■ REVIEW ARTICLE

The management of septic arthritis in children

SYSTEMATIC REVIEW OF THE ENGLISH LANGUAGE LITERATURE

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We performed a systematic review of the optimal management of septic arthritis in children as recommended in the current English literature using MEDLINE, EMBASE, CINAHL, the Cochrane Library and reference lists of retrieved articles without date restrictions up to 31 January 2009. From 2236 citations, 227 relevant full-text articles were screened in detail; 154 papers fulfilled the inclusion criteria, from which conclusions were drawn on the management of infected joints in children.

Our review showed that no single investigation, including joint aspiration, is sufficiently reliable to diagnose conclusively joint infection. The roles of aspiration, arthrotomy and arthroscopy in treatment are not clear cut, and the ideal duration of antibiotic therapy is not yet fully defined. These issues are discussed. Further large-scale, multi-centre studies are needed to delineate the optimal management of paediatric septic arthritis.

Although uncommon, septic arthritis must be ruled out in the child with a painful joint. Delay or failure in instituting appropriate management may be due to several factors, such as difficulties in obtaining an accurate history and problems encountered examining young children in pain. We performed a systematic review of the literature to identify the best available evidence on the diagnosis and treatment of paediatric septic arthritis. The aims were to identify relevant diagnostic factors, and to review the current evidence underlying the most commonly used treatment strategies.

Materials and Methods

We used the following electronic bibliographic databases: MEDLINE (Medical Literature Analysis and Retrieval System online, Bethesda, Maryland), EMBASE (Excerpta Medica Database, Amsterdam, The Netherlands), CINAHL (Cumulative Index to Nursing and Allied Health Literature, Ipswich, Massachusetts) and the Cochrane Library¹ without date restrictions up to 31 January 2009. In order to avoid missing contemporary studies that remain unpublished the Google Scholar search engine was also used. The keywords and Medical Subject Heading (MeSH) terms which were used were p(a)ediatric, 'joint infection', 'septic arthritis', 'antibiotics', 'surgery' and 'joint aspiration'. We screened the reference lists of included articles to identify any further relevant studies. We then reviewed the titles,

abstracts and full texts of apparently relevant articles to determine their eligibility.

Eligibility criteria. Only comparative studies, analytical studies and case series written in English were included. We excluded studies with fewer than 20 cases, abstract-only publications and review articles (Table I). A total of 154 papers fulfilled the inclusion criteria (Fig. 1).

Extraction of data. Data were extracted from the eligible articles and differences were resolved by discussion. Each study was also reviewed for the quality of its methodology. Comparative studies were assessed using Detsky et al's² scoring system for randomised controlled trials, and case series were assessed using Bland-Altman³ analysis, which allowed assessment of inter-rater agreement for the quality of studies. A descriptive summary of the results is presented.

Results

Incidence. Paediatric articular infection is uncommon. Studies performed over two different decades in Dallas^{4,5} demonstrated an unchanging incidence of 1 in 100 000. In Israel, an incidence of 37 in 100 000 has been noted.⁶ However, in the developing world the situation is different. The incidence of septic arthritis in children in Malawi has recently been reported to be 1 in 5000.⁷ Another prospective African study reported an incidence of 1 in 20 000.⁸

Causative organisms. The most common organism causing septic arthritis in children is

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doi:10.1302/0301-620X.91B9.22530 \$2.00

J Bone Joint Surg [Br]
2009;91-B:1127-33.

Table I. Inclusion and exclusion criteria

Inclusion	Exclusion
Randomised studies	Patients > 16 years of age
Retrospective, observational studies	Case series < 20 patients
Controlled clinical trials	Studies not on articular infections such as cellulitis
Meta-analyses	Review articles
English language publications	Management of septic arthritis beyond the first three weeks Reactive, tuberculous or Lyme arthritides

Fig. 1

Flow chart showing the number of full-text articles that fulfilled the inclusion criteria.

Staphylococcus aureus, followed by group A *Streptococcus* and *Enterobacter*.⁹⁻¹⁴ *Haemophilus influenza* has been virtually eliminated by vaccination,¹⁵ but given the decrease in uptake of childhood immunisation as a result of the recent erosion of public confidence in vaccine safety, this organism should be reconsidered. Children with sickle-cell disease are at risk for salmonella-related osteoarticular infections¹⁶ and salmonella is the most common cause of septic arthritis in infants in Kenya,¹⁷ Malawi¹⁸ and Zambia.¹⁹

Improved techniques have led to the detection of unusual organisms such as *Kingella kingae*.^{6,20} Recent reports have emphasised the changing microbiological patterns in musculoskeletal infections, especially with respect to the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA).^{5,21}

Risk factors. Several risk factors for septic arthritis in children have been recognised (Table II). Prematurity and low birth weight have been excluded as risk factors.²²

Clinical symptoms and signs. Children with acute septic arthritis typically have a painful, swollen joint. Parents may

ascribe this to a preceding minor injury. Physical examination is likely to demonstrate an effusion, a restriction in the range of movement of the affected joint, tenderness and increased local warmth.⁹ With later presentations the child may be systematically unwell, with swelling of the entire extremity or associated cellulitis or abscess formation. Unfortunately, in infants and neonates typical symptoms and signs may be lacking.²³ Signs may be as subtle as irritability or limited spontaneous movement in one limb (pseudo-paralysis).²³

Any joint may be affected, although the hips and knees are the most commonly involved.^{24,25} Owing to the variation in defining the presence or absence of pyrexia, direct comparison between papers is difficult. All the studies reviewed concluded that other clinical signs, imaging and inflammatory markers were necessary in combination with pyrexia to exclude septic arthritis.²⁶⁻³²

Laboratory findings. *White cell count.* The response of the white cell count is related to age and is usually elevated in

Table II. Risk factors for the development of septic arthritis in children

Young age ^{10,15,34,82}
Male gender ^{6,22,34,45,53,64,82-84}
Increased susceptibility to infection, whether by sickle-cell haemoglobinopathy/underdevelopment/low birth-weight/prematurity ^{57,85}
Respiratory distress syndrome ⁵⁷
Umbilical artery catheterisation ⁵⁷

older children, sometimes elevated in younger children and only rarely elevated in neonates.^{33,34} In one study, only a third of patients with infected hips had an elevated white cell count.³⁵

Erythrocyte sedimentation rate (ESR). In a retrospective review of the medical records of 138 children, including neonates, presenting with acute hip pain, the ESR alone had a sensitivity of 79%.³⁰ The ESR in isolation is of variable sensitivity, but in combination with an elevated temperature, white cell count and an inability to bear weight, it is an important exclusion parameter, with sensitivities consistently above 98%.^{26,31}

C-reactive protein (CRP). In one prospective trial the CRP level had the highest predictive value for septic arthritis and was the only risk factor strongly associated with outcome at a 5% level of significance.²⁷ This is borne out by other studies that advocate a more conservative approach to treatment for limping children with a proven hip effusion and CRP < 10 mg/ml, as septic arthritis is very unlikely.^{32,36,37}

Management algorithms. Several studies have attempted to define algorithms to improve the diagnosis and subsequent treatment of septic arthritis, especially of the hip.^{27,29,31,38,39} The algorithms include clinical and serological parameters such as weight-bearing status, the presence of pyrexia, and raised white cell count, ESR and CRP. They are not necessarily applicable in all settings, and their validity must be tested locally.^{29,31,39} However, other than weight-bearing status, the currently published clinical algorithms do not include physical examination. Algorithms should supplement and not substitute clinical decision-making in all cases.^{27,39}

Microbiological culture. The rate of positive identification of pathogens from blood and synovial fluid culture ranges from 34% to 82% in the current literature.^{25,40-43} Synovial fluid Gram stains may only be positive in 30% of aspirates.⁴³ Synovial fluid white cell count > 50 000 must be correlated with the clinical picture to exclude other diagnoses, such as juvenile idiopathic arthritis.⁴⁴

Three studies have looked at the prognosis related to the findings of blood and synovial cultures, and two^{45,46} of these found that culture-negative patients ran a milder clinical course, although the third⁴³ found no difference. Synovial fluid cultures were more sensitive than blood cultures in these studies.^{43,45,46} However, in several cases blood cultures but not joint aspirates were positive, and should therefore be performed in tandem.^{43,45,46}

Imaging. Plain radiographs. Plain radiographs are required to differentiate septic arthritis from other diagnoses, such as established osteomyelitis, fractures and neoplasia. An increase in joint space may reflect an effusion.⁴⁷

Ultrasound. Ultrasound remains the most sensitive tool for detecting an effusion in the hip.⁴⁸ However, there is a false-negative rate of 5%.⁴⁹ Ultrasound-guided aspiration of the hip evacuates pus, reduces damage to the articular surfaces, differentiates joint sepsis from other arthritides and helps direct antibiotic treatment.⁵⁰ A negative ultrasound result when excluding septic arthritis in children must be interpreted with caution when symptoms have been present for less than 24 hours, or when there is bilateral disease.⁴⁹

Magnetic resonance imaging (MRI). MRI is extremely sensitive and specific in diagnosing septic arthritis of the hip and differentiating it from osteomyelitis and non-infective causes of hip pain in children.⁵¹ Statistically significant MRI findings in transient synovitis are an effusion in the contralateral (asymptomatic) joint and the absence of signal intensity abnormalities of the bone marrow.⁵² It is less common to have signal intensity alterations and contrast enhancement of the adjacent soft tissues. The statistically significant MR findings in septic arthritis are signal intensity alterations of the bone marrow, and signal intensity alterations and contrast enhancement of the adjacent soft tissues.^{53,54} MR scanning in very young patients requires a general anaesthetic, which limits its applicability.

There are no current studies evaluating the use of either ultrasound or MRI in diagnosing septic arthritis in joints other than the hip.

Bone scintigraphy. This is particularly useful in identifying multifocal musculoskeletal infections, but lacks sensitivity and specificity in distinguishing septic arthritis from nearby osseous or soft-tissue infections.^{55,56}

Management. Antibiotics. Early administration of antibiotics is widely supported in the literature,^{33,57-61} and although microbiological evidence of infection is preferred,⁴⁶ antimicrobials should not be withheld once diagnostic procedures have been performed.^{46,62} Conversely, there is little consensus on the choice of antibiotic, the choice often being made locally based on the most likely infecting organism. Suggested or recommended regimens include the septic arthritis Clinical Practice Guideline algorithm⁶³ and the current British Society for Antimicrobial Chemotherapy guidelines (Table III).⁶²

Although there is agreement that antibiotics should be initially given intravenously and then orally once clinical improvement is evident, there is debate on the recommended duration of intravenous (IV) therapy, varying greatly from two to six or seven weeks.⁶⁴⁻⁶⁶ However, there is growing evidence in the recent literature for short-course IV therapy.⁶⁷ One prospective randomised trial concluded

Table III. Empirical therapy guidelines from the British Society for antimicrobial chemotherapy⁶²

Because of the potential for permanent joint damage if suboptimal treatment is given, treatment should be discussed with your microbiologist

The following are suitable empirical antibiotic regimens:

Non high-risk patients

High-dose, μ V flucloxacillin plus benzylpenicillin (plus either fusidic acid or rifampicin, depending on the severity of infection)

If the patient is in a high-risk group, has pre-existing rheumatoid arthritis, or Gram-negative organisms were identified on Gram stain, treatment can be modified as follows:

High-dose, intravenous flucloxacillin plus either an aminoglycoside such as gentamicin or a quinolone such as ciprofloxacin (plus either fusidic acid or rifampicin depending on severity)

or

A second-generation cephalosporin such as cefuroxime (plus either fusidic acid or rifampicin depending on severity)

In penicillin-allergic patients:

Clindamycin plus a quinolone such as ciprofloxacin

or

Vancomycin plus a quinolone such as ciprofloxacin

If MRSA* is suspected, consult your microbiologist, as treatment will depend on local antibiotic susceptibilities. The following general principles usually apply:

intravenous vancomycin should be used instead of flucloxacillin

Gentamicin or a quinolone such as ciprofloxacin can be added to vancomycin, subject to local policies and the advice of your microbiologist

If clinical signs indicate gonococcal septic arthritis, suitable treatments include:

High-dose IV second- or third-generation cephalosporin such as cefuroxime or cefotaxime

or

A quinolone such as ciprofloxacin plus flucloxacillin

* MRSA, methicillin-resistant *Staphylococcus aureus*

that short-course IV antibiotic treatment (seven days) is adequate, and that longer term treatment should be reserved for patients who failed to respond to the shorter regimen or who otherwise presented with clear clinical and microbiological counter-indicatory criteria.⁶⁸ An earlier study found that shortened IV therapy in accordance with a patient's response to treatment resulted in no recurrence or persistence of infection.¹²

There are no publications on the use of intra-articular antibiotics in children.

Joint aspiration versus arthrotomy and washout. As the sequelae of paediatric hip sepsis can be devastating, arthrotomy has been advocated as the best method of treatment.⁶⁹ It may also provide an opportunity to obtain specimens for microbiology and histology. Arthrotomy for infants diagnosed with a septic hip, and joint aspiration for older children presenting within four days of the onset of symptoms, have also been advocated.²³

Aspiration under ultrasound guidance⁷⁰ has been proposed for the diagnosis of hip sepsis, although doubt remains as to both the adequacy of decompression and the need for further aspiration. In a prospective, randomised study, aspiration of septic shoulder joints showed no significant difference in clinical and radiological outcome at one year compared to open arthrotomy and washout.⁷¹ There are no studies comparing aspiration *versus* arthrotomy for septic arthritis of hip in children.

Arthroscopy. A prospective controlled study comparing the outcome of formal arthrotomy of the hip *versus* arthroscopic drainage showed the only significant difference to be a shortened in-patient stay (6.4 days *vs* 3.8 days).⁷² There are currently no studies examining the role of arthroscopy in the treatment of infection of the knee joint in children.

Prognosis. The advances in diagnosing and treating septic arthritis, including the use of antibiotics, have led to a significantly reduced mortality, from 50% in 1874⁷³ to < 1% in 1973.⁷⁴ Indicators of poor prognosis include:

1. Young age. This is due to difficulties in diagnosing septic arthritis, leading to a delay in initiating treatment,^{33,45} and to the presence of transphyseal vessels in neonates seeding bacteria from adjacent osteomyelitis. This may be compounded by the immaturity of the immune response.

2. Delay in initiating treatment. An excellent outcome is obtained in 75% of cases if symptoms are present for less than four days; this falls to 15% if symptoms are present for more than four days.^{33,35,75,76}

3. Organism. Many studies indicate a worse prognosis for infections with *Staphylococcus aureus*,^{25,33,44,77} which may be related to the virulence of this organism and an associated cell-mediated immunological reaction in response to the bacterial exoprotein.⁴⁵ The presence of collagen receptors may account for the tropism of *Staphylococcus aureus* to septic joints.⁴⁵

Table IV. Summary findings

<i>Staphylococcus aureus</i> and group A streptococci are among the most common organisms associated with septic arthritis in children
Typical signs and symptoms may be absent, particularly in neonates and infants
C-reactive protein combined with weight-bearing status, temperature and white cell count is a useful tool in the diagnosis of septic arthritis in children
Ultrasonography is a quick, non-invasive technique that aids diagnosis, especially for the hip joint
Early initiation of intravenous therapy is recommended, although choice of therapy is a local decision based on the most likely pathogen
The length of antibiotic therapy should be based on responses of clinical and serological parameters
Arthrotomy and/or arthroscopy provide an opportunity to obtain specimens that identify the pathogen(s) where other culture samples may have failed
A multidisciplinary approach to management of septic arthritis in children is required

4. Site. The hip has the worst outcome of all joints, as elevated intracapsular pressure causes occlusion or thrombosis of retinacular and transphyseal vessels, and also because sepsis induces subluxation of the femoral head.^{8,78,79}

Discussion

This paper is a comprehensive review of the current English language literature on the management of septic arthritis in children. Systematic reviews are useful as a tool in clinical decision making, especially in orthopaedic surgery where primary studies of small sample size predominate, provided the review is performed with strict methodological criteria. For this study, broad eligibility criteria were chosen for generalisability. However, restricting the study selection to English language journals was a potential source of bias. Conclusions based on English language studies has been shown to lead to significant overestimation of effects.^{80,81} As there was only one randomised controlled trial, the other studies carried the risk of ascertainment bias, as they were retrospective and narrative in nature. Outcome measures are difficult to compare between studies included in this review because of their considerable heterogeneity.

This review of current evidence identified key findings related to the management of septic arthritis in children. Given the low incidence of this condition in the antibiotic era, recognising and diagnosing septic arthritis is difficult. This may be compounded by the lack of clear clinical signs and symptoms, especially in younger, less co-operative patients. Unfortunately, a single gold standard test for diagnosing septic arthritis in children does not exist. However, current studies^{27,32,36,37} have emphasised the importance of normal CRP levels as having a high predictive value for excluding septic arthritis.

The hip is the only joint that has been extensively evaluated with respect to imaging, and although there are several drawbacks with respect to all imaging modalities, ultra-

sound appears to be the investigation of choice.^{10,18,50} The implementation of diagnostic algorithms^{27,29,31,38,39} does not guarantee detection of all cases. Careful examination by an experienced clinician is therefore mandatory.

The problem of low sensitivities of blood and synovial cultures can be addressed by newer techniques such as real-time polymerase chain reaction for detecting organisms such as *Kingella kingae*,^{6,20} but this requires a high level of awareness. The causative pathogen in most children is a Gram-positive micro-organism.¹⁰⁻¹⁴ β -lactam antibiotics can therefore be commenced as first-line treatment in the absence of allergy. If there is doubt, or the child is at high risk for less typical organisms, then consultation with a microbiologist is advised.⁶²

Once a diagnosis of septic arthritis is made, questions remain about the optimal method of treatment. Although literature exists regarding the efficacy of antibiotic therapy,^{33,57-60} no articles prospectively comparing outcomes following the use of antibiotics alone *versus* arthrotomy and antibiotics in combination could be identified. Given the unreliability of microbiological cultures,^{25,41,42,44-46} arthroscopy and/or arthrotomy provide the clinician with an opportunity to obtain tissue for culture. The ideal duration of antibiotic therapy and the route of administration are also yet to be defined. However, there is mounting evidence that a shortened duration^{12,67,68} (less than six weeks) of therapy does not have a deleterious effect.

It is clear that the management of septic arthritis in children requires a multidisciplinary approach involving surgeons, paediatricians, radiologists, microbiologists and nurses. Therefore, an integrated evidence-based approach is required in ensuring optimal management with minimal variation in the standards of care for this group of patients.

It was for this reason that the literature review, was not restricted to orthopaedic publications alone to define the optimal management regimen. However, there is a paucity

of stringent evidence, which is likely to be multifactorial in origin. The low incidence^{4,6,15} of septic arthritis in children and its presentation to different specialties creates difficulties in recruiting sufficient numbers of patients into prospective, randomised controlled trials. The establishment of a national registry would help provide a source of continuous data, which could be used to benchmark care. Important findings from this review are summarised in Table IV.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. No authors listed. The cochrane library. <http://www.thecochranelibrary.com> (date last accessed 27 July 2009).
2. Detsky AS, Naylor CD, O'Rourke K, McGeer AJ, L'Abbe K. Incorporating variations in the quality of individual randomized trials into meta-analysis. *J Clin Epidemiol* 1992;45:225-65.
3. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;327:307-10.
4. Jackson MA, Nelson JD. Etiology and medical management of acute suppurative bone and joint infections in pediatric patients. *J Pediatr Orthop* 1982;2:313-23.
5. Gafur OA, Copley LA, Hollmig ST, et al. The impact of the current epidemiology of pediatric musculoskeletal infection on evaluation and treatment guidelines. *J Pediatr Orthop* 2008;28:777-85.
6. Yagupsky P, Bar-Ziv Y, Howard CB, Dagan R. Epidemiology, etiology, and clinical features of septic arthritis in children younger than 24 months. *Arch Pediatr Adolesc Med* 1995;149:537-40.
7. Lavy CB, Peek AC, Majolo G. The incidence of septic arthritis in Malawian children. *Int Orthop* 2005;29:195-6.
8. Nunn TR, Cheung WY, Rollinson PD. A prospective study of pyogenic sepsis of the hip in childhood. *J Bone Joint Surg [Br]* 2007;89-B:100-6.
9. Georgens ED, McEvoy A, Watson M, Barrett IR. Acute osteomyelitis and septic arthritis in children. *J Paediatr Child Health* 2005;41:59-62.
10. Gordon JE, Wolff A, Luhmann SJ, et al. Primary and delayed closure after open irrigation and debridement of septic arthritis in children. *J Pediatr Orthop [B]* 2005;14:101-4.
11. Kao HC, Huang YC, Chiu CH, et al. Acute hematogenous osteomyelitis and septic arthritis in children. *J Microbiol Immunol Infect* 2003;36:260-5.
12. Kim HK, Alman B, Cole WG. A shortened course of parenteral antibiotic therapy in the management of acute septic arthritis of the hip. *J Pediatr Orthop* 2000;20:44-7.
13. Maraqa NF, Gomez MM, Rathore MH. Outpatient parenteral antimicrobial therapy in osteoarticular infection in children. *J Pediatr Orthop* 2002;22:506-10.
14. Luhmann JD, Luhmann SJ. Etiology of septic arthritis in children: an update for the 1990s. *Pediatr Emerg Care* 1999;15:40-2.
15. Jackson MA, Burry VF, Olson LC. Pyogenic arthritis associated with adjacent osteomyelitis: identification of the sequela-prone child. *Pediatr Infect Dis* 1992;11:9-13.
16. Al-Salem AH, Ahmed HA, Qaisaruddin S, et al. Osteomyelitis and septic arthritis in sickle cell disease in the eastern province of Saudi Arabia. *Int Orthop* 1992;16:398-402.
17. Nduati RW, Wamola IA. Bacteriology of acute septic arthritis. *J Trop Paediatr* 1991;37:172-5.
18. Molyneux E, French G. Salmonella joint infection in Malawian children. *J Infect* 1982;4:131-8.
19. Lavy CB, Lavy VR, Anderson I. Salmonella septic arthritis of the shoulder in Zambian children. *J R Coll Surg Edinb* 1996;41:197-9.
20. Chometon S, Chaker M, Benito Y, et al. Specific real-time polymerase chain reaction places *Kingella kingae* as the most common cause of osteoarticular infections in young children. *Pediatr Infect Dis* 2007;26:377-81.
21. 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;26:703-8.
22. Deshpande PG, Wagle SU, Mehta SD, Bharucha BA, Irani SF. Neonatal osteomyelitis and septic arthritis. *Indian Pediatr* 1990;27:453-7.
23. Wilson NI, Di Paola M. Acute septic arthritis in infancy and childhood: 10 years' experience. *J Bone Joint Surg [Br]* 1986;68-B:584-7.
24. Ahmed H, Dix-Peek S, Martin N, Hoffman EB. Septic arthritis in children: a 20-year study. *J Bone Joint Surg [Br]* 2005;87-B(Suppl III):279.
25. Welton CJ, Long SS, Fisher MC, Alburger PD. Pyogenic arthritis in infants and children: a review of 95 cases. *Pediatr Infect Dis* 1986;5:669-76.
26. Jung ST, Rowe SM, Moon ES, et al. Significance of laboratory and radiologic findings for differentiating between septic arthritis and transient synovitis of the hip. *J Pediatr Orthop* 2003;23:368-72.
27. Caird MS, Flynn JM, Leung YL, et al. Factors distinguishing septic arthritis from transient synovitis of the hip in children: a prospective study. *J Bone Joint Surg [Am]* 2006;88-A:1251-7.
28. Klein DM, Barbera C, Gray ST, et al. Sensitivity of objective parameters in the diagnosis of pediatric septic hips. *Clin Orthop* 1997;338:153-9.
29. Kocher MS, Mandiga R, Zurakowski D, Barnewolt C, Kasser JR. Validation of a clinical prediction rule for the differentiation between septic arthritis and transient synovitis of the hip in children. *J Bone Joint Surg [Am]* 2004;86-A:1629-35.
30. Del Beccaro MA, Champoux AN, Bockers T, Mendelman PM. Septic arthritis versus transient synovitis of the hip: the value of screening laboratory tests. *Ann Emerg Med* 1992;21:1418-22.
31. Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children. *J Bone Joint Surg [Am]* 1999;81-A:1662-70.
32. Levine MJ, McGuire KJ, McGowan KL, Flynn JM. Assessment of the test characteristics of C-reactive protein for septic arthritis in children. *J Pediatr Orthop* 2003;23:373-7.
33. Bennett OM, Namyak SS. Acute septic arthritis of the hip joint in infancy and childhood. *Clin Orthop* 1992;281:123-32.
34. Chen CE, Ko JY, Li CC, Wang CJ. Acute septic arthritis of the hip in children. *Arch Orthop Trauma Surg* 2001;121:521-6.
35. Morrey BF, Bianco AJ, Rhodes KH. Supportive arthritis of the hip in children. *J Bone Joint Surg [Am]* 1976;58-A:388-92.
36. Eich GF, Superti-Furga A, Umbricht FS, Willi UV. The painful hip: evaluation of criteria for clinical decision making. *Eur J Paediatr* 1999;158:923-8.
37. Kunnamo I, Kallio P, Pelkonen P, Hovi T. Clinical signs and laboratory tests in the differential diagnosis of arthritis in children. *Am J Dis Child* 1987;141:34-40.
38. Delaney RA, Lenehan B, O'Sullivan L, McGuinness AJ, Street JT. The limping child: an algorithm to outrule musculoskeletal sepsis. *Ir J Med Sci* 2007;176:181-7.
39. Luhmann SJ, Jones A, Schootman M, et al. Differentiation between septic arthritis and transient synovitis of the hip in children with clinical prediction algorithms. *J Bone Joint Surg [Am]* 2004;86-A:956-62.
40. Lyon RM, Evanich JD. Culture-negative septic arthritis in children. *J Pediatr Orthop* 1999;19:655-9.
41. Fink CW, Nelson JD. Septic arthritis and osteomyelitis in children. *Clin Rheum Dis* 1986;12:423-35.
42. Gandini D. Acute septic arthritis of the hip in children in northern Australia. *ANZ J Surg* 2003;73:136-9.
43. Geirsson AJ, Statkevics S, Vikingsson A. Septic arthritis in Iceland 1990-2002: increasing incidence due to iatrogenic infections. *Ann Rheum Dis* 2008;67:638-43.
44. Baldassare AR, Chang F, Zuckner J. Markedly raised synovial fluid leucocyte counts not associated with infectious arthritis in children. *Ann Rheum Dis* 1978;37:404-9.
45. Wang CL, Wang SM, Yang YJ, Tsai CH, Liu CC. Septic arthritis in children: relationship of causative pathogens, complications, and outcome. *J Microbiol Immunol Infect* 2003;36:41-6.
46. Chang WS, Chiu NC, Chiu H, Li WC, Huang FY. Comparison of the characteristics of culture-negative versus culture-positive septic arthritis in children. *J Microbiol Immunol Infect* 2005;38:189-93.
47. Volberg FM, Sumner TE, Abramson JS, Winchester PH. Unreliability of radiographic diagnosis of septic hip in children. *Pediatrics* 1984;73:118-20.
48. Zamzam MM. The role of ultrasound in differentiating septic arthritis from transient synovitis of the hip in children. *J Pediatr Orthop B* 2006;15:418-22.
49. Gordon JE, Huang M, Dobbs M, et al. Causes of false-negative ultrasound scans in the diagnosis of septic arthritis of the hip in children. *J Pediatr Orthop* 2002;22:312-16.
50. Zawin JK, Hoffer FA, Rand FF, Teele RL. Joint effusion in children with an irritable hip: US diagnosis and aspiration. *Radiology* 1993;187:459-63.
51. Mazur JM, Ross G, Cummings J, Hahn GA Jr, McCluskey WP. Usefulness of magnetic resonance imaging for the diagnosis of acute musculoskeletal infections in children. *J Pediatr Orthop* 1995;15:144-7.
52. Kwack KS, Cho JH, Lee JH, et al. Septic arthritis versus transient synovitis of the hip: gadolinium-enhanced MRI finding of decreased perfusion at the femoral epiphysis. *AJR Am J Roentgenol* 2007;189:437-45.

53. Yang WJ, Im SA, Lim GY, et al. MR imaging of transient synovitis: differentiation from septic arthritis. *Pediatr Radiol* 2006;36:1154-8.
54. Lee SK, Suh KJ, Kim YW, et al. Septic arthritis versus transient synovitis at MR imaging: preliminary assessment with signal intensity alterations in bone marrow. *Radiology* 1999;211:459-65.
55. Tuson CE, Hoffman EB, Mann MD. Isotope bone scanning for acute osteomyelitis and septic arthritis in children. *J Bone Joint Surg [Br]* 1994;76-B:306-10.
56. Sundberg SB, Savage JP, Foster BK. Technetium phosphate bone scan in the diagnosis of septic arthritis in childhood. *J Pediatr Orthop* 1989;9:579-85.
57. Frederiksen B, Christiansen P, Knudsen FU. Acute osteomyelitis and septic arthritis in the neonate, risk factors and outcome. *Eur J Pediatr* 1993;152:577-80.
58. Herndon WA, Knauer S, Sullivan JA, Gross RH. Management of septic arthritis in children. *J Pediatr Orthop* 1986;6:576-8.
59. Learmonth ID, Dall G, Pollock DJ. Acute osteomyelitis and septic arthritis in children: a simple approach to treatment. *S Afr Med J* 1984;65:117-20.
60. Yuan HC, Wu KG, Chen CJ, Tang RB, Hwang BT. Characteristics and outcome of septic arthritis in children. *J Microbiol Immunol Infect* 2006;39:342-7.
61. Petersen S, Knudsen FU, Andersen EA, Egeblad M. Acute haematogenous osteomyelitis and septic arthritis in childhood: a 10-year review and follow-up. *Acta Orthop Scand* 1980;51:451-7.
62. No authors listed. British Society for Antimicrobial Chemotherapy. <http://www.bsac.org.uk/pyxis/Bone%20and%20joint/Septic%20arthritis/Septic%20arthritis.htm> (date last accessed 28 February 2009).
63. Kocher MS, Mandiga R, Murphy JM, et al. A clinical practice guideline for treatment of septic arthritis in children: efficacy in improving process of care and effect on outcome of septic arthritis of the hip. *J Bone Joint Surg. [Am]* 2003;85-A:994-9.
64. Peltola H, Vahvanen V. Acute purulent arthritis in children. *Scand J Infect Dis* 1983;15:75-80.
65. Cole WG, Elliott BG, Jensen F. The management of septic arthritis in childhood. *Aust N Z J Surg* 1975;45:178-82.
66. Lavy CB, Thyoka M. For how long should antibiotics be given in acute paediatric septic arthritis: a prospective audit of 96 cases. *Trop Doct* 2007;37:195-7.
67. Vinod MB, Matussek J, Curtis N, Graham HK, Carapetis JR. Duration of antibiotics in children with osteomyelitis and septic arthritis. *J Paediatr Child Health* 2002;38:363-7.
68. Jaber FM, Shahcheraghi GH, Ahadzadeh M. Short-term intravenous antibiotic treatment of acute hematogenous bone and joint infection in children: a prospective randomized trial. *J Bone Joint Surg [Br]* 1970;52-B:474-82.
69. Paterson DC. Acute suppurative arthritis in infancy and childhood. *J Bone Joint Surg [Br]* 1970;52-B:474-82.
70. Givon U, Liberman B, Schindler A, Blankstein A, Ganel A. Treatment of septic arthritis of the hip joint by repeated ultrasound-guided aspirations. *J Pediatr Orthop* 2004;24:266-70.
71. Smith SP, Thyoka M, Lavy CB, Pitani A. Septic arthritis of the shoulder in children in Malawi: a randomised, prospective study of aspiration versus arthrotomy and washout. *J Bone Joint Surg [Br]* 2002;84-B:1167-72.
72. El-Sayed AMM. Treatment of early septic arthritis of the hip in children: comparison of results of open arthrotomy versus arthroscopic drainage. *J Child Orthop* 2008;2:229-37.
73. Smith T. On the acute arthritis of infants. *St Bartholomew's Hospital Reports* 1874;10:189-204.
74. Gillespie R. Septic arthritis of childhood. *Clin Orthop* 1973;96:152-9.
75. Samilson RL, Bersani FA, Watkins MB. Acute suppurative arthritis in infants and children: the importance of early diagnosis and surgical drainage. *Pediatrics* 1958;21:798-804.
76. Fabry G, Meiere E. Septic arthritis of the hip in children: poor results after late and inadequate treatment. *J Pediatr Orthop* 1983;3:461-6.
77. Lunseth PA, Heiple KG. Prognosis in septic arthritis of the hip in children. *Clin Orthop* 1979;139:81-5.
78. Wang EB, Ji SJ, Zhao Q, Zhang LJ. Treatment of severe sequelae of infantile hip sepsis with trochanteric arthroplasty. *J Pediatr Orthop* 2007;27:165-70.
79. Hunka L, Said SE, MacKenzie DA, Rogala EJ, Cruess RL. Classification and surgical management of the severe sequelae of septic hip in children. *Clin Orthop* 1982;171:30-6.
80. Egger M, Zellweger-Zahner T, Schneider M, et al. Language bias in randomised controlled trials published in English and German. *Lancet* 1997;350:326-9.
81. Gregoire G, Derderian F, Le Lorier J. Selecting the language of the publications included in a meta-analysis: is there a Tower of Babel bias? *J Clin Epidemiol* 1995;48:159-63.
82. Riise ØR, Handeland KS, Cvancarova M, et al. Incidence and characteristics of arthritis in Norwegian children: a population-based study. *Pediatrics* 2008;121:299-306.
83. Umer M, Hashmi P, Ahmad T, Umar M. Septic arthritis of the hip in children: Aga Khan University Hospital experience in Pakistan. *J Pak Med Assoc* 2003;53:472-8.
84. Caksen H, Öztürk MK, Uzüm K, et al. Septic arthritis in childhood. *Pediatr Int* 2000;42:534-40.
85. Mijiyawa M, Oniankita O, Attah-Mensah K, et al. Musculoskeletal conditions in children attending two Togolese hospitals. *Rheumatology (Oxford)* 1999;38:1010-13.