Original Article

Role of Ultrasonography in Early Diagnosis of Acute Osteomyelitis

Bhim Sigdel[1], Suresh Uprety[1],Prawesh Singh Bhandari[1], Sharma Paudel[2]

[1]Department of Orthopedics, Tribhuvan University Teaching Hospital, Maharajgunj, Kathmandu

[2]Department of Radiology and Imaging, Tribhuvan University Teaching Hospital, Maharajgunj, Kathmandu

Correspondence Author: Dr. Bhim Sigdel

Email: drbhimsigdel@gmail.com

Abstract

Background: Osteomyelitis is the inflammation involving bone and bone marrow caused by a pathogenic organism. Acute osteomyelitis is one of the commonest bone infection in childhood and is a significant cause of morbidity. Timely diagnosis and intervention is critical for outcome. Imaging studies play an important role in diagnosis of osteomyelitis. Various modalities, including conventional radiography, bone scintigraphy, ultrasonography, computed tomography (CT) and magnetic resonance (MR) imaging have all been used. The purpose of this study is to evaluate the diagnostic value of ultrasonography in early diagnosis of acute osteomyelitis

Methods: A prospective non-randomised analytical study in 30 children with sign and symptoms suggesting acute osteomyelitis presenting in Emergency Room(ER) and Out-patient department(OPD) of Tribhuvan University Teaching Hospital (TUTH) was carried out. Plain radiograph was done to each patient followed by Ultrasonography.

Results: Twenty four patients (80%) were finally diagnosed to have osteomyelitis. Distal femur was most commonly involved site (33.33%). Sensitivity of USG was found to be 91.6% and specificity to be 83.3%.

Conclusion: Ultrasonography was found to be highly sensitive and highly specific in early diagnosis of acute osteomyelitis in children with clinical suspicion of the disease and negative plain radiographs.

Keywords: Acute hematogenous osteomyelitis, Cortical erosion, Deep soft tissue swelling, periosteal elevation, pericortical fluid, Ultrasonography.

Introduction

Osteomyelitis is the inflammation involving bone and bone marrow caused by a pathogenic organism. [(1)] Acute hematogenous osteomyelitis(AHOM) is defined as any bone infection presenting with a time period between diagnosis and symptom onset <2 weeks .[(2)] Hematagenous route is the most common route of infection in paediatrics population.[(3, 4)] Acute hematogenous osteomyelitis is one of the commonest bone infection in childhood and is a significant cause of morbidity.[(1, 5)] The appendicular skeleton is the most common site of osteomyelitis. The lower extremity, especially the femur, is involved more often than the upper extremity, where the humerus is most likely to be infected. The pelvic bones or clavicles are less likely to be involved than the long bones of the extremities.[(6)]

It is heterogenous disease in its pathophysiology, clinical presentation and management. Progressive destruction of bone and formation of sequestra are characterstics of disease. The clinical diagnosis in the late stages is achieved easily; an accurate early diagnosis is more challenging. Prompt and precise diagnosis can determine morbidity and extent of the infection[(7)]

Early diagnosis of AHO is critical, so that definitive and adequate treatment is not delayed to avoid irreversible damage and morbidity. The clinical diagnosis of osteomyelitis especially in the early stage still remains

a challenge. A multimodal approach is often needed to estabilish diagnosis. This involves routine laboratory tests, such as White blood cell(WBC),Erythrocyte sedimentation rate(ESR),and C-reactive protein(CRP), bacteriological test such as blood and bone culture and radiological examination.[8]

Imaging studies play an important role in diagnosis of osteomyelitis. Various modalities, including plain radiography, bone scintigraphy, sonography, computed tomography (CT) and magnetic resonance (MR) imaging, have all been used. Therefore imaging technique play a key role in diagnosis and follow up. [9]

Plain radiography still is the mainstay and the initial imaging modality but plain radiographs are unable to pick up early changes in osteomyelitis At the beginning of the disease plain radiographs can be negative. Changes on radiographs are seen only when significant bone destruction has occurred. It appears within 10-14 days.[5, 6, 9]

In such circumstances, bone scan and MRI remain sensitive tests. Unfortunately, these modalities of investigations are not available in all centers, especially so in developing countries like ours. Furthermore, expenses and radiation associated with CT and bone scan make repeated use of this tests undesirable and beyond reach of most people.[8]

Ultrasound is emerging as a new imaging modalities for early diagnosis of osteomyelitis.[8] The physical properties of bone donot usually lend themselves to ultrasonic investigation, because of reflection of sound wave at soft tissue-bone interface. However the periosteal and soft tissue changes adjacent to bone alongside dense bone can be seen. [9] Continual technological development has led to high-resolution transducers, with which it is now also possible to demonstrate the soft-tissue region close to the bone and the surface of the bone itself in great detail, particularly in the extremities. Thus, sonography is now also able to detect early changes in inflammatory osseous processes as soon as they have spread beyond the level of cortical bone.[10]

Ultrasound (US) is a rapid, cheap, easily available, non ionizing and reasonably accurate diagnostic modality which can be performed at the bedside. It also helps in localizing the lesion for diagnostic aspiration.[9]

Many studies were done to evaluate how Ultrasound may be useful in early detection of acute osteomyelitis. In the last decade, the usefulness of ultrasonography in the diagnosis of AHO has been consistently shown and diagnostic criteria have been defined.[9]

The purpose of this study was primarily to evaluate the efficacy of ultrasound in early diagnosis of osteomyelitis.

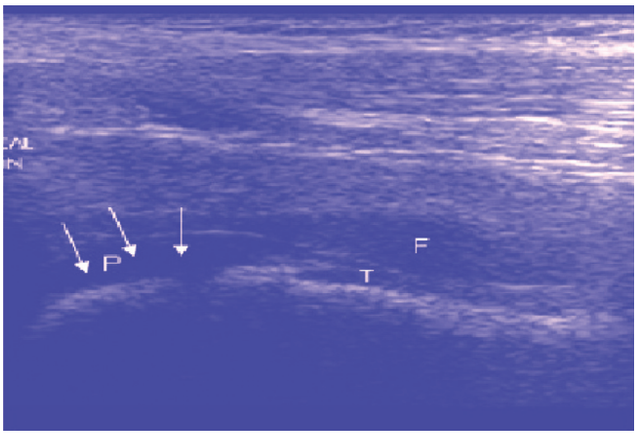

Fig. 1 Periosteal thickening(T) and elevation(arrows) with subperiosteal fluid collection(P). Also fluid adjacent to thickened peiosteum was noted(F)[9]

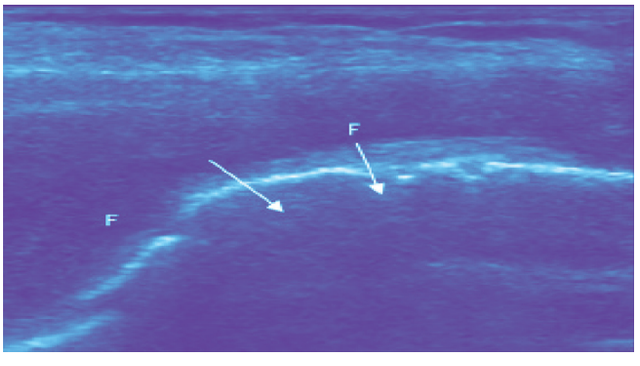

Fig 2 Sonography showing anechoic layer of fluid (F) adjacent to the echogenic bony cotex,with cortical erosion[9]

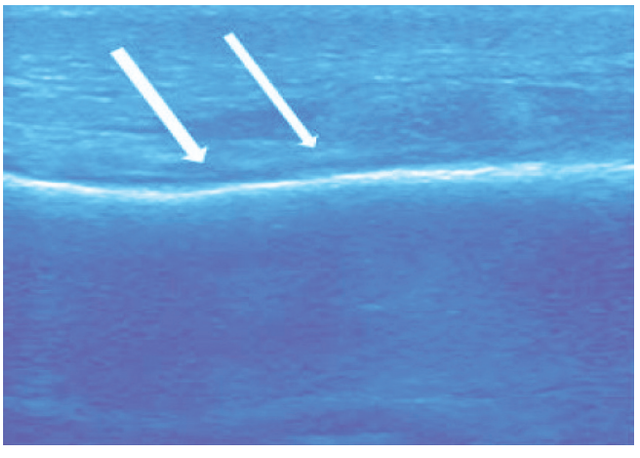

Figure 3: Ultrasound shows elevation of the periosteum (arrows) consistent with osteomyelitis[11]

Methods

All the patients who were clinically suspected to have acute osteomyelitis fulfilling following inclusion criteria were included in the study. A prospective non-randomized analytical study was conducted from Feb 2016 to June 2017.

Inclusion criteria

- Age from 1to 16 years
- Children with clinical suspicion of acute osteomyelitis
- Symptoms: high grade fever, inability to use the extremity, localised swelling and redness
- Sign : local tenderness and painful restriction of movements
- Negative conventional plain radiographic findings.
- Presentation within two weeks from the onset of disease

Exclusion criteria

- Chronic osteomyelitis(more than two weeks after symptom onset and Obvious radiological changes)
- Already treated cases
- Post surgical cases.

The clinical diagnosis of osteomyelitis was based on the diagnostic criteria established by Petola and Vahvanen[12]. They considered that in the presence of two of the following four criteria, the diagnosis of osteomyelitis was firm :

- Pus aspirated from bone,
- Positive bone or blood culture,
- Classic symptoms of localised pain, swelling, warmth and limited range of motion (ROM) of the adjacent joint,
- Radiographic changes typical of osteomyelitis.

Once the patients were enrolled in this study the relevant background information were collected:

Each patient included in the study was subjected to the following at the time of admission

- History and clinical examination: fever, tenderness, decreased ROM
- Laboratory tests : white blood cell count , ESR , CRP, Blood C/S
- Conventional plain radiograph: Initial radiographs including two basic views (AP& lateral views) of the affected bone were done at the time of hospitalization.

Ultrasonography

Patients were categorized according to time of presentation into three groups.

GroupI within first 3 days after onset of symptoms, Group II 4-6 days after onset of symptoms and Group III 1-2 weeks after onset of symptoms.

Gray-scale and whenever applicable power Doppler sonography were done for each patient. Comparative study between both normal and painful limbs was performed by the radiologist within first two weeks from the onset of symptoms.

The Sonographic machine used was Nemio, Toshiba IU 22 using a linear multifrequency transducer 7.5-10 MHz linear probe

Technique of examination

- Longitudinal and transverse scans covering the full thickness of the relevant areas were obtained. Both proximal and distal joints were always scanned as part of the ultrasonographic examination.
- The contralateral normal side was also examined to obtain equivalent views for comparison. This allowed for detection of subtle changes.

Abnormal sonographic findings

- Deep soft tissue swelling.
- Periosteal thickening and elevation with a thin layer of subperiosteal fluid.
- Pericortical fluid
- Cortical erosions, in later stage.
- Increased flow within or around periosteum on power Doppler sonography.

We considered any one of the above criterion sufficient to make the diagnosis.[9]

- Ultrasonography-guided aspiration of pus was performed under local anaesthesia or sedation (depending on age and co-operation of the patient) in cases where subperiosteal fluid was demonstrated, and the pus thus obtained was sent for Gram staining, culture and sensitivity. A large bore, shallow, tapered needle was used for the aspiration. Care was taken to insert the needle till it came in contact with the bone.
- Patients who underwent conservative treatment (antibiotic therapy), follow-up sonography at

different intervals was performed to judge the effectiveness of antibiotic therapy and to predict the need for surgical intervention.

Intravenous (IV) antibiotic was started in patients whose USG showed only deep soft tissue swelling adjacent to the affected bone. Repeated sonographic examination was performed on the third day after initiation of therapy. All cases which demonstrated an abnormal fluid collection adjacent to the bone, underwent surgery.

Follow-up to confirm the sonographic diagnosis

One of these methods had been used for each patient to confirm his/her sonographic diagnosis:

- Findings of surgical intervention
- Clinical improvement: resolution of signs and symptoms after effective antibiotic therapy, with follow up plain radiograph and USG.

Data Analysis

All the data analyses was performed using Microsoft Excel office 2007 and SPSS (Statistical Package for the Social Sciences) version 22 A $P < 0.05$ was accepted as significant and 95% confidence interval was taken Calculation of Sensitivity, Specificity, Positive predictor value and Negative predictor value was done using 2x2 tables.

Ethical issues

Informed consent was obtained from all the patients

Ethical clearance was obtained from the Institutional Review Board (IRB), TUTH

Results

Thirty patients were included in our study. All the patients with clinical suspicion of acute osteomyelitis were referred to department of radiology for Ultrasonographic evaualation of the same.

Majority of patients 19(63.3%) visited hospital 1week after onset of symptoms, 10 (33.3%)patients between 4-6 days after onset of symptoms whereas only 1 (3.3%) within first 3 days.

Out of the thirty cases, twenty four patients (80%) had a confirmatory diagnosis of acute osteomyelitis while six patients (20%) did not. The diagnosis of acute osteomyelitis was confirmed by surgery in 88%, while in 13% it was confirmed on subsequent follow-up (clinical and radiological).

Table-1 Duration between onset of symptoms and time of presentation among patients

Duration	Number	Percentage
First3 Days (Group1)	1	3.3%
4-6 Days (Group2)	10	33.3%
1-2 Weeks (Group3)	19	63.33%

Anatomical distribution

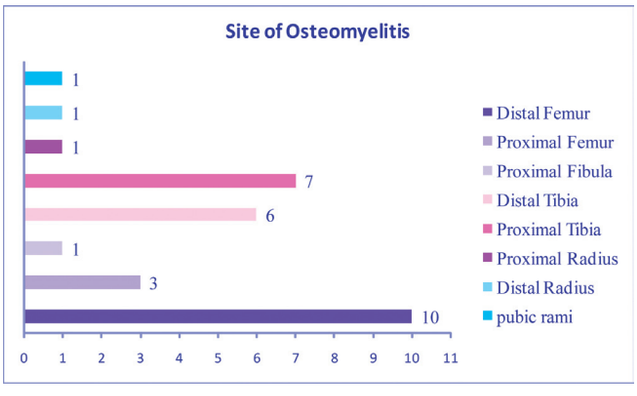

Figure 4: Site of involvement

Distal femur was most commonly involved in 33.33%(10) followed by proximal tibia 23.33 % (7),distal tibia 20%(6) and proximal femur 10 % (3).

Distal radius , proximal radius, proximal fibula and pubic rami were involved in 3.33%.

Table 2-The definitive diagnosis of patients according to confirming methods.

Modality of Final Diagnosis	Osteomyelitis	No osteomyelitis	Percentage
Surgery	22	4	86.6%
Follow Up	2	2	13.4%

A final diagnosis of osteomyelitis was made by surgery in 86.6% and on subsequent follow up (clinical , radiolographic or repeat ultrasound) in 13.4% of the cases.

Table 3-Sonographic findings among patients on the day of presentation

Sonographic Findings	Number
Deep Soft Tissue Swelling	18
Periosteal Elevation/thickening	18
Pericortical fluid	14
Cortical Erosion	3
Adjacent Joint Effusion	6

Five characteristic ultrasound findings were noted. Deep soft tissue swelling and periosteal thickening/ elevation were noted in most patients, while cortical erosion was noted in least number of patients. Both periosteal elevation/thickening and pericortical fluid was seen in 9 cases.

Table 4-Final diagnosis of acute osteomyelitis

Sensitivity of USG in diagnosis of acute osteomyelitis was found to be 91.6% and Specificity to be 83.3%. Positive predictive value and negative predictive value of USG in diagnosis of AOM was found to be 95.6% and 71.4% respectively.

Final Diagnosis	USG Finding		Total	Sensitivity	Specificity	PPV	NPV	Accuracy
OM	USG Normal	USG positive for OM						
Absent	5	1	6	91.6	83.3	95.6	71.4	90.0
Present	2	22	24					
Total	**7**	**23**	**30**					

Discussion

Acute hematogenous osteomyelitis is one of the common childhood infection. It is regularly encountered in pediatric orthopaedic emergency and managed at our centre. It can cause significant morbidity, if is not diagnosed early and effective treatment started promptly.[8]

Though bone scan and MRI are highly sensitive in making diagnosis, these imaging modalities are usually unfeasible and impractical in our setting due to high cost, anesthesia requirement and radiation hazard of bone scan. Ultrasound (US) is a rapid, cheap, easily available, non ionizing and reasonably accurate diagnostic modality which can be performed at the bedside. Ultrasound is a tool that can give strength to the clinical diagnosis of acute osteomyelitis.

Sensitivity and specificity of test and correlation

The sensitivity of ultrasound in diagnosis of acute osteomyelitis was found to be 91.6% which is in agreement with study by George et al. whose result revealed 93% sensitivity.[20] The high values of sensitivity and specificity in our study might be explained by the strict inclusion and exclusion criteria for our patients which narrowed the scope of our selection to those with clinical suspicion of osteomyelitis together with negative radiographs for any other bone lesions.

While specificity of all signs were very high reaching 83% for deep soft tissue swelling and periosteal elevation whereas 100% for pericortical fluid and cortical erosion , This is in agreement with Ezzat et al which showed specificity of 100%.[9]

This high specificity of each sonographic sign could be because of our selection of cases when patients were clinically suspected to have acute osteomyelitis, plain radiograph was obtained to exclude other causes of pain(e.g. tumors, fractures etc.) in each patient, hence our list of differential diagnosis was narrowed to obtain this high specificity.

False negative cases

Two cases of osteomyelitis, proximal femur and pubic rami were missed by Ultrasonography in our study.

In similar study, Mah et al. found USG did not detect all deep soft tissue swelling and periosteal elevation in case of proximal femur[13] and Ogonda et al. found USG was not helpful in diagnosis of acute osteomyelitis of pelvis. [17] which is similar to our study.

This might be because initially the involvement of periosteum is not circumferential and occurs only on one side of the bone. Ultrasound examination is therefore not complete until the whole circumference has been examined, and attachment of joint capsule in proximal femur made difficult in diagnosis of proximal femoral osteomyelitis.[13]

False positive case

In one suspected case of osteomyelitis, USG showing periosteal elevation with minimal subperiosteal fluid was found to be resolving hematoma during surgery. Similar findings was seen by Hui H in his study. He described in case of trauma or physeal injury,the periosteum is torn and hematoma is formed across the fracture site in inflammatory phase. If the periosteum is intact, hematoma will form under the periosteum. [18] Multiple related studies also described USG cannot distinguish between and hematoma and pus.[19][7, 9, 20]

True negative cases

Five true negative cases were found in our study who were clinically suspected of having osteomyelitis.

In three cases(out of 30), the USG showed localised muscle oedema, with distortion of the muscular fibrillary patterns along with ill defined hypoechoic areas, a possible diagnosis of pyomyositis was made as described by Robben in his study [21], which was later confirmed during surgery.

The fourth was eventually diagnosed as a vaso occlusive crisis in sickle cell anaemia as the patient responded to treatment with fluids and analgesia according to the Vasocclusive crisis(VOC) protocol.[22]

The fifth patient was followed up with radiograph which showed hairline fracture in distal 3rd femur . Multiple related studies have described trauma or tumor mimicking acute osteomyelitis in children.[23-26]

Conclusion

This prospective non-randomized analytical study was performed to analyse the application of Ultrasound in early diagnosis of acute osteomyelitis in our center in 30 children. Distal femur was the most common site involved. Ultrasound was found to be highly sensitive and specific in early diagnosis of acute osteomyelitis ..

High index of clinical suspicion should remain the mainstay for diagnosing acute osteomyelitis in its early stage where ultrasound helps to augment this clinical entity for prompt and efficient management.

Limitations

Since the sample size is small, a larger sample might have provided a better result.

There could have been interobserver variability during USG examination as it was not performed by a single person.

High resolution ultrasound machine has better resolution and less chance of error.

Power Doppler could not be performed in all cases.

References

1. Agarwal A, Aggarwal AN. Bone and Joint Infections in Children: Acute Hematogenous Osteomyelitis. Indian journal of pediatrics. 2016;83(8):817-24.
2. Chiappini E, Camposampiero C, Lazzeri S, Indolfi G, De Martino M, Galli L. Epidemiology and Management of Acute Haematogenous Osteomyelitis in a Tertiary Paediatric Center. International journal of environmental research and public health. 2017;14(5).
3. DiPoce J, Jbara ME, Brenner AI. Pediatric osteomyelitis: a scintigraphic case-based review. Radiographics. 2012;32(3):865-78.
4. Pineda C, Espinosa R, Pena A. Radiographic imaging in osteomyelitis: the role of plain radiography, computed tomography, ultrasonography, magnetic resonance imaging, and scintigraphy. Seminars in plastic surgery. 2009;23(2):80-9.
5. Blickman J, Van Die C, De Rooy J. Current imaging concepts in pediatric osteomyelitis. European Radiology Supplements. 2004;14(4):L55-L64.
6. Denis CA. Acute Hematogenous Osteomyelitis. Pediatrics in Review. 2010;Vol.31 No.11 464-74.
7. Pineda C, Vargas A, Rodriguez AV. Imaging of osteomyelitis: current concepts. Infectious disease clinics of North America. 2006;20(4):789-825.
8. Azam Q, Ahmad I, Abbas M, Syed A, Haque F. Ultrasound and colour Doppler sonography in acute osteomyelitis in children. Acta orthopaedica belgica. 2005;71(5):590.
9. Ezzat T, El-Hamid AA, Mostafa M, El-Kady L. Early diagnosis of acute osteomyelitis in children by high-resolution and power Doppler sonography. The Egyptian Journal of Radiology and Nuclear Medicine. 2011;42(2):233-42.
10. Riebel T, Nasir R, Nazarenko O. The value of sonography in the detection of osteomyelitis. Pediatric radiology. 1996;26(4):291-7.
11. Artul S, Habib G. Ultrasound findings of the painful ankle and foot. Journal of clinical imaging science. 2014;4.

12. Peltola H, Vahvanen V. A comparative study of osteomyelitis and purulent arthritis with special reference to aetiology and recovery. Infection. 1984;12(2):75-9.

13. Mah ET, LeQuesne GW, Gent RJ, Paterson DC. Ultrasonic features of acute osteomyelitis in children. Bone & Joint Journal. 1994;76(6):969-74.

14. Wright N, Abbott G, Carty H. Ultrasound in children with osteomyelitis. Clinical radiology. 1995;50(9):623-7.

15. Sia IG, Berbari EF. Osteomyelitis. Best practice & research Clinical rheumatology. 2006;20(6):1065-81.

16. Dich VQ, Nelson JD, Haltalin KC. Osteomyelitis in infants and children: a review of 163 cases. American journal of diseases of children. 1975;129(11):1273-8.

17. Ogonda L, Bailie G, Wray A. Acute osteomyelitis of the ilium mimics septic arthritis of the hip in children. The Ulster medical journal. 2003;72(2):123.

18. h HHaL. Subperiosteal Hematoma of the Ankle. journal of orthopaedics case reports. 2016;6:63-4.

19. Solomon Louis WD, Nayagam Selvadurai. Apley's Systematic of Orthopaedics and fractures. 9th ed: CRC; 2015.

20. George J, Teo S, Adan M. The Role of Real Time Ultrasound in Differentiating between Osteomyelitis and Tumour in Long Bones. Malaysian Orthopaedic Journal. 2008;2(1):33-7.

21. Robben S. Ultrasonography of musculoskeletal infections in children. European Radiology Supplements. 2004;14(4):L65-L77.

22. Inusa BP, Oyewo A, Brokke F, Santhikumaran G, Jogeesvaran KH. Dilemma in differentiating between acute osteomyelitis and bone infarction in children with sickle cell disease: the role of ultrasound. PloS one. 2013;8(6):e65001.

23. Santos JMM. Diagnostic imaging of pediatric hematogenous osteomyelitis: lessons learned from a multi-modality approach. European radiology. 2006;16(9):2109-19.

24. Canale Terry. S BJH. Campbell's Operative Orthopaedics. 12th ed. .D DG, editor: Elsevier mosby; 2013.

25. Morrissy RTW, Stuart L. Lovell & Winter's Pediatric Orthopaedics. 6th ed. Stans AA, editor: Lippincott Williams & Wilkins; 2006.

26. John HA. Tachdjian's Pediatric Orthopaedics 5th ed: Elsevier saunders; 2014.

27. Nath AK, Sethu AU. Use of ultrasound in osteomyelitis. The British journal of radiology. 1992;65(776):649-52.

28. Larcos G, Antico VF, Cormick W, Gruenewald SM, Farlow DC. How useful is ultrasonography in suspected acute osteomyelitis? Journal of ultrasound in medicine. 1994;13(9):707-9.