International Journal Of

Recent Scientific Research

ISSN: 0976-3031
Volume: 7(6) June -2016

OSTEOMYELITIS – A REVIEW ARTICLE

Siddhartha Paluvadi, Sachin Kumar, Satish Kumar, Rahul Khare and Raghav Rai Verma

THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

ISSN: 0976-3031

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 7, Issue, 6, pp. 11653-11657, June, 2016

International Journal of Recent Scientific Research

Review Article

OSTEOMYELITIS – A REVIEW ARTICLE

***Siddhartha Paluvadi, Sachin Kumar, Satish Kumar, Rahul Khare and Raghav Rai Verma**

Department of Orthopaedics, PGIMER and Dr Ram Manohar Lohia Hospital, New Delhi

ARTICLE INFO

Article History:

Received 20th March, 2016
Received in revised form 29th April, 2016
Accepted 30th May, 2016
Published online 28th June, 2016

Key Words:

Orthopedics, Infection, Osteomyelitis.

ABSTRACT

Osteomyelitis is heterogeneous in pathophysiology and can affect every bone in the body at any age. When suspected, patient should be investigated by imaging modalities and serum inflammatory markers. When possible, biopsy should be obtained from deep bone samples prior to starting antibiotic therapy. The mainstay of treatment of osteomyelitis is drainage of pus and immobilization. Surgical drainage may be required and treatment of established chonic osteomyelitis is notoriously difficult.

INTRODUCTION

Nelaton coined the term Osteomyelitis in 1834 from the root words osteon (bone) and myelo (marrow). Osteomyelitis is defined as an inflammation of the bone caused by an infecting organism which may be limited to a single portion of the bone or may involve marrow, cortex, periosteum and surrounding soft tissue[1].

It is classified by duration of disease into Acute (<3weeks), Sub acute (3 weeks- 3 months) and Chronic (>3 months). The mechanism of infection can be hematogenous or exogenous (open fractures, surgery, and contiguous spread). The type of host response to infection can be pyogenic or non-pyogenic.

The term acute osteomyelitis is used clinically to signify a newly recognized bone infection. Patients usually present within a day to several days after the onset of symptoms. In addition to local signs of inflammation and infection, patients have signs of systemic illness.

The relapse of a previously treated or untreated infection is considered a sign of chronic disease. There is development of necrotic bone. The clinical pattern may evolve over months or even years and is characterized by low grade inflammation, the presence of pus, and sequestra. A compromised soft-tissue envelope and multiple sinuses are present.

ACUTE HEMATOGENOUS OSTEOMYELITIS

It is commonest during period of active bone growth in childhood. It is bimodal, <2 years and 8-12 years. It is decreasing as hygiene and standard of living improve[2]. It affects boys more than girls (4:1). It affects metaphyses of rapidly growing bones and is caused by bacteremia and seeding. Most common site is the upper end of tibia. The most common causative organism is Staphylococcus aureus which affects children and adults. Group B Streptococcus infects neonates (2-4wk) and causes multiple lesions. Gram negative and coliforms cause vertebral body infections in adults. Staphylococcus epidermidis is coagulase negative and acts by biofilm formation especially over implants. Hemophilus influenza was previously common in the 6m-4yr age group, but has now reduced due to immunization. Pneumococcus, Clostridium welchii, Salmonella, Pseudomonas and Fungal infections are atypical.

General predisposing factors are Age (bimodal), Malnourishment, Immunocompromised status including AIDS, Long term steroid therapy and Diabetes. Local factors include focus of infection, Open fractures / contaminated wounds, Radiation fibrosis, Arteritis /peripheral vascular disease, Lymphedema or Neuropathy.

Etiopathogenesis

Bacteremia precedes onset of disease. Anatomical arrangement (hair pin bend[3]) at epiphyseometaphyseal junction favors localization of bacteria. Lack of active phagocytosis in the metaphysis predisposes the site to OM, esp. in children. Trauma, hemorrhage and cell destruction lead to diminished tissue resistance. Bacteria are thus delivered into a culture of degenerating cells. New growing metaphyseal vessels lack endothelial lining, facilitating spread.

Corresponding author: **Siddhartha Paluvadi*
Department of Orthopaedics, PGIMER and Dr Ram Manohar Lohia Hospital, New Delhi

Arterial loops empty into venous sinusoids. Turbulence and slow flow provide opportunity for bacteria to colonise[4]. On electron microscopy, these loops are terminal branches originating from "sprouts". Gaps in sprouts allow bacteria and blood cells to pass out of vascular system into extravascular space. Polymorphonuclear leucocytes secrete IL-1 and PGE2, which stimulate bone resorption. LTB4, TNF-A, IL-1B, IL-6 and IL-8 are elevated.

Primary focus is in vascular cancellous tissue of metaphysis. Raised pressure, edema and pus formation leads to spread of infection to medullary canal. Pus spread through the Haversian canals to the periosteum, leading to a subperiosteal abscess. Impairment of blood supply due to lifting of periosteum and increasing pressure causes necrosis of bone and formation of tubular sequestrum. New subperiosteal reactive bone is formed with return of vascularity. This is the involucrum. Separation of sequestrumoccurs and there is discharge of smaller bone particles through the cloacae in involucrum. Sinuses may form on the skin.

In Children less than 2 years old, vessels cross the physis and infection spreads into the epiphysis, leading to limb shortening or angular deformity. The abscess also usually breaks through the thin metaphyseal cortex, forming subperiosteal abscess. Diaphysis is rarely involved and extensive sequestration is rare. Common blood supply may allow spread of metaphyseal abscess into a contiguous joint[5]. Hip joint is most commonly affected. Physes of proximal humerus, radial neck and distal fibula are also intraarticular, can lead to septic arthritis. In severe infection, epiphyseal separation may occur.

In Children older than 2 years, physis acts as barrier to direct spread of metaphyseal abscess into epiphysis. The metaphyseal cortex is thicker and infection spreads to the diaphysis. There is concurrent subperiosteal abscess. Extensive sequestration and Chronic OM occur.

Acute hematogenous OM is rare in adults. It is seen in immunocompromised hosts and IV drug users, generally in vertebral bodies. S.aureus, P.aeruginosa, Serratia marscescens are causative organisms. Abscesses spread slowly and large sequestra are rare. Localised destruction may lead to pathological fractures. Since physes are closed, infection may extend directly to the epiphysis and involve the joint.

Disease onset is rapid. The patient, usually a child or adolescent, complains of a severe pain in a limb, and the pain is not relieved by rest. There might be history of trauma or recent infection. Severe general illness, fever, headache, flushing and vomiting are common. The affected limb held in position of minimal pressure with neighboring joints flexed. Tenderness and guarding are omnipresent. In infants and elderly patients, clinical findings may be minimal. In later stages as toxemia develops, child becomes apathetic. Swelling may be significant, compartment syndrome has been reported. Fluctuation is a sign of abscess formation. Complications include Pseudo paralysis, Septic arthritis and pathological fractures.

Investigations

Routine hemogram shows leukocytosis; Leukergy may be present. ESR and CRP are raised, CRP is more sensitive. Blood culture may grow the organism. Pus culture should be performed from bone aspirate. in area of maximal swelling and tenderness. Subperiosteal space is aspirated first. If no pus is encountered, go through the cortex for a marrow aspirate Radiological changes lag two weeks behind the disease process. Within 48 hours, soft tissue changes may be apparent, including loss of normal demarcation line between subcutaneous shadow and muscle. At 10-12 days, periosteal new bone formation and bony destruction is apparent. Lytic changes are delayed. Ultrasound may detect a subperiosteal collection of fluid in early stages of osteomyelitis. Computerized tomography detects smaller areas of cortical destruction, gas or foreign bodies, sequestra, involucra and cloacae, surrounding soft-tissue abscesses, and pus in medullary canal. It predicts the need for surgical debridement. It is also helpful in planning and determining the need for surgical therapy. Magnetic resonance imaging has high sensitivity and specificity. It localises area of abnormal marrow with decreased signal intensity on T1 and increased signal intensity on T2-WI. It also differentiates between bone and soft-tissue infection, which is often a problem with radionuclide studies. It is particularly suited to the evaluation of osteomyelitis, with superior soft tissue contrast and multiplanar imaging. MRI is useful for evaluation of children presenting with sepsis and acute musculoskeletal pain, early diagnosis of osteomyelitis and to prevent unnecessary hospital admission and work-up[6].

Bone Scans are performed when the diagnosis of osteomyelitis is ambiguous or to help gauge the extent of bone and soft-tissue inflammation. Technetium-99m MDP bone scanning can detect abnormalities as early as 24–48 hours, and is almost always positive by 8 days. Osteomyelitis causes increased uptake in all the three phases (flow phase, equilibrium phase and delayed phase). A Technetium^{99m}scan may be negative in documented osteomyelitis due to decreased blood flow. Trauma, arthritis, overlaying cellulitis, tumor, and synovitis can cause false-positive scans. Gallium^{67} citrate scan is sensitive but not specific. Overlying cellulitis, inflammatory arthritis, tumors, hematomas, and fractures cause positive scans[7]. Indium^{111}-labelled leukocyte scan is likely more specific than bone scans, though it is false positive in cellulitis, inflammatory conditions and false negative in chronic infections. To enhance spatial resolution, gallium or indium scanning is sometimes combined with bone scanning, which increases not only the cost but also the time of obtaining the results.

Morrey and Peterson concluded the infection is DEFINITE if the pathogen is isolated from bone or adjacent soft tissue, or there is histologic evidence of osteomyelitis. PROBABLE if a blood culture is positive in the setting of clinical and radiographic features of osteomyelitis. LIKELY if there are typical clinical findings and definite radiographic evidence of osteomyelitis, and there is specific response to antibiotic therapy[8].

Peltola and Vahvanen established diagnosis when two of the following four criteria are met[9]:

1. Pus is aspirated from bone.
2. A bone or blood culture is positive.

3. The classic symptoms of localized pain, swelling, warmth, and limited range of motion of the adjacent joint are present.
4. Radiographic features characteristic of osteomyelitis are present.

Treatment

If osteomyelitis is suspected on clinical grounds, blood and fluid samples should be taken and then treatment should be started immediately without waiting for final confirmation of the diagnosis. Surgical and antibiotic treatment go hand in hand. Empirical cloxacillin/flucloxacillin and ampicillin combination is administered till blood culture and sensitivity reports are available. The patient is hydrated, electrolyte and protin is replaced. Immobilization and anti-inflammatory drugs are necessary.

Nade believed that an appropriate antibiotic is effective before pus formation[10]; antibiotics do not sterilise avascular tissues or abscesses, and such areas require surgical removal; If such removal is effective, antibiotics should prevent their reformation, and primary wound closure should be safe. He stressed that surgery should not damage further already ischemic bone and soft tissue, and that antibiotics should be continued after surgery.

Aspiration should be done at the most tender part of diaphysis. Areas of simple inflammation are treated with antibiotics alone. Aspiration confirms bacteriological diagnosis and sensitivity to guide the antibiotic treatment, reduces pressure in the marrow and allows blood flow; prevents further stripping of periosteum and preserves blood supply.

Antibiotics are empirical if gram stain is negative. CRP is monitored every 2-3 days. Surgical drainage for occult abscesses should be done if there is no clinical improvement in 24-48 hours. Indications for Surgery include presence of an abscesses requiring drainage, failure to improve despite appropriate IV antibiotics for 24 hours, and localizing signs for over 48 hours. The objective is to remove all nonviable and necrotic tissue. Several holes drilled though the cortex into medullary canal. If medullary pus found, a 1.5*1.5 cm oval cortical window is removed. Skin is closed loosely over drains. Limb is splinted and protected to prevent pathological fractures.

Duration of antibiotic treatment is controversial. For most children with AHOM who respond quickly to treatment and whose CRP values normalize within 10 days, intravenous followed by oral therapy for a total of 20 days will be adequate duration of therapy and that extensive surgery is rarely needed[11, 12, 13]. By convention, antibiotic therapy is continued for a period of 6 weeks.

Early Complications include acute septicemic shock, Metastatic bone infection, Septic arthritis, Pathological fracture&Massive sequestration. Late complications are Damage to epiphyseal growth plate leading to shortening& progressive deformity, and chronic osteomyelitis. Presence of unabsorbed and retained sequestra, presence of unobliterated cavities, and change of aerobic cocci infection to gram negative bacterial infection are the factors responsible for chronicity. Other late complications are bone loss causing instability, joint stiffness & deformities.

SUBACUTE OSTEOMYELITIS

It is insidious in onset and less severe. There are minimal systemic signs and symptoms and thus diagnosis is delayed. Blood counts may be normal and ESR is elevated in only half the patients. Blood cultures are usually negative. Bone aspirate and biopsy identify pathogen only in 60% cases. Radiographs and bone scans show findings. The indolent course of subacute osteomyelitis can be due to increased host resistance, low virulence of the pathogen or administration of antibiotics before onset of symptoms. Gledhill classified subacute osteomyelitis. Type 1 is a solitary localized zone of radiolucency surrounded by reactive new bone formation. Type 2 shows metaphyseal radiolucencies with cortical erosion. Type 3 has cortical hyperostosis in diaphysis but no onion skinning. In Type 4 subperiosteal new bone and onion skin layering occurs. Diagnosis established by open biopsy and culture of the purulent material or granulation tissue encountered. S. Aureus and S. Epidermidis are the common causative organisms. For simple abscess in metaphysis or epiphysis and benign appearing lesions, IV antibiotics are administered for 48 hours followed by a 6 week couse of oral antibiotics. Aggressive appearing lesions require biopsy and curettage and antibiotics (Ross and Cole).

Brodie's Abscess is a localized form of subacute OM which usually localizes to the long bones of lower extremities and occurs before physeal closure in the metaphysis. In adults metaphyseal or epiphyseal area may be involved. 50% are caused by S.aureus and 20% are culture negative. Patient has intermittent pain of long duration and local tenderness. X ray shows a lytic lesion with a rim of sclerotic bone. Open biopsy with curettage should be done, and wound closed loosely over drain.

Differential diagnosis includes Tuberculous abscess, Syphilitic gumma, Simple bone cyst and Osteoclastoma/ GCT.

CHRONIC OSTEOMYELITIS

The Hallmark of chronic OM is Infected dead bone within a compromised soft tissue envelope. It is notoriously difficult to eradicate- Infected foci are surrounded by sclerotic, relatively avascular bone, thickened periosteum and scarred soft tissues, rendering systemic antibiotics ineffective. Secondary infections common and sinus tract cultures do not correlate with bone biopsy cultures.

Sequestrum (Table 1) is defined as devitalized avascular segment of bone surrounded by pus or infected granulation tissue; it is denser than surrounding bone. Because of avascularity, sequestrum does not decalcify, is more radio opaque and heavy. Its outer surface is usually jagged or irregular due to erosive process by proteolytic enzymes in granulation tissue.

Table 1 Types of Sequestrae

Type of Sequestra	Found In
Tubular (Diaphyseal)	Pyogenic Osteomyelitis
Trapezoid	Pyogenic Osteomyelitis
Ring	At end of stumps, around pins
Flake/ Feathery	Tuberculous Osteomyelitis(in cavity)
Coarse sandy	Tuberculous Osteomyelitis (out of cavity)
Fine sandy	Viral Osteomyelitis
Black	Actinomycosis

Involucrum is derived from the word "volvere" i.e. to wrap. It is the result of reactive new bone formed by periosteal reaction, in an attempt to wall off the infection by forming a thick tense wall. It is jagged on its inner surface and smooth on its outer surface. Cloacae are openings in involucrum and are caused by rupture of periosteum due to pus under tension. Exudates, sequestra are extruded through the cloacae on the surface.

Cierny and Mader Staging system is a composite system taking into account both the local and systemic condition of the patient[14, 15, and 16]. Anatomically the patient is staged into medullary, superficial, localized or diffuse types. The host is then classified physiologically into normal, compromised or prohibitive types. The anatomical and physiological classes are combined to designate one of the 12 clinical stages of chronic osteomyelitis. This classification system is helpful in determining treatment- simple/complex, curative/palliative, and limb sparing/ablative.

Investigations

Diagnosis is clinical; lab and imaging studies may be useful adjuncts. Gold standard is biopsy for Histopathological and microbiological evaluation. On physical examination, tenderness, bone stability and neurovascluar status are evaluated. ESR and CRP elevated in most patients but WBC count elevated only in 35%. Imaging is non-conclusive and only aid diagnosis and to prepare operative plan. X ray is the initial investigation and shows cortical destruction and periosteal reaction. Sinography can be performed if a sinus track is present and can be a valuable adjunct to surgical planning. CT defines cortical bone & detects sequestra. MRI shows soft tissue edema and extent of pathology by showing margins of bone and soft tissue edema. 'Rim sign' is a well defined rim of high signal intensity surrounding the focus of active disease on MRI. Sinus tracks and cellulitis are well defined on T2WI. MRI more sensitive than bone scans. But during first year, MRI could not differentiate between infection and fibrovascular scar; combined nuclear medicine studies most useful during this period. Typically S.aureus, sometimes anaerobes and gram negative bacteria are found on culture.

Treatment

Eradication requires surgery. Antibiotics are alone not effective as bacteria adhere to implants and bone matrix through various receptors and some hide intracellularly. A few gram positive cocci form biofilm that protects them from phagocytosis and antibiotics. Relatively avascular scarred tissue surrounds the focus of infection leading poor penetration by antibiotics. Goal of surgery is eradication of infection by achieving a viable and vascular environment. Indications for surgery are chronic discharging sinus and chronic excessive pain. Non discharging chronic OM may need surgery if there are systemic or local symptoms, or sequestrum is present.

During sequestrectomy and curettage, wide resection necessary as recurrence rate is 28% in marginal resection (<5mm). No recurrence occurs when margins are wide (>5mm). More recurrences occur in type B hosts than type A hosts.

Preoperatively, sinus tracts can be injected with methylene blue. Infected bone is exposed and sinus tracts are excised. Indurated periosteum is incised and elevated. Cortical window is outlined& removed. Sequestra, purulent material and scarred necrotic tissues are excised. Canal is opened for blood vessels to grow back and revascularise the bone. Cavity is filled with surrounding soft tissue, local muscle flap or free tissue transfer. If the patient has an infected nonunion, fracture is stabilised externally. If loose closure is not possible, defect is packed open loosely or antibiotic bead pouch technique can be used, followed by secondary closure. Limb is splinted. Duration of post-operative antibiotics is controversial. Traditionally 6 week intravenous therapy was given, but fluoroquinolones have equivalent serum concentrations IV or orally.

The dead space created needs to be managed to prevent recurrence and bony instability. Reconstruction is needed after organism has been identified, antibiotics given, imaging and careful planning have been done. Reconstruction is done preferably in collaboration with an infectious disease expert and a plastic surgeon skilled in coverage techniques. Methods to eliminate dead space include bone grafting with primary or secondary closure, antibiotic PMMA beads, local muscle flaps and skin grafting, microvascular transfer of flaps, bone transport by Ilizarov and open grafting by Papineau Technique. Papineau technique is a novel method of bone grafting. Papineau propounded that granulation tissue markedly resists infection and autogenous cancellous grafts rapidly revascularised & is resistant to infection. The infected area completely excised. Stage 1 is debridement- sinus tracts and sequestra are excised and bone is saucerised. Wound is packed open with antibiotic soaked dressings. If needed, stabilisation with external fixator is done. Stage 2 is bone grafting which is delayed till granulation develops. Strips of autogenous cancellous bone from posterior iliac crest are harvested and grafted at the area of bone loss in concentric and overlapping layers. Wound is packed open, dressed at 3-5 days, and changed till graft stabilizes. Local muscle pedicle grafts may be done to enhance vascularity. Stage 3 is wound coverage. There might be spontaneous epithelialization; otherwise skin grafts, myocutaneous flaps, muscle pedicle flaps and free flaps can be used to provide coverage.

PMMA Antibiotic Bead Chains deliver antibiotics locally in high concentrations exceeding the MIC (200 times) while maintaining low serum levels and low systemic toxicity. Antibiotic is leached from beads. Primary closure or bead pouch technique can be used. Aminoglycosides, penicillin, clindamycin and cephalosporins in conjuction with porous, high viscosity cements are used to make the beads. Implantation may be short term (10 d), long term (80 d) or permanent. Most authors recommend removal at 6 wks. Bactericidal antibiotic levels last only 2-4 weeks, thereafter the beads acts as a foreign body and may be colonised by glycocalyx forming bacteria which inhibit local immune response by impairing phagocytic cells. Bead pouch, changed every 72 hrs, is preferred in open fractures, and where primary cover is not possible after debridement.

Biodegradable antibiotic delivery systems have been evaluated; though use is still to be approved. The advantage of these is that a second procedure to remove the implants is not required. Bioabsorbable substrates like calcium sulphate or calcium phosphate are used. They act as an osteoconductive bone graft substitute. They deliver antibiotics locally like

PMMA beads and get reabsorbed in about 8 weeks after surgery.

Closed Suction ingress and egress high volume irrigation systems can be used over 3-21 days. They have mostly been abandoned due to risk of secondary contamination & long duration of treatment[17].Vacuum assisted closure provides controlled levels of negative pressure which accelerates debridement and promotes healing.125 mmHg appears to be optimum when applied in a cyclical fashion. Soft-Tissue Transfer can be used to fill up dead space. There is significant improvement in biological environment- vascularity, immunity, antibiotic delivery, healing. Local muscle flaps like gastrocnemius in proximal tibia, soleus in middle third tibia are used. Microvascular free muscle transfer is needed for distal tibia. Ilizarov Technique is useful in infected nonunion and allows radical resection of bone. Corticotomy through normal bone proximal and distal to area of disease increases local vascularity. 'Infection burns in the fire of the regenerate'. Bone is transported until union achieved. Complications of ilizarov are pin tract infection, loss of fixation, delayed or nonunion at docking site, fracture of regenerate.

Complications of chronic osteomyelitis are recurrent flares (acute on chronic OM), pathological fractures, Epithelioma, Growth interference- 5% overgrowth, 31% growth arrest and Amyloidosis Sclerosing Osteomyelitis of Garre is a form of chronic OM. Bone thickened and distended; no abscesses or sequestra are seen. It occurs in young adults and is caused by low grade anaerobic bacteria. Pain is of long duration and tenderness and swelling may be present. X ray shows expanded bone with generalised sclerosis. Biopsy shows chronic low grade nonspecific OM and cultures are negative. Treatment is by fenestration of sclerotic bone and antibiotics.

References

1. Dabov GD. Osteomyelitis. In: Canale S T, Beaty J H, editors. *Campbell's Operative Orthopaedics*. 11th edition. Mosby Elsevier; 2008.
2. Craigen MAC, Watters J, Hackett JS. The changing epidemiology of osteomyelitis in children. *J Bone Joint Surg* 74B:541, 1992.
3. Trueta J. The three types of acute haematogenous osteomyelitis. J Bone Joint Surg Br. 1959; 41-B:671–680.
4. Hobo T. Zur pathogenese der akuten haematogenen osteomyelitis. Acta Sch Med Univ Kioto. 1921;4:1–29
5. Emslie KR, Fenner LM, Nade SML. Acute hematogenous osteomyelitis, II: the effect of a metaphyseal abscess on the surrounding blood supply. *J Pathol* 142:129, 1984.
6. Aloui N, Nessib N, Jalel C, Ellouze S, Ben Chehida F, Sayed M *et al*. Acute osteomyelitis in children: early MRI diagnosis. *Journal Radiology* 2004 Apr; 85(4 Pt. 1):403-8.
7. The accuracy of different imaging techniques in diagnosis of acute hematogenous osteomyelitis. Malcius D, Jonkus M, Kuprionis G, Maleckas A, Monastyreckiene E, Uktveris R, Rinkevicius S, Barauskas V; Medicina (Kaunas). 2009; 45(8):624-31.
8. Morrey BF , Peterson HA. Hematogenous pyogenic osteomyelitis in children. The Orthopedic Clinics of North America [1975, 6(4):935-951]
9. Peltola H, Vahvanen V. A comparative study of osteomyelitis and purulent arthritis with special reference to aetiology and recovery. Infection. 1984 Mar-Apr; 12(2):75-9.
10. Nade S. acute hematogenous osteomyelitis in infancy nd childhood. J Bone Joint Surg 65B:109, 1983.
11. Peltola H, Paakkonen M, Kallio P, *et al*. Osteomyelitis-Septic Arthritis Study Group. Short- versus long-term antimicrobial treatment for acute hematogenous osteomyelitis of childhood: prospective, randomized trial on 131 culture-positive cases. Pediatr Infec Dis J. 2010; 29:1123-1128.
12. Jagodzinski, Nikolas Alan; Kanwar Rajeev. Prospective Evaluation of a Shortened Regimen of Treatment for Acute Osteomyelitis and Septic Arthritis in Children. Journal of Pediatric Orthopaedics 29(5), July/August 2009, pp 518-525.
13. Peltola *et al*. Hematogenous Osteomyelitis in Children: Differences in Clinical Manifestations and Management, The Pediatric Infectious Disease Journal, December 2010
14. Cierny III G: Classification and treatment of adult osteomyelitis. In: Everts CM, ed. Surgery of the musculoskeletal system, 2nd ed. New York: Churchill Livingstone; 1990.
15. Cierny III G, Mader JT: Approach to adult osteomyelitis. Orthop Rev 1987; 16:259.
16. Cierny III G, Mader JT: Adult chronic osteomyelitis:an overview. In: D'Ambrosia RD, Marier RL, ed. Orthopae dic infections, Thorofare, NJ: Slack; 1989.
17. Closed double-lumen suction irrigation in the management of chronic diaphyseal osteomyelitis: long-term follow-up. J Bone Joint Surg Br. 2009 Sep; 91(9):1243-8. Caesar BC, Morgan-Jones RL, Warren RE, Wade RH, Roberts PJ, Richardson JB.

****

How to cite this article:

Siddhartha Paluvadi *et al*. 2016, Osteomyelitis – A Review Article. *Int J Recent Sci Res.* 7(6), pp. 11653-11657.

TSSN 0976-3031