# Current Approach to the Evaluation and Management of Septic Arthritis

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**Abstract:** Septic arthritis is an emergent condition caused by bacterial infection of a joint space. The most common etiology is hematogenous spread from bacteremia, but it can also occur from direct inoculation from bites, injection injuries, cellulitis, abscesses, or local trauma. Septic arthritis occurs most frequently in the lower extremities, with the hips and knees serving as the most common locations. The most sensitive findings include pain with motion of the joint, limited range of motion, tenderness of the joint, new joint swelling, and new effusion. Laboratory testing and imaging can support the diagnosis, but the criterion standard is diagnostic arthrocentesis. Treatment involves intravenous antibiotics and joint decompression.

**Key Words:** arthritis, infection, septic joint

## TARGET AUDIENCE

This CME activity is intended for all practitioners who care for pediatric patients presenting with possible septic arthritis, which may include general pediatricians, pediatric emergency physicians, general emergency physicians, sports medicine physicians, and orthopedic surgeons.

## LEARNING OBJECTIVES

After completion of this article, the reader should be better able to:

1. Describe the signs and symptoms of pediatric septic arthritis.
2. Assess the laboratory and imaging tests that can be utilized to facilitate the diagnosis.
3. Explain the management strategies for pediatric septic arthritis.

Joint pain is a common presentation to the emergency department and can have a wide range of etiologies ranging from benign to life-threatening. One of the most dangerous causes is septic arthritis. Bacterial septic arthritis has been suggested to account for up to 6.5% of all childhood arthritis cases.[1] The overall incidence of septic arthritis has been estimated at 4 to 10 cases per 100,000 children.[2,3]

Risk factors for the development of septic arthritis include young age (ie, aged <3 years), male sex, preceding trauma, immunocompromised state, respiratory distress syndrome, and history of umbilical cord catheterization.[1,4–6] Septic arthritis most commonly affects the lower extremities, primarily involving the knee, hip, and ankle joints.[1,3] While the hip and knee each account for approximately one-third of all pediatric septic joint infections,

the knee is the most frequent overall location in young infants and neonates.[3,7,8] Interestingly, up to 20% of septic arthritis cases may be polyarticular, although this is most common in immunocompromised patients.[7,9,10] Importantly, among pediatric patients with septic arthritis, 10% to 13% of children will have a concomitant osteomyelitis, and 9% to 11% of children will develop bacteremia or sepsis.[1,11]

Septic arthritis is important to diagnose and rapidly treat in order to prevent long-term disability. Therefore, it is essential for providers to understand the historical features, physical examination findings, diagnostic testing, and management options in order to provide optimal care for these patients.

## Anatomy and Pathophysiology

The most common cause of septic arthritis is hematogenous spread of bacteria from concomitant bacteremia, whereas a much smaller proportion of cases are due to direct inoculation from bites, injection injuries, cellulitis, abscesses, or local trauma.[3,7,10,12] Because the cells of the joint lining lack a basement membrane, the joint space is particularly vulnerable to bacteremic seeding.[7,13] Neonates and children younger than 18 months are at the highest risk because of significantly increased vascularity at the physeal plate, allowing for easy translocation of bacteria.[4,5]

Several factors play a role in the evolving epidemiology of pediatric septic arthritis, including improvements in vaccinations, antibiotics, and the changing prevalence of bacteria.[1,13] The causative agent often varies depending on the geographical location and age group.[8,13,14] One study from India found that the majority of cases were caused by methicillin-sensitive *Staphylococcus aureus* (MSSA; 53%), followed by *Escherichia coli* (18%), and *Klebsiella pneumoniae* (13%).[13] Whereas a study of neonates at a hospital in the United States isolated higher rates of group B streptococcus, *Streptococcus pneumoniae*, *Haemophilus influenza*, *Salmonella enterica*, and *Candida albicans*.[14] However, the most frequent organism isolated from the joints of children and adolescents remains *S. aureus*, with a steady rise in the incidence of community-acquired methicillin-resistant *S. aureus* (MRSA) strains.[15,16] These organisms usually gain access to the bloodstream through small breaks in the skin or mucous membranes, whereas septic arthritis from gram-negative species is more likely to arise from bacteremia following injection drug use or damage to the lining of the genitourinary or gastrointestinal tracts.[7,17,18]

Once the bacteria have entered the joint space, they adhere to the synovium and cause damage through several mechanisms, including direct damage from the bacterial toxins and from the host's inflammatory response.[7] The joint cartilage is also susceptible to ischemic injury as it is avascular and dependent on the synovium for oxygen and nutrients.[7] Excessive pressure from the purulent joint fluid accumulation can decrease blood flow to the synovium, further worsening the joint damage.[7]

## History and Physical Examination

Patients may present with a myriad of symptoms, including fever, joint pain, refusal to walk, or limited range of motion in

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the affected joint.[13,17,18] The most sensitive findings include pain with motion of the joint, limited range of motion, tenderness of the joint, new joint swelling, and new effusion.[10,17–21] However, swelling, tenderness, and effusions may be more difficult to detect in deeper joints (eg, hip, shoulder, sacroiliac). Although commonly described, fever is found in only 34% to 54% of patients, and axial load pain is seen in only 36% of cases.[17,18] Several comorbidities increase the likelihood of septic arthritis. For example, diabetes mellitus and rheumatoid arthritis significantly increase the risk of septic arthritis due to immunosuppression, existing joint damage, and a higher propensity for skin infections, which can lead to direct inoculation of the joint.[17,18,22,23]

Unfortunately, younger children and neonates often have a delay in diagnosis because they present in a more atypical fashion and may not be able to provide a reliable history or examination.[8,13] This age group may present with more subtle signs, such as irritability, poor feeding, local warmth, mild joint pain, or pseudoparalysis.[8] Risk factors in this population include prolonged hospital or neonatal intensive care unit stays with multiple peripheral or central intravenous lines, anemia, human immunodeficiency virus infection, low birth weight, and prematurity.[8]

## Diagnostic Testing

While blood tests are often obtained, they are inadequate to exclude the diagnosis of septic arthritis. The serum white blood cell (WBC) may be elevated, but the sensitivity ranges from 42% to 90% with a positive likelihood ratio of only 1.4 to 1.7.[12,17,18,24–27] The erythrocyte sedimentation rate (ESR) differs based on the threshold value that is selected, ranging from a sensitivity of 66% for 15 mm/h to 97% for 30 mm/h.[17,26,28] C-reactive protein (CRP) greater than 10 mg/dL has a sensitivity of 87% to 91%.[28,29] Unfortunately, both CRP and ESR are poorly specific with values ranging from 11% to 49%.[17,26,28,29] Procalcitonin has been found to have a much higher specificity, ranging from 94% to 100%.[29,30] While promising, more data are needed on the diagnostic accuracy of procalcitonin prior to routine use. Blood cultures should be obtained in all patients with suspected septic arthritis, as they can help identify the etiologic agent if the synovial fluid culture is negative. Importantly, up to 14% of patients with negative synovial fluid cultures will have positive blood cultures.[7,10,12,20,21]

Radiographs are often obtained of the affected joint and may demonstrate soft tissue swelling or a joint effusion.[7,31] Ultrasound, computed tomography, and magnetic resonance imaging may be more accurate for identifying the effusion but are unable to confirm or exclude the diagnosis of septic arthritis.[7,31,32] Ultrasound has the added benefit of identifying the optimal site for aspiration and providing real-time guidance during the procedure.[7,32]

The criterion standard for diagnosing septic arthritis is aspiration of the synovial fluid. Synovial fluid analysis can also help with determining alternate etiologies for the joint effusion,

including hemarthrosis, gout, pseudogout, and other forms of inflammatory arthritis (Table 1).[7,12,17,18,21]

While a synovial WBC greater than $50 \times 10^9$/L is concerning for septic arthritis, a synovial WBC greater than $100 \times 10^9$/L is highly specific for the diagnosis.[17,18,33–36] Importantly, an elevated synovial WBC can be found with other inflammatory causes of arthritis (eg, gout, pseudogout).[17,18,21,37] Additionally, one study found that up to half of all patients with culture-proven septic arthritis had a synovial WBC of less than $28 \times 10^9$/L.[37] Synovial polymorphonuclear leukocytes (PMNs) are also typically elevated in septic arthritis but are only 60% sensitive and 78% specific when the synovial PMNs are greater than 90%.[17] Therefore, while synovial WBC or PMNs can suggest the diagnosis, they are insufficiently accurate to confirm or exclude the diagnosis in isolation.

Lyme arthritis can present a challenge to clinicians practicing in Lyme-endemic areas, as patients can present with an isolated monoarthritis, and synovial fluid findings often overlap those of septic arthritis.[38–40] The following features are more suggestive of septic arthritis in these populations: age younger than 2 years, involvement of a nonknee joint, fever, refusal to bear weight, pain with short arc motion, elevated peripheral WBC count, elevated ESR, elevated CRP, and a significantly elevated synovial WBC count ($>100 \times 10^9$/L).[40–43] However, given the significant overlap in features, it is advisable to also obtain Lyme serology (ie, immunoglobulins M and G) in endemic areas when there is suspicion of Lyme arthritis.[43]

Other diagnostic studies, such as glucose, protein, lactate, and crystal analysis, may also be helpful; however, the single most important study to obtain is a Gram stain and culture.[17] This is particularly important with neonates and younger infants, in whom the total synovial fluid may not be sufficient to run all of the available tests. While the Gram stain can be used to suggest the diagnosis, it should not be relied upon to exclude septic arthritis in isolation, as studies have found that the sensitivity is only 29% to 65%.[12,37,44–48] Synovial fluid cultures will identify the underlying pathogen in more than 80% of cases.[7,17,18] False-negatives can occur due to a variety of reasons, including presentation very early in the clinical course, obtaining a sample after antibiotics are given, inadequate fluid sample, arthrocentesis of a nearby incorrect joint space or bursa, and poor plating technique.[7,17,12,18,21,49] In these cases, the diagnosis is often made based on a combination of clinical and laboratory results or operative findings. To decrease the likelihood of a false-negative culture, larger amounts of synovial fluid should be collected when possible, and samples intended for culture should be placed in blood culture bottles.[7]

## Management

The management of pediatric septic arthritis includes intravenous antibiotics and joint decompression with irrigation. Antibiotic

**TABLE 1.** Synovial Fluid Findings in Monoarticular Arthritis[7,12,17,18,21]

| Synovial Fluid Measure | Normal Fluid | Noninflammatory | Hemorrhagic | Inflammatory | Septic |
|---|---|---|---|---|---|
| Color | Clear | Yellow | Red | Yellow | Yellow/green |
| Clarity | Transparent | Transparent | Bloody | Translucent-opaque | Opaque |
| Viscosity | High | High | Variable | Low | Variable |
| WBCs | $<2 \times 10^9$/L | $<2 \times 10^9$/L | $<2 \times 10^9$/L | $2–100 \times 10^9$/L | $10–100 \times 10^9$/L |
| Percentage of PMNs | <25% | <25% | 50%–75% | >50% | >75%–80% |
| Culture result | Negative | Negative | Negative | Negative | Usually positive |

therapy is initiated empirically to cover the suspected organism based on age, vaccination status, and underlying comorbidities.[4,5,50] Historically, *H. influenza* was a common cause of septic arthritis and osteomyelitis.[51] However, with the widespread prevalence of vaccination against *H. influenza*, infections have declined dramatically.[51] The underlying causes can vary significantly by age group. For example, the primary causes of septic arthritis in neonates are group B streptococcus, *S. aureus*, and gram-negative organisms.[52–54] Therefore, first-line treatment usually consists of oxacillin or cefotaxime plus gentamicin.[52–54] In older children, pathogens include MSSA, *Streptococcus pyogenes*, and *Kingella kingae*.[52] As a result, antibiotic coverage for this group includes either an antistaphylococcal penicillin (eg, oxacillin, nafcillin) or a first-generation cephalosporin.[52]

*Staphylococcus aureus*, including both MSSA and MRSA, remains the most common overall cause of septic arthritis in all age groups, but the proportion of resistant organisms has increased over the past 2 decades.[55–57] In a retrospective study of confirmed osteomyelitis or septic arthritis, rates of MRSA rose from 11.8% in 2001–2002 to 34.8% in 2009–2010.[15] Consequently, it has been recommended to provide empiric coverage for MRSA if local MRSA rates are higher than 10% or the patient has MRSA risk factors (eg, recent hospitalization, injection drug use, immunocompromise).[4,5,15,54] Vancomycin is considered first-line for MRSA coverage, whereas linezolid, clindamycin, and daptomycin are alternatives that may provide adequate coverage depending on local resistance patterns.[54,58–63] Importantly, *K. kingae* is often resistant to vancomycin and clindamycin, so a penicillin or cephalosporin should also be given pending culture results.[64] Special consideration should be paid to patients with sickle cell disease as they are at higher risk of infection from *Salmonella* species.[65,66] Treatment for these patients should include a third-generation cephalosporin (eg, cefotaxime, ceftriaxone) or a fluoroquinolone (eg, ciprofloxacin).[65,67] Additionally, if Lyme arthritis is on the differential, providers should include an agent that is active against *Borrelia burgdorferi* (ie, doxycycline, amoxicillin with probenecid, or ceftriaxone) while awaiting serologic results.[68]

Classically, intravenous antibiotics for septic arthritis have been continuously given for 4 to 6 weeks.[69] However, recent studies have demonstrated that shorter durations of therapy are noninferior, while also having a lower rate of adverse effects.[70,71] One prospective study of pediatric patients found that 86% of patients were able to transition to oral antibiotics by day 5.[71] In this study, a persistently elevated CRP was the most common finding associated with the need for continued parenteral therapy.[71] Another study found that patients could safely be transitioned to oral antibiotics when the CRP levels dropped below 2 mg/dL.[66,72] If CRP testing is not readily available, current literature supports transitioning to oral antibiotics within 5 days in uncomplicated cases.[70,71,73–78] Ten total days of oral therapy is typically sufficient for treatment of uncomplicated septic arthritis, although this should be extended to 20 days if there is concomitant osteomyelitis.[64,73]

Several studies have suggested a potential short-term benefit to glucocorticoid therapy; however, long-term results have been inconclusive.[64,79–81] These studies have found that patients treated with dexamethasone had a shorter duration of fever, fewer local inflammatory signs, less pain, lower levels of acute phase reactants, shorter duration of parenteral antibiotics, and a shorter hospital length of stay.[79–81] Most studies used a dose of 0.15 mg/kg of dexamethasone given every 6 hours for 4 days.[79–81] However, it is important to discuss the use of this agent with the orthopedic surgery and infectious disease team prior to initiation.

Rapid joint decompression is another important component of therapy to reduce the risk of subsequent complications.[82] Joint decompression can include either open arthrotomy or serial needle aspirations. The type and number of repeat procedures vary, depending on the severity of illness, patient age, and involved joint.[83] The literature remains controversial regarding whether to pursue open arthrotomy or needle aspiration. However, several studies have found that needle aspiration with irrigation is associated with similar outcomes and a shorter length of hospital stay when compared with open arthrotomy.[82–86] While needle aspiration has similar outcomes in many joints, open arthrotomy is usually preferred in the hip due to the potential for worse outcomes in this area.[82,83] However, one recent study suggested that if the patient had symptoms for less than 5 days and is otherwise healthy, repeated needle joint aspirations may be as effective as arthrotomy in this location.[87]

## Complications

Potential complications from septic arthritis include osteomyelitis, bacteremia, and sepsis, as well as direct joint damage.[64,88] Destruction of the surrounding cartilage and bone can also result in growth disturbance, joint dislocation, premature degenerative arthritis, and loss of joint function.[88–94] The rate of complications is highest in neonates and those with delayed diagnoses.[89,91–93] Neonates may not manifest growth deformities for years and should be followed through skeletal maturity.[92,95] Deformities and bone length discrepancies are usually tolerated better in the upper extremities than the lower extremities.[96] Septic arthritis caused by MRSA infections is associated with an increased risk of subperiosteal abscesses, as well as higher rates of septic shock, longer hospital stays, more surgical interventions, and a higher risk of long-term sequelae.[57,88]

## Disposition

All cases of septic arthritis require admission and the initiation of intravenous antibiotics. An orthopedic surgeon should be consulted as soon as septic arthritis is suspected. Patients may additionally benefit from an infectious disease consult, although this is less urgent. Patients with septic arthritis should be followed after discharge to monitor for long-term complications.

## CONCLUSIONS

Septic arthritis is an emergent condition caused by bacterial infection of a joint space. This review article discusses the pathophysiology, historical features, physical examination findings, diagnostic strategies, and treatment for this dangerous condition. Knowledge of these aspects can assist providers in effectively identifying and managing this important condition.

## REFERENCES

1. Okubo Y, Nochioka K, Marcia T. Nationwide survey of pediatric septic arthritis in the United States. *J Orthop*. 2017;14:342–346.

2. Montgomery NI, Epps HR. Pediatric septic arthritis. *Orthop Clin North Am*. 2017;48:209–216.

3. Arnold JC, Bradley JS. Osteoarticular infections in children. *Infect Dis Clin North Am*. 2015;29:557–574.

4. Agarwal A, Aggarwal A. Bone and joint infections in children: septic arthritis. *Indian J Pediatr*. 2016;83:825–833.

5. Agarwal A, Aggarwal A. Bone and joint infections in children: acute hematogenous osteomyelitis. *Indian J Pediatr*. 2016;83:817–824.

6. Grammatico-Guillon L, Maakaroun Vermesse Z, Baron S, et al. Paediatric bone and joint infections are more common in boys and toddlers: a national epidemiology study. *Acta Paediatr*. 2013;102:e120–e125.

7. Ross JJ. Septic arthritis of native joints. *Infect Dis Clin North Am*. 2017;31: 203–218.

8. Sankaran G, Zacharia B, Roy A, et al. Current clinical and bacteriological profile of septic arthritis in young infants: a prospective study from a tertiary referral centre. *Eur J Orthop Surg Traumatol*. 2018;28:573–578.

9. Dubost JJ, Fis I, Denis P, et al. Polyarticular septic arthritis. *Medicine (Baltimore)*. 1993;72:296–310.

10. Goldenberg DL, Reed JI. Bacterial arthritis. *N Engl J Med*. 1985;312: 764–771.

11. Montgomery CO, Siegel E, Blasier RD, et al. Concurrent septic arthritis and osteomyelitis in children. *J Pediatr Orthop*. 2013;33:464–467.

12. Goldenberg DL, Cohen AS. Acute infectious arthritis. A review of patients with nongonococcal joint infections (with emphasis on therapy and prognosis). *Am J Med*. 1976;60:369–377.

13. Motwani G, Mehta R, Aroojis A, et al. Current trends of microorganisms and their sensitivity pattern in paediatric septic arthritis: a prospective study from tertiary care level hospital. *J Clin Orthop Trauma*. 2017;8:89–92.

14. Bono KT, Samora JB, Klingele KE. Septic arthritis in infants younger than 3 months: a retrospective review. *Orthopedics*. 2015;38:e787–e793.

15. Sarkissian EJ, Gans I, Gunderson MA, et al. Community-acquired methicillin-resistant *Staphylococcus aureus* musculoskeletal infections: emerging trends over the past decade. *J Pediatr Orthop*. 2016;36:323–327.

16. Mahmoudi S, Pourakbari B, Borhani K, et al. Acute osteomyelitis and septic arthritis in children. *Wien Med Wochenschr*. 2017;167:259–263.

17. Carpenter CR, Schuur JD, Everett WW, et al. Evidence-based diagnostics: adult septic arthritis. *Acad Emerg Med*. 2011;18:781–796.

18. Margaretten ME, Kohlwes J, Moore D, et al. Does this adult patient have septic arthritis? *JAMA*. 2007;297:1478–1488.

19. Kaandorp CJ, Dinant HJ, van de Laar MA, et al. Incidence and sources of native and prosthetic joint infection: a community based prospective survey. *Ann Rheum Dis*. 1997;56:470–475.

20. Cooper C, Cawley MI. Bacterial arthritis in an English health district: a 10 year review. *Ann Rheum Dis*. 1986;45:458–463.

21. Mathews CJ, Coakley G. Septic arthritis: current diagnostic and therapeutic algorithm. *Curr Opin Rheumatol*. 2008;20:457–462.

22. Gardner GC, Weisman MH. Pyarthrosis in patients with rheumatoid arthritis: a report of 13 cases and a review of the literature from the past 40 years. *Am J Med*. 1990;88:503–511.

23. Weston VC, Jones AC, Bradbury N, et al. Clinical features and outcome of septic arthritis in a single UK Health District 1982–1991. *Ann Rheum Dis*. 1999;58:214–219.

24. Schlapbach P, Ambord C, Blöchlinger AM, et al. Bacterial arthritis: are fever, rigors, leucocytosis and blood cultures of diagnostic value? *Clin Rheumatol*. 1990;9:69–72.

25. Jeng GW, Wang CR, Liu ST, et al. Measurement of synovial tumor necrosis factor-alpha in diagnosing emergency patients with bacterial arthritis. *Am J Emerg Med*. 1997;15:626–629.

26. Li SF, Henderson J, Dickman E, et al. Laboratory tests in adults with monoarticular arthritis: can they rule out a septic joint. *Acad Emerg Med*. 2004;11:276–280.

27. Li SF, Cassidy C, Chang C, et al. Diagnostic utility of laboratory tests in septic arthritis. *Emerg Med J*. 2007;24:75–77.

28. Ernst AA, Weiss SJ, Tracy LA, et al. Usefulness of CRP and ESR in predicting septic joints. *South Med J*. 2010;103:522–526.

29. Fottner A, Birkenmaier C, von Schulze Pellengahr C, et al. Can serum procalcitonin help to differentiate between septic and nonseptic arthritis? *Art Ther*. 2008;24:229–233.

30. Martinot M, Sordet C, Soubrier M, et al. Diagnostic value of serum and synovial procalcitonin in acute arthritis: a prospective study of 42 patients. *Clin Exp Rheumatol*. 2005;23:303–310.

31. Coakley G, Mathews C, Field M, et al., British Society for Rheumatology Standards, Guidelines and Audit Working Group. BSR & BHPR, BOA, RCGP and BSAC guidelines for management of the hot swollen joint in adults. *Rheumatology (Oxford)*. 2006;45:1039–1041.

32. Valley VT, Stahmer SA. Targeted musculoarticular sonography in the detection of joint effusions. *Acad Emerg Med*. 2001;8:361–367.

33. Söderquist B, Jones I, Fredlund H, et al. Bacterial or crystal-associated arthritis? discriminating ability of serum inflammatory markers. *Scand J Infect Dis*. 1998;30:591–596.

34. Krey PR, Bailen DA. Synovial fluid leukocytosis. A study of extremes. *Am J Med*. 1979;67:436–442.

35. Shmerling RH, Delbanco TL, Tosteson AN, et al. Synovial fluid tests: what should be ordered? *JAMA*. 1990;264:1009–1014.

36. Kortekangas P, Aro HT, Tuominen J, et al. Synovial fluid leukocytosis in bacterial arthritis vs. reactive arthritis and rheumatoid arthritis in the adult knee. *Scand J Rheumatol*. 1992;21:283–288.

37. McCutchan HJ, Fisher RC. Synovial leukocytosis in infectious arthritis. *Clin Orthop Relat Res*. 1990;226–230.

38. Nigrovic LE, Bennett JE, Balamuth F, et al. Accuracy of clinician suspicion of Lyme disease in the emergency department. *Pediatrics*. 2017; 140:e20171975.

39. Deanehan JK, Nigrovic PA, Milewski MD, et al. Synovial fluid findings in children with knee monoarthritis in Lyme disease endemic areas. *Pediatr Emerg Care*. 2014;30:16–19.

40. Dart AH, Michelson KA, Aronson PL, et al. Hip synovial fluid cell counts in children from a Lyme disease endemic area. *Pediatrics*. 2018; 141:e20173810.

41. Baldwin KD, Brusalis CM, Nduaguba AM, et al. Predictive factors for differentiating between septic arthritis and Lyme disease of the knee in children. *J Bone Joint Surg Am*. 2016;98:721–728.

42. Deanehan JK, Kimia AA, Tan Tanny SP, et al. Distinguishing Lyme from septic knee monoarthritis in Lyme disease–endemic areas. *Pediatrics*. 2013;131:e695–e701.

43. Milewski MD, Cruz AI Jr, Miller CP, et al. Lyme arthritis in children presenting with joint effusions. *J Bone Joint Surg Am*. 2011;93:252–260.

44. Argen RJ, Wilson CH Jr, Wood P. Suppurative arthritis. Clinical features of 42 cases. *Arch Intern Med*. 1966;117:661–666.

45. Riordan T, Doyle D, Tabaqchali S. Synovial fluid lactic acid measurement in the diagnosis and management of septic arthritis. *J Clin Pathol*. 1982;35: 390–394.

46. Faraj AA, Omonbude OD, Godwin P. Gram staining in the diagnosis of acute septic arthritis. *Acta Orthop Belg*. 2002;68:388–391.

47. McGillicuddy DC, Shah KH, Friedberg RP, et al. How sensitive is the synovial fluid white blood cell count in diagnosing septic arthritis? *Am J Emerg Med*. 2007;25:749–752.

48. Belhaj A, Badawi A, Lee C, et al. Utility of Gram stain and cell counts for diagnosing septic arthritis. *Int J Antimicrob Ag*. 2009;34:S2.

49. Fye KH. Arthrocentesis, synovial fluid analysis, and synovial biopsy. In: Klippel JH, ed. *Primer on the Rheumatic Diseases*. 12th ed. Atlanta, GA: Arthritis Foundation; 2001:138–144.

50. Faust SN, Clark J, Pallett A, et al. Managing bone and joint infection in children. *Arch Dis Child*. 2012;97:545–553.

51. Bowerman SG, Green NE, Mencio GA. Decline of bone and joint infections attributable to *Haemophilus influenza* type b. *Clin Orthop Relat Res*. 1997;128–133.

52. Afghani B, Kong V, Wu FL. What would pediatric infectious disease consultants recommend for management of culture-negative acute hematogenous osteomyelitis? *J Pediatr Orthop*. 2007;27:805–809.

53. Harik NS, Smeltzer MS. Management of acute hematogenous osteomyelitis in children. *Expert Rev Anti Infect Ther*. 2010;8:175–181.

54. Kaplan SL. Osteomyelitis in children. *Infect Dis Clin North Am*. 2005;19: 787–797.

55. Combs K, Cox K. Clinical outcomes involving patients that develop septic arthritis with methicillin sensitive *Staphylococcus aureus* versus methicillin resistant *Staphylococcus aureus*. *J Orthop*. 2017;15:9–12.

56. Thomsen I, Creech CB. Advances in the diagnosis and management of pediatric osteomyelitis. *Curr Infect Dis Rep*. 2011;13:451–460.

57. Arnold SR, Elias D, Buckingham SC, et al. Changing patterns of acute hematogenous osteomyelitis and septic arthritis: emergence of community-associated methicillin-resistant *Staphylococcus aureus*. *J Pediatr Orthop*. 2006;26:703–708.

58. Martínez-Aquilar G, Hammerman WA, Mason EO Jr, et al. Clindamycin treatment of invasive infections caused by community-acquired, methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* in children. *Pediatr Infect Dis J*. 2003;22:593–598.

59. Liu C, Bayer A, Cosgrove SE, et al., Infectious Diseases Society of America. Clinical practice guidelines by the Infectious Disease Society of America for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children. *Clin Infect Dis*. 2011;52:e18–e55.

60. Carrillo-Marquez M, Hulten K, Hammerman W, et al. USA300 is the predominant genotype causing *Staphylococcus aureus* septic arthritis in children. *Pediatr Infect Dis J*. 2009;28:1076–1080.

61. Feigin RD, Pickering LK, Anderson D, et al. Clindamycin treatment of osteomyelitis and septic arthritis in children. *Pediatrics*. 1975;55:213–223.

62. Kaplan SL, Mason EO Jr, Feigin RD. Clindamycin versus nafcillin or methicillin in the treatment of *Staphylococcus aureus* osteomyelitis in children. *South Med J*. 1982;75:138–142.

63. Namtu K, Crain J, Messina AF, et al. Clinical experience with daptomycin in pediatrics. *Pharmacotherapy*. 2017;37:105–108.

64. Dodwell E. Osteomyelitis and septic arthritis in children: current concepts. *Curr Opin Pediatr*. 2013;25:58–63.

65. Lorrot M, Gillet Y, Gras Le Guen C, et al. Antibiotic therapy of bone and joint infections in children: proposals of the French Pediatric Infectious Disease Group. *Arch Pediatr*. 2017;24:S36–S41.

66. Castellazzi L, Mantero M, Esposito S. Update on the management of pediatric acute osteomyelitis and septic arthritis. *Int J Mol Sci*. 2016;17.

67. Peltola H, Pääkkönen M. Acute osteomyelitis in children. *N Engl J Med*. 2014;370:352–360.

68. Arvikar SL, Steere AC. Diagnosis and treatment of Lyme arthritis. *Infect Dis Clin North Am*. 2015;29:269–280.

69. Grimbly C, Odenbach J, Vandermeer B, et al. Parenteral and oral antibiotic duration for treatment of pediatric osteomyelitis: a systematic review protocol. *Syst Rev*. 2013;2:92.

70. Peltola H, Pääkkönen M, Kallio P, et al., Osteomyelitis-Septic Arthritis Study Group. Short- versus long-term antimicrobial treatment for acute hematogenous osteomyelitis of childhood: prospective, randomized trial on 131 culture-positive cases. *Pediatr Infect Dis J*. 2010;29:1123–1128.

71. Jagodzinski NA, Kanwar R, Graham K, et al. Prospective evaluation of shortened regimen of treatment for acute osteomyelitis and septic arthritis in children. *J Pediatr Orthop*. 2009;29:518–525.

72. Arnold J, Cannavino C, Ross MK, et al. Acute bacterial osteoarticular infections: eight-year analysis of C-reactive protein for oral step-down therapy. *Pediatrics*. 2012;130:e821–e828.

73. Peltola H, Pääkkönen M, Kallio P, et al. Osteomyelitis-Septic Arthritis Study Group. Prospective, randomized trial of 10 days versus 30 days of antimicrobial treatment, including a short-term course of parenteral therapy, for childhood septic arthritis. *Clin Infect Dis*. 2009;48:1201–1210.

74. Bachur R, Pagon Z. Success of short-course parenteral antibiotic therapy for acute osteomyelitis of childhood. *Clin Pediatr (Phila)*. 2007;46:30–35.

75. Le Saux N, Howard A, Barrowman NJ, et al. Shorter courses of parenteral antibiotic therapy do not appear to influence response rates for children with acute hematogenous osteomyelitis: a systemic review. *BMC Infect Dis*. 2002;2:16.

76. Vinod MB, Matussek J, Curtis N, et al. Duration of antibiotics in children with osteomyelitis and septic arthritis. *J Paediatr Child Health*. 2002;38: 363–367.

77. Pääkkönen M, Peltola H. Antibiotic treatment for acute haematogenous osteomyelitis of childhood: moving towards shorter courses and oral administration. *Int J Antimicrob Agents*. 2011;38:273–280.

78. Zaoutis T, Localio AR, Leckerman K, et al. Prolonged intravenous therapy versus early transition to oral antimicrobial therapy for acute osteomyelitis in children. *Pediatrics*. 2009;123:636–642.

79. Odio CM, Ramirez T, Arias G, et al. Double blind, randomized, placebo-controlled study of dexamethasone therapy for hematogenous septic arthritis in children. *Pediatr Infect Dis J*. 2003;22:883–888.

80. Harel L, Prais D, Bar-On E, et al. Dexamethasone therapy for septic arthritis in children. *J Pediatr Orthop*. 2011;31:211–215.

81. Fogel I, Amir J, Bar-On E, et al. Dexamethasone therapy for septic arthritis in children. *Pediatrics*. 2015;136:e776–e782.

82. Tornero E, De Bergua-Domingo JM, Domenech P, et al. Knee arthritis in children: when can be safely treated with needle joint aspiration? A large children's tertiary hospital study [published online ahead of print September 22, 2016]. *J Pediatr Orthop*. 2016.

83. El-Sayed AM. Treatment of early septic arthritis of the hip in children: comparison of results of open arthrotomy versus arthroscopic drainage. *J Child Orthop*. 2008;2:229–237.

84. Thompson R, Gourineni R. Arthroscopic treatment of septic arthritis in very young children. *J Pediatr Orthop*. 2017;37:e53–e57.

85. Griffet J, Oborocianu I, Rubio A, et al. Percutaneous aspiration irrigation drainage technique in the management of septic arthritis in children. *J Trauma*. 2011;70:377–383.

86. Johns B, Loewenthal M, Ho E, et al. Arthroscopic versus open treatment for acute septic arthritis of the knee in children. *Pediatr Infect Dis J*. 2018;37: 413–418.

87. Xu G, Spoerri M, Rutz E. Surgical treatment options for septic arthritis of the hip in children. *Afr J Paediatr Surg*. 2016;13:1–5.

88. Dohin B, Gillet Y, Kohler R, et al. Pediatric bone and joint infections caused by Panton-Valentine leukocidin-positive *Staphylococcus aureus*. *Pediatr Infect Dis J*. 2007;26:1042–1048.

89. Peters W, Irving J, Letts M. Long-term effects of neonatal bone and joint infection on adjacent growth plates. *J Pediatr Orthop*. 1992;12:806–810.

90. Cheng JC, Lam TP. Femoral lengthening after type IVB septic arthritis of the hip in children. *J Pediatr Orthop*. 1996;16:533–539.

91. Fabry G, Meire E. Septic arthritis of the hip in children: poor results after late and inadequate treatment. *J Pediatr Orthop*. 1983;3:461–466.

92. Gillespie R. Septic arthritis of childhood. *Clin Orthop Relat Res*. 1973;152:159.

93. Howard JB, Highgenboten CL, Nelson JD. Residual effects of septic arthritis in infancy and childhood. *JAMA*. 1976;236:932–935.

94. Hunka L, Said SE, MacKenzie DA, et al. Classification and surgical management of the severe sequelae of septic hips in children. *Clin Orthop Relat Res*. 1982;30–36.

95. Strong M, Lejman T, Michno P, et al. Sequelae from septic arthritis of the knee during the first two years of life. *J Pediatr Orthop*. 1994;14:745–751.

96. Lejman T, Strong M, Michno P, et al. Septic arthritis of the shoulder in the first 18 months of life. *J Pediatr Orthop*. 1995;15:172–175.