Treatment

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QUESTION 1: What are the indications for surgical intervention in cases of osteomyelitis/septic arthritis? How should treatment progress and resolution be monitored?

RECOMMENDATION: Septic arthritis is an orthopaedic emergency and needs prompt surgical treatment. Based on current evidence, there are no clear indications for the timing of surgical intervention in cases of osteomyelitis. The current literature does suggest monitoring disease progression, treatment efficacy and resolution by trending C-reactive protein (CRP) levels.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 91%, Disagree: 3%, Abstain: 6% (Super Majority, Strong Consensus)

RATIONALE

The treatment of musculoskeletal infections in children has long been debated. Evidence has shown that it can be appropriate to treat this condition medically. However, surgery can play a critical therapeutic role for patients not responding to medical treatment or those presenting with massive bioburden in the joint that may require evacuation.

Osteomyelitis in the pediatric population often has overlapping clinical features with other diseases, making its diagnosis challenging [1]. Not only are the clinical presentations diverse, the epidemiologic aspects of the pathology also play a critical role in its therapy. Patient age, sex, socioeconomic status and even geographical location all point to different etiologies, making treatment choices challenging [1,2]. Patients living in the United States can be at particular risk of aggressive osteomyelitis infections due to the presence of highly virulent strains of methicillin-resistant *Staphylococcus aureus* (MRSA). Ninety percent of MRSA isolates found in the U.S. are related to the USA300 strain which is positive for *pvl* and *fnbB* genes–coding for the Panton-Valentine Leucocidin toxin and fibronectin binding factor respectively [3]. Patients contracting strains such as these are at increased risk of subperiosteal abscess formation, septic thrombophlebitis, endocarditis and large muscle abscesses [3]. Another pathogen, *Kingella kingae*, has also recently emerged as an etiology of osteomyelitis and septic arthritis with a milder clinical presentation as well as lower inflammatory markers and white-blood cell (WBC) counts [4]. This further emphasizes the diversity in which these conditions can present.

Because of the multifaceted nature of osteomyelitis, care of these patients requires a coordinated, multidisciplinary approach in order to avoid potentially devastating complications of a missed osteomyelitis diagnosis [1]. As with many conditions in medicine, early diagnosis and treatment initiation are paramount. Unfortunately, there are no gold standard tests to aid in the diagnosis of septic arthritis or osteomyelitis in the pediatric patient population [5]. Additionally, the lack of clear-cut surgical indications makes treatment plans complicated [1,6–9].

Osteomyelitis was found to be concomitant with septic arthritis in about 30% of cases [1,3]. Typically, bacteria seed in the metaphyseal region of long bones where capillaries make sharp turns resulting in serpentine routes of blood flow [1,3,5]. If the infection develops in the intracapsular portion of metaphyseal bone (i.e., proximal femur, humerus, radius or lateral distal tibia) there is a higher likelihood of extension into the joint space [1,3]. Joint space involvement creates an increase in intra-articular pressure, recruitment of leukocytes and subsequent release of cytokines, which can cause cartilage damage in as little as eight hours [4,10].

Proponents for surgical intervention have argued that the operative intervention can halt the disease progression [1,6,11]. Surgery and debridement of the joint can reduce the likelihood for osteonecrosis by enhancing the vascular supply to the bone, thereby allowing for improved antibiotic delivery and penetration to the site of infection [6]. Likewise, with osteoarticular involvement, decompressing and washing out the joint helps stem permanent damage by decreasing intra-articular pressure and reducing proteolytic enzymes resulting in degradation of the cartilage and sub-chondral bone [10,11].

Despite these valid arguments, studies have not been conducted that effectively define surgical indications for osteomyelitis and septic arthritis. Indications for surgery in the literature are based on expert opinions, case series and cohort studies with none providing evidence-based clinical guidelines for surgical intervention in the case of osteomyelitis [6,7,9]. Additionally, the surgical procedures used for osteomyelitis are diverse, ranging from bone biopsy and subperiosteal abscess drainage to more involved procedures, such as the creation of a cortical window and extensive debridement [1]. Dartnell et al. conducted a systematic review of the literature and found very little evidence to support surgical intervention in pediatric patients with osteomyelitis and/or septic arthritis due to a lack of randomized controlled trials [8]. At best, current recommendations for surgery include [1,6–8,12]:

- Failure to improve in 48-72 hours despite antibiotic treatment
- Presence of frank pus on aspiration of the joint
- Identification of sequestered abscess

However, none of these recommendations come with quantitative evidence from randomized controlled studies.

Septic arthritis is considered an orthopaedic emergency and necessitates prompt treatment [13–15]. Across the current literature, it is well agreed that septic arthritis requires surgical removal of the inciting materials [5,10]. Guidelines and appropriate randomized trials to establish statistical evidence are still lacking. Moreover, numerous suggestions of the exact joint decompression technique exist (i.e., arthrotomy versus arthroscopy versus needle aspiration).

El-Sayed et al. conducted a prospective controlled study to compare hip arthrotomy versus arthroscopy in the setting of septic

hip arthritis [13]. Open arthrotomy had been considered the gold standard at the time of his study. The latter study reported no statistical differences in clinical results (according to Bennett's clinical assessment criteria), such as prolonged post-operative joint aches, joint range of motion limitations or infection recurrence [13]. Mean hospital length of stay was shorter for the arthroscopic group compared to the arthrotomy group (mean of 3.8 days versus 6.4 days, $p < 0.0001$) [13]. The results of this study suggest that hip arthroscopy is a valid alternative to hip arthrotomy for septic arthritis of the hip joint. Similar findings were reported by another study [5].

For septic arthritis of the knee, arthroscopy tends to be the operative choice [12,13]. Again, data is lacking to support these claims. Other studies have suggested that arthrotomy may be better for septic arthritis of the shoulder and the hip joint due to the tight space in these joints to allow entry of arthroscopic instruments [10,12]. Baker et al. noted that arthroscopy can be a viable alternative as well in the shoulder and ankle joints [12]. Conversely, Peltola et al. report in their prospective randomized trial that most of the included patients in their study did not require any operative procedures beyond a diagnostic aspiration [16]. Despite the debate over the technique and necessity of surgical interventions, the literature does emphasize that early diagnosis and prompt treatment are paramount when caring for suspected septic arthritis patients [5,8,10,13].

Other studies have attempted to streamline the diagnostic approach to patients with suspected septic arthritis. Kocher et al. established a clinical algorithm in order to aid in early diagnosis of pediatric septic hips [14]. Their criteria included the inability or refusal of the patient to bear weight, history of fever (defined as an oral temperature >38.5 °C), a serum WBC count greater than 12,000 cells/mm^3 and an erythrocyte sedimentation rate (ESR) greater than 40 mm/hr [14]. Later studies found greater efficacy when incorporating CRP into this algorithm [17–19]. However, this clinical algorithm has not been fully validated across all populations and further studies must be carried out before it can be applied universally [15,20].

Despite significant heterogeneity in the literature regarding surgical indications and operative techniques for osteomyelitis and septic arthritis, there is more of a consensus on the use of CRP and ESR for aiding in diagnosis and monitoring treatment response [8,17]. CRP has been proven as an effective test for diagnosis and monitoring of response to treatment [5,8,10,16]. ESR was classically associated as a laboratory marker for osteomyelitis but has now been widely replaced by CRP [10]. The short half-life of CRP allows for more precise monitoring for efficacy of treatment. Decreasing CRP levels are indicative of treatment efficacy [8,16]. Pääkkönen et al. found that even with persistent pyrexia, decreasing CRP levels could be used to justify switching antibiotics from intravenous to oral [10]. They also report that they were able to safely discontinue antibiotics after 10 days as long as CRP levels were less than 20 mg/dL [10,16]. In circumstances when the CRP levels does not decline or continues to increase, further workup or additional interventions may be necessary as this suggests a suboptimal clinical response to the current treatment [16].

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QUESTION 2: How radical should surgery be for osteomyelitis/septic arthritis?

RECOMMENDATION: In pediatric patients with osteomyelitis/septic arthritis who require surgical intervention, aggressive debridement and copious irrigation of the infected joint is required.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 89%, Disagree: 7%, Abstain: 4% (Super Majority, Strong Consensus)