A 2-week-old 61-kg (134 lb) Morgan filly was examined because of right forelimb lameness of 5 days' duration and bilateral carpal valgus deformities. The owner thought the filly had injured itself while out on pasture with the mare. The owner noticed that the foal had a bilateral nasal discharge the same day that she first noticed the lameness. Parturition of the foal was reportedly normal and on time.

On initial examination, the foal had a grade 1 to 2 of 5 right forelimb lameness at a walk and mild to moderate bilateral carpal valgus deformities. The foal also had bilateral serous nasal discharge, although the respiratory rate was normal, and results of auscultation of the heart and lung fields were unremarkable. Palpation of the umbilicus revealed no abnormalities. Rectal temperature was mildly elevated at 39°C (102.2°F).

Four radiographic projections of the right forelimb centered on the carpus were obtained, and an approximately 1-cm-diameter round region of bone lysis centered on the distal radial physis on the craniocaudal view and slightly palmar to the center of the bone on the lateral view was seen (Fig 1). This lesion appeared to originate from the physis and had eroded into the ossification zones of the metaphysis and epiphysis. Both forelimbs had a valgus deformity of 13°, which was considered unrelated to the physeal lesion.

A venous blood sample was obtained, and a CBC was performed. The WBC count was slightly high (12.7 X 10^9/L; reference range, 6.0 to 12.0 X 10^9/L), and the plasma fibrinogen concentration was 500 mg/dL (reference range, 100 to 400 mg/dL). The foal's IgG concentration was low (< 400 mg/dL; reference range, 800 to 1,000 mg/dL). "

A diagnosis of septic physitis of the distal radial physis (P-type osteomyelitis) was made on the basis of the clinical and radiographic findings. The high WBC count and fibrinogen concentration supported the diagnosis.

The foal was anesthetized and placed in left lateral recumbency; a single dose of potassium penicillin (22,000 U/kg [10,000 U/lb], IV) was administered prior to anesthesia. An Esmarch bandage was tightly wrapped from the coronary band of the right forelimb to mid metacarpus. A second Esmarch bandage was loosely wrapped over the carpus and distal portion of the radius and tightly wrapped to the mid radius. A pneumatic tourniquet was also placed over the mid radius. The second Esmarch bandage was then removed from the carpal region, and the surgical field...
was prepared for aseptic surgery. A sample of blood-tinted material was collected by means of needle aspiration from the physeal lesion and submitted for aerobic and anaerobic bacterial culture and susceptibility testing. A synovial fluid sample collected from the radiocarpal joint appeared grossly normal but was also submitted for aerobic and anaerobic bacterial culture. No bacteria were isolated from either sample.

A 1-cm incision was made over the dorsolateral aspect of the proximal right third metacarpal bone, and a 3.2-mm hole was drilled. The hole was tapped with a 4.5-mm tap, and a custom-made 4.5-mm cannulated screw to which a quarter-inch square bolt head and Luer attachment had been welded (Fig 2) was inserted in the cortical hole and tightened with a wrench. Five hundred milligrams of amikacin diluted in 25 mL of saline (0.9% NaCl) solution was injected, followed by 1 million units of penicillin G potassium diluted in 12 mL of saline solution. The antimicrobials were injected with several 1-mL syringes, which were refilled as necessary until all the perfusate was injected. The tourniquet and cannulated screw were removed after 1 hour. The skin was closed with a single simple interrupted suture, and a sterile bandage was applied. Intraosseous regional perfusion was repeated 3 and 8 days later using the same technique, except that the foal was sedated with xylazine (0.8 mg/kg [0.37 mg/lb], IV) and butorphanol (0.016 mg/kg [0.007 mg/lb], IV) rather than being anesthetized. The same cortical hole was used for all 3 perfusions.

The foal was treated with procaine penicillin G (22,000 U/kg, IM, q 12 h) and amikacin (8 mg/kg [3.6 mg/lb], IV, q 24 h) for 8 days, and then was treated with trimethoprim-sulfamethoxazole (30 mg/kg [13.6 mg/lb], PO, q 12 h) for an additional 14 days. On days 3 and 8 when intraosseous regional perfusion was performed, amikacin was not administered systemically.

On radiographs obtained 10 days after the initial perfusion, the lesion appeared static with no additional extension into adjacent bony tissues. The foal was discharged that day with instructions that it be confined to a stall until reexamined 3 weeks later. At the time of reexamination, the foal was no longer lame, and the bilateral valgus deformities had resolved. Radiography revealed increased mineralization and a reduction in the relative size of the lytic lesion in the physis. The relative reduction in size of the lesion was attributed to bone growth. Soft tissue overlying the site of intraosseous perfusion was noticeably thickened. Radiographically, the proximal metaphyseal region of the third metacarpal bone had an increase in opacity, and this region had a mottled appearance with loss of the normal trabecular pattern, suggesting a response to the perfusion procedures.

The foal was sound during a subsequent evaluation 3 months later, and the site of the physeal lesion was barely visible as a subtle radiolucency, compared with surrounding bone (Fig 3).

In foals, septic physitis is a result of hematogenous spread of bacteria from another site to the growth plate. The metaphyseal vascular loops and sinusoidal veins in the growth plate are areas of low blood flow and low oxygen tension, making them susceptible to infection.1-3 The foal described in the present report had signs of a respiratory tract infection, which might have been the source of bacteria. The low IgG concentration might have been indicative of partial failure of passive transfer at the time of birth, which could have...
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lactam antimicrobials. Whether this will adversely affect antimicrobials used in combination with some concentrations can remain higher than the minimum concentrations are low within 4 to 8 hours. However, tissue clearance of the antimicrobials is delayed, allowing time for inactivation to occur. In renal impairment, in whom clearance of the antimicrobials is typically eliminated quickly enough that there is no septicemia in foals undergoing intravenous regional perfusion. If an antimicrobial is administered systemically before regional perfusion, selection of one with a gram-negative spectrum may be more effective; however, no septicemic complications occurred in this foal. With septic physis, bacterial colonization of the physis is followed by an acute inflammatory reaction with subsequent ischemia and bone necrosis. Once ischemic necrosis has occurred, systemic administration of antimicrobials usually does not result in sufficiently high concentrations in infected tissue and, therefore, is often not effective in resolving the infection. Regional perfusion may allow antimicrobials to reach the ischemic area by diffusion from surrounding vascular tissue, resulting in higher concentrations of the antimicrobials.

We elected to use amikacin for intraosseous regional perfusion in this foal, because amikacin has a broad spectrum of activity against gram-negative bacteria. Amikacin was also a good choice because bacterial killing with aminoglycoside antimicrobials is dependent on concentration, and high concentrations can be achieved in affected tissues with regional perfusion. We elected to combine amikacin with penicillin to obtain as broad a spectrum of coverage as possible. Although bacterial killing with β-lactam antimicrobials such as penicillin is dependent on time, the use of penicillin in intraosseous regional perfusion can be justified, because this technique is likely to result in therapeutically effective concentrations of the antimicrobial in infected ischemic bone for a longer time than is possible with systemic administration.

Aminoglycoside antimicrobials can be inactivated in vitro by some β-lactam antimicrobials. This is usually not a problem in vivo, because both antimicrobials are typically eliminated quickly enough that there is not sufficient time for inactivation to occur. In human medicine, for instance, such inactivation is considered clinically relevant only in patients with renal impairment, in whom clearance of the antimicrobials is delayed, allowing time for inactivation to occur. After regional perfusion, serum antimicrobial concentrations are low within 4 to 8 hours. However, tissue concentrations can remain higher than the minimum inhibitory concentration for 24 hours, which is a sufficient time for inactivation of some aminoglycoside antimicrobials used in combination with some β-lactam antimicrobials. Whether this will adversely affect the efficacy of regional perfusion is unknown; however, it is likely that the greatest benefits of regional perfusion occur before this time. In addition, inactivation is dependent on time, temperature, and concentration of the β-lactam antimicrobial and varies with the combination of antimicrobials used. In a previous study, the combination of amikacin and penicillin resulted in no loss of amikacin activity in vitro after 24 hours at room temperature. In general, regional perfusion should be performed with a single antimicrobial, ideally one selected on the basis of results of bacterial culture and susceptibility testing, and the possible inactivation of aminoglycoside antimicrobials in tissues should be considered when combining antimicrobials.

Intraosseous regional perfusion with antimicrobials has been used successfully to treat osteomyelitis associated with orthopedic implants in horses, and we used a similar technique for regional perfusion in the foal described in the present report. This method of local antimicrobial treatment was first described for use in intraosseous or intravenous regional perfusion with antimicrobials, compared with only 35% of animals treated with antimicrobials systemically. In 1 study of 15 people with chronic osteomyelitis of 2 months’ to 38 years’ duration treated with intraosseous regional perfusion, all but 1 had a cessation of drainage, a reduction in swelling, and a decrease in local and systemic temperature after 1 week of twice daily perfusion. The number of regional perfusion episodes needed to resolve infection is not known. In 1 study of 20 human patients with chronic osteomyelitis who underwent a total of 33 regional perfusion episodes, 10 had complete and long-lasting healing without surgical débridement or systemic antimicrobial treatment, 2 had a reduction in drainage and pain, and 2 in whom perfusion was performed in conjunction with surgical débridement or subsequent systemic antimicrobial treatment had a resolution of infection. These patients initially received a single perfusion, and perfusion was repeated weeks or months later if the infection did not resolve following the initial perfusion.

Treatment regimens reported for horses are similar, with each horse receiving either a single perfusion or up to 3 or 4 perfusions on the basis of clinical evidence of improvement in conjunction with systemic antimicrobial administration and, often, débridement of infected material or lavage. In the foal described in the present report, we chose to perform 3 perfusions in conjunction with systemic antimicrobial administration. The most appropriate treatment protocol remains to be determined; however, a single perfusion is not sufficient to resolve infection in every animal, and the efficacy of perfusion is likely to depend on a number of factors other than the number of treatments, such as the lesion being treated, the ability to debride infected tissue, the susceptibility pattern of the organism, the...
mechanism of action of the antimicrobial used, the chronicity and extent of the infection, the dose and concentration of the antimicrobial, and, possibly, the technique used for perfusion.

Both intraosseous and intravenous regional perfusion have been described, and both have been successful in treating osteomyelitis and other infections of the extremities in people and animals. In this case, we chose to use intraosseous regional perfusion of the third metacarpal bone. The radius was not used as the perfusion site because it is generally thought that a site distal to the lesion is preferable, and a perfusion site in the radius would have been near the proximal tourniquet, possibly making leakage of the perfusate under the tourniquet more likely. Intraosseous regional perfusion into the long bone distal to the site of infection results in perfusion of at least the distal region of the more proximal long bone. As demonstrated by high-pressure perfusion of radiopaque material into the medullary cavity of the tibia in rabbits with a tourniquet applied in the midfemur, perfusion first resulted in dilatation of vessels around the femoral joint, and continued injection resulted in reversal of flow into the central venous system of the femur. In rabbits with osteomyelitis of the distal portion of the femur, the radiopaque material diffused into the infected area. In horses, injection of contrast material into the medullary cavity of the third metacarpal bone, following application of Esmarch bandages distal to the perfusion site and proximal to the carpus, resulted in contrast material leaving the medullary cavity through the small epiphyseal veins and entering the synovial venous system of the carpus. Contrast material also entered the carpal bones and the distal portion of the radius, indicating that injection into the medullary cavity of the third metacarpal bone can result in perfusion of the distal portion of the radius. To our knowledge, there are no studies demonstrating the intraosseous venous pathways following perfusion into the radius, although it is likely that high concentrations of antimicrobials would reach the distal portion of the radius with this technique as well.

Intraosseous regional perfusion was chosen in this foal because repeated catheterization of the veins for IV antimicrobial administration can be difficult to perform, and it remains to be determined whether antimicrobial concentrations in bone are as high following intravenous regional perfusion as they are following intraosseous regional perfusion. Higher pressure may be generated when intraosseous regional perfusion is performed, resulting in reversal of blood flow into the medullary cavity vasculature followed by diffusion into the surrounding tissue. Multiple 1-mL syringes were used for perfusion in the foal described in the present report, rather than larger ones, to generate the highest pressure possible during injection. With higher injection pressures, diffusion of the antimicrobial into surrounding healthy tissue may also be increased. Antimicrobials reach necrotic tissue by diffusion from the surrounding healthy tissues, which serve as a depot even after the perfusion is completed.

The cannulated screw used for intraosseous regional limb perfusion in this foal was custom made by drilling a lumen in a 4.5-mm cortical bone screw and welding a quarter-inch square bolt head and Luer attachment to the screw head. A self-tapping cannulated screw with a Luer attachment is commercially available and can be used for regional perfusion. However, because equine bone may be too dense for this screw to self-tap without risk of breaking the screw, the hole should be drilled and tapped before placing the screw. Another option for intraosseous regional perfusion includes direct placement of the male adapter of an intravenous extension set into a 4-mm drill hole. This technique has been shown to be effective in attaining high concentrations of antimicrobials in joints and soft tissue.

Radiographic changes in the trabecular pattern of the bone proximal to the injection site may be the result of the application of pressure during intraosseous regional perfusion or might be an effect of the drug administered. The cause of this alteration has not been determined, and no adverse clinical consequences were associated with this finding.

Debridement of necrotic and infected bone is a commonly recommended treatment protocol for septic physisis. Complete debridement of infected tissue in conjunction with systemic antimicrobial treatment would be expected to be effective in resolving the infection, but septic physitis lesions are often in the center of the growth plate, making them relatively inaccessible. In addition, debridement likely would result in extensive damage to the growth plate and adjacent bone, increasing the risk of a fracture into the adjacent joint and angular limb deformity. Intraosseous regional perfusion is a technique that can potentially eliminate infection without debridement of infected bone.

In this foal, intraosseous regional perfusion was easy to perform, did not require advanced surgical skills, and was not prohibitively expensive. Intraosseous regional perfusion in conjunction with systemic antimicrobial treatment, but without surgical debridement of the lesion, resulted in fairly rapid and uncomplicated resolution of the septic physitis in this foal. Because of the prognosis generally associated with this condition, we chose to provide systemic antimicrobial treatment in addition to performing regional perfusion in this foal, and this may have played a substantial role in resolution of the infection. Regional perfusion without systemic antimicrobial administration might be an effective method of treatment for some foals with septic physitis; however, as with many aspects of regional perfusion, further studies are needed to determine whether this is true. Further studies are also needed to determine optimal drug dose, treatment interval, number of perfusions, and duration of systemic antimicrobial treatment.

References


5SUR-FAST intraosseous infusion needle, Cook Veterinary Products, Bloomington, Ind.