Musculoskeletal *Corynebacterium pseudotuberculosis* infection in horses: 35 cases (1999–2009)

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Objective—To describe the clinical course and outcome in horses in which *Corynebacterium pseudotuberculosis* infections were associated with musculoskeletal disease and lameness.

Design—Retrospective case series.

Animals—35 horses.

Procedures—Clinical and clinicopathologic data were collected from horses diagnosed with lameness associated with *C pseudotuberculosis* infection between 1999 and 2009.

Results—32 (91.4%) horses had grade 4/5 lameness. Three (8.6%) horses had grade 5/5 lameness. Abscesses were diagnosed by clinical or ultrasonographic examination. Abscesses were located in the axillary or triceps region in 25 (71.4%) horses, the stifle region in 2 (5.7%), and the popliteal lymph node in 1 (2.9%). Diffuse lymphangitis was seen in 4 (11.4%) horses, osteomyelitis in 2 (5.7%) horses, and septic arthritis in 2 (5.7%) horses. Horses commonly had clinicopathologic abnormalities characterized by neutrophilia (96.4%), anemia (67.8%), hypoalbuminemia (66.6%), or hyperfibrinogenemia (42.8%). Treatment included surgical drainage of the abscess in 21 (60%) horses, performed under ultrasonography in 20 horses; anti-inflammatory medications in 34 (97.1%) horses; and antimicrobials in 30 (85.7%) horses.

Conclusions and Clinical Relevance—*C pseudotuberculosis* infection of the limbs in horses typically results in severe lameness but may have a favorable prognosis. The diagnosis may be challenging, and results of blood work consistent with inflammation are nonspecific, but anemia, hyperglobulinemia, and increased synergistic hemolysis inhibition titers are common. Ultrasonography may localize the lesions and facilitate surgical drainage to alleviate lameness. When *C pseudotuberculosis* musculoskeletal infection results in osteomyelitis or septic arthritis, the prognosis for survival is poor. (*J Am Vet Med Assoc* 2012;241:771–777)

Corynebacterium pseudotuberculosis is a Gram-positive, facultative intracellular, pleomorphic bacterium with a worldwide distribution.[1] The most common clinical form of the disease associated with infection with *C pseudotuberculosis* in horses is formation of external abscesses most often in the pectoral and ventral abdominal regions.[1] This form of the disease is most prevalent in California[2–6] and Texas,[7,8] where it is referred to as pigeon fever or dryland distemper. Less commonly, *C pseudotuberculosis* infection causes a diffuse and potentially chronic infection of the limbs known as ulcerative lymphangitis. The mode of infection is speculative, but it is postulated that the organism enters the horse through abrasions in the skin.[9] Results of a 2004 study[9] support the hypothesis that insects such as the horn fly (*Haematobia irritans)*, stable fly *(Stomoxys calcitrans)*, and house fly (*Musca domestica)* act as vectors. Internal abscessation, generalized infections, and abortions have been reported in horses in areas where external abscessation caused by *C pseudotuberculosis* is prevalent.[2–7,10–13] A smaller subgroup of horses has been reported[14] to develop abscesses deep in the musculoskeletal structures of the limbs, resulting in severe lameness. Rarely, the organism can cause primary osteomyelitis or septic arthritis.[6] Horses with musculoskeletal infection can present a diagnostic challenge because in most cases, the abscesses are not readily apparent or there is a low index of suspicion for *C pseudotuberculosis* abscessation as a potential cause of the lameness. Time to resolution of the infection reported in 1 study[6] was approximately 35 days but could be as long as 97 days reported in a case series[15] on *C pseudotuberculosis* infection causing internal abscessation.

Abbreviation

SHI Synergistic hemolysis inhibition

The objectives of the study reported here were to describe the history, clinical signs, treatment course, and outcome of *C pseudotuberculosis* disease in horses where the infection was associated with musculoskeletal disease and resultant lameness and to describe best the diagnostic testing methods used to localize the source of the septic process. An additional goal of the

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study was to describe clinical features of this disease that have not been previously reported (eg, horses with primary septic arthritis caused by *C pseudotuberculosis*).

Materials and Methods

Selection criteria—Medical records were searched in the electronic database of the Veterinary Medical Teaching Hospital, University of California-Davis, from 1999 to 2009. Horses were included in the study if they were evaluated for lameness and were subsequently diagnosed with musculoskeletal *C pseudotuberculosis* infection on the basis of aspiration or drainage of tan, odor-free exudate from abscesses within the musculoskeletal structures and one of the following criteria: isolation of *C pseudotuberculosis* by bacteriologic culture of samples from aspirates or draining abscesses or a positive serum antibody titer (≥ 256), as measured by the SHI test.[6]

Data collection from records—Additional data collected included date of admission, signalment, history, housing situation, initial clinical signs, presence of swelling, duration of lameness, affected limb, presence of external or internal abscesses, American Association of Equine Practitioners lameness grade,[16] heart rate, respiratory rate, highest temperature, plasma fibrinogen concentration, blood neutrophil count, PCV, serum albumin, serum globulin and total protein concentrations, SHI titer, bacteriologic culture results,[a] radiographic findings, ultrasonographic findings, scintigraphic findings, size of the abscess, treatment of the abscess, type and duration of antimicrobial and NSAID administration, complications, outcome, and necropsy findings (where relevant).

Statistical analysis—Descriptive statistics and analyses were performed with a commercial statistical software.[b] Synergistic hemolysis inhibition titer values were converted to $\log_2$ form. Linear regression analysis was to used compare the days of lameness prior to initial examination with the $\log_2$ SHI titers. Values of $P < 0.05$ were considered significant.

Results

Signalment and seasonality—Thirty-five horses met the inclusion criteria. Breed distribution was similar to that for the general hospital population. Of the 35 horses, 19 (54.3%) were females, 12 (34.3%) were geldings, and 4 (11.4%) were sexually intact males. Median age of horses was 5 years (range, 0.5 to 24 years). Cases were detected during 10 months of the year. Number of cases was unevenly distributed regarding month of admission, and the disease was most common during late fall and early winter, with the highest incidence in November and December of every year.

History and clinical findings—Housing type was recorded in 24 cases. Ten horses were housed in a dry lot, 8 horses were kept on pasture, and 6 horses were housed in a stall with occasional turnout. In 24 cases, the farm where the horses were kept had a history of *C pseudotuberculosis* infection. Initial clinical signs included severe lameness with or without swelling of the affected limb in all horses. Median duration of lameness prior to initial examination was 16 days (1 to 60 days). Thirty-two (91.4%) horses had grade 4/5 lameness, and 3 (8.6%) horses had grade 5/5 non–weight-bearing lameness. One limb was affected in 34 (97.1%) cases, and multiple limb lameness was observed in 1 (2.9%) case. Vital signs were recorded at the time of initial examination. Twenty-three of the 35 (65.7%) horses were febrile on initial examination (temperature > 102°F [38.9°C]), with a median rectal temperature of 102.1°F (38.9°C; range, 99.5° to 106.0°F [37.5° to 41.1°C]). A solitary abscess in the axillary or triceps region was the most common location, affecting 25 (71.4%) horses, followed by diffuse lymphangitis of the affected limb in 4 (11.4%) horses, extra-articular abscessation of the stifle region in 2 (5.7%) horses, osteomyelitis in 2 (5.7%) horses, septic arthritis in 2 (5.8%) horses, and an abscessed popliteal lymph node in 1 (2.9%) horse. One horse had both septic arthritis and osteomyelitis.

Clinicopathologic data—Complete blood cell counts were available in 28 cases. Nineteen (67.9%) horses were anemic (PCV < 30% [30% to 46%]), 27 (96.4%) were neutrophilic (neutrophil count > 6,800/μL [2,600 to 6,800/μL]), 12 (42.9%) had hyperfibrinogenemia (fibrinogen concentration > 400 mg/dL [100 to 400 mg/dL]), and 11 (39.3%) had hyperproteinemia (plasma protein concentration > 7.9 g/dL [5.8 to 7.9 g/dL]). Serum biochemistry panels were performed on 24 horses; 16 (66.7%) had hypoalbuminemia (albumin concentration < 2.7 g/dL [2.7 to 4.2 g/dL]), and 11 (45.8%) had hyperglobulinemia (globulin concentration > 5 g/dL [1.6 to 5.0 g/dL]). Bacteriologic culture of the purulent material from the site was attempted in 27 cases, and the pure growth of *C pseudotuberculosis* was obtained in 24 (88.9%) of those cases. Sampling sites included draining abscesses, microabscesses of ulcerative lymphangitis, or synovial fluid. The serum SHI test was performed in 21 cases. The median titer was 640 (range, 128 to 5,120). There was no significant ($P = 0.3$) linear correlation between the days of lameness prior to initial examination and the $\log_2$ SHI titers.

Diagnoses—Twenty-five (71.4%) horses were diagnosed with an abscess located in the axillary or triceps region, 2 (5.7%) horses had an abscess in the stifle region, and 1 (2.9%) horse had an abscess in the popliteal lymph node. Diffuse lymphangitis was seen in 4 (11.4%) horses, osteomyelitis in 2 (5.7%), and septic arthritis in 2 (5.7%; 1 horse had both osteomyelitis and septic arthritis).

Of the 25 horses with abscessation of the axillary-triceps region, 10 had no visible swelling or edema and 4 had signs of depression and anorexia on initial examination. Duration of lameness prior to initial examination ranged from 1 to 60 days. The lameness in these horses was characterized by a decreased cranial phase of the stride. Three horses with grade 4/5 lameness and no swelling of the affected limb were referred for nuclear scintigraphy after the lameness could not be localized to the distal limb with diagnostic nerve blocks by the referring veterinarians. Nuclear scintigraphy was performed in 3 horses and revealed increased

radiopharmaceutical uptake in the elbow region in 2 of those horses. One of 25 horses was referred for an evaluation of neurologic status because of a history of severe front limb ataxia and falling. Weakness of the affected limb and an abscess deep in the axillary region were found in this horse. One horse was referred because of suspected humeral fracture, and the final diagnosis in this horse was an abscess deep in the triceps region. Ultrasonographic examination of the triceps region was performed in 22 of 25 horses with a 2.5- to 5.0-MHz curvilinear transducer and revealed large, well-encapsulated abscesses deep to the triceps musculature directly overlying the heart and thoracic cavity. These abscesses ranged from 2 to 28 cm in width as well as length and were located up to 10 cm deep to the skin surface. Abscesses were commonly described as loculated with heterogeneous contents (Figure 1). Fifteen horses had an SHI test performed, with titers ranging between 1:128 and 1:2,560. Culture of the purulent material was performed in 21 cases, and growth of *C pseudotuberculosis* was observed in 19 cases.

Out of the 4 horses determined to have ulcerative lymphangitis, all had marked limb edema with multiple nodules or open draining tracts along the affected limb. Three of 4 horses had marked elevation of rectal temperature (40.5° to 41.1°C [105° to 106 F°]). Two horses had acute swelling (lasting < 48 hours' duration), and 2 had a history of chronic limb swelling, lameness, and draining tracts for up to 28 days prior to initial evaluation. All 4 cases involved hind limbs. Diagnosis was confirmed by positive culture of the organism in 3 horses while culture yielded no growth in 1 horse that was treated with antimicrobials for 2 weeks prior to the initial evaluation. This horse had a positive result of SHI testing, with a titer of 1:5,120. Ultrasonographic examination was performed in all 4 cases and revealed diffuse cellulitis with multiple small areas of abscessation. Diffuse lymphangiectasia of the entire limb was seen in 1 case.

Two horses developed an extra-articular abscess in the stifle region. Both had severe swelling in the stifle area and were referred specifically for ultrasonographic examination of the stifle joint and suspected septic arthritis. Duration of lameness was 21 days in both cases. Ultrasonographic examination performed with a 2.5- to 5.0-MHz curvilinear transducer revealed large, well-encapsulated abscesses containing cellular fluid deep to the quadriceps musculature just proximal to the stifle joint. One horse underwent ultrasonographic-guided aspiration and lavage. Bacteriologic culture of the aspirate yielded positive growth in this horse, and diagnosis was confirmed with positive results of SHI testing in the other horse.

Two horses were determined to have osteomyelitis associated with *C pseudotuberculosis*. One horse initially had a grade 4/5 lameness and swelling at the mid-metacarpal region. Radiographs on examination revealed no bony abnormalities; however, ultrasonographic examination of the metacarpus revealed an abscess in the midmetacarpal region and osteomyelitis of the underlying bone. Sequestrum formation in the third metacarpal bone was identified on follow-up radiographs obtained 7 days later. The other horse was examined because of a draining tract and swelling of the coronary band with a 7-day history of lameness. Results of ultrasonographic examination were consistent with septic arthritis of the distal interphalangeal joint, and distal extremity radiographs revealed osteomyelitis of the third phalanx with secondary fracture of the extensor process (Figure 2).

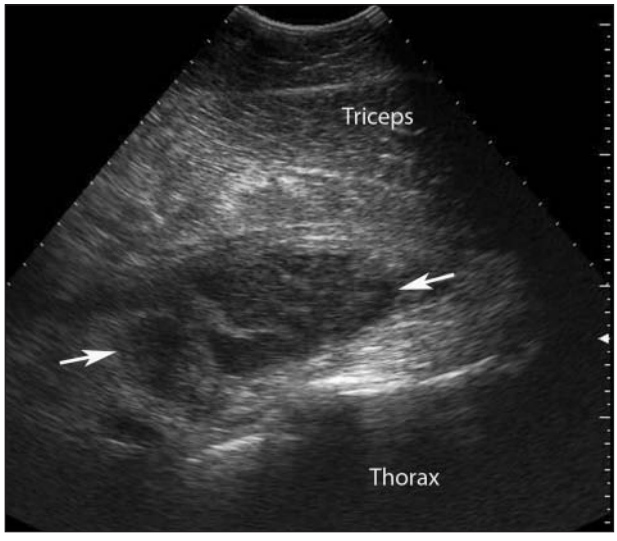

Figure 1—Ultrasonographic image of an abscess deep to the triceps musculature in a 2-year-old female Thoroughbred referred for nuclear scintigraphy because of severe right forelimb grade 5/5) lameness not localized with diagnostic nerve blocks and a subsequent diagnosis of *Corynebacterium pseudotuberculosis* musculoskeletal infection after aspiration of the abscess and bacteriologic culture of the sample. (Image obtained with a 4.0-MHz curvilinear transducer at a depth of 21 cm).

Figure 2—Radiographic image of osteomyelitis of the third phalanx of the left hind limb in a 1-year-old Quarter Horse filly with *C pseudotuberculosis* musculoskeletal infection. Note the pathological fracture of the extensor process (white arrows). Dorsolateral palmaromedial oblique projection.

Diagnosis was confirmed in both cases by positive bacterial culture of *C pseudotuberculosis*.

One horse was determined to have primary septic arthritis of the left tarsocrural joint. This horse had a grade 4/5 lameness and diffuse swelling of the tarsus. Ultrasonographic and radiographic examinations of the tarsus were consistent with septic arthritis. No abscesses in the surrounding soft tissues or other external abscesses were found. Synovial fluid culture yielded pure growth of *C pseudotuberculosis*.

The remaining horse developed an abscess deep to the semimembranosus muscles and edema of the distal aspect of the limb, and diagnosis was confirmed with positive results of an SHI titer (1:1,280).

Treatment and outcome—In the 25 horses diagnosed with an axillary or triceps abscess, the abscess was lanced and drained successfully in 17 horses, with ultrasonographic guidance performed on 16 of those horses. A wide-bore thoracic tube[c] was inserted into the abscess to facilitate drainage and lavage in 6 horses. The remaining 8 horses underwent spontaneous drainage of the abscess either at the time of evaluation or during the treatment course. All 25 horses received NSAIDs (19 cases received phenylbutazone [2.2 to 4.4 mg/kg [1.0 to 2.0 mg/lb], PO, q 12 to 24 h], 3 cases received flunixin-meglumine [1.1 mg/kg [0.5 mg/lb], PO or IV, q 12 to 24 h], and 3 cases received both phenylbutazone and flunixin-meglumine at some point during their treatment course). Twenty-one horses received antimicrobials following drainage of the abscess, including trimethoprim-sulfamethoxazole (30 mg/kg [13.6 mg/lb], PO, q 12 h) in 14 cases, rifampin (5 mg/kg [2.3 mg/lb], PO q 12 h) in 7 cases, penicillin G procaine (22,000 U/kg [10,000 U/lb], IM, q 12 h) in 6 cases, gentamycin (6.6 mg/kg [3.0 mg/lb], IV, q 24,h) in 3 cases, ceftiofur (2.2 mg/kg, IV or IM, q 12 h) in 2 cases, ampicillin (20 mg/kg [9 mg/lb], IV, q 8 h) in 2 cases, chloramphenicol (50 mg/kg [22.5 mg/lb], PO, q 8 h) in 1 case, and oxtetracycline (6.6 mg/kg, IV, q 24 h) in 1 case. Combination treatment with 2 different antimicrobials was used in 9 cases. Long-term follow-up was available for 17 horses. Recovery times ranged between 21 and 120 days. Complications included cellulitis of the triceps region following surgical lancing of the abscess (n = 2), antimicrobial-associated diarrhea (1), and support limb laminitis (1).

Out of the 2 horses with an abscess in the stifle region, 1 horse underwent surgical drainage under standing sedation and lavage. This horse was treated with phenylbutazone (2.2 mg/kg, PO, q 12 h) and trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) for 10 days and was lost to long-term follow-up. Severe osteochondrosis dissecans was concurrently diagnosed in the right shoulder joint in the second horse, which was euthanized because of financial constraints.

The 4 horses diagnosed with ulcerative lymphangitis were treated with systemic antimicrobials, antiinflammatory medications, and bandaging of the affected limbs for 21 to 60 days. Antimicrobials included the combination of ceftiofur (2.2 mg/kg, IV, q 12 h) and gentamycin (6.6 mg/kg, IV, q 24 h), followed by the doxycycline (10 mg/kg, PO, q 12 h) in 1 horse; administration of enrofloxacin (7.5 mg/kg, PO, q 24 h) in another case; and the combination of gentamicin (6.6 mg/kg, IV, q 24 h) and potassium-penicillin (22,000 U/kg, IV, q 6 h), followed by trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) in 1 case. The fourth horse received the combination of ceftiofur (2.2 mg/kg, IV and then IM, q 12 h) and rifampin (5 mg/kg, PO, q 12 h), followed by the combination of trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) and rifampin for a total treatment time of 21 days and had a recurrence of the lymphangitis 4 weeks after discontinuation of the antimicrobial treatment. One horse developed an abscess above the tarsus, and another horse developed an abscess in the inguinal region during the treatment course that was drained. Three of 4 horses with ulcerative lymphangitis were available for long-term follow-up. All responded well to initial treatment, although chronic lymphedema of the affected limb with no apparent lameness was reported in these 3 horses up to 2 years after diagnosis.

Out of the 2 horses diagnosed with osteomyelitis due to *C pseudotuberculosis*, treatment included surgical debridement, multiple regional limb perfusions with amikacin, and systemic antimicrobial treatment (ceftiofur [2.2 mg/kg, IM, q 12 h] for 7 days, followed by enrofloxacin [7.5 mg/kg, PO, q 24 h] for 2 weeks, and then chloramphenicol [50 mg/kg, PO, q 8 h] for 5 weeks) in 1 horse. This horse fully recovered within 60 days. The other horse, diagnosed with septic arthritis of the distal interphalangeal joint and osteomyelitis of the third phalanx with secondary fracture of the extensor process, was euthanized because of the poor prognosis. Necropsy in this case revealed disseminated *C pseudotuberculosis* infection with multiple abscesses in the lungs, spleen, subcutaneous tissues, and right axilla. The suppurative and necrotizing osteomyelitis of the third phalanx was presumed to be secondary to bacterial emboli.

The horse with septic arthritis of the tarsocrural joint was treated with a standing intra-articular joint lavage on a single occasion, regional limb perfusions with gentamycin for 3 consecutive days, systemic antimicrobials, and stall rest. Antimicrobial treatment in this case was first started with a combination of penicillin G procaine (20,000 U/kg, IM, q 12 h) and gentamicin (6.6 mg/kg, IV, q 12 h), followed by the combination of ceftiofur (2.2 mg/kg, IV, q 12 h) and rifampin (5.0 mg/kg, PO, q 12 h) for 3 weeks after bacteriologic culture results became available; the horse was then orally administered doxycycline (10 mg/kg, PO, q 12 h) for 3 months. Follow-up examination 3 months later revealed resolution of the septic arthritis as determined on the basis of synovial fluid analysis, with improved lameness score. Mild changes consistent with osteoarthritis were seen on follow-up radiographs in the tarsocrural, proximal intertarsal, distal intertarsal, and tarsometatarsal joints.

The horse with the abscess deep to the semimembranosus muscles was treated with surgical incision and drainage under sedation and local anesthesia. The horse received trimetorpim-sulfamethoxazole (30 mg/kg, PO, q 12 h) for 21 days, and then full recovery was achieved by 28 days.

In summary, 23 horses had at least 1 follow-up evaluation until complete recovery, 10 horses were lost to follow-up, and 2 horses were euthanized. Median recovery time, defined as resolution of the lameness, was 60 days (range, 21 to 120 days). Only 1 horse (treated with the combination of trimethoprim-sulfamethoxazole and rifampin) developed diarrhea that was self-limiting after cessation of the antimicrobial treatment, and no other complication related to antimicrobial treatment was noted.

Discussion

In the present study, horses with musculoskeletal *C pseudotuberculosis* had notable but nonspecific clinicopathologic abnormalities consistent with inflammation. A thorough physical examination accompanied by ultrasonographic examination were the most reliable methods of diagnosis. Abscesses were located in the axillary or triceps region in 71.4% of horses studied, and grade 4/5 lameness (91.5% of horses) was a prominent feature of the disease. Early diagnosis and treatment are recommended to prevent life-threatening complications such as support limb laminitis or osteomyelitis.

The age distribution of horses in our study (median, 5 years; range, 0.5 to 24 years) with musculoskeletal *C pseudotuberculosis* infections was consistent with findings from previous reports.[2,5,6,10–15] *Corynebacterium pseudotuberculosis* infections typically have a seasonal occurrence in California, with most infections diagnosed during September, October, and November.[2,5,6] In the present study, musculoskeletal *C pseudotuberculosis* infections were most often diagnosed in November and December, a finding that is similar to a previous report[15] of internal abscess formation. A previous retrospective study[6] found the month of October to have the highest numbers of cases in California, suggesting a longer time to diagnosis for internal infection and musculoskeletal infection causing lameness. No age, sex, or breed predilection was identified in the present study.

Clinicopathologic data for horses in the present study suggestive of inflammation illustrate the chronicity of this condition and show similarities or overlap with data from horses with internal abscesses.[15] Whereas anemia and neutrophilia can be marked, hyperglobulinemia and hyperfibrinogenemia were not consistent findings in horses with musculoskeletal infection, as only 45.8% (11/24) of the horses from which data were obtained had such elevations, compared with 79% for horses with internal abscessation.[15]

The triceps-axillary region was the most common location of *C pseudotuberculosis* abscess formation in the present case series. Abscessation of the axillary lymph node, deep to the triceps musculature and directly overlying the heart and thoracic cavity, is considered an external form of the disease, as is the extra-articular abscess formation in the stifle region. Ten of the 25 horses with axillary abscesses had no visible swelling in the area, and there were horses that had abscesses as small as 2 cm in diameter. These findings suggest that the size of the abscess does not correlate with the degree of discomfort because all horses had severe (4/5 or 5/5) lameness. Two-dimensional B-mode ultrasonography performed with a 2.5- to 5.0-MHz curvilinear transducer (minimum penetration depth, 25 cm) is often needed for definitive diagnosis and facilitates ultrasonographic-guided aspiration and drainage of the abscess. Unlike other external *C pseudotuberculosis* abscesses, these sites may take a long time to spontaneously drain, likely because of their depth (up to 10 cm) from the skin surface. This long maturation process can compromise the horse's systemic health by the ongoing inflammatory process, and the severe lameness is a risk for the development of support limb laminitis. Although only 1 horse developed support limb laminitis in this case series, we recommend aggressive attempts to localize the abscess and initiate treatment in cases of musculoskeletal infection to decrease the likelihood of such complications. Depending on the size of the abscess and its proximity to the skin surface, drainage can be achieved by surgical dissection or placement of an indwelling drain. The 1 horse that underwent neurologic examination because of front limb ataxia suggests that not only lameness but also neurologic dysfunction may occur as a result of compression of adjacent nerves causing lower motor neuron signs.

Ulcerative lymphangitis was found to be an uncommon clinical manifestation of *C pseudotuberculosis* infection in this population of horses because only 4 cases were found during the study period of 10 years. Despite the severe lameness and systemic inflammation seen in horses with ulcerative lymphangitis, all horses survived in the present study. Chronic lymphedema as a complication was seen in 3 of the 4 horses and is consistent with a previous report.[14] On the basis of the patients in the present study, follow-up ultrasonographic examinations of the affected limb are recommended to identify and drain abscesses that form along the lymphatic vessels during the healing process. The 1 horse that was treated with antimicrobials (combination of ceftiofur and rifampin) for only 21 days had a recurrence of the infection, suggesting that patients with ulcerative lymphangitis may benefit from prolonged antimicrobial treatment, even after resolution of the fever and clinicopathologic abnormalities, to ensure the complete resolution of the septic process. Interestingly, only pelvic limbs were affected with ulcerative lymphangitis in the patients of the present report; however, the cause for this is unknown.

To our knowledge, no primary cases of septic arthritis caused by *C pseudotuberculosis* have been previously reported. The present report provides data indicating that bacteremia and hematogenous infection can occur without evidence of external infection; therefore, veterinarians should consider *C pseudotuberculosis* as a causative agent for primary septic arthritis in geographic areas where the disease is prevalent. Septic arthritis in horses can carry a poor prognosis without aggressive treatment.[17] One horse in the present report responded to prolonged systemic antimicrobial treatment with a single joint lavage under standing sedation and 3 regional limb perfusions. This horse had complete resolution of the septic process but maintained a grade 3/5 lameness on the affected limb and had marked changes consistent with osteoarthritis on follow-up radiographs 3 months after initial diagnosis. The other horse that

was diagnosed with septic arthritis in the present case series and was euthanized because of a poor prognosis likely developed the joint infection secondary to septic osteomyelitis affecting the third phalanx.

The 2 horses with osteomyelitis from *C pseudotuberculosis* infection were examined in different stages of the disease. The horse that survived was evaluated after a 1-day history of grade 4/5 lameness and had no radiographic evidence of bony involvement on initial examination. The other horse was examined after a 7-day history of non–weight-bearing (grade 5/5) lameness and, on the basis of radiographs, was in advanced stages of the disease and thus euthanized. Although no treatment was attempted in the second case, we suggest that osteomyelitis secondary to *C pseudotuberculosis* infection may be a life-threatening complication. As evidenced by the horse in this study, evaluation of the underlying bony structures via advanced imaging (ie, ultrasonography, CT, or MRI) may be crucial for early diagnosis of osteomyelitis, improving the prognosis if aggressive treatment is given early in the course of disease.

Corynebacterium pseudotuberculosis is susceptible in vitro to many of the antimicrobials commonly used in horses, including penicillin G, macrolides, tetracyclines, cephalosporins, fluoroquinolones, chloramphenicol, and rifampin.[18–20] On the basis of the present report, musculoskeletal abscessation can cause severe pain in affected horses and may result in life-threatening complications, such as development of laminitis of the contralateral limb or osteomyelitis of the underlying bony structure. Therefore, the primary goal of treatment in such patients should be localization of the septic process and effective drainage. Systemic antimicrobial treatment may also be used in such cases to prevent secondary cellulitis at the site, and it is always necessary in cases of ulcerative lymphangitis, osteomyelitis, or primary osteoarthritis. Because *C pseudotuberculosis* is an intracellular organism, in patients with an ongoing septic process, an antimicrobial with intracellular penetration and improved activity in the presence of exudates, such as rifampin, tetracyclines, enrofloxacin or chloramphenicol, is recommended.[14] A majority of the horses in the present report received antimicrobials not known for having intracellular activity (penicillin) or which may be inactivated in the presence of exudates (trimethoprim-sulfamethoxazole), once drainage was established, suggesting the importance of achieving drainage. However, since treatment was not randomly applied, it would be inappropriate to draw conclusions on the efficacy of the individual antimicrobial choices. Antimicrobial treatment in horses has been previously associated with development of diarrhea,[20] which can be a life-threatening complication. However, no data are available to compare the inherent risk of complications related to the use of antimicrobials with the risk of continued discomfort and clinical deterioration of the patient if antimicrobials were not used. In a previous study,[6] 39% of horses developed diarrhea during antimicrobial treatment for internal abscesses. In the present study, 1 of 30 (3%) horses treated with antimicrobials developed a change in fecal consistency. This marked difference could be related to the difference in the length of antimicrobial treatment between the 2 populations or related to anorexia due to abdominal discomfort in horses with internal abscesses,[6] increasing the risk of diarrhea. Only 4 of the 35 horses in our study population were inappetent on initial examination, which may have contributed to the decreased incidence of antibiotic-induced colitis.

Horses with severe lameness caused by *Corynebacterium pseudotuberculosis* present a diagnostic challenge because they do not have visible external swelling but often have clinical signs and blood work consistent with systemic inflammation. Whereas this may raise the suspicion for a septic process, ultrasonographic evaluation of suspect regions is often required to identify areas of abscessation, ulcerative lymphangitis, osteomyelitis, or septic arthritis. Ultrasonographic guidance is especially useful for aspiration and drainage of deep muscular abscesses to avoid entry into the thoracic cavity in cases of triceps abscessation, with the risk of pneumothorax as well as inadvertent puncture of nearby vital structures such as the heart. It is also essential to avoid damage to underlying joints such as the stifle joint. *Corynebacterium pseudotuberculosis* infection of musculoskeletal structures should be considered in horses with severe lameness and inflammatory leukograms during the winter months in regions where *C pseudotuberculosis* is prevalent.

a. Veterinary Medical Teaching Hospital Microbiology Laboratory, University of California-Davis, Davis, Calif,
b. Minitab, version 15, Minitab Inc, State College, Pa.
c. Kendall Argyle catheter, 24F, Covidien AG, Mansfield, Mass.

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From this month's *AJVR*

Hemodynamic effects in dogs after intramuscular administration of a combination of dexmedetomidine-butorphanol-tiletamine-zolazepam or dexmedetomidine-butorphanol-ketamine

Rebecca A. Krimins et al

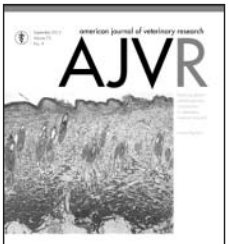
Objective—To evaluate hemodynamic effects in dogs after IM administration of dexmedetomidine (7.5 μg/kg), butorphanol (0.15 mg/kg), and tiletamine-zolazepam (3 mg/kg [DBTZ]) or dexmedetomidine (15 μg/kg), butorphanol (0.3 mg/kg), and ketamine (3 mg/kg [DBK]).

Animals—5 healthy adult mixed-breed dogs.

Procedures—Each dog received DBTZ and DBK in a randomized crossover study with a 48-hour interval between treatments. Anesthesia was induced and maintained with sevoflurane in oxygen while instrumentation with Swan-Ganz and arterial catheters was performed. Following instrumentation, hemodynamic measurements were recorded at 3.54% (1.5 times the minimum alveolar concentration) sevoflurane; then sevoflurane administration was discontinued, and dogs were allowed to recover. Six hours after cessation of sevoflurane administration, baseline hemodynamic measurements were recorded, each dog was given an IM injection of DBTZ or DBK, and hemodynamic measurements were obtained at predetermined intervals for 70 minutes.

Results—DBTZ and DBK induced hypoventilation ($Paco_2$, approx 60 to 70 mm Hg), respiratory acidosis (pH, approx 7.2), hypertension (mean arterial blood pressure, approx 115 to 174 mm Hg), increases in systemic vascular resistance, and reflex bradycardia. Cardiac output, oxygen delivery, and oxygen consumption following DBTZ or DBK administration were similar to those following sevoflurane administration to achieve a surgical plane of anesthesia. Blood L-lactate concentrations remained within the reference range at all times for all protocols.

Conclusions and Clinical Relevance—In healthy dogs, both DBTZ and DBK maintained oxygen delivery and oxygen consumption to tissues and blood lactate concentrations within the reference range. However, ventilation should be carefully monitored and assisted when necessary to prevent hypoventilation. (*Am J Vet Res* 2012;73:1363–1370)



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