IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 6 Ser. 7 (June. 2024), PP 01-04
www.iosrjournals.org

Role Of MRI In Diagnosis Of Acute Haematogenous Osteomyelitis In Paediatric Patients.

Rajeev Kumar Roy[1],Pooja Mishra[2] ,Bijayendra Nath Chaturvedi[3], Sanjeev Kumar[4], N K Singh[5]

1. *Assistant Professor, Department Of Orthopedics, Nmch, Patna*
2. *Senior Resident, Department Of Paediatrics, Igims, Patna*
3. *Senior Resident, Department Of Orthopedics , Nmch, Patna*
4. *Junior Resident, Department Of Orthopedics, Nmch, Patna*
5. *Head Of Department, Orthopedics, Nmch, Patna*

Abstract
Osteomyelitis is a significant cause of morbidity in children throughout the world. Multiple imaging modalities can be used to evaluate for suspected osteomyelitis, however magnetic resonance imaging (MRI) has distinct advantages over other modalities given its ability to detect early changes related to osteomyelitis, evaluate the true extent of disease, depict extraosseous spread of infection, and help guide surgical management. MRI has assumed a greater role in the evaluation of osteomyelitis with the increase in musculoskeletal infections caused by methicillin-resistant Staphylococ-cus aureus which have unique imaging features that are well-demonstrated with MRI. This review focuses primarily on the use of MRI in the evaluation of osteomyelitis in children and will include a discussion of the clinically important and characteristic findings on MRI of acute bacterial osteomyelitis and related conditions.

Keywords: *Magnetic resonance imaging; Osteomyelitis; Pediatrics Infectious diseases.*

Date of Submission: 07-06-2024 Date of Acceptance: 17-06-2024

I. Introduction

Musculoskeletal infection is a significant cause of morbidity and mortality in children throughout the world. This category of disease encompasses both osteomyelitis and septic arthritis, however this review will be primarily focused on the former. Osteomyelitis is typically categorized as either hematogenous or non-hematogenous. Hematogenous osteomyelitis typically occurs when circulating pathogenic organisms take up residence in the metaphyses of long bones due to sluggish circulation in these regions. Non-hematogenous osteomyelitis, on the other hand, results from direct inoculation of organisms into bone due to penetrating trauma, open fractures, etc. Acute hematogenous osteomyelitis (AHO) is the most common type of musculoskeletal infection in children with an estimated incidence of 1 case per 5000 children per year in the United States[1]. It is primarily a disease of young children with approximately half of all cases occurring in children 5 years of age or younger[2]. Some recent studies have indicated that the incidence of AHO is increasing with a concurrent increase in the number of cases due to methicillin-resistant Staphylococcus aureus (S. aureus) (MRSA) infections[3]. The signs and symptoms of AHO in children are nonspecific and as such, imaging frequently plays a significant role in the diagnosis and management of this condition.

Infection by S. aureus is the most common cause of osteomyelitis. Community acquired S. aureus is implicated in most cases with 30% of these cases caused by community acquired MRSA (CA-MRSA)[4,5]. Other organisms that cause osteomyelitis include Streptococcus pneumoniae, Streptococcus pyogenes, Pseudomonas aeruginosa and Bartonella henselae. Salmonella is an important cause of osteomyelitis in patients with Sickle cell disease. Gram-negative bacteria and group B streptococci are common causes in newborns and Kingella Kingae in the first two years of age[5].

II. Pathophysiology

Hematogenous osteomyelitis is the most common type of osteomyelitis in children[4]. This occurs when an infection elsewhere in the body spreads to the bone via the bloodstream. Risk factors for development of hematogenous osteomyelitis include trauma, prematurity, urinary tract infections, vascular catheters and immunodeficiencies. The blood vessels in the metaphyses have sluggish flow and discontinuous endothelium, which predispose to infection[4]. The most common bones to be affected are the fastest growing bones that have highly vascularized long bone metaphyses and metaphyseal equivalents. Common sites include the distal femur, proximal tibia, proximal humerus and distal radius. Most cases start with a focal infection in the

metaphyseal marrow which progresses to local decalcification and bony destruction. Occasionally, multiple foci may be infected which eventually coalesce. This infection can spread within the marrow cavity and as the pressure increases within the marrow cavity, the infection can spread through Haversian canals in the cortex into the subperiosteal space, giving rise to a subperiosteal abscess. Similarly, the infection can traverse the periosteum and infect the adjacent soft tissues leading to pyomyositis. Infection may also spread across the physis into the epiphysis and joint space[4]. The first stage of osteomyelitis occurs with vascular congestion, intravascular thrombosis and increased intraosseous pressure. Next is the suppurative stage where pus traverses the Haversian canals and forms a subperiosteal abscess. Subsequently a sequestrum may form when the periosteal and endosteal blood supply is compromised from increased pressure and vascular obstruction. This may lead to formation of an involucrum (new bone growing from the periosteum) . Depending on medical or surgical treatment at this point the infection may resolve or progress with complications. The site of osteomyelitis varies with patient age and is related to the blood supply. In early infancy osteomyelitis occurs in epiphyses and metaphyses and epiphysealequivalent regions. Transphyseal vessels are present in infants younger than 18-24 mo of age, which allow easier spread of infection across the physis from the metaphysis to the epiphysis[4,6]. This is the reason that infantile osteomyelitis frequently involves the epiphysis and joint space. It is important to note that this is not the most common cause of septic arthritis, which more often results from direct hematogenous synovial seeding[4]. During early infancy, isolated involvement of the epiphyseal growth plate can occur. Infection of the epiphyseal growth plate during infancy can result in growth disturbance. In the 2-16 years age group, osteomyelitis is most often located in the metaphyses[6].

Imaging approach to Osteomyelitis

Osteomyelitis in children demonstrates abnormalities on nearly all imaging modalities, including radiography, ultrasound, computed tomography, radionuclide bone scintigraphy, and magnetic resonance imaging (MRI). The conventional approach to the imaging evaluation of suspected AHO in the past has been radiography followed by bone scintigraphy if the radiographs were negative. In this algorithm, MRI was typically been reserved for cases of poor treatment response or suspected vertebral diskitis-osteomyelitis. However, due to multiple factors, including the rise of rapidly aggressive and invasive musculoskeletal infections with CA-MRSA, this approach may no longer be ideal[7].

As a first line modality radiography is useful for excluding other differential diagnoses such as trauma or tumor, however radiographs are insensitive for the detection of early osteomyelitis. Radiography may be normal in cases of osteomyelitis up to 14 d after the onset of infection and even then, only 20% of cases demonstrate radiographic abnormalities after this two-week delay[8]. Additionally, the early radiographic findings, including soft tissue swelling, vague bony lucency, and periosteal reaction, may be subtle and may not reflect the true extent of disease.

Triple-phase bone scintigraphy using 99mTc-methylene diphosphonate (99mTc-MDP) can demonstrate evidence of infection as soon as 24 h after onset and also has the advantage of being able to depict multiple sites of infection. Osteomyelitis typically manifests as increased radiotracer uptake on all phases (angiographic, blood pool, and delayed) of the triple-phase examination. However 99mTc-MDP scintigraphy is limited by poor anatomic detail and is insensitive for the detection of abscesses and extraosseous involvement. Furthermore, the sensitivity of 99mTc-MDP scintigraphy for the diagnosis of osteomyelitis, which in the past has been reported to be as high as 80%[9], may be decreasing with the increasing incidence of MRSA infections that tend to have significant soft-tissue involvement[7]. Positron emission tomography with 18-fluorodeoxyglucose appears to be sensitive (95%) and specific (87%) for the diagnosis of osteomyelitis[9], however it has limited availability and involves a significant amount of radiation exposure. Scintigraphic studies using white blood cells labeled with indium-111 or 99mTc hexamethylpropyleneamine oxime require relatively large volumes of blood and are not used frequently in younger children.

In contrast to the modalities listed above, MRI is both sensitive for the detection of early osteomyelitis and can also accurately depict the extent of disease as well as any associated abscess or soft-tissue extension without the risks associated with radiation exposure. MRI combines high-resolution anatomic delineation of the medullary space, cortex, and periosteum with high soft tissue contrast for detection of edema and fluid. Preoperative MRI has been shown to reduce operative time and extent of surgical exposure in cases requiring surgical debridement[10]. MRI does have distinct disadvantages in children including long scan times and susceptibility to motion artifacts which necessitate sedation or anesthesia in young children (approximately 6 mo to 8 years of age). Additionally, MRI is contraindicated in some patients with metallic foreign bodies and certain types of implanted hardware. However, the overall superiority of MRI in evaluating osteomyelitis is reflected in recent clinical practice guidelines which indicate that MRI is the imaging modality of choice for the detection of osteomyelitis and associated infection of the extraosseous soft tissues[11]. As such, the current best imaging approach for suspected osteomyelitis is radiography followed by MRI.

MRI Technique

Multiple variations of MRI protocols for the evaluation of osteomyelitis exist, however the essential sequences include both multiplanar T1 and T2-weighted fast-spin echo or turbo spin-echo (FSE/TSE) sequences and shorttau inversion recovery (STIR) or T2-weighted FSE/TSE sequences with fat-suppression (T2-FS). STIR and T2FS sequences are particularly helpful for increasing the conspicuity of bone marrow edema and fluid collections. There is some controversy regarding when to use gadolinium in infants and children with suspected osteomyelitis. Intravenous gadolinium contrast does not appear to improve the sensitivity or specificity for the diagnosis of osteomyelitis overall. Recent studies suggest that if the fluid-sensitive images (e.g., STIR, T2-FS) are normal, gadolinium enhancement provides no additional diagnostic value[12,13]. If the fluid-sensitive images are abnormal, however, gadolinium enhancement is of value in increasing confidence in the diagnosis of an abscess (if present) and planning of the approach to abscess aspiration and drainage[12]. Despite these recent studies that suggests that gadolinium contrast administration may not be needed for all cases, there are some specific indications for which contrast is always indicated. In cases of suspected vertebral osteomyelitis, contrast is necessary to assist in the differentiation of abscess in the epidural space or paravertebral masses from inflammatory masses[4]. Additionally, epiphyseal growth plate involvement by osteomyelitis may sometimes only be seen on gadolinium enhanced T1 sequences and not seen on non-contrast T1 and fluid sensitive sequences or on radiography or bone scintigraphy. Active epiphyseal infection manifests as one or more areas of decreased or no enhancement of the epiphyseal cartilage which otherwise should enhance uniformly[14,15]. As mentioned above, infection of the epiphyseal growth plate during infancy can result in growth disturbance and therefore gadolinium use in this age group is advised.

Because it is frequently difficult to precisely localize sites of involvement by clinical exam, especially in infants, an initial large field-of-view coronal STIR or T2-FS sequence of the general region of concern can be used to help localize the site(s) of disease followed by a tailored evaluation of the involved areas. In cases of suspected osteomyelitis affecting the lower extremities, imaging of the contralateral extremity may also be considered: abnormalities in the contralateral extremity are common, however they may not affect clinical management[16]. Whole-body MRI (WBMRI) may be indicated in cases of suspected multifocal involvement such as in cases of severe CA-MRSA infections, which frequently involve multiple sites, or in cases of suspected chronic multifocal recurrent osteomyelitis (CRMO). WBMRI is typically performed using a series of coronal STIR acquisitions obtained in multiple anatomic stations using receiver coils spanning the entire body, with the scan table moved through the magnet between stations. The images from each station are then digitally fused at points of overlap to create a single whole body image stack.

III. Mri Features Of Acute Osteomyelitis

Because MRI is able to detect early marrow involvement, it is an important modality for detection of osteomyelitis in early stages. Additionally, MRI is helpful for detection of fluid collections and abscesses that may occur in themarrow, subperiosteal region or in soft tissues. Anatomical information provided by MR can be helpful for drainage and surgical treatment. T1 fat saturation gadoliniumenhanced images will show non-enhancement of fluid and pus with peripheral enhancement. The earliest finding of osteomyelitis on MRI is bone marrow edema and T2 and STIR sequences are very important for detecting these early changes. MRI is also sensitive for detection of periosteal elevation and the presence of a subperiosteal fluid collection or abscess. Distinguishing normal hematopoietic marrow from abnormal marrow can be challenging in certain situations because of the normal hematopoietic marrow often seen in the metaphyses in children. Normal hematopoietic marrow T1 signal should be hyperintense relative to muscle. If there is marrow infiltration or edema, the T1 signal is generally isointense or hypointense to muscle. Normal hematopoietic marrow should appear similar in adjacent or contralateral metaphyses.Imaging of the contralateral body part is often helpful for this and is more easily obtained during imaging of the pelvis and lower extremities. Since detailed small structure anatomical information is less important during evaluation of osteomyelitis (OM), imaging with a body coil should be considered if large field of view imaging would be helpful. Pelvic osteomyelitis often occurs in metaphyseal equivalents such as the ischiopubic synchondrosis, pubic symphysis, triradiate cartilage, iliac apophyses and adjacent to the sacroiliac joint. Involvement of adjacent soft tissues, muscles and bowel is not uncommon and MRI is helpful in imaging the extent and often the source of infection.

Diagnostic Challenges

Differentiating osteomyelitis from Ewing sarcoma can often be challenging. The fact that children often do not present with the classic signs and symptoms of an infection makes the clinical differentiation between these two diagnoses difficult. Plain film findings of both osteomyelitis and Ewing sarcoma are often similar with an aggressive intramedullary process destroying normal cancellous and cortical bone creating a moth eaten and permeative appearance. . MRI can be helpful in differentiating between these two aggressive diseases. Both may produce periostitis, periosteal elevation, adjacent soft tissue mass and effacement of fat planes. Soft tissue enhancement, cystic and necrotic foci and cortical destruction are found in both diseases and

are less reliable at differentiation. The presence of fat globules within the infiltrating marrow process or in a subperiosteal location is a feature of osteomyelitis more often than neoplasia[18]. A recent study by Henninger et al[19] showed that all cases of Ewing sarcoma had a sharp or defined margin of the bone lesion between normal bone and edematous/affected bone on T1 which was not present in cases of osteomyelitis. Langerhans cell histiocytosis often has a very similar appearance to osteomyelitis with an aggressive lytic lesion with ill-defined borders and surrounding inflammatory changes. A process centered in the diaphysis favors langerhans cell histiocytosis over OM. However, differentiation from Langerhans cell histiocytosis, lymphoma and leukemia can be challenging and biopsy is necessary for definitive diagnosis. Fractures, bone infarcts and healed osteomyelitis may pose a diagnostic challenge in differentiating between active osteomyelitis due to common features.

Bibliography

[1] Steer Ac, Carapetis Jr. Acute Hematogenous Osteomyelitis In Children: Recognition And Management. Paediatr Drugs 2004; 6: 333-346 [Pmid: 15612835]

[2] Nelson Jd. Acute Osteomyelitis In Children. Infect Dis Clin North Am 1990; 4: 513-522 [Pmid: 2212603]

[3] Arnold Sr, Elias D, Buckingham Sc, Thomas Ed, Novais E, Arkader A, Howard C. Changing Patterns Of Acute Hematogenous Osteomyelitis And Septic Arthritis: Emergence Of Community-Associated Methicillin-Resistant Staphylococcus Aureus. J Pediatr Orthop 2006; 26: 703-708 [Pmid: 17065930]

[4] Jaramillo D. Infection: Musculoskeletal. Pediatr Radiol 2011; 41suppl 1: S127-S134 [Pmid: 21523583 Doi:10.1007/S00247-011-2001-Y]

[5] Kalyoussef S, Tolan Rw, Noel Gj. Pediatric Osteomyelitis. 2014. Available From: Url: Http: //Emedicine.Medscape.Com/Article/967095-Overview6 Dipoce J, Jbara Me, Brenner Ai. Pediatric Osteomyelitis: A Scintigraphic Case-Based Review. Radiographics 2012; 32: 865-878 [Pmid: 22582364 Doi: 10.1148/Rg.323115110]

[6] Browne Lp, Mason Eo, Kaplan Sl, Cassady Ci, Krishnamurthy R, Guillerman Rp. Optimal Imaging Strategy For Community-Acquired Staphylococcus Aureus Musculoskeletal Infections In Children. Pediatr Radiol 2008; 38: 841-847 [Pmid: 18560822 Doi: 10.1007/S00247-008-0888-8]

[7] Capitanio Ma, Kirkpatrick Ja. Early Roentgen Observations In Acute Osteomyelitis. Am J Roentgenol Radium Ther Nucl Med1970; 108: 488-496 [Pmid: 5415924]

[8] Gotthardt M, Bleeker-Rovers Cp, Boerman Oc, Oyen Wj.Imaging Of Inflammation By Pet, Conventional Scintigraphy,And Other Imaging Techniques. J Nucl Med 2010; 51: 1937-1949 [Pmid: 21078798 Doi: 10.2967/Jnumed.110.076232]

[9] Kan Jh, Hilmes Ma, Martus Je, Yu C, Hernanz-Schulman M. Value Of Mri After Recent Diagnostic Or Surgical Intervention In Children With Suspected Osteomyelitis. Ajr Am J Roentgenol2008; 191: 1595-1600 [Pmid: 18941107 Doi: 10.2214/Ajr.08.1115]

[10] Liu C, Bayer A, Cosgrove Se, Daum Rs, Fridkin Sk, Gorwitz Rj, Kaplan Sl, Karchmer Aw, Levine Dp, Murray Be, J Rybak M, Talan Da, Chambers Hf. Clinical Practice Guidelines By The Infectious Diseases Society Of America For The Treatment Of Methicillin-Resistant Staphylococcus Aureus Infections In Adults And Children: Executive Summary. Clin Infect Dis 2011; 52: 285-292 [Pmid: 21217178 Doi: 10.1093/Cid/Cir034]

[11] Averill Lw, Hernandez A, Gonzalez L, Peña Ah, Jaramillo D. Diagnosis Of Osteomyelitis In Children: Utility Of Fat Suppressed Contrast-Enhanced Mri. Ajr Am J Roentgenol2009; 192: 1232-1238 [Pmid: 19380545 Doi: 10.2214/Ajr.07.3400]

[12] Kan Jh, Young Rs, Yu C, Hernanz-Schulman M. Clinical Impact Of Gadolinium In The Mri Diagnosis Of Musculoskeletal Infection In Children. Pediatr Radiol 2010; 40:1197-1205 [Pmid: 20180105 Doi: 10.1007/S00247-010-1557-2]

[13] Browne Lp, Guillerman Rp, Orth Rc, Patel J, Mason Eo, Kaplan Sl. Community-Acquired Staphylococcal Musculoskeletal Infection In Infants And Young Children:Necessity Of Contrast-Enhanced Mri For The Diagnosis Of Growth Cartilage Involvement. Ajr Am J Roentgenol 2012; 198: 194-199 [Pmid: 22194497 Doi: 10.2214/Ajr.10.5730]

[14] Guillerman Rp. Osteomyelitis And Beyond. Pediatr Radiol2013; 43 Suppl 1: S193-S203 [Pmid: 23478935 Doi: 10.1007/S00247-012-2594-9]

[15] Metwalli Za, Kan Jh, Munjal Ka, Orth Rc, Zhang W, Guillerman Rp. Mri Of Suspected Lower Extremity Musculoskeletal Infection In The Pediatric Patient: How Useful Is Bilateral Imaging? Ajr Am J Roentgenol 2013; 201: 427-432 [Pmid: 23883225 Doi: 10.2214/Ajr.12.9644]

[16] Khanna G, Sato Ts, Ferguson P. Imaging Of Chronic Recurrent Multifocal Osteomyelitis. Radiographics 2009; 29: 1159-1177 [Pmid: 19605663 Doi: 10.1148/Rg.294085244]

[17] Davies Am, Hughes De, Grimer Rj. Intramedullary And Extramedullary Fat Globules On Magnetic Resonance Imaging As A Diagnostic Sign For Osteomyelitis. Eur Radiol 2005; 15: 2194-2199 [Pmid: 15864595]

[18] Henninger B, Glodny B, Rudisch A, Trieb T, Loizides A, Putzer D, Judmaier W, Schocke Mf. Ewing Sarcoma Versus Osteomyelitis: Differential Diagnosis With Magnetic Resonance Imaging. Skeletal Radiol 2013; 42: 1097-1104 [Pmid: 23685708 Doi: 10.1007/S00256-013-1632-5]