

Radiological Investigation for Osteomyelitis and its Complications

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Abstract

Introduction: Osteomyelitis by definition is bone infection, it is an inflammatory reaction that involves the bone and its structures, it can be acute or chronic, it usually occurs as secondary infection to pyogenic organisms such as bacteria, fungi, and mycobacteria. Osteomyelitis is considered to be an old disease, as some animal archeological fossils was found with evidence of bone infection.

Aim of Work: In this review we aim to discuss the most recent advances in the radiological investigations that are used for the detection, diagnosis, and follow-up of Osteomyelitis.

Methodology: We did a systematic search for Osteomyelitis radiological investigations using PubMed search engine (<http://www.ncbi.nlm.nih.gov/>) and Google Scholar search engine (<https://scholar.google.com>). All relevant studies were retrieved and discussed. We only included full articles.

Conclusion: Radiological imaging is a very important step in evaluating patients with suspected osteomyelitis. Magnetic resonance imaging (MRI) and technetium-99 bone scintigraphy are the most important imaging modalities in clinical assessment. Plain X-ray imaging is usually the initial imaging modality, osteomyelitis suggestive findings can take up to 14 days to appear on X-ray images. X-ray imaging cannot be used to detect early bone lesions, as radiological findings cannot be seen before 50% to 75% of the bone matrix is destroyed. On the other hand, X-ray images are used to rule out the possibility of other diagnosis such bone metastasis and fractures. Other less used imaging modalities are Positron emission tomography (PET), leukocyte scintigraphy, gallium scan, and computed tomography (CT scan). PET is very expensive and not always available. CT is better than X-ray imaging in assessing the state of bone tissues, it is considered to be better than MRI in detecting bone necrosis. However, CT imaging is more expensive than X-ray images and plays a limited role in the diagnosis of osteomyelitis. It is usually used to detect the extent of bony destruction, in guided biopsy operations and in patients who cannot use MRI.

Keywords: Osteomyelitis; Radiology; Management; Investigations; CT Scanning

Introduction

Osteomyelitis by definition is bone infection, it is an inflammatory reaction that involves the bone and its structures, it can be acute or chronic, it usually occurs as secondary infection to pyogenic organisms such as bacteria, fungi, and mycobacteria. Osteomyelitis is considered to be an old disease, as some animal archeological fossils was found with evidence of bone infection [1]. The term osteomyelitis was first introduced in 1844 by Nelaton [1]. Historically, before penicillin was firstly introduced in the 1940s, osteomyelitis was mainly managed by surgery, extensive debridement, saucerization, and wound packing, and the inflamed areas were left to heal by secondary intention [1]. Such an approach was associated with high rates of sepsis and mortality. The introduction of antibiotics and its wide availability contributed to the significant drop in osteomyelitis related mortalities.

In this review we aim to discuss the most recent advances in the radiological investigations that are used for the detection, diagnosis, and follow-up of Osteomyelitis.

Methodology

We did a systematic search for Osteomyelitis radiological investigations using PubMed search engine (<http://www.ncbi.nlm.nih.gov/>) and Google Scholar search engine (<https://scholar.google.com>). All relevant studies were retrieved and discussed. We only included full articles.

The terms used in the search were: Osteomyelitis, radiology, management, investigations, CT scanning.

Etiology

Normally, healthy bones are highly resistant to infections. Infections and pathologies occur when large amount of organisms is introduced following a trauma, ischemia or due to the presence of a foreign body, as the microorganisms can be attached to the exposed areas [2]. *Staphylococcus aureus* and other bacteria strands can adhere bone structures by expressing adhesin receptors to some bone components such as laminin, collagen, fibronectin and bone sialoglycoprotein. A collagen-binding adhesin allows *S. aureus* bacteria to attach to bone cartilage. Recently, it was discovered that fibronectin-binding adhesin plays a role in the attachment of bacteria to surgically implanted devices [2]. *S. aureus* bacteria is able to survive intracellularly by producing a protective biofilm coating the underlying surface and the bacteria itself. Those two characteristics may explain the failure of short antibiotic courses, bacterial resistance to antibiotics and the longstanding persistence bone infections after bone traumas and surgeries [2].

Epidemiology

Overall osteomyelitis incidence in the United States has not been calculated yet. Recent reports suggests the incidence to be around 50,000 new cases every year or 1 in 675 US hospital admissions each year [3]. some recent studies calculated the incidence of osteomyelitis to be around 21.8 cases per 100,000 person-years [4]. Such a prevalence was found to be associated with Male gender and the old age, the association of osteomyelitis with old age was explained with the high prevalence of risk factors like diabetes and peripheral vascular disease [4]. Recently, the increased availability and sensitivity of imaging modalities, such as magnetic resonance imaging (MRI) and bone scintigraphy has been associated with increasing the accuracy of the diagnosis and the ability to characterize the infection [5].

Pathophysiology

Infections can be delivered to the bones either via the hematogenous or contiguous route. A distant infection can be transmitted hematogenously causing bacteremia, which may lead to further bone infections. Contiguous spread can be caused either from infection in the adjacent tissue and joints or can be transmitted by direct inoculation after traumas and surgeries [1,2]. Hematogenous osteomyelitis incidence is higher in children than in adults, and usually affects long bones [5]. In adults, hematogenous osteomyelitis are mostly seen

in vertebrae. While in young adults, Contiguous osteomyelitis is usually related to trauma or surgery. Meanwhile, osteomyelitis in older adults is mostly related to pressure ulcer and arthroplasties of infected joint arthroplasties [1].

In diabetic patients, cases of vascular related osteomyelitis can be seen, where the blood supply is usually be interrupted, decreasing the efficacy of skin healing and local immunity. Thus spreading the infection to the adjacent tissues. Furthermore, pressure ulcers associated with diabetic neuropathy can make the case even more complicated [1,2,5].

Contiguous osteomyelitis is usually seen in cases of disabled, bedridden and wheel chaired patients who are predisposed to pressure ulcers in dependent areas. Such ulcers can be infiltrated by skin and gastrointestinal flora, and infections can spread to underlying bone tissue [1]. Contiguous osteomyelitis can also be caused by infected trauma with exposed soft tissue. Osteomyelitis can be caused by direct bacterial inoculation in cases of open fractures, and orthopedic surgeries [1,2].

Diagnosis of osteomyelitis

Clinical picture of osteomyelitis can vary depending on its etiology. Establishing a diagnosis may be challenging and requires the physician to be clinically oriented. Certain patients have higher risk of developing osteomyelitis, including patients with endocarditis, IV drug addicts, bacteremia, endocarditis, trauma, and bone fractures. Patients with delayed healing have greater risk of osteomyelitis such as patients with diabetes, vascular disease, peripheral neuropathy or patients with orthopedic hardware [1].

Usually, acute osteomyelitis develops gradually over a time period between a few days to 2 weeks. Local symptoms include swelling, erythema, and warmth at the site of infection. Dull pain may be presented with occasional fever or chills. Acute osteomyelitis can take the clinical picture of septic arthritis mainly in the bone metaphyses with infected joint capsule. Sub-acute osteomyelitis may be presented with malaise, mild pain and fever for few weeks. Osteomyelitis can be complicated with septic arthritis. In cases of neck or back pain accompanied with fever and elevated inflammatory markers, the diagnosis of osteomyelitis must be kept in mind [6]. Cases of endocarditis and bacteremia have high risk of vertebral osteomyelitis (NVO) [7].

Symptoms in chronic osteomyelitis develop over a period of time longer than two weeks. Patients may be presented with pain, swelling, and erythema at the infected area, but with less constitutional symptoms. Cases of longstanding and severe ulcers do not heal after the proper time and management, such as diabetic and disabled patients at high risk of pressure ulcers, such patients must be suspected as cases of osteomyelitis. Physical examination focuses mainly on finding the source of infection and testing the sensory neural and vascular functions in high risk patients. In cases where the patients have vertebral tenderness to palpation, the possibility of vertebral osteomyelitis must be kept in mind. In cases of ulcers, the probe to bone test is highly suggestive of osteomyelitis. In such test the ulcer is probed with blunt sterile instrument, if the probe reached the bone the physician must suspect osteomyelitis [2]. The probe to bone test is considered a screening test which helps in addition to physical examination to determine if the patient will need any further imaging modality or bone biopsy are needed to establish a diagnosis [8].

Laboratory tests are usually nonspecific to osteomyelitis. Leukocytosis, elevation of ESR and CRP might be seen. The CRP level can be used to assess the success of the therapeutic plan as it can reflect the patient's response to the treatment. In cases of hematogenous osteomyelitis, blood culture are usually positive.

Imaging in osteomyelitis

Radiological imaging is a very important step in evaluating patients with suspected osteomyelitis. Magnetic resonance imaging (MRI) and technetium-99 bone scintigraphy are the most important imaging modalities in clinical assessment [5]. Plain X-ray imaging is usually the initial imaging modality, osteomyelitis suggestive findings can take up to 14 days to appear on X-ray images [1,5]. X-ray imaging cannot

be used to detect early bone lesions, as radiological findings cannot be seen before 50% to 75% of the bone matrix is destroyed. On the other hand, X-ray images are used to rule out the possibility of other diagnosis such bone metastasis and fractures [5].

MRI is considered the best imaging modality in diagnosing osteomyelitis. As it is highly sensitive and specific (78% to 90% and 60 % to 90% respectively). It can detect early cases of osteomyelitis within 3 to 5 days after the initial infection [5,6]. MRI has a high negative predictive value, it can be used to roll out the diagnosis within a week after infection. IV contrast can be used to increase the image quality and contrast between types of lesions. As MRI cannot be used in cases with surgical implants, nuclear imaging is usually used in cases with metal hardware, it is highly sensitive for detecting bone disease but with a very poor specificity. Other imaging modalities used in the diagnosis of osteomyelitis are three phase technetium-99 bone scan and tagged white blood cell scans.

Other less used imaging modalities are Positron emission tomography (PET), leukocyte scintigraphy, gallium scan, and computed tomography (CT scan). PET is very expensive and not always available. CT is better than X-ray imaging in assessing the state of bone tissues, it is considered to be better than MRI in detecting bone necrosis. However, CT imaging is more expensive than X-ray images and plays a limited role in the diagnosis of osteomyelitis. It is usually used to detect the extent of bony destruction, in guided biopsy operations and in patients who cannot use MRI.

Bone biopsy is considered to be an essential tool in establishing osteomyelitis diagnosis, it can isolate the causative organism and provide antibiotic sensitivity data to guide the treatment. However, bone biopsy are found to be not useful in the cases with positive blood cultures with positive radiological finding [7]. Recently, open biopsy technique has been preferred to percutaneous one. Some guidelines suggest to stop the antibiotics treatment 48 to 72 hours prior to open biopsy to increase the microbial yielding. Usually bone cultures are positive regardless of prior antibiotic therapy.

In cases of percutaneous biopsy, the procedure must be done through areas of healthy, intact skin in order to decrease contamination and sampling errors, it is better to perform the biopsy under fluoroscopic or CT guidance. Percutaneous biopsy must be done before starting antibiotic therapy in order to increase the microbial yielding. Usually two samples are collected for histopathology and culturing.

Treatment/management

In most cases of osteomyelitis, cases of hematogenous osteomyelitis are caused by a single bacterial strand, while cases of contiguous osteomyelitis or direct inoculation osteomyelitis can be caused either by single or multiple bacterial strands [1]. Mostly, the type of bacterial strand causing osteomyelitis varies according to the patient's age. Most cases of acute and chronic hematogenous osteomyelitis in adults and children are caused by *Staphylococcus aureus* [1,5]. Methicillin-resistant *Staphylococcus aureus* (MRSA) caused osteomyelitis have been increasing recently, it has been found that more than one third of all staphylococcal caused osteomyelitis cases in the united states are caused by MRSA bacteria [5]. Other bacterial strands usually isolated from osteomyelitis are coagulase-negative staphylococcus, beta-hemolytic streptococcus, enterococci, aerobic gram-negative bacilli and anaerobic gram-negative bacilli.

Other less frequently seen bacterial strands must be kept in mind in special cases like immunocompromised patients. *Mycobacterium tuberculosis* bacteria can be spread from lungs infection to the spine, Non-tuberculous strands of *Mycobacteria*, *Candida* species and fungi. Traumatic inoculation osteomyelitis are usually caused by *Actinomyces* and *Sporothrix*, hematogenous osteomyelitis in sickle cell anemia patients are usually caused by *Salmonella* and *S. aureus*, while *Brucella* and *Salmonella* are usually seen in spinal osteomyelitis [1,2]. Osteomyelitis cases in HIV are found to be caused by *Bartonella henselae*, and osteomyelitis associated with human bites are caused by *Pasteurella multocida* or *Eikenella corrodens*.

In order for osteomyelitis treatment to be successful, it has to cover both medical and surgical aspect. Surgical debridement of the infected bone tissue is an essential step, because most antibiotics have poor penetration to necrotic bone tissue and abscesses [1,2].

Preoperative MRI imaging helps in determining the severity and extent of the infection and postoperative pathology report assesses the detriment procedure and of decide if further debridement is needed. In cases of osteomyelitis with prosthetic joints, the infected joint must be removed [2]. However, in cases of stable prosthetic joints that cannot be removed, or where surgical debridement cannot be done like pelvic osteomyelitis, we can skip surgery or the removal of the joint and medical therapy with extended antibiotic course is found to be effective [2]. Vertebral osteomyelitis usually does not need surgical debridement. Certain cases need surgery to drain spinal abscesses, relief spinal cord compression or to remove a spinal implant [2,6].

Complications

Early treatment of osteomyelitis can reduce the complications of the infection. In some cases of neglected or inappropriately treated osteomyelitis, many complications may occur like Septic arthritis, Pathological fractures, Squamous cell carcinoma, Sinus tract formation, Amyloidosis, Abscess, Bone deformity, Systemic infection and Contiguous soft tissue infection

Deterrence and patient education

Patient education is considered to be an essential step in the treatment of osteomyelitis. The patient must be informed about the extended antibiotic course and its prolonged period so he can be compliance with treatment recommendations. Adequate information about proper wound dressing must be given to the patient in order to reduce the risk of recurrent infection.

Enhancing healthcare team outcomes

The treatment of osteomyelitis is a complicated process that involves coordination between many healthcare providers. Primary care providers usually establish the initial diagnosis and coordinate between medical and surgical specialists.

The process and approach of treatment of can vary according to the site, vascularity and the general condition of the infected area. In cases of suspected vertebral osteomyelitis, an image guided aspiration of the vertebral disc is required to establish the diagnosis, especially if there is radiological findings suggesting osteomyelitis [7]. However, image guided aspiration is not recommended in suspected sub-acute vertebral osteomyelitis with positive *Brucella* serology. In cases of neurological complications, a 6-week course of parenteral antibiotics recommended [7].

In cases of diabetes mellitus, there must be coordination between the surgical and vascular as diabetes patients are usually presented with vascular insufficiency. In order to ensure proper wound healing, it is essential to re-vascularize the affected areas either by therapeutic angiogram or by femoral to popliteal by-pass. Surgical revascularization includes using a muscular and mucocutaneous flap in order to provide vascular supply to the affected area [2].

After surgical debridement of the infected area, a prolonged course of antibiotics and proper wound dressing is essential for proper healing. The response to antimicrobial therapy is usually monitored by an Infectious disease specialist, and antimicrobial regimens can be adjusted according to each case. According to the microbiological tests, some patients continue on an outpatient intravenous antimicrobial regiment, while others convert to highly bioavailable oral antimicrobial like quinolones. Nurses and Family members and caregivers are also an integral part of the care team, providing proper wound dressing and providing support and care between healthcare provider visits.

Conclusion

Radiological imaging is a very important step in evaluating patients with suspected osteomyelitis. Magnetic resonance imaging (MRI) and technetium-99 bone scintigraphy are the most important imaging modalities in clinical assessment. Plain X-ray imaging is usually the initial imaging modality, osteomyelitis suggestive findings can take up to 14 days to appear on X-ray images. X-ray imaging cannot be

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