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Role of ultrasound in the diagnosis of paediatric acute osteomyelitis

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Abstract

Aim: The aims of our study were to evaluate cases of extremity pain or swelling in paediatric patients using USG to diagnose acute osteomyelitis, and correlate USG findings with MRI findings. **Material and methods:** 18 paediatric patients with extremity pain or swelling were evaluated. After the clinical and laboratory work-up, imaging was done using radiographic examination, USG and MRI of the affected limb. **Results:** 5 patients (27.8%) out of 18 were diagnosed with acute osteomyelitis based on USG findings, confirmed by MRI and surgical drainage. The mean age of the patients with acute osteomyelitis was 8.2 years. Male children were more commonly affected as compared to female. The distal metaphysis of the femur was the most common site involved (80%). The right lower limb was more commonly affected. The most frequent presentation was pain at the affected site. On USG, deep soft tissue fluid collection around the bone was present in all cases (100%). Periosteal thickening or elevation with subperiosteal fluid collection was seen in 4 cases (80%). Increased vascularity within or around the periosteum on colour Doppler was seen in 4 cases (80%). **Conclusions:** Acute osteomyelitis is a common entity in the paediatric population, presenting with acute limb pain and swelling. Early diagnosis and management of acute osteomyelitis are essential to prevent serious complications. USG can play an important role in the early diagnosis of paediatric acute osteomyelitis, and should be incorporated into the treatment protocols followed in cases of suspected acute osteomyelitis. MRI should be reserved as problem-solving tool.

Introduction

Acute limb pain and swelling are a common entity in the paediatric setting, caused by various aetiologies, however in certain circumstances – such as acute osteomyelitis (AOM) – early diagnosis and management are essential to prevent serious sequelae⁽¹⁾.

Acute osteomyelitis refers to acute infection of the bone and/or bone marrow with a duration of infection prior to treatment of less than 2 weeks. In subacute osteomyelitis, the duration of infection prior to treatment is 2 weeks to approximately 3 months, while in chronic osteomyelitis the duration of infection before treatment is greater than 3 months. In paediatric AOM, the most commonly affected site is the metaphysis of the long bones, and patient management requires early

diagnosis and prolonged intravenous antibiotic treatment for 6 weeks, either with or without surgical debridement⁽²⁾.

It is essential to suspect AOM clinically in a child with pain and swelling of the limb, followed by further evaluation with laboratory parameters and imaging in order to establish diagnosis in the early phase and avoid complications. In our study, we evaluated the role of ultrasonography (USG) in the early diagnosis of paediatric AOM, and also correlated the findings with magnetic resonance imaging (MRI) results.

Aim

The aims of our study were to evaluate cases of extremity pain or swelling in paediatric patients using USG to

diagnose AOM, and to correlate USG findings with MRI findings.

Material and methods

A total of 18 paediatric patients referred to the radiology department of our hospital from July 2019 to July 2020 were evaluated. Following clinical assessment and laboratory work-up, the patients were sent to the radiology department for imaging evaluation. The clinical criteria considered to be indicative of AOM included pain and swelling of the extremity/joint, with fever, local tenderness, and/or redness. The laboratory criteria suggestive of possible AOM in a clinically suspected case of AOM were comprised elevated total leucocyte count (TLC), and elevated erythrocyte sedimentation rate (ESR) and C-reactive protein values (CRP). The initial radiographic examination of the affected limb was followed by USG and MRI scans.

Inclusion criteria

All paediatric patients (age <18 years) with extremity pain or swelling reporting for the first time to the radiology department for an imaging examination were included.

Exclusion criteria

The same patients reporting with the same extremity involvement were excluded.

Equipment

USG examinations were performed on a Wipro GE Vivid T8 USG/Echo Machine using L6-12-RS Linear array transducer with a frequency of 6–13 MHz.

MRI scans were performed on a Wipro GE Signa HDx 1.5 T machine with basic T1W, T2W sequences in the coronal plane, supplemented by STIR (short Tau inversion recovery) coronal and PDFS (proton density fat suppressed) sequences in three planes. Post intravenous gadolinium contrast scans were done in selected cases.

Examination technique

USG scans in the longitudinal and transverse planes at the site of maximum tenderness or swelling were performed. If required, a comparison with the contralateral side was also done, and the patients underwent MRI scans of the affected limb for correlating the findings of AOM seen on USG, to confirm the diagnosis as the gold standard, or for follow-up.

Sonographic criteria to diagnose AOM

A. Deep soft tissue fluid collection around the bone.

- B.** Periosteal thickening or elevation with a thin layer of subperiosteal fluid collection.
C. Increased vascularity within or around the periosteum on Doppler sonography.

We considered the presence of any one sign from the above list as indicative of AOM.

MRI criteria to diagnose AOM

- A.** Alteration of the normal marrow signal intensity showing low signal intensity on T1-weighted images (compared with the adjacent muscle) and high signal intensity on STIR or T2-weighted images suggestive of marrow oedema. On fat-suppressed gadolinium-enhanced T1-weighted images, AOM is seen as an area of increased enhancement relative to the adjacent normal marrow.
B. Subperiosteal collection.

Results

A total 18 paediatric patients (15 boys and 3 girls) with a mean age of 8 years were evaluated

Out of 18 children, 7 children had no obvious clinical signs of infection, with essentially normal laboratory parameters, and radiographic examinations of the affected limb revealing alternative diagnoses, with fractures in 2 cases, osteosarcoma in 1 case, and osteoid osteoma in 1 case. In the remaining 2 cases in this group, USG findings showed a soft tissue collection which was away from the bone. Fine-needle aspiration cytology (FNAC) results in these cases were suggestive of soft tissue haematoma.

In the remaining 11 children, AOM was suspected on the basis of clinical findings including pain and swelling of the extremity/joint, with fever and local tenderness, and redness in a few cases. Elevated TLC, ESR and CRP values were present in most of these patients. Out of these 11 children, 6 had superficial collection and, based on FNAC results, 4 were diagnosed with cellulites, and 2 had soft tissue haematoma. Finally, a total of 5 patients (27.8%) were diagnosed with acute osteomyelitis meeting the USG criteria for AOM, which was also confirmed by MRI and surgical drainage. Therefore, out of 18 patients evaluated in the study, 13 patients (72.2%) had other causes of limb pain, as detailed above (Tab. 1).

The mean age of AOM patients was 8.2 years (the youngest child was 6 years, and the oldest 12 years old). Male children were more commonly affected compared to females (male 80%, female 20%). The femur was the most common bone involved (80%), and the most common site was the distal metaphysis. Tibial involvement was seen in only 1 case (20%). The right lower limb was more commonly affected, with 3 cases (60%), while the left lower limb was involved in 2 cases (40%). None of the cases of AOM in our study was characterised by upper limb involvement. The

Tab. 1. Distribution of cases as per diagnosis after the final evaluation (n =18)

Diagnosis	Number of cases	Percentage
AOM	5	27.8
Soft tissue haematoma	5	27.8
Cellulitis	4	22.2
Osteosarcoma	1	5.56
Osteoid osteoma	1	5.56
Fractures	2	11.1

Tab. 2. Distribution of diagnosed AOM cases (n = 5)

Case	Age (years)	Gender	Clinical profile	Site of involvement	Day of USG scan after onset
1	6	Male	Pain and swelling, left distal thigh	Left distal femoral metaphysis	4
2	9	Male	Pain, right proximal leg	Right proximal tibial metaphysis	7
3	6	Female	a. Swelling, pain, redness, right distal thigh and knee b. Fever	Right distal femoral metaphysis	4
4	12	Male	a. Pain, left proximal thigh b. Fever	Left proximal femoral metaphysis	3
5	8	Male	Pain and swelling, right distal thigh	Right distal femoral metaphysis	5

Tab. 3. Sonographic findings in confirmed cases of AOM at presentation (n = 5)

USG finding	Number of cases	Percentage
Deep soft tissue fluid collection around the bone	5	100
Periosteal thickening or elevation with subperiosteal fluid collection	4	80
Increased vascularity within or around the periosteum on colour Doppler	4	80

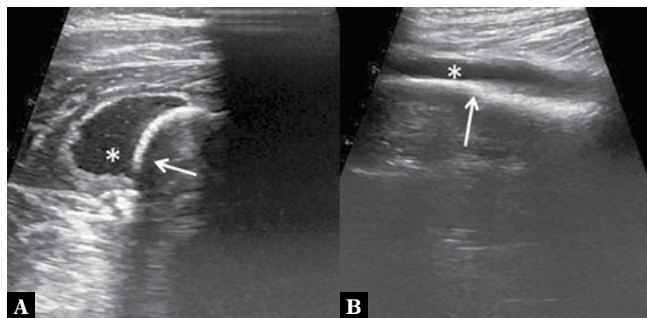


Fig. 1. Deep soft tissue fluid collection around bone. Axial (A) and sagittal (B) sections through distal thigh showing deep fluid collection (white star) in relation to distal femoral metaphysis (white arrow)

most common presentation was pain at the affected site (seen in all cases), while swelling was observed in 4 out of 5 cases of AOM (80%). No significant clinical swelling was seen in the case where the proximal tibia was involved. Redness and adjacent joint swelling due to synovial effusion were noted in 1 case out of 5 (20%). Fever was present in 2 cases (40%). The mean time of presentation to hospital and USG was 4.6 days (range: 3 to 7 days) (Tab. 2).

On the USG images, deep soft tissue fluid collection around the bone was present in all cases (100%). The collection showed internal echoes in all the patients. In a single case, significant internal echoes were seen, and the collection appeared hyperechoic. Periosteal thickening or elevation with subperiosteal fluid collection was seen in a total of 4 cases (80%). Increased vascularity within or around the periosteum on colour Doppler was noted in 4 cases (80%) (Tab. 3, Fig. 1, Fig. 2, Fig. 3).

All AOM patients underwent MRI examinations after the USG for the correlation of the findings, confirmation of

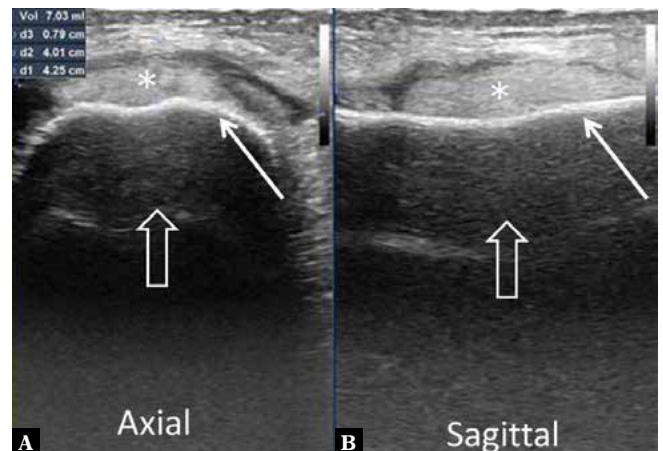


Fig. 2. Hyperechoic deep soft tissue fluid collection with superiosteal abscess. Axial (A) and sagittal (B) sections through proximal leg showing hyperechoic deep fluid collection (white star) in relation to proximal femoral metaphysis (white arrow) and superiosteal collection (white empty arrow)

diagnosis, and evaluation of extent. The MRI showed alteration of the normal marrow signal intensity in all 5 cases, and also subperiosteal collection in 4 cases, as seen in USG (Fig. 4). An additional finding of intramedullary collection was observed in 1 case of AOM.

Surgical drainage was performed in all patients (Fig. 5).

Discussion

One of the most common causes of acute limb swelling, pain and joint effusion in children is AOM¹. It has been

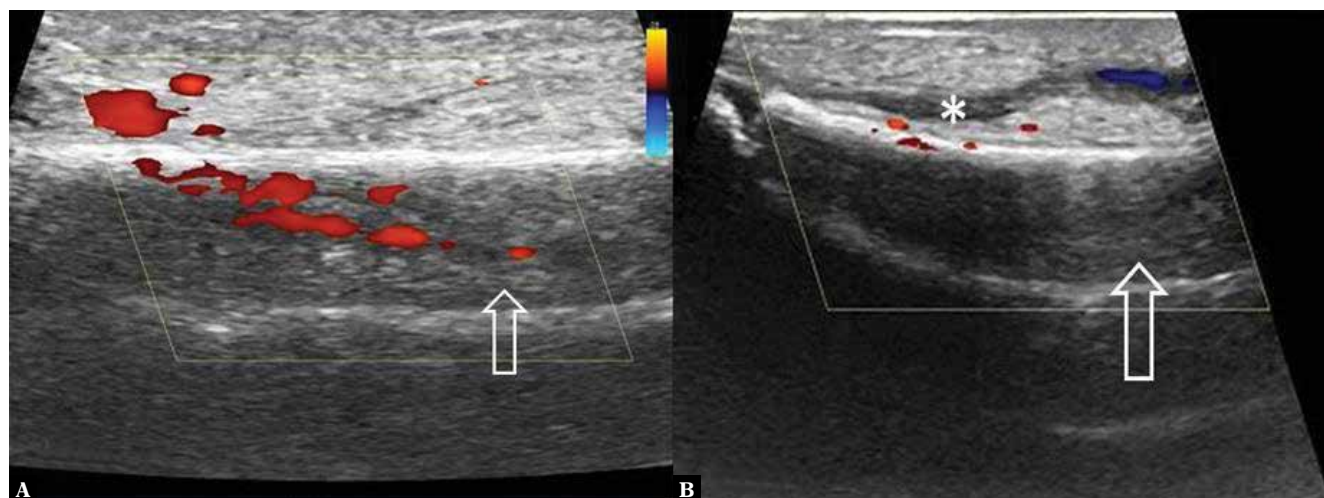


Fig. 3. Colour Doppler. **A.** Increased vascularity around bone and superiosteal collection (white arrow). **B.** Increased vascularity around bone, deep soft tissue (white star) and superiosteal collection (white empty arrow)

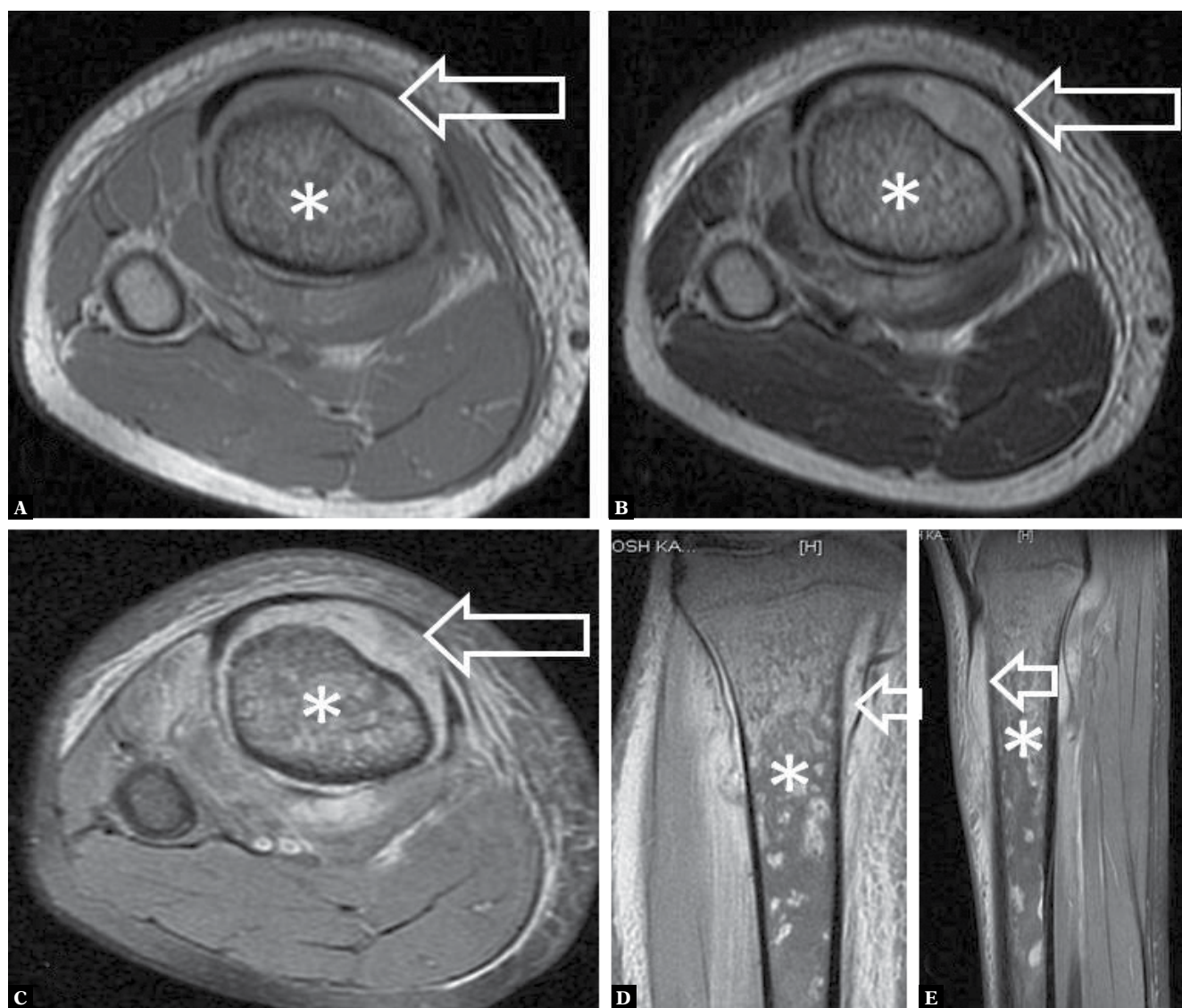


Fig. 4. MRI of the right proximal leg (**A.** T1W axial image, **B.** T2W axial image, **C.** PDFS axial image, **D.** Coronal PDFS image, **E.** Sagittal PDFS images) subperiosteal abscess (white empty arrow) and altered marrow signals (white star)



Fig. 5. Intra op image – surgical drainage subperiosteal abscess left distal femur

established over that years that on account of its peculiar vascularity the metaphysis of the long bones in children is particularly predisposed to AOM⁽³⁻⁵⁾. It is essential to diagnose AOM in the early phase by clinical examination complemented by diagnostic imaging (including conventional radiography, USG, computed tomography (CT), MRI and bone scan) in order to reach an accurate diagnosis^(2,6,7). The first-choice imaging modality in acute limb pain and swelling is plain radiography, being a readily available, relatively safe, inexpensive, and rapid technique. There are no

definite changes seen in initial radiographs in AOM, and the role of radiographs is to establish alternative diagnoses rather than exclude AOM^(7,8).

CT is associated with radiation hazard, and thus it is not the modality of choice for marrow abnormalities as seen in AOM. However, CT visualises the cortical bone well, and thus has a role in the diagnosis of chronic osteomyelitis, foreign bodies or gas associated with infection^(9,10).

MRI is highly sensitive for bone marrow abnormalities and soft tissue infection, and highly accurate in the diagnosis of AOM. Our study also depicted changes of AOM in MRI in the acute phase. Additionally, MRI demonstrated the presence of intramedullary collection in 1 case, indicating that MRI is helpful in diagnosing complications of AOM more accurately than USG. Consequently, in view of more limited availability, high cost, and technical difficulties in the paediatric population MRI should be reserved as a problem-solving tool^(7,11,12).

USG is a rapid, cheap, easily available, non-ionising and fairly accurate diagnostic modality. It also helps to locate the lesion for diagnostic aspiration^(6,8). The first use of USG as a diagnostic imaging modality in AOM was reported in 1988 by Abiriet *et al.*⁽¹²⁾. The authors suggested that fluid around the bone seen on USG might indicate AOM. In 1994, Kang *et al.*⁽¹³⁾ demonstrated that the presence of subperiosteal collection/abscess as early as on the 4th day of onset indicates the presence of AOM. In our study, all paediatric

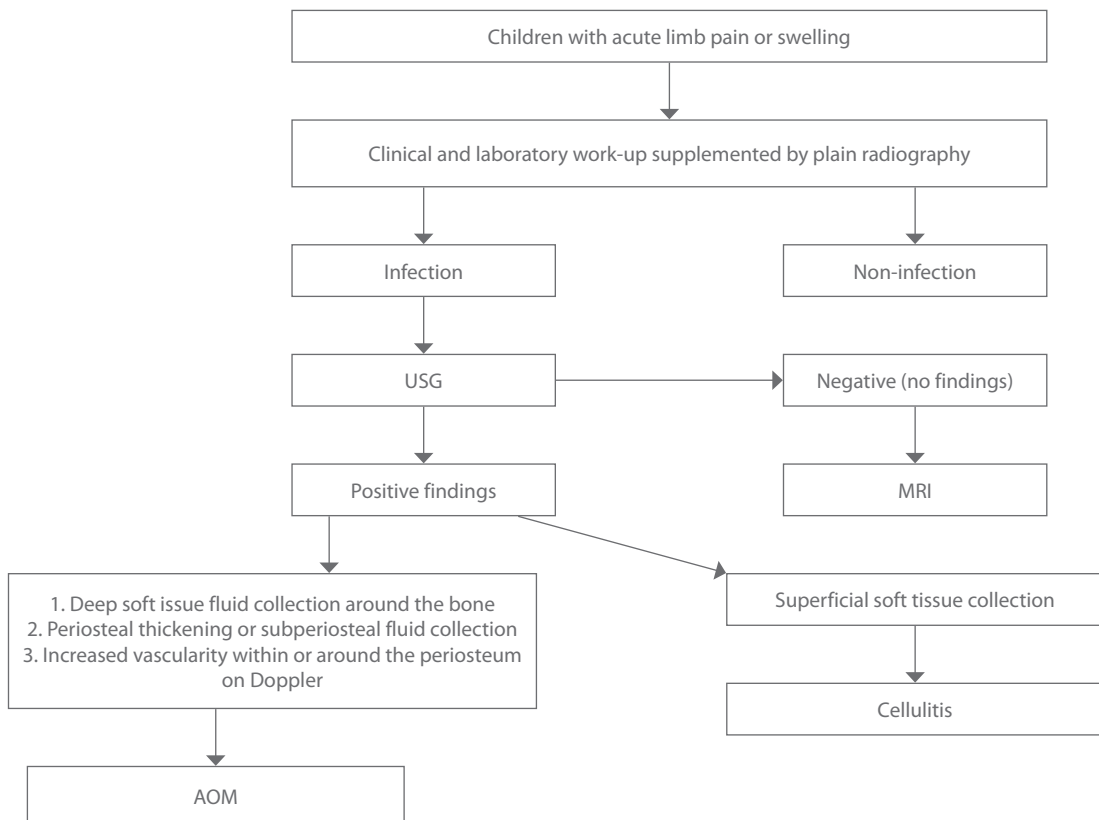


Fig. 6. Algorithm for the early diagnosis of paediatric AOM on USG

patients with limb pain or swelling were included, but only 27.8% were diagnosed with AOM. Previous studies^(12–15) demonstrated either deep soft tissue thickening or collection in most cases of AOM, while in our study the most important USG finding observed in all confirmed cases of AOM was deep soft tissue fluid collection around the bone. In our study, fluid was seen around the bone instead of deep soft tissue thickening, as the majority of cases were evaluated after 3 days of onset, whereas in most other studies the thickening on USG was seen during the first three days of onset. We also demonstrated periosteal thickening or elevation with subperiosteal fluid collection/abscess formation in most cases of AOM.

Over the years, with advances in ultrasound technology and improvements in resolution, the sensitivity and specificity of USG in diagnosing AOM has increased. The use of colour Doppler in the diagnosis of AOM was described by Chao *et al.* in 1999 in 12 paediatric cases of AOM⁽¹⁴⁾. In our study, increased vascularity within or around the periosteum was also seen on colour Doppler in most of the cases (80%). In 2005, Azam *et al.*¹⁵ published a study comprising of 55 children with AOM of limbs, where subperiosteal abscess was demonstrated in 42 cases (76.3%), while soft tissue swelling contiguous with bone was seen in all cases except for 3 patients in the early phase (1–3 days) of the disorder. The authors also demonstrated an increased vascular flow within or around the affected periosteum in all cases on colour Doppler. In their study, the most common site of involvement was the distal femur (45.4%), and our study is also consistent with this finding. Upper limb involvement was seen in 12 percent cases in their study, while none of our cases had upper limb involvement, which can be attributed to a smaller sample size in our study.

In 2011, Ezzat *et al.*⁽¹⁶⁾ published their study of 27 children with AOM, highlighting that AOM can be detected in the early phase by high-resolution USG and power Doppler sonography. They also showed the presence of cortical erosions in 48% cases of AOM, while none of our cases showed them, which is likely due to the fact that the scanning time in our study was between 3 to 7 days, and cortical erosions are normally seen after the 7th day. In addition, the authors demonstrated the presence of synovial effusion in the adjacent joint in nearly 26% cases. In contrast, in our study only 1 case had an associated joint effusion.

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Malicus *et al.*⁽¹⁷⁾ reported that the sensitivity of USG in diagnosing AOM was significantly lower than MRI in the early phase, however in our study we demonstrated that an early diagnosis of acute AOM was feasible with USG, especially after the 3rd day of onset, revealing similar changes as those visualised by MRI. Therefore, being a cheap and readily available imaging modality, USG should be included in the treatment protocols of AOM to enable an early diagnosis.

We propose the following algorithm for the early diagnosis of paediatric AOM by USG (Fig. 6):

1. In all children with acute limb pain or swelling, a distinction should be made between infection versus non-infection on the basis of clinical signs (fever, local tenderness, and redness) and laboratory parameters (elevated TLC, ESR and CRP values). This should be followed by a plain radiographic examination for establishing a possible alternative diagnosis.
2. In the infection group, USG should be performed to identify AOM or establish an alternative diagnosis of cellulites/soft tissue collection.
3. MRI may be done when USG does not show any findings suggestive of AOM. In a diagnosed case of AOM, MRI is indicated as per the clinical requirements of the treating orthopaedic surgeon, where the extent of disease is not clear or complications are suspected.

Conclusions

AOM is a common entity in the paediatric population, presenting with acute limb pain and swelling. Early diagnosis and management of AOM are essential to prevent serious complications. USG can play an important role in the early diagnosis of paediatric AOM, and should be incorporated into treatment protocols followed in cases of suspected AOM. MRI should be reserved as a problem-solving tool.

Conflict of interest

Authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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