clinical signs are not pathognomonic for EMPF and can be caused by a variety of other inflammatory pulmonary disorders. A diagnosis of EMPF is generally suspected based on history, clinical signs, imaging studies of the thoracic cavity and analysis of pulmonary fluids. The current gold standard diagnostic techniques to confirm EMPF include demonstration of characteristic microscopic lesions (interstitial fibrosis, mixed inflammatory cells in the interstitium, pneumocyte type II hyperplasia, intraluminal accumulation of neutrophils and macrophages) coupled with positive EHV-5 qPCR analysis of the affected lung. The aforementioned diagnostic techniques require collection of lung tissue either via percutaneous biopsy procedure or during post-mortem examination. Due to the invasive nature of percutaneous biopsies and expected complications (epistaxis, tachypnoea, coughing, respiratory distress), the testing of bronchoalveolar lavage fluid (BALF) for EHV-5 by qPCR is commonly used to support a laboratory diagnosis of EMPF. A recent study determined that qPCR testing of BALF or a combination of whole blood and nasal secretions should be regarded as clinically useful in support of EMPF [3]. The latter testing may be relevant when dealing with horses in respiratory distress, for which invasive procedures such as BALF collection or lung biopsies may be detrimental to their health.

References
Chlamydia psittaci – don’t be embarrassed

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Introduction
Chlamydia psittaci, a Gram-negative obligate intracellular bacterium, is an avian pathogen that infects birds globally. The organism may undergo successful cross-host transmission to a number of mammalian hosts, resulting in sporadic infection in other species including sheep, goats, cattle, horses and cats. Infection with C. psittaci has been associated with abortion, pneumonia, polyarthritis and conjunctivitis. In humans, infection with C. psittaci typically results from direct contact with birds (most commonly parrots) or bird excreta and causes a systemic infectious disease, psittacosis, which is characterised by fever, atypical pneumonia, malaise and myalgia. Furthermore, complications of psittacosis may develop in humans, including myocarditis, endocarditis, hepatitis, reactive arthritis and neurological disease [1]. Recently, C. psittaci has emerged as a potential cause of placentitis, abortion or neonatal disease in horses. In addition, outbreaks of psittacosis in humans have developed in association with exposure to products of equine abortion [1] or critically-ill equine neonates, reflecting the emergence of a novel source of infection.

Chlamydia psittaci infection in horses
In 2014, a cluster of five human psittacosis cases occurred at a veterinary school in Australia and at a local horse stud. All cases had exposure to grossly abnormal fetal membranes from a mare with placentitis: C. psittaci was subsequently detected in the membranes by PCR [1] and C. psittaci-specific multilocus sequence typing identified an avian-like C. psittaci strain [2]. Subsequently, surveillance of equine abortion in New South Wales (NSW) by the Department of Primary Industries during 2015–2017 has identified over 30 further cases of abortion in which C. psittaci nucleic acid has been detected. Abortion occurs in the last trimester and may occur over multiple years. Histologically, nonsuppurative placentitis, fetal pneumonia and nonsuppurative hepatitis are typically present. On affected studfarms, C. psittaci-associated abortions can be single or multiple events and may occur over multiple years (J. Carrick, personal communication). While serological testing may detect increased serum concentrations of antibodies against C. psittaci in affected mares, increased titres are unpredictable and often short-lived.

In foals, C. psittaci infection has been associated with neonatal acute respiratory distress syndrome (nARDS) and high rates of mortality. Over the 2016–17 foaling season, 13 cases of C. psittaci-associated nARDS were presented to three neonatal intensive care units (NICU) in NSW. At the time of presentation to the NICU, foals were 30 minutes to 5 days old. They were usually recumbent, inappetent, markedly obtunded and hypothermic. The foals had variable heart rates (40–160 beats/min) and respiratory rates (4-106 breaths/min). Common abnormalities present in haematological and blood biochemical analyses were leucopenia, hypoglycaemia, hyperlactataemia, azotaemia and increased concentrations of acute phase proteins. Arterial blood gas analysis typically revealed hypoaxemia, hypercapnia and mixed acidosis. Radiographic examination revealed marked, diffuse interstitial changes to the lungs. Intensive management of all foals was initiated, including administration of parenteral antimicrobial drugs, i.v. fluid therapy, positive inotropes, parenteral nutrition and respiratory support. Most foals demonstrated progressive clinical deterioration despite treatment and died or were subjected to euthanasia within 36 hours of presentation. Only 2 of 13 foals survived to discharge.

Post-mortem examination of nonsurviving foals identified diffuse bronchopneumonia, pulmonary congestion and atelectasis in all foals and hepatic congestion and inflammation was also often present. C. psittaci nucleic acid was variably detected from nasal secretions, rectal mucosa, lung tissue and fetal membranes. Six foals were born on farms with a previously history of abortions that were PCR positive for C. psittaci nucleic acid. All foals were negative for equine herpesvirus-1 infection, and leptospirosis was excluded in all foals that had a post-mortem examination. As an unprecedented event, an outbreak of psittacosis in veterinary staff and students involved in the intensive care of one of the surviving foals occurred, representing a further emerging route for human infection.

These recent experiences in Australia indicate that C. psittaci should be considered as a differential diagnosis for late-term abortion in mares and neonatal foals with signs of severe systemic disease, including nARDS. Furthermore, the emergence of associations between exposure to products of equine abortion and sick equine neonates has important implications for zoonotic disease and prevention and control of psittacosis in these settings. Personnel involved in the reproductive management of foaling/aborting mares and management of critically-ill neonatal foals may be at increased risk of exposure to C. psittaci and development of psittacosis. As such, appropriate use of personal protective equipment should be considered during these high-risk situations. As the equine manifestations of C. psittaci infection represent an emerging and poorly understood aspects of this pathogen, it remains uncertain as to whether manifestations of disease will occur in other geographical locations.

References
Coronavirus in the UK?

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**Background**
Equine coronavirus (ECoV) is a betacoronavirus associated with disease in individual animals and in groups of horses. Since 2011 it has been increasingly reported in disease outbreaks, mainly involving adult horses in the USA and Japan [1–3]. The virus primarily infects the small intestine, causing enteritis, and a faeco-oral route of transmission is suspected [4–6]. The main clinical signs associated with infection in adult horses are anorexia, lethargy and fever, with diarrhoea and colic signs less frequently reported [1,3]. In clinical adult cases the main haematological abnormalities are leucopenia with lymphopenia and/or neutropenia [1] and quantitative PCR (qPCR) to detect viral RNA in faeces is currently the test of choice to confirm infection. Most horses recover with supportive care and serious complications are rare; however, sepsis and encephalopathy associated with hyperammonaemia have been reported [1,7].

Equine coronavirus has also been associated with enteric infection in foals; however, it commonly presents a co-infection with other infectious agents and in one USA study it was frequently detected in the faeces of healthy foals [8,9].

ECoV has an international distribution and molecular detection has been reported in horses from the USA and Japan, with the first detection in Europe being reported in France in the winter season of 2011/2012 [10].

**Current situation in the UK**
At Rossdales laboratories we began offering qPCR testing for ECoV in March 2015. Between March 2015 and July 2017, we tested 381 faecal samples from adult horses, yearlings, foals and donkeys for the presence of ECoV RNA. The samples were divided into two groups. Group 1 consisted of 156 faecal samples for which the submitting veterinary surgeon had requested ECoV testing. In addition to this we screened 225 faecal samples that were submitted to the laboratory from predominantly healthy horses for other diagnostic tests (group 2).

Equine coronavirus RNA was detected in faeces from four horses, all within group 1 (2.6% of group 1 horses). No ECoV RNA was detected in samples from group 2 horses.

The first positive case was detected in December 2016 and was a 19-year-old cob that presented with clinical signs of inappetence, lethargy, pyrexia and low-grade colic, and haematological abnormalities of leucopenia with neutropenia and lymphopenia, similar findings to those reported in clinical cases of ECoV infection in other countries [1,3]. The horse made a full recovery with supportive care and ECoV infection was considered to be the cause of disease in this case.

The other positive cases were detected in March 2017. These were three Thoroughbred yearlings from the same premises, and main presenting clinical signs included weight loss and lethargy. All yearlings were diagnosed with and successfully treated for concurrent larval cyathostomiasis. The significance of ECoV infection in these younger horses was more difficult to determine and larval cyathostomiasis was considered to be the primary cause of the clinical signs; however, coronavirus may have played a role as a co-infection. Faecal samples from six healthy in-contact yearlings tested qPCR negative for ECoV RNA.

ECoV from the first positive case was submitted for sequencing, and partial sequencing of the N gene showed 99% homology with previously reported ECoV strains from the USA and Japan (ECoV-NC99 and ECoV-Tokachi09). Since July 2017 we have detected three additional qPCR positive cases in the UK.

**Conclusion**
The true incidence of ECoV infection in horses in the UK is not known; however, our initial screening suggests that prevalence of ECoV infection is low, both in healthy horses and horses with enteric disease. However, in horses with compatible clinical signs, ECoV should be considered as a potential pathogen, with qPCR testing of faeces being the diagnostic test of choice.

**References**
Introduction
Equine herpesvirus-1 (EHV-1) is a contagious viral disease of horses that is spread by direct horse-to-horse contact, indirectly by contaminated hands, equipment and tack, and probably through aerosolisation of the virus within enclosed environments.

Clinical signs include fever, nasal discharge and coughing in the respiratory form of the disease. Abortion, stillbirth and early neonatal death are seen in infected pregnant mares, usually in the final trimester of pregnancy. Weakness, incoordination, ataxia, paralysis and difficulty urinating and defaecating may be seen in the neurological form of EHV-1 infection, which tends to affect adult horses and may be fatal as affected animals are often euthanised on humane grounds.

Clinical signs alone may be suggestive of EHV-1 but laboratory diagnoses are strongly recommended. These include quantitative PCR assay on nasal swabs, fetal, placental and/or central nervous system (CNS) tissues; immunohistochemistry on fetal, placental and/or CNS tissues; paired serology using the complement fixation (CF) test and elevated CF antibodies in neurological cases in the absence of recent EHV vaccination. EHV-1 is considered endemic worldwide, with the exception of Iceland, which has no evidence of infection and has not imported horses in over 1000 years.

EHV-1 is not notifiable in the UK, although voluntary control measures are detailed in an industry code of practice produced by the Horserace Betting Levy Board (https://codes.hblb.org.uk/index.php/page/32). No zoonotic risks are recognised for EHV-1.

Rationale for EHV-1 control measures
Latent infections are the cornerstone of EHV-1 outbreaks. Consequently, EHV-1, unlike equine influenza and even strangles (Streptococcus equi), is not an infection that can practically be eradicated from equine populations. Confirmation and containment of EHV-1 outbreaks is necessary to avoid spread of infection and to minimise the potential for significant impact to the equine industry from more widespread outbreaks and, in particular, large and widely disseminated outbreaks of EHV-1 neurological disease. In recent years, experience gained through management of EHV-1 neurological disease outbreaks in the UK has led to establishment of protocols to control the spread of disease and minimise equine industry losses.

Staging of an EHV-1 disease investigation and control strategy
In broad terms there are considered to be six fundamental stages in an EHV-1 disease outbreak investigation and control strategy (outlined in Table 1), which follow the broad principles of segregation of the population, collection and testing of samples and observation of clinical disease [1]. Based on evidence accrued from these elements, informed decisions can then be made on safe resumption of normal activity, including lifting of movement restrictions.

Three tiers of approach to controlling EHV-1
The Animal Health Trust, working with the UK equine industry, has proposed three possible tiers of approach to how EHV-1 neurological outbreaks can be practically managed [1]. The three tiers of approach are referred to

<table>
<thead>
<tr>
<th>Stage</th>
<th>Details</th>
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<tbody>
<tr>
<td>1. Preliminary recognition</td>
<td>Owners recognise there is a problem and request veterinary assistance in investigating it. The attending veterinary surgeon may seek specialist advice prior to attending the affected premises or after confirmation of the diagnosis.</td>
</tr>
<tr>
<td>2. Preliminary veterinary investigation</td>
<td>Information regarding the history of the affected horse/s, in-contacts, duration and nature of clinical signs, number of animals on the premises and vaccination status is recorded. This history may be acquired prior to the attending veterinary surgeon visiting the affected premises or after confirmation of the diagnosis. Suspected animal/s should be immediately isolated and preliminary movement restrictions applied on the premises.</td>
</tr>
<tr>
<td>3. Establishing the diagnosis</td>
<td>Confirmation of cases of EHV-1 infection based on laboratory investigation of aborted fetuses and/or placenta, post-mortem samples, nasopharyngeal swabs and/or sera from cases and/or in-contacts of neurological disease. The attending veterinary surgeon may seek specialist advice only after confirmation of the diagnosis.</td>
</tr>
<tr>
<td>4. Understanding and managing the outbreak</td>
<td>The owner and the attending veterinary surgeon (with or without consultation with specialist advice) establish a plan to manage the outbreak in a feasible way that is relevant to the specific circumstances of the affected premises.</td>
</tr>
<tr>
<td>5. Establishing freedom from active infection</td>
<td>This is invariably based on segregation of the population into smaller groups of animals followed by a period of systematic clinical monitoring ideally accompanied by laboratory testing in order to establish that all horses no longer pose an infectious risk.</td>
</tr>
<tr>
<td>6. Returning the affected premises to normal activity</td>
<td>This is based on clinical and laboratory evidence that animals no longer pose an infectious risk to others. The population may for practical purposes on the basis of accrued evidence be safely phased in its return to normal activity.</td>
</tr>
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</table>
as gold, silver and bronze and, while they are all based on the same set of principles outlined above, there are clear differences between them in terms of the strength of evidence accrued, the time required and the costs incurred. Segregation into smaller discrete groups is common to all three approaches and is believed to be key to a successful strategy through minimising the spread of disease through the population and allowing clearance and release of quarantine measures as soon as possible.

The gold tier option provides insight into both the extent of recent infectious spread (based on CF test serology) and current infectiousness (based on agent detection tests, especially PCR) in each segregated group, while allowing risk management to then be optimised specifically to each group. This option also facilitates prompt removal to an isolation area of infectious horses from segregated groups, so reducing likelihood of ongoing infectious transmission within the group and overall morbidity. The silver tier option incurs fewer costs than the gold option, but it only provides an insight into the extent of actively shedding and exposed horses. The bronze tier option provides a retrospective insight into the extent of infectious spread but relies on observation of neurological signs and/or abortions/neonatal foal deaths to trigger further investigations, thereby potentially missing subclinical infectious spread, which is a recognised phenomenon in propagating EHV-1 outbreaks. This option may be the cheapest of the three with respect to laboratory costs but the lack of initial information about the infectious status in all segregated groups might ultimately lengthen the time for effecting overall control of the outbreak and, depending on how many segregated groups are further investigated, may ultimately not significantly reduce laboratory costs.

Conclusions
Effective EHV-1 outbreak control requires rapid confirmation of EHV-1 infection as the cause of disease, prompt restrictions placed and maintained on movements of horses on and off affected premises, segregation of the affected population into small groups and use of laboratory tests to provide confidence in freedom from infection when dealing with neurological EHV-1 infection. The combination of repeated CF test serology and sensitive qPCR viral detection provide a means of initially assessing the extent of pre-existing viral activity within the affected horse population, monitoring ongoing viral activity during the investigation and ultimately demonstrating disease clearance, thereby providing evidence with which to safely resume normal activity with minimal infectious risk being posed to other horses subsequently.

References
The horse in ICU has cultured positive for Salmonella...

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Salmonella enterica can be an important cause of healthcare-associated infections and zoonotic disease in veterinary hospitals [1]. Salmonella are Gram-negative, facultative, anaerobic bacteria, which usually gain access to the intestinal tract via the faecal-oral route. Salmonella commonly infects foals between 12 hours and 4 months of age. Young animals are more susceptible to Salmonella infections, maybe because of a less sophisticated or less well-established microflora within the gastrointestinal tract. The most common source of exposure and infection in the foal is another horse. Often the mare herself is an asymptomatic carrier. Mares have been shown to shed Salmonella at or shortly after parturition despite having as many as 19 negative cultures before foaling [2]. Observations of foalings revealed that all mares defaecated during stage 2 labour and that contamination of fetal membranes and the perineum/udder of the mare was possible if Salmonella was in the faeces. During udder seeking, foals will have extensive contact with the perineum and therefore may be at risk of Salmonella ingestion.

Once Salmonella has overcome the host defence mechanisms (gastric acidity, intestinal flora, peristalsis, intestinal mucus and lactoferrin) the bacteria migrate through the enterocytes and access the lamina propria where they stimulate an inflammatory response. Both phagocytised and free Salmonella organisms travel via the lymphatics to regional lymph nodes where they persist in stimulating an inflammatory response. Salmonella can also reach the circulation from efferent lymphatics. The neonate predisposition towards bacteraemia and sepsis may be because of factors such as delayed gut closure at birth, immature cellular immune response and decreased complement activity. Salmonella enterotoxins, cytotoxins and generalised inflammation within the bowel induce secretions of fluid from the intestinal epithelium.

Outbreaks associated with Salmonella among equine patients can result in high case fatality rates and substantial financial cost; and infections with multi-drug resistant (MDR) strains are especially problematic because of the decreased ability to treat infections with antimicrobial drugs in horses and humans alike [3]. As such, routine surveillance to detect this organism among equine patients is commonly performed on targeted high-risk subgroups (e.g., gastrointestinal disease) and upon recognition of epidemic disease [3,4], and less commonly performed continuously on all equine inpatients [5,6]. While there are many reports suggesting patients are more likely to shed Salmonella in their faeces at times of stress or systemic compromise [6,7] there are no reports that indicate whether risk factors may be different for susceptible vs. MDR strains.

Our hospital in 2012 evaluated what effect Salmonella shedding may have on health outcomes of previously hospitalised horses that were positive for Salmonella and their stablemates. Overall, horses shedding Salmonella during hospitalisation were not less likely to survive or more likely to experience episodes of colic or abnormal faeces during the year after hospital discharge. Rather, the risk for long-term nonsurvival was increased for hospitalised horses receiving a moderate to high level of care – suggesting that it is the severity of disease that is likely the more important factor with respect to long-term survival. Our finding of no difference in risk for having colic or abnormal faeces after hospital discharge among Salmonella-positive or negative horses is in agreement with a previous report. This is important with respect to counselling owners on what it means when Salmonella shedding is detected in their animal.

Interestingly, stablemates were more likely to be hospitalised during the follow-up period if the previously hospitalised horse was a Thoroughbred or if the farm of residence managed resident horses separately (i.e., separate housing) upon return from the hospital. We suspect that this finding is related to the rigour of farm management among Thoroughbred farms in central Kentucky – farms with more rigorously managed populations will employ more rigorous infection control practices and be more likely to seek veterinary care for horses displaying clinical signs of disease. That said, we also found that stablemates were more likely to develop abnormal faeces during the follow-up period if the previously hospitalised horse was a Thoroughbred, but this was not associated with the faecal culture status of the previously hospitalised horses.

The findings of this study provide more information for veterinarians when counselling owners on the repercussions of detecting Salmonella shedding in their horse. In general, shedding Salmonella did not decrease long-term survival or increase the occurrence of colic or abnormal faeces in the hospitalised horse nor increase the risk for hospitalisation or abnormal faeces in its stablemates. Despite this, it is still recommended to manage horses shedding Salmonella separately from other resident horses and employ rigorous personal and environmental hygiene to mitigate the exposure risk to other horses and personnel.

References
The new horse on the livery yard has a draining SMLN abscess

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Timelines for strangles infection and investigation

- Pyrexia and lethargy are the first clinical signs, in most cases occurring 3–14 days after exposure.
- Within hours of infection the bacteria cease to be detectable on the pharyngeal mucosa.
- Pyrexia occurs before horses become contagious, providing an opportunity to isolate and halt the spread of infection.
- Pyrexia is often marked and may persist as abscesses develop and rupture.
- After infection, abscesses typically take 1–4 weeks to develop and rupture.
- Nasal shedding typically starts 2–3 days after the onset of fever and persists for 2–3 weeks: far longer, and potentially indefinitely, if infection establishes within the sinuses or guttural pouches.
- Horses may remain infectious for 6 weeks after purulent discharge ceases; if guttural pouches are infected shedding occurs indefinitely.
- Transmission from outwardly healthy horses is often more of a problem than transmission from horses with clinical signs.
- Immune responses, and seroconversion, develop 2–3 weeks after the onset of infection.
- Antibody levels typically peak at 5 weeks after infection and remain elevated for at least 6 months in most horses.
- Serological testing for carriers should be performed at least 3 weeks after the resolution of all clinical cases.
- 10% of horses in an outbreak are expected to develop persistent guttural pouch infection.
- Up to 50% of horses infected with strangles will have transient infection of the guttural pouches which lasts, on average, 2 months.
- 25% of horses remain susceptible to repeat infection within months of initial infection.
- S. equi rarely survives longer than 1–3 days on environmental surfaces; however, in water it may survive for 4–6 weeks.
- Following vaccination with the strangles vaccine licensed in the UK, immunity persists for around 3 months.

Control measures to prevent transmission of Streptococcus equi equi

- Quarantine new horses for 3 weeks.
- Screen with serology and/or guttural pouch lavage and PCR.

Eliminating persistent infection

- Investigation of persistently infected horses should start a minimum of 3 weeks after resolution of clinical signs and a minimum of 3 weeks after cessation of antimicrobials. Horses that have discharge which persists for 2 weeks or more might be investigated sooner with endoscopy as further treatment may be warranted.
- Culture/PCR of three nasopharyngeal swabs to identify persistently infected horses is unreliable.
- Horses in the red group all warrant guttural pouch endoscopy, lavage and culture/PCR.
- Horses in amber and green groups should have serology performed and positive cases should be investigated with guttural pouch endoscopy, lavage and culture/PCR. Alternatively, all horses can be examined with endoscopy, lavage and culture/PCR.
- Horses with equivocal serology results can be re-tested after 10–14 days or should be examined with endoscopy, lavage and culture/PCR.
- Horses with positive PCR results on guttural pouch washes should be considered contagious even if pouches look grossly normal.
- Movement of horses off an affected property should be prevented for a minimum of 3 weeks after all cases are declared negative.

Further reading
Might this recumbent horse have West Nile?

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Introduction
The risk of West Nile virus (WNV) infection becoming established in the UK and causing horse cases is considered to be low. There is no current evidence of infection in birds, mosquitoes, animals or humans in the UK, although little testing has been performed in the past. Competent vectors such as Culex modestus are present in the UK. As in other countries, WNV can potentially be introduced to the UK via migratory birds or via imported mosquitoes, birds and animals infected with WNV. Therefore, it is important to be familiar with the clinical presentation and laboratory changes of WNV infection in equids as well as tests used to support a diagnosis.

Historical data and predisposing factors
WNV infection is seasonal with the highest incidence of cases in the late summer/early fall or year-round in temperate climates. All ages have been affected (4 months to 38 years with mean of 14 years). Factors that influence progression of disease in exposed individuals are unknown; however, elderly horses are more likely to manifest severe illness and have a fatal outcome. Having an accurate travel history may be important in considering WNV infection as a differential diagnosis. It is relevant to know whether the horse has recently travelled from regions of low WNV activity (Europe, northern climates) or those of high or year-round activity (USA). Vaccination history is important to consider as well since current WNV vaccines have excellent immunogenicity and even an annual vaccination which occurs post-vaccination against WNV. The preferred test is an IgM antibody-capture enzyme-linked immunosorbent assay (MAC-ELISA). The sensitivity and specificity of this test are 81% and 100% respectively. Methods to confirm WNV infection at post-mortem include antigen detection via qPCR, culture and immunohistochemistry in CNS tissues.

Clinical presentation of WNV infection
While many horses become infected with WNV, only few horses end up developing clinical disease. The average incubation period for WNV is 8 days. Since equids are considered dead-end hosts, the level of viraemia is low and of short duration. WNV has an affinity to neural cells of the caudal brainstem and spinal cord; therefore, clinical signs reflect a myelitis or encephalomyelitis. Equids infected with WNV often display general signs including mild to moderate increase in rectal temperature (38.6–39.4°C), lethargy and anorexia. Initial neurological deficits may include gait abnormalities (insidious to overt lameness, dragging of a limb), ataxia and paresis with hindlimbs most commonly affected, recumbency and cranial nerve deficits (CN VII and XII). The onset of neurological deficits is frequently sudden and progressive, and the exact course of disease in any one animal is unpredictable. A common presentation for WNV encephalomyelitis consists of fine and coarse fasciculations of the muscles of the face and neck. Fasciculations can be severe and can involve all four limbs and trunk, affecting normal activities. The mortality for WNV infected horses is 40–50%. Clinical signs and ante-mortem clinical pathological findings are not specific for mosquito-borne encephalitides. Even in endemic areas where veterinarians frequently see multiple mosquito-borne illnesses, it is not possible to diagnose WNV infection in the horse with any certainty based on clinical signs and epidemiological circumstances. Infectious diseases that should be considered as differential diagnoses for WNV infection should include alphavirus encephalitis, rabies, equine herpesvirus-1 myeloencephalopathy, equine protozoal myeloencephalitis, botulism and verminous meningoencephalomyelitis.

Ancillary diagnostic testing
Tests to include during the diagnostic work-up of a horse with suspected myelitis/encephalomyelitis should include complete blood count (CBC), serum biochemistry and cerebrospinal fluid (CSF) analysis. CBC may display a mild absolute lymphopenia and biochemical analysis can rule out systemic causes of CNS abnormalities such as liver disease. CSF is generally characterised by a mononuclear pleocytosis and elevated protein concentration. The colour of the CSF fluid can be mildly xanthochromic.

Serology provides the mainstay of presumptive ante-mortem diagnosis. Serological testing developed by the National Veterinary Services Laboratory (NVSL, Iowa, IA) is based on detecting IgM antibody response that promptly occurs after acute infection and lasts approximately 6 weeks. Horses are known to develop a strong IgM response following natural infection. Furthermore, IgM response rarely occurs post-vaccination against WNV. The preferred test is an IgM antibody-capture enzyme-linked immunosorbent assay (MAC-ELISA). The sensitivity and specificity of this test are 81% and 100% respectively. Methods to confirm WNV infection at post-mortem include antigen detection via qPCR, culture and immunohistochemistry in CNS tissues.

Treatment
There is no specific anti-viral treatment for WNV. Efforts are focused on supportive treatment (fluid, slewing) and the use of anti-inflammatory drugs such as flunixin meglumine. Therapy for recumbent horses is generally more aggressive and may include dexmethasone sodium, DMSO and mannitol. The overall mortality is 30% and doubles in recumbent horses. A high rate of recovery can be expected from patients with resolving clinical signs but horses may maintain residual signs for many months.

Further reading
Equine viral arteritis (EVA) is a respiratory and reproductive disease of horses that is caused by equine arteritis virus (EAV). The vast majority of EAV infections are subclinical, although clinical outbreaks are most importantly associated with abortion, neonatal mortality and establishment of persistent infection in stallions.

EVA is a notifiable disease in the UK, controlled under the Equine Viral Arteritis Order 1995. Guidance on EVA from the Department for Environment, Food and Rural Affairs (Defra) and the Animal and Plant Health Agency (APHA) is provided on the government website (https://www.gov.uk/guidance/equine-viral-arteritis). In addition, the British Equine Veterinary Association (BEVA) provides guidance on EVA (https://www.beva.org.uk/Home/Resources-For-Vets/Guidance/BEVA-BEF-BHS-Equine-Viral-Arteritis-Briefing-Document) as well as the well-established and respected voluntary recommendations made in the 2018 version of the Horserace Betting Levy Board (HBLB) Code of Practice (https://codes.hblb.org.uk/downloads/EVA%202018.pdf).

Clinical cases suspected as being EVA should, by law, be reported to Defra/APHA. However, given that EVA can be persistent in stallions.

**What happens if a stallion has a positive blood test for EVA antibodies?**

In the UK many local veterinary laboratories routinely screen for EAV antibodies using a kit-based ELISA test. Any inconclusive or positive result should subsequently be referred to the APHA’s Weybridge Laboratory, the Animal Health Trust (AHT), or other appropriate laboratory for a virus neutralisation (VN) test. If a stallion is unexpectedly found to be seropositive on serology by VN test (at a titre of 1:4) in the absence of any evidence of vaccination, under the EVA Order 1995 this should be reported to the Divisional Veterinary Officer (DVO) at the local APHA office. A UK-resident stallion will have a ‘restriction order’ placed on it restricting movement and breeding activities, which will extend to any chilled or frozen semen originating from that stallion. Then, once the seropositive status of the stallion has been confirmed by APHA, in order to ascertain whether or not EAV exists, a veterinarian inspector will carry out inquiries. The likely procedure is that described in the HBLB Code of Practice, with a semen sample requested from the stallion and analysed by qPCR and VI at the OIE (World Organisation for Animal Health) reference laboratory at the APHA’s Weybridge Laboratory. It is likely that a repeat semen analysis will be performed after 7 days. In addition, all potential contacts may be traced, isolated and sampled and all other horses on the affected premises may be screened. Once the veterinary inspector is happy that the stallion and in contacts are free from EAV, as is any preserved frozen semen, restriction notices will be lifted. If a stallion is found to be positive for EAV in its semen, it is possible that, if it had been recently imported, it would either be re-exported or castrated to ensure the virus was eliminated and the animal could be declared EAV-free.

If a stallion has been vaccinated against EAV with Equip Artervac (Zoetis) and it does not have a negative serology result prior to vaccination entered in the ‘health tests’ section of the passport, or vaccinations have been allowed to lapse (i.e. not boosted at 6-monthly intervals), then Defra and international trading partners may interpret that the current positive serological status of these animals may not be guaranteed to have arisen solely from vaccination and the stallion may have been exposed to EAV infection. As serology cannot differentiate infection from vaccination, testing of semen for presence of EAV will be necessary.

The author’s approach would be to screen low-risk stallions at the earliest opportunity for EAV in semen by PCR or VI, at the APHA’s Weybridge Laboratory, all normal semen samples, with a VN titre of ≥ 1:4 in the absence of any evidence of vaccination, under the EVA Order 1995.

**What happens if a mare has a positive blood test for EVA antibodies?**

In previously vaccinated stallions the only way to certify a stallion as free from disease, in the absence of appropriate vaccinations is reported to the APHA, the authorities may have no choice other than to serve notice of restrictions on the stallion and perform the testing as directed by the EVA Order 1995, whether or not those tests are ideal for the stallion or convenient for its owner.

BEVA guidance appropriately suggests that semen shipments within the UK are certified for disease, including EVA. In previously vaccinated stallions the only way to certify a stallion as free from disease, in the absence of appropriate vaccination, is to PCR-screen a semen sample for EAV.

**What happens if a mare or gelding is positive on blood testing for EVA antibodies?**

If a mare or gelding is found to be seropositive without having previously demonstrated a positive antibody titre, an animal may be the possibility of recent EAV infection. The mare or gelding should be isolated, and a second blood sample taken 14 days after the first and sent to the same laboratory that confirmed the first positive VN result. Stable or declining VN antibody titres indicate that the mare or gelding is not considered likely to be infectious. In the author’s experience, all positive mares so far encountered have originated from outside the UK. Increasing antibody levels or clinical signs of EVA infection, especially in a mare that has been naturally mated or artificially inseminated within the last 14 days, necessitates reporting under the EVA Order 1995 to the DVO at the local APHA office.

NOTES
Guidelines for equine clinical practice: analgesia and wound management

Panel: Debra Archer, Neal Ashton, Mark Bowen, Bettina Dunkel, Yvonne Elce, Anna Hollis and Sarah Freeman

Clinical Practice Guidelines (CPG) set a benchmark in time evaluating common clinical practice against the strength or weakness of the evidence that support them. BEVA recognises a need to support clinical practice by developing CPG for common conditions encountered in primary care practice. The topics have been identified by the Editors of Equine Veterinary Journal in consultation with BEVA's Clinical Practice, Health and Medicines, Allied Professionals, and Welfare and Equestrian Sport committees and were informed by a poll taken amongst delegates at BEVA Congress 2017.

The CPG are being developed by multidisciplinary teams using GRADE evidence-to decision frameworks. Input from BEVA members will be obtained by review and discussion of interim reports at Congress and by open review of a final draft version which will be posted online.

Two teams will report on progress at this year’s Congress: Analgesia: Mark Bowen (team leader), and Wound Management: Sarah Freeman (team leader), Anna Hollis, Yvonne Elce, Neal Ashton, and reviewed by Bettina Dunkel and Debbia Archer.

BEVA clinical practice guidelines – wounds

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Remit
To produce a series of consensus statements on wounds in horses addressing clinical guidelines relevant to primary care practice for equine veterinarians.

This session will present the first report from the panel developing recommendations for clinical guidelines on the management of wounds in the horse. The findings from the panel will be presented, with feedback from appointed reviewers and open to questions and feedback from Congress attendees.

Process
1. Formulation of a panel representing a range of disciplines, including a representative from general practice and an international representative.
2. Nomination of topics for review by the panel.
   • 14 topics nominated
3. Voting and ranking of priority for reviewing topics and allocation of roles within the panel.
   • Topics ranked, then grouped into three main categories
   • Three main categories identified as: wound lavage; wound debridement and closure; therapeutics to enhance wound healing
4. Evidence searches.
   • Initial searches for evidence summaries in veterinary literature in VetSRRev (http://webapps.nottingham.ac.uk/refbase/), Prospero (www.crdyork.ac.uk/prospero/) and Veterinary Evidence (https://www.veterinaryevidence.org/index.php/ve/search)
   • Systematic searches of databases using keyword searches
   • Identification of evidence by review of search outcomes against inclusion and exclusion criteria
5. Appraisal of evidence using GRADE evidence-to-decision frameworks.
6. Discussion and agreement of outcomes within panel.
7. Initial report for presentation at Congress and feedback from appointed reviewer and BEVA members.
Options for analgesia

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Introduction

Pain is a normal response to harmful stimuli and as such serves to protect and maintain the integrity of the body. However, pain can be associated with deleterious behavioural, physiological, immunological and metabolic effects. Pathological pain may produce increased stress and suffering, which may in turn lead to increased morbidity and reduced quality of life. Pain management is therefore of great importance for all our animal patients for a range of reasons including animal welfare and improved convalescence.

The specific aim of pain management is to make the horse return to as normal a behaviour as possible, including eating when allowed. Immobilisation should always be achieved by mechanical means and not by leaving the horse without analgesics with the purpose of keeping it from moving.

This lecture will review the management of pain in the acutely traumatised and/or critically ill horse with emphasis on special considerations that apply for these patients.

Specific considerations for acutely traumatised and critically ill horses

Acutely traumatised or critically ill horses may be more agitated; they may have suffered blood loss or have other reasons for hypovolaemia; they may have various organ diseases (liver, kidney) that interfere with metabolism and hence effectiveness and excretion of drugs; and/or they maybe have been administered multiple drugs. These issues should all be considered when tailoring an analgesic plan, in order to avoid unwanted side effects, unwanted interactions or ineffectiveness of the drug.

Sedation

It is advisable always to combine α agonists and opioids to exploit their synergistic effects and reduce hypotension. Despite its lack of direct analgesic effect, acepromazine in low doses should also be considered since it may reduce sympathetic tone and hence stress and pain.

Special considerations apply for horses with acute head trauma as these patients are prone to increased intracranial pressure. Since raised intracranial pressure might be exacerbated by hypoventilation, opioids should be administered with caution in these patients.

General guidelines for pain management of acutely traumatised and critically ill horses

Analgesia in horses often relies predominantly on systemic administration of nonsteroidal anti-inflammatory drugs (NSAIDs) and opioids (depending on national legislation and traditions). However, various contraindications based on the reasons stated above may apply and therefore careful planning and the combination of different drugs, with an increased focus on the use of local and or regional techniques over systemic pain therapy, are very important in these patients.

NSAIDs

NSAIDs should always be considered since they will reduce inflammation and pain. Contraindications for the use of NSAIDs in trauma patients include the potential risk of increased bleeding, as well as the risk of nephrotoxicity in hypovolaemic and/or dehydrated patients.

Opioids

Opioids are very efficient analgesics in horses, and morphine, butorphanol and buprenorphine amongst others all play important roles in equine analgesia. They may be administered as bolus injections, as constant rate infusions, epidurally, intrasynovially or transdermally.

Local analgesics

Local analgesics should be considered in many patients, particularly because of the low risk of unwanted side effects on the cardiovascular and respiratory systems. In particular, systemic constant rate infusion (CRI) and regional CRI via locally placed indwelling catheters should be considered.

Epidural analgesia

Epidural is the preferred route of administering analgesia for moderate to severe hindlimb pain that does not respond to NSAIDs combined with bolus injections of i.v. morphine potentially in combination with α agonists and ketamine.

Other systemic analgesics for post-operative pain management

In addition to the ‘conventional’ analgesics of the NSAID and opioid classes, several substances may be utilised as part of a multimodal analgesic protocol, either to decrease the risk of dose-dependent adverse effects of individual analgesics, or in pain states that are nonresponsive to conventional treatments. These drugs include but are not limited to corticosteroids, paracetamol, gabapentin, ketamine, topical NSAIDs and physical methods.

Further reading


Managing hypoxaemia

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Hypoxaemia is defined as an arterial partial pressure of oxygen (PaO₂) of less than 8 kPa (60 mmHg) [1]. Despite the provision of maximal fractional inspired oxygen (FiO₂) and controlled mechanical ventilation in anaesthetised horses, hypoxaemia remains a relatively common intraoperative complication. Hypoxaemia can lead to inadequate tissue oxygen delivery (DO₂).

Causes

Causes of intraoperative hypoxaemia include hypoventilation, diffusion impairment, intrapulmonary shunt and ventilation-perfusion mismatch. Atelectasis develops early in the anaesthetic period and is caused by thoracic compression, alveolar gas absorption and impairment of surfactant function. Volatile anaesthetic agents inhibit hypoxic pulmonary vasoconstriction and functional residual capacity is reduced in dependent lung regions, thereby increasing the susceptibility to hypoxaemia in anaesthetised horses. Furthermore, since horses tolerate relatively large increases in arterial carbon dioxide tension and hypoxaemia during maximal exercise without exhibiting a compensatory response [2], the response during general anaesthesia is also delayed.

Body shape and recumbency have been associated with hypoxaemia. There is a strong positive correlation between both height and thoracic circumference per unit body mass and arterial oxygen tension in spontaneously breathing halothane-anaesthetised horses [3]. Horses positioned in dorsal recumbency developed lower PaO₂ values compared to those positioned in lateral recumbency [4].

Treatment

Treatment for hypoxaemia is aimed at re-establishing ventilation-perfusion relationships and is therefore directed at improving alveolar ventilation and pulmonary perfusion. Preoxygenation via nasal cannulae prior to anaesthetic induction in adult horses was shown to increase arterial oxygen tension during the early maintenance phase [5]. Changing body position from dorsal to lateral or sternal recumbency improves oxygenation, and further improvements are seen once the horse is standing [4].

Administration of aerosolised salbutamol via the endotracheal tube improved arterial oxygenation in hypoxaemic anaesthetised horses [6]. A combination of bronchodilation and increased pulmonary perfusion secondary to an increase in cardiac output may be involved. Controlled mechanical ventilation (CMV) acts to decrease the work of breathing, reduces oxygen consumption and the application of positive airway pressure can aid in the reduction of atelectasis formation during anaesthesia. However, positive pressure in the thorax acts to reduce cardiac venous return, producing a reduction in cardiac filling, stroke volume and cardiac output. Excessive airway pressures can induce lung injury and alveolar over-expansion causes compression of pulmonary capillaries which exacerbates alveolar dead space [6]. The implementation of CMV after hypoxaemia had developed in anaesthetised spontaneously breathing horses improved PaO₂ values in laterally recumbent horses but not those in dorsal recumbency [7].

Continuous positive airway pressure (CPAP) maintains pressure above atmospheric pressure during both inspiration and expiration in spontaneously breathing horses. CPAP of 8 cmH₂O improved oxygenation indices in dorsally recumbent spontaneously breathing anaesthetised horses without significantly affecting cardiovascular function [8]. Positive end expiratory pressure (PEEP) can be applied during CMV and maintains positive pressure extending to the end of the expiration. Recruitment manoeuvres (RM) are prolonged consecutive breath-holds reaching peak inspiratory pressures of 40–60 cmH₂O. The resulting increase in intrathoracic pressure causes significant decreases in venous return and cardiovascular function [1].

In horses undergoing colic surgery, CMV with constant PEEP and alveolar RM resulted in a higher PaO₂ compared to CMV alone suggesting that there was recruitment of previously atelectatic lung areas [9].

Lower FiO₂ values minimise absorption atelectasis in humans but in horses no clinical benefit was observed by using FiO₂ 65% compared to 90% [10] or by using a FiO₂ of 50% [11]. The use of a demand valve in recovery to ventilate apnoeic horses or to supplement spontaneously breathing horses has been shown to improve arterial oxygenation [12].

Systemic hypotension results in further reductions in pulmonary perfusion and should be addressed by minimising anaesthetic depth and the delivery of volatile anaesthetic agent where possible and administering positive inotropes such as dobutamine to effect.

References

Managing hypotension
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Hypotension (low blood pressure) during anaesthesia is usually defined as a mean arterial pressure of less than 60 mmHg, although some anaesthetists prefer to maintain a higher mean pressure in anaesthetised patients [1]. Tissue blood flow is determined by the pressure gradient from artery to vein, so as arterial pressure rises flow will increase; however, autoregulation (vasoconstriction of resistance vessels in the face of rising perfusion pressure) ensures constant flow over a range of pressures between approximately 55 and 180 mmHg [2]. When arterial pressure falls below this, autoregulation fails and tissue blood flow reduces. This can have fatal consequences especially in horses, where reduced muscle blood flow may cause post-anaesthetic myopathy [3,4].

Arterial pressure is the product of cardiac output and systemic vascular resistance, with cardiac output being the product of stroke volume and heart rate. Commonly during anaesthesia, arterial pressure and heart rate are monitored, with a good blood pressure assumed to indicate good cardiac output; however, this is not the case. When an increased arterial pressure results from vasoconstriction, this dramatically reduces cardiac output and muscle blood flow downstream to the constricted vessels [2,5]. Direct monitoring of arterial pressure allows pressure waveforms to be displayed and subjective assessment of the underlying cause of the hypotension. Changes in the area under the pressure waveform will reflect changes in stroke volume caused by changes in preload and afterload, whereas changes in the upstroke of the pressure waveform reflect changes in contractility. Although in a clinical situation, hypotension is often treated symptomatically, or drugs are given as a preventive measure, an understanding of the underlying cause is important if ongoing therapy is to be successful. Continuing to increase myocardial contractility by infusing the inotrope dobutamine will have a limited effect on cardiac output if there is no preload and the ventricle is empty; in this case, continuing the infusion will merely result in tachycardia with an increased myocardial oxygen consumption and risk of arrhythmia.

Causes of hypotension

Reduced systemic vascular resistance
Systemic vascular resistance is reduced with endotoxaemia (see afterload below) and hypercapnia. If blood pressure fails to respond as expected, arterial gases should be analysed for a possible cause.

Reduced heart rate
Compared to other species, heart rate in horses is usually reasonably constant during anaesthesia; however, where bradycardia is thought to be the cause of the hypotension, heart rate should be increased by using atropine or glycopyrrolate. Bradycardias are often more common during total intravenous techniques and further heart rate reductions may be a harbinger of overdose.

Reduced stroke volume
Reductions in stroke volume may result from reduced venous return to the heart (preload), changes in contractility and increases in afterload.

Preload
Reductions in preload can occur as a result of changes in body position, hypovolaemia and positive pressure ventilation (PPV). Where PPV is affecting venous return, reductions in the area under the pressure waveform will be observed in the waveform following the inspiratory cycle of the ventilator. Such respiratory variations in the pressure waveforms are an indicator of hypovolaemia and should be treated with fluid therapy. This is the subject of the next presentation and will be discussed in the following abstract.

Contractility
The volatile anaesthetics produce a dose-dependent decrease in cardiovascular function, and although isoflurane and sevoflurane reduce contractility to a much lesser extent than halothane, there will be individual variation with some individuals showing a marked reduction in contractility with these agents. The upstroke of the pressure waveform will be less steep when contractility is poor. However, it must be remembered that the ventricle itself is load dependent, with increases in preload increasing contractility via the Frank-Starling mechanism [2]. Similarly, large increases in afterload will decrease and delay the upstroke of the pressure waveform giving the impression of reduced contractility. Reductions in contractility can be treated where possible by reducing the fraction of inspired volatile agents; this may necessitate the use of additional analgesics or local anaesthetics to maintain anaesthesia. If this is not possible, positive inotropes (dobutamine, dopamine, epedrine, epinephrine) may be given. Dobutamine will cause a degree of vasoconstriction as well as an increase in contractility and therefore arterial pressure will rise, whereas dopamine, although it will increase contractility and cardiac output, may reduce arterial pressure due to peripheral vasodilatation [6,7]. If only arterial pressure is being monitored the benefits of dopamine administration may not be noted.

Afterload
When a reduction in systemic vascular resistance (SVR) is thought to be the cause of low blood pressure, phenylephrine or noradrenaline can be used to increase afterload. However, it must be appreciated that, although phenylephrine will increase mean arterial pressure, it will decrease cardiac output and peripheral blood flow in halothane and isoflurane-anaesthetised horses [8,9]. Noradrenaline, however, will maintain peripheral blood flow while increasing SVR and arterial pressure [9]. Alpha-2 agonists can also be used to cause vasoconstriction and increased arterial pressure. These agents will also allow the fraction of inspired volatile agents to be reduced; however, cardiac stroke volume will also be decreased.

Considerations with specific cardiac conditions

Atrial fibrillation
When using positive inotropes to treat hypotension in horses with atrial fibrillation it must be remembered that sympathomimetic agents will increase conduction of the ‘F’ waves at the atrioventricular node and may increase heart rate in these cases.

Aortic regurgitation
In horses with more severe aortic regurgitation, arterial pressure will fall during diastole as blood regurgitates back through the aortic valve into the left ventricle. As the myocardium receives its blood supply during diastole, it is important to maintain diastolic pressure, while appreciating that increases in diastolic pressure will increase the amount of regurgitant flow. In these cases it is important to try to maintain a normal pressure and heart rate as bradycardia will increase the time available for valvular regurgitation.
References

NOTES
Perioperative fluid therapy guidelines and fluid resuscitation goals for colic patients have advanced over recent years but the veterinary scientific literature is still sparse in this area.

Accurate calculation of fluid deficits can be difficult, so it is important to re-evaluate changes in physical and clinicopathological variables during the fluid resuscitation process to avoid overhydration. Haemodilution of substances including erythrocytes, platelets, albumin and coagulation factors can have detrimental effects, and overhydration may lead to gastrointestinal tissue oedema and disruption of gastrointestinal motility. Intestinal motility can be disrupted by crystalloid-induced intramural oedema [1].

Transcapillary fluid flux is influenced by colloid osmotic pressure (COP), which can be disrupted with the use of large volumes of crystalloid fluids and thus potentiate tissue oedema [2]. A low intraoperative haematocrit predicted failure to recover from anaesthesia and a need for gastric decompression after surgery for small intestinal strangulation [3].

Early goal-directed fluid therapy (EGDFT) is a concept which was introduced into human medicine more than 15 years ago and has been shown to significantly reduce in-hospital mortality. EGDFT aims to utilise specific resuscitation end points to better re-establish the agreement between tissue oxygen delivery and demand. Macrovascular parameters such as central venous pressure, mean arterial pressure and urine output are already routinely used to assess hydration status. Optimal tissue oxygen delivery is our ultimate aim, and this is appreciated on a microvascular level.

Goals described in the medical literature include cardiac index, pulse pressure variation, stroke volume variation and mean arterial pressure. These indices act to indicate fluid responsiveness and distinguish those patients which would benefit from ongoing fluid loading from those which will not. Integration of these indices could aid in the determination of optimal fluid resuscitation; however, measurement of such variables in the horse can be difficult and interpretation of the values yielded requires further investigation.

Fluid type may also be an important consideration in horses with gastrointestinal disease. Balanced crystalloid solutions are the mainstay of fluid therapy and may be combined with colloids to facilitate rapid volume resuscitation. Hypertonic saline solution (HSS) is a small volume resuscitation fluid which causes an increase in intravascular volume, induces vasodilation and pulmonary osmoreceptor stimulation due to its high osmolarity. In horses, it causes an increase in stroke volume, left diastolic volume, cardiac output, mean systolic and pulmonary arterial pressures [4]. Hypertonic saline can be used preoperatively to optimise intravascular volume prior to induction of general anaesthesia. Hydroxyethyl starch (HES), a synthetic colloid, also promotes COP and can be used for preoperative small volume fluid resuscitation in horses undergoing colic surgery [5]. While there is little evidence to recommend one fluid type over another, it seems that a combination of crystalloid and colloid fluids is beneficial in the fluid resuscitation process [6].

Hypoproteinaemia is a commonly reported complication in horses following surgical correction of large colon volvulus and, if persistent, is a poor prognostic indicator [7]. Administration of fresh (frozen) plasma can be beneficial in these cases.

References
Anaesthesia in the field – preventing mishaps

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Financial claims reported to the Veterinary Defence Society (VDS) involving horses lost through accidental injury or death while under anaesthesia are thankfully very rare. However, when they do occur they are very traumatic, not only for the owner, but for all the practice staff who were involved with the patient. Such mishaps can never be completely avoided, but the chances of something going wrong can be greatly reduced by careful planning in advance.

(++) poor planning makes for (++) poor performance

Non-anaesthetists are operating in the field, not in theatre, and by implication that means anaesthesia is intended to be of short duration and the surgery being performed is almost always performed on healthy patients. However, there are many ways in which things may go wrong and, if and when they do, this is usually in front of your client’s very eyes. Therefore, anticipating as many of those possibilities in advance goes a long way towards ensuring that they don’t occur.

Beforehand
When the visit is being booked, find out whether the horse is insured or not. Many insurance companies will refuse to pay out unless they have been informed in advance that the horse is insured. After giving the go-ahead.

Beforehand
• Do carry out a basic clinical preoperative check, and be clear as common as in small animal practice, it is still a good idea as it gives you the chance to discuss the risks. However, verbal consent is fine, and the owner’s very presence at the time of surgery is strong confirmation that consent has been given.

Consent is required both for anaesthesia and surgery. Although asking a horse-owner to sign a consent form is not as common as in small animal practice, it is still a good idea as it gives you the chance to discuss the risks. However, verbal consent is fine, and the owner’s very presence at the time of surgery is strong confirmation that consent has been given.

Most horse-owners are aware that their animals present a higher anaesthetic risk than dogs, cats or humans and, if it is the only thing they remember from their undergraduate anaesthesia rotation, many veterinary surgeons carry around in their heads the statistic: 1 death in 100 equine anaesthetics. However, the incidence of anaesthetic-related deaths involving field anaesthesia is much lower, somewhere probably in the region of 1 in 300 being nearer the mark.

On arriving at your client’s premises, a number of important assessments have to be made prior to going any further:
• Is there a suitable place for induction of anaesthesia and safe recovery to occur?
• What assistance do you have? Are you relying on the owner, a student, or a stablegirl? If so, do they have the strength to restrain the patient and, as is often overlooked, do they have sufficient mobility to get out of the way quickly if necessary?
• Students are extremely useful to have around in these circumstances, and it is very helpful to rehearse the procedure and possible problem scenarios in the car prior to arriving at the farm.
• A detailed preanaesthetic work-up is impractical and also unnecessary in a young healthy horse. If relevant, the owner should be warned that animals over 12 years old are statistically at greater risk [1].
• Do carry out a basic clinical preoperative check, and be seen to be doing one. If you are not used to listening to horses’ hearts, this can be unnerving; however, arrhythmias are usually physiological and if you push the horse backwards, will often disappear.

• Any sign of respiratory disease is an absolute contraindication for elective surgery under general anaesthesia.
• Guessing the weight: a girth tape is better than nothing, but unless you are weighing horses regularly, you are unlikely to have an accurate idea of the weight just by looking at them.
• Because you don’t know the patient’s weight precisely, it is vitaly important that you overdose the patient rather than underdose it, which will often result in the horse waking up at just the critical moment.

The most common anaesthetic regime under field conditions is the combination of an α agonist with ketamine. Many practitioners prefer to use xylazine under these circumstances as it is the shortest acting, although it also produces the greatest degree of ataxia. So, in order to avoid mishaps at induction:

• Place an i.v. catheter before you start so that you have immediate i.v. access should the need for a ‘top-up’ arise. It also avoids the risk of accidental injection into the carotid artery. Do not hesitate to sedate the horse if you need to in order to accomplish this.
• Don’t stick slavishly to the commonly recommended dose for ketamine of 2.2 mg/kg bwt. You can give up to one-third more than that, and it is almost impossible to grossly overdose a large horse.
• Look at your watch when the horse goes down. You will get 10 minutes decent anaesthesia following ketamine administration, but you should top up at 10 minutes by your watch. Don’t wait until the horse moves: it will be too late at that point to prevent a dangerous situation developing.
• Have a top-up dose already drawn up, usually half the induction dose of each agent. Beware if you are using a three-way tap: in a stressful situation when quick action is required, ‘three-way tap dyslexia’ can overcome your assistant.
• Give the drugs in the correct order!

During
Make sure someone is responsible for observing the horse throughout; it is bad form to be so engrossed in the surgery that you fail to notice the patient has stopped breathing. You do not need fancy monitoring kit, just an alert human observer.

Afterwards
Whichever method of recovering the horse you prefer, there is one golden rule: do not leave the premises until the patient is on its feet and looks as if it is going to stay on them. You may not be able to prevent a disaster, but at least you are there in person. Leaving an anaesthetised animal unattended is a sure recipe for either a financial claim against you, or worse still, a trip to Belgravia House to explain to a panel of your peers why you were in such a rush that day.

Reference
Local blocks every practitioner ought to know

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Ophthalmic blocks

To properly examine the eye of a horse, sedation and akinesia of the eyelids are usually required. Sedation may take the form of an i.v. bolus or a constant rate infusion. The following is a brief discussion of the techniques used to give complete anaesthesia of all the structures of the eye [1–3].

Sensory nerve blocks

Corneal anaesthesia

Topical anaesthetics are commonly used to examine the cornea and to perform minor procedures. They are also useful during an enucleation to reduce the discomfort associated with the surgical preparation of the adnexal tissues of the eye. Local anaesthetics are cytotoxic so should not therefore be used for long-term analgesia. The onset of analgesia in humans is within 1 minute and duration of action is up to 15 minutes.

Anaesthesia of the superior eyelid

The supraorbital nerve is part of the ophthalmic branch of the trigeminal nerve (cranial nerve (CN) V). It provides the sensory supply to the middle third of the superior eyelid. The supraorbital foramen can be located using Tóth’s law, which states that when the thumb and third finger are placed on the medial and lateral canthi, the index finger will automatically be placed over the opening of the foramen. Using a 22–25 gauge needle, 2 mL of local anaesthetic is injected over the foramen opening. An alternative technique is to inject directly into the foramen; this may also block some of the small fibres coming from the auriculopalpebral nerve, thus resulting in motor blockade of the medial aspect of the superior eyelid [2].

The lacrimal nerve (ophthalmic branch of CN V) is a sensory nerve which supplies the lateral aspect of the superior eyelid. It is located on the superior rim of the orbit, approximately one-third of the way along the orbital rim. A small line block (2–3 mL) is injected as close to the orbital rim as possible. An alternative to this technique is to make a line block along the entire superior orbital rim.

The infraorbital nerve is located within a notch along the superior orbital rim near the medial canthus. It supplies the sensory innervation to the superior and inferior eyelids adjacent to the medial canthus as well as to the nictitans and lacrimal gland. Again, injecting a small line block (2–3 mL of local anaesthetic) close to the orbital rim will desensitise this portion of the palpebral fissure.

Anaesthesia of the inferior eyelid

There are two nerves which innervate the inferior eyelid: the infraorbital and zygomaticofacial nerves, both of which are branches of the ophthalmic nerve (CN V). See the previous section for the description of the infraorbital block. The zygomaticofacial nerve is located on the lateral and inferior aspect of the orbital rim and supplies approximately 75% of the sensation of the inferior eyelid [3]. Local anaesthesia (2–3 mL) may be deposited at each site. An alternative is to make a line block along the entire inferior orbital rim, extending dorsally at the medial canthus.

Retrobulbar anaesthesia

The techniques described here will anaesthetise the optic (CN II), oculomotor (CN III), trochlear (CN IV), abducens (CN VI) and parts of the trigeminal (CN V) nerve. Four-point block

This is a commonly used technique to anaesthetise the extraocular muscles. Either a 22 or a 20 gauge 2.5 inch spinal needle (with a slight curve) is inserted through the orbital septum at the 12:00, 3:00, 5:00 (or 7:00) and 9:00 positions. Avoiding the 6:00 position will minimise the chances of damaging the optic nerve and blood vessels [3]. Local anaesthesia is induced by depositing 5–10 mL of local anaesthetic at each site. Peribulbar blocks like this one have been associated with higher intraocular pressures following the injection of local anaesthetic and a lower probability of success when compared with retrobulbar techniques [4].

Conus ocularis block (retrobulbar block)

This is another technique used to anaesthetise the extraocular muscles. Palpate the lowest point in the supraorbital fossa. Insert a 22 or 20 gauge 2.5 inch spinal needle which is directed 5 degrees off vertical in a lateral to medial, and rostral to caudal direction. When observing the eye during the insertion, it will be seen to move dorsally as the tip of the needle engages the conus ocularis. As the outer layer of the conus ocularis is penetrated by the needle, the eye will rotate back to a neutral position again. Local anaesthetic (5–8 mL) may now be injected after aspirating for blood; no resistance should be detected during injection. This block will desensitise the globe as well as all the muscles of the eye.

Motor nerve block

The auriculopalpebral nerve is one of the branches of the facial nerve (CN VII). The auriculopalpebral nerve crosses the lateral aspect of the zygomatic arch near the base of the ear, and then follows the arch along its dorsomedial aspect. It supplies the motor innervation to the orbicularis oculi muscle. This block is used to produce akinesia of the eyelids and to facilitate an eye examination. A 22 gauge needle may be inserted along the dorsomedial margin of the most dorsal aspect of the zygomatic arch. A small volume of local anaesthetic (3–5 mL) may be deposited in a fan-like shape at this site under the fascial plane. You will feel a pop as your needle pierces the fascial plane. Do not forget to use some artificial tears or ointment for a few hours post-administration to prevent dessication of the cornea, because the horse will be unable to blink.

Adjunct therapies

The onset of action of lidocaine can be shortened by the addition of bicarbonate: to every 9.5 mL of 2% lidocaine, add 0.5 mL of 8.4% sodium bicarbonate [5]. By alkalisation the solution, the un-ionised fraction of lidocaine will increase, thus favouring its movement into the neuron, quicker penetration of neuronal tissue by lidocaine results in shorter onset time. Alkalisation of the solution will also reduce pain on injection of lidocaine. If using bupivacaine, the amount of sodium bicarbonate required is one-tenth the volume of that used for lidocaine (i.e. 0.05 mL of sodium bicarbonate 8.4%); however, there is a risk of causing a precipitate [5]. The addition of 5 µg/mL adrenaline (0.1 mg adrenaline diluted to 20 mL using 0.9% saline) to the solution will approximately double the duration of blockade by lidocaine by reducing the amount of vascular absorption of the local anaesthetic from the infiltration area. This is not true for bupivacaine because the duration of action of bupivacaine is longer than the effect of adrenaline-induced vasoconstriction. The addition of adrenaline also has the advantage of causing a transient tachycardia if accidental...
intravascular injection has taken place: monitoring the heart rate during the performance of loco-regional anaesthesia can help detect this phenomenon.

References


Epidural anaesthesia

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When can epidural anaesthesia be useful?
Epidural anaesthesia is useful to provide analgesia as part of a multimodal analgesic regime and facilitate various (painful) interventions, e.g. obstetric manipulations, perineal or vulval surgery, intraoperative analgesia and post-operative pain management.

How does epidural anaesthesia work?
The epidural space lies outside the dura mater (the outermost membrane of the spinal cord), between the spinal cord/nerves and the vertebrae. It is filled with fat and a few venous plexuses. Drugs administered into the space, depending on their lipid and blood solubility, will diffuse through the space to eventually be redistributed around the body. If drugs pass near to a spinal nerve, they can diffuse into that nerve to exert an (e.g. analgesic) action.

Where do I perform the injection?
Two locations are possible: the first (and second) intercoccygeal space, and the lumbosacral junction. In the horse, the spinal cord ends around L6–S1, so the former location is most commonly employed; it is the easiest site to access and is inherently safer (for the horse) as it completely avoids the risk of entering the subarachnoid space (true spinal injection). This talk will therefore focus on epidural anaesthesia in the first intercoccygeal space.

How do I perform an epidural in the intercoccygeal space?
1. Make sure that it is safe to stand at the horse’s tail, e.g. use stocks or back the horse up to a stable door or bales of shavings. The author often sedates horses to perform epidural injections, preferring romifidine at 40 µg/kg bwt, as it results in less ataxia, and it is helpful if the horse stands ‘square’.
2. Palpate the first intercoccygeal joint by lifting and ‘pumping’ the tail. It is the first joint in the tail where both vertebrae can be felt to move slightly as the tail is pumped, and is normally two to four finger-widths above the top of the middle tail hairs. The space can be difficult to find in fat animals so try this out on thinner animals first.
3. Clip and aseptically prepare the area.
4. Inject local anaesthetic subcutaneously and along the proposed needle path in the dorsal midline (2 mL of 2% mepivacaine, 25 gauge 16 mm needle). It is useful to use the needle to then scour/mark the skin to mark the injection site as the subcutaneous local anaesthetic can subsequently make palpating the intercoccygeal space more difficult.
5. Two approaches to injection can be taken (Fig 1): the needle is advanced perpendicular to the skin surface (labelled A); or the needle is advanced approximately 30 degrees from horizontal, in a cranioventral direction (can require horizontal or craniodorsal orientation in some horses) (labelled B). The techniques have subtle differences but the author’s preference is for approach B. With the horse standing square, insert a spinal needle (19 or 20 gauge 60 or 90 mm), bevel facing forward. Once the spinal needle is through the skin, withdraw the stylet and fill the needle hub with saline. Advance the spinal needle until either:
   • You hit bone – dorsal vertebral arch or floor of spinal canal.
   • You feel a change in resistance to needle advancement – penetration of interspinous and interarcuate ligament.
   • Saline disappears from hub – penetration into (subatmospheric) epidural space.
   • Horse jumps – you hit one of the nerves of the cauda equina.
   Some, all or none of the above may occur. The needle may be advanced to full depth if the more horizontal approach is used. It is perfectly possible to perform an epidural injection using a 2 inch 19 or 21 gauge hypodermic needle, although in some horses, such a needle may not be long enough if using the horizontal approach.
6. Perform a test injection of saline (3 mL saline + 2 mL air in a 5 mL syringe). Connect the syringe to the needle and inject. It should be possible to inject with very little pressure and without compressing the air bubble.
7. Lift the tail to promote cranial spread of the administered drugs.

Fig 1: Outline of the horse’s lumbosacral and coccygeal vertebrae and body surface depicting two common approaches to performing an intercoccygeal epidural injection. A indicates the ‘perpendicular’ approach where the angle of the needle is perpendicular to the skin. B indicates the angled approach where the needle is angled 30 degrees from horizontal.
What drugs can I use?
A wide variety of drugs have been administered into the epidural space with varying degrees of efficacy. Three classes of drugs that the author commonly uses are opioids, local anaesthetics and α₂ agonists. Two principles are important: firstly, the drugs should be administered aseptically and ideally the drugs should be without preservatives or additives; and secondly, it is important to understand that the extent of cranial spread of the drugs used depends both on their total volume and total mass (e.g. µg or mg) of drug administered. This latter point is especially important to consider when administering local anaesthetics, to prevent the horse becoming nonambulatory due to motor nerve blockade.

Local anaesthetics
Lidocaine (without adrenaline) 0.2–0.4 mg/kg bwt: Take care, as recumbency can occur if the volume administered is too great (>6 mL for a 500 kg horse). The effect lasts 40–60 minutes.

Alpha-2 agonists
Xylazine 0.17 mg/kg bwt; effect lasts for up to 3 hours.

Opioids
Morphine and methadone: 0.1 mg/kg bwt of each, mixed together in same syringe. The effect lasts up to 12 hours.

Has it worked?
Studies in horses have shown that, even with good technique, only about half of epidurals work [1]. In my experience, the success rate is much higher and one of the keys to this is ensuring horses are standing ‘square’ when performing the technique and for a short while afterwards. With local anaesthetics (and to a lesser extent xylazine), the tail and anus will become flaccid and the horse should be nonresponsive to insertion of a needle into the skin in the perineal area. With the opioids, reduced pain scores and a decreased requirement for additional analgesics indicate success.

Contraindications
Do not perform an epidural if:
• There is infected or inflamed skin at the injection site (e.g. sweet-itch).
• The horse has a clotting disorder.
• The horse is hypotensive or hypovolaemic.

Reference
Introduction
Animal welfare is an increasing concern, which has led to a higher awareness of pain management in our equine patients. Combined with the fact that better pain management may lead to better and faster recovery after trauma and surgery, this puts a higher demand on us all for improved pain management.

Optimal pain management is dependent on objective evaluation of pain, and, over the last two decades, several studies aiming at identifying behavioural and physiological indicators of pain have been published, and several pain scales for objective evaluation of pain in horses have been suggested.

Pain evaluation
In addition to being a physiological event, pain is also a very emotional entity, making objective pain evaluation an extremely difficult task. Another reason for this difficulty is the subjective nature of the phenomenon in question; what is ‘no pain’ and what is the magnitude of ‘maximal pain’ or ‘worst imaginable pain’ and what are the levels in between? Furthermore, pain cannot necessarily be inspected visually in an obvious way, as is the case with, for example, lameness evaluation.

In man, pain evaluation is relatively straightforward since the patient can communicate verbally about where, how and how much it hurts. However, self-reporting is not possible in the case of human infants and animals and consequently evaluation of pain relies on an observer. In order to make the evaluation of pain as objective and standardised as possible, it is imperative to implement a systematic and objective pain assessment system. This will allow the clinician to evaluate pain and observe trends over time or response to administered analgesia, as well as improving documentation and communication with colleagues. It is believed that pain scales of the composite (measure) pain scale (C(M)PS) type are more reliable, since they are based on a number of carefully described categories of behaviour and/or physiological parameters that are indicative of pain. A plethora of different, useful scales have been developed and reported over the last decade.

The Equine Pain Scale (EPS) suggested by Gleerup and Lindegaard is a newly developed CPS which includes the types of pain related behaviours most commonly mentioned in the literature, including facial expressions of pain and excluding all physiological parameters [1]. This CPS is easy to use, taking less than 2 minutes to perform a complete pain evaluation (Table 1).

Several of these pain scales now include systematic evaluation of the horse's facial expression, since research has shown certain movements of the eyes, ears, muzzle and chin to be associated with pain (Fig 1).

A more recent development is the description of facial and behavioural expression of pain in horses when ridden.

<table>
<thead>
<tr>
<th>Table 1: Definitions of the Equine Pain Scale, Gleerup and Lindegaard 2016 [1]</th>
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<tbody>
<tr>
<td>Behaviour category</td>
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<td></td>
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<tr>
<td>Pain face</td>
</tr>
<tr>
<td>Gross pain behaviour*</td>
</tr>
<tr>
<td>Activity</td>
</tr>
<tr>
<td>Location in the stall</td>
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<tr>
<td>Posture/weight bearing</td>
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<tr>
<td>Head position</td>
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<tr>
<td>Attention towards the painful area</td>
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<td>Interactive behaviour</td>
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<td>Response to food</td>
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*Gross pain behaviour includes all readily visible behaviours like excessive head movements (vert/lat), flehmen, kicking, pawing, rolling, tail swishing, mouth playing, repeated stretching etc.
which will further improve pain management and welfare in our horses in the future.

These and other pain scales and their implementation in the equine clinic will be discussed in the lecture, but for a comprehensive review, the reader is referred to the review by Gleerup and Lindegaard [1].

References

Further reading

NOTES

Fig 1: The equine pain face. The evaluation of the facial expression of the horse is best performed when the horse is undisturbed. Look at the horse systematically, starting with the ears, then the eyes and finally evaluate the facial expression as a whole; in most cases one feature of the pain face is present when the horse is in pain [2].

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td>Lowered ears (basis)</td>
<td>Contraction of m. levator anguli oculi medialis</td>
</tr>
<tr>
<td>Nostril, dilated in the medio-lateral direction</td>
<td>Tension of the facial muscles</td>
</tr>
<tr>
<td>Edged shape of the muzzle with lips pressed together and flattened chin</td>
<td>Normal elongated comma-shaped nostril</td>
</tr>
</tbody>
</table>

The general emergencies workshop has been one of the best attended congress sessions in recent years and with a panel of renowned and very practical tutors leading discussion this year you are advised to get there early to ensure you can take part. Participants will work through challenging scenarios that are common in equine practice and will have the opportunity to discuss different approaches with one another and the specialists leading the session.

NOTES
NURSING: IMAGING WORKSHOP

Chair: Jonathon Dixon

9.00–10.30
Panel: Ceri Sherlock, Rebecca Trousdale and Marieke Zimmerman

The nurses’ imaging workshop will be aimed at nurses who are involved in performing imaging within their practices. The focus will be on practical tips to improve radiographic techniques but there will be some case discussion and some discussion of advanced imaging modalities such as nuclear scintigraphy and computed tomography. The panel leading the discussion will include recognised imaging specialists and experienced nurses.
11.00–12.30
Panel: Will Barker, Lynn Irving and Tim Mair

This session will help nurses to understand the important principles of theatre nursing and will discuss the management of more challenging cases in the operating theatre. Delegates will work in small groups with experienced vets and nurses leading discussion.
The nurses’ neonatology workshop will be led by recognised experts in equine neonatology who will use their wealth of experience to guide participants through case scenarios and give practical advice on nursing critically ill foals. Discussion will include fluid therapy, nutrition and abdominal disease.
NURSING: ASSESSING, TREATING AND MONITORING COLIC

Chair: Bettina Dunkel

15.45–17.15
Panel: Bettina Dunkel, Kate Loomes and Patrick Pollock

The panel will present clinical cases and facilitate discussion of approaches to the assessment and management of colic in horses for the practicing equine nurse.

NOTES
Reproduction and Neonatology

Chair: Huw Griffiths
Sponsor: HBLB

9.00
Investigation into the safety and clinical effects of a new progesterone releasing intravaginal device in mares
J.R. Crabtree1, S. Mateu-Sánchez2, C.D. Cooke3, I. Rogers2, D.I. Rendle2 and S. Wilsher3

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Email: james.rcrabtree@gmail.com

Background: Progesterone releasing intravaginal devices are utilised in broodmare practice. The PRID®Delta (Ceva Santé Animale, Libourne, France) is a new triangular plastic device containing 1.55 g progesterone.

Objectives: To evaluate the clinical effects of the PRID®Delta regarding delivery of progesterone, comfort and safety.

Study design: Observational study of 10 reproducitively healthy mares from day of PRID®Delta insertion (Day 0), through removal (Day 10), to 7 days post removal. Retrospective analysis of PRID®Delta use (n = 112).

Methods: Visual inspection of vaginal discharge, vaginal mucosal integrity, vaginal cytology, vaginal and endometrial bacteriology were performed at Days 0, 10, 14 and 17. Blood samples were taken through Days 0-14 and assayed for progesterone by amplified enzyme-linked immunoassay and serum amyloid A (SAA) by latex agglutination.

Results: Progesterone was significantly elevated (n = 9; P < 0.05) for 10 days with mean concentration 3.79 ng/mL (range 2.22-5.87). No significant difference in mean SAA between insertion and removal (n = 10). Vaginal discharge was significantly increased at Day 10 and was significantly lower at Days 14 and 17 (P < 0.01). No cases of vaginal mucosal damage were noted. Vaginal cytology demonstrated a significant increase in white blood cell score on Day 10 (P = 0.01) and significant decrease on Days 14 and 17 (P < 0.01). Vaginal bacteriology at Day 0 was positive in 5/10 and significantly increased at Day 10 (P = 0.04) with 9/10. Day 14 growth was significantly lower (P = 0.0006) with 1/10 positive. All endometrial swabs were negative at Days 0 (n = 9) and 17 (n = 10). Retrospective analysis of records revealed four complications (3.57%), those being: PRID®Delta protruding from the vulva, migrating into the uterus, mild and marked discomfort with the latter necessitating removal.

Main limitations: Mare inclusion was not randomly selected nor were controls available.

Conclusions: These results suggest that the PRID®Delta is safe and effective at supplying progesterone for a period of 10 days.

Ethical animal research: Informed consent was obtained for the ‘off-label’ use of the PRID®Delta in the clinical management of mares and the prospective study performed on these clinical cases.

Sources of funding: None declared.

Competing interests: None declared.

9.10
Is aspiration of blastocoelic fluid essential to vitrify large equine embryos?
S. Wilsher, F. Rigali, G. Couto, S. Camargo and W.R. (Twick) Allen

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Background: Historically, cryopreservation of equine embryos >300 µm in diameter resulted in poor pregnancy rates until researchers collapsed the blastocoel cavity prior to vitrification. Subsequently, pregnancy rates have increased following puncture of blastocysts and aspiration of >90% of their fluid prior to vitrification.

Objectives: To determine if aspiration of the blastocoelic fluid prior to vitrification is essential for post thaw survival.

Study design and methods: Thirty-two, grade 1 embryos were recovered on Day 7–8 then washed in holding medium (HM; M-199HEPES containing 20% FBS + antibiotics). Embryos were punctured using a micromanipulator and a 30 µm biopsy needle; 16 had >90% of their blastocoelic fluid aspirated while the remaining 16 were not aspirated.

Embryos were then vitrified using increasing concentrations of DMSO, ethylene glycol and sucrose before being loaded onto a Cryolock device and plunged into liquid nitrogen. The embryos were thawed by plunging the Cryolock tip into HM with 1M sucrose at 37°C. After 1 min the embryos were transferred to HM + 0.5M sucrose at RT for 4 min before being transferred into HM for a further 4 min. Each embryo was transferred to a recipient mare. Results: Mean ± SEM embryo diameter was not significantly different between the punctured and punctured plus aspirated group (561.3 ± 60.0 vs. 681.3 ± 65.8, respectively; one-way ANOVA, P = 0.74). Nonaspirated embryos gave a pregnancy rate of 8/16 (50%) compared with 12/16 (75%) for aspirated embryos (z-test, P = 0.27). Sub-dividing embryos on the basis of size showed that vitrification of larger embryos (>550 µm) yielded a significantly higher pregnancy rate when they were aspirated vs. nonaspirated (6/8 vs. 1/8, respectively; z-test, P = 0.04) whereas there was no difference for smaller embryos (6/8 vs. 7/8, respectively; z-test, P = 1.00).

Main limitations: Group sizes are small.

Conclusions: Aspiration of the fluid from embryos ≤550 µm is not a prerequisite for successful vitrification.

Ethical animal research: The use and care of the experimental mares used for this study was reviewed by the ethical review committee of Sharjah Equine Hospital.

Competing interests: None declared.

Sources of funding: None.

9.20
Major histocompatibility complex (MHC) class I expression on trophoblast of full term equine placentae
L. Thompson1, R. Robinson1, T. Leaman2 and J.H. Kydd3

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Background: The equine placenta maintains the developing fetus throughout gestation. Characterising the placenta will improve understanding of its function.

Major histocompatibility (MHC) class I is a polymorphic cell surface protein that is thought to play a major role in regulating maternal tolerance to the fetal allograft.

Objectives: To determine which MHC class I molecules are expressed by the trophoblast of the equine placenta.

Methods: The study was divided into two main parts: 1) The identification of MHC class I antigens expressed by the trophoblast using Flow Cytometry and Immunohistochemistry and 2) The identification of specific MHC class I alleles using MHC typing.

Results: Our study identified 4 major MHC class I antigens expressed by the trophoblast: MHC class I-A, MHC class I-B, MHC class I-C and MHC class I-D.

Conclusions: Our study highlights the complexity of the MHC class I expression on the trophoblast and suggests that the equine placenta may be able to evade maternal immune responses by expressing a variety of MHC class I alleles.

Sources of funding: None.

Competing interests: None declared.
in maternal immunological recognition of pregnancy, enabling survival of the semi-allogeneic placenta. MHC class I is expressed on the chorionic girdle of early equine trophoblast, but its expression on term placenta has not been studied. Objectives: To determine the pattern of MHC class I expression on full term equine trophoblast. The two hypotheses were that: 1) MHC class I is expressed on trophoblast of term equine placentae and 2) intensity of MHC class I expression differs between the microcotyledons and areolar areas of equine trophoblast.

Study design: An experimental, in vitro study using indirect immunohistochemistry. Methods: Snap-frozen samples were collected from the gravid and nongravid horns and uterine body of full term placentae in five Thoroughbred mares. Tissue sections (7 µm) were stained with a mouse anti-equine MHC class I monoclonal antibody (CVS522; Biorad Ltd, Oxford; 1:100) and detected using a Vectastain ABC elite kit (Vector Labs, Peterborough). Negative controls included an irrelevant, isotype matched monoclonal antibody (Abcam, Cambridge). Staining intensity was measured using Image Pro software, then a randomised block one-way ANOVA was used to compare intensity of each placental region (duplicate samples). Results: MHC class I expression was detected on the trophoblast of the microcotyledons and areolae and placental endothelia in all regions. There was significantly greater intensity of MHC class I expression in areolar trophoblast compared with microcotyledons and endothelium (P<0.001). Main limitations: The specific antibody detects maternal and paternal MHC class I. The number of replicates was small. Conclusions: MHC class I was expressed on full term equine trophoblast but the immunological consequences remain to be determined. Ethical animal research: This project was approved by the School of Veterinary Medicine and Science, Ethics Review Panel. Informed consent was received from the studfarm’s owners and their veterinary surgeons. Sources of funding: This project was funded by the School of Veterinary Medicine and Science, University of Nottingham. Competing interests: None declared.

9.30 Validation and application of a tablet app for equine semen analysis
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Background: Field assessment of chilled and frozen semen is limited by an effective inability to assess concentration in extended samples and variable ability to assess motility. Objectives: The goal of this study was to evaluate a tablet app (iSperm Equine, v4.4.5) for analysis of extended semen. Study design: Prospective cross-sectional observational study comparing quantitative measures with reference methods. Methods: Semen samples (n = 77) were compared with concentration by NucleoCounter (SP-100; Chemometec, Denmark), motility by visual assessment of a 10 µl sample on a warmed slide under coverslip and (n = 12) computer assisted semen analysis (CASA; Hamilton-Thorne). iSperm concentrations were compared with NucleoCounter (r = 0.9319). Spermatozoon concentration ranges were evaluated and concentrations >300 x 10^6/mL were not significantly correlated (r = -0.3924). Agreement between the methods for concentration with ranges 25-100 and 100-300 x 10^6/mL were not significantly different with the iSperm reading a mean 10.03 (1.96s 30.81) and 27.14 (1.96s 30.71) higher than NucleoCounter respectively. iSperm motility was correlated with visual assessment (r = 0.8874). iSperm motility was on average 1.52% (1.96s 13.56) and 7.01% (1.96s 12.43) higher than visual assessment for semen concentrations 25-100 and 100-300 x10^6/mL respectively with the difference in agreement being significant (P = 0.001). CASA motility was correlated with iSperm motility (r = 0.8263) and with visual motility assessment (r = 0.9319). Intra- and inter-assay coefficients of variation for iSperm motility were 4.49 and 6.69%, and for concentration 4.42 and 10.50%, respectively. Inter-assay concentration in semen was 14.59% for semen at approximately 50 x 10^6/mL. Main limitations: Coefficients of variation were not calculated for the NucleoCounter or visual motility assessment in this study. Conclusions: The iSperm app is useful for assessment of chilled and frozen semen samples; intra-assay variation of extended semen is, however, high and an average of a number of samples would be necessary to give a more accurate evaluation. Ethical animal research: Owners or their agents gave informed consent for use of clinical data and semen obtained during clinical sampling. Sources of funding: None. Competing interests: None declared.

9.40 Incidence of retained fetal membranes and oxytocin use in North American equids
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Background: Reported incidence of retained fetal membranes (RFM) in mares is in the range of 2-10% of foalings. Disease and treatment have not been investigated on a large and varied population of parturient equids. Objectives: To determine the incidence of RFM and related oxytocin use in a large equine population. Study design: A retrospective cross-sectional study on big data from a population of equids from USA and Canada. Methods: Electronic patient records (EPR) were obtained from 12 veterinary practices (with 35 branches) across North America between 2006 and 2017, which included 439,762 equids. For text-mining processing was used to identify all parturitions, RFM cases, relevant drug usage and demographic information. RFM incidence was calculated from the total number of parturitions. Results: Overall RFM incidence was 5.5% (574/10,367) but was as high as 13.1% (53/404) in abortion cases. Reoccurrence of RFM was present in 2.8% (16/574) of the affected population. Incidence of RFM was highest in Andalusians (12.5%; 11/88), Percherons (14.5%; 19/131) and miniature donkeys (16.1%; 37/241). Mean age of equids affected by RFM was 9.6 years (median: 10; range: 0–33). Oxytocin treatment was reported in 56.5% of all RFM cases (324/574), which was lower than previously reported. Main limitations: Data on oxytocin dosage were often missing; therefore, it was decided not to include such data in the study. Some data on RFM had been recorded in the EPR of foals. Due to some missing age (159/574) and breed (105/574) data, results should be interpreted with caution. Conclusions: Incidence of RFM described in this study is in line with the literature, though further studies are required around the dose of oxytocin used. Further studies may be warranted on Andalusians, Percherons and miniature donkeys to determine breed-specific risk factors that contribute to their higher incidence of RFM. Ethical animal research: The study was approved by University of Nottingham Medical School Research Ethics Committee. Owner informed consent not stated. Sources of funding: School of Veterinary Medicine and Science, University of Nottingham. Competing interests: None declared.
9.50
Hospital admission of mares showing colic signs within 7 days of parturition
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Background: Part-pant colic presents a diagnostic challenge as abdominal discomfort from normal uterine involution/minor post-faoting bruising requires differentiation from more serious conditions. Objectives: To describe causes, clinical signs, treatments and outcome of colic in post-partum mares. Study design: Retorspective case series. Methods: Clinical record review of mares admitted for colic within 7 days of foaling to Rossdales Equine Hospital, January 2004–December 2017. Clinical data, survival to hospital discharge and future breeding success, were collated. Wilcoxon rank-sum and Fisher’s exact tests were used to evaluate differences between variables, especially between mares undergoing exploratory laparotomy and those that did not, with P≤0.05. Results: Of 58 cases meeting inclusion criteria, 55 (95%; 95% CI: 85–99%) survived to discharge. All three nonsurvivors underwent exploratory laparotomy. Of 28 cases with long-term follow-up, 23 (82%; 95% CI: 62–93%) were rebred and 17 (61%; 95% CI: 41–78%) produced live foals. Of 58 cases, 21 (36%; 95% CI: 25–49%), 19 (33%; 95% CI: 21–46%) and 18 (31%; 95% CI: 20–45%) were diagnosed with gastrointestinal, reproductive and other causes of colic, respectively. Of 28 cases with reproductive causes of colic were statistically significantly more likely to have experienced dystocia (P = 0.037), with hospital admission significantly earlier post-parturition (P = 0.009) than those with gastrointestinal disease, which were more likely to undergo exploratory laparotomy (P = 0.007). Mares undergoing exploratory laparotomy had statistically significantly longer hospitalisation periods (P<0.0001) with fewer being rebred (P = 0.03) and subsequently producing live foals (P = 0.006) than those treated medically. No significant differences in clinical parameters were identified between groups. Main limitations: Only hospital admitted post-partum colic cases were included, with reliance on hospital medical records limiting data for analysis. Conclusions: Colic in post-foaling mares, independent of cause, has a good prognosis for survival but cases necessitating exploratory laparotomy on average require longer periods of hospitalisation and subsequently have reduced fertility. Ethical animal research: Research ethics committee oversight not required by this study and subsequent interpretation by the authors. Conclusions: The prevalence of post-operative complications identified in this study was twice that previously reported. Associations between the development of a complication and both horse type and season of castration were identified, which have potential importance for influencing clinical practice.

10.10
The influence of sex in the incidence and outcome of neonatal sepsis in horses: a retrospective study, 2008–2016
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Background: Sepsis remains a significant cause of death in foals [1]. Studies in human patients have demonstrated a preponderance of male patients developing septic complications, along with an increased survival in females with sepsis when compared with male patients [2]. Objectives: To investigate if sex has an influence in the incidence and outcome of neonatal sepsis in horses. Study design: We compared percentages of males and females in septic and sick but nonseptic groups of foals admitted to a neonatal unit during an 8-year period. Results: Despite an apparently higher percentage of males in the septic group (70.6%) when compared to the nonseptic group (61.3%), an analysis of sex distribution showed no significant differences. However, when comparing the outcome of septic and nonseptic animals within each sex category we found a significantly higher mortality rate in septic males (54.5%) compared to nonseptic males (23.9%, P<0.01), while no significant differences were found between septic and nonseptic females (31.8% vs. 24.4%, P>0.05). Main limitations: The
Objective measurement of navicular bursa volume

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Background: Navicular bursa (NB) effusion can be related to pathology. An objective method for measuring NB volume would be useful diagnostically and for patient monitoring.

Objectives: To evaluate an approach to measuring NB effusion and to compare measurements from horses with different pathologies. Study design: Clinical case series.

Methods: Twenty front feet MRI studies acquired using a low field MRI machine (0.31 T; Scan Equine, Esaote S.p.a., Genoa, Italy) were evaluated by a board certified radiologist. NB effusion was classified as normal, mild, moderate or severe. NB volume was measured from sagittal T2 sequences using Slicer 3D® software. The ability of objective measurements would be useful diagnostically and for patient monitoring.

Results: Average volumes were 1322 ± 387 mm³, 1187 ± 486 mm³, 2636 ± 1012 mm³ and 3833 ± 1569 mm³ for normal, mild, moderate and severe cases. There was a significant difference in volume measured between normal or mild and severe effusion (P<0.05). There was no significant difference between moderate and all other groups. ROC analyses showed that for a cut-off value of 1796 mm³ the test was 80% sensitive and 100% specific to identify moderate effusion; a cut-off value of 1767 mm³ was 100% sensitive and specific for severe effusion. Four out of five horses with severe effusion had deep digital flexor tendon (DDFT) lesions. Main limitations: Sample size and single reader.

Conclusions: Measurement of NB volume using MRI and Slicer 3D software consistently identified a difference between normal or mild effusion and severe NB effusion, and supports the subjective evaluation of clinical cases. Further investigation of the technique to increase sample size and evaluate the guidelines for different grades of NB effusion is merited. Horses with DDFT injuries appear to have a greater NB effusion with a higher risk of other lesions of the podotrochlear apparatus. Ethical animal research: The study design was approved by the Ethics and Welfare Committee of the School of Veterinary Medicine, University of Glasgow. Horse-owners gave informed consent.

Competing interests: None declared. Source of funding: None declared.


Mechanisms of action of an intra-articular 2.5% polyacrylamide hydrogel in a model of osteoarthritis: Preliminary observations

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Background: Polyacrylamide hydrogel (PAAG; Arthramid® Vet, Contura International A/S, Seborg, Denmark) is a polymer gel consisting of 97.5% sterile water and 2.5% cross-linked polyacrylamide. PAAG was recently used to successfully treat osteoarthritis (OA) in horses. Objectives: To describe preliminary observations of the mechanisms of action of a 2.5% PAAG in an OA knee model in goats based on MRI, pathology and joint capsule elasticity investigations.

Study design: Randomised controlled experiment. Methods: A randomised controlled study was conducted on an OA knee model in goats: treatment group (intra-articular PAAG), control group (intra-articular saline). Magnetic resonance imaging (MRI) was performed prior to surgery and 3, 4, 5 and 7 months post-surgery. Seven months post-surgery, gross pathology, histopathology, including immunohistochemistry for nerve endings, were performed on both knees. Joint capsule elasticity of the knees was measured in both groups. Results: MRI showed reduction followed by stabilisation of OA lesions after PAAG treatment. At gross pathology, PAAG was seen adhering to synovial membrane. Histopathology showed that intra-articular PAAG injection added to the thickness of the synovial membrane by allowing angiogenesis, collagen and synovial cell increase; PAAG was integrated into the synovial membrane. Nerve endings were intact with normal morphology and numbers. Joint capsule elasticity investigation showed that treated knees had a higher elasticity when compared with control knees. Main limitations: There were some study limitations including a low number of goats and the fact that joint range of motion was not measured. Conclusions: This study presents preliminary observations of the mechanisms of action of PAAG on OA joints: 1) Pathology and joint capsule elasticity suggest that PAAG, by acting on synovial membrane, may reduce overall joint capsule stiffness, a major source of pain in OA. 2) MRI and pathology revealed stabilisation of OA lesions in PAAG treated goats, possibly caused by the high viscosupplementation and the nondegradability of PAAG. Ethical animal research: This study was approved by the Danish Council for Animal Experimentation (Authorisation number: 2011/561-202). Sources of funding: Contura International A/S, Seborg, Denmark. Competing interests: None declared.

Comparison of ultrasonographic imaging of the accessory ligament of the deep digital flexor tendon from the lateral and palmar aspects of the metacarpus

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Background: Polyacrylamide hydrogel (PAAG; Arthramid® Vet, Contura International A/S, Seborg, Denmark) is a polymer gel consisting of 97.5% sterile water and 2.5% cross-linked polyacrylamide. PAAG was recently used to successfully treat osteoarthritis (OA) in horses. Objectives: To describe preliminary observations of the mechanisms of action of a 2.5% PAAG in an OA knee model in goats based on MRI, pathology and joint capsule elasticity investigations. Study design: Randomised controlled experiment. Methods: A randomised controlled study was conducted on an OA knee model in goats: treatment group (intra-articular PAAG), control group (intra-articular saline). Magnetic resonance imaging (MRI) was performed prior to surgery and 3, 4, 5 and 7 months post-surgery. Seven months post-surgery, gross pathology, histopathology, including immunohistochemistry for nerve endings, were performed on both knees. Joint capsule elasticity of the knees was measured in both groups. Results: MRI showed reduction followed by stabilisation of OA lesions after PAAG treatment. At gross pathology, PAAG was seen adhering to synovial membrane. Histopathology showed that intra-articular PAAG injection added to the thickness of the synovial membrane by allowing angiogenesis, collagen and synovial cell increase; PAAG was integrated into the synovial membrane. Nerve endings were intact with normal morphology and numbers. Joint capsule elasticity investigation showed that treated knees had a higher elasticity when compared with control knees. Main limitations: There were some study limitations including a low number of goats and the fact that joint range of motion was not measured. Conclusions: This study presents preliminary observations of the mechanisms of action of PAAG on OA joints: 1) Pathology and joint capsule elasticity suggest that PAAG, by acting on synovial membrane, may reduce overall joint capsule stiffness, a major source of pain in OA. 2) MRI and pathology revealed stabilisation of OA lesions in PAAG treated goats, possibly caused by the high viscosupplementation and the nondegradability of PAAG. Ethical animal research: This study was approved by the Danish Council for Animal Experimentation (Authorisation number: 2011/561-202). Sources of funding: Contura International A/S, Seborg, Denmark. Competing interests: None declared.
1.10 Comparison of long-term outcome following surgical treatment of septic pedal osteitis in horses under standing sedation and general anaesthesia

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Background: Septic pedal osteitis (SPO) has historically been treated surgically with clinical debridement under general anaesthesia (GA) [1]. Recognisation of anaesthesia-associated risks and additional costs have led to more conservative treatments (CTs), especially with median nerve (MN) blocks [2]. Objectives: To compare outcome following surgical treatment of septic pedal osteitis under standing sedation (SS) and GA. Study design: Retrospective cohort study. Methods: Clinical data of horses treated surgically for SPO at two equine referral hospitals from 2011 to 2016 were reviewed and treatment recorded. Medical records and telephone interviews were used to determine long-term survival and return to athletic performance. A Fisher’s exact test ascertained whether GA or SS were associated with outcome. Results: Data were retrieved from 39 cases and follow-up information was available for 28 cases. 57% returned to previous levels of athletic activity and 7% to a lower level of ridden exercise. 11% were retired due to ongoing associated lameness and 25% were euthanased, 14% of which were directly related to SO. No significant difference was noted in long-term prognosis between horses treated under SS or GA (P = 0.3). Main limitations: Inclusion criteria limited case numbers. Conclusions: This study identified a moderate long-term outcome for return to previous athletic ability in horses treated surgically for SPO, lower than that which was previously reported [1]. There was no difference in outcome between GA or SS cases, making the latter a favourable choice for clinicians with appropriate cases wishing to avoid GA. Ethical animal research: Ethical approval was granted through the University of Edinburgh Ethics Committee. Informed consent was obtained from all owners for inclusion of their horses. Sources of funding: Horserace Betting Levy Board. Competing interests: None declared.


11.20 Nondisplaced radius fracture in 20 horses.

Outcome following conservative management

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Background: Fracture of the radius can result from external trauma, typically a kick. Horses with nondisplaced fractures often present with a small wound but greater degree of lameness than would be anticipated. Fracture lines may not be visible on radiographs in the first instance and conservative management with restriction of exercise is recommended based on clinical suspicion. Outcome following nondisplaced radius fracture has only been reported sporadically. Objectives: To review and investigate clinical outcome of conservatively managed, nondisplaced radial fractures. Study design: Retrospective study. Methods: Clinical records of horses seen at Donnington Grove Equine Hospital between 1998 and 2018 were examined. Inclusion criteria were horses which had radiographically confirmed nondisplaced fractures of the radius. Exclusion criteria were complete or displaced fractures and cases with more subtle radiographic abnormalities more typical of a bone sequestrum. Outcome and return to work were recorded, along with the time from trauma to diagnosis. Results: Nondisplaced radius fractures were identified in 20 horses with diagnosis based on clinical history and examination, radiography and, in four cases, nuclear scintigraphy. The interval from trauma to diagnosis was median 1 day (range 1-14 days). Three horses were radiographed and no abnormalities were detected initially. All horses were box rested, and eight horses were also cross tied. Seventeen horses (85%) were successfully discharged and returned to exercise, including seven on cross ties. Three (15%) were euthanased due to complete fracture development after rearing on cross ties or during anesthetic recovery from colic surgery (1) and economic grounds (n = 2). Main limitations: Treatment was similar but not standardised between cases. Small sample size and retrospective study.

Conclusions: Nondisplaced radial fractures may be present with no radiographic abnormalities for several weeks. The prognosis with conservative management is good, though complete fractures developed in 10% of horses. Ethical animal research: Research ethics committee oversight not
required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated. Source of funding: None. Competing interests: None declared.

11.30 Could saddle design affect performance in the racing Thoroughbred? A pilot study
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Background: Back pain is a frequent problem in racehorses, but saddle fit and design are rarely assessed. In sport horses, it is increasingly recognised that the horse-saddle interaction can be associated with back pain and altered kinematics, but there are virtually no studies investigating horse-saddle interaction in racehorses. In sport horses at trot, lower pressures under saddles at thoracic vertebrae 10–13 were associated with improved fore/hindlimb kinematics [1]. We hypothesised that reducing pressures under saddles at T10–13 in racehorses is associated with improved kinematics. Objectives: 1) To determine the pressure magnitude/distribution under three frequently-used race-exercise saddles and a saddle designed to reduce peak pressures at T10-13 on racehorses at gallop; 2) To compare hindlimb kinematics at gallop between four saddle types.

Study design: Cross-over design.

Methods: Four Thoroughbred racehorses in active National Hunt training (490–575 kg) were galloped overground at a standardised speed wearing four saddles: half tree, three-quarter tree, full tree race-exercise saddles (Saddles H/Q/T), and a saddle designed to reduce paraspinal pressure under the saddle at T10–13 (Saddle F). Pressure distribution under saddles was recorded using a pressure-mat system, and technique features using high-speed-motion-capture. Data were collected in the mid-50 m of 150 m straight side of a flat oval track. Results were compared between saddle types within horses. Results: Peak pressures, femur angle to vertical and hip flexion angle were significantly different between saddle types (P<0.0001–0.02). Saddle F had significantly lower peak pressures at T10–13, greater hip flexion, femur angle to vertical and stride length than H/Q/T. Main limitations: Small sample size.

Conclusions: Pressure distribution/magnitude varied significantly with saddle type, showing importance of saddle design. Results suggest that the femur has greater protraction in saddles with lower pressures at T10–13. It is possible that saddles with lower pressures at T10–13 allow increased range of spinal motion and altered muscle use, supporting improved hindlimb function. Ethical animal research: Approved by the Ethical Review Committee of the Animal Health Trust (project number: AHT 57-2016). Trainers gave consent for their animals’ inclusion in the study. Source of funding: Animal Health Trust and Fairfax Saddles. Competing interests: Vanessa Fairfax is employed by Fairfax Saddles.


11.40 Small non-coding RNAs as early biomarkers of osteoarthritis
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Background: Equine osteoarthritis (OA) results in substantial morbidity and mortality. We have previously identified small non-coding RNA dysregulation in OA and as potential OA biomarkers. Synovial fluid represents a potential source of disease-specific small non-coding RNAs that could aid in the understanding of the pathogenesis of OA, be used as therapeutic targets and in its early diagnosis. Objectives: We hypothesised that there are differentially expressed small non-coding RNAs that can be identified in early OA synovial fluid. Study design: Cross-sectional. Methods: RNA was extracted using miRNEasy serum kits (Qiagen) from synovial fluid from the metacarpophalangeal joints of five normal and five early OA Thoroughbred horses following macroscopic and microscopic scoring of joints. Samples were submitted for library preparation using NEB small RNA library kit. Samples were size selected using a range 120–300 bp. Small RNA sequencing was undertaken on the Illumina HiSeq 4000 platform using 150 base paired-end reads and reads aligned to the horse reference genome. Differential expression analysis was conducted using edgeR. Significantly differentially expressed (DE) snoRNAs were identified with a FDR-adjusted P-values<5%. Results: There was a significant increase (P = 0.02) in both gross and histological scores for samples assigned normal and mild OA (1.3 ± 0.6, 5.2 ± 2.6 and 1.3 ± 1.5, 6.6 ± 2.0, respectively). There were 21 small non-coding RNAs DE including 13 mirs; mir-10a, mir-223, let7a, mir-99a, mir-23b, and mir-143 (and six novel mirs), four snRNAs; U12, U11, U12, 3 snoRNAs; U13, snoR38, snoR96, and one scaRNA; scarn4. Conclusions: Using synovial fluid from mild OA have identified mild OA-specific patterns of small non-coding RNAs which could act as potential biomarkers of early OA or act as future treatment targets. Ethical animal research: Hospital samples were collected during post-mortem examination with informed consent. Other samples were obtained from an abattoir. Source of funding: Wellcome Trust, University of Liverpool Technical Directorate. Competing interests: None declared.

11.50 Associations between the radiographic appearance of vascular channels in proximal sesamoid bones, their microstructural characteristics and past racing performance in Thoroughbreds
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Background: The presence of and abnormalities in vascular channels has an association with racing performance. The presence, number and size of vascular channels has an association with racing performance is inconsistent. The understanding of the pathogenesis of OA, be used as therapeutic targets and in its early diagnosis. Objectives: We hypothesised that there are differentially expressed small non-coding RNAs that can be identified in early OA synovial fluid. Study design: Cross-sectional. Methods: RNA was extracted using miRNEasy serum kits (Qiagen) from synovial fluid from the metacarpophalangeal joints of five normal and five early OA Thoroughbred horses following macroscopic and microscopic scoring of joints. Samples were submitted for library preparation using NEB small RNA library kit. Samples were size selected using a range 120–300 bp. Small RNA sequencing was undertaken on the Illumina HiSeq 4000 platform using 150 base paired-end reads and reads aligned to the horse reference genome. Differential expression analysis was conducted using edgeR. Significantly differentially expressed (DE) snoRNAs were identified with a FDR-adjusted P-values<5%. Results: There was a significant increase (P = 0.02) in both gross and histological scores for samples assigned normal and mild OA (1.3 ± 0.6, 5.2 ± 2.6 and 1.3 ± 1.5, 6.6 ± 2.0, respectively). There were 21 small non-coding RNAs DE including 13 mirs; mir-10a, mir-223, let7a, mir-99a, mir-23b, and mir-143 (and six novel mirs), four snRNAs; U12, U11, U12, 3 snoRNAs; U13, snoR38, snoR96, and one scaRNA; scarn4. Conclusions: Using synovial fluid from mild OA have identified mild OA-specific patterns of small non-coding RNAs which could act as potential biomarkers of early OA or act as future treatment targets. Ethical animal research: Hospital samples were collected during post-mortem examination with informed consent. Other samples were obtained from an abattoir. Source of funding: Wellcome Trust, University of Liverpool Technical Directorate. Competing interests: None declared.

11.40 Small non-coding RNAs as early biomarkers of osteoarthritis
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Background: Equine osteoarthritis (OA) results in substantial morbidity and mortality. We have previously identified small non-coding RNA dysregulation in OA and as potential OA biomarkers. Synovial fluid represents a potential source of disease-specific small non-coding RNAs that could aid in the understanding of the pathogenesis of OA, be used as therapeutic targets and in its early diagnosis. Objectives: We hypothesised that there are differentially expressed small non-coding RNAs that can be identified in early OA synovial fluid. Study design: Cross-sectional. Methods: RNA was extracted using miRNEasy serum kits (Qiagen) from synovial fluid from the metacarpophalangeal joints of five normal and five early OA Thoroughbred horses following macroscopic and microscopic scoring of joints. Samples were submitted for library preparation using NEB small RNA library kit. Samples were size selected using a range 120–300 bp. Small RNA sequencing was undertaken on the Illumina HiSeq 4000 platform using 150 base paired-end reads and reads aligned to the horse reference genome. Differential expression analysis was conducted using edgeR. Significantly differentially expressed (DE) snoRNAs were identified with a FDR-adjusted P-values<5%. Results: There was a significant increase (P = 0.02) in both gross and histological scores for samples assigned normal and mild OA (1.3 ± 0.6, 5.2 ± 2.6 and 1.3 ± 1.5, 6.6 ± 2.0, respectively). There were 21 small non-coding RNAs DE including 13 mirs; mir-10a, mir-223, let7a, mir-99a, mir-23b, and mir-143 (and six novel mirs), four snRNAs; U12, U11, U12, 3 snoRNAs; U13, snoR38, snoR96, and one scaRNA; scarn4. Conclusions: Using synovial fluid from mild OA have identified mild OA-specific patterns of small non-coding RNAs which could act as potential biomarkers of early OA or act as future treatment targets. Ethical animal research: Hospital samples were collected during post-mortem examination with informed consent. Other samples were obtained from an abattoir. Source of funding: Wellcome Trust, University of Liverpool Technical Directorate. Competing interests: None declared.
previously published and novel radiographic grading systems, then imaged using µCT. Uni- and multi-variable generalised linear models accounting for clustering at the horse level were generated to investigate associations between radiographic, µCT and performance variables. Results: All PSB had vascular channels observed on µCT originating from the abaxial border (mean 3.6, s.d. 0.89), yet in only 63.6% (75/118) were channels observed radiographically, PSB with a higher bone volume fraction (OR 1.08; P = 0.031) and wider channel diameter on µCT (OR 20.67, P = 0.001) were more likely to have vascular channels identified on radiographs. Radiographic channel number (OR 0.96; P = 0.043) and channel size (OR 0.96; P = 0.049) were negatively associated with career placings.

Main limitations: Radiographs of isolated bones avoided the normal superimposition of tissue encountered in the live horse.

Background: Vascular channels observed on µCT originating from the abaxial border (mean 3.6, s.d. 0.89), yet in only 63.6% (75/118) were channels observed radiographically, PSB with a higher bone volume fraction (OR 1.08; P = 0.031) and wider channel diameter on µCT (OR 20.67, P = 0.001) were more likely to have vascular channels identified on radiographs. Radiographic channel number (OR 0.96; P = 0.043) and channel size (OR 0.96; P = 0.049) were negatively associated with career placings. 

Main limitations: Radiographs of isolated bones avoided the normal superimposition of tissue encountered in the live horse. 

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Main limitations: Radiographs of isolated bones avoided the normal superimposition of tissue encountered in the live horse.
12.20
Development of the inter-fascicular matrix in the equine superficial digital flexor tendon
D.E. Zamboulis1, C.T. Thorpe2, H.L. Birch3, H.R.C. Screen4 and P.D. Clegg1

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Background: Tendon injuries remain a common problem in horses and mainly occur in energy-storing tendons, such as the equine superficial digital flexor tendon (SDFT). The inter-fascicular matrix (IFM) of tendons has been demonstrated to be a key determinant of mechanical properties and to be specialised for its function in the high-strain energy-storing SDFT [1]. Objectives: We hypothesised that the IFM is optimised in the SDFT in the post-natal period. Study design: We assessed the biomechanical properties of the fascicles and IFM of the SDFT and the positional common digital extensor tendon (CDET) through development and characterised the proteome of the SDFT fascicular matrix (FM) and IFM through development. Methods: Tendons were collected from fetuses and foals 0–2 years, euthanised for reasons unrelated to this project. Samples were collected following owner’s consent or from an abattoir as by-product of the agricultural industry (under the Animal (Scientific Procedures) Act 1986). Fascicles and IFM were dissected and tested biomechanically using an electrodynamic testing machine. Proteome characterisation was performed on laser-captured microdissection of FM and IFM following liquid chromatography-mass spectrometry. Results: Biomechanical analysis revealed changes through development mainly in the SDFT IFM with a significant interaction between tendon and age for force and extension at maximum stiffness, with the SDFT showing higher values than the CDET with development. Fascicles’ properties were similar between tendons through development. Proteomic analysis showed most proteins’ abundance in the IFM increased with development and peaked at 3–6 months whereas fascicles’ proteins’ abundance mainly peaked in fetus and then decreased. Main limitations: Additional samples would contribute to a more detailed timeline of developmental changes. Conclusions: These results highlight the importance of the IFM in the function of the energy-storing SDFT and support the post-natal specialisation of the SDFT IFM. Ethical animal research: Approved by the University Committee on Research Ethics of the University of Liverpool. Samples were obtained from an abattoir. Sources of funding: Horserace Betting Levy Board. Competing interests: None declared.


12.30
Are different equine mesenchymal stem cells affected equally by an inflammatory environment in vitro? L.C. Berg and L. Bundgaard

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Background: Mesenchymal stem cells (MSC) are a promising therapy in orthopaedic conditions. MSC from bone marrow and adipose tissue are available commercially for horses, but very little is known about the effect of inflammation on MSC. Objectives: To test the effect of different proinflammatory molecules on equine MSC and evaluate if MSC from different tissues respond equally. Study design: In vitro cell culture. Methods: MSC from bone marrow (BM), adipose tissue (AT), peripheral blood (PB) from five horses. Cells (p3) were cultured in DMEM + 2% FCS + 1% penicillin/streptomycin + 50 µg/mL gentamicin (only AT) + 10-11 M dexamethasone (only PB) until 70–80% confluence. Four treatment protocols for 48 h: Interleukin-1β (IL-1β) 10 ng/mL, tumour necrosis factor α (TNFα) 50 ng/mL, serum amyloid A (SAA) 1 µg/mL, untreated controls. Effect was evaluated using quantitation of mRNA expression of inflammation regulatory markers: IL-1β, IL-6, TNFα, SAA, cyclo-oxygenase 2 (COX2), hypoxia-inducible factor 1α, transforming growth factor β. Cell types were compared by two-way ANOVA and Tukey’s post-test with significance level P<0.05. Results: Control cultures showed low expression of inflammatory markers. All cell types were affected by treatment with strongest effect of IL-1β. SAA showed limited effect. Expression pattern of IL-1β, IL-6, TNFα, SAA, and COX2 varied markedly between cell types, e.g. COX2 expression was significantly increased in BM and AT but not PB after IL-1β treatment, but only in PB after TNFα treatment. Main limitations: In vitro study. Conclusions: This is the first direct comparison of response between clinically relevant MSC. Our findings support previous evidence that MSC are affected by inflammation, but also shows that different MSC are not affected equally. Choice of cell type for treatment could depend not only on injury type and tissue, but also presence of inflammation. Further studies are required to determine consequences on regenerative capability. Ethical animal research: Study was approved by local Ethical Committee at Department of Veterinary Clinical Sciences. Owners’ consent obtained. Sources of funding: Independent Research Fund Denmark, grant number 1335-00133B. Competing interests: None declared.

Medicine

Chair: Michael Hewetson
Sponsor: HBLB

13.40
Effect of dietary supplementation with ubiquinol on muscle concentrations of CoQ10 E. Thueson1, D. Leadon2, R. Heaton3, I. Hargreaves3 and W. Bayly4

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Background: Coenzyme Q10 (CoQ10) has been studied extensively in people but not horses. Its biologically active form is ubiquinol. Objectives: To evaluate the effects of daily supplementation with ubiquinol on gluteal muscle CoQ10 concentrations and related them to citrate synthase (CS) activities in fit Thoroughbreds. CS is an important Kreb’s cycle enzyme and an indicator of oxidative phosphorylation status. Study design: Randomised, controlled crossover study. Methods: Six horses received either 1 g ubiquinol for 3 weeks followed by 21 days without supplement, or had a 3-week unsupplemented period
13.50
Serum hypoglycin A and MCPA-carnitine concentrations vary with clinical severity and correlate with underlying muscle damage in horses with atypical myopathy
S. González-Medina\(^1\), C. Hyde\(^2\), C. Massey\(^2\) and R.J. Piercy\(^1\)

\(^1\)Comparative Neuromuscular Diseases Laboratory, The Royal Veterinary College, London, NW1 0UJ, UK; \(^2\)Bio-Assay Analysis Centre, 2 Royal College Street, London, NW1 ONH, UK

**Objectives:** To describe horses with atypical myopathy (AM) that presented with exercise-induced rhabdomyolysis following low-level exercise, or exercise intolerance. Study design: A case report of five clinical cases seen. Methods: Case records were reviewed from horses that were diagnosed with AM after developing clinical signs following or during exercise. Results: Five horses with increased serum muscle enzyme activities were identified. Clinical signs included exercise-induced rhabdomyolysis following light exercise (n = 3), perceived abdominal pain during light exercise (n = 1) and exercise intolerance (n = 1). AM was diagnosed by detecting hypoglycin A in serum (n = 3) or characteristic plasma acylcarnitine and urine organic acid profiles (n = 1). Muscle biopsy of one horse following abnormal exercise testing, revealed rhabdomyolysis and prominent lipid accumulation in oxidative fibres, consistent with AM. All cases resolved and returned to exercise following supportive management; one horse developed another episode of rhabdomyolysis. Sycamore exposure was confirmed in four cases. Main limitations: Low case numbers. Conclusions: In these horses, myopathic signs were unusual, given the low levels of exercise prompting further investigation and, in each case, revealing underlying AM. Previous reports describe AM as a severe, commonly fatal disorder with systemic compromise; in contrast, these horses developed an exercise-associated myopathy following low-level athletic activity but had characteristic AM biochemical or histological features. Prognosis appears to be excellent for survival and horses can return to previous levels of exercise with supportive management. Sub-clinical hypoglycin A toxicity might predispose horses to exercise-induced rhabdomyolysis following low levels of exercise and therefore should be considered when cases of exertional rhabdomyolysis cannot be explained. Ethical animal research: Research ethics committee oversight not required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated. Sources of funding: None. Competing interests: None declared.

14.00
Exercise-associated atypical myopathy in five adult horses
C.J. McGuire\(^1\), R.J. Piercy\(^2\), S. González-Medina\(^2\), C. Massey\(^2\), K. Robinson\(^3\) and K.F. McGovern\(^1\)

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**Background:** Interest in a novel presentation of a known disease. Objectives: To describe horses with atypical myopathy (AM) that presented with exercise-induced rhabdomyolysis following low-level exercise, or exercise intolerance. Study design: A case report of five clinical cases seen. Methods: Case records were reviewed from horses that were diagnosed with AM after developing clinical signs following or during exercise. Results: Five horses with increased serum muscle enzyme activities were identified. Clinical signs included exercise-induced rhabdomyolysis following light exercise (n = 3), perceived abdominal pain during light exercise (n = 1) and exercise intolerance (n = 1). AM was diagnosed by detecting hypoglycin A in serum (n = 3) or characteristic plasma acylcarnitine and urine organic acid profiles (n = 1). Muscle biopsy of one horse following abnormal exercise testing, revealed rhabdomyolysis and prominent lipid accumulation in oxidative fibres, consistent with AM. All cases resolved and returned to exercise following supportive management; one horse developed another episode of rhabdomyolysis. Sycamore exposure was confirmed in four cases. Main limitations: Low case numbers. Conclusions: In these horses, myopathic signs were unusual, given the low levels of exercise prompting further investigation and, in each case, revealing underlying AM. Previous reports describe AM as a severe, commonly fatal disorder with systemic compromise; in contrast, these horses developed an exercise-associated myopathy following low-level athletic activity but had characteristic AM biochemical or histological features. Prognosis appears to be excellent for survival and horses can return to previous levels of exercise with supportive management. Sub-clinical hypoglycin A toxicity might predispose horses to exercise-induced rhabdomyolysis following low levels of exercise and therefore should be considered when cases of exertional rhabdomyolysis cannot be explained. Ethical animal research: Research ethics committee oversight not required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated. Sources of funding: None. Competing interests: None declared.

14.10
GSY1 status affects muscle activity as measured with surface EMG in Austrian cold blood Noriker horses
R.R. Zsoldos\(^1\), N. Khayatzadeh\(^1\), J. Söllker\(^2\) and T.F. Licka\(^2,3\)
Background: The GYS1 gene mutation is associated with polysaccharide storage myopathy (type 1 PSSM) in horses, but muscle effects of this mutation prior to the development of clinical disease remain unclear. Objectives: To document muscle activity based on the GYS1 genetic status of Austrian cold blood horses. Study design: Matched observational study. Methods: In clinically healthy Noriker horses matched for sex, body mass, and age either homozygous for GYS1 mutation (n = 7, affected), or homozygous without GYS1 mutation (n = 7, control) the muscle activity of the gluteus muscle was measured using surface EMG at walk and at trot. The density of muscle fibres with the accumulation of clumped muscle glycogen present in the affected horses. The method of sEMG analysis used in the present study may potentially develop into a tool to identify type 2 PSSM, a similar disease currently without identified genetic basis. Ethical animal research: This study was approved by the Commission for Ethics and Animal Welfare, University of Veterinary Medicine Vienna, protocol number ETK-20/06/2016. Owners gave consent for their animals’ inclusion in the study. Sources of funding: This work was financially supported by Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). Competing interests: None declared.

14.20 Multipulse transcranial electrical stimulation (TES) to diagnose spinal cord injury in horses S.L. Journée1, C.J.G. Delesalle2, C.M. de Brujin3, W. Bergmann4 and H.L. Journée5

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Background: There is need for additional sensitive diagnostic techniques to assess spinal cord injury in horses. Objectives: To compare the outcomes of motor latency times (MLTs) from transcranial electrical stimulation (TES) with myelographic and post-mortem findings in horses suspected of suffering from cervical myelopathy. Study design: Cross-sectional observations. Methods: Eight horses, age range: 0.54–11.7 years, mean height at withers: 156.4 (147–163) cm and with mean ataxia grade: 3.25 (2–4 out of 5) were studied. TES was performed with the previously described method using a multipulse bilateral at the extensor carpi radialis (ECR) and tibialis cranialis (TC) muscles. Myelography was performed under general anaesthesia by contrast injection at atlanto-occipital level with the head respectively in flexed, extended and neutral position to identify reduction in dural diameter. Post-mortem histopathological examination was performed between C1 and T1 of the spinal cord. Statistical comparisons were made between these clinical cases and previously published healthy horses [1]. Results: All MLTs were significantly prolonged (P<0.001) compared with published data from normal horses with mean values of 33.2 (28.2–41.7) ms (left, n = 8) and 32.7 (27.8–41.2) ms (right, n = 8) for the ECR and for the TC: 80.3 (53.0–110) ms (left, n = 8) and 78.2 (58.0–95.0) ms (right, n = 7). Six horses had pronounced reduction in dural diameter at various segmental levels. However, there were histopathological abnormalities in all cases. Main limitations: Small sample size, lack of observer masking and historical controls. Conclusions: TES detects myelopathy even in cases with normal myelograms. Ethical animal research: Owners gave informed consent for their horses’ inclusion in the study. Sources of funding: JS Center and Wolvega Equine Clinic. Competing interests: None declared.


14.30 Clinical equine nutrition in the post-operative colic: Survey of Diplomates of the American Colleges of Veterinary Internal Medicine (ACVIM) and Veterinary Surgeons (ACVS), and the European Colleges of Equine Internal Medicine (ECEIM) and Veterinary Surgeons (ECVS) A.L. Lawson1, C.E. Sherlock2 and T.S. Main2

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Background: Evidence is lacking concerning optimal post-operative colic nutrition with regards to when to feed, the amount and frequency. Objectives: To report the different approaches favoured by European and American specialists to re-feeding adult horses following surgical treatment of common intestinal lesions, assuming an uncomplicated recovery. Study design: Cross-sectional survey. Methods: Electronic invitations were sent to 1430 Large Animal specialists, including ECVS, ACVS, ECEIM and ACVIM colleges, allowing access to complete the online survey. Results: The response rate was 12.6% (180/1430) including partial respondent data. Responses for each multiple-choice question were between 123 and 175. The following results are expressed as the percentage of the total number of responses. Respondents reported different large intestinal displacements to be offered free choice water (63–65%) and to introduce water at <3 h (55–63%), whereas various small intestinal strangulating lesions were reintroduced <2 L water (64–74%) and 212 h but <24 h (28–34%). Large colon displacements were offered feed as early as <3 h (16%) but the majority were offered feed ≥6 h but <12 h (35–36%). Small intestinal strangulating lesions and small colon lesions were offered feed ≥24 h but <48 h (34–42%). Following various types of small intestinal, small colon or caecal lesions, horses were re-introduced feed with handfuls (79–93%) and initially grass (41–54%). Large colon displacements were mostly given handfuls (49–50%) of forage initially, but compared with other lesions, a greater number of respondents would offer larger quantities such as a small bucket (35–37%) and predominantly offered hay (50–51%). Main limitations: Low response rate. This study did not take into account common complications that may occur post-operatively that may alter clinical approach. Conclusions: The post-operative colic nutrition survey is the first to describe current clinical practice. Further research is required to investigate nutritional strategies in post-operative colic patients. Ethical animal research: Research ethics committee oversight not stated. Sources of funding: None. Competing interests: None declared.
**EXECUTIVE ROOM 1**

**SATURDAY 15 SEPTEMBER**

**14.40**

**Transabdominal ultrasonography in healthy small equid species: establishment of standards and comparison with the horse**

**T. Hermange, N. Paille and A. Couroucé**

Unité de nutrition, PhysioPathologie et Pharmacologie (NP3), Ecole Nationale Vétérinaire, agro-alimentaire et de l’alimentation Nantes-Atlantique (Oniris), Université Bretagne Loire (UBL), Nantes F-44307, France. Email: tanguy.hermange@gmail.com

**Background:** There is little information regarding small equine species transabdominal ultrasonographic examination. **Objectives:** To establish transabdominal ultrasonography standards in small equine species and to compare data with horses. **Study design and methods:** Transabdominal ultrasonographic examination was performed in 46 healthy unsedated adult equids: 10 horses, 9 donkeys, 8 small ponies measuring less than 107 cm, 9 middle size ponies and 10 American Miniature Horses. The colon, caecum, small intestine, stomach, spleen, liver, and both kidneys were examined. Position, size, appearance, content, and wall thickness were recorded. Statistical analysis was performed using a one-way ANOVA and significant difference was considered if P<0.05. **Results:** Donkey and small pony stomachs spanned over a significantly higher area than in horses. Whereas stomach cranial and ventral limits were not significantly different between all groups, caudal limits were significantly higher in donkeys (14.75 ± 1.28) than in horses (ICS: 12.60 ± 1.73). Also, dorsal limits were significantly higher in donkeys and small ponies (middle of the tuber coxae line for both) compared with horses (tuber ischia line). Stomach wall was significantly thicker in horses (0.65 ± 0.20 cm) compared with donkeys (0.46 ± 0.12 cm), small ponies (0.47 ± 0.12 cm) and miniature horses (0.39 ± 0.09 cm). The liver on the right side spanned over significantly more intercostal spaces in donkeys (8.22 ± 0.97) compared with horses (5.70 ± 1.83). Regarding right and left kidney maximal length and width, there was a significant difference between all groups except between donkeys and small ponies. Caeco-colic band vessels were observed in all equids. **Main limitations:** Small sample size. **Conclusions:** Transabdominal ultrasonographic examination standards are significantly different between horses and small equids. These differences should be taken into account during diagnostic investigations. **Ethical animal research:** The study was approved by the regional Animal Ethic Committee (CEROV-2017-10-V). Owners gave consent for their animals’ inclusion in the study. **Sources of funding:** Oniris, AVEF (French Equine Veterinarian Association), IDEXX laboratories, SCIL animal care company. **Competing interests:** None declared.

**14.50**

**Computed tomographic features of equine oromaxillary sinus and oronasal fistulae**

**L. Hargreaves and J.J. Dixon**

Rainbow Equine Hospital Ltd, Rainbow Lane, Malton, North Yorkshire, YO17 6SG, UK. Email: lauhr93@aol.com or imaging@rainbowequinehospital.co.uk

**Background:** Formation of an oronasal or oromaxillary sinus fistula may occur secondary to the removal or loss of a maxillary cheek tooth, or as a consequence of periapical infection derived from compression of feed material into a diastema situated between two maxillary cheek teeth. The benefits of computed tomography (CT) for surgical planning following identification of a fistula have been described, but the detailed appearance of oronasal and oromaxillary sinus fistulae have not been described. **Objectives:** To describe the CT features of oronasal and oromaxillary sinus fistulae in a population of horses with findings confirmed using alternative methodology. **Study design:** Retrospective, descriptive case series. **Methods:** CT examinations of 17 horses with confirmed fistulae were evaluated for the location of fistulae, defect size, presence of previous tooth extraction, communicating tract characteristics including representative Hounsfield unit values and the presence of concurrent pathology. **Results:** All fistulae were clearly identifiable as variably sized focal defects (median 1.0 cm, range 0.3-1.6 cm) in the alveolar bone. Communicating material extending through the defects was often a linear tract of heterogeneous material combined with gas bubbles, representing feed material. Representative tract Hounsfield units varied widely within and between cases (median -26.0 HU, range -966.0 to +910.0 HU). Concurrent dental disease was identified in 16/17 cases. **Main limitations:** Masked image review was not possible. The use of CT as a definitive diagnostic modality has not been fully assessed therefore sensitivity and specificity cannot be calculated. **Conclusions:** Oronasal and oromaxillary sinus fistulae appear to be consistently visible on CT images. Identification of feed material within the sinus or nasal passages remains gold standard for diagnosis, but the imaging features identified in this manuscript may offer a useful adjunctive diagnostic technique in order to define the characteristic of fistulae prior to treatment due to the anatomical detail acquired. **Ethical animal research:** Research ethics committee oversight not required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated. **Sources of funding:** None. **Competing interests:** None declared.

**15.40**

**Reproducibility of arterial diameter measurements using B- and M-mode ultrasonography in standing Warmblood horses**

**L. Vera, D. De Clercq, A. Decloedt, G. Van Steenkiste and G. van Loon**

Department of Large Animal Internal Medicine, Faculty of Veterinary Medicine, Ghent University, Belgium. Email: Lisse.vera@ugent.be

**Background:** In human medicine, arterial wall stiffness (AWS) parameters are calculated from ultrasonographically measured diastolic (Dd) and systolic arterial diameter (Ds) in order to assess vascular health. In horses, information regarding reproducibility of ultrasonographic measurements of arterial diameters is lacking. **Objectives:** To evaluate inter-day, inter-observer and intra-observer variability of ultrasonographic arterial diameter measurements in horses. **Study design:** Cross-sectional. **Methods:** In 10 healthy, adult Warmblood horses, ultrasound images were recorded on two different days from aorta (B-mode), common carotid and femoral artery (B-mode and M-mode). In addition, heart rate and noninvasive blood pressure were
recorded simultaneously. From masked data, Dd and Ds were measured over nine cardiac cycles from images of both days, and from each horse, one exam was measured again by the same observer and by a second, independent observer. Inter-day, inter-observer and intra-observer coefficients of variation were calculated. Carotid and femoral diameter measurements from M-mode were compared with diameters derived from measured areas on B-mode images using a paired $t$ test. 

**Results:** There was no significant difference between heart rate or blood pressure between the two days. Mean B-mode Dd and Ds (± s.d.) for aorta, carotid and femoral artery were 59.8 ± 4.1 mm and 66 ± 4.4 mm, 11.7 ± 11 mm and 12.3 ± 1.2 mm, and 12.8 ± 1.1 mm and 13.2 ± 1.0 mm, respectively. The latter were not significantly different from M-mode measurements. For Dd and Ds from M and B-mode images of all three arteries, inter-day (4–9%), inter-observer (1–3%) and intra-observer (1–2%) variability was low. 

**Main limitations:** A larger group of healthy horses must be examined to define reference ranges for arterial diameters.

**Conclusions:** Our results show good reproducibility of aortic, carotid and femoral diameter measurements using both B- and M-mode ultrasonography, suggesting these are potentially useful variables for assessing AWS in horses.

**Ethical animal research:** This study was approved by the Ethical Committee of the Faculties of Veterinary Medicine and Bioscience Engineering, Ghent University (2016/104).

**Sources of funding:** Lisse Vera and Glenn van Steenkiste are funded by the Research Foundation Flanders (FWO-Vlaanderen).

**Competing interests:** None declared.

15.50 Temporal trends in bacterial isolate and antimicrobial susceptibility data from Thoroughbred racehorse tracheal aspirates: analysis of laboratory submissions from 2003 to 2016

L. Palmer, K. Grimes, A.P. Fletcher, A.K. Foote and P.H.L. Ramzan

Rossdales LLP, Beaufort Cottage Stables, Newmarket, UK. Email: lorraine.palmer@rossdales.com

**Background:** Antimicrobial stewardship is a topical concern and the potential resistance/patterns of common horses’ antimicrobials merits further investigation.

**Ethical animal research:** Research ethics committee oversight not required by this journal: retrospective analysis of clinical data. Explicit owner informed consent for inclusion of animals in this study was not stated.

**Source of funding:** None. 

**Competing interests:** None declared.

16.00 Combined Antigen A and C serologic response in horses vaccinated for strangles with a modified live intranasal vaccine

A.G. Boyle1, C. Mitchell1, D. Stefanovski2 and A.S. Waller2

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**Background:** Strangles is a highly infectious upper respiratory disease with a high morbidity rate and financial burden. The iELISA [1] is currently used to identify recent infection and to identify exposed animals without signs. This serological test uses two surface protein antigens composed of N-terminal portions of SEG_2190 (Antigen A) and SeM (Antigen C) and has the capability to differentiate vaccines from infected animals (DIVA), depending on which vaccine is used. 

**Objectives:** We hypothesise that horses vaccinated for strangles with Pinnacle® IN (Zoetis, Parsippany, New Jersey, USA) which is based on a live attenuated, nonencapsulated SeM-2 strain of S. equi, will seroconvert when tested with iELISA [1] 5 weeks after annual revaccination.

**Study design:** Cohort study.

**Methods:** Serum samples from 26 horses (mean 15.1 years) in a stable with a strangles outbreak 11 years prior were obtained at the time of annual strangles vaccination (S1) and 5 weeks post vaccination (S2). 

**Results:** None of the horses had a history of strangles and mean medical record history was 4.28 years; mean historical Pinnacle® vaccines was 5. For each antigen (Ag), seroconversion was determined as an OD450nm value above 0.5. Five out of 25 (20%) horses were seroconverted to Ag A prior to vaccination (2 of these 5 were seroconverted to both Ag A and C). Five weeks post vaccination, 12 out of 25 (48%) were seroconverted to Ag A (mean S2 1.09) and 18 of 25 (72%) to Ag C (mean S2 1.7). 

**Main limitations:** 

- Cohort study design.
- Conclusions: With a high rate of seroconversion to both antigens, the DIVA capabilities of this iELISA [1] in horses vaccinated with Pinnacle® appears poor.

**Ethical animal research:** This study was approved by the University of Pennsylvania’s Institutional Animal Care and Use Committee (IACUC) Privately-Owned Animal Protocol #806403. All owners gave informed consent and agreed to the Privately-Owned Animal Protocol #806403.

**Source of funding:** Faculty start-up funds from University of Pennsylvania, New Bolton Center.

**Competing interests:** One of the authors (Waller) shares patent on the diagnostic test for Strptococcus equi subsp. equi exposure. Vet. J. 197 (2019) 168-171.
16.10  
Aerogenic factors facilitating respiratory equine herpesvirus-1 infection  
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Background: Equine herpesvirus type 1 (EHV1) outbreaks annually lead to respiratory, reproductive and neurological disorders, since vaccines and antivirals are not effectively available. Compared with other alphaherpesviruses, EHV1 has a unique strategy to limit its replication in the equine respiratory tract and to infect leukocytes for reaching target organs.  
Objectives: We determined 1) whether epithelial cell intercellular junctions (ICJ) are key boundaries in limiting EHV1 infection in the respiratory tract and 2) which factors affect these ICJ.  
Study design: Ex vivo experiments.  
Methods: Equine respiratory mucosal explants were treated with various agents (e.g. EGTA, Lysomucil®, pollen proteases) to disrupt ICJ, prior to inoculation with EHV1. Destruction of ICJ was assessed by microscopic image analysis of haematoxylin-eosin stainings. EHV1 replication in explants was visualised by immunofluorescence staining and confocal microscopy. Experiments in explants were corroborated in in vitro equine respiratory epithelial cells (EREC), which were inoculated at either the apical or the basolateral surfaces, following destruction of their ICJ.  
Results: The drugs affecting cellular calcium levels (EGTA and Lysomucil®), together with pollen proteases, were able to alter ICJ. Subsequent EHV1 binding to and infection of explants was greatly enhanced upon destruction of ICJ. In addition, EHV1 preferentially bound to and entered EREC at basolateral cell surfaces.  
Main limitations: Although ex vivo explants most likely reflect what happens in the horse, our findings need to be validated in vivo.  
Conclusions: We demonstrated that integrity of the horse’s respiratory epithelium is crucial in the defence against an EHV1 infection. Veterinarians should be cautious when using Lysomucil® in the aerosol therapy of horses. Finally, it can be postulated that during pollen season, air quality might have influenced the results.  
Ethical animal research: Tissues were collected at an abattoir.  
Sources of funding: The study was supported by the 11475-4/2016/FEKUT grant of the Hungarian Ministry of Human Resources.  
Competing interests: None declared.

16.30  
Propidium monoazide-quantitative realtime polymerase chain reaction for the detection of viable Streptococcus equi  
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Background: Propidium monoazide (PMA) quantitative real-time PCR (qPCR) has been used to differentiate DNA from live and dead bacterial cells. PMA enters nonviable cells with leaky cell membranes and binds the DNA inside the cell once photoactivated by strong visible light. This makes the DNA unable to act as templates for PCR, resulting in quantification of only the viable cells. An in vitro study successfully demonstrated pre-treatment with PMA prior to qPCR can identify substantial percentages of heat-killed and viable cells on samples with known colony forming units of Streptococcus equi.  
Objectives: The aim of this study was to evaluate the ability of PMA eqbE SEG2190 triplex qPCR to differentiate DNA from viable and nonviable S. equi in positive and suspect positive clinical samples.  
Study design: Case-control study.  
Methods: 57 stored (frozen and refrigerated) positive (n = 36) or suspect positive (n = 21) clinical samples (determined via SeeI qPCR as the gold standard) were tested using eqbE SEG2190 triplex qPCR with (+) and without (-) PMA pre-treatment.  
Results: Number of S. equi positive samples were as follows: 6/57 eqbE (+)PMA, 10/57 SEG2190 (+)PMA, 13/57 eqbE PMA, 53/57 SEG2190 –PMA. The cycle threshold count action, and increased lung compliance, but independent clinical trials in horses suffering from equine asthma have not been performed. Objectives: The aim of our study was to investigate the efficacy of dembrexine as a mucolytic drug in horses diagnosed with mild (inflammatory airway disease, IAD) or moderate to severe (recurrent airway obstruction, RAO) equine asthma.  
Study design: Randomised, placebo-controlled clinical trial.  
Methods: Sixteen treated horses and eight control horses, all suffering from equine asthma, were included in the study. Each horse was examined three times, on Days 0, 14 and 28. Examinations included physical examination, respiratory endoscopy, collection of tracheal mucus and bronchoalveolar lavage fluid (BALF), thoracic ultrasonography, haematology, culture and rheological analysis of tracheal mucus, and cytology of BALF.  
Dembrexine (Sputolysin powder, Boehringr Ingelheim, Budapest, Hungary) was administered orally to each horse in the treatment group at a dose of 0.3 mg/kg bwt twice daily for 28 days. Control horses received the same amount of glucose powder. Data was analysed by descriptive statistics, tests for normality, paired t tests and repeated measures analysis of variance.  
Competing interests: None declared.
(CT) for SEQ2190 was lower than the corresponding Seel suggesting that SEQ2190 is a good target gene. The CT for all +PMA positive samples were higher than the corresponding -PMA sample indicating there was a mixture of viable and nonviable cells in these samples. **Main limitations:** The low number of aPCR +PMA positive samples indicates that a large number of the samples had nonviable cells most likely due to storage time. **Conclusions:** PMA aPCR can be used to determine S. equi viability, but testing should be performed on fresh samples. **Ethical animal research:** The samples used were submitted for routine clinical testing. Owner informed consent not stated. **Source of funding:** Boehringer Ingelheim 2015 Advancement in Equine Research Award. **Competing interests:** None declared.

### 16.50 Equine euthanasia – how do we know when the time is right?

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**Background:** Euthanasia decisions can be challenging and complex, and delayed euthanasia has been identified as a significant risk to the welfare of UK horses; however, little is known about the factors influencing this decision. **Objectives:** To identify the most prevalent human factors and animal-based indicators that lead to horses in the UK being euthanased. **Study design:** Online survey. **Methods:** A 24 question survey with a range of response options (e.g. drop down menus, Likert scales etc.) was developed using Survey Gizmo<sup>®</sup>. Responses were anonymised and all questions were optional. The survey was run online between 13 October 2015 and 2 January 2016, and publicised on social media. Statistical analysis included Generalised Linear Mixed Models. **Results:** 746 useable responses were returned. The majority of respondents were the horse’s owner (92%). Respondents were most likely to euthanase the horse because its current (50.9%) or future (36.1%) welfare was compromised, veterinary opinion suggested a poor prognosis (49.7%) or because of illness/disease (48.5%). Horses were most commonly euthanased because of lameness (39.8%), difficulty standing up/lying down or rolling (35.3%), increased or ongoing performance of pain behaviours (28.4%) and being unresponsive to positive things he/she would normally respond to (17.9%). Euthanising the horse because it could not be used for its intended purpose was more likely to be reported where the horse exhibited dangerous or unwanted behaviour when ridden/driven (co-efficient 1.688, s.e. 0.381, P<0.001). Respondents were less confident in their decision if the horse was euthanased because of financial constraints (co-efficient -1.213, s.e. 0.462, P<0.009). **Main limitations:** As with any questionnaire, answers on an emotive topic may be subject to bias in sampling, recall or declaration of the truth. **Conclusions:** These data provide novel insights into the factors that can influence euthanasia decisions. Veterinary surgeons can help avoid delayed euthanasia by proactively supporting owners/keepers. **Ethical animal research:** The survey was approved by the Royal Veterinary College’s Clinical Research Ethical Review Board. **Sources of funding:** The Horse Trust and the Royal Veterinary College Mellon Fund. **Competing interests:** L. Preshaw is employed by The Horse Trust.
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