Septic Arthritis of the Hip in Children

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Abstract

Recent advances in the management of septic arthritis of the hip in children include a better understanding of the effects of infection on articular cartilage; improvements in diagnostic tests, including erythrocyte sedimentation rate, C-reactive protein analysis, and ultrasonography; and more efficacious home intravenous and oral antibiotic therapy. Early diagnosis is essential to successful treatment. Needle aspiration is the most specific diagnostic test; however, false-negative results are possible. Prompt surgical drainage and postoperative antibiotic therapy until signs of infection resolve are necessary to prevent late sequelae. Surgical treatment of limb-length inequality is more useful than attempts to salvage the destroyed or incongruent joint.

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Septic arthritis in children has historically been difficult to treat successfully. Mortality rates were reported to be greater than 50% at the end of the 19th century. After the introduction of antibiotic therapy in 1935, mortality and morbidity rates declined dramatically to less than 1% in 1973.[1] However, diagnosing and managing this condition continue to be challenging, and poor outcomes unfortunately still occur.

Although septic arthritis of the hip is second in frequency to that of the knee, most disastrous results occur in the hip. Early diagnosis, prompt open drainage, and appropriate antibiotic administration are of paramount importance in achieving a successful result.

Anatomy and Pathophysiology

The synovial membrane is a distinct anatomic structure separate from the fibrous joint capsule. The inner layer is composed of intimal cells arranged in an interlacing fashion with a rich blood supply. The main arterial supply travels through the fibrous capsule to enter the synovium, where rapid division occurs to form an intercommunicating network. The deepest plexus of vessels lies immediately beneath the intimal cells, allowing rapid transfer of both bacteria and antibiotics from the arterial vessels into the joint.[2] Lymphatic vessels are also present, located slightly deeper to the innermost arterial plexus.

Synovial fluid is a dialysate of blood plasma with approximately one third as much protein as serum; albumin accounts for 60% to 70% of the total protein in the joint. The cell count is about 60 cells per milliliter, mostly monocytes and some polymorphonuclear leukocytes, the primary function of which is phagocytosis.

Bacteria gain access into the hip-joint cavity by two principal mechanisms, either directly via the hematogenous route or indirectly from the proximal femoral metaphysis. Trueta[3] postulated that contiguous blood flow from the proximal femoral metaphysis to the epiphysis persists until the second year of life, which could lead to septic hip arthritis. However, we agree with Chung,[4] who used three-plane analysis to show that the physis is a barrier to blood flow between the epiphysis and the metaphysis.

Bacteria most commonly enter via the blood, are deposited in the rich vascular network in the sub-

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synovial layer, and may then cross from the permeable blood vessels into the joint. In a rabbit model, approximately 90% of bacteria injected into the joint were taken up by synovial cells, where they multiplied and then passed into the joint cavity.[5] The host's response to this bacterial burden, which is dependent on the type and virulence of the organism and the local and general resistance of the patient, determines the clinical outcome. In the acute inflammatory stage, polymorphonuclear cells rapidly enter the joint cavity, followed by passage of plasma proteins across the synovial membrane.[6] A tense effusion occurs with increased intracapsular pressure, resulting in pain, especially when the hip is held in extension and maximum internal rotation.

Articular cartilage destruction occurs by means of two mechanisms. The first is degradation by proteolytic enzymes (e.g., collagenase, proteinases) elaborated by the cells of the synovial membrane,[7] activated polymorphonuclear leukocytes,[8,9] and certain bacteria.[10] The second is the cascade of events in which interleukin-1 from monocytes acts as an inflammatory hormone to trigger the release of acid and neutral proteases by chondrocytes and synoviocytes.[11]

Animal models have been used to study the events of articular cartilage destruction in septic arthritis. In a model involving an experimentally produced *Staphylococcus aureus* joint infection, articular cartilage destruction followed a sequence in which proteoglycan matrix (hexosamine) was lost at 5 days, followed by a loss of collagen by 9 days.[12] In another experimental study, antibiotics administered within 8 hours of joint infection failed to completely prevent articular cartilage damage.[13] In a study on rabbits, open surgical lavage 4 and 7 days after bacterial inoculation did not prevent matrix degradation but did limit collagen breakdown, although the inflammatory process was still evident 11 weeks after the joint had been lavaged to a sterile state.[14] Continuous passive motion was beneficial in a rabbit model of septic arthritis.[15]

Clinical Presentation

The child with septic arthritis of the hip presents with localized pain in the anterior aspect of the hip joint that often radiates toward the knee. The child may be irritable and have a limp and limited spontaneous motion in the lower extremity (pseudoparalysis). A history of preceding trauma may be present; however, data defining the exact incidence are not yet available. A careful history should include information concerning recent infections and increased susceptibility to infection, such as an altered immune status. Fever (temperature of 39˚C to 40˚C) is often present in the older child; however, in the neonatal period and early childhood, fever and other symptoms may be absent or mild.

The affected child typically lies with the hip in external rotation, abduction, and mild flexion to maximize joint volume. In this position, the richly innervated joint capsule is under less tension. Increased intracapsular pressure occurs with the leg in extension and internal rotation or with the hip flexed to more than 60 degrees. Motion of the hip results in pain and guarding by the hip muscles. In the early stage of infection, the child may allow motion of the hip, although abduction and extension are usually limited. The anterior aspect of the hip joint in a thin child may be tender.

Careful palpation of the pelvic region is important because two thirds of patients with pelvic osteomyelitis have localized tenderness.[16] Osteomyelitis of the greater trochanter may also be characterized by localized tenderness, and the leg is held in slight extension. The psoas sign of pain on extension and internal rotation of the hip is present in as many as 89% of patients with a primary pyogenic abscess of the psoas muscle, a condition often confused with septic hip arthritis.[17] An abdominal and lumbosacral spine examination should be performed to eliminate other causes for the presenting symptoms.

Evaluation

The evaluation for suspected hip sepsis should include serologic tests (white blood cell [WBC] count with differential, erythrocyte sedimentation rate [ESR], and C-reactive protein [CRP] analysis if available), blood cultures, and serum glucose determination. An anteroposterior pelvic radiograph and a lateral view of the hip should also be obtained.

The WBC count is elevated in 40% to 60% of patients, and the polymorphonuclear leukocyte count is elevated in as many as 80%. The WBC count is more often elevated in the older child with septic arthritis of the hip, whereas it is often normal in affected neonates.

The ESR reflects changes in the fibrinogen concentration, increasing 24 to 48 hours after the onset of infection. In one study,[18] it was found to be elevated in the 50 to 90 mm/hr range in more than 90% of patients tested and is, therefore, highly sensitive. However, it is nonspecific and simply indicates inflammation.

C-reactive protein is an acute-phase protein synthesized by the liver. Normal serum values are less than 20 mg/L. The CRP level increases in response to bacterial infection, rising earlier than the ESR (within 6 to 8 hours) in a patient with a septic hip and normalizing more rapidly.[19] Normalization of the CRP concentration appears to indicate the end of the invasive bacterial process and is therefore useful as a monitor of duration of antibiotic therapy. The CRP level can be used to detect associated septic arthritis in patients who have acute hematogenous osteomyelitis.[20] If the CRP concentration on the third day is more than 1.5 times the level on admission, there is a high likelihood that associated septic arthritis is present.[20]

Blood cultures should be drawn at the initial evaluation before antibiotics are given. Cultures are positive in only 40% to 50% of cases. A baseline serum glucose level should be obtained for comparison with the synovial fluid glucose level.

It is often difficult to distinguish between septic arthritis and transient synovitis of the hip. According to Del Beccaro et al,[21] the combination of an ESR of more than 20 mm/hr and a temperature higher than 37.5˚C can identify 97% of cases of septic hip arthritis.

Depending on the duration and severity of the infection, radiographic changes in the hip may include soft-tissue edema and loss of tissue planes, widening of the joint space and capsular distention, and subluxation of the hip or associated osteomyelitis of the proximal femoral metaphyseal region (Fig. 1).

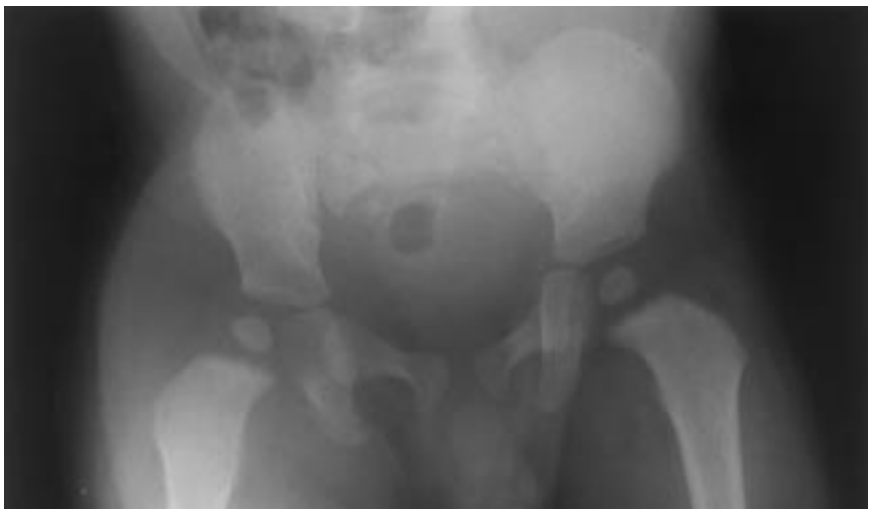


Fig. 1 Radiograph of an 8-month-old girl with a 4-day history of fever and a painful right hip demonstrates soft-tissue swelling lateral to the right hip, pelvic obliquity, diminished contrast between the bone and the soft tissues, and right hip subluxation.

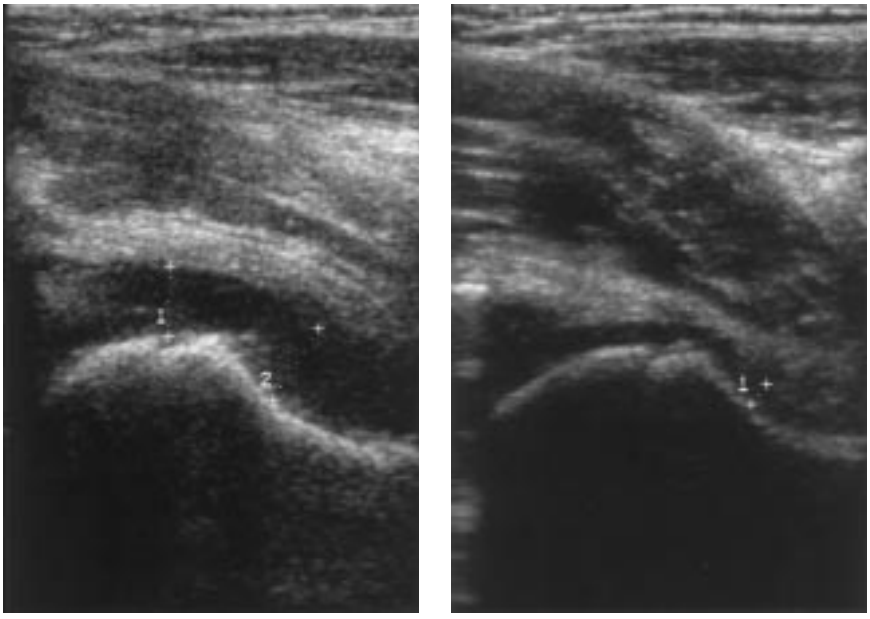
Ultrasonography is of diagnostic value when there is uncertainty about the presence of a septic effusion (Fig. 2). Both the hip with suspected infection and the normal hip should be evaluated. Ultrasonography is performed along the axis of the neck with the hip in external rotation to better visualize the fluid. Compared with the contralateral hip, the affected hip will show asymmetry of the capsule-to-bone distance of 2 mm or more, indicating an intra-articular effusion. An echo-free effusion indicates transient synovitis or fresh hemorrhagic effusions. Echogenicity indicates septic arthritis or clotted hemorrhagic collections. When these criteria were used, ultrasonography was found to have a sensitivity of 100% in detecting a joint effusion.[22] However, it is not highly specific; therefore, the clinical data must be combined with the ultrasound findings to determine whether hip aspiration should be performed. For example, if there is a strong clinical suspicion of septic hip arthritis and an echo-free effusion is demonstrated on ultrasound examination, hip aspiration should be performed. In contrast, if a patient presents with acute onset of hip pain but there is not a strong clinical suspicion of sepsis and an echo-free effusion is found on ultrasound, close clinical observation is warranted.

The sine qua non for identifying septic hip arthritis is large-bore (20-gauge or larger) needle aspiration performed via an anterior or medial approach. Performing aspiration in conjunction with arthrography or with ultrasound guidance can ensure that the needle is inside the hip joint. Cytologic and chemical examination of the joint fluid should be performed. The WBC count is most diagnostic and can be considered positive for bacterial infection if it exceeds 50,000 cells per milliliter, with 90% usually being polymorphonuclear cells.[23] In septic arthritis, the glucose level in synovial fluid is generally 40 mg/dL less than the serum level. In contrast, lactate levels are usually higher, except in gonococcal arthritis, in which lower levels are demonstrated.

A positive Gram stain will confirm the diagnosis in as many as 50% of cases and is an important finding because it can be used to guide the choice of antibiotic ther-

apy. Synovial fluid should be plated on agar medium, and a specimen should be sent for culture in broth medium. Synovial fluid yields positive cultures in 50% to 80% of patients with septic hip arthritis. Study of synovial fluid for bacterial antigen by agglutination or immunoelectrophoresis techniques can also be used to identify *Haemophilus influenzae*, meningococcus, pneumococcus, and group B *Streptococcus* organisms.[24]

Isotope bone scanning is rarely needed to diagnose septic hip arthritis, but it can be useful in the difficult case in which the diagnosis remains uncertain despite clinical, radiographic, and ultrasonographic examination. It also has utility in establishing the diagnosis of isolated proximal femoral osteomyelitis in a child with mild signs and symptoms. Three radiopharmaceuticals are currently used: technetium 99m diphosphonate, gallium 67 citrate, and indium 111. The technetium bone scan is not useful in differentiating infectious from noninfectious arthritis. However, in one study of delayed uptake images,[25] the predictive value was 100% for low-uptake ("cold") scans and 82% for high-uptake ("hot") scans for both osteomyelitis and septic arthritis.[26] In the subgroup of patients with a septic hip in that study, the positive predictive value for both hot and cold scans was 78%, and the sensitivity was 93%. In a septic joint, the distribution of uptake is uniform within the joint capsule (Fig. 3, A); asymmetric uptake indicates osteomyelitis. If the clinical signs indicate a septic hip or osteomyelitis, a normal technetium scan should not be relied on to rule out infection.



A B

Fig. 2 **A,** Longitudinal sonogram of the proximal left femur of a 7-year-old child with a septic hip joint. The joint space is increased to 5.6 mm at the physis (1) and 7.0 mm at the femoral neck (2). The capsule is also thickened. **B,** Comparison view of the normal right proximal femur demonstrates a 2.1-mm joint space at the level of the femoral neck (1).

Scintigraphy performed with Ga-67 citrate, which preferentially localizes in bacteria, polymorphonuclear leukocytes, and inflammatory exudative proteins, is more sensitive than technetium scintigraphy in identifying a localized inflammatory response. Borman et al[26] demonstrated a 91% diagnostic accuracy for gallium scintigraphy in detecting acute osteomyelitis or septic arthritis. Because they found gallium more sensitive than technetium, they recommend its use in difficult cases, such as deep pelvic and spinal infections, when the diagnosis cannot be established clinically or with other imaging studies. Gallium scintigraphy results in average whole-body dosimetric values up to three times greater than those with technetium scintigraphy and should not, therefore, be used routinely. In-111–labeled WBC studies have not been used in children because of the relatively large blood specimen needed, the longer imaging time, and the difficulties with the labeling technique.

We have used magnetic resonance (MR) imaging in patients with septic hip arthritis that has not responded to conventional therapy. This modality is useful in delineating areas of residual infection and defining associated osteomyelitis (Fig. 3, B and C).

Differential Diagnosis

The spectrum of disorders in the differential diagnosis of septic hip arthritis is broad, ranging from very common to relatively rare disorders. Because septic hip arthritis carries a poor prognosis when the diagnosis is delayed, it is critical to prioritize the differential diagnosis and determine the likelihood of each condition. The threshold for performing needle aspiration should be low if

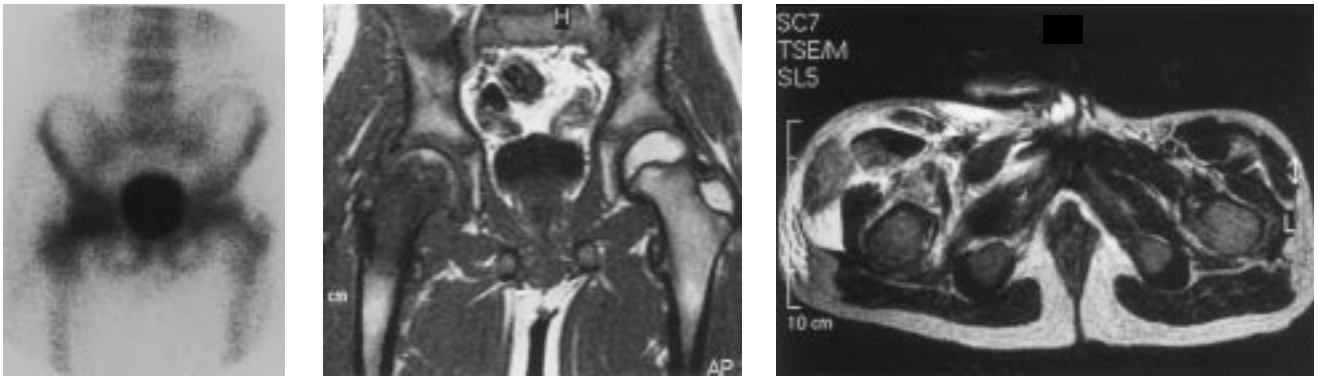


Fig. 3 **A,** Technetium bone scan of a 13-year-old boy with persistent hip pain and a limp for 3 days after receiving a direct blow to the hip. Radiographs were normal. The scan demonstrates increased uptake in the proximal femur. Open arthrotomy was performed on the right hip with drainage of pus and irrigation of the joint. **B,** A T1-weighted coronal MR image obtained 5 days after arthrotomy, when the patient had persistent fever, hip pain, and swelling despite antibiotic therapy. There is loss of signal in the right femoral head and neck, representing osteomyelitis associated with septic arthritis. **C,** A T2-weighted fast spin-echo transverse MR image demonstrates considerable soft-tissue edema with residual infection and loss of muscle-plane definition.

there is a strong possibility that a septic hip is present on the basis of the clinical history and examination findings.

Transient synovitis typically presents with a history and physical examination findings similar to those seen with septic arthritis. Initial complaints of hip pain progress over several days to a limp and then the inability to walk. Physical examination demonstrates a painful range of motion; however, there is generally less acute pain and less restricted motion than found in a patient with septic hip arthritis. The WBC count and ESR are less often elevated than in septic arthritis. In the study by Del Beccaro et al,[21] 28% of patients with toxic synovitis had an ESR greater than 30 mm/hr, compared with 79% of patients with septic hip arthritis. An ultrasound examination is helpful in determining whether fluid is present in the joint and whether it is echo-free (indicating toxic synovitis) or echogenic (indicating septic arthritis). Needle aspiration should be performed if any doubt remains.

Other infectious diagnoses to consider include psoas abscess, pelvic acetabular osteomyelitis, piriformis or adductor pyomyositis, pyogenic sacroiliitis, and Lyme disease. Sickle cell disease should be considered in the differential diagnosis of any young black child presenting with a painful extremity.

Pyogenic abscess of the psoas muscle is uncommon. In children, it most frequently occurs in association with infection of the abdominal viscera. The diagnosis is often delayed because of unfamiliarity with the condition and because it can mimic disorders of the hip. There is a flexion deformity of the hip with a tender mass in the flank just cephalad to the inguinal ligament. A psoas sign is present, and the pain is relieved by flexion, external rotation, and adduction of the hip. The posterior aspect of the hip is not tender, and a fully flexed hip can be rotated without pain. A rectal examination may elicit tenderness to palpation. A plain abdominal radiograph may show enlargement or loss of definition of the psoas shadow, although the latter finding is sometimes present in healthy patients.[27] Ultrasonography is the best diagnostic test due to its accuracy, the ease with which it can be performed, and its low cost.[28] Furthermore, it can image the hip joint to help exclude septic hip arthritis. In our clinical experience, we have found that MR imaging can depict the early stages of myositis in a variety of muscles about the hip. The preferred treatment of a primary pyogenic psoas abscess is operative drainage through a retroperitoneal approach, followed by intravenous antibiotic therapy to cover *S aureus*, the most common pathogen.[29]

Pyomyositis of the piriformis or adductor muscles is very rare. It usually occurs in tropical regions and is typically caused by *S aureus.* The patient has pain with active movement through the range of motion and tenderness on palpation of the affected muscles. An MR imaging study will clearly define the extent of the infection. Treatment is a combination of surgical drainage and antibiotics.

Acute hematogenous pelvic osteomyelitis is uncommon. It presents in much the same way as septic arthritis but with a more insidious onset. In the study by Mustafa et al,[16] 75% of patients presented with the triad of fever, pain, and limp. On physical examination, 83% had pain through the range of motion, and 70% had point tenderness. The ESR was greater than 20 mm/hr in 95% of cases, but a pelvic radiograph was positive in only 25%. Intravenous antibiotic therapy alone was successful for 75% of patients, and 25% required surgical drainage. Therefore, the differentiation of pelvic osteomyelitis from septic hip arthritis should begin with a careful physical examination looking for less pain through the range of motion and for point tenderness in the affected area of the pelvis. Technetium bone scans are useful in early diagnosis when radiographs reveal no abnormalities.[30]

Lyme disease is a growing public health problem in the United States and should be a consideration when evaluating a patient who lives in an area where the disease is endemic and who presents with unusual findings. The infectious agent is a spirochete, *Borrelia burgdorferi*, which is transmitted by the deer tick *Ixodes* during the summer months, especially in the Northeast, northern Midwest, and West. Of the five patterns of articular involvement, the acute pauciarticular ("pseudoseptic") type most closely resembles septic arthritis. Articular involvement is preceded by a rash (erythema chronicum migrans), which is associated with myalgias, arthralgias, fatigue, and malaise, followed by cardiac and neurologic abnormalities. Twenty percent of children recall being bitten by a tick, and 20% to 70% exhibit erythema migrans,[31] which is often associated with fever. We recommend that a serologic evaluation for Lyme disease be performed on any child with an irritable hip who resides in an area where the disease is endemic. Such an evaluation includes testing for antibodies to *B burgdorferi* conducted with the use of both enzyme-linked immunosorbent assay (ELISA) and Western blot techniques. A decline in the ELISA titer throughout the treatment period indicates a good response to therapy. Various antibiotic regimens have been recommended, among them amoxicillin, doxycycline for children older than 8 years of age, and intravenous ceftriaxone followed by either amoxicillin or doxycycline. The prognosis for children is better than for adults, with chronic arthritis developing in approximately 2% of children older than 6 months.[31]

Juvenile rheumatoid arthritis can present with single joint involvement. The onset of pain is generally more gradual and less severe than is seen with septic hip arthritis. The child does not have severe constitutional symptoms and continues to walk. The hip is not as sensitive to movement and can be put through a nearly normal range of motion. An effusion is typically present, with a leukocyte count of less than 100,000 per milliliter. Aspiration of the joint may yield purulent-appearing material.

Less likely to cause confusion are Legg-Perthes disease, acute slipped capital femoral epiphysis, rheumatic fever, leukemia, and Henoch-Schönlein purpura. Legg-Perthes disease has a more prolonged onset of symptoms, less severe physical examination findings than seen in a case of septic hip, and fairly typical radiographic changes. Acute slipped capital femoral epiphysis can mimic the acute onset and exquisite pain of infection, but trauma is a common antecedent, and the radiographic findings are characteristic. Rheumatic fever, due to group A streptococcal infection, results in migrating arthritis or arthralgias typically involving the knees, ankles, elbows, and wrists; the hips are less commonly affected. Pharyngitis or a febrile illness 2 weeks before the onset of joint pain is often remembered.

Acute leukemia, the most common cancer in childhood, may mimic many orthopaedic conditions. Bone pain or musculoskeletal symptoms or both are presenting complaints in approximately 30% of cases. The clinical findings are less likely to raise suspicion of a septic hip because the local signs and symptoms are mild. The most important clues to the diagnosis of leukemia are prolonged preceding symptoms, anemia, a low leukocyte count, and inconsistent findings on sequential technetium bone scans.[32]

Henoch-Schönlein purpura is a vasculitis of unknown etiology. Its manifestations include arthritis, a purpuric rash, abdominal pain, and nephritis. The arthritis typically involves the knees and ankles and is characterized by periarticular swelling with minimal joint effusion. The purpuric rash may begin as small hemorrhagic lesions involving the buttocks and legs and often precedes the arthritic symptoms. Henoch-Schönlein purpura is self-limiting, and treatment is directed toward prevention of ischemic changes in the kidneys and intestines.

Treatment

Several treatment principles are important for a successful outcome. First, the diagnosis must be made early in the course of the illness. Second, synovial fluid should be obtained for culture to confirm the

diagnosis before antibiotic administration. Third, hip arthrotomy is the definitive therapeutic procedure. Finally, empirical antibiotic therapy should be based on the clinical situation and the age of the patient; the final choice of antibiotic is dependent on the culture reports.

Table 1
Most Common Pathogens and Initial Parenteral Antibiotics of Choice, by Age Group

Age	Pathogen	Antibiotic
Neonate	Group B streptococci, *S aureus*, Gram-negative bacilli	Nafcillin or oxacillin
1 month to 3 years	*S aureus, Streptococcus pneumoniae, Streptococcus pyogenes*	Nafcillin, oxacillin, cefotaxime, or ceftriaxone
3 years to 13 years	All the above and *H influenzae* type B	Nafcillin or oxacillin
Adolescent	*S aureus, Neisseria gonorrhoeae*	Nafcillin or oxacillin

Antibiotic Therapy

The causative organism can generally be predicted accurately on the basis of the age of the patient (Table 1).

In the high-risk, low-birthweight neonate, the most common infectious organism is *S aureus*, followed by group B *Streptococcus*. Catheterization of umbilical vessels or another invasive procedure often precedes the infection. Care must be taken to identify sites of other invasive procedures that may have become infected, such as the scalp (secondary to fetal monitoring), the calcaneus (secondary to heel puncture), and the symphysis pubis (secondary to bladder puncture).

In neonates, septic hip arthritis may be the result of invasion of the joint by osteomyelitis extending from the proximal femur. The most common findings are swelling, flexion contracture, and overlying inflammation of the hip. In the otherwise healthy neonate, group B streptococcal infection is most common, usually presenting with only single joint involvement. In one series of 92 patients with septic arthritis who were less than 3 months old, streptococci were the most common organisms (52%) in community-acquired septic arthritis, followed by staphylococci (26%) and gonococci (17%); in contrast, in hospital-acquired septic arthritis, the most common organism was *Staphylococcus* (62%).[33] Initial antibiotic coverage should consist of nafcillin or oxacillin, with gentamicin added for the high-risk neonate.

In patients between the ages of 3 months and 3 years, *H influenzae* type B has, in the past, been the most common organism, followed by *Staphylococcus* and *Streptococcus*. However, with the widespread use of the *H influenzae* type B vaccine in the late 1980s, there has been a drastic decline in the incidence of infections due to this pathogen, especially in patients aged 6 to 11 months.[34] As many as 20% of patients may have concomitant *H influenzae* meningitis; therefore, a cerebrospinal fluid examination is important. The preferred antibiotics are cefotaxime and ceftriaxone, which cover the pathogens most commonly seen and display good penetration across the blood-brain barrier, achieving high concentration in the cerebrospinal fluid.

In children older than 2 or 3 years, septic hip arthritis is most commonly caused by *S aureus* (50%) or streptococci (25%). The initial choice of antibiotic is either a semisynthetic penicillin (oxacillin) or a first- or second-generation cephalosporin (cefazolin or cefuroxime).

Recently, there have been an increasing number of reports of sepsis due to *Kingella kingae*, a Gram-negative coccobacillus that appears in pairs or short chains. This organism was first described in 1960 and most likely has remained unrecognized or has been dismissed as a pathogen because of its slow, fastidious growth in culture. Colonization occurs in the nasopharynx, with later dissemination into the bloodstream and distal localization in skeletal tissue, the endocardium, and the vascular space.[35] Septic arthritis usually occurs in children less than 4 years of age who have no underlying illness. Suppurative arthritis due to *K kingae* is an acute illness with symptoms occurring more than 4 days before diagnosis in 70% of cases. Fever is present in 85% of patients with septic arthritis. All cases reported to date have been monarticular; the knee is most commonly affected, followed by the hip and ankle. The culture yield for *K kingae* is 87% for joint aspirates, but only 5% to 7% of the patients with joint infections have positive blood cultures.[36] It may take up to 14 days to isolate, with a

greater rate of recovery if the specimen is inoculated in a BACTEC culture bottle (Johnston Laboratories, Towson, Md).[36] The treatment of choice is penicillin therapy.

Gonococcal septic arthritis is caused by the Gram-negative diplococcus *Neisseria gonorrhoeae*. It predominantly affects two age groups: newborns (contracted during birth) and sexually active adolescents (disseminated from a genitourinary tract infection). In adolescents, the typical presentation is tenosynovitis of the hands and feet, rash, and migratory polyarthralgias. The knee is most commonly affected, followed by the hip. The involved joints are painful but generally less so than in other forms of septic arthritis. Special care is needed in the handling of cultures from children suspected of having gonococcal arthritis. Cultures should be placed on warm media (chocolate agar for sterile sites [blood and synovial fluid] and Thayer-Martin agar for nonsterile sites [vagina, rectum, and throat]). Ceftriaxone, administered either intravenously or intramuscularly, is the drug of choice because of increased resistance to penicillin and tetracycline.

Antibiotic therapy is begun only after all specimens have been obtained for culture. Guidelines based on the patient's age and history and the likely source of the infection (i.e., hospital-acquired or community-acquired) can be useful in selecting empirical antibiotic coverage until culture results are available. Antibiotics should initially be administered parenterally to achieve high concentrations quickly in the vascular plexus surrounding the hip joint. This reliably exposes the synovium to a therapeutic concentration of the drug. Joint fluid concentrations average 30% of serum drug concentrations soon after administration and can exceed those in serum just prior to the next dose. Because the concentration of antibiotics is high within the joint fluid during parenteral administration, monitoring of serum levels is rarely needed. The disadvantage of intravenous administration is that it is more expensive and far more inconvenient for the patient.

Oral administration of antibiotics is instituted after an initial good clinical response is seen during intravenous administration. Fever should subside, and the child should demonstrate an increased energy level and appetite, improvement in range of motion of the hip, and increased weight-bearing ability. We generally use parenteral antibiotics for the first 7 days and then switch to oral antibiotics, provided the child has responded well to parenteral antibiotics. Oral administration is more convenient and less expensive and has been shown to be successful in the treatment of septic arthritis when used after parenteral antibiotics. Generally, oral doses for septic arthritis are two to three times the customary dose for a less serious infection and are equivalent to the parenteral dosage (Table 2).[37] Because serum levels are dependent on intestinal absorption, clinical and laboratory monitoring should be performed. Serum bactericidal activity, defined as the greatest dilution of the patient's serum that remains bactericidal for a particular pathogen, correlates best with a successful outcome. It is generally agreed that a serum bactericidal level of at least 1:8 is needed for a successful result. In addition to serum bactericidal levels, the minimum inhibitory concentration of the organism and the peak serum antibiotic concentration (equal to three to five times the minimum inhibitory concentration) are used at our institution.

The duration of antibiotic therapy for septic hip arthritis is controversial, but it is shorter than that required for osteomyelitis and is longer when the pathogen is a more virulent organism, such as *S aureus* or a Gram-negative bacillus. A total of 2 weeks of antibiotic treatment is used for less virulent bacteria. Two to three weeks of antibiotic treatment is added if either *S aureus* or a Gram-negative bacillus is the causative organism.

Table 2
Dosages of Oral Antibiotics Used for Treatment of Serious Infections

Drug	Daily Dose, mg/kg of body weight	Maximum Daily Dose, g	Dosage Interval*
Amoxicillin	100	4	q6h
Ampicillin	150	4	q6h
Cefaclor	120–150	4	q6h
Cefuroxime	75–100	4	q8h
Cephalexin	100	4	q6h
Chloramphenicol	75	2–4	q6h
Clindamycin	30–40	1.2–1.8	q6h
Cloxacillin	100	4	q6h
Dicloxacillin	75–100	4	q6h
Penicillin V	100	4	q6h

*Abbrevations: q6h = once every 6 hours; q8h = once every 8 hours.

If prolonged parenteral antibiotic administration is needed, a peripherally inserted central catheter is safe and very effective and does not carry the risks associated with direct central access.

Surgical Management

Operative intervention should be performed expeditiously in all cases of septic hip arthritis regardless of patient age or causative organism. If purulent fluid is obtained by aspiration in the operating room, we generally perform arthrotomy immediately without waiting for the laboratory fluid analysis. Surgical intervention includes open arthrotomy, evacuation of purulent material, and thorough irrigation of the joint with normal saline. Drilling or curettage of the proximal femoral metaphysis may be necessary if associated osteomyelitis is likely. Arthrotomy thus achieves several objectives: removal of the products of the inflammatory response more rapidly than achievable by the host's response; reduction of the bacterial inoculum, allowing more efficient antibiotic action; and debridement of dead tissue, including the thick fibrinous exudate within the joint, along with joint decompression.

We use a modified anterolateral (Watson-Jones) approach through the interval between the tensor fasciae latae and the gluteus medius. An oblique transverse incision is made just anterior to the tip of the greater trochanter. The tensor fasciae latae is retracted anteriorly, and the gluteus medius is pulled posteriorly. The small fat pad evident in this interval is entered bluntly. This leads one directly onto the anterior capsule at the level of the midportion of the femoral neck. A partial capsulectomy (approximately 0.5 to 1.0 cm^2) should be performed to allow drainage after surgery. Drains placed into the joint to aid in clearance of fluid that has leaked into the adjacent soft tissue should be left for 24 to 48 hours or until the drainage is minimal. All fascial layers should remain open, although subcutaneous and skin layers may be closed.

A direct anterior (Smith-Petersen) approach between the sartorius and the rectus femoris can be used. This avoids the femoral vessels while giving a direct approach to the joint and the proximal femoral metaphysis. More soft-tissue dissection is necessary, and the planes of dissection may be obscured by the edema associated with a septic hip. A posterior approach allows for dependent drainage postoperatively; however, it does not give direct access to the hip joint and may compromise the blood supply of the femoral head.

Postoperatively, external immobilization with a cast or splint is not recommended unless there is instability of the hip. In neonates and infants, instability is more likely; a spica cast or Pavlik harness can be used for several weeks. Bed rest for 24 hours allows time for the synovial inflammation to subside. Passive range-of-motion activity is begun as soon as possible to avoid the deleterious effects of joint immobilization, including proliferation of connective tissue, atrophy of cartilage, and decreases in collagen content.[38]

The incidence of associated osteomyelitis in septic hip arthritis is greater in young infants. Because the proximal femoral metaphysis is intracapsular, direct spread may occur from metaphyseal osteomyelitis into the joint space. The rate of coexisting joint and bone infection is approximately 15%,[39,40] with poor results in 50% to 57% of cases. The presentation of a dual infection is similar to that of an isolated septic hip; however, the diagnosis is not considered in more than 50% of cases. Plain radiographs usually fail to demonstrate changes early in the course of the disease. Technetium bone scanning is useful in diagnosing an associated bone infection. Special attention should be paid to the delayed images. This modality has a high sensitivity (90%) but a low specificity.

A high index of suspicion for associated osteomyelitis is warranted in all cases of septic hip arthritis, especially in young children, those who do not respond to arthrotomy, and those with a prolonged onset of symptoms before hospitalization. If there is a strong suspicion of osteomyelitis, drilling of the proximal metaphysis can be performed at the time of arthrotomy.

Outcome and Management of Sequelae

Of the reported poor results from septic arthritis involving all joints, the hip accounts for approximately 75%. The hip is deeply situated and difficult to assess; furthermore, associated proximal femoral osteomyelitis is common in neonates, and osteonecrosis and pathologic dislocation are unique to the hip.[1] Risk factors for a poor prognosis are patient age less than 6 months, delay in treatment greater than 4 days, associated osteomyelitis of the proximal femur, and infection with *S aureus*.[1,37]

The severe sequelae of septic hip arthritis most often occur in newborns and infants. These include premature closure of the proximal femoral physis or triradiate cartilage, subluxation, dislocation, osteonecrosis of the femoral head, pseudarthrosis of the femoral neck, complete destruction of the femoral head and neck, acetabular dysplasia, and limb-length discrepancy. A classification of these sequelae

was first described by Hunka et al[41] (Fig. 4).

A review of the literature disclosed four long-term follow-up studies evaluating late sequelae of septic hip arthritis.[41-44] In one multicenter study,[42] 28 patients were grouped into two categories on the basis of age.[42] Group I consisted of 18 patients (19 hips) in whom the onset of infection occurred at less than 3 months of age; group II consisted of 10 patients (13 hips) in whom the onset of infection occurred after age 3 months. Group I patients retained more mobility than group II patients and had less pain. In group I, reconstructive surgery resulted in stiffer and more painful hips. The authors recommended avoiding surgical procedures, with the exception of epiphysiodesis and lengthening procedures for residual limb-length discrepancies.

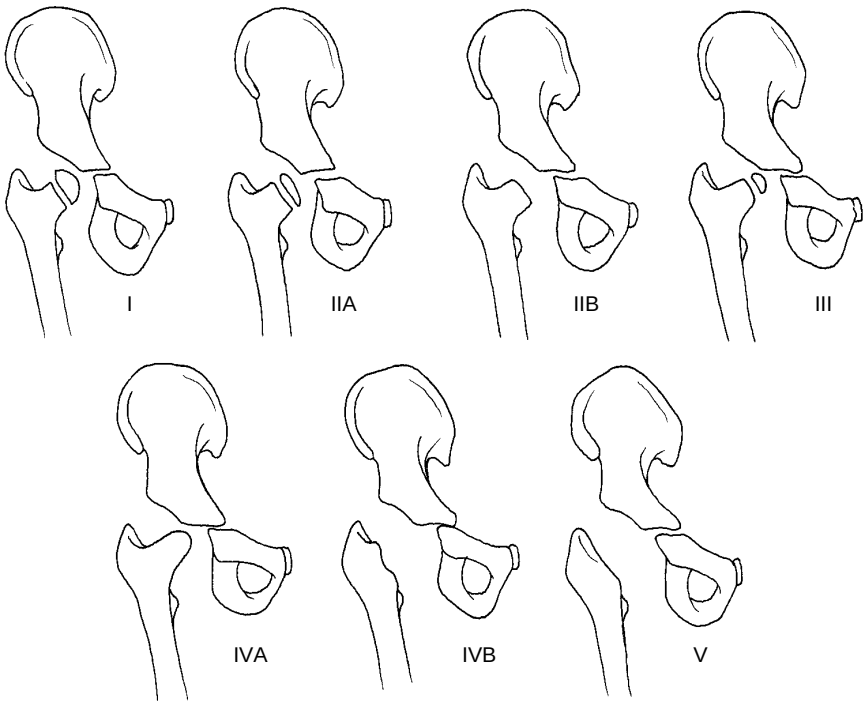


Fig. 4 Radiographic classification of the sequelae of septic hip in children, as developed by Hunka et al.[41]

Because of the small numbers of patients reported on in the literature, it is difficult to provide specific treatment plans. However, on the basis of the five-part classification developed by Hunka et al,[41] we recommend the following guidelines:

In type I hips, there is minimal femoral head collapse, and the most common findings are radiographic changes indicating ischemia or reossification. When this is evident, the treatment is much like that for Perthes disease, with maintenance of hip motion or use of an abduction orthosis or both. The prognosis is generally very good.

Type IIA hips have deformity of the femoral head with an intact physis and should be treated like type I hips. Type IIB hips are characterized by premature fusion of the physis with or without femoral head deformities. Because the premature physeal closure is asymmetric, a residual valgus or varus alignment results, which should be treated with a proximal femoral osteotomy. An acetabular osteotomy may be needed for residual dysplasia. The rate of good results has been reported to be 60% to 70%.[43]

Type III hips are characterized by pseudarthrosis of the femoral neck. Bone grafting of the pseudarthrosis should be attempted only if there is a viable femoral head. If grafting is unsuccessful, the hip should be converted to a type V hip, followed by a greater trochanteric arthroplasty or Girdlestone resection.

Type IVA hips are characterized by complete destruction of the proximal epiphysis with a stable neck segment. The results of treatment are largely dependent on the status of the neck remnant and its relationship to the acetabulum. If the neck remnant is well seated in the acetabulum, adductor and psoas releases will allow greater range of motion. Type IVB hips have a small unstable neck fragment that is not seated in the acetabulum. Hunka et al[41] had three patients with type IVB hips; two underwent proximal femoral osteotomies, and the third was treated with a Chiari osteotomy. All three patients had a successful result.

Type V hips have complete loss of the femoral head and neck and no articulation with the hip. In the review of Choi et al,[43] the only patients with a type V hip who did well were four of seven patients who underwent a trochanteric arthroplasty, which was combined with varus osteotomy and pelvic osteotomy to obtain coverage of the trochanteric arthroplasty. The authors predicted that their patients would eventually have progressive degenerative changes and an unsatisfactory result. On the basis of the experience of the senior author (R.G.), we recommend minimal reconstructive surgery, which may result in weakness and an

abductor lurch but leaves the patient with a pain-free hip with a nearly full range of motion.[44]

Summary

Septic hip arthritis in children continues to be a challenge because of the devastatingly poor results when treatment fails or is begun late. A high index of suspicion is needed when any child presents with a painful hip. A detailed history and careful physical examination, together with a serum analysis and radiographs, help to define the likelihood of septic hip arthritis. Ultrasonography is a powerful diagnostic tool when used in combination with clinical examination. Open drainage, when performed early, offers the best result. Antibiotic therapy is administered for at least 2 weeks and can usually be completed at home. Poor prognostic factors are a patient age less than 1 year, a duration of symptoms longer than 4 days, and associated proximal femoral osteomyelitis. Severe sequelae are best managed with minimal surgical intervention, with the exception of equalization of limb-length discrepancies, soft-tissue releases for a well-seated neck remnant, and realignment procedures in the adequately formed head. Long-term follow-up of all patients is necessary, including the patient with an apparently good early result, because late degenerative changes of the joint may occur.

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