Treatment of methicillin-resistant 
Staphylococcus epidermidis infection following repair of an ulnar fracture and humeroradial joint luxation in a horse

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The combination of an ulnar fracture and luxation of the humeroradial joint is known as a Monteggia fracture; such fractures are rare in horses but can be successfully treated. However, mechanical assistance may be required to achieve reduction. Postoperative infection of surgical sites with methicillin-resistant staphylococci is becoming more common in horses. Methicillin-resistant staphylococci may be resistant to a broad range of antimicrobials. Vancomycin should be used to treat such infections only if other treatment alternatives have been ruled out and results of in vitro susceptibility testing suggest that vancomycin will be effective; empirical treatment with vancomycin should be avoided to minimize the risk that vancomycin-resistant organisms will develop.

A 27-month-old 350-kg (770-lb) female Rocky Mountain Horse was brought to the University of Wisconsin veterinary medical teaching hospital because of acute non-weight-bearing lameness of the right forelimb that began 4 hours previously when the horse became entangled in a tubular steel gate. On physical examination, the horse would not bear weight on the right forelimb, and there was marked lateral deviation of the distal portion of the limb with severe external rotation distal to the elbow. The elbow was markedly swollen, particularly medially, and manipulation of the elbow elicited crepitus and signs of pain. The proximal articular surface of the radius was palpable in the pectoral region, medial to its normal location. On radiographs of the right elbow, an oblique comminuted fracture of the proximal portion of the ulna, which extended to the humeroulnar joint, and luxation of the humeroradial joint with proximomedial displacement of the radius and distal portion of the ulna were evident (Fig 1). This combination of an ulnar fracture and humeroradial joint luxation is commonly referred to as a Monteggia fracture.

Surgical options for treatment were discussed with the owners, and they elected to attempt surgical repair. An indwelling catheter was placed in a jugular vein, and blood was submitted for a CBC. Results were interpreted as a stress leukogram. Results of serum biochemical analyses, including determination of serum electrolyte concentrations, were within reference limits. The horse was treated with gentamicin (6.6 mg/kg [3 mg/lb] of body weight, IV, q 24 h), potassium penicillin G (22,000 U/kg [10,000 U/lb], IV, q 6 h), dexamethasone (20 mg, IV), and phenylbutazone (4.4 mg/kg [2 mg/lb], PO, q 12 h). A tetanus toxoid booster was administered IM. The horse remained quiet the remainder of the evening, and surgery was performed the following morning.

The morning after admission, the horse was anesthetized with xylazine hydrochloride (150 mg, IV), diazepam (30 mg, IV), and ketamine (1,000 mg, IV). An orotracheal tube was placed, and anesthesia was maintained with halothane. The horse was placed in left lateral recumbency, and closed reduction was attempted but was unsuccessful. The limb was prepared for surgery, and a mechanical distraction device was placed in the axilla and attached to the distal aspect of the forelimb to facilitate reduction. Continuous traction was applied to the limb by the mechanical distractor during final preparation for surgery. The limb was aseptically prepared and draped, and a 25-cm long curvilinear incision was made along the caudolateral aspect of the antebrachium, starting at the olecranon and extending distally between the ulnaris lateralis muscle and the ulnar head of the deep digital flexor muscle. Traction exerted by the mechanical distraction device was increased, and the humeroradial joint luxation and ulnar fracture were reduced. A 12-hole bone plate was contoured to the caudolateral aspect of the ulna and secured to the bone with 5.5-mm cortical bone screws. The bellies of the ulnaris lateralis muscle and the ulnar head of the deep digital flexor tendon were reapposed with size 0 polyg lựcin 910 in a simple continuous pattern. The subcutaneous tissue was closed with 2-0 polyg lựcin 910 in a continuous horizontal pattern. The skin was closed with skin staples. The horse was assisted to stand during recovery with head and tail ropes; anesthetic recovery was uncomplicated.

The horse was bearing full weight on the limb immediately after surgery. On radiographs obtained after surgery, anatomic reduction of the fractured ulna and reduction of the humeroradial joint luxation were evident (Fig 2). Administration of gentamicin, potassium penicillin G, and phenylbutazone was continued...
until the fourth day after surgery, when a marked increase in swelling of the soft tissues of the proximal-medial aspect of the antebrachium was evident. The horse was febrile (rectal temperature, 39.9°C [103.8°F]), and lameness developed as the horse became reluctant to extend the foot forward or bear weight on the limb. Radiographs of the elbow were obtained, and no signs of implant failure or osteomyelitis were evident. Ultrasonography of the antebrachium and elbow revealed a discreet fluid pocket along the proximal-medial aspect of the antebrachium. Fine-needle aspiration of this pocket yielded 12 ml of red-yellow fluid. The WBC count of the fluid was 9,000 cells/µl, and, cytologically, most cells were nondegenerative neutrophils, with a few lymphocytes and macrophages. No microorganisms were observed.

The fluid was submitted for bacterial culture and susceptibility testing. Preliminary culture results suggested that the fluid contained methicillin-resistant gram-positive staphylococci, and enrofloxacin (7.5 mg, PO, q 24 h) was added to the antibiotic regimen. In addition, hydrotherapy was performed, and dimethyl sulfoxide was applied topically twice daily. The lameness persisted; however, and the horse spent most of the time lying in left lateral recumbency. Intermittent febrile episodes were recorded.

Final bacterial culture and susceptibility test results were available 7 days after surgery. Bacterial culture yielded a pure growth of methicillin-resistant Staphylococcus epidermidis that was susceptible to erythromycin, chloramphenicol, tetracycline, and vancomycin and resistant to enrofloxacin. The horse was moved to an isolation facility, and barrier precautions were implemented. On the basis of results of bacterial culture and susceptibility testing, treatment with enrofloxacin, gentamicin, and potassium penicillin G was discontinued, and treatment with oxytetracycline (7 mg/kg [3.2 mg/lb], IV, q 12 h) was initiated. Each dose of oxytetracycline was diluted in 1 L of saline solution for administration. The dosage of phenylbutazone was decreased to 2.2 mg/kg (1 mg/lb), PO, every 12 hours. Swelling of the antebrachium initially decreased, but within 24 hours, the antebrachium was more swollen than 12 hours prior to initiation of oxytetracycline treatment. The lameness persisted, and a decubital ulcer developed over the left tuber coxae.

On postoperative day 9, treatment with oxytetracycline was discontinued, and treatment with vancomycin (6 mg/kg [2.7 mg/lb], IV, q 8 h; each dose was diluted in 1 L of saline solution for administration) and rifampin (5 mg/kg [2.3 mg/lb], PO, q 12 h) was begun. The horse remained afebrile after initiation of vancomycin and rifampin treatment. Swelling of the antebrachium decreased greatly over the ensuing 5 days, and the horse spent more time standing and began to again bear weight on the affected limb.
On postoperative day 17, the horse spent substantial time in left lateral recumbency. On postoperative day 18, radiographs of the elbow were obtained. The fracture fragments and implants had not apparently moved; however, there was osteolysis at the fracture site and around 1 screw (Fig 3). Ultrasonography of the antebrachium was performed and demonstrated fluid pockets on the proximomedial aspect of the radius and ulna and at the distal end of the bone plate. Skin over these areas was clipped, aseptically prepared, and infiltrated with 10 ml of 2% mepivacaine solution. Fine-needle aspirates were obtained from each fluid pocket, and fluid was submitted for bacterial culture and susceptibility testing, which yielded a pure culture of methicillin-resistant \textit{S} \textit{epidermidis} with an antimicrobial susceptibility profile similar to that of the previous isolate.

At that time, a decision was made to drain fluid from the surgical site. A 4-cm longitudinal incision was made over the proximolateral aspect of the ulna and was extended to establish a connection with the medial fluid pocket. A 3-cm incision was made that communicated with the fluid pocket at the distal end of the bone plate. Fluid was drained from both incisions, and each pocket was lavaged with 1 L of sterile saline solution. Vancomycin-impregnated \textit{polymethyl methacrylate} (PMMA) beads were created by mixing 1 g of powdered vancomycin in 40 g of PMMA and hand-rolling beads. The beads were placed in the 2 incisions, and a sterile bandage was applied to the limb. Gentamicin (6 mg/kg [2.7 mg/lb], IV, q 24 h) was added to the antimicrobial treatment regimen. The bandage was changed.
and the horse was discharged to its owners on postoperative day 30. The owners were instructed to monitor the limb for increases in swelling or lameness, to monitor the horse’s rectal temperature daily for the next 14 days, and to return the horse in 4 to 6 weeks for follow-up radiography and reassessment. All together, the horse was treated with vancomycin and rifampin for 17 days. Adverse effects were not detected. Serum biochemical analyses were performed every 4 to 5 days during this period, and no clinically important abnormalities were detected.

The horse returned to the clinic 10 days after discharge. The proximal wound had dehisced, and the owners reported that there had been an appreciable increase in swelling in that area during the previous 48 hours and an associated increase in lameness. On radiographs of the elbow, the position of the bone plate and screws appeared unchanged. Osteolysis at the fracture gap was less remarkable, but there appeared to be more osteolysis around 1 screw. Ultrasonographic examination did not reveal any fluid accumulation. Results of a CBC and serum biochemical analyses, including determination of serum electrolyte concentrations, were within reference limits. A bandage was applied to protect the wound, and treatment with phenylbutazone (1.1 mg/kg [0.5 mg/lb], PO, q 12 h) was initiated. Within 12 hours, the lameness had improved dramatically. The wound had healed by second intention, and the horse was bearing complete weight on the limb when it was discharged 14 days after the second admission.

Six months after surgery, the horse was sound at a walk or trot. Bony union was evident on radiographs of the elbow, but 1 bone screw had backed out approximately 5 mm (Fig 4). In addition, there was bony proliferation along the proximolateral aspect of the ulna and distolateral aspect of the humerus that was suspected to be a result of dystrophic mineralization of the previously traumatized collateral ligament.

To our knowledge, successful repair of a Monteggia fracture in a horse has been reported only once previously, suggesting that this type of fracture is rare in horses.

Although the pathophysiology of this type of fracture in animals is unknown, it has been proposed that it results from trauma to the caudal aspect of the antebrachium while the limb is fully extended in a weight-bearing position. The horse described in the present report was found by its owners with its right forelimb caught under a tubular steel gate, and it is possible that the horse’s attempts to rise with the limb under the gate caused this unique type of fracture.

Because the radial head and proximal end of the ulna remained in alignment in this horse, it was apparent that the annular ligament was undamaged. Therefore, the ulnar fracture could be reduced only when the humeroradial joint was reduced. The humeroradial joint could not be reduced manually, and a mechanical distractor had to be used. In the previous report of successful repair of a Monteggia fracture in a horse, neuromuscular blocking agents had to be administered, and a second incision allowing direct manipulation of the radius had to be made before the humeroradial joint could be reduced.

Figure 4—Lateromedial radiographic view of the elbow joint of the horse in Figure 1, obtained 7 months after surgery. One bone screw has backed out approximately 5 mm (white arrow). Osteolysis is no longer evident around the bone screw or at the fracture gap.
In the horse described in the present report, the ulnar fracture was stabilized with a bone plate and 3.5- mm cortical bone screws. Range of motion of the elbow joint was assessed during surgery by flexing and extending the joint. Because of concerns about trauma to the collateral ligaments of the elbow joint, lateromedial stability of the joint was assessed during surgery. There was no clinical evidence of lateromedial instability after fracture repair, and it was decided that even if the collateral ligaments had been damaged, the interdigitation of the 3 bones of the elbow joint would provide sufficient stability. Therefore, no attempts were made to directly examine the collateral ligaments.

Infection of the surgical site will reportedly develop in between 13 and 53% of horses undergoing surgical repair of olecranon fractures, and infection is a common complication of open reduction and internal fixation in horses. Clinical signs associated with postoperative infection include lameness with localized swelling and inflammation, fever, and leukocytosis. All of these signs were evident in the horse described in the present report. However, radiographic signs of osteomyelitis were not evident until 18 days after surgery. On postoperative day 4, ultrasonography identified a fluid pocket in the proximomedial aspect of the antebrachium, and bacterial culture of fluid from this pocket yielded a pure growth of methicillin-resistant *S. epidermidis*. To our knowledge, this is the first report of methicillin-resistant *S. epidermidis* infection in a horse.

Methicillin-resistant *Staphylococcus aureus* is a common nosocomial pathogen in human surgical patients and has recently been isolated from equine surgical patients as well. The incidence of infection with methicillin-resistant staphylococci in humans appears to be increasing, and this is causing concern for 2 major reasons. First, infection with methicillin-resistant staphylococci is becoming the most common cause of infection associated with surgical implants. Second, methicillin-resistant staphylococci are becoming resistant to an increasing number of antimicrobials. The mechanism by which methicillin-resistant staphylococci develop antimicrobial resistance is not completely understood, but many investigators believe that the biofilm produced by these bacteria has an important role.

The epidemiology of methicillin-resistant staphylococcal infections in horses is not known. Methicillin-resistant staphylococci are a part of the resident bacterial microflora on human skin and are believed to be an opportunistic pathogen in humans. It is unclear whether methicillin-resistant staphylococci that cause infections in horses are derived from humans or are a part of the resident microflora of equine skin. In 1 study, molecular typing by means of pulsed-field gel electrophoresis of methicillin-resistant *S. aureus* isolates from horses and humans demonstrated that the isolates were different. However, in another study, isolates from horses with methicillin-resistant *S. aureus* surgical site infections were closely related to isolates from veterinarians treating those horses. For the horse described in the present report, barrier precautions (wearing of gloves, gowns, and foot gear) were implemented to protect the horse and its human handlers. Until the pathogenesis of methicillin-resistant staphylococcal infections can be determined, we recommend use of barrier precautions for affected horses.

Preliminary results of bacterial culture of a sample of fluid from the horse described in the present report suggested that the organism was a methicillin-resistant staphylococcus, and treatment with enrofloxacin was initiated. Enrofloxacin was chosen on the basis of antimicrobial susceptibility profiles for methicillin-resistant staphylococci previously isolated from patients in the veterinary teaching hospital. Unfortunately, final bacterial culture results indicated that the organism was resistant to enrofloxacin, and antimicrobial treatment was changed to oxitetracycline. Surprisingly, the horse did not respond to this treatment, even though the organism was susceptible to oxitetracycline in vitro. A recent report suggests that for staphylococci, in vitro susceptibility to tetracyclines may not be representative of in vivo efficacy. We did consider treating this horse with erythromycin but elected not to because of concerns about adverse gastrointestinal effects. We also considered treating the horse with chloramphenicol; however, the teaching hospital has a policy to not use chloramphenicol unless absolutely necessary because of the potential for blood dyscrasias in humans who come in contact with the drug.

Vancomycin is a bacterioidal glycopeptide antimicrobial that has activity primarily against gram-positive bacteria. Vancomycin works by inhibiting cell wall synthesis by binding with high affinity to cell wall precursors of susceptible bacteria. Use of vancomycin in animals is controversial because of the emergence of resistant organisms in human medicine, and vancomycin should be used in animals only if there are no other treatment alternatives and in vitro susceptibility testing of the causative organism suggests that vancomycin will be effective. Vancomycin and rifampin were selected to treat the surgical site infection in the horse described in the present report on the basis of results of in vitro susceptibility testing. The pharmacokinetics and pharmacodynamics of vancomycin in horses have not been completely determined. Therefore, the dosage used was selected on the basis of clinical experience of others. Rifampin was added to the treatment regimen because of its synergistic properties in treating methicillin-resistant staphylococcal infections.

Originally, we attempted to manage the surgical site infection in this horse in a closed manner. However, only partial clinical improvement was obtained, and radiography demonstrated continued lysis around 1 bone screw. Therefore, the fluid pockets were surgically drained, and the wounds were allowed to heal by second intention. Gentamicin was added to the treatment regimen at that time to obtain broad-spectrum antimicrobial coverage and because gentamicin has been reported to be synergistic with vancomycin.

Local antimicrobial treatment, consisting of implantation of vancomycin-impregnated PMMA beads, was also performed in an attempt to increase the
concentration of antimicrobials in the local environment and decrease adverse systemic effects. 

Vancomycin has been documented to elute from Vancomycin-impregnated PMMA beads had on resolution of the surgical site infection. 

References