Incidence and risk factors

Septic arthritis is a common consequence of bacteremia and septicemia in foals. In one study, septicemia was the most common cause of death (30%) in foals under 7 days of age. In the same study, septic arthritis was identified as the cause of death in 12.5% of foals aged 8 to 31 days.\(^1\) Establishment of infection depends on several factors including host defense, virulence of the organisms, and local joint factors. In foals, host defense is mainly associated with passively acquired immunity.\(^2\) Failure of passive transfer is the highest risk factor for development of septicemia in foals. The incidence of disease resulting from FPT has been reported to be as high as 78%.\(^3\) Organisms virulence is related to the ability to establish infection. Attachment factors, ability to resist phagocytosis, or resistance to cell killing all contribute to establishment of infection. Local joint factors that may predispose to establishment or maintenance of infection include low blood flow, particularly in end-loop capillaries, or poor blood supply, which is more a factor in bone. Although not commonly used in foals, certain intra-articular medication such as corticosteroids, hyaluronan, and polysulfated glycosaminoglycans have been associated with a higher risk for septic arthritis potentially by decreasing articular defense.

Pathogenesis

Articular blood supply is provided through a main arteriole that branches to the synovial membrane and epiphysis. Blood supply to the metaphysis is provided by the nutrient artery, but in young foals, transphyseal vessels exist that connecting the metaphyseal and epiphysial blood supply.\(^4\) Intravenous injection of bacteria results in rapid inoculation of articular and peri-articular capillaries. Three types of hematogenous articular infection have been described: Type S (synovial), where a septic arthritis resulting from inoculation of the synovial membrane is present; type E (epiphysis) where subchondral bone infection is present; and type P (physis) where infection of the physis on the metaphyseal side of the growth plate is identified.\(^4\) In young foals, functional transphyseal vessels allow communication of the metaphysis and epiphysis, such that bacteria localize preferentially in the synovial membrane and subchondral bone. Thus young foals suffer from predominantly from type S and E infectious arthritis. Closure of transphyseal vessels occurs approximately after 7-10 days of age, such that localization of infection to the metaphyseal vessel loops occurs in older foals. Intraarticular inoculation of bacteria results in influx of neutrophils, secretion of cytokines by local synovial cells, and production of destructive enzymes by neutrophils, synoviocytes and chondrocytes. Depolymerization of hyaluronate occurs, as well as rapid proteoglycan depletion in articular cartilage.\(^5\) In addition, increased vascular permeability resulting from the acute inflammation leads to rapid and severe joint effusion. The consequences of effusion are impaired synovial and subchondral bone blood flow, and pain. Hyaluronate depolymerization impairs the barrier function of the joint, favorizing neutrophil influx. Fibrin formation on the articular surface, and immobilization caused by
pain impairs diffusion of nutrients to the articular cartilage, further depleting the articular matrix. Matrix depletion is initially a biochemical event, such that articular surfaces appear grossly normal. However, untreated septic arthritis can lead to visible cartilage damage in a few days.

Subchondral or metaphyseal bone inoculation also results in local infiltration of neutrophils, as well as initiation of demineralization. In addition, bacteria or cellular debris can occlude bone blood supply, resulting in avascular necrosis. Although bone inoculation can occur simultaneously to synovial inoculation in young foals, identification can be delayed because of a delay in radiographic identification of lesions.

**Diagnosis**

Septic arthritis, osteomyelitis, or physitis should be ruled out in any lame foal. Foals with septicemia are at high risk of developing septic arthritis, which generally is noted clinically hours to days after the initial signs of septicemia. Although owners often complain of external trauma, septic arthritis is the most common cause of lameness in foals. In young foals with types S and/or E arthritis, inoculation of the synovial membrane is the first event, which can be identified by the astute clinician as periarticular edema. Joint effusion rapidly follows. Multiple joint involvement is common, and identification of all affected joints is essential for successful management. Effusion of the shoulder, elbow, or hip joints is more difficult to discern, therefore arthrocentesis of these joints should be performed in any unidentified lameness. In the stifle, femoro-patellar joint involvement results in marked effusion. Femoro-tibial joint effusion is usually subtler to discern. Because of the usual communication between the femoro-patellar and the medial femoro-tibial joint, both are usually involved concurrently. Lateral femoro-tibial infection is more subtle to discern and can occur separately. Distension of the long extensor pouch is often present in lateral femoro-tibial infection, and is a clue to involvement of that joint. In older foals (>7 days) physeal infection may be observed. The presence of concurrent synovial effusion depends on the intra or extraarticular localization of the growth plate. For example, distal metacarpal physeal infection results in periphyseal edema, initially without joint effusion. The infection can break out the skin, rather than involving the joint. In septic arthritis in foals, laboratory data is consistent with infection, and includes a neutrophilic leukocytosis, and a high fibrinogen concentration.

Arthrocentesis is the mainstay of diagnosis of septic arthritis. A high protein concentration (>2.5 g/dl), and a high leukocyte count are observed. Classic counts diagnostic of septic arthritis in foals exceed 30,000 cells/uL, with greater than 90% neutrophils. Neutrophils are rarely degenerate. Although gram stains should be performed they uncommonly will reveal the etiologic agent. In foals with a separate physeal infection, a sympathetic joint inflammation and effusion can occur. This is manifest by a moderate increase in white blood cell count, with <90% neutrophils. The presence of such should alert the clinician to the presence of physeal sepsis.

Radiographs of all affected joints are essential. The presence of osteomyelitis may affect prognosis, or at least dictate prolonged antibiotic therapy. Radiographs should be repeated on a weekly basis until resolution of clinical signs, or any time there is deterioration in the clinical condition.
Nuclear scintigraphy has been used to diagnose infectious foci in odd localization in foals. For example, vertebral and atlanto-occipital involvements have been diagnosed using this imaging modality. It is to be remembered that local bone infarcts will result in areas of decreased rather than increased uptake. Technetium-labeled white blood cell scans have potential uses in foals with multiple limb involvement, and warrants further investigation as an imaging modality for septic arthritis. Newer imaging capabilities such as MRI or computed axial tomography may evolve as diagnostic modalities in septic arthritis.

Identification of the organism should be attempted in all cases of septic arthritis. Gram stains, culture of the synovial fluid collected in blood culture bottles, and of synovial biopsies have all been suggested to increase the likelihood of identification of the organism. Because bacteremia or septicemia precedes the local signs, blood cultures should be obtained. In addition, culture of any other local sites of infection should be performed. In cases of septic physitis, needle aspiration under radiographic or fluoroscopic guidance should be performed.

**Treatment**

Septic arthritis in foals is an emergency. Immediate assessment and institution of treatment should be performed. The systemic condition of the foal must be addressed. Management of failure of passive transfer, and all other problems associated with foal septicemia, should be done.

The principles of treatment of septic arthritis in foals are: systemic broad-spectrum antibiotics; local joint lavage and debridement; and local antibiotics. The most common organisms isolated in foal septic arthritis are: Actinobacillus; E.coli; Klebsiella sp; Pseudomonas sp; and Salmonella. In older foals, gram-positive organisms such as Strep sp may be isolated. In older foals with physeal lesions Rhodococcus equi is often involved. In young foals, systemic antibiotics should be effective against gram-negative organisms. A combination of a B-lactam and an aminoglycoside is a good choice, until results of culture are obtained. In older foals, gram stains of a physeal aspirate or of a trans-tracheal wash are helpful to identify Rhodococcus equi. If present, appropriate therapy with erythromycin and rifampin should be instituted.

Local lavage can be performed by through-and-through needle technique, with the foal under heavy sedation or short-term intravenous anesthesia. This technique may be sufficient in joints where the diagnosis was made early, where the infection is not severe, and in simple joints (fetlock, carpus). In joints with multiple compartments (stifle, hock), in cases of severe infection, or in cases of longer duration or lack of response to joint lavage, arthroscopic debridement is indicated. Arthroscopy has several advantages over simple needle lavage. It allows thorough debridement, removal of fibrin and lavage of all compartments; and it allows evaluation and debridement of cartilage lesions. Arthroscopy may have prognostic value in cases where radiographic lesions are equivocal.

Intra-articular antibiotics are advocated for the management of septic arthritis. Aminoglycosides have been shown to maintain levels above MIC for 24 hours following a single intra-articular injection. Other local treatment modalities include antibiotic-impregnated PMMA beads, or biodegradable antibiotic-impregnated disks. Regional intravenous or intraosseous perfusion has recently been advocated for the treatment of
septic arthritis complicated with osteomyelitis. The potentially detrimental effects of temporary vascular occlusion on foal bone circulation need to be investigated.

The presence of osteomyelitis may warrant the use of an antibiotic combination that reaches effective bone levels. Rifampin is often used for that purpose. Other antibiotics that reach effective bone concentrations include tetracyclines, chloramphenicol, and cephalosporins. Third-generation cephalosporins should be used, as they are more effective against gram-negative bacteria. Fluoroquinolones should not be used in foals, as there is enough evidence of cartilage lesions developing in immature animals with the use of this class of drugs.

In the case of extensive physeal lesions, curettage, bone graft and external coaptation may be required. Angular limb deformities may result from growth disturbances, or collapse of the physis on the affected side.

**Prognosis**

There have been no long-term longitudinal studies looking at athletic performance in foals following septic arthritis. Prognosis for septic arthritis should always be guarded. Elements that will influence prognosis are: systemic condition of the foal; number of joints involved; localization of joint involvement; severity of the infection; early vs delayed identification and institution of treatment; presence of osteomyelitis; and virulence of organisms. Clients should be forewarned of the high cost of treatment.

**References**