How to Perform Equine Intravenous Digital Perfusion

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Sepsis of the distal limb of the horse carries a poor prognosis for return to function. The eradication of infection before irreversible damage to critical structures occurs will help return horses to athletic function, and it will also increase their survival rate. An intravenous digital perfusion technique for the eradication of naturally occurring digital sepsis in the horse is described.

1. Introduction

The distal limb of the horse and its synovial structures (digital tendon sheath, metacarpal or metatarsal–phalangeal joint, proximal and distal interphalangeal joints, and navicular bursa) are commonly affected by sepsis. Causes of synovial infection include bacterial introduction by the vasculature, traumatic wounds, surgery, and intra-articular injection. The prognosis for return to function is poor for infections of the distal interphalangeal joint and navicular bursa, and mortality rates can reach 40–50%, in spite of appropriate surgical and medical therapies. The major reason for treatment failure is the delay from the onset of infection to its eradication. The eradication of infection before irreversible damage to critical structures occurs will help return horses to athletic function and increase the survival rate.

The systemic administration of antimicrobials is essential in the treatment of synovial sepsis, and a combination of an aminoglycoside and a beta-lactam antibiotic is the most commonly recommended therapy. However, very little is known about the pharmacokinetics of the tissues of the equine distal limb. The bactericidal effect of aminoglycoside antibiotics is concentration dependent, and bacterial kill is proportional to the initial peak concentration of aminoglycoside attained. Amikacin and gentamicin are the most commonly used drugs for the treatment of equine gram-negative infections, and amikacin is the aminoglycoside that shows the greatest efficacy against equine orthopedic pathogens. Therapy that rapidly achieves high levels of aminoglycoside in infected synovial structures of the horse should promote the rapid elimination of bacteria and decrease damage to these structures.

The regional perfusion of antibiotics to achieve high local concentrations of antibiotic into the extremities of several species, including the horse, has been described. Regional perfusion delivers antibiotics into the venous system either by intraosseous or intravenous infusion. The antibiotic is
confined to the infected area by a tourniquet placed in a proximal position to the infected tissue. The perfusate distends the venous vasculature, allowing the perfusate to enter the healthy tissues. The perfusate then enters ischemic tissue and exudate by diffusion. The treatment of both experimental and clinical infections with regional perfusion suggests that this method is beneficial in the treatment of orthopedic sepsis. An intravenous digital perfusion (IDP) technique that does not use special equipment and can be performed easily has been described. Intravenous digital perfusion delivers a small dose of aminoglycoside diluted in saline through a catheter inserted in the digital vein. Experimental studies using 125 mg of amikacin in equine digital perfusions resulted in mean peak synovial fluid concentrations of drug 25–50 times the minimum inhibitory concentration. In adult horses after perfusion, but they have occurred in foals, particularly those with large affected areas, or multiple sites, of sepsis. In foals, intravascular perfusion to treat septic conditions of the hocks has been associated with secondary septic foci. Therefore, one author (EMS) does not routinely perfuse neonates and reserves perfusion for septic processes that do not respond to conventional therapy. Systemic antimicrobials should be administered before IDP in foals.

2. Methods
Intravenous digital perfusion is performed with the horse under general anesthesia and positioned in lateral recumbency after primary treatment has been performed. Primary treatments include joint flushes, debridement of infected bone, and drainage procedures. The skin over the lateral or medial palmar–plantar vein at the level of the proximal sesamoid bones is surgically prepared. For adult horses, a 20 gauge, 1-in. (2.54 cm) over-the-needle catheter attached to a heparinized extension set is introduced into the vein proximally to distally. The catheter and extension set are glued to the skin by using Super Glue and then taped in place. A 22-gauge catheter is used in foals. In horses with thickened skin, an 18-gauge catheter threads more easily. One-inch catheters are less likely to exit the vein distally. Cut-down procedures can be used in horses in which it is difficult to access the vein percutaneously. An Esmarch bandage is applied distally to proximally to remove blood from the superficial vasculature. The Esmarch ends at a pneumatic tourniquet in the midmetacarpal–metatarsal region. The tourniquet is inflated, and the Esmarch is removed. The digit is perfused in adult horses with 60 ml of a balanced electrolyte solution containing 125–250 mg of amikacin or 100–300 mg of gentamicin; young foal digits are perfused with 10–12 ml of balanced electrolyte solution containing 50 mg of amikacin or gentamicin. An injection of the perfusate is performed by hand over 1 min, and the extension set is then occluded. After 30 min the tourniquet and catheter are removed.

Proper tourniquet placement is the most important aspect of a successful perfusion to avoid loss of antibiotics into the systemic circulation. Multiple attempts at catheterization should also be avoided to prevent subcutaneous leakage of perfusate from the venipuncture sites. Only one drug should be used in a perfusion, and the drug should be water soluble; we have only used gentamicin, amikacin, and penicillin. There are no data on the optimal dose of drug to be used in an intravascular perfusion. However, very small doses (125 mg) achieve very high synovial fluid concentrations. Anecdotally, cellulitis and soft-tissue sloughing have been reported in limbs perfused with larger (>1 g) doses of antibiotics.

In humans, it is thought to be important that the patients are treated with systemic antibiotics before intravascular perfusion, as fever and other clinical signs consistent with septicemia have been documented. Signs of septicemia have not been seen in adult horses after perfusion, but they have occurred in foals, particularly those with large affected areas, or multiple sites, of sepsis. In foals, intravascular perfusion to treat septic conditions of the hocks has been associated with secondary septic foci. Therefore, one author (EMS) does not routinely perfuse neonates and reserves perfusion for septic processes that do not respond to conventional therapy. Systemic antimicrobials should be administered before IDP in foals.

3. Results and Discussion
Septic equine digital conditions that have responded to adjunctive therapy with IDP include laminitis; navicular bursitis or navicular osteomyelitis; arthritis of the fetlock, pastern, and coffin joints; ostitis of the third phalanx; physitis of the first and second phalanx and third metacarpus or metatarsus; tenosynovitis; and sesamoid ostitis (Table 1). We have used IDP in over 50 cases of digital sepsis and include results on 29 representative cases.

Our overall survival rate in horses in which IDP was used is 86%, with many horses returning to riding soundness. Several horses with a long-standing infection of critical structures were salvaged. The average duration of infection in the four horses euthanized was 22 days. Two were euthanized for reasons that were not directly due to the digital sepsis (pneumonia and frostbite), and a third was presented with severe contralateral laminitis. One horse with a 2-week history of septic sesamoid osteomyelitis was euthanized because of a failure to eliminate the infection. From the results of our clinical cases and examination of dye-perfused digits, IDP is best suited in adult horses for the treatment of sepsis of the third phalanx, navicular bone and bursa, laminae, joints, and tendon sheaths. It is our impression that cortical bone of adult horses is not well perfused by IDP. For foals, however, IDP is a valuable adjunctive treatment of all digital septic conditions.

It is important to emphasize that IDP is an adjunctive therapy, meant to speed the resolution of sepsis to limit damage to critical structures, and is not meant to replace appropriate surgical and medical therapies. The successful treatment of equine orthopedic sepsis requires many weapons. For example, an 85% survival rate is reported in horses...
with septic arthritis, but it requires, in addition to systemic antibiotics, many adjunctive therapies including joint lavage (80% of horses treated), intra-articular antibiotics (19%), arthrotomy (26%), and the placement of intra-articular drains (34%). Intra-venous digital perfusion is another clinical weapon in the treatment of digital sepsis.

The poor treatment response of many septic conditions of the equine foot warrants the development of additional therapies that are economical and practical. IDP is a powerful adjunctive therapy in the treatment of septic digital conditions. We believe IDP is effective because higher concentrations of antibiotics increase bacterial killing in poorly perfused tissues. It is our impression that IDP both accelerated the elimination of infection and eliminated infection that would have been resistant to conventional therapy. The former will return horses to performance, and the latter will salvage horses that may not have responded to conventional therapy. One disadvantage to this technique is the need for general anesthesia. In horses that require surgical treatment of the septic condition, the disadvantage is limited to additional anesthetic time to allow for the perfusion. Intravascular perfusion can be performed in the standing horse under sedation, but the effect of weight bearing on the concentration of drug achieved is unknown.

4. Conclusions
The technique of IDP requires no specialized training or equipment. We have not identified any complications associated with IDP. Many questions remain about the appropriate dose of antibiotic, best perfusion volume and duration, the ideal number of perfusions, and the appropriate interval between perfusions for horses with septic conditions of the distal aspect of the limb. However, the present study has demonstrated that retrograde intravenous

<table>
<thead>
<tr>
<th>Condition</th>
<th>No. of Cases</th>
<th>Age</th>
<th>Duration</th>
<th>Fore Hind</th>
<th>Additional Treatments</th>
<th>No. of IDP’s</th>
<th>Sepsis Resolved</th>
<th>Long-term Outcome</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septic laminitis</td>
<td>1</td>
<td>16 y</td>
<td>3 w</td>
<td>1</td>
<td>50% hoof-wall resection; shoeing</td>
<td>1</td>
<td>1/1</td>
<td>Riding</td>
<td></td>
</tr>
<tr>
<td>Septic osteitis, third phalanx</td>
<td>2</td>
<td>4 m</td>
<td>20 d</td>
<td>2</td>
<td>Debridement of infection; drainage</td>
<td>1</td>
<td>2/2</td>
<td>1 juvenile; 1 salvaged</td>
<td></td>
</tr>
<tr>
<td>Septic coffin joint</td>
<td>2</td>
<td>30 d</td>
<td>1 w</td>
<td>1</td>
<td>1 joint flush; 1 joint flush + cast (also P3 osteitis)</td>
<td>2/2</td>
<td>2 juvenile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navicular bone-bursa sepsis</td>
<td>3</td>
<td>22 y</td>
<td>60 d</td>
<td>3</td>
<td>2 street nail + cast; 1 street nail + shoe</td>
<td>1</td>
<td>3/3</td>
<td>1 light riding; 1 salvaged; 1 LTFU (shortest duration)</td>
<td>Longest duration horses both ruptured DDF</td>
</tr>
<tr>
<td>Septic tenosynovitis</td>
<td>6</td>
<td>2-18 y</td>
<td>6-60 d</td>
<td>4</td>
<td>6 drain and flush tendon sheath; 3 annular lig. desmot.</td>
<td>1-2</td>
<td>5/6</td>
<td>5 riding; 1 euthanized</td>
<td>Euth horse: severe laminitis at admission</td>
</tr>
<tr>
<td>Septic physisitis (multiple)</td>
<td>2</td>
<td>10 d</td>
<td>7 d</td>
<td>1</td>
<td>Bandage Quadrilateral casts</td>
<td>3</td>
<td>1/2</td>
<td>Salvage (varus support limb) Tendon laxity Euth (pneumonia)</td>
<td>4 physis (1 limb)</td>
</tr>
<tr>
<td>Septic fetlock joint</td>
<td>3</td>
<td>3-7 y</td>
<td>1 w-3 m</td>
<td>2</td>
<td>1 FA; 1 cast for large wound; all flushed</td>
<td>1-2</td>
<td>3/3</td>
<td>FA salvaged; 2 riding</td>
<td></td>
</tr>
<tr>
<td>Proximal sesamoid osteitis</td>
<td>2</td>
<td>3 m</td>
<td>1 w</td>
<td>2</td>
<td>Foal perfused and joint flushed; other debrided + cast</td>
<td>1</td>
<td>1/2</td>
<td>1 juvenile; 1 euthanized</td>
<td></td>
</tr>
<tr>
<td>Severe foot wounds</td>
<td>8</td>
<td>5 m-20 y</td>
<td>1 d-9 m</td>
<td>4</td>
<td>All debrided; coffin joint flushed if involved</td>
<td>1</td>
<td>7/8</td>
<td>5 riding; 2 salvaged; 1 euth from digital frostbite</td>
<td></td>
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</tbody>
</table>

*aAll horses were perfused with amikacin or gentamicin. All also received systemic antimicrobials.
*bAbbreviations are as follows: y, year; m, month; d, day; and w, week.
*cAbbreviations are as follows: P3, third phalanx; FA, facilitated arthrodesis; LTFU, lost to follow-up; DDF, deep digital flexor tendon; and euth, euthanized.*
regional perfusion of the equine digit is a useful adjunctive treatment of septic digital conditions.

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References and Footnotes


j) Jelco IV catheter, Teflon, Johnson & Johnson Medical, Arlington, TX 76004.
k) Extension set, Baxter Healthcare Corp., Deerfield, IL 60015.
l) Plasmalyte, Baxter Healthcare Corp., Deerfield, IL 60015.