ULTRASONIC FEATURES OF ACUTE OSTEOMYELITIS IN CHILDREN

EDWARD T. MAH, GARRY W. LEQUESNE, ROGER J. GENT, DENNIS C. PATERSON

From the Women’s and Children’s Hospital, Adelaide, South Australia

The ultrasonic findings in 38 children with osteomyelitis of the limb bones were analysed in four time-related groups based on the interval between the onset of symptoms and the ultrasonic examination. Deep soft-tissue swelling was the earliest sign of acute osteomyelitis; in the next stage there was periosteal elevation and a thin layer of subperiosteal fluid, and in some cases this progressed to form a subperiosteal abscess. The later stages were characterised by cortical erosion, which was commonly present in those who had had symptoms for more than a week.

Concurrent septic arthritis was revealed in 11 patients, most frequently in association with osteomyelitis of the proximal femur or the distal humerus. Four weeks after clinical cure, ultrasonic examination showed no abnormalities. Ultrasonography is therefore a useful additional method for the diagnosis and assessment of osteomyelitis and its complications.

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Acute osteomyelitis in childhood may be difficult to diagnose because of the lack of specific clinical signs and symptoms. With early diagnosis, however, appropriate antibiotic treatment is usually curative without the need for surgical intervention (Cole, Dalziel and Leitl 1982; Scott et al 1990). Technetium bone scanning is the most sensitive method for early diagnosis (Howie et al 1983; Paterson, Foster and Savage 1987).

Ultrasonography has also been shown to be useful in establishing the diagnosis and its complications before radiographic changes are seen (Nath and Sethu 1992). The ultrasonic features of osteomyelitis include subperiosteal fluid collection (Abiri, Kirpekar and Ablow 1989; Nath and Sethu 1992), cortical breach or destruction (Williamson et al 1991; Taneja et al 1992) and soft-tissue swelling (Howard et al 1993). There is, however, no published description of the chronological evolution of these ultrasonic findings. We report the ultrasonic features of acute osteomyelitis as the condition evolves and subsequently responds to treatment.

PATIENTS AND METHODS

Over a four-year period from January 1990 to December 1993, 77 cases of acute osteomyelitis of the limbs and pelvis were diagnosed according to specific criteria at the Women’s and Children’s Hospital, Adelaide. Symptoms were of not more than four weeks’ duration and the diagnosis was based on:
1) a positive $^{99m}$Tc-methylene diphosphonate (MDP) bone scan and a positive culture from pus drained at operation; or
2) a positive $^{99m}$Tc-MDP bone scan and raised ESR and C-reactive protein levels (Rasmussen and Rasmussen 1982) with or without a positive blood culture or leucocytosis (McCarthy, Jekel and Dolan 1978), and the subsequent radiological appearance of either cortical erosion or osteopenia (Blockley and Watson 1970).

Of the 77 patients, 38 had had ultrasonic examination before the bone-scan results were known; in 14 of these, repeated ultrasonic examination was used to monitor the progress of the condition. All investigations were timed with reference to the date of onset of symptoms. There were 21 males and 17 females with a mean age of 6 years 5 months (15 days to 13 years).

The patients were examined by an ATL UM9 machine (Advanced Technology Laboratories, Bothell, Seattle) using a 5 MHz 4.5 cm linear array transducer. Longitudinal and transverse sections covering the full circumference of the relevant area were obtained. The unaffected, contralateral side was also examined to obtain equivalent views for comparison. This allowed the detection of subtle changes and the differentiation of early periosteal elevation from normal soft-tissue planes adjacent to bone. A soft gel pad was used, where necessary,
to achieve additional standoff from the bone surfaces. This improved contact and reduced artifacts. The adjacent joint was always examined as part of the ultrasonic study.

Blood pool and delayed bone scans were done, including anterior and posterior views, using K-99mTc-MDP as described by Howie et al (1983). All images were interpreted by a consultant nuclear physician with knowledge of the clinical information, but no knowledge of the ultrasonic findings.

RESULTS

The anatomical sites involved are given in Table I. The infecting organism was Staphylococcus aureus in most cases. In three children under two years of age Haemophilus influenzae type B was identified. In all proximal femoral and distal humeral cases there was concurrent septic arthritis of the adjacent joint but of the five patients with proximal humeral osteomyelitis, only one had septic arthritis of the shoulder. None of the 12 patients with osteomyelitis of the distal tibia had septic arthritis at the ankle, but this did occur in the single case of osteomyelitis involving the distal fibula (Table I).

Four arbitrary time intervals from the onset of symptoms were used to analyse the changing ultrasonic features. The findings were grouped as follows: 1) 1 to 3 days after the onset of symptoms (20 patients); 2) 4 to 6 days (8 patients); 3) 1 to 2 weeks (6 patients); and 4) 2 to 4 weeks (4 patients).

The ultrasonic findings are summarised in Figure 1. They represent a continuum of the evolving pathological process, rather than discrete stages.

Deep soft-tissue swelling adjacent to the affected bone (Fig. 2) was the earliest sign of acute osteomyelitis except in the cases of infection of the proximal femur. This was not observed in proximal femoral osteomyelitis superior to the attachment of the joint capsule. It was present in a high proportion of cases in groups 1 (93%), 2 (94%) and 3 (93%) but its incidence was less in group 4 (75%).

Early periosteal thickening (Fig. 3) with elevation up to 3 mm was seen most often in group 1 (33%) but it was much less frequent than deep soft-tissue swelling and was present in not more than 35% of cases in any group.

Subperiosteal collections of fluid more than 3 mm deep were detected in two forms. One was the ‘elongated’ type which sometimes extended for several centimetres.

Fig. 1

Ultrasonic findings related to the duration of symptoms.

Fig. 2a

Longitudinal views of the left (a) and right (b) distal tibia (T). There is deep soft-tissue swelling (DS) on the left. The epiphysis plate is marked (E).
Longitudinal views of left (a) and right (b) distal tibia (T) showing deep soft-tissue swelling (DS) and early periosteal elevation (PE) on the left.

Longitudinal view of the anterolateral margin of the distal left fibula (Fl), showing deep soft-tissue swelling (DS) and an 'elongated' type of subperiosteal collection (PC). The periosteum (P) is inserted distal to the metaphysis (M).

Longitudinal view of the posterior margin of the proximal tibia (T), showing deep soft-tissue swelling (DS) and a 'focal' type of subperiosteal collection (PC). The periosteum is inserted into the metaphysis (M).

Longitudinal view of the margin of the distal right humerus (H), showing deep soft-tissue swelling (DS), subperiosteal collection (PC) and early cortical erosion (ER).

up and down the bone (Fig. 4) and the other was the 'focal type' in which the distended periosteum appeared convex or crescentic in shape (Fig. 5). The shape of the collection appeared to be determined not only by the volume of fluid present, but also by the configuration of adjacent capsular and muscle attachments.

These subperiosteal collections were most commonly found in group 3 (40%). They were less frequent in group 2 (33%) and least common in group 1 (13%).

Cortical erosion was recognised by progressively increased transmission of sound through the bone as calcium was reabsorbed. The early stage of this process is seen in Figure 6. In the later stages, echoes were detected from fat in the medullary cavity due to increased ultrasonic penetration (Fig. 7). As expected, there was a progressive increase in focal bone resorption from group 1 (7%) to group 4 (100%).
Eleven patients were treated surgically, six of whom had concurrent septic arthritis (Fig. 9). The other five had all experienced severe pain and were found to have a large subperiosteal collection on ultrasonic examination which was confirmed at surgery in all. Two patients with infection of the distal tibia and one with osteomyelitis of the whole femur required repeated drainage after confirmation of a continuing subperiosteal collection by subsequent ultrasonic examinations. The patient with osteomyelitis of the whole femur developed chronic osteomyelitis.

All cases of concurrent septic arthritis were diagnosed by ultrasound. The three cases of septic arthritis of the elbow were in young patients with a mean age of seven months (5 to 19), and were treated with antibiotics only with complete resolution by the fourth week. All the other patients with septic arthritis were treated by surgical drainage and washout plus antibiotics.

DISCUSSION

Our serial ultrasonic examinations, collated with the duration of symptoms, revealed the spectrum of findings in the course of acute osteomyelitis and its treatment. We have related, in a chronological manner, the ultrasonic features previously described (Abiri et al 1989; Williamson et al 1991; Nath and Sethu 1992; Taneja et al 1992; Howard et al 1993), and added some new ones so that it is now possible roughly to determine the stage and progression of acute osteomyelitis by sonography.

Deep soft-tissue swelling is an accurate sign of early osteomyelitis and persists throughout the inflammatory process. It can be readily differentiated by ultrasound from the superficial soft-tissue swelling of cellulitis.

Periosteal thickening and elevation were seen in some patients in all groups but they were less frequent than deep soft-tissue swelling and cannot be relied upon for the recognition of osteomyelitis.

All patients were treated with intravenous antibiotics until their symptoms had settled for 48 hours. Oral antibiotics were continued for another five to six weeks. In those successfully treated with antibiotics only, a completely normal ultrasonic picture was found at the follow-up examinations four or more weeks after the onset of symptoms.

All the patients with early acute osteomyelitis responded to antibiotic treatment and none had a recurrence. There were, however, two patients with osteomyelitis of the proximal humerus in whom a subperiosteal collection was seen to rupture into the adjacent soft tissues (Fig. 8). Both experienced rapid resolution of pain, and their recovery was uneventful.
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Ultrasonic examination also accurately identified concurrent septic arthritis when radiographs of the joints were normal. The most commonly affected joint was the hip, while the most common site for osteomyelitis was the tibia, as has been reported previously by Jackson and Nelson (1982). An unusual observation in our series was that none of the 12 patients with distal tibial osteomyelitis had septic arthritis of the ankle.

Although it is generally accepted that septic arthritis with or without concurrent osteomyelitis should be treated by drainage, controversy exists as to the place of surgery in acute osteomyelitis in childhood. Although many have favoured conservative management (Cole et al 1982; LaMont et al 1987; Scott et al 1990), the concept that pus should be drained as early as possible remains a strong argument for surgery (Dirschl and Almekinders 1993; Howard et al 1993).

Ultrasound proved valuable in precisely locating the subperiosteal abscess but the question remains open as to how much periosteal elevation or subperiosteal fluid needs to be present for surgical drainage to become necessary. Howard et al (1993) suggested that a subperiosteal collection of 2 mm was an indication for surgery but in our study subperiosteal collections of more than 3 mm were seen to resolve completely with antibiotic treatment alone. Our decisions to perform surgical drainage were taken entirely on clinical grounds, mainly on the degree of pain and the clinical response to intravenous antibiotics. We did not operate on patients who were clinically well even if there was a proven subperiosteal collection, and in these patients we used repeated ultrasonic examinations to document progress or resolution.

In the two cases of proximal humeral osteomyelitis in which subperiosteal pus ruptured through the periosteum to form an adjacent soft-tissue abscess, the illness resolved without further complication. It is debatable whether it might have shortened the duration of the disease if these subperiosteal collections had been drained before they ruptured.

In two patients in whom surgical drainage was performed, ultrasound accurately diagnosed a reaccumulation of subperiosteal pus which necessitated a second drainage operation.

In summary, ultrasound is a useful additional diagnostic tool for the early detection and management of osteomyelitis.

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REFERENCES


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Table I. Anatomical sites of osteomyelitis in 38 patients

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of patients (%)</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Proximal humerus</td>
<td>5 (13.2)</td>
<td>Septic arthritis in shoulder (1)</td>
</tr>
<tr>
<td>Distal humerus</td>
<td>3 (8)</td>
<td>All had septic arthritis in elbow</td>
</tr>
<tr>
<td>Pelvis</td>
<td>6 (15.8)</td>
<td>Septic arthritis in hip (1)</td>
</tr>
<tr>
<td>Proximal femur*</td>
<td>4 (10.5)</td>
<td>All had septic arthritis in hip</td>
</tr>
<tr>
<td>Distal femur</td>
<td>1 (2.6)</td>
<td>Septic arthritis in hip</td>
</tr>
<tr>
<td>Whole femur</td>
<td>1 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Proximal tibia</td>
<td>1 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Distal tibia</td>
<td>12 (31.6)</td>
<td>None had arthritis in ankle</td>
</tr>
<tr>
<td>Whole tibia</td>
<td>1 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Distal fibula</td>
<td>1 (2.6)</td>
<td>Septic arthritis in ankle</td>
</tr>
<tr>
<td>Calcaneum</td>
<td>2 (5.3)</td>
<td></td>
</tr>
<tr>
<td>Clavicle</td>
<td>1 (2.6)</td>
<td></td>
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* all cases of proximal femoral osteomyelitis were at or proximal to the base of the neck of the femur

Many of the ultrasonic features such as deep soft-tissue swelling, periosteal thickening and early subperiosteal fluid collection preceded the radiological changes. Ultrasonic examination therefore allows early medical treatment and a better chance of resolution of the disease.

Cortical erosion is a feature of established osteomyelitis and was seen with increasing frequency from groups 1 to 4. The corresponding radiographs of these patients were sometimes normal in the early stages, but later showed osteopenia and lytic changes.

By the fourth week no ultrasonic abnormality could be found in any of the successfully treated cases.


Paterson DC, Foster BK, Savage JP. The present status of bone scanning and treatment recommendations. Drugs 1993; 45:29-43.


