Acute Osteomyelitis in Children

Heikki Peltola, M.D., and Markus Pääkkönen, M.D.

Bacteria may reach bone through direct inoculation from traumatic wounds, by spreading from adjacent tissue affected by cellulitis or septic arthritis, or through hematogenous seeding. In children, an acute bone infection is most often hematogenous in origin.1

In high-income countries, acute osteomyelitis occurs in about 8 of 100,000 children per year,2 but it is considerably more common in low-income countries. Boys are affected twice as often as girls.2,3 Unless acute osteomyelitis is diagnosed promptly and treated appropriately,4 it can be a devastating or even fatal disease with a high rate of sequelae, especially in resource-poor countries where patients present with advanced disease and survivors often have complications that are serious and long-lasting.

Staphylococcus aureus is by far the most common causative agent in osteomyelitis, followed by the respiratory pathogens Streptococcus pyogenes and S. pneumoniae.5-9 For unknown reasons, Haemophilus influenzae type b is more likely to affect joints than bones. Salmonella species are a common cause of osteomyelitis in developing countries and among patients with sickle cell disease.10 Infections due to Kingella kingae are increasing and are most common in children younger than 4 years of age.11

Common Manifestations

When osteomyelitis is diagnosed, it is classified as acute if the duration of the illness has been less than 2 weeks, subacute for a duration of 2 weeks to 3 months, and chronic for a longer duration.1,2,12 Since any bone can be affected, patients can present with a wide variety of symptoms and signs. Multifocal osteomyelitis may occur at any age but occurs most frequently in neonates.1

Classic clinical manifestations in children are limping or an inability to walk, fever and focal tenderness, and sometimes visible redness and swelling around a long bone, more often in a leg than in an arm (Fig. 1). Often the patient’s condition has deteriorated in the days preceding clinical presentation. Calcaneal osteomyelitis may proceed insidiously and lead to a delay in seeking treatment. Spinal osteomyelitis is characteristicly manifested as back pain, whereas pain on a digital rectal examination suggests sacral osteomyelitis. Acute osteomyelitis should be considered in any patient who presents with a fever of unknown origin. Acute cases occur in all age groups, with a small peak in incidence among prepubertal boys, presumably because of strenuous physical activity and microtrauma.1,9 Children with methicillin-resistant S. aureus (MRSA) osteomyelitis have a high temperature, tachycardia, and a painful limp more often than those with methicillin-susceptible S. aureus (MSSA).13

Diagnosis

The approach to the diagnosis of osteomyelitis in children is shown in Figure 2. If physical examination suggests bone involvement, further tests are performed.
Serum C-reactive protein (CRP) and procalcitonin levels are sensitive as diagnostic tests and useful in follow-up, but measurements of procalcitonin are more expensive and rarely outperform those of CRP, which are easily determined from a whole-blood finger-prick sample. Results of CRP testing are available within 10 minutes. Declining levels of CRP usually suggest a favorable response to treatment, even if the fever continues. Since the erythrocyte sedimentation rate increases rapidly but decreases significantly more slowly than the CRP level, it is less useful in monitoring the course of the illness. As compared with other types of osteomyelitis, osteomyelitis due to MRSA causes greater elevations in the CRP level, erythrocyte sedimentation rate, and white-cell count.

The “rat bite” in bone that is often seen in osteomyelitis becomes visible on plain radiography 2 to 3 weeks after the onset of symptoms and signs. A normal radiograph on admission to the hospital by no means rules out acute osteomyelitis, but it can be helpful in ruling out a fracture or detecting Ewing’s sarcoma or another type of malignant condition. In resource-poor countries, plain radiography is of great value, since no other imaging methods may be available.

Scintigraphy is sensitive and useful, especially if a long bone is affected or symptoms are not precisely localized. Although computed tomography (CT) is useful, it is cumbersome and entails extensive radiation exposure. Magnetic resonance imaging (MRI) is often considered the best imaging method, especially in difficult-to-diagnose cases. CT and MRI are costly, are not always available, and require anesthesia in young children. Ultrasonography is of minor importance, but visible fluid in an adjacent joint suggests septic arthritis.

Determining the causative organism is pivotal. Osteomyelitis can be diagnosed by means of imaging, but it is essential, whenever possible, to obtain a sample for the antibiogram that may disclose problematic agents such as MRSA. Representative samples can be obtained percutaneously or through a small incision by drilling. Blood cultures should be performed routinely, even though they identify the causative agent in only 40% of the cases. The yield of K. kingae can be increased with the use of special culture methods or polymerase-chain-reaction assays. K. kingae should be actively searched for, since it is difficult to isolate and appears to be more common among young children than previously thought.

**MANAGEMENT**

**ANTIBIOTIC TREATMENT**

Treatment of acute osteomyelitis is almost always instituted empirically before the causative agent and its resistance pattern are known. The most relevant antibiotics are listed in Table 1\(^9,9,14,20-26\); they must have an acceptable side-effect profile when administered orally because the doses are unusually large.\(^27\) Absorption and penetration into the bony structure should be satisfactory, and time-dependent antibiotics with a short circulating half-life are likely to require frequent dosing. Clindamycin and first-generation cephalosporins fulfill these requirements. Their efficacy as

---

**Figure 1. Skeletal Distribution of Acute Osteomyelitis in Children.**

Osteomyelitis may affect any bone, with a predilection for the tubular bones of the arms and legs. Estimated percentages of all cases according to the data in Krogstad, Gillespie and Mayo, Peltola et al., and Dartnell et al. are shown. Darker shades of red denote a higher burden of infection.
Symptoms suggestive of acute osteomyelitis

- Serum CRP, ESR, blood culture, and plain radiograph

Elevated CRP or ESR, or abnormal radiograph?
- No → Observation, repeat CRP and ESR next day
- Yes → MRI, bone scan, CT, bone biopsy, or all

MRI, bone scan, CT, bone biopsy, or all?
- No → Elevated CRP or ESR?
- Yes → Repeat examinations Consider other diagnosis or discharge

Elevated CRP or ESR?
- No → Observation, repeat CRP and ESR next day
- Yes → MRI, bone scan, or CT suggestive of osteomyelitis?

MRI, bone scan, or CT suggestive of osteomyelitis?
- No → Positive cultures from blood or bone?
- Yes → Intravenous antibiotic

Positive cultures from blood or bone?
- No → Observation, repeat CRP and ESR next day
- Yes → Intravenous antibiotic

Intravenous antibiotic

Antibiotic-resistant or atypical agent?
- Yes → Check suitability of antibiotic, switch if needed
- No → Intravenous antibiotic

Abscess or complicated disease?
- No
- Yes → Intravenous antibiotic to individual patient

Clinical improvement and decrease in CRP in 2–4 days?
- No → Evaluate need for surgery
- Yes → MRSA?

MRSA?
- No → Intravenous antibiotic
- Yes → Intravenous antibiotic

Same high-dose antibiotic orally?
- No
- Yes → Extended oral antibiotic treatment

Extended oral antibiotic treatment
- No → CRP normalized by day 20?
- Yes → Discontinue antibiotic

Discontinue antibiotic
- No → CRP normalized by day 20?
- Yes → Intravenous antibiotic

Intravenous antibiotic treatment to individual patient
- Total antibiotic treatment, usually 4–6 wk

Discontinue antibiotic
- Total antibiotic treatment, approximately 3 wk

Treatment tailored to individual patient

Check suitability of antibiotic, switch if needed

Prolonged intravenous antibiotic Consider repeat imaging to rule out complications

Switch to oral antibiotic treatment if signs of clinical improvement and decrease in CRP

CRP normalized by day 20?

Copyright © 2014 Massachusetts Medical Society. All rights reserved.
monotherapy for osteomyelitis has been documented, and large doses usually have an acceptable side-effect profile. Treatment with antistaphylococcal penicillins has also been shown to be effective and safe, albeit in noncomparative or small prospective trials. Most MRSA strains remain susceptible to clindamycin, but it (as well as vancomycin) should not be used against *K. kingae*. Beta-lactams are the drugs of choice for cases of osteomyelitis due to *K. kingae*, as well as for those due to *S. pyogenes* or *S. pneumoniae*. The rare cases caused by *H. influenzae* type b respond to ampicillin or amoxicillin, if the strain is beta-lactamase-negative, or to a second- or third-generation cephalosporin, if the strain is beta-lactamase-positive. This agent should be considered especially in children younger than 4 years of age who have not been vaccinated against *H. influenzae* type b and who present with osteomyelitis and septic arthritis. For patients in unstable condition, and in areas where resistance to clindamycin is widespread, vancomycin should be chosen as a first-line agent, whereas the more costly linezolid should be reserved for patients who do not have a response to vancomycin. The adequacy of bone penetration is a concern when vancomycin is used, and measurement of trough levels is warranted to guarantee sufficient dosing. A small retrospective survey yielded encouraging results with “old-fashioned” trimethoprim–sulfamethoxazole for osteomyelitis due to MRSA, but in the absence of data from larger trials, the use of this inexpensive and in many respects favorable agent remains controversial. Osteomyelitis due to salmonella warrants a third-generation cephalosporin, such as cefotaxime or ceftriaxone, or a fluoroquinolone. If these agents are not affordable, an older agent, chloramphenicol — which is currently not easy to obtain in developed countries — is a possibility, depending on the antibiogram profile. Its potential bone marrow effects are usually deemed to be outweighed by its benefits.

Patients with osteomyelitis may require other medications. At the attending clinician’s discretion, nonsteroidal antiinflammatory drugs (NSAIDs) can be used to lower the patient’s temperature and to relieve any harsh symptoms such as pain or fever. Data are lacking to support the use of glucocorticoids in acute osteomyelitis, but anticoagulants may be needed in cases that are complicated by deep-vein thrombosis, septic pulmonary emboli, or both; these conditions are characteristic of osteomyelitis due to MRSA.

**Switch from Intravenous to Oral Medication**

Traditionally, a child with osteomyelitis received intravenous medication for weeks, with a switch to oral medication when recovery was almost complete. This was understandable, since osteomyelitis killed many children or left them crippled. Antimicrobial agents revolutionized treatment, although few clinicians realize that the first sulfonamide regimens in the late 1930s were mostly oral and lasted for only a few days. Long intravenous courses were gradually adopted, and it took decades to relearn that switching to oral administration at an earlier point is not harmful. The pressing question continues to be how soon the switch can safely be achieved.

Three trials showed no change in outcomes when the intravenous phase was shorter than a week. A review from the United Kingdom concluded that short-term parenteral medication is acceptable in uncomplicated cases of osteomyelitis. In our prospective series involving 131 immunocompetent children who were older than 3 months of age, to our knowledge the largest study as of this writing, intravenous treatment was administered for only 2 to 4 days, followed by oral administration. There were no recrudescences, but no cases of MRSA were encountered. In countries such as the United States, where MRSA is a common pathogen, a more conservative approach is probably well founded while we await sufficiently powered prospective clinical trials to assess this important issue.