Fatal musculoskeletal injuries of Quarter Horse racehorses: 314 cases (1990–2007)

Tiffany L. Sarrafian, DVM; James T. Case, DVM, PhD; Hailu Kinde, DVM, MPVM; Barbara M. Daft, DVM, DACVP; Deryck H. Read, BVSc, PhD, DACVP; Janet D. Moore, BVSc; Francisco A. Uzal, DVM, PhD, DACVP; Susan M. Stover, DVM, PhD, DACVS

Objective—To determine major causes of death and the anatomic location of musculoskeletal injuries in Quarter Horse racehorses in California.

Design—Retrospective case series.

Animals—314 Quarter Horse racehorses with musculoskeletal injuries that were necropsied through the California Horse Racing Board Postmortem Program from 1990 to 2007.

Procedures—Postmortem pathology reports were retrospectively reviewed. Musculoskeletal injuries were categorized by anatomic region and described. The number of Quarter Horse starts and starters for the same period of time were obtained from a commercial database for determination of fatal injury incidence.

Results—Musculoskeletal injuries accounted for 314 of the 443 (71%) Quarter Horse racehorses that died during the 18-year study period. Fatal musculoskeletal injuries occurred at a rate of 2.0 deaths/1,000 race starts and 18.6 deaths/1,000 horses that started a race. Musculoskeletal injuries occurred predominantly during racing (84%) and in the forelimbs (81%). The most common fatal musculoskeletal injuries were metacarpophalangeal and metatarsophalangeal joint ( fetlock) support injuries (40%), vertebral (10%), and scapular (8%) fractures. Proximal interphalangeal (pastern) joint luxations resulted in death of 3% of horses. Fracture configurations of some bones were consistent with those of Thoroughbred racehorses. Evidence of preexisting stress remodeling of bone was reported for some fractures.

Conclusions and Clinical Relevance—Knowledge of common locations and types of fatal musculoskeletal injuries in racing Quarter Horses may enhance practitioners’ ability to detect mild injuries early, rest horses, and help prevent catastrophic injuries. (J Am Vet Med Assoc 2012;241:935–942)

Musculoskeletal injury is the greatest cause of morbidity and death in Thoroughbred racehorses. Lameness is the leading cause of wastage in Thoroughbreds intended for racing.1–8 The reported incidence of musculoskeletal-injury related fatalities in Thoroughbred racehorses in the United States and Canada ranges from 1.20 to 1.99 injuries/1,000 race starts.9–13 Musculoskeletal injury accounts for 67% to 88% of racetrack-related deaths of Thoroughbred racehorses.10,14–16.a The rate of musculoskeletal-related fatalities in Thoroughbred racehorses in California has been reported to be as high as 5 horses/1,000 starts or 24 horses/1,000 starters (ie, horses) annually.11,12 Injuries to the proximal sesamoid bones and third metacarpal bones are the most common musculoskeletal causes of death in Thoroughbred racehorses.13–18 Fatal injuries in Thoroughbreds, knowledge that fatal injuries may represent the progression of milder injuries,17,20–24 identification of the skeletal predilection sites for injuries25 in racnhorses,9,11,12,14,17,18,26–29 and improvement in diagnostic equipment and imaging techniques20,30–32 have all enhanced the ability to detect and enable treatment of mild injuries, thereby possibly preventing catastrophic injuries and death in some racehorses. Consequently, understanding the skeletal distribution and nature of injuries is key to injury prevention.

Although the skeletal distribution of fatal musculoskeletal injuries in Thoroughbreds has been described9,11,14,16 less is known about fatal musculoskeletal injuries in Quarter Horses and no reports documenting the distribution and configuration of fatal musculoskeletal injuries in Quarter Horse race-
horses have been published. Reported rates for Quarter Horses are 0.83 catastrophic race-related injuries that resulted in death and 2.17 noncatastrophic musculoskeletal injuries/1,000 race starts. However, there is some evidence that the skeletal distribution of injuries of Quarter Horse racehorses may differ from that of Thoroughbred racehorses. The proportions of fatalities due to carpal, vertebral, and scapular fractures were reported to be higher in Quarter Horse racehorses than in Thoroughbred racehorses. However, the nature of the injuries was not described.

It is our goal as well as that of all equine veterinarians to prevent musculoskeletal injuries in racehorses. To achieve this goal, the predilection sites for and nature of musculoskeletal injuries incurred during racing and training must be known. Musculoskeletal injuries in Thoroughbred racehorses have been characterized by means of postmortem examination, but this has not been performed for Quarter Horse racehorses. Furthermore, injuries in Quarter Horses have only been reported for racing, but not training, activities. Therefore, the objectives of the study reported here were to determine the prevalence and characteristics of musculoskeletal injuries that occurred during racing and training activities for Quarter Horses in California.

Materials and Methods

Horses—All horses that died or were euthanized on racetracks under the jurisdiction of the California Horse Racing Board were transported to a California Animal Health and Food Safety laboratory under the direction of the regulatory veterinarian at respective racetracks. The regulatory veterinarians submitted a necropsy request form that included the date of death and activity of the horse at time of injury (racing, training, and other). Free text necropsy reports were generated by California Animal Health and Food Safety pathologists who performed the necropsies as part of the California Horse Racing Board Postmortem Program. The postmortem records for all Quarter Horse racehorses that were submitted to California Animal Health and Food Safety from January 1, 1990, to September 2, 2007, were examined by 1 author (TLS). Records were not available for a 3-month period (July to September 1991) when the program had temporary suspension of funding. The skeletal distribution of injuries that resulted in death or euthanasia (fatal injuries) was described, with an emphasis on consistent patterns of injuries within each skeletal structure (bone).

The number of Quarter Horses that started a race under the jurisdiction of the California Horse Racing Board in the state of California and the number of Quarter Horse starts that occurred under the jurisdiction of the California Horse Racing Board in the state of California during the period studied were obtained from a customized report from a commercial database to obtain incidences of fatalities in Quarter Horse racehorses in California. Note that horses that died came from a larger population than did horses that started a race under the jurisdiction of the California Horse Racing Board in the state of California because some horses died without ever having raced. The distributions of fractures by limb (left or right) and sex (male or female) were examined by means of a χ² test or the Fisher exact test when cell numbers were small. Values of P < 0.05 were considered significant.

Results

Postmortem examinations were performed on 465 horses by 20 pathologists during the 18-year study period. Horses were excluded from further study if they were not racehorses (ie, pony horses) or were >10 years old or if records had insufficient information to categorize the cause of death. Information on 314 horses (of the remaining 443 horses) that died related to musculoskeletal causes was therefore included in the study. It was unknown whether these individual horses ever participated in a race. During the same time period, 158,817 Quarter Horse racehorse starts occurred in California, resulting in an incidence of 2.8 deaths/1,000 starts (95% CI, 2.5 to 3.1 deaths/1,000 starts) and 2.0 musculoskeletal deaths/1,000 starts (95% CI, 1.8 to 2.2 deaths/1,000 starts); 16,849 Quarter Horse starters raced in California, resulting in an incidence of 26.3 deaths/1,000 horses that started a race (95% CI, 23.9 to 28.8 deaths/1,000 starts) and 18.6 musculoskeletal deaths/1,000 horses that started a race (95% CI, 16.6 to 20.8 deaths/1,000 starts). When only those horses that died of a musculoskeletal injury incurred during a race (264 horses) were included, incidences were 1.7 musculoskeletal deaths/1,000 starts (95% CI, 1.5 to 1.9 deaths/1,000 starts) and 15.7 musculoskeletal deaths/1,000 horses that started a race (95% CI, 13.8 to 17.7 deaths/1,000 starts).

Musculoskeletal injury to appendicular and vertebral regions was responsible for the death of 71% of horses necropsied during the 18-year period. Seven horses with muscle disorders, 4 horses with septic arthritis, and 15 horses with laminitis were not included in the present study.

Musculoskeletal injuries occurred most commonly during racing (84% of horses) and less commonly during training (8%; Table 1). Other injuries were the result of accidents (ie, related to external trauma, 7%) or unknown circumstances (1%). Metacarpophalangeal and metatarsophalangeal joint (fetlock) and carpal injuries occurred predominantly during racing (92% and 96% of affected horses, respectively). Rib, pelvic, humeral, tibial, and radial fractures occurred commonly during nonracing activities. Over half of the pelvic fractures were nonexercise related.

Forelimb injuries accounted for 81% of limb injuries. Bilateral injuries occurred in 9% of horses, predominantly horses with scapular, carpal, or proximal sesamoid bone fractures. For unilateral bone fractures, injuries occurred more commonly (χ²; P < 0.001) in the right forelimb (63%) than in the left forelimb (37%). The limb discrepancy is largely related to the distribution of scapular (χ²; P = 0.001) and carpal (χ²; P < 0.001) injuries, which occurred predominantly in the right limb (Table 1). A limb predilection was not observed for the most commonly fractured bone, the proximal sesamoid bone. Bone fractures occurred more commonly in males (67%; geldings and sexually intact males) than in females (33%).

The median age for horses with a scapular, humeral, tibial, or vertebral fracture was lower than the median age for horses with a carpal, metacarpal, or proximal sesamoid bone, and horses with a pelvic fracture had the highest...
median age (Table 1). Injury to the fetlock region and supporting structures was most common, followed by carpobone injuries. Vertebral and scapular fractures were less common. Metacarpal or metatarsal, pelvic, humeral, and tibial fractures and proximal interphalangeal (pattern) joint luxation each resulted in death of < 5% of horses.

**Fetlock injuries**—Fetlock injuries were most commonly related to disruption of supporting structures of the fetlock region. Disruption of the suspensory apparatus was most common and included biaxial proximal sesamoid bone fracture (82% of horses with fetlock injuries), unilateral proximal sesamoid bone fracture with ligamentous disruption (eg, contra-axial branch of the suspensory ligament), disruption of the suspensory ligament (or extensor branches), or disruption of distal sesamoidian ligaments. Suspensory apparatus disruption was often accompanied by injury to the superficial or deep digital flexor tendons. Occasionally, affected horses also had collateral ligament disruption and fetlock joint luxation, intersesamoidian ligament disruption, distal fracture of the third metacarpal bone, or a combination of these findings.

Proximal sesamoid bone fracture occurred in 108 horses. Biaxial fractures (ie, medial and lateral bones of 1 limb) occurred in 75 horses (4 also had uniaxial fracture in the contralateral limb): 34 affected in the left forelimb, 38 affected in the right forelimb, and 3 affected in bilateral forelimbs. Uniaxial fracture occurred in 33 horses (3 with a bilateral uniaxial and 4 with a biaxial fracture in the contralateral limb). Comminuted fractures were common and occurred in the medial bone (107 bones, with 51 comminuted) and the lateral bone (87 bones, with 40 comminuted). Mild body fracture was reported for 59 of the 193 bones fractured, but not all fractured bones had fracture location described.

Metacarpophalangeal joint disruption (42 luxations and 7 subluxations) occurred in 49 horses with proximal sesamoid bone fracture. Two of these horses had bilateral fetlock luxation with bilateral biaxial proximal sesamoid bone fracture and suspensory apparatus rupture. Three other horses had bilateral fetlock luxation with bilateral proximal sesamoid bone fractures, but only biaxial fracture in 1 limb. One horse with unilateral medial proximal sesamoid bone fracture had ipsilateral fetlock luxation and contralateral pattern luxation.

Concurrent metacarpal condylar fracture was described for 3 horses. Two horses had lateral condylar fracture with ipsilateral suspensory apparatus and ex-
tensive soft tissue damage. One horse had medial condylar fracture with ipsilateral suspensory apparatus disruption and biaxial sesamoidean fracture. One horse had a mid-diaphyseal comminuted metacarpal fracture of the contralateral limb.

The suspensory apparatus was the most commonly affected soft tissue structure involved in fetlock injuries, although horses often had multiple soft tissues injured. Suspensory ligament rupture occurred in 67 horses (23 ligament body, 25 biaxial [medial and lateral] branches, 18 lateral branch, and 5 medial branch), and distal sesamoidean ligament rupture occurred in 43 horses. Other commonly reported injured structures were the deep digital flexor tendon (74 horses), superficial digital flexor tendon (56), intersesamoidean ligament (47), and palmar annular ligament (27). Only 21 horses had injury to fetlock supporting soft tissue structures without accompanying fracture of proximal sesamoidean bones. Although injury to the superficial or deep digital flexor tendons was commonly observed in association with suspensory apparatus failure of the fetlock region, only 9 horses were euthanized due to tendon injury without accompanying suspensory apparatus failure.

**Carpus**—Carpal bone fracture occurred in 79 horses. Some horses also sustained concurrent metacarpal fracture (7 horses with proximal metacarpal fracture and 1 horse with contralateral mid-diaphyseal fracture), femoral physseal fracture (1), and tibial fracture (1). A single carpal bone was fractured in 13 horses. Multiple (2 to 11) carpal bones were fractured in 66 horses; 43 horses had carpal bone fractures in both the proximal and distal rows of bones. Bones in the distal row were affected more often (73 horses) than bones in the proximal row (51). Six horses had only proximal bones affected, and 28 horses had only distal bones affected. The most common bone fractured was the third carpal bone of the right limb, with comminuted slab fracture the most commonly described configuration (detailed description of fracture configuration was not provided for all cases).

**Vertebrae**—Vertebral body fracture occurred in 32 horses. A single vertebra was fractured in 16 horses, 2 vertebrae in 8 horses, 3 or 4 vertebrae in 7 horses, and 7 vertebrae in 1 horse. Horses also sustained metacarpal fracture (1 horse), pelvic fracture (4), rib fracture (1), femur fracture (1), skull fracture (1), humeral fracture (1), and atlantoaxial luxation (1). Major spinal cord damage was reported for 17 horses. Paralysis was reported for 9 horses, 7 of these with lumbar fractures.

Fractures occurred in cervical (8 horses), thoracic (6), lumbar (19), and sacral (4) vertebrae. Cervical fractures were predominantly located at C2 to C3, thoracic fractures at T1 to T2 or T14 to T18, and lumbar fractures at L5 to L6. Sacral fractures were usually associated with lumbar vertebral or ilial fractures. Fractures through the body of the vertebrae were commonly reported for cervical and lumbar regions. Callus was noted to be associated with lumbar fracture in 4 horses. Only lumbar vertebral fractures were seen in more female horses than in male horses.

**Scapular fracture**—Scapular fracture occurred in 26 horses. Unilateral fractures were more prevalent in the right than in the left forelimb (Fisher exact test P < 0.001). Ipsilateral carpal bone chip fractures (2 horses), contralateral radius fracture (1), and cerebral contusion (1) were each observed in some horses with a scapular fracture.

The most common scapular fracture configuration recorded was a transverse, comminuted fracture through the distal end of the scapular spine (24 horses). An articular component was documented for 19 horses. The major distal bone fragment was divided by a fracture line in a mediolateral plane that extended from the transverse fracture into the glenoid cavity. An incomplete fracture line that extended proximally from the transverse fracture, approximately parallel to the spine of the scapula or through the supraspinous fossa, was recorded for 4 horses.

Periosteal callus was documented in association with the scapular fracture for 6 horses. In 3 horses, cal- lus bridged the transverse component of the fracture through the distal aspect of the spine of the scapula. Stress fracture was noted at the proximal aspect of the neck in 2 horses. Periosteal callus was reported on bilateral scapulae in 2 horses, although 1 horse only sustained complete fracture of 1 scapula. One horse was only described as having a 2.5-cm osteochondral chip fracture of the glenoid.

**Third metacarpal or third metatarsal fracture**—Metacarpal or metatarsal fracture, unassociated with fetlock injury, occurred in 17 horses. Several horses had an additional major injury at another site: vertebral body fracture (1 horse), carpal bone fracture (2), and contralateral proximal sesamoidean bone fracture (1). A complete comminuted fracture in the middle of the metacarpal diaphysis with comminution of the major proximal fragment was recorded for 9 horses, with 1 horse affected bilaterally. An oblique, predominantly sagittal fracture line that coursed into the proximal articular surface was recorded for 7 of these horses. Other recorded observations associated with this fracture configuration included fracture of the second and fourth metacarpal bones (5 horses), suspensory ligament rupture or transection at the location of the metacarpal bone fracture (6), and carpal bone fracture (1).

Three additional horses had a comminuted fracture at the distal third of the metacarpus. Another horse had a lateral condylar metacarpal bone fracture that was the sole metacarpal lesion. Note that distal fractures of the third metacarpal bone also occurred in other horses classified in the fetlock injury category.

**Pastern luxation**—Pastern joint luxation without an accompanying fracture of the proximal phalanx occurred in 11 horses and was accompanied by skin laceration and exposure of the proximal phalanx (6 horses), common digital extensor tendon injury (2), distal sesamoidean ligament injury (6), or superficial or deep digital flexor tendon injury (4). Many horses had multiple soft tissue structures that were simultaneously compromised.

**Pelvic fracture**—Pelvic fracture occurred in 11 horses. Two horses sustained comminuted pelvic fracture after an accident while on the walker. One horse was injured within the chute prior to racing. Several
horses (n = 4) had concurrent hemoperitoneum of unknown origin or hemorrhage from vessel rupture. Horses also sustained lumbar vertebral body fracture (4 horses), thoracic vertebral body fracture (1), and sacral fracture (3). One horse had traumatic injury on the rail during a race, leading to lumbar vertebral body fracture and femoral fracture, in addition to a fractured pelvis. Two mares were also in gestation (4 and 8 months) when injury occurred.

Fracture occurred in multiple locations on the pelvis in 4 horses, with 6 horses sustaining fracture only to the ilium, which was bilateral and comminuted (2 horses) or located unilaterally (4), with comminution occurring in 3 of those cases. If the ilium was involved, injury was more frequently confined to the wing of the ilium (7 fractures in the wing and 3 in the body).

Other fractures—Fracture of other bones each occurred in <2% of deceased horses (Table 1).

Discussion

In the present study that examined postmortem records of Quarter Horse racehorses that died in California during the period from 1990 to 2007, musculoskeletal injuries accounted for 314 (71%) of racehorse fatalities, with 9% of horses having bilateral injuries. The incidence of musculoskeletal injuries that resulted in death was 2.0 deaths/1,000 race starts and 18.6 deaths/1,000 starters (horses that started a race). The proximal sesamoid bones and third carpal bone had the most common catastrophic injuries. Thereafter, vertebral and scapular fractures were most common. Pastern luxation occurred in 11 horses. Scapular and carpal bone injuries affected the right limb more commonly than did the left limb. Consistent locations and patterns of fractures were observed for commonly affected bones. Evidence of preexisting periosteal callus was described in some fractures.

The musculoskeletal fatality rate was higher for Quarter Horses in California than for Quarter Horse racehorses in other racing jurisdictions, but was within the range for Thoroughbred racehorses at North American racetracks. The Quarter Horse musculoskeletal fatality rate for starts in California (2.0 deaths/1,000 race starts; 95% CI, 1.8 to 2.2 deaths/1,000 race starts) was over twice that observed in Quarter Horses that raced at 5 Texas racetracks and 1 New Mexico racetrack (0.8 deaths/1,000 race starts).12 The most likely reason for the higher rate in the present study is inclusion of racehorses that died during training, which were not included in the Texas and New Mexico study. The Quarter Horse musculoskeletal fatality rate for starters in California (18.6 deaths/1,000 race starters; 95% CI, 16.6 to 20.8 deaths/1,000 race starters) was also higher than that reported for 3 Midwestern racetracks (1.46 deaths/1,000 race starters), but it was unclear whether catastrophic injuries that occurred during racing and training were included in the reported abstract.12 When only those horses that died of a musculoskeletal injury during a race in the present study were considered, the relationships still held, although the Midwestern rate was near the lower CI for the rate in the present study.

The proportion of horses that died of catastrophic musculoskeletal injury in the present study (71%) is lower than that reported by Johnson et al14 in both Thoroughbred (83%) and Quarter Horse (80%) racehorses, even though the population in that study is a 2-year subset (1990 to 1992) of the present study population. However, the proportion in the present study is similar (67%) to that observed in Thoroughbreds from 2 racetracks in Ontario, Canada, in another study30 that examined postmortem records for all horses that died in the study period. Unfortunately, other reported proportions are not comparable with those in the present study because of differences in the populations studied. Reported proportions of musculoskeletal injuries among only those horses that died of injury associated with a race (ie, does not include training injuries) are lower (43% to 44% in Thoroughbred racehorses11,17 and 36% in Quarter Horse racehorses20) than the proportion of musculoskeletal injuries among horses that died of an injury associated with either racing or training in the present study.

There were similarities between fatal musculoskeletal injuries observed in Quarter Horses of the present study and reports of catastrophic or fatal musculoskeletal injuries in Thoroughbred racehorses. For both breeds and in similarly aged horses, the most common site of fatal injury was the fetlock region, with biaxial proximal sesamoid bone fracture and suspensory apparatus disruption occurring most often.9,11,12,14,15,17–19 In only 1 Thoroughbred study19 others did metacarpal and carpal injuries exceed proximal sesamoid bone injuries. Scapular, humeral, proximal sesamoid bone, tibial, and pelvic fracture configurations were consistent with those described for Thoroughbred racehorses.13,19,20,24,26,32,34–39 Evidence of preexisting periosteal callus was noted in association with complete fractures of the scapula, humerus, and pelvis for some Quarter Horses of the present study. The locations of periosteal callus that bridged the fractures in Quarter Horses in the study reported here are consistent with locations in Thoroughbreds reported elsewhere.13,19,24,31,33,36–38,40

Consequently, strategies used for detecting mild injuries that predispose to catastrophic injuries in Thoroughbred racehorses can be applied to Quarter Horse racehorses. Index of suspicion should be high for characteristic locations of stress remodeling lesions within bones. Palpation should be useful for detection of some distal scapular spine lesions35; ultrasonography for scapular and ilial wing lesions36; radiography for humeral, metacarpal and metatarsal, and tibial lesions39,42–44; and scintigraphy for scapular, humeral, metacarpal and metatarsal, pelvic, and tibial stress remodeling.30–32,40–42,45 Magnetic resonance imaging has also been used for the diagnosis of predominantly subchondral bone injury in racehorses. Additionally, the availability of standing magnets aids usefulness for racehorse injury diagnosis.46–51 Computed tomography has yet to become widely used for the detection of clinical injury apparent in racehorses at the track. However, with the advent of standing CT equipment, this imaging modality may gain increased use as a diagnostic screening tool.32,35 Rehabilitation of affected horses is likely to result in a return to full performance.

Beyond fetlock injuries, the skeletal distribution of musculoskeletal injuries appears to be different between
Quarter Horse and Thoroughbred racehorses. The carpus, vertebrae, and scapula were more commonly affected in Quarter Horses while the metacarpus and carpus are more commonly affected in Thoroughbreds during race activity.9,11,14,15,17,18 The prevalence of fracture was higher in the distal row of bones than in the proximal row of bones. Therefore, disease of the distal row of carpal bones may be more likely to lead to catastrophic injury than disease of the proximal row of carpal bones. The high right-sided prevalence of carpal breakdown is similar to the right-sided prevalence of third carpal bone slab fractures in Thoroughbred racehorses.55–59

Vertebral fractures were common in Quarter Horses. Fractures occurred in all regions of the axial skeleton except for coccygeal vertebrae. Notably, most affected vertebrae were adjacent or near transitions between spinal regions (eg, thoracolumbar and lumbosacral sites). Although it has been postulated that vertebral fractures are promoted by bumping as horses come out of the gate,60 only two-thirds of the fractures in the present study occurred during racing. Clearly, the vertebral column is highly stressed when loaded during training and racing. The axial skeleton should be examined in racehorses that have lameness or poor performance or that die suddenly without another known cause.

Right limb predominance was apparent for carpal and scapular fractures. The limb prevalence is consistent with nonfatal third carpal bone fractures55–59 and fatal scapular fractures in Thoroughbred and Quarter Horse racehorses.61 The reason for the limb dominance is unknown. We speculate that for Quarter Horses, the right limb could consistently incur higher loads than the left limb because Quarter Horses race only on the straight portion of the racetrack, which is banked in the United States so that the left side of the racetrack is lower than the right side of the racetrack. Quarter Horses could also have a preferential lead during racing, which would affect limb loading.62 A preference for the left lead would result in larger loads and stresses distributed to the trailing right front limb.62–64 However, it is unclear why only some bones of the limb would have a left-right limb preference. Perhaps bones in the more proximal aspect of the limbs (scapula, carpus, and potentially the tibia) are preferentially affected over bones of the distal aspect of the limbs (proximal sesamoid bones of the fetlock).

To our knowledge, pastern joint luxation has not been described elsewhere as a musculoskeletal cause of death in racehorses. Forelimb pastern joint luxation occurred in 11 Quarter Horses of the present study (3% of the Quarter Horses with catastrophic musculoskeletal injury). Soft tissue injuries (distal sesamoidal ligaments, flexor or extensor tendons, or both) accompanied luxation, but phalangeal fractures were not observed. Pastern disease is common in Western working horses, with the Quarter Horse breed often represented in affected samples.55–70 Although unknown, conformation and musculoskeletal geometry of the distal aspect of the forelimb in Quarter Horses, distal limb stresses, or both during training and sprint races may predispose Quarter Horses to pastern joint luxation.

The primary weakness of the present study is the retrospective review of free text postmortem reports generated by multiple pathologists. Variability in fracture description was large among the 20 pathologists that examined horses during the 18-year period of the study. Horses with catastrophic injuries in > 1 region of the body could have been categorized in several ways. The period of study encompassed a period of rapid growth with knowledge of fracture findings and sites of preexisting injury that were being discovered through the program. The prevalence of evidence of preexisting periosteal callus in the present study likely is an underestimate of the real prevalence because the study period spans the time frame during which the discovery of the association of preexisting diseases with complete fractures in Thoroughbred racehorses was made.9,11,14,15,17,18

Despite these shortcomings, the postmortem reports from a large number of deceased Quarter Horses were available for study and consistent fracture configurations and trends were elucidated.

Quarter Horse racehorses most commonly died of fetlock injuries, followed by carpal, vertebral, and scapular fractures. Consistent fracture configurations and evidence of preexisting periosteal callus paralleled those observed for Thoroughbred racehorses. However, pastern joint luxations appear unique to Quarter Horse racehorses. Knowledge of common sites of catastrophic injury and the possibility of preexisting diseases should be useful for detection of horses susceptible to catastrophic injury. Physical examination of lame or poor performing horses should include thorough palpation and consideration for ultrasonographic, radiographic, scintigraphic, MRI, or CT examinations of vertebrae, scapula, humeri, metacarpus, metatarsus, proximal sesamoid bones, ilium, and tibia.


References


52. Estberg L, Gardner IA, Stover SM, et al. A case-crossover study of intensive racing and training schedules and risk of cata-


---

**From this month’s AJVR**

**Evaluation of factors important in modeling plasma concentrations of tetracycline hydrochloride administered in water in swine**

Sharon E. Mason et al

**Objective**—To model the plasma tetracycline concentrations of *Sus scrofa domestica* treated with medication administered in water and determine the factors that contribute to the most accurate measured plasma concentrations.

**Sample**—Plasma tetracycline concentrations measured in blood samples from 3 populations of swine.

**Procedures**—Data from previous studies provided plasma tetracycline concentrations that were measured in blood samples collected from 1 swine population at 0, 4, 8, 12, 24, 32, 48, 56, 72, 80, 96, and 104 hours during administration of tetracycline hydrochloride dissolved in water and from 2 swine populations at 0, 12, 24, 48, and 72 hours. A 1-compartment pharmacostatistical model was used to analyze 5 potential covariate schemes and determine factors most important in predicting the plasma concentrations of tetracycline in swine.

**Results**—2 models most accurately predicted the tetracycline plasma concentrations in the 3 populations of swine. Factors of importance were body weight or age of pig, ambient temperature, concentration of tetracycline in water, and water use per unit of time.

**Conclusions and Clinical Relevance**—The factors found to be of importance, combined with knowledge of the individual pharmacokinetic and chemical properties of medications currently approved for administration in water, may be useful in more prudent use of approved medications administered to swine. Factors found to be important in pharmacostatistical models may allow prediction of plasma concentrations of tetracycline or other commonly used medications administered in water. The ability to predict in vivo concentrations of medication in a population of food animals can be combined with bacterial minimum inhibitory concentrations to decrease the risk of developing antimicrobial resistance. (*Am J Vet Res* 2012;73:1641–1649)