Abstract
Ultrasound is a useful modality for the diagnosis of different types of pelvic fractures in horses of many breeds and uses.
Ultrasound provides the referral veterinarian and the ambulatory practitioner an alternative to traditional diagnostic modalities (radiography and nuclear scintigraphy). Pelvic fracture should be suspected in horses with acute onset, severe hind limb lameness with or without a history of known trauma, crepitus, pelvic asymmetry, and/or muscle atrophy. Transcutaneous and transrectal ultrasound should be performed in all cases to best evaluate the number and location of pelvic fractures.

1. Introduction
The incidence of pelvic fractures has historically been considered relatively low [1-3]. Recent publications have suggested their incidence is higher than previously reported, especially in Thoroughbred racehorses [4-7]. In either case, the equine practitioner is likely to be faced with a horse that he/she suspects to have a pelvic fracture at some point in his or her career. The definitive diagnosis of a pelvic fracture in these cases can be a challenge, especially in the ambulatory setting. Clinical exam findings of crepitus, pelvic asymmetry, muscle atrophy, soft tissue swelling, and abnormal rectal exam findings are useful indicators of pelvic fracture; however, these clinical findings are often absent in many horses with pelvic fractures [2,3]. Radiographic examination is generally accepted as the most accurate method of diagnosing pelvic fractures [1,8]. Although a standing technique has been described, its availability is somewhat limited [9]. Ventrodorsal projections under general anesthesia produce the most diagnostic images [10]; however, owners and practitioners are often reluctant to subject the horse to the inherent risks of recovery as well as potential displacement of fracture fragments. Nuclear scintigraphy is also useful in the diagnosis of pelvic fractures; however, it may be inconclusive in the acute phase of injury [7]. In addition, both radiography and nuclear scintigraphy are relatively expensive procedures and require transportation to a referral center. Ultrasonography, on the other hand, is a non-invasive modality that is readily available to many practitioners. The technique for the ultrasonographic evaluation of the equine pelvis has been described [6,7,11]. The ultrasonographic diagnosis of equine pelvic fractures has also been reported; however, the focus has been on ilial wing fractures/stress fractures in the Thoroughbred racehorse [4,12]. Previous studies based on radiographic and post-mortem diagnosis reveal that pelvic fractures occur at many sites in the equine pelvis [2,3,8]. The purpose of this study is to encourage the use of ultrasound in the diagnosis of many types of pelvic fractures in horses of varying breeds and uses. We will also describe the clinical features in horses where a pelvic fracture was diagnosed via ultrasound and compare the ultrasonographic findings with other imaging modalities when available.

2. Materials and Methods
Records were reviewed for all horses that were presented to the Large Animal Ultrasound Service at the University of California, Davis, Veterinary Medical Teaching Hospital (UCD-VMTH) for ultrasonographic evaluation of the pelvis between August 1999 and December 2002. Lameness was localized to the upper hind limb or pelvis by the Equine Surgery Service based on history, clinical exam findings, and, in some cases, nuclear scintigraphy performed before ultrasonographic evaluation. Data collected included age, sex, breed, use, degree of lameness at presentation, onset, duration of clinical signs before presentation, known history of trauma, presence of asymmetry, muscle atrophy and/or crepitus, and rectal exam findings.

Ultrasonographic evaluation of the hemipelvis was performed with either an Ausonics Impact [a] and/or a GE Vingmed
System 5 [b] ultrasound machine. The entire hemipelvis was clipped with a #50 clipper blade, washed thoroughly, and ultrasound coupling gel was applied. The horses were placed in stocks and were lightly sedated when needed with detomidine HCL [c] (0.004 - 0.008 mg/kg, IV). The superficial structures of the pelvis, including the tuber sacrale, tuber coxae, and tuber ischii, were evaluated transcutaneously with a 10-MHz linear transducer. The ilial wing, ilial shaft, and coxofemoral joint region were evaluated transcutaneously with either a 2.5- to 3.5-MHz sector transducer or 3.5-MHz curvilinear transducer. The ischium was primarily evaluated transrectally using a 5.0-MHz rectal transducer. The scanning technique used was similar to that described in previous reports [6,7,11]. The bony contours of the pelvis were evaluated for the presence of cortical irregularity, step defects, or bony fragments. The soft tissues of the pelvis were evaluated for the presence of muscle tearing and/or hematoma formation. The coxofemoral joint was also evaluated for joint effusion.

3. Results
Seventy hemipelves were evaluated ultrasonographically in 53 horses. Thirty-two fractures were diagnosed in 28 horses. Three horses required more than one ultrasonographic evaluation to detect the fracture site. Fractures were identified in the following locations: coxofemoral joint/acetabulum (12), tuber coxae (9), tuber ischii (4), ilial wing (4), ischium (2), and ilial shaft (1). Four horses demonstrated fractures in two locations. Two horses with tuber coxae fractures also had ilial wing fractures. Two horses with acetabular fractures demonstrated a second fracture site. One involved the tuber coxae, and one involved the ischium. Coxofemoral joint effusion was seen in six horses, all with acetabular fractures. Muscle tearing/hematoma was seen in 15 (54%) horses. Figure 1, Figure 2 and Figure 3 demonstrate normal and abnormal ultrasonographic findings. Transrectal ultrasound was performed in 10 of 28 affected horses. Seven horses revealed evidence of fracture and/or soft tissue swelling on transrectal ultrasound. Transrectal ultrasound was the only means to visualize the fracture site (ischium) in one horse and identified a second fracture site (ischium) in another horse.

![Figure 1. Normal coxofemoral joint.](image1.png)

(A) Close-up view of the coxofemoral joint with a similar orientation as the ultrasound image in B. The contour of the femur and greater trochanter are indicated by the red line on the anatomic specimen and by the red arrows on the ultrasound image. The contour of the acetabulum is indicated by the blue line on the anatomic specimen and by the blue arrows on the ultrasound image. The articulation of the joint is indicated by the white arrow. The ultrasound image was obtained with a 3.5-MHz curvilinear transducer at a scanning depth of 20 cm. Medial is to the right of the image, and lateral is to the left of the image.

![Figure 2. Abnormal coxofemoral joint.](image2.png)

(A) Comminuted fracture of the acetabular region. The red arrows are pointing to several bony fragments. (B) Another horse with an acetabular fracture. There is coxofemoral joint effusion with a small bony fragment floating in the fluid (white arrow). The acetabular surface is irregular (blue arrows). The greater trochanter/femur is smooth (red arrow). Both images were obtained with a 3.5-MHz curvilinear transducer at a scanning depth of 14 and 20 cm, respectively. Medial is to the right of the image, and lateral is to the left of the image.

![Figure 3. Normal and abnormal tuber ischii.](image3.png)

(A) Normal appearance of the tuber ischii. Note the smooth bony contour (blue arrow) and the normal appearance of the semimembranosus muscle belly (white arrows). (B) Tuber ischii fracture (red arrow) with ventral displacement of the fracture fragment (blue arrows). There is significant muscle tearing of the semimembranosus muscle (white arrows). Both images were obtained with a 3.5-MHz curvilinear transducer at a scanning depth of 20 and 14 cm, respectively. Dorsal is to the right of the image, and ventral is to the left of the image.

Affected horses included 2 males, 13 females, and 13 geldings. The mean age of affected horses was 7.0 yr, ranging in age from 6 mo to 20 yr. Breeds affected included Quarter horses (8), Thoroughbreds (7), Arabians (4), Warmbloods (3), and other breeds (6). A wide variety of uses were represented, including horses kept on pasture. The three Thoroughbreds in active race training at the time of injury all demonstrated ilial wing fractures. All but six horses were presented within 30 days of the onset of the clinical signs (range = 1 - 1100 days). Degree of lameness at presentation ranged from Grade 3 - 5/5 (AAEP grading scale) with a mean lameness grade of 4/5. Twenty-five (89%) horses had acute onset of lameness. Eleven (39%) horses had a known history of trauma or falling. Crepitus was present in 11 (39%) horses. Pelvic asymmetry was present in eight (28%) horses. Muscle atrophy was present in another eight (28%) horses. The combination of pelvic asymmetry and muscle atrophy was present in five (18%) horses. Rectal palpation was performed in 19 horses (68%). Eleven horses were negative on rectal palpation, and eight horses demonstrated positive rectal exam findings.

Nuclear scintigraphy was performed in 14 affected horses. Twelve horses demonstrated increased radionucleotide uptake ranging from intense (3) to moderate (4) to mild/diffuse (5). The location of radionucleotide uptake corresponded to the
Ultrasonographic evaluation of the equine pelvis has been a very useful tool in the diagnosis of many types of pelvic fractures. Acetabular fractures carried a poor prognosis for return to function. Five of nine euthanized horses had acetabular fractures. Previous studies have reported conflicting data regarding outcome and prognosis for horses with acetabular fractures [1-3,10,13]. In our study, acetabular fractures were the most common fracture site; however, these studies primarily included Thoroughbred racehorses [1,3]. Previous studies have reported by Little and Hilbert, [2] who also reported on a variety of breeds. Other studies have reported the ilium to be the most common fracture site in horses [1-3,10,13]. In our study, acetabular fractures carried a poor prognosis for return to function. Five of nine euthanized horses had acetabular fractures. Of the remaining six cases with follow-up information, three horses remain unchanged. The other three horses have reportedly improved but have not been able to resume athletic activities. The positive outcome of tuber coxae and ilial wing fractures seen in our study has also been documented in previous reports [1,3,7,11,12]. However, the poor outcome of tuber ischii fractures in our study has not been previously reported [1,14]. Three of four horses diagnosed with tuber ischii fractures were euthanized, one because of exsanguination and one because of uncontrollable pain. The third horse was euthanized for unrelated reasons but remained grade 4/5 lame. Necropsy revealed a non-union fracture of the tuber ischii 4 mo post-diagnosis.

4. Outcome
Nine horses were euthanized because of poor prognosis, persistent lameness, or severe pain. The euthanized horses included five acetabular fractures, three tuber ischii fractures, and one ilial body fracture. One horse with a tuber ischii fracture showed evidence of exsanguination before euthanasia. Necropsy was performed in five horses, and it confirmed the location of the pelvic fracture. Eight horses returned to the UCD-VMTH for follow-up evaluation between 2 and 16 mo post-diagnosis. Two horses were unchanged (acetabular fractures), two horses improved 1 - 3 lameness grades, and four horses were sound (tuber coxae and/or ilial wing fractures). Six horses were followed by owner/RDVM communication, including four with acetabular fractures. One horse was unchanged, and the other three horses were improved but have not returned to their previous use. One horse with an ilial wing fracture is improved, and one horse with a tuber coxae fracture has returned to racing. Five horses were lost to follow-up.

5. Discussion
Ultrasonographic evaluation of the equine pelvis has been a very useful tool in the diagnosis of many types of pelvic fractures in horses at the UCD-VMTH. A positive diagnosis was made in 28 of 53 horses (53%) presented for pelvic ultrasound in a 3.5-yr time period. Ultrasound was the sole means of diagnosis in 13 horses and was corroborated by nuclear scintigraphy or radiography in the remaining 15 cases. Many of the horses in the study were referred for nuclear scintigraphy for suspected pelvic fracture. Nuclear scintigraphy was useful in locating the general site of injury; however, it provided little information regarding the bony detail of the fracture site and associated soft tissue damage. Ultrasound was able to provide excellent detail of the bony contours of the fracture sites and was useful in identifying associated muscle tearing and hematoma formation.

Radiographic examination of the pelvis under general anesthesia is not routinely performed at the UCD-VMTH. Although previous studies have reported the incidence of complications during recovery from general anesthesia to be low, [2,3]. most UCD-VMTH clinicians and owners are not willing to accept that risk in horses with suspected pelvic fracture. Standing ventrodorsal radiographs were not performed in our study because of the inability of our radiographic equipment to obtain these views. It should be noted that standing lateral radiographs were useful in the diagnosis of pelvic fractures in three horses in our study. Previous reports have not been supportive of this technique [1,2].

Coxofemoral joint fractures involving the acetabulum were the most common fracture in our study. This is similar to that reported by Little and Hilbert, [2] who also reported on a variety of breeds. Other studies have reported the ilium to be the most common fracture site; however, these studies primarily included Thoroughbred racehorses [1,3]. Previous studies have reported conflicting data regarding outcome and prognosis for horses with acetabular fractures [1-3,10,13]. In our study, acetabular fractures carried a poor prognosis for return to function. Five of nine euthanized horses had acetabular fractures. Of the remaining six cases with follow-up information, three horses remain unchanged. The other three horses have reportedly improved but have not been able to resume athletic activities. The positive outcome of tuber coxae and ilial wing fractures seen in our study has also been documented in previous reports [1,3,7,11,12]. However, the poor outcome of tuber ischii fractures in our study has not been previously reported [1,14]. Three of four horses diagnosed with tuber ischii fractures were euthanized, one because of exsanguination and one because of uncontrollable pain. The third horse was euthanized for unrelated reasons but remained grade 4/5 lame. Necropsy revealed a non-union fracture of the tuber ischii 4 mo post-diagnosis.

Ultrasonographic evaluation of the pelvis can be performed in the field with ambulatory equipment; however, a complete evaluation requires the use of a low frequency transducer (2.5 - 3.5 MHz for adult horses). These transducers are available for most of today's ambulatory machines, but many practitioners do not currently own such a transducer. Evaluation of the equine pelvis requires some experience before the examiner will feel comfortable diagnosing pelvic fractures; however, this is the case for ultrasound of all regions in the horse. The coxofemoral joint is the most technically challenging aspect of the exam. This should not discourage individuals from attempting to evaluate less confusing regions of the pelvis, especially in cases where transportation to a referral hospital or performance of other diagnostic modalities are not an option. The examiner also needs to be aware of edge artifacts produced by vessels and fascial planes that can replicate an irregular bony contour and mimic the appearance of a fracture [7,11].

Practitioners should also recognize that a negative ultrasound does not rule out the presence of a pelvic fracture. Fractures with minimal or no displacement may not be visible sonographically [7]. In the case of a negative exam, repeat ultrasonographic evaluation should be performed if the horse persists with lameness and/or clinical signs of pelvic fracture. In our study, three horses with pelvic fractures were negative on initial examination. One horse demonstrated severe tearing of.
the semimembranosus musculature on two ultrasound evaluations performed 10 days apart. The tuber ischii fracture was not identified until the third exam when it was obviously ventrally displaced. In another case, a Thoroughbred racehorse was diagnosed with a deep gluteal abscess on initial exam. A follow-up exam performed 2 wk later revealed callus formation secondary to an ilial wing stress fracture. The ilial wing was unremarkable on the initial exam. In the third case, transcutaneous ultrasound was negative for fracture, and transrectal ultrasound was not performed because of negative rectal palpation. The horse’s clinical signs persisted, and a transrectal exam performed 10 days later revealed a fracture of the ischium that remained undetectable on transcutaneous exam. This reinforces the value of performing a transrectal ultrasound exam in all cases, even with negative findings on rectal palpation. Early in this study, many horses did not undergo transrectal ultrasound based on negative rectal palpation. It is therefore possible that additional horses had fractures of the ischium that went undetected.

In summary, pelvic fractures should be suspected in horses with acute onset of severe hind limb lameness localized to the upper limb in performance or pasture horses of many breeds and uses. The absence of known trauma, crepitus, pelvic asymmetry, and/or muscle atrophy does not rule out the presence of a pelvic fracture as was found in our study and in previous reports [2,3]. Transcutaneous and transrectal ultrasonographic evaluation of the pelvis should be performed in all cases to characterize the fracture site and establish a prognosis and treatment plan. Ultrasound may also be used to monitor the healing process. The use of ultrasound has proven valuable in many horses; however, the practitioner should keep in mind the limitations of ultrasound as described above.

Footnotes

[a] Universal Ultrasound, 299 Adams Street, Bedford Hills, NY 10507.
[b] GE Medical Systems, 4855 West Electric Avenue, Milwaukee, WI 53219.
[c] Dormoseden, Orion Corporation, Espoo, Finland.

References

12. Pilsworth RC, Shepherd MC, Herinckx BMB, et al. Fracture of the wing of the ilium, adjacent to the sacroiliac joint, in


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