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10.30 Machine intelligence for the detection of equine heart murmurs

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Background: Machine-learning algorithms combined with electronic stethoscopes have shown promise in automating the detection of murmurs and valvular heart disease in humans. However, there has been no previous work exploring the applicability of these methods to the detection of abnormal equine heart sounds. Objectives: To design a machine-learning algorithm to automatically detect the presence of murmurs in electronic stethoscope recordings made on the chest. Study design: Diagnostic method development and assessment. Methods: Heart sounds of 128 horses presented to Rossdales Equine Hospital were recorded using an electronic stethoscope at four standard auscultation sites. In total, 491 recordings (167 minutes) were made. The presence and grade of each murmur was assessed by an equine internal medicine specialist and an echocardiographic diagnosis was recorded. Horses with non-valvular pathology were excluded. A recurrent neural network model was trained to automatically identify the presence of a murmur in an audio recording. The algorithm was trained primarily on a large open-access database of human heart sounds, and then fine-tuned on half of the equine dataset. Results: Evaluated on an unseen test half of the equine dataset, the algorithm is able to detect loud murmurs (at least grade 3 of 6) with an area under the receiver operating characteristic (AUROC) of 0.86 (95% CI 0.80–0.92). The algorithm can achieve a sensitivity and specificity of 82% (95% CI 70–90%) and 82% (95% CI 76–87%) respectively, which are promising metrics for use as an assistive tool for general veterinarians. Main limitations: The number of control cases (including innocent flow murmurs) and the size of the test set was limited. Conclusions: Machine learning algorithms offer a promising method to increase repeatability and accessibility of auscultation and reduce reliance on echocardiography. Future data collection will focus on predicting the presence of valve disease using echocardiographic diagnosis as ground truth. Ethical animal research: Research ethics committee oversight not required by this congress: retrospective data collection. Informed consent: Not stated. Competing interests: None declared. Sources of funding: A. McDonald was supported by a doctoral training award from the Engineering and Physical Sciences Research Council (EPSRC).

10.45 Morphological evidence of a potential arrhythmogenic substrate in the caudal right atrium of horses

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Background: Previously, in 11 of 12 horses with sustained atrial tachycardia, three-dimensional electroanatomical mapping demonstrated that the caudal right atrium, especially the region 1–8 cm caudal to the fossa ovalis (FO), is a ‘hot spot’ for atrial ectopic foci or re-entry, often associated with areas of slow conduction and conduction block. All 11 horses underwent successful radiofrequency catheter ablation. Objectives: To investigate the anatomical and histological characteristics of the myocardial sleeves (MS) or atrial myocardial extensions, between FO and caudal vena cava (CaVC) in order to identify a potential substrate for atrial arrhythmias such as atrial tachycardia or atrial fibrillation. Study design: Cross-sectional. Methods: In post-mortem specimens from 17 Warmblood horses without cardiovascular disease, the distribution of myocardium in the area between FO and CaVC was examined macroscopically and the area, length, width and shape of the myocardium were recorded. At least six tissue samples from the area between FO and CaVC were histologically examined using a Masson’s trichrome staining. Results: All horses showed MS caudal to the FO over a median area of 23.7 (range 12.2–35.5) cm². The distal end of the MS was located 5.3 (3.5–7.5) cm caudal to the FO and the dorsoventral width was 4.2 (3.4–7.0) cm. In 11 horses (65%) a ventral extension of 0.7 (0–1.4) cm was present. Histologically, myocardial fibres were not well aligned (predominantly circular arrangement) and were surrounded by fibrous and adipose tissue, features known to result in slow conduction and pro-arrhythmia. Main limitations: Horses had no history of atrial arrhythmia. Conclusions: This study identified that equine MS between the FO and CaVC have characteristics known to favour re-entry and slow conduction. These MS are a potential substrate for atrial tachyarrhythmias and a possible target for treatment. Further tissue characterisation of this area is needed to improve treatment of right atrial arrhythmias by radiofrequency catheter ablation. Ethical animal research: Approved by the Institute’s Ethical Committee. Informed consent: Owner consent was obtained. Competing interests: None declared. Sources of funding: Department of Morphology, Ghent University.

11.00 Effect of multiple lead electrocardiogram recording and electrode position on measured durations of waves, complexes and intervals

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Background: One of the cornerstones of electrocardiogram (ECS) interpretation is the measurement of the duration of intervals, P and T waves, and QR complexes. Electrode positioning for ECS recording in horses is non-standardised and little is known about the effect of different electrode positions on those measurements. Objectives: Comparing measurements from a commonly used modified base apex ECG to those of a multiple lead recording. Study design: Experimental study. Methods: In 52 standing unsedated horses, a 29-lead ECG was recorded for 5 minutes. The ECG electrode configuration allowed offline reconstruction of different ECS lead configurations. Data analysis was semi-automatic with a custom-made algorithm that identified all QR waves, calculated multiple ECG interval durations over a 12 second sliding window and annotated P, P' offset, QRS, QRS' offset, QRS' offset, and T onset, on the root mean square of the median complexes: ECG measurements included duration
The differences in duration of P onset-Pnotch, P notch-Poffset and P onset-Poffset could be used for QRS-T and P wave annotations, respectively. Of 52 recordings, 48 and 27 were visually checked by an observer who rejected poor quality intervals were significantly different when “true” ECG durations (−3±6 ms, p < 0.001) QRS intervals were compared with those of the base-apex lead.

Differences for PQ and QRS duration were relatively small but for accurate QT duration measurement multiple lead recording is required to avoid underestimation. Ethical animal research: Approved by the Ethical Committee of the Faculty of Veterinary Medicine, Ghent University (EC2018/11). Informed consent: Informed owner consent was obtained. Competing interests: Not applicable. Sources of funding: None.

11.15
Long–term use of an insertable cardiac monitor (loop recorder) in horses
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Background: Short–term use of insertable cardiac monitors (loop recorders) has been reported in horses; however, information about long-term use in this species is lacking. Objectives: The aim of the study was to investigate the outcomes of long–term use of Reveal XT cardiac monitors in adult horses. Study design: Longitudinal. Methods: The cardiac monitors were implanted in 12 horses in standing position, under sedation and local anaesthesia. The site for implantation was the ventral body wall, approximately 5 cm from the midline on the left side, just behind the girth area. Stored data were downloaded from the devices every 8 weeks. A Televet 100 electrocardiograph was used to obtain standard electrocardiograms from each horse. Horses were regularly exercised. Arrhythmias were recorded by the cardiac monitors using the built–in human algorithm: number of total episodes, ventricular tachycardias, asystoles, bradyarrhythmias, atrial tachycardias, atrial fibrillations, and the percentage of time spent in atrial tachycardia or atrial fibrillation. Results: The mean duration of data recording was 420.4 days (minimum: 138 days, maximum: 671 days, standard error: 53.1 days). The number of total episodes was 425,437 (mean ± SD: 35,453±11,668 per horse). The number of asystolic and bradyarrhythmic episodes was 413,363; 97.2% of the total episodes. Based on manual evaluation of the data, these were falsely detected. Ventricular tachycardias (818 episodes) were also falsely recorded during exercise, as most T waves were recognised as QRS complexes. One horse had a naturally developed, persistent atrial fibrillation which was detected correctly 8,159 times, although when the heart rate was low, false bradycardia or asystole were recorded. Main limitations: Only one horse had pathologic arrhythmia in the population. Conclusions: The Reveal XT loop recorders worked reliably without complications. The human algorithm could not be used for automatic detection of arrhythmical episodes in the study population. Ethical animal research: Approved by the Institutional Animal Care and Use Ethical Committee of the University of Veterinary Medicine Budapest, Hungary (reference: PE/EA/1442–7/2019). Informed consent: All horses are owned by the University of Veterinary Medicine Budapest, Hungary. Competing interests: None declared. Sources of funding: Supported by Medtronic Hungary Ltd.

11.30
T wave changes in horses with dynamic upper airway obstruction
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Background: Horses with upper airway obstructions have been shown to be predisposed to the development of dysrhythmias. Although relatively common during the recovery phase, ventricular arrhythmias are of concern as they may contribute to sudden deaths on the racetrack. Objectives: To identify changes in resting electrocardiograms (ECG) and compare the prevalence of T wave abnormalities in horses with various forms of upper airway obstruction. Study design: Retrospective case series. Methods: We included trotters in racing condition, both warm- and cold-blooded, from 3 years of age that had heart rates ≤ 40 bpm on resting ECG. Resting endoscopy and overground endoscopy were also performed and horses were divided into groups based on their upper airway diagnosis. The number of horses with T wave morphological changes were compared between airway diagnosis groups using Fisher’s exact test. Results: T wave morphological changes were seen in 21 of 48 horses (0 of 8 horses with palatal instability, 7 of 13 horses with dorsal displacement of the soft palate, 2 of 3 horses with laryngeal hemiplegia, 10 of 18 horses with epiglottic retroflexion and 2 of 8 horses without any endoscopic changes in the upper airway). The proportion of T wave morphological changes was significantly different between the airway diagnosis groups (p = 0.02). Main limitations: Horses included in the study were being examined because of a history of poor performance or suspected airway problems. Exercising ECG was not performed. Conclusions: T wave morphological changes were prevalent in horses with airway obstruction. The role of T wave morphological change in arrhythmiogenesis is unknown. Ethical animal research: Research ethics committee oversight not required by this congress: retrospective data collection. Informed consent: Not stated. Competing interests: None declared. Sources of funding: None.

11.45
Comparison of sampling sites and diagnostic methods for fungal detection in the equine respiratory tract
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Background: Potential involvement of fungi in equine asthma was previously investigated based on tracheal wash (TW) rather than bronchoalveolar lavage (BAL). Objectives: To characterise fungal detection from equine airways. Study design: Prospective study. Methods: Thirty racehorses in training and 32 adult horses referred for respiratory disease were included. TW and BAL samples from each lung were collected through a guarded catheter and gastroscope. Fungi were detected by cytology and culture. Results: Fungal culture was positive for 51/62 (82%) TW and 15/62 (24%) BAL. All horses with positive culture from pooled BAL (BAL+) were also positive on TW. Fungi were identified by cytology in 43/62 (68%) TW; 15/62 (24%) BAL from right lung (BAL+), 15/62 (24%) left lung (BAL~), and 14/62 (23%) BAL, Nine
horses exhibited fungi on both BAL and BALy cytology, while 6 horses were respectively positive for BAL and BALy only (κ = 0.472 [CI 0.217–0.728]). Four BALy were positive for both methods, while 9 and 10 BALy respectively were positive for culture and cytology only (κ = 0.10 [CI –0.145–0.396]). All 14 horses positive for BALy cytology were also positive for BAL, and/or BALy, while 7 horses with negative BALy cytology were positive for BALy and/or BAL. Detecting fungi by cytology on either BALy or BALy+BAL was not found to be equivalent (p = 0.023; Se = 0.67 [CI 0.45–0.83], Sp = 1.00 [CI 0.91 – 100]). Main limitations: Small sample size. Conclusions: Pooling BAL is a highly specific while fairly sensitive alternative to combined cytology of individual left/right samples for mould/fungi detection. Ethical animal research: Approved by the regional Ethic Committee for Clinical and Epidemiological Veterinary Research (CERCO-2020-3-V). Informed consent: A consent form was signed by the owner. Competing interests: None declared. Sources of funding: Financial support was provided by the IFCE (French Institute for Horses and Equestrians), LABÉO and CISCO-Oniris.

12.00 Characterisation of the cellular landscape in equine asthma using single-cell transcriptomics

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Background: Equine asthma is a complex disease associated with both genetic and environmental factors. The disease can be subdivided into severe equine asthma and mild-to-moderate equine asthma, but at present there is no clear-cut criteria or biomarkers identified for distinction between the subtypes. Objectives: To characterise the cellular landscape in the equine lung. Study design: We performed single-cell RNA sequencing of bronchoalveolar lavage (BAL) samples obtained from horses with and without asthma. Methods: The transcriptomes of approximately 65,000 BAL cells from 11 horses with clinical signs of asthma and 8 healthy controls were analysed using the Drop-Seq technology. Results: We were able to analyse all the major cell populations in BAL, although granulocytes (neutrophils, eosinophils and mast cells) were detected in lower numbers than expected. This is consistent with previous reports that these cell types are challenging to capture with droplet-based sequencing techniques. We identified several subpopulations of alveolar macrophages and T-lymphocytes which have not been previously characterised in horse lungs. We detected novel genes differentially expressed in horses showing signs of asthma compared to healthy horses. Several of these genes have previously been associated with asthma in humans and mice. Main limitations: Droplet based single cell RNA-sequencing methods have limited capacity to capture granulocytes. Therefore, the proportion of those cell type were lower in our data compared to cytology data. Conclusions: We have constructed the first single cell atlas of the immune cell population in the alveolar compartment of the equine lung. These data will be useful as a reference for further studies of airway disease in horses. Ethical animal research: Approved by the Regional Ethical Review Board (Dnr: 218-18/2019). Informed consent: Owners gave consent for their animals’ inclusion in the study. Competing interests: None declared. Sources of funding: Formas.

12.15 Increased body condition score has a detrimental effect on arterial oxygen tension and increases the risk of hypoxaemia in anaesthetised horses

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Background: Impaired oxygenation during anaesthesia can be detrimental. Bodyweight and body shape influence arterial oxygen tension (PaO₂) but the effect of body condition score (BCS) has not been investigated. Objectives: To examine the effect of BCS on respiratory indices. Study design: Retrospective. Methods: 524 anaesthetic records were reviewed. Records from healthy adult horses under isoflurane anaesthesia in dorsal recumbency, receiving controlled mechanical ventilation, with complete ventilation and arterial blood gas data and BCS assessment by one person (K.L.) were included. Data were analysed using students t-test, Mann Whitney U test, chi squared analysis and logistic regression. Results: 135 records for 85 horses with BCS < 6/9 (group N) and 50 horses with BCS ≥ 6/9 (group O) were included. Overall, there was a strong negative correlation between BCS and PaO₂ (Spearman’s r = 0.72, p < 0.001). Group O had significantly lower PaO₂ (112 (50 – 546 mmHg)) compared to group N (380 (65 – 858 mmHg), p < 0.001) which remained when horses were categorised by bodyweight > 500kg (188 mmHg vs. 390 mmHg, p < 0.001) and < 500 kg (160 mmHg vs. 451 mmHg, p < 0.04). Group O were 34 times more likely to be hypoxaemic (PaO₂ < 100 mmHg) compared to group N (p = 0.03) (OR = 34.39, 95%CI = 13 – 911, p = 0.03). Physiological dead space was greater in group O (0.27 (0.10–0.41)) versus group N (0.24 (0.12–0.35), p < 0.001. Multivariate analysis identified a significant association between PaO₂ and bodyweight (p = 0.01), physiological dead–space (p = 0.005) and BCS (p < 0.001). Main limitations: Retrospective clinical design. Conclusions: BCS ≥ 6 has a detrimental effect on PaO₂, physiological dead space and is a risk factor for hypoxaemia in healthy anaesthetised horses positioned in dorsal recumbency. Ethical animal research: Ethical approval (AVA 2020-012) was granted for this study. Informed consent: Not stated. Competing interests: None declared. Sources of funding: None.