Equine Wounds over Synovial Structures

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KEYWORDS

• Equine • Wound • Synovial • Septic arthritis • Synovitis

KEY POINTS

- Septic synovitis commonly occurs secondary to traumatic wounds that are adjacent to, or communicate with, a synovial structure. Synovial sepsis can be debilitating due to the resulting degenerative changes.
- Treatment goals include rapid resolution of infection, reduction of inflammation, pain management, and the restoration of normal synovial physiologic functions.
- Synovial fluid collection and analysis is the most important diagnostic tool to confirm synovial sepsis.
- A combination of systemic, regional, and/or intrasynovial antibiotics; joint lavage; wound debridement; and analgesic and antiinflammatory medications are often necessary for the treatment of wounds that involve synovial structures.
- Timely diagnosis and treatment of wounds involving synovial structures is critical for obtaining a successful outcome in affected horses.

In adult horses, septic synovitis most commonly occurs secondary to traumatic wounds that are adjacent to, or communicate with, a synovial structure.[1,2] Organic material or bacteria introduced through a wound into a synovial structure can result in inflammation and infection, disrupted homeostasis, and metabolic changes, and these abnormalities can progress to degenerative joint disease, tenosynovitis, or bursitis.[3,4] Synovial sepsis can be a debilitating disorder due to difficulties clearing established infections and the degenerative changes that result from ongoing inflammation.[5,6]

The distal limbs of horses have minimal soft tissue protection, thus wounds in these areas are more likely to have involvement of adjacent synovial structures.[3] Within an affected synovial structure, the degrees of the inflammatory and immunologic responses depend on factors such as the horse's age and immune status, presence of preexisting synovial pathology, virulence and concentration of the microorganism introduced, and duration of infection.[7,8]

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Synovial inflammation, fluid changes, fibrin accumulation, organism proliferation, and pain due to established synovial infection require multimodal therapies for successful control and resolution.[2] Prompt diagnosis of a septic synovial structure allows for immediate treatment, improving the prognosis.[9] After treatment of synovial infection, 56% to 81% of horses can return to their original function.[1,10] Goals for successful treatment of infected synovial structures due to wounds include early and accurate recognition of the condition, rapid resolution of pain and inflammation, complete elimination of microorganisms, appropriate healing of the original wound, and a timely return to function.[2,5]

INCIDENCE AND PATHOPHYSIOLOGY OF SYNOVIAL WOUNDS AND INFECTIONS

Hematologic spread or the direct introduction of bacteria or fungi into a synovial structure can result in septic arthritis, tenosynovitis, or bursitis.[11] Penetrating wounds are the most common cause of septic arthritis in adult horses.[1] Synovial structures most commonly affected with infection due to traumatic wounds are the fetlock joint (32.6%), tendon sheaths (21.7%), tarsus (17.4%), coffin joint (13%), navicular bursa (6.5% of synovial structures), carpus (4.3%), stifle joint (2.2%), and pastern joint (2.2%).[1] Contusions or abrasions near synovial structures can result in synovial infection that develops within a few days of injury, because organisms within the infected, surrounding soft tissue can move through the damaged synovium and into the synovial structure.[8] Commensal microorganisms on the horse's skin or within the environment are the bacteria generally involved in synovial infections. *Staphylococcus aureus*, *Pseudomonas spp.*, Enterobacteriaceae, and other staphylococci species are commonly isolated bacteria.[5,12] Other infecting bacteria include *Escherichia coli*, *Salmonella spp.*, *Corynebacterium pseudotuberculosis,* streptococci species, and anaerobic species.[1,11]

The introduction of microorganisms into the synovial membrane or synovial fluid results in an inflammatory reaction, microorganism proliferation and attachment, and the establishment of active infection within the synovial structure.[2,7] Normally, the synovial membrane prevents bacterial proliferation and infection through the phagocytic properties of certain synovial cells and the actions of inflammatory mediators and cytokines produced by synovial cells.[5,7,13] Synovial damage, organism pathogenicity and virulence, and the number of microorganisms inoculated into the synovial structure all contribute to whether the synovial structure's defense mechanisms are overcome and infection is established.[5,7] Within an affected synovial structure, inoculated microorganisms can release extracellular toxins and enzymes, bind to the synovial tissues, and proliferate.[7] The synovium responds to this bacterial colonization by releasing inflammatory mediators, enzymes, and free radicals.[5,7] This can increase vascular permeability, resulting in intrasynovial hemorrhage and extravasation of macrophages, neutrophils, and fibrin into the compartment.[5,11]

Neutrophils kill bacteria by phagocytosis and by releasing enzymes such as oxygen-derived free radicals, cathepsin G, collagenase, elastase, lysozyme, or gelatinase.[7] Free radicals cleave proteoglycans, collagen, and hyaluronic acid, which can lower synovial fluid viscosity, reducing boundary lubrication and biomechanical protection.[7,11,14] Inflammatory mediators activate synoviocytes and chondrocytes, resulting in the production of inflammatory cytokines such as interleukin 1 (IL-1), IL-6, and tumor necrosis factor alpha (TNFα).[11] IL-1 and TNFα increase the production of matrix metalloproteinases (MMP) by activated chondrocytes, synoviocytes, macrophages, fibroblasts, osteoblasts, and endothelial cells.[14,15] The main classes of MMP are stromelysins, gelatinases, and collagenases, which contribute to the breakdown of

proteoglycans, collagens, and elastins.[14,15] In addition, MMP presence can cause cartilage degradation, cartilage fibrillation, and chondrocyte necrosis, perpetuating the intrasynovial inflammatory process.[14] Furthermore, the response to infection leads to synovial effusion, increased intrasynovial pressure, reduced blood flow to the synovium, ischemia of subchondral bone and synovial structures, and pain.[5,7]

The extravasation of fibrin from the synovial membrane results in fibrin deposition and free fibrin within the synovial fluid.[5,7] The presence of fibrin can lead to the formation of pannus, which is an intrasynovial fibrinocellular accumulation of tissue, foreign material, and bacteria.[5,7] Organisms within the pannus can be protected from phagocytic white blood cells and antimicrobial agents in the synovial fluid.[11]

If untreated, sepsis can result in substantial synovial structure and cartilage damage.[2] The destruction and loss of proteoglycan and collagen reduces the biomechanical resistance of cartilage, leading to articular cartilage loss and osteoarthritis.[11,14] The resulting synovial changes can prevent a horse from returning to work and may even be severe enough to necessitate euthanasia.

IDENTIFICATION OF WOUNDS OVER SYNOVIAL STRUCTURES

Clinical Signs

When presented with a horse having a wound over a synovial structure, the veterinarian should obtain a patient history and perform a complete physical examination.[2,4] The history will help determine the duration of infection, possible microorganisms involved, and the horse's tetanus prophylaxis status.[2] Because of increased intrasynovial pressure, hypersensitivity of the synovial membrane, and surrounding soft tissue inflammation, horses with septic synovial structures are often very lame (non–weight-bearing lame, American Association of Equine Practitioners grade 5).[5,16] However, if the affected synovial structure is open and draining or if analgesic medications were recently administered, minimal to no lameness may be present.[4,5] In addition, lameness may be less severe if the injury occurred shortly before evaluation.[4,7]

A careful physical examination should evaluate for evidence of trauma or wounds, such as presence of blood or exudate on the skin.[2] Clipping hair may be required to see small puncture wounds, which can quickly seal and are difficult to identify.[2] Vital parameters can vary, with heart rate and respiratory rate ranging from normal to elevated, depending on the level of pain.[4,5] Perisynovial soft tissue heat and swelling, synovial structure effusion, and sensitivity to palpation and manipulation of the synovial structure are clinical findings associated with synovial infection.[5,7] Affected adult horses usually do not have substantial change to their peripheral blood analysis.[5,7] However, the most common complete blood count abnormalities include an elevated white blood cell count, mild neutrophilia, and mild hyperfibrinogenemia.[4,5,7] Horses with infected synovial structures are not consistently febrile or depressed, and therefore, these clinical findings should not rule synovial sepsis in or out.[3,4,17]

Wound Preparation and Exploration

Before exploring a wound with a suspect open septic synovial structure, proper wound preparation is essential. Typically the edges of the wound should be clipped and debris removed. Placement of sterile, water-based lubricating gel in the bed of a wound before clipping can help prevent further contamination, especially in wounds where primary closure is being considered. The wound should be aseptically cleaned with an antiseptic solution and lavaged with sterile saline. Aggressive wound lavage using high volumes of sterile lavage solutions under pressures up to 15 psi can help decrease bacterial numbers and wound contaminants. This can easily be

accomplished by using a 35-mL syringe and a 19-gauge needle. After thorough cleaning, exploration of a wound using sterile gloves can be performed. If no obvious communications of the wound with a synovial structure can be identified, distention of a joint or tendon sheath may be required to determine if there is communication. Before distention of a synovial structure, collection of synovial fluid for analysis and culture should be attempted. Care should be taken not to advance needles through infected or compromised periarticular tissue during synoviocentesis. The safest possible approach distant from the wound should be used to minimize the possibility of iatrogenic contamination. Once a needle has been placed into the synovial compartment and a sample obtained, sterile saline or lactated Ringer solution should be infused under pressure to determine if any fluid egresses from the wound (**Fig. 1**). If fluid does not exit through the wound, and intrasynovial pressure builds, the synovial structure is not likely involved. The veterinarian may choose to infuse the suspected compartment with an antibiotic before removing the needle.

Diagnostic Imaging

Diagnostic imaging of a suspected area via radiography, ultrasonography, nuclear scintigraphy, computed tomography (CT), or MRI can aid in determining if a wound involves a synovial structure and if sepsis is established.[2] A complete radiographic

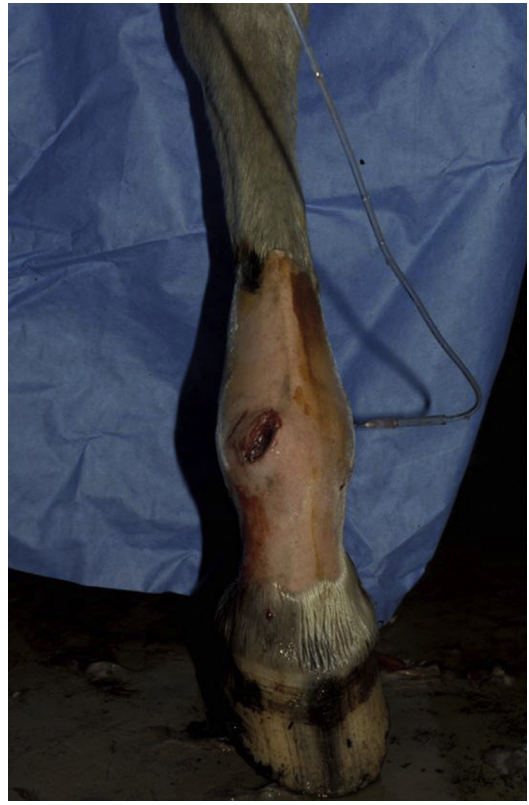

Fig. 1. Sterile saline being infused into fetlock joint to help determine if there is communication with the adjacent wound.

series of an affected joint is warranted for evaluation of bone involvement, such as fractures, physitis, osteomyelitis, osteitis, or osteoarthritis.[5,7] Other than the rare presence of air within a synovial capsule, radiographic signs are most commonly normal in the acute stages after wounding. The presence of bone lysis in association with a septic joint raises the level of concern and will negatively affect prognosis. Contrast radiography, such as fistulograms or the intrasynovial injection of radiographic contrast solution, can be used to determine communication of a wound with a synovial structure or to help reveal cartilage defects (**Fig. 2**).[5,7]

Ultrasonography can be used to evaluate joint, tendon sheath, or bursal effusion, and ultrasound is generally noninvasive.[5,7,18] In addition, ultrasonography can identify inflammation of the synovium, foreign bodies within a synovial compartment or surrounding tissues, and communication between an adjacent wound and a synovial structure.[5,7,18] Ultrasonographic findings in horses affected with synovial sepsis include marked synovial effusion (81% of cases), moderate to severe synovial thickening (69%), presence of intrasynovial fibrin (64%), echogenic synovial fluid (55%), and focal hyperechogenic areas (33%).[18]

Although infrequently used to assess septic synovial structures, nuclear scintigraphy, CT, and MRI can be used to localize infection or inflammation.[2] Although they provide excellent detail of soft tissues and bones, MRI and CT are expensive and may require general anesthesia. These imaging modalities can help determine if lameness is due to chronic synovitis and osteoarthritis, if there is ongoing infection, or if there is a nidus of infection.[19]

Synovial Fluid Collection and Analysis

Synovial fluid collection and analysis is the most important diagnostic tool to confirm synovial sepsis.[2,4] By providing information regarding the severity of inflammation within the synovial structure, synovial fluid analysis helps to distinguish between septic synovitis, nonseptic synovitis, and normal structures.[17,20] The large amount of

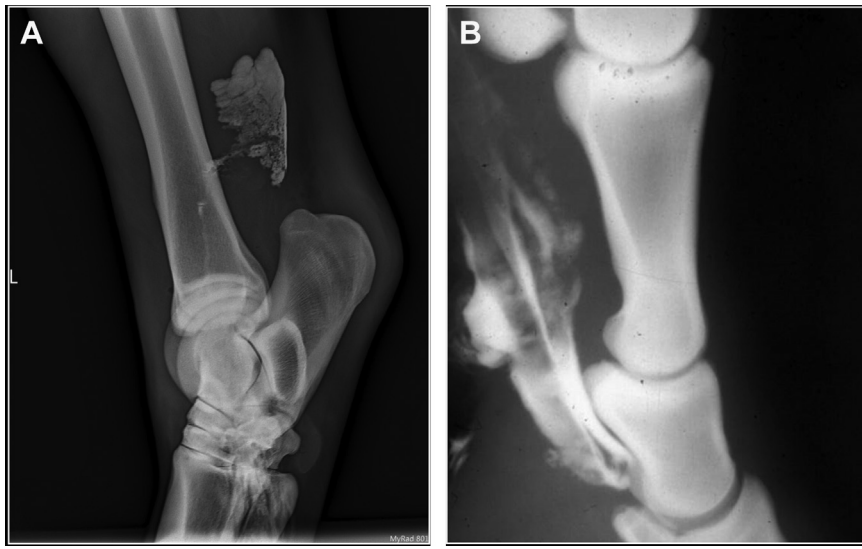

Fig. 2. Sterile contrast solution can be infused into a wound (*A*) or injected into a synovial structure (*B*) to determine communication between a wound and a synovial structure.

variability in clinical symptoms and changes in synovial fluid parameters can make it difficult to properly diagnose septic synovitis.[2] Normal synovial fluid is transparent to pale yellow in color, the fluid's total nucleated cell count (TNCC) is very low (less than 500 cells/μL), and the total protein (TP) concentration is less than 2.0 g/dL.[13,15,20] Normal cellular composition is 90% mononuclear cells, and the remaining 10% of cells are usually neutrophils.[20,21] Normal synovial fluid is viscous due to its hyaluronic acid content, and it does not clot because it does not contain clotting factors or fibrinogen.[13,15,20] Synovial fluid is generally considered to be septic when it has a TP greater than 4.0 g/dL, a TNCC greater than 30,000 cells/μL, and a cellularity greater than 80% neutrophils.[20,22,23]

Synovial fluid collection should be aseptically performed to prevent the introduction of microorganisms or debris during synoviocentesis.[20] Following collection of synovial fluid, the needle can remain within the synovial structure for distension with sterile fluids (see wound exploration, discussed earlier). Collected synovial fluid should be used for cytologic evaluation, culture and sensitivity, and other analyses.[2] A routine synovial fluid analysis includes evaluation of gross appearance (color, turbidity, viscosity), TP concentration, TNCC, and fluid cytology.[20]

Synovial fluid may contain blood from iatrogenic trauma after synoviocentesis; however the entire sample is usually not bloody in this situation.[20] In contrast, hemorrhage from inflamed synovium results in a uniformly bloody synovial fluid sample.[20] Septic synovial fluid may be serosanguinous in color, cloudy, turbid, and nonviscous (**Fig. 3**).[17,20] As a result of synovial inflammation, increased fluid cellularity causes the fluid to seem turbid, and the enzymatic breakdown of hyaluronic acid reduces

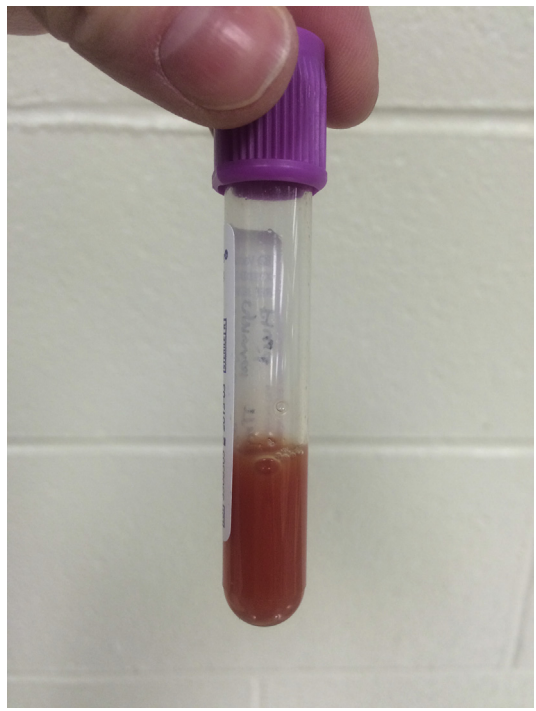

Fig. 3. Sample of septic synovial fluid with characteristic appearance abnormalities (serosanguinous in color, cloudy, and turbid).

the fluid's viscosity.[20] Synovial inflammation damages synovial vessels, resulting in protein leaking from these vessels and increasing the synovial fluid TP concentration.[7,20] The increase in TP concentration is related to the duration and severity of the disease process, with septic synovial fluid usually having TP concentrations greater than 4.0 g/dL, whereas nonseptic synovial inflammation results in lower concentrations.[20,23]

Diagnosis of sepsis should not be based solely on TP concentrations, because concentrations of less than 2.5 g/dL have been reported in cases with positive synovial fluid bacterial cultures.[24] Changes in synovial fluid TNCC can take 12 to 24 hours after inoculation, and a TNCC greater than 30,000 cells/μL suggest synovial sepsis.[7,11,23] The predominant cell type in septic synovial fluid is the neutrophil; neutrophil counts greater than 80% of the nucleated cells are common, and these neutrophils are often normal in appearance or rarely have degenerative changes.[22]

A positive bacterial culture from synovial fluid is often considered to be the gold standard for the diagnosis of septic arthritis. In addition, bacterial culture determines the present microorganisms and sensitivity and susceptibility testing aids in the selection of an appropriate antimicrobial drug.[11] However, the isolation and growth of synovial fluid bacteria can be challenging. Bacteria can be hidden in the pannus or synovial membrane, and cultures from infected joints are negative in almost 50% of clinical cases.[20,24,25] One study showed that when synovial fluid samples had no bacterial growth on initial culture, the reculture of samples that were incubated in blood culture medium for 24 hours resulted in a positive bacterial culture for all samples.[26] A synovial fluid sample should be collected for bacterial culture and sensitivity before the administration of antibiotics.[2] As bacterial culture can take several days to provide results, a Gram stain can be performed on a synovial fluid sample immediately following collection. Although a Gram stain of synovial fluid has a low rate of detection for bacteria, it is positive for microorganisms in about 25% of clinical cases. If bacteria are identified earlier, appropriate antimicrobial selections can procede.[1,20]

Additional Diagnostics

Horses with synovial inflammation (synovitis) can have clinical signs that are very similar to horses with septic synovitis.[17] Nonseptic synovitis due to synovial trauma can result in synovial fluid TNCC, TP concentrations, and cytologic findings equivalent to classic septic synovial fluid parameters.[17,20] Alternatively, horses early in the septic disease process, infection with an organism of low virulence, or nonseptic inflammation can result in synovial fluid TNCC less than 30,000 cells/μL.[20] Therefore, the combination of clinical signs, physical examination findings, wound exploration, diagnostic imaging, and a complete synovial fluid analysis is essential for an accurate diagnosis. The use of additional diagnostics may be warranted to help confirm a diagnosis of synovial sepsis. Commonly used additional diagnostic exercises include the measurement of synovial fluid pH, lactate concentration, glucose concentration, MMP activity, and the activity of myeloperoxidase.[2,20,27,28] In addition, serum amyloid A (SAA) concentration can be a useful aid in the diagnosis of synovial sepsis.[17]

SAA is an acute phase protein that increases in response to inflammation or infection.[2,17,29] Generally, systemic SAA markedly increases in response to bacterial or viral infections, whereas local inflammation usually results in mild to moderate concentration increases.[2,17,30,31] SAA concentrations increase quickly in response to infection and inflammation, and its short half-life makes it a good diagnostic test for monitoring disease progression and response to treatment.[17,31,32] The liver mainly produces SAA isoforms, but specific isoforms are produced locally in certain tissues, including within synovial structures.[2,17,29,31,33] Both serum and synovial fluid SAA concentrations can

increase with synovitis and septic arthritis, with the most substantial SAA elevations occurring with septic arthritis.[17,29] In addition, serum SAA concentrations begin to increase 12 hours before synovial fluid SAA concentrations, making it an earlier marker for sepsis.[17] Serum SAA quantification can easily be performed via simple blood collection and the use of a handheld SAA assay (Epona Biotech Limited, Ireland) and can be used as a convenient diagnostic and monitoring modality.[2,17]

The combination of clinical signs, examination findings, and diagnostic results help determine whether a wound involves a synovial structure and whether the synovial structure is infected. If the cumulative diagnostic results suggest sepsis, abrupt treatment is warranted.[4,8] If in doubt, it is always appropriate to assume synovial sepsis is present until proven otherwise.

TREATMENT OF WOUNDS AND SEPTIC SYNOVIAL STRUCTURES

After diagnosis that a wound involves a synovial structure, immediate and aggressive treatment should be implemented to manage both the wound and the synovial structure. The goals of treatment include rapid resolution of infection, reduction of inflammation, pain management, and the restoration of normal synovial physiologic functions.[2,8,34] A combination of systemic, regional, and/or intrasynovial antibiotics; joint lavage; wound debridement; and analgesic and antiinflammatory medications are often necessary for the treatment of wounds that involve synovial structures.

Antimicrobial Therapy

Broad-spectrum antibiotics should be administered following the collection of synovial fluid and continued until otherwise indicated by the synovial fluid bacterial culture and sensitivity results.[5] Most often, a combination of local, regional, and systemic antibiotics are indicated for treatment of synovial sepsis. Systemic antibiotics can be administered orally, intramuscularly, or intravenously.[2] Intravenous antimicrobials are often advised in the acute stages after injury, and oral antibiotics can be administered when the prolonged presence of antibiotics is required after the septic process seems to be resolving (**Tables 1** and **2**).

If no improvement in clinical signs is noted after 72 hours of treatment, diagnostic efforts should be repeated and treatment altered accordingly.[5,8] Antibiotic administration should be continued for 2 to 4 weeks following the resolution of clinical signs, to

Table 1
Commonly used injectable antibiotic combinations for synovial sepsis

	Route	Dose	Frequency
Potassium Penicillin, or	IV—slowly	22,000 IU/kg	Every 6 h
Procaine Penicillin, with	IM	22,000 IU/kg	Every 12 h
Gentamicin	IV	6.6 mg/kg	Every 24 h
Potassium Penicillin, or	IV—slowly	22,000 IU/kg	Every 6 h
Procaine Penicillin, with	IM	22,000 IU/kg	Every 12 h
Amikacin	IV	15–25 mg/kg	Every 24 h
Cefazolin, and	IV	11 mg/kg	Every 8 h
Gentamicin, or	IV	6.6 mg/kg	Every 24 h
Ceftiofur	IV or IM	1 mg/lb	Every 12 h
Enrofloxacin	IV	5–7.5 mg/kg	Every 24 h

Abbreviations: IM, intramuscular; IV, intravenous.

Table 2
Commonly used oral antibiotic combinations for synovial sepsis

	Route	Dose	Frequency
Trimethoprim/sulfa (960 mg)	Oral	15 mg/lb	Every 12 h
Doxycycline	Oral	11 mg/kg	Every 12 h
Minocycline	Oral	4 mg/kg	Every 12 h
Enrofloxacin	Oral	7.5 mg/kg	Every 24 h

ensure infection is completely eliminated and recurrence of sepsis is minimized.[5,8] In addition, if there is no growth on bacterial culture or if the sensitivity and specificity are inconclusive, broad-spectrum antibiotics are recommended for 2 to 4 weeks following clinical sign resolution and normalization of synovial fluid parameters.[5]

Local and regional antibiotic administration techniques include intrasynovial injection, regional limb perfusion, continuous rate infusion into the synovial structure, or antibiotic-impregnated delivery systems.[2,11] Intrasynovial antibiotic administration results in elevated concentrations of antibiotic drugs and is performed via synoviocentesis, which must be repeated during the course of treatment.[2] Broad spectrum, concentration-dependent antibiotics are primarily used for the treatment of synovial and orthopedic infections, and aminoglycosides are frequently administered.[7,35,36] However, the results of synovial fluid bacterial culture and sensitivity testing can help determine the most appropriate, case-dependent antibiotic selection.[36]

An alternative to repeated synoviocentesis is the use of specialized infusion systems. These systems are attached to a catheter placed within the affected synovial structure and can facilitate repeated administration or the continuous infusion of an antibiotic.[5,37] Continuous antibiotic infusion can be administered via an intrasynovial catheter attached to a "balloon" continuous rate infusion system, and the continuous rate antibiotic infusion helps maintain the minimal inhibitory concentration (MIC) of the antibiotic in the synovial fluid for longer durations than systemic antibiotic administration alone.[5,38] These systems require asepsis and extensive management to prevent intrasynovial catheter kinking, leakage, or other catheter site complications. These techniques may be beneficial for cases that require repeated intrasynovial treatments.[37]

Regional perfusion of antibiotics can be performed via intravenous or intraosseous routes. Regional antibiotic administration can result in synovial fluid antibiotic concentrations that exceed MIC during the 24 hours after drug administration.[8,39] Regional intravenous perfusions are frequently used for treatment of distal limb wounds in horses. These perfusions are performed via a peripheral vein within a selected portion of the limb distal to a preplaced tourniquet (**Fig. 4**).[36]

The selected antibiotic should be diluted in a solution to create the perfusate, with final perfusate volumes ranging from 10 to 60 mL.[36,40] Although the ideal perfusate volume is unknown, the volume of tissue to be perfused helps determine the final perfusate volume, and volumes of 30 to 60 mL are commonly used for equine distal limb regional perfusions.[4,36,40] After tourniquet application, antibiotic solution is slowly infused into the vein, and the tourniquet is maintained for 20 to 30 minutes to allow the medication to remain within the isolated area.[3,8] As movement of the horse can result in failure of vascular occlusion by the tourniquet and leakage of the perfused antibiotic into the systemic circulation, sedation and appropriate patient restraint is advised.[41] Wide tourniquets, such as Esmarch bandages (Medline, Northfield, IL) or pneumatic tourniquets, provide appropriate vascular occlusion, helping to maintain

Fig. 4. An Esmarch tourniquet placed above the carpus isolates the distal limb during a regional limb perfusion. The butterfly catheter is inserted in the cephalic vein.

the antibiotic's concentration higher than the MIC within the synovial fluid.[42] Regional perfusion is usually repeated every 24 to 48 hours, and 3 sequential treatments are typically recommended, but additional treatments may be necessary.[8]

Intraosseous regional limb perfusions are performed by drilling a unicortical hole in the bone immediately proximal or distal to the affected joint.[5,43] An intraosseous bone port or temporary tubing is inserted into the hole, allowing antibiotic solutions to be administered directly into the medullary cavity of the bone.[5,43] A tourniquet is placed proximal to the site of administration to help concentrate the antibiotic during perfusion. Intravenous regional limb perfusion is easier to perform and requires less specialized equipment than intraosseous perfusion; however, the intraosseous technique can be used when soft tissue trauma, cellulitis, or vascular damage precludes intravenous perfusion.[8] Intravenous and intraosseous regional limb perfusions result in similar synovial fluid antibiotic concentrations.[43]

Bioabsorbable, or nonabsorbable, antibiotic-impregnated delivery systems (implants) are another way to reach high levels of antibiotic concentration at the site of application.[8,44] One nonabsorbable implant material is polymethylmethacrylate (PMMA), which is a high-density polymer to which antimicrobial drugs can be added, and the mixture is formed into beads or cylinders.[8,45] The local concentration of antibiotic released from PMMA can be up to 200 times greater than that achieved by systemic antibiotic administration. Approximately 5% of the antibiotic solution is released

from PMMA within the first 24 to 48 hours after implantation. This is followed by a slow release of the remaining antibiotic over years.[45] PMMA implants can be placed in periarticular tissue and are often removed after 2 to 4 weeks.[5,8] If left in place, PMMA implants can result in localized inflammation or bacterial resistance. PMMA implants should not be placed within a synovial structure, because they induce synovitis and superficial cartilage damage.[5,8,44–46]

Bioabsorbable materials have advantages over PMMA implants because they have a faster and more constant release of antibiotics, better biocompatibility, and biodegradability.[5,47] Chitosan, microspheres, plaster of paris, hydroxyapatite, and collagen-based systems are successfully used bioabsorbable materials.[5,8,44] Gentamicin-impregnated collaged sponges placed intraarticularly after arthroscopic lavage in horses with septic arthritis have resulted in excellent clinical outcomes and may stimulate wound healing.[44,48]

Synovial Lavage and Debridement

The physical removal of inflammatory mediators, devitalized tissue, debris, bacteria, and fibrin from infected synovial structures is one of the most important treatment goals for horses with septic synovitis.[4,5] These materials disturb synovial function and metabolism, which can lead to irreversible joint damage, osteoarthritis, tenosynovitis, and bursitis.[4,11] Synovial lavage and drainage can be performed with through-and-through lavage with hypodermic needles, arthroscopy/tenoscopy, and open incision.[5,7,8,11] Through-and-through lavage is inexpensive and easy to perform under general anesthesia or with standing sedation.[12] Three to five liters of isotonic fluids are recommended and administered through large (usually 18–14 gauge) ingress and egress needles that have been aseptically placed into the affected synovial structure (**Fig. 5**).[11,12,49] If needles become obstructed with fibrin or debris, a stab arthrotomy may be necessary for fluid egress.[11,12] The wound itself can also serve as an egress portal. Through-and-through lavage is frequently used for acute synovial infection, before the development of substantial fibrin deposition. This technique does not allow for the removal of large fibrin clots, foreign material, assessment of the articular cartilage, or the debridement of bone or soft tissue lesions.[3,49]

Arthroscopic lavage is often the preferred treatment, because it allows for directed removal of fibrin or foreign material, visualization of synovial structures, and debridement of bone or soft tissue lesions (**Fig. 6**).[4,5,10,49] Visualization of an affected synovial structure and articular cartilage helps determine the prognosis. Osteomyelitis, osteochondral lesions, and marked deposits of pannus are associated with nonsurvival.[10,49] Overall, arthroscopic evaluation and treatment can decrease the duration of systemic antibiotic administration and decrease the length of hospitalization.[5,10]

Arthrotomy into the distal aspect of a joint can provide surgical access and drainage.[8,49] When combined with systemic and local antibiotics and joint lavage, arthrotomy can successfully resolve infection in cases that have been unresponsive to other treatment methods.[34] Arthrotomy incisions must be appropriately managed to prevent further contamination of the joint. Incisions can be surgically closed or left open to heal by second intention depending on case progression.[34] Although rare, complications associated with arthrotomy include secondary joint infection, joint capsule fibrosis, delayed incision healing, and decreased range of motion.[34] Similar complications can occur in tendon sheaths and bursae. Arthroscopic lavage combined with systemic and local antimicrobial administration is a very effective treatment method, so the need for arthrotomy is not common.[3,49]

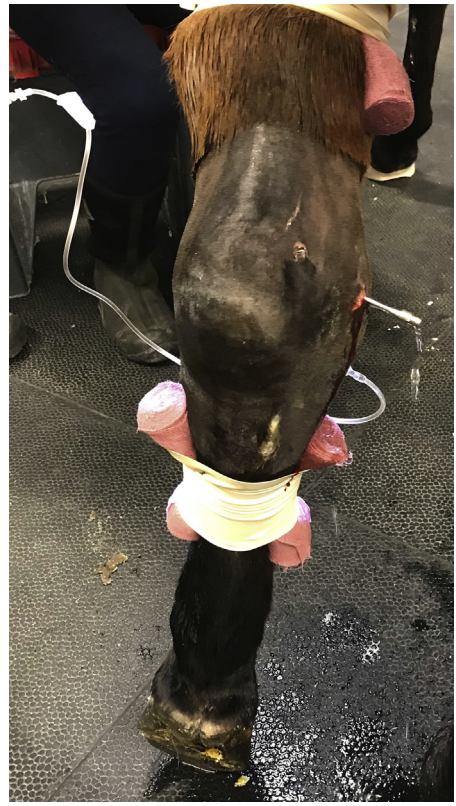

Fig. 5. Through-and-through lavage of the tibiotarsal joint. An 18-gauge needle was aseptically placed into the dorsal aspect of the tibiotarsal joint and pressurized sterile, isotonic fluids were lavaged through the joint. Fluid can be visualized exiting a teat cannula placed within the wound.

Additional Therapies

Septic synovitis typically creates substantial pain. Surgical and antimicrobial treatments help improve comfort in affected horses.[5,11] Maintaining comfort and weight bearing can lead to improved ambulation and joint motion, decreased formation of fibrous adhesions, improved articular cartilage nutrition, and a reduced risk for supporting limb laminitis.[7,49] Nonsteroidal antiinflammatory medications provide analgesia and reduce inflammation, with phenylbutazone, flunixin meglumine, or firocoxib being commonly used.[5,7,50] Alternative methods of analgesia include constant rate intravenous infusions of lidocaine, opioids, or ketamine, epidural analgesia for severe hind limb pain, or topically applied antiinflammatory medications such as diclofenac[5] (see R. Reid Hanson's article, "Medical Therapy in Equine Wound Management," in this issue).

Local and systemic medications directed at enhancing synovial fluid character may be useful additional treatments. However, the status of a septic process and timing of administration are important to determine. Intraarticular polysulfated glycosaminoglycan (PSGAG) and corticosteroids can increase the risk of synovial infection and should not be used during active sepsis.[7,49,51] Intraarticular PSGAG can bind local

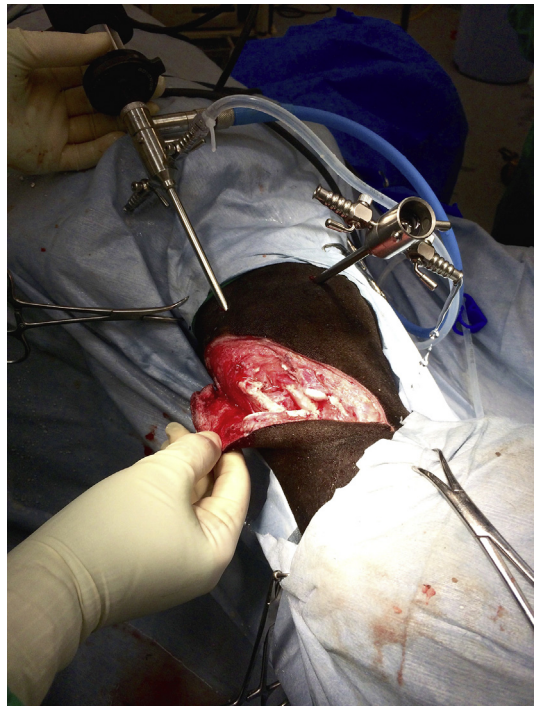

Fig. 6. Arthroscopy of a joint affected with a wound allows for visualization of the synovial structures, lavage, and debridement of associated lesions.

complement, which can reduce the inoculum required to establish sepsis and retard resolution of compartmental infection.[52] Intraarticular hyaluronan can be used for its antiinflammatory effects on septic synovial structures; however, the synovial inflammation may degrade the hyaluronan before it exerting desired effects.[49] To reduce the risk of secondary inflammation or infection, intrasynovial administration of these agents should be performed no sooner than 2 weeks after the resolution of a synovial infection.[49] The systemic administration of hyaluronan (intravenously) or PSGAG (intramuscularly) may provide the most benefit with reduced risk for septic synovial structures.[7,49]

Prognosis

Up to 85% of horses affected with septic synovial structures survive and 33% to 77% of these horses return to athletic function.[1,9,10,49,53] One report found that horses with open wounds involving a synovial structure that were treated medically or surgically within 24 hours of injury were less likely to develop septic arthritis, more likely to survive, and more likely to return to function than horses that were treated more than 24 hours after joint injury occurred.[9] In this clinical report, 53% of horses with open wounds in joints that were treated within 24 hours of injury developed septic arthritis, and these horses had a 65% survival rate.[9] Ninety-two percent of the horses that were treated 2 to 7 days following open joint injury developed septic arthritis, with only 39% of these horses surviving.[9] Therefore, timely diagnosis and treatment of wounds involving synovial structures is critical for obtaining a successful outcome in affected horses.[2]

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