The role of preoperative appendicular magnetic resonance imaging in cases of suspected acute bone and joint infection in the paediatric age group

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Abstract
Background: Acute haematogenous osteomyelitis is mainly a disease of children. It is a challenge to differentiate it from septic arthritis as they have overlapping signs and symptoms. Septic arthritis is a surgical emergency when acute osteomyelitis, presenting early, can be treated with parenteral antibiotics. There is paucity in imaging guidelines and treatment for cases where acute septic arthritis is associated with osteomyelitis.

Objectives: To analyse the role of preoperative magnetic resonance imaging (MRI) in cases of suspected acute bone and joint infection in the paediatric age group.

Method: This is a prospective study in 38 children suspected to have acute bone and joint infections. All the patients underwent emergency appendicular MRI on suspicion of bone and joint infections. Based on the MRI findings, the patients were classified into cases of isolated septic arthritis and cases of septic arthritis with concomitant osteomyelitis. There was a change in the treatment modality between the two categories of patients.

Results: In our study 14 (36.8%) cases of suspected bone and joint infection had concomitant osteomyelitis with septic arthritis. These 14 cases were seen involving the knee, hip, elbow and shoulder joints. The incidence of septic arthritis with coexisting osteomyelitis was 36.8% in our study, which was diagnosed with preoperative emergency appendicular MRI.

Conclusions: Our study concludes that MRI should be included in the work up for suspected bone and joint infections provided MRI is done in a timely fashion without unnecessarily delaying surgical intervention if needed.

(Key words: Preoperative appendicular MRI, Acute bone and joint infection, Children)

Introduction
Acute haemotogenous osteomyelitis and septic arthritis can occur at any age but is mainly a disease of children. It is a challenge to differentiate them as they have overlapping signs and symptoms. Many of the children may present late after initial ‘suppression’ of infection with antibiotics. Acute osteomyelitis, when seen early before 48 hours of onset of symptoms and before abscess formation can be managed with intravenous administration of antibiotics but septic arthritis, which is more common, is a surgical emergency. Kocher’s criteria are still considered important clinical practice guideline for diagnosis of septic arthritis of the hip. Commonly in infants, septic arthritis and metaphyseal osteomyelitis may co-exist.

The imaging work-up for suspected septic arthritis includes radiographs, ultrasound and at times magnetic resonance imaging (MRI). Because the radiography (x-ray) results may be normal in the setting of acute septic arthritis and osteomyelitis, MRI may be a useful tool to confirm the diagnosis. MRI helps us to differentiate septic arthritis, osteomyelitis without abscess, osteomyelitis with abscess, combination of septic arthritis and osteomyelitis and sometimes soft tissue infection without bone/joint infection. This helps us to plan our surgical strategy and decide on the antibiotic protocol as osteomyelitis requires a longer duration of therapy than septic arthritis. However, the availability of MRI as an emergency investigation and the difficulty of procuring good images without sedation, especially in children, are the caveats. At our institution, we were able to perform urgent MRIs in all children with suspected bone and joint infection. We hypothesized that MRI may be of significant benefit in the management of a child with suspected septic arthritis/osteomyelitis.

Objectives
To analyse the role of preoperative MRI in cases suspected of acute bone and joint infection in the paediatric age group.

Method
A prospective study was carried out from April 2014 to June 2019 on all children clinically suspected to have acute bone and joint infections. All patients underwent emergency appendicular musculoskeletal MRI examinations for any suspected bone and joint infection. Exclusion criteria included patients above the age of 17 years, involvement of small joints of hand and feet, spinal infections and any previous intervention at the site of suspected infection. Children with a history of underlying fracture or implantation were also excluded because the objective of this study was to evaluate acute haematogenous septic arthritis and osteomyelitis. All the MRIs were done using a 1.5 T MRI scanner available in our Institution.
After obtaining consent from the parents, proformas were filled up. The proformas included the symptoms, duration of symptoms, previous treatment taken (including medications with the duration), details of laboratory investigations, radiologic findings (including ultrasound, MRI).

MRI reports were interpreted as osteomyelitis if intramedullary low T1 signal intensity and/or increased signal intensity on T2/ fluid sensitive sequences - findings that can be attributable to oedema, hyperaemia or exudate. MRI reports for septic arthritis were reported as joint effusion if in the supraphysiologic levels.

**Ethical issues:** Approval for the study was obtained from the Institutional Research Ethics Committee of Sri Ramachandra University (No. CSP-MED/14/NOV/20/214) on 01.10.2016. Written informed consent was obtained from the parents/guardians of the study participants.

**Results**
A total of 36 patients with symptoms suspected of acute bone and joint infection were studied of which 2 had bilateral involvement. Hence a total of 38 joints were screened. There were 21 (58.3%) boys and 15 (41.7%) girls. There were 18 (47.3%) cases involving the right side, 16 (42.1%) cases involving the left side and 2 (5.3%) cases had bilateral involvement. The age distribution was between 14 days to 15 years (mean age 28.35 months). MRI findings are shown in Figure 1.

MRI found only effusion (supra physiologic levels of fluid) in 22 patients (24 joints) and effusion with osteomyelitis (hypointense T1 signals + hyperintense T2/STIR in the adjacent epiphyseal-metaphyseal region) in 14 cases. Figure 2 shows the presence or absence of infection on the preoperative MRI.

The duration between the onset of symptoms to surgery ranged from 1 to 21 days, (mean 5.65 days). All the cases underwent arthrotomy with sampling of the synovial fluid and synovial tissue biopsy, followed by joint lavage. In the cases where concomitant osteomyelitis of the adjacent epiphysis/metaphysis were also noted on the MRI, in addition to the lavage, 3-4 holes (using 1.8 mm Kirschner- wires) were made in the affected bone-metaphyseal region. Even though there is controversy that the small holes may be insufficient to address the osteomyelitis as they may become clogged, we felt that it may be safer than a larger window, which increases the risk of pathological fracture. All the cases were closed in layers with a suction drain, which was monitored and removed postoperatively.
In all 14 cases with concomitant osteomyelitis, there was serous (6 cases) / sero-purulent (8 cases) discharge from the osteomyelitis decompression site. Swabs were taken from the decompression sites. Among the 14 cases 9 (64.3%) had growth of organisms. The same organisms grew from the synovial fluid/tissue as well as the swab taken from the fluid, which came out of the holes made in the bone in all 9 cases. In 5 cases the cultures were negative for growth, both in synovial tissue as well as in the swab taken from the fluid that came out from the metaphyseal drill sites. This was probably due to the injudicious use of oral antibiotics by the physicians who had seen the patient before they presented to us. Staphylococcus aureus grew in 5 (55.6%) cases, coagulase negative staphylococcus (CONS) in 2 (22.2%) cases, Escherichia coli in 1 (11.1%) case and Klebsiella pneumoniae in 1 (11.1%) case (Figure 3).

Histopathology reports of the tissue and the cytology of the fluid from the metaphysis holes showed acute inflammatory cells with predominant neutrophils suggestive of septic arthritis /osteomyelitis. This definitely correlated with the preoperative diagnosis of septic arthritis with concomitant osteomyelitis. Sensitivity of the MRI in diagnosing coexisting infections was 100% but specificity may be slightly less. A normal MRI definitely excludes osteomyelitis. Based on the above findings, the cases with concomitant osteomyelitis in addition to septic arthritis were treated with parenteral antibiotics for a longer duration (4 weeks) than septic arthritis (2 weeks) cases as per the Paediatric Infectious Diseases Consultant’s advice. Culture negative cases were treated with empirical antibiotics as decided by the Paediatric Infectious Diseases Consultant.

The symptom to surgery interval for the 14 cases of septic arthritis with concomitant osteomyelitis ranged from 1 to 21 days (mean 5.92 days), which was higher than the mean duration for all cases combined (septic arthritis + septic arthritis with osteomyelitis). The ages of the 14 cases are shown in Figure 4,

The osteomyelitis was noted in the proximal femur in the case of hip joint (Figure 5), distal femur and proximal tibia in the case of the knee joint (Figure 6), proximal humerus in the case of the shoulder joint (Figure 7) and proximal radius/ ulna and distal humerus in the case of elbow joint (Figure 8).
Figure 5: Coronal short tau inversion recovery (STIR) (a) and T2W image (b) showing effusion in the left hip (arrows) and marrow oedema in left proximal femur (arrow heads)

Figure 6: Sagittal STIR (a) and T2W image (b) showing synovial thickening-effusion in the left knee (arrows) and marrow oedema in left distal femur and proximal tibia (arrow heads)

Figure 7: Coronal STIR (a) and axial T2W image (b) showing effusion in the left shoulder joint (arrows) and marrow oedema in left proximal humerus (arrow heads). Oedema seen in the periarticular soft tissues (open arrows)

Figure 8: Plain radiograph of the elbow (a) showing widening of the humerus with a lytic lesion in the distal metaphysis (arrow). Coronal STIR (b) and sagittal STIR (c) images showing synovial thickening-effusion in elbow joint (broken arrows), marrow oedema in the distal humerus, proximal radius and ulna (arrow heads). Diffuse periarticular thickening seen in the humerus (open arrows)
The involvement of the knee joint with osteomyelitis of distal femur and proximal tibia was seen in 5 (35.7%) of the 14 cases. The elbow joint with involvement of the radius ulna, and distal humeral epiphysis/metaphysis was seen in 3 (21.4%) cases. The involvement of proximal femur especially in the femoral neck region was seen in 4 cases of the hip joint (28.6%) and 2 (14.3%) cases in the shoulder joint with involvement of the proximal humerus.

Discussion

In our study, emergency appendicular MRI was made mandatory in all suspected bone and joint infection among the paediatric age group. Most of the MRIs in younger children were done under sedation (Triclofos, Pheniramine) in consultation with the Paediatricians. A few MRIs were done under anaesthesia and the child was directly shifted to the operation theatre with the provisional report of the MRI. Surgery was done under the same anaesthesia.

The incidence of septic arthritis with concomitant osteomyelitis in various studies was between 17-33%..

22. The incidence of osteomyelitis with septic arthritis was 14 (36.8%) cases among the 38 joints that were studied. The current paediatric septic arthritis diagnostic criteria for hip joint (Kocher’s criteria) do not include routine MRI. The American College of Radiology (ACR) advocates the use of ultrasound in a limping child with suspected underlying infection. However, the ultrasound can detect, quantify effusion in a joint and can also detect abscess underneath the peristeum, which occurs quite late in the pathogenesis of osteomyelitis. Our study suggests that MRI should be preferably done compared to an ultrasound in a safe and timely fashion. The previous study by Montgomery CO, et al.4 found an incidence of 21.5% of concomitant osteomyelitis in septic arthritis among 200 cases studied retrospectively. Montgomery CO, et al.4 found that 72% of their shoulder cases had concurrent osteomyelitis. In our study we had maximum incidence of concomitant septic arthritis and osteomyelitis involving the knee joint based on the preoperative MRI. Another study by Perlman ML, et al.24 reported the incidence of osteomyelitis associated with septic arthritis as 33%. It was a study with 66 children who were divided into two groups. One group was cases of osteomyelitis with no involvement of adjacent joint. The second group consisted of cases of osteomyelitis with adjacent joint involvement. There was however no clear data on the number patients who underwent MRI. Monsalve J, et al.25 published a retrospective study on septic arthritis with consistent osteomyelitis, but there is no clarity about the timing of MRI or change in the treatment plan in cases of septic arthritis associated with osteomyelitis. The sensitivity and specificity of MRI done preoperatively was 38% and 95% respectively in a study by Schlung JE, et al.26, but the drawback was that it studied only infections of the hip. It was a retrospective study with the possibility of missing or inaccurate data. In 2014 Gottschalk HP, et al.27 did a retrospective study about the analysis of pelvic and hip MRI versus emergency hip aspiration for suspected hip sepsis and concluded that re-operation was 2.8 times more likely to be required in patients who did not have early advanced imaging as compared with patients who received early advanced imaging. The drawbacks were that it was a study done for hip infections alone and no proper data about the sensitivity was discussed.

There is potential for delay in the emergency procedure of arthrotomy if pre-operative MRI is performed for all cases of suspected infection. The clinical significance of this is however not known. We also believe that MRI prevents neglecting or missing a co-existing osteomyelitis or a periarticular abscess that could require a return to the operating room. The significance in the cartilage injury related to the delay in the surgical treatment (while taking MRI) is far less than subjecting the neonate/infant/child to another surgery or worse under treatment. Ten (71.4%) out of the 14 cases of concomitant osteomyelitis with septic arthritis in our series were found in patients less than 2 years of age. In infants and particularly neonates, septic arthritis is more likely to occur secondary to adjacent spread of osteomyelitis especially in joints having an intra-articular metaphysis e.g., shoulder, elbow and hip.

The sequelae of untreated or under-treated osteomyelitis are far more devastating for the child than a few hours spent in the MRI room before surgery. The other drawback we had to encounter in slightly older children >2 years was the need for sedation/ anaesthesia due to lack of co-operation and fear. Stress reaction/ reactive osteitis have been misinterpreted as osteomyelitis on MRI images. However, this bias is limited when clinical features and laboratory findings are correlated and a re-review of the imaging diagnosis is done.

Though short-term and mid-term follow-up of the cases are available, the weakness of our study is that we do not know whether a change in surgical strategy or antibiotic protocol based on the MRI findings has affected the long-term outcome of all the patients. However, MRI is now easily available in most centres and at reasonable cost. It also entails no risk of unnecessary radiation. In our institution, performing an MRI in a child delayed the surgical procedure by only an average of 6 hours. There is evidence from various animal studies that visible chondral damage can occur in septic arthritis as early as 24 hours, however irreparable damage usually takes place in 3-4 days.28-30 There is an option of treating all cases of septic arthritis as septic arthritis with co-existing osteomyelitis and follow the treatment regimen as done for septic arthritis associated with osteomyelitis. However, the need for prolonged parenteral antibiotics for a period of at least 2 weeks, its financial implications in terms of prolonged hospitalization (OPAT’s- Out patient parenteral antibiotic therapy are relatively less common in India) and the cost of procuring the drugs. Secondly the side effects of the prolonged use of antibiotics in unwarranted situations are also to be kept in mind.

When all cases of suspected septic arthritis undergo MRI, coexisting osteomyelitis is frequently present in all age groups, especially <2 years. Important advantages of MRI are its ability to detect early changes in septic arthritis/ osteomyelitis, depict the true extent of the disease, evaluate the extra-osseous spread of infection and help in planning the surgical management.
Conclusions
Our study concludes that MRI should be included in the work-up for suspected bone and joint infections provided it is done in a timely fashion without unnecessarily delaying surgical intervention if needed.

References


