Osteomyelitis

Dr. Sushil Paudel

Osteomyelitis

- Nelaton (1834) : coined osteomyelitis
- The root words *osteon* (bone) and *myelo* (marrow) are combined with *itis* (inflammation) to define the clinical state in which bone is infected with microorganisms.

Introduction

- Osteomyelitis is an inflammation of bone caused by an infecting organism.
- It may remain localized, or it may spread through the bone to involve the marrow, cortex, periosteum, and soft tissue surrounding the bone.

Classification

- Attempts to classify are based on
  (1) the duration and type of symptoms
  (2)the mechanism of infection
  (3)the type of host response

Osteomyelitis

Based on the duration and type of symptoms

Acute:	<2weeks	▪Early acute ▪Late acute(4-5days)
Subacute:	2weeks—6weeks	Less virulent – more immune
Chronic:	>6 weeks	

Classified according to mechanism

- Osteomyelitis may be

1. Exogenous(trauma, surgery (iatrogenic), or a contiguous infection)

2. Hematogenous (bacteremia)

Etiology

In infants:
Staphylococcus aureus
Streptococcus agalactiae
Escherichia coli

In children over one year of age:
Staphylococcus aureus,
Streptococcus pyogenes
Haemophilus influenzae[1]

Staphylococcus aureus common organism isolated.[2]

- Single pathogenic organism → ematogenous osteomyelitis,
- Multiple organisms → rect inoculation or contiguous focus infection.

- *Staphylococcus aureus* ---most commonly isolated pathogen.
- gram-negative bacilli and anaerobic organisms are also frequently isolated

1.Song KM, Sloboda JF. Acute hematogenous osteomyelitis in children. *J Am Acad Orthop Surg.* 2001;9:166-75

2.Lew DP, Waldvogel FA. Osteomyelitis. *N Engl J Med.* 1997;336:999-1007

Organisms Isolated in Bacterial Osteomyelitis

Organism	*Comments*
Staphylococcus aureus	*Organism most often isolated in all types of osteomyelitis*
Coagulase-negative staphylococci or Propionibacterium species	*Foreign-body–associated infection*
Enterobacteriaceae species or*Pseudomonas aeruginosa*	*Common in nosocomial infections and punchured wounds*
Streptococci or anaerobic bacteria	*Associated with bites, fist injuries caused by contact with another person's mouth, diabetic foot lesions, decubitus ulcers*
Salmonella species or*Streptococcus pneumoniae*	*Sickle cell disease*

Lew DP, Waldvogel FA. Osteomyelitis. N Engl J Med 1997;336:999-1007.

Rare organisms Isolated in Bacterial Osteomyelitis

Bartonella henselae	Human immunodeficiency virus infection
Pasteurella multocida or *Eikenella corrodens*	Human or animal bites
Aspergillus species, *Mycobacterium avium-intracellulare* or *Candida albicans*	Immunocompromised patients
Mycobacterium tuberculosis	Populations in which tuberculosis is prevalent.
Brucella species, *Coxiella burnetii* (cause of chronic Q fever) or other fungi found in specific geographic areas	Population in which these pathogens are endemic

Why staphylococcus most common?

- S.aureus and S.epidermis ----- elements of normal skin flora
- S.aureus -----increased affinity for host proteins (traumatised bone)
- Enzymes (coagulase, surface factor A) ----- hosts immune response .
- Inactive "L" forms ------dormant for years
- "Biofilm" (polysaccharide "slime" layer) ---- increases bacterial adherence to any substrate .
- Large variety of adhesive proteins and glycoproteins ----- mediate binding with bone components.

Epidemiology

- The number of cases of osteomyelitis involving long bones is decreasing while the rate of osteomyelitis at all other sites remained the same[4].

- The prevalence of *Staphylococcus aureus* infections is also decreasing, from 55% to 31%, over the twenty-year time period[4].

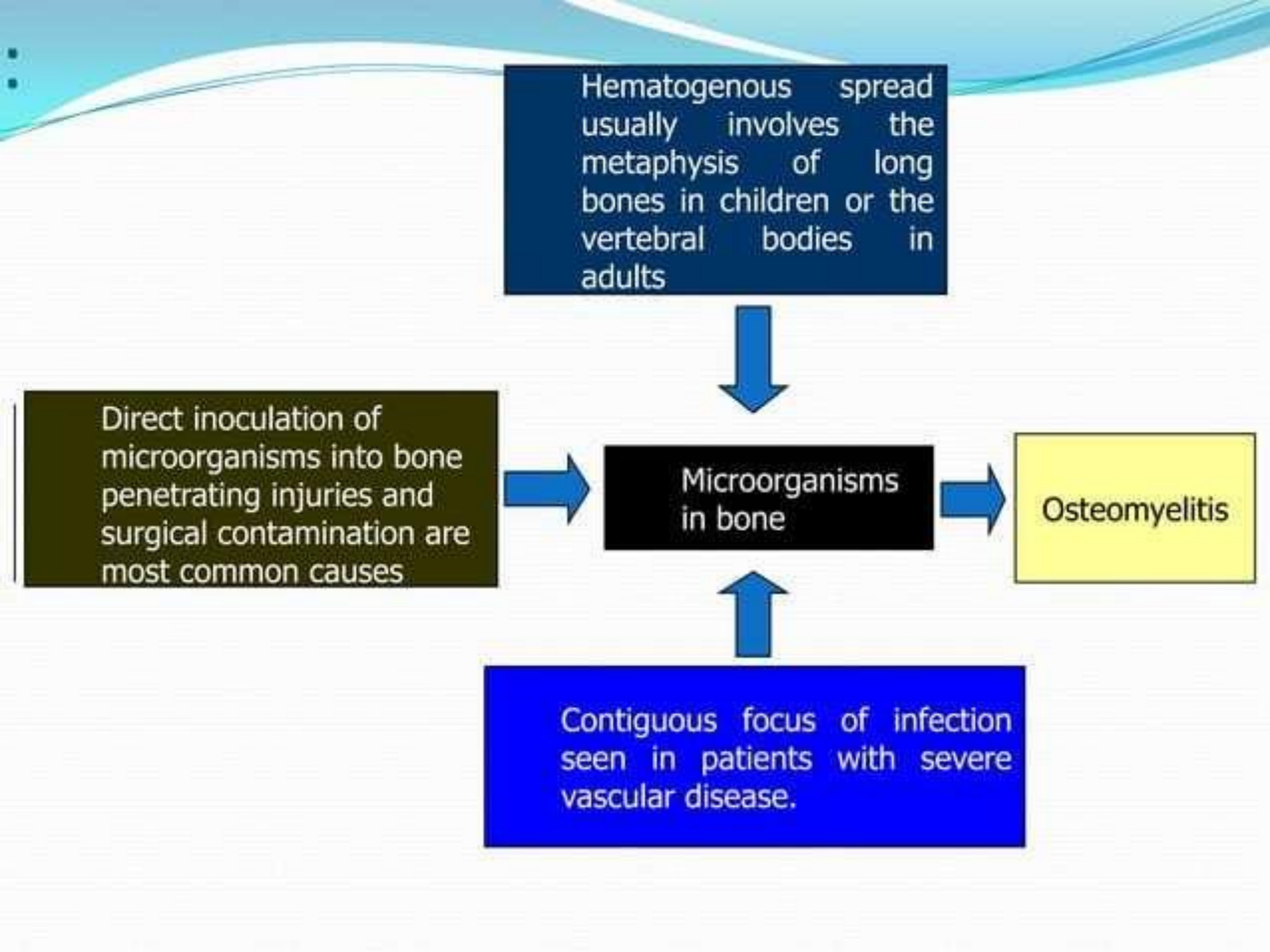
- The incidence of osteomyelitis due to direct inoculation or contiguous focus infection is increasing due to[5]:
  - motor-vehicle accidents
  - the increasing use of orthopaedic fixation devices
  - total joint implants.

- Males have a higher rate of contiguous focus osteomyelitis than do females[5].

4. Blyth MJ, Kincaid R, Craigen MA, Bennet GC. The changing epidemiology of acute and subacute haematogenous osteomyelitis in children. *J Bone Joint Surg Br.* 2001;83:99-102.
5.Gillespie WJ. Epidemiology in bone and joint infection. *Infect Dis Clin North Am.* 1990;4:361-76.

Epidemiology

- Incidence of infection increases with increase in grade of compounding (Guistilo, Anderson) :
  - Approx. 2% for type I and type II
  - Approx. 10% to 50% for type III
- The tibia


Hematogenous spread usually involves the metaphysis of long bones in children or the vertebral bodies in adults
Direct inoculation of microorganisms into bone penetrating injuries and surgical contamination are most common causes
Microorganisms in bone
Osteomyelitis
Contiguous focus of infection seen in patients with severe vascular disease.

Pathogenesis:

- *Host Factors*

TABLE II Systemic or Local Factors That Affect Immune Surveillance, Metabolism, and Local Vascularity

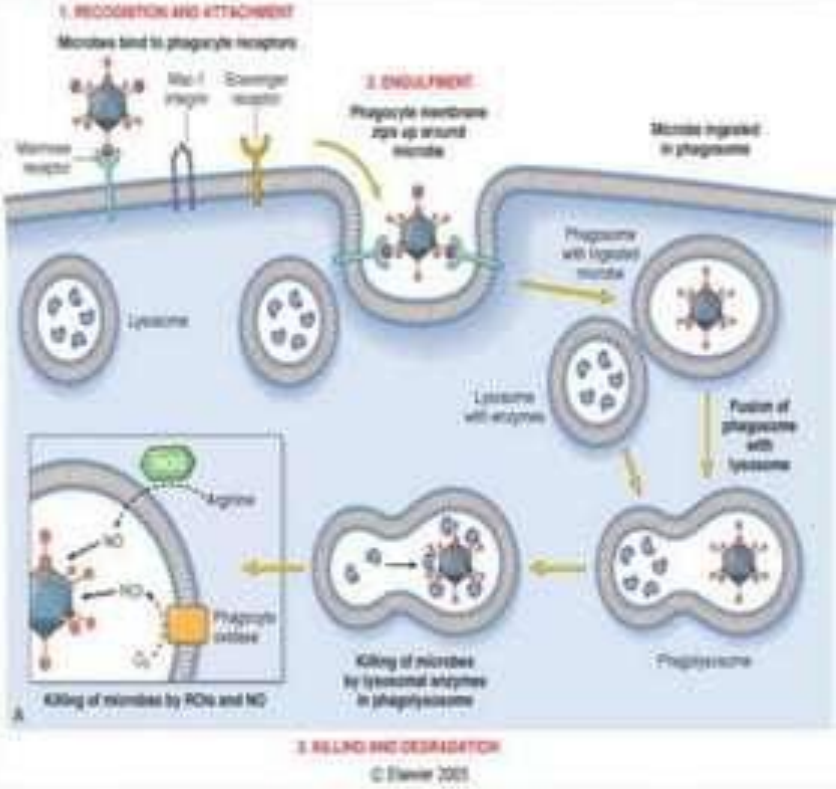
Systemic (Bs)	Local (Bl)
Malnutrition	Chronic lymphedema
Renal, hepatic failure	Venous stasis
Diabetes mellitus	Major vessel compromise
Chronic hypoxia	Arteritis
Immune disease	Extensive scarring
Malignancy	Radiation fibrosis
Extremes of age	Small vessel disease
Immunosuppression or immune deficiency	Neuropathy
Asplenia	
HIV/AIDS	
Ethanol and/or tobacco abuse	

Bacterial factors:

- Formation of a glycocalyx surrounding the infecting organisms.
  - protects the organisms from the action of phagocytes and prevents access by most antimicrobials.
  - A surface negative charge of devitalized bone or a metal implant promotes organism adherence and subsequent glycocalyx formation.

osteomyelitis:

- Prostaglandin-E production has been shown to be five to thirty fold higher in infected bone than in normal bone
  - postulated to be responsible for bone resorption and sequestrum formation[6,7].
- Effective phagocytosis is defense in patients with osteomyelitis[8].
- Intramedullary oxygen tensions important for phagocytic function
  - oxygen tensions of <30 mm Hg impair normal phagocytic function[9].



6.Plotquin D, Dekel S, Katz S, Danon A. Prostaglandin release by normal and osteomyelitic human bones. *Prostaglandins Leukot Essent Fatty Acids*.1991;43:13-5.
7.Ralston SH. Role of cytokines in clinical disorders of bone metabolism. In:Gowen M, editor. *Cytokines and bone metabolism*. Boca Raton, FL: CRCPress; 1992.p 370-1.
8.Subasi M, Kapukaya A, Kesemenli C, Kaya H, Sari I. Effect of granulocytemacrophage colony-stimulating factor on treatment of acute osteomyelitis. An experimental investigation in rats. *Arch Orthop Trauma Surg*. 2001;121: 170-3.
9. Mader JT, Brown GL, Guckian JC, Wells CH, Reinarz JA. A mechanism forthe amelioration by hyperbaric oxygen of experimental staphylococcal osteomyelitis in rabbits. *J Infect Dis*. 1980;142:915-22.

Pathology:

Hematogenous osteomyelitis:

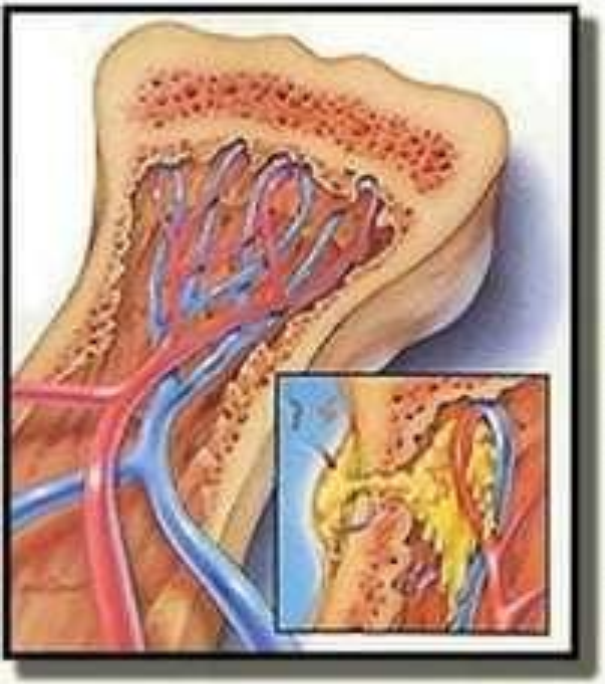
- occurs in children < 15 years of age although adults can have this disease
- occurs in the metaphysis of the long bones.
  - In metaphysis decreased activity of macrophages
  - Frequent trauma
  - Precarious blood supply

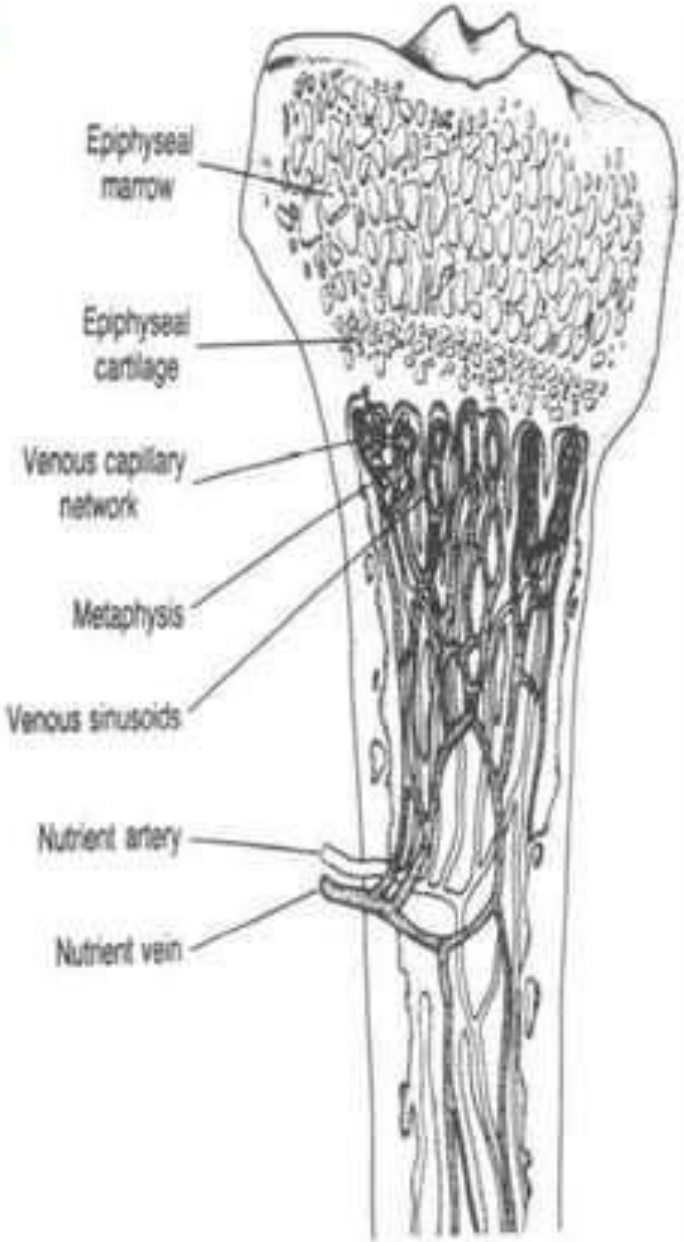
Diaphysial osteomyelitis :

- Earlier metaphysis but due to growth becomes diaphyseal mostly in children.
- Direct trauma to diaphysis
- Tubercular

Pathology:

- sharp hairpin turns
- flow becomes considerably slower and more turbulent





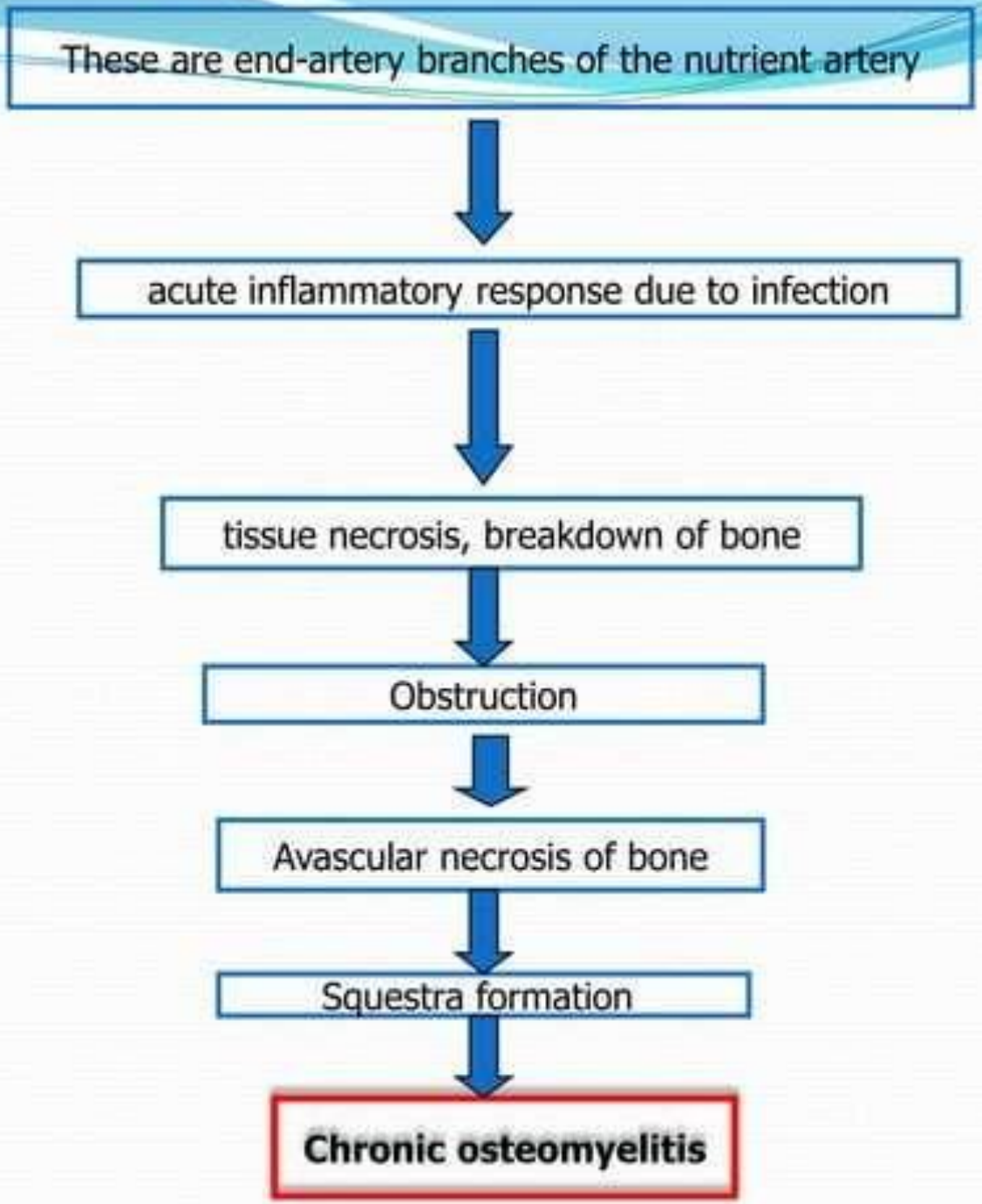
Pathogenesis

Whatever may be the inciting cause the bacteria reaches the metaphysis of rapidly growing bone & provokes an inflammatory response.

why metaphysis is involved

1. Infected embolus is trapped in U-shaped small end arteries located predominantly in metaphyseal region
2. Relative lack of phagocytosis activity in metaphyseal region
3. Highly vascularised region ---minor trauma—hemorrhage ----locus minoris resistantae---excellent culture medium

Pathology

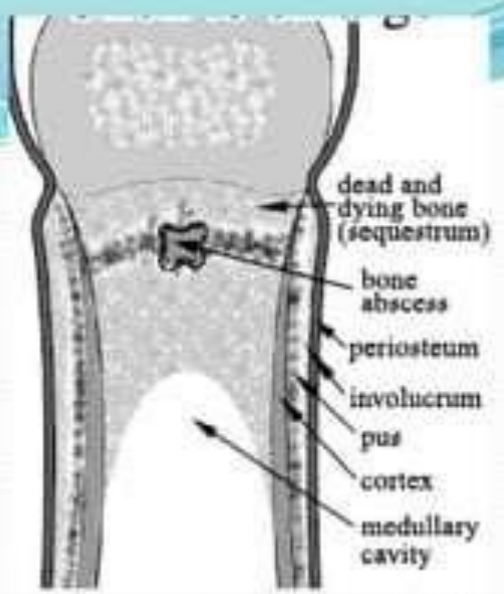

These are end-artery branches of the nutrient artery
acute inflammatory response due to infection
tissue necrosis, breakdown of bone
Obstruction
Avascular necrosis of bone
Squestra formation
Chronic osteomyelitis

Pathology:

- Pathologic features of chronic osteomyelitis are :
  - The presence of sclerotic, necrotic piece of bone usually cortical surrounded by radiolucent inflammatory exudate and granulation tissue known as sequestrum.

  - Features:
    - Dead piece of bone
    - Pale
    - Inner smooth ,outer rough
    - Surrounded by infected granulation tissue trying to eat it
    - Types-
      - ring(external fixator)
      - tubular/match-stick(sickle)
      - coke and rice grain(TB)
      - Feathery(syphilis)
      - Colored(fungal)
      - Annular(amputation stumps)

Pathology:



- The involucrum is the sheath of reactive, new, immature, subperiosteal bone that forms around the sequestrum, effectively sealing it off the blood stream just like a wall of abscess.
  - The involucrum is irregular and is often perforated by openings.
  - The involucrum may gradually increase in density and thickness to form part or all of a new diaphysis.

- New bone formation
- There is exudation of polymorphonuclear leukocytes joined by large numbers of lymphocytes, histiocytes, and occasionally plasma cells.

local signs

- calor, rubor, dolor, tumor
- Heat, red, pain or tenderness, swelling
- Initially, the lesion is within the medually cavity, there is no swelling, soft tissue is also normal.
- The merely sign is deep tenderness.
- Localized finger-tip tenderness is felt over or around the metaphysis.
- it is necessary to palpate carefully all metaphysic areas to determine local tenderness, pseudoparalysis

Clinic picture

Very ill or toxic

- An increase effusion in the adjacent joint proves in most cases to be a sympathetic synovitis with sterile clear fluid..
- It is important to remember that the metaphysis lies within the joint capsule of the hip, shoulder, ankle. Therefore these joints can develop septic arthritis by extension of osteomyelitis.
- If the infection and septicemia proceeded unabated, the patient may have toxic shock syndrome.

Clinical features

- During the period of inactivity, no symptoms are present.
- Only Skin-thin, dark, scarred, poor nourished, past sinus, an ulceration that is not easily heal
- Muscles-wasting contracture, atrophy
- Joint-stiffness
- Bone-thick, sclerotic,
- often contains abscess cavity

Clinical features

- At intervals, a flare-up occurs,
- The relapse is often the result of poor body condition and lower resistance.
- A lighting up of infection is manifested by aching pain that is worse at night.
- Locally there will be some heat, swelling, redness, tenderness, edema, because pus may build up in cavity, then a sinus may open and starts to exudate purulent material and small sequestra.
- The sinus closes and the infection subsides.

Laboratory findings

- The white blood cell count will show a marked leucocytosis as high as 20,000 or more
- The blood culture demonstrates the presence of bacteremia, the blood must be taken when the patient has a chill, especially when there is a spiking temperature.
- Aspiration. The point of maximal tenderness should be aspirated with a large-bore needle.
- The thick pus may not pass through the needle.
- Any material aspirated should be gram stained and cultured to determine the sensitivity to antibiotics.

Microbiology :

- In patients with Cierny-Mader Stage-1, or hematogenous, osteomyelitis, positive cultures of blood or joint fluid diagnostic.
- Definitive diagnosis obtained from intraop biopsy samples.
- Best samples are tissue fragments directly from center of infection.
- If possible, culture specimens should be obtained before antibiotics are initiated.
- The empiric regimen should be discontinued for three days before the collection of samples for cultures.[a]
- Cultures of specimens from the sinus tract are not reliable for predicting which organisms will be isolated from infected bone.

a.Ericsson HM, Sherris JC. Antibiotic sensitivity testing. Report of an international collaborative study. *Acta Pathol Microbiol Scand [B] Microbiol Immunol.* 1971;217(Suppl 217):1-90.

Microbiology :

- Improved techniques for processing purulent materials:
  - A lysis-centrifugation technique
  - Mild ultrasonication removes hardware to provide optimal bacterial removal.
  - Polymerase chain reaction
    - Used in the diagnosis of bone infection due to unusual or difficult pathogens, such as
      - *Mycoplasma pneumoniae*
      - Brucella species
      - *Bartonella henselae*,
      - Both tuberculous and nontuberculous mycobacterium species.

X-ray findings

- X-ray films are negative within 1-2 weeks
- Careful comparison with the opposite side may show abnormal soft tissue shadows.
- It must be stressed that x-ray appearances are normal in the acute phase. There are little value in making the early diagnosis.
- By the time there is x-ray evidence of bone destruction, the patient has entered the chronic phase of the disease.

X-ray findings

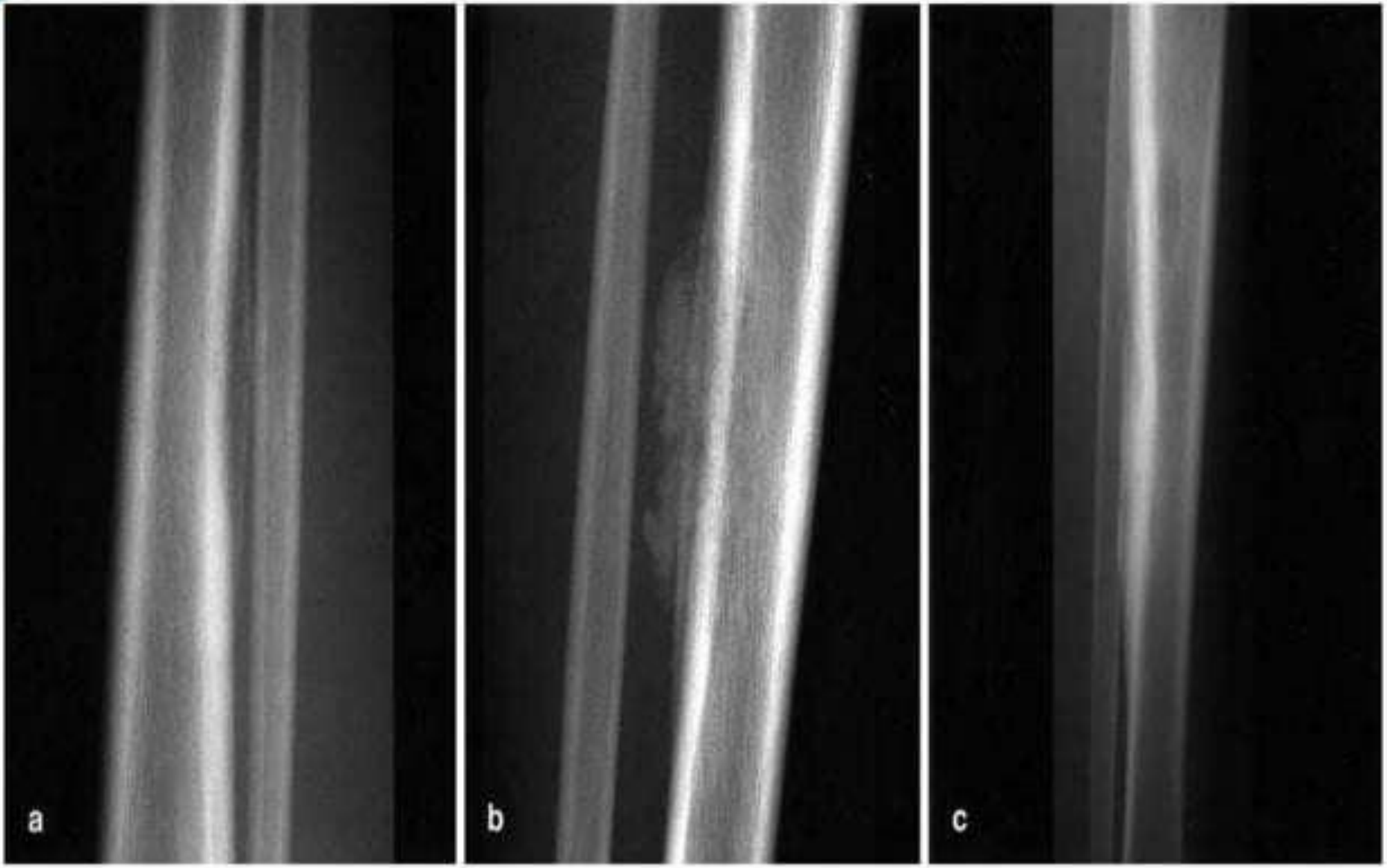
- It takes from 10 to 21 days for an osseous lesion to become visible on conventional radiography, because a 30–50% reduction of bone density must occur before radiographic change is apparent

Bonakdarpour A, Gaines VD (1983) The radiology of osteomyelitis. Orthop Clin North Am 14:21–33

X-ray findings

1. Localized osteopaenia and trabecular destruction are early signs of a suppurative acute process in the bone.

2. The type and extent of cortical destruction is variable . A wide spectrum is encountered, ranging from a solitary radiolucency to irregular, multiple radiolucencies (mottling) to a permeative pattern. The individual lesions are generally indistinct and irregular in outline.


a
b
c

X-ray findings

3. Lamellated periosteal reactions are invariably present .

4. The reparative phase during therapy is characterized by endosteal and periosteal new bone formation, development of surrounding sclerosis and sometimes large osteosclerotic areas.

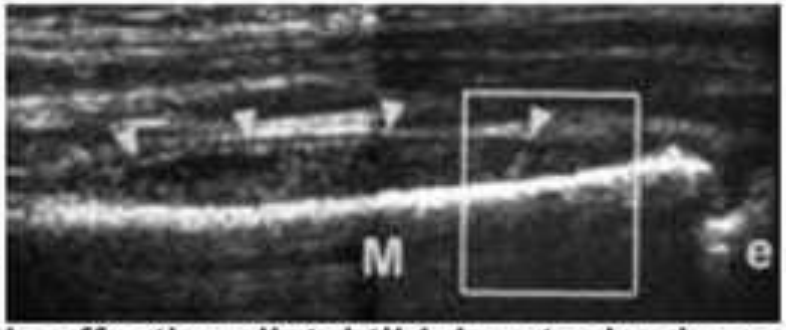
5. Soft tissue changes, such as swelling and obliteration of tissue planes, are rarely of diagnostic value in adults.

6. In newborns and infants, however, loss of normal fat planes within days of the onset of symptoms may be an early sign of soft tissue swelling. In this age group lamellated periosteal changes are generally discernible before any bone destruction. A late manifestation is the ballooned metaphysis, sometimes with involvement of the epiphysis.

Sonography

- Ultrasound cannot directly access bone marrow abnormalities present in osteomyelitis but can document osteomyelitis indirectly by identifying periosseous soft tissue abnormalities

- The very first sonographic sign, seen even before any periosteal reaction, is edematous swelling of the deep soft tissues

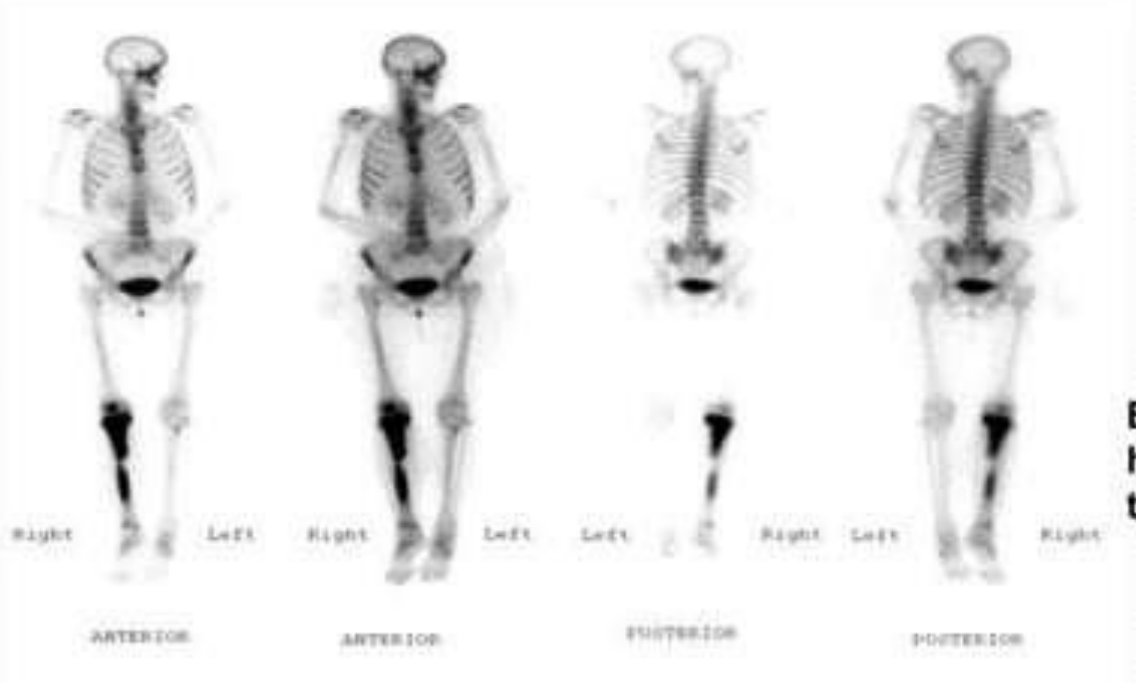


osteomyelitis affecting distal tibial metaphysis seen on ultrasound

Cardinal E, Bureau NJ, Aubin B, Chhem RK (2001) Role of ultrasound in muskuloskeletal infections. Radiol Clin North Am 39:191–201

Bone scan

- Radioisotopic bone scanning is valuable in early localization (within 48 hrs) of bone infection.
- The specificity of radioactive isotopic imaging techniques have improved in the evaluation of musculoskeletal infection.
- Technitium-99m imaging is very sensitive , it is the choice for acute hematogenous osteomyelitis, the overall accuracy being 92%.



Bone scan revealing hot spot in right tibia

- Ga^{67} scintigraphy provides the best way to detect vertebral osteomyelitis radiologically.

- In^{111} labeled leucocyte imaging is the test of choice for osteomyelitis elsewhere in body.

Magnetic Resonance Imaging:

- Magnetic resonance imaging has very high sensitivity and specificity.
- Advantage:
  - Useful for differentiating between bone and soft-tissue infection.
  - Helpful in surgical planning.
- Disadvantage:
  - A metallic implant in the region of interest may produce focal artifacts.
  - False positives in tumors and healing fractures.

Plain film and MR images chronic osteomyelitis of right distal femur.

A case of chronic osteomylitis of fibula

Early diagnosis depends on following:

1. severe acute illness, rapid onset and toxemia
2. local severe pain and unwillingness to move limbs
3. deep tenderness
4. WBC count is as high as 20,000 or more
5. Every effort must be made to obtain a bacterial culture and determinate the sensitivity to antibiotics

- Tc99m scaning
- CT or MRI: MRI rather than planar bone scintigraphy should be considered for the detection of chronic non bacterial osteomyelitis lesions at diagnosis[1]

1. Comparison of magnetic resonance imaging and 99mTechnetium-labelled methylene diphosphonate bone scintigraphy in the initial assessment of chronic non-bacterial osteomyelitis of childhood and adolescents. Morbach H, Schneider P. Clin Exp Rheumatol. 2012 Jul 5

MORREY AND PETERSON'S CRITERIA

- Definition- the pathogen is isolated from bone or adjacent soft tissue as there is histologic evidence of osteomyelitis
- Probable- a blood culture is positive in setting of clinical and radiological features of osteomyelitis
- Likely- typical clinical finding and definite radiographic evidence of osteomyelitis are present and response to antibiotic therapy

Morrey, B.- F. & Peterson, H. A. **(1975)** Hematogenous pyogenic osteomyelitis in children. ***Orthop. Clin. N. Amer. 6, 935-951.***

Peltola and Vahvanen's criteria

-Pus on aspiration

-Positive bacterial culture from bone or blood

-Presence of classic signs and symptoms of acute osteomyelitis

-Radiographic changes typical of osteomyelitis

*--Two of the listed findings must be present for establishment of the diagnosis.

Peltola H, Vahvanen V (1984) A comparative study of osteomyelitis and purulent arthritis with special reference to aetiology and recovery. Infection 12:75–79

Differential diagnosis

- Tuberculosis –
  - Thin watery d/s
  - Undermining ,bluish discoloration
  - Diaphyseal involv. More common
  - H/o pulm. T.B.
  - Often multifocal
- Soft tissue infection
  - absence of bony changes
- Ewing sarcoma
  - radiological d/d
  - acute presentation
  - Bx is diagnostic.

- Foreign body
- Osteoid osteoma
- Histiocytic eosinophilic granul
- Garre's osteomyelitis

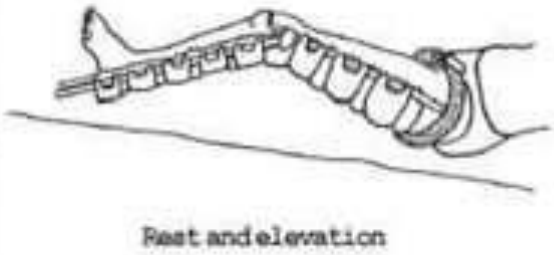
Treatment

1. General treatment: *nutritional therapy or general supportive treatment by intaking enough caloric, protein, vitamin etc.*

2. Antibiotic therapy

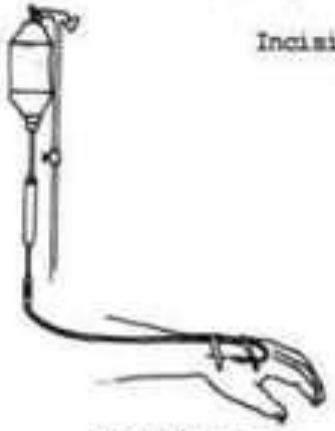
3. Surgical treatment

4. Immobilization



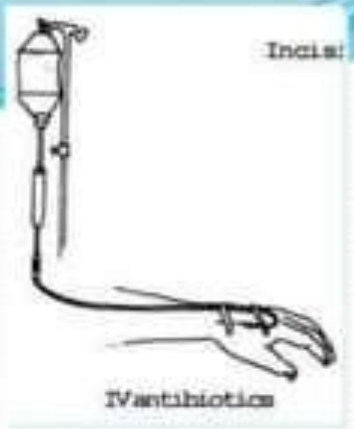
Rest and elevation

Incision and drainage



IV antibiotics

Nade's principles



- Antibiotic is effective before pus forms
- Antibiotic cannot sterilise avacular tissue
- Antibiotic prevents reformation of pus once removed
- Pus removal restores periosteum---- restores blood flow
- Antibiotic should be continued after surgery

Nade S. Antibiotics in the management of acute haematogenous osteomyelitis and acute septic arthritis in infancy and childhood. Aust New Zealand J Surg. 1978;48:78–80

Prospective Evaluation of a Shortened Regimen of Treatment for Acute Osteomyelitis and Septic Arthritis in Children

- Included 70 consecutive, eligible children aged 2 weeks to 14 years.
- Staphylococci were the only organisms isolated in cases of osteomyelitis
- Found that 59% of children could be converted to oral therapy after 3 days of intravenous therapy and 86% after 5 days.
- Established that 3 weeks of oral therapy was appropriate for those patients who received 5 days or less intravenous treatment.

Journal of Pediatric Orthopaedics Issue: Volume 29(5), July/August 2009, pp 518-525

Nade's indications for surgery

1. Abscess formation
2. Severely ill & moribund child with features of acute osteomyelitis
3. Failure to respond to IV antibiotics for >48 hrs

Complications

- Chronic osteomyelitis- 2% in >3wks, 19% in < 3wks
- Septic arthritis
- Growth disturbance
- Septicemia
- DVT
- Pulmonary embolism

Ramos OM: Chronic osteomylitis in children. Paedi Infe Dis J 2002; 21:431

SUBACUTE HEMATOGENOUS OSTEOMYELITIS

- More insidious onset and lacks the severity of symptoms
- Diagnosis typically is delayed for more than 2 weeks.
- a pathogen is identified only 60% of the time
- ***S. aureus* and *Staphylococcus epidermidis***
- The diagnosis often must be established by an open biopsy and culture

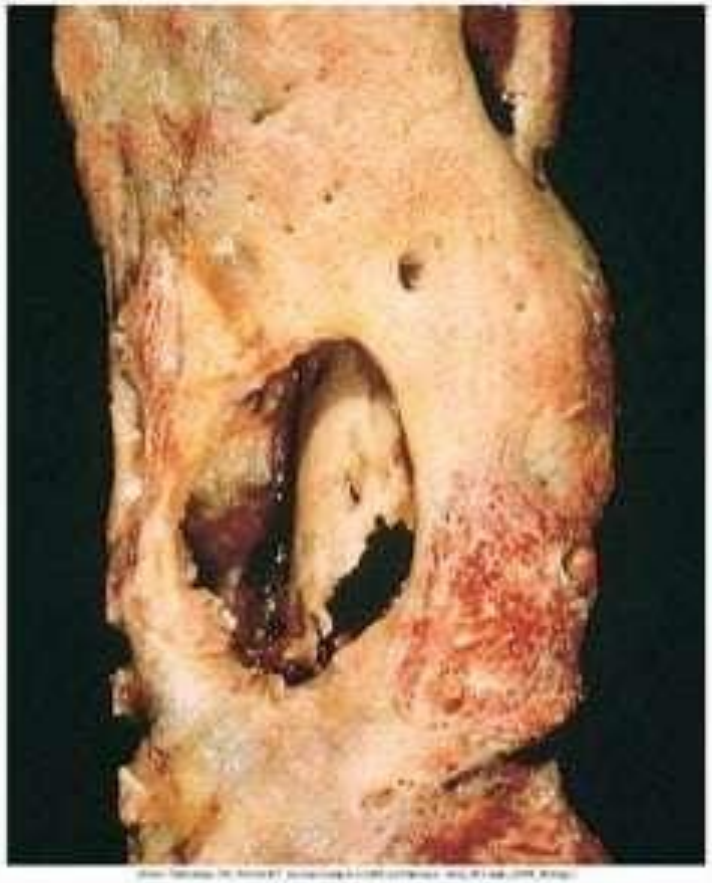
Sub acute osteomyelitis classification

Type	Gledhill Classification	Robert et al. Classification
I	Solitary localized zone of radiolucency surrounded by reactive new bone formation	Ia—Punched-out radiolucency
		Ib—Punched-out radiolucent lesion with sclerotic margin
II	Metaphyseal radiolucencies with cortical erosion	—
III	Cortical hyperostosis in diaphysis; no onion skinning	Localized cortical and periosteal reaction
IV	Subperiosteal new bone and onion skin layering	Onion skin periosteal reaction
V	—	Central radiolucency in epiphysis
VI	—	Destructive process involving vertebral body

Brodie's abcess

- Bone abscess containing pus or jelly like granulation tissue surrounded by a zone of sclerosis
- Age 11-20 yrs, metaphyseal area, usually upper tibia or lower femur
- Deep boring pain, worse at night, relieved by rest
- Circular or oval luscency surrounded by zone of sclerosis
- Treatment:
  - Conservative if no doubt - rest + antibiotic for 6 wks.
  - if no response – surgical evacuation & curettage, if large cavity - packed with cancellous bone graft

Chronic Osteomyelitis of the Femur



Chronic osteomyelitis

If any of ***sequestrum, abscess cavity, sinus tract or cloaca*** is present.

Hematogenous infection with an organism of low virulence may be present by chronic onset.

- Infection introduced through an external wound usually causing a chronic osteomyelitis.
- It is due to the fact that the causative organism can lie dormant in avascular necrotic areas occasionally becoming reactive from a flare up.

Classification

- The two most widely used in the medical literature and in clinical practice are those presented by :
  - Waldvogel et al-
    - Osteomyelitis is described as either acute or chronic, depending on the absence or presence of dead bone.
    - Osteomyelitis is also classified according to the source of the infection:
      - hematogenous when it originates from a bacteremia
      - contiguous focus when it originates from an infection in nearby tissue
      - A third category in this classification is osteomyelitis in the

Classification

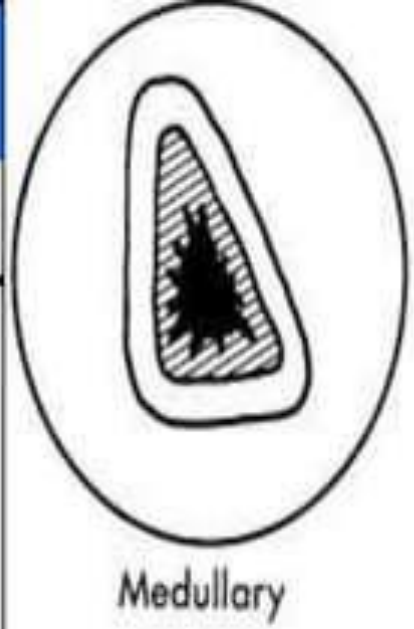
- Cierny et al -
  - Includes four anatomic stages
    - Stage-1, or ***medullary***, osteomyelitis is confined to the medullary cavity of the bone.
    - Stage-2, or ***superficial,*** osteomyelitis involves only the cortical bone.
    - Stage-3, or ***localized***, osteomyelitis usually involves both cortical and medullary bone but does not involve the entire diameter of the bone.
    - Stage-4, or ***diffuse***, osteomyelitis involves the entire thickness of the bone, with loss of stability.

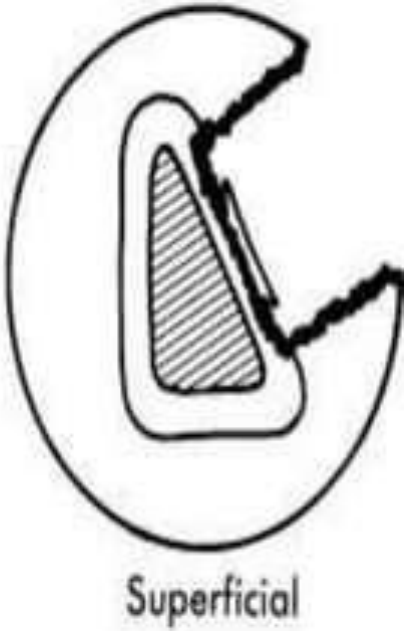
Classification

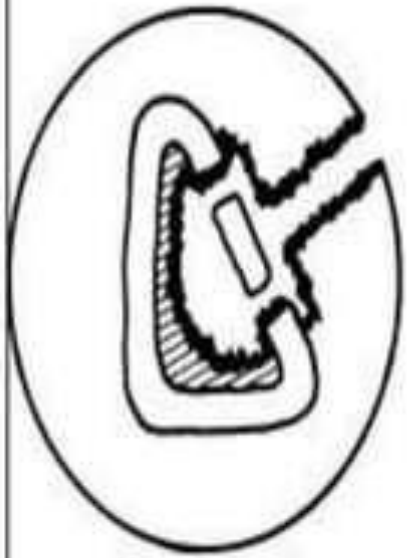
- With this system, a patient with osteomyelitis is classified as an A, B, or C host.
  - An "A" host has no systemic or local compromising factors.
  - A "B" host is affected by one or more compromising factors.
    - Bs-systemic compromise
    - Bl-local compromise
    - Bls-both sys and local compromise
  - A "C" host is so severely compromised that the radical treatment necessary would have an unacceptable risk-benefit ratio (Table I).

TABLE I Cierny-Mader Staging System

	Description
Anatomic type	
Stage 1	Medullary osteomyelitis
Stage 2	Superficial osteomyelitis
Stage 3	Localized osteomyelitis
Stage 4	Diffuse osteomyelitis
Physiologic class	
A host	Normal
B host	
Bs	Systemic compromise
Bl	Local compromise
Bls	Systemic and local compromise
C host	Treatment worse than the disease







Clinical features

- During the period of inactivity, no symptoms are present.
- Only Skin-thin, dark, scarred, poor nourished, past sinus, an ulceration that is not easily to heal
- Muscles-wasting contracture, atrophy
- Joint-stiffness
- Bone-thick, sclerotic,
- often contain abscess cavity

Clinical features

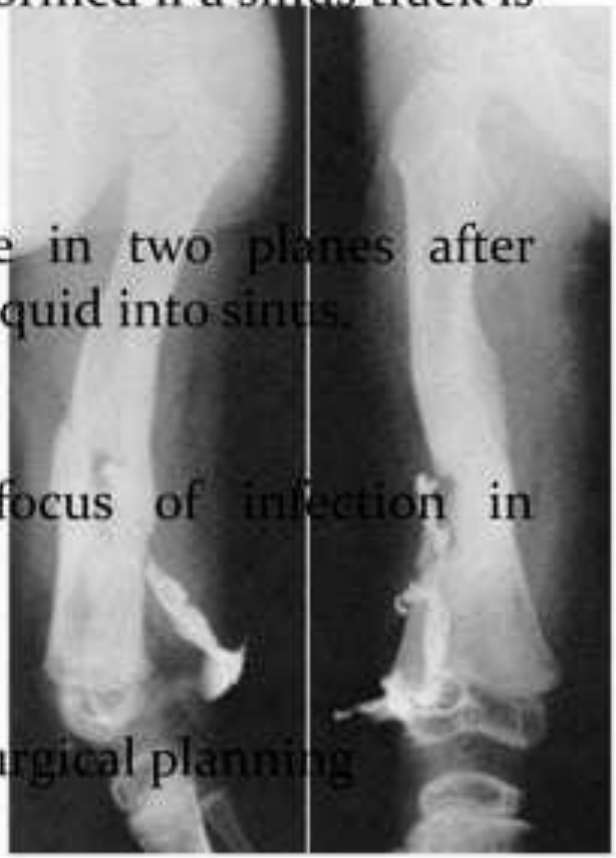
- At intervals, a flare-up occurs,
- The relapse is often the result of poor body condition and lower resistance.
- A lighting up of infection is manifested by aching pain that is worse at night.
- Locally there will be some heat, swelling, redness, tenderness, edema, because pus may build up in cavity, then a sinus may open and start to exudates purulent materials and small sequestra.
- The sinus closed and the infection subsided.

PERIOSTEAL NEW BONE FORMATION
INVOLUCRUM

SEQUESTRUM

Sinography:

- Sinography can be performed if a sinus track is present
- Roentgenograms made in two planes after injection of radiopaque liquid into sinus.
- Helpful in locating focus of infection in chronic osteomyelitis.
- A valuable adjunct to surgical planning



^{18}FDG PET Scan

Meta-analysis showed –Fluorodeoxyglucose positron emission tomography has the highest accuracy for confirming or excluding the diagnosis of Chronic Osteomyelitis.[1]

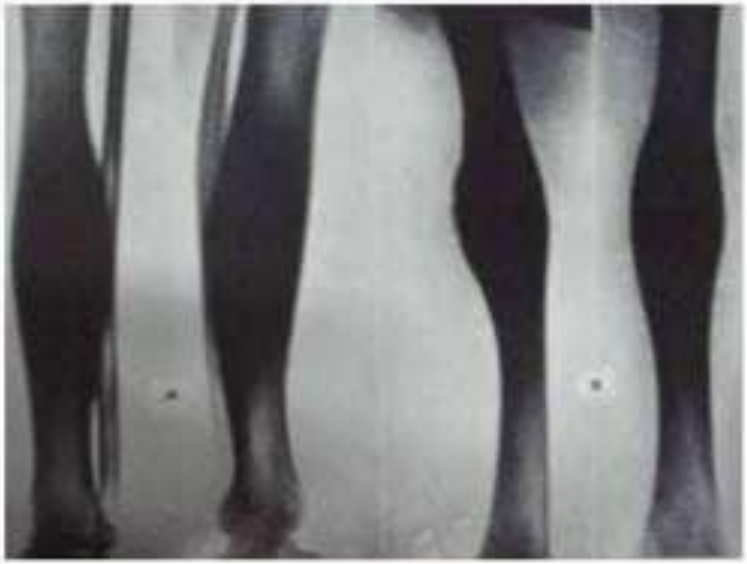
PET/CT images allowing correct differentiation between osteomyelitis and soft-tissue infection in patients of Diabetes Mellitis when MRI picture is not clear. [2]

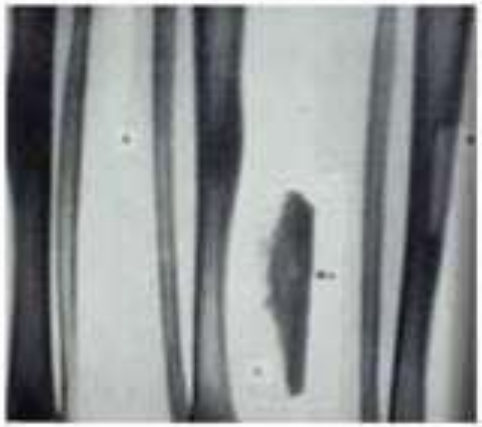
1."The Accuracy of Diagnostic Imaging for the Assessment of ChronicOsteomyelitis: A Systematic Review and Meta-Analysis" *The Journal of Bone and Joint Surgery (American)*. 2005;87:2464- 2471.

2. "FDG PET/CT imaging in the diagnosis of osteomyelitis in the diabetic foot" Kagna O, Srour S Eur J Nucl Med Mol Imaging. 2012 Jul 17

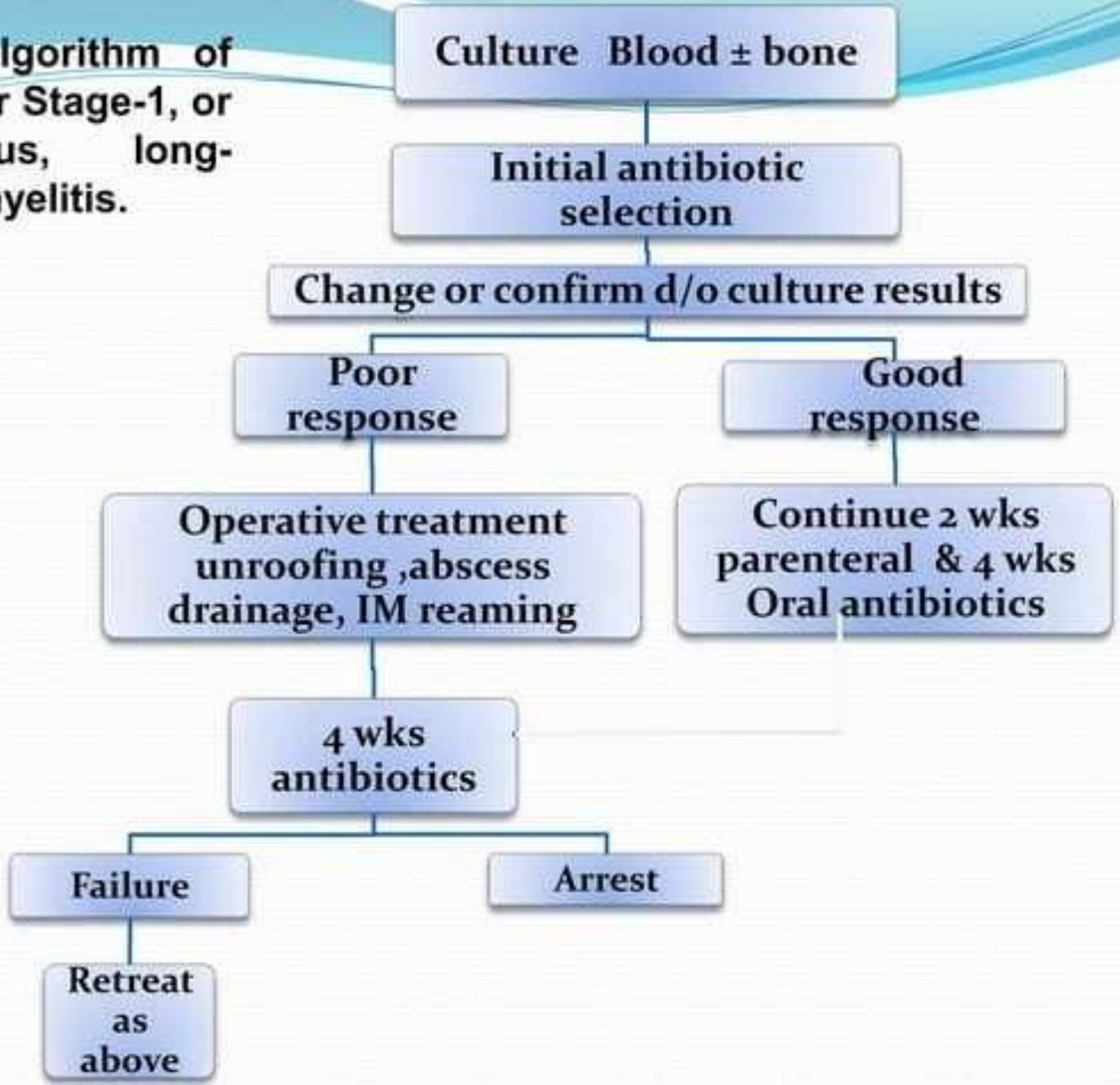
Garre’ s osteomyelitis

- Sclerosing, nonsuppurative
- Jaw (mandible)
- No abcess, cortical thickening
- Acute local pain, pyrexia subside-fusiform swelling
- Acute stage-rest, antibiotics
- Sx: Gutter holing, excision+curettage



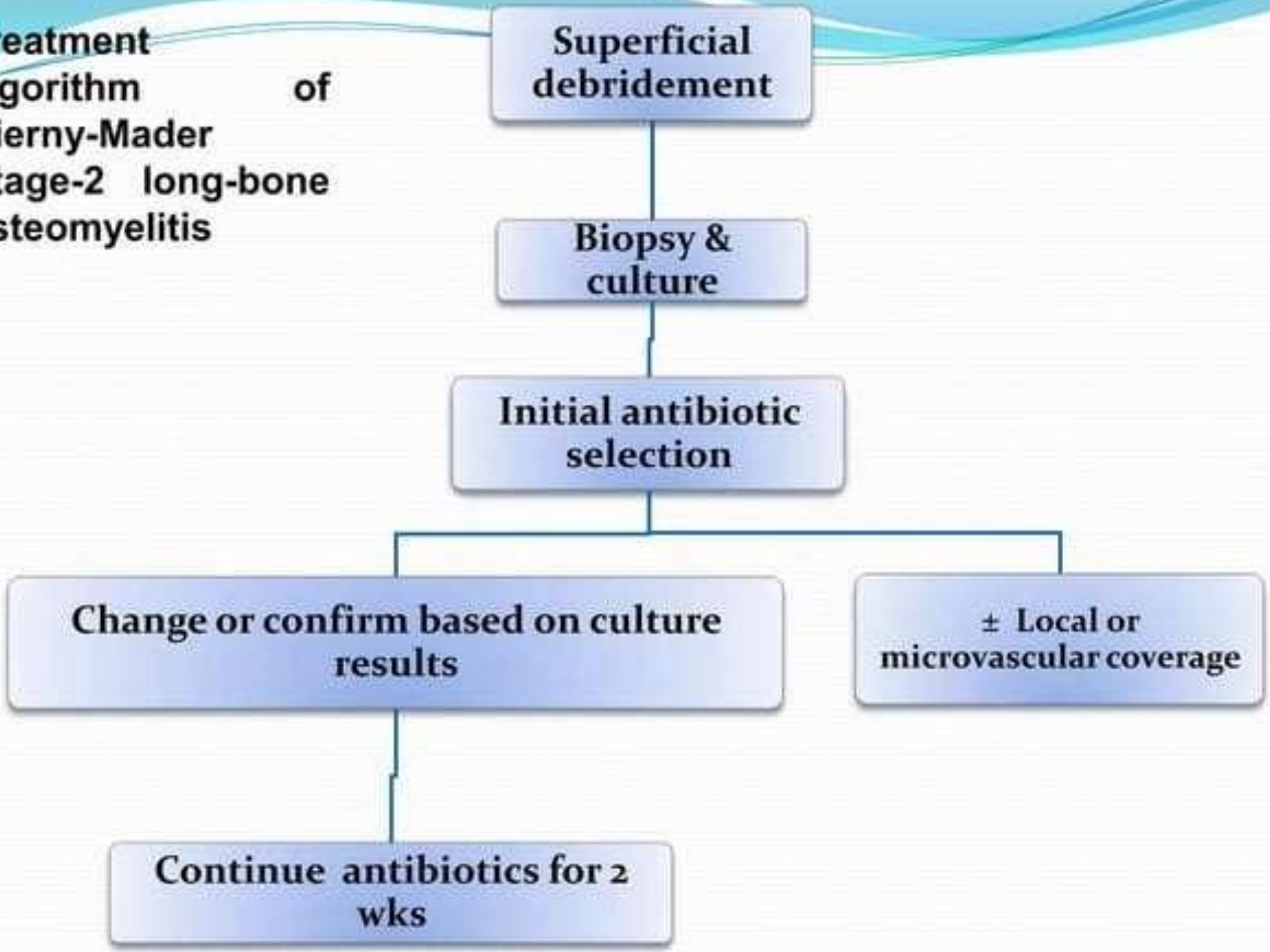


Treatment algorithm of Cierny-Mader Stage-1, or hematogenous, long-bone osteomyelitis.

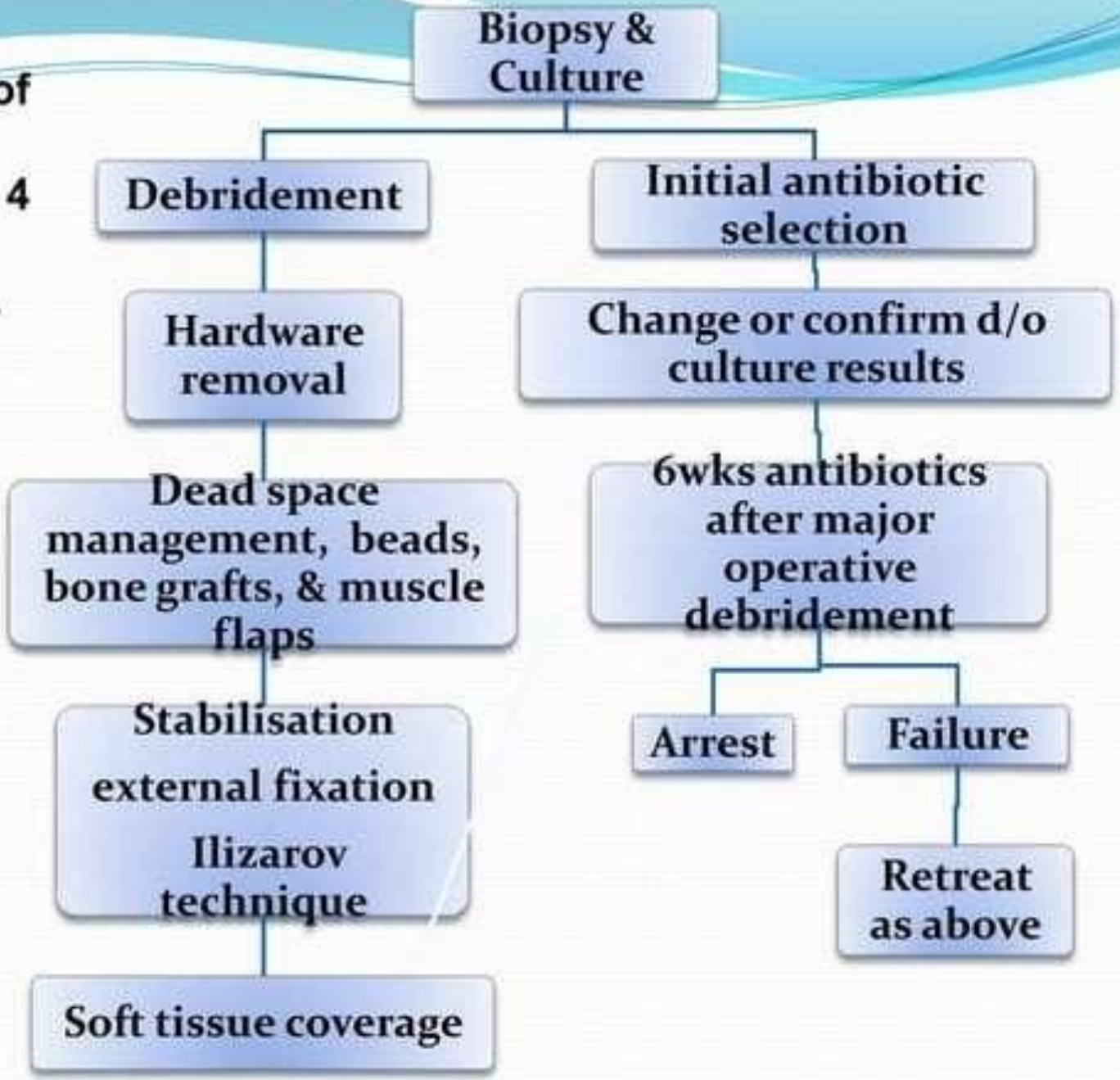


Treatment algorithm of Cierny-Mader Stage-1 long-bone osteomyelitis associated with infection at the site of hardware

Treatment algorithm of Cierny-Mader Stage-2 long-bone osteomyelitis



Treatment algorithm of Cierny-Mader Stages-3 and 4 long-bone osteomyelitis.



Osteomyelitis in long bones, L . Lazzarini,J.T.Mader,JBJS.Am.2004;86:2305-2318

ANTIBIOTICS

IV antibiotics

- Nafcillin/oxacillin/nafcillin with rifampcin
- Vancomycin/ampicillin/cefazolin/ceftriaxone
- Clindamycin/sulbactum/piperacillin/tazobactam

ORAL antibiotics

- Clindamycin/rifampcin/cotrimoxazole
- Fluoroquinolones in gram –ve organisms
- Linezolid-oral & IV antibiotics—MRSA

- Rifampicin - 1st line anti staph antibiotic in chronic infection
- It achieves intraleukocytic bactericidal action.

Ramos OM: Chronic osteomylitis in children. Paedi Infe Dis J 2002; 21:431

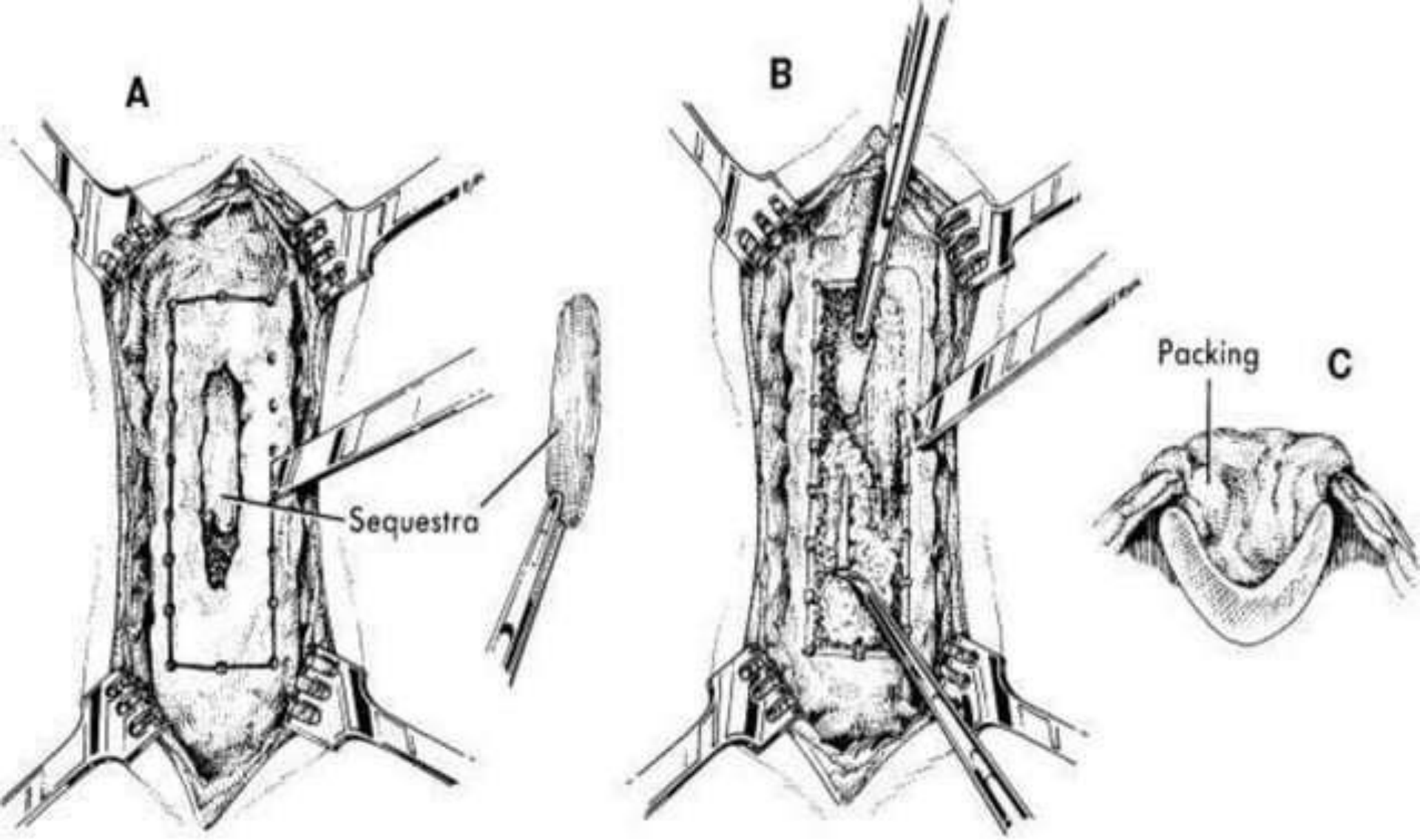
To wait is to invite disaster.

Surgical treatment

Bone Debridement:

- The goal of debridement is to leave healthy, viable tissue.
- Débridement of bone is done until punctate bleeding is noted, giving rise to the term ***the paprika sign.***
- Copious irrigation with ***10 to 14 L of normal saline.***
- Pulsatile lavage using fluid ***pressures 50-70 pounds per square inch and 800 pulses per min.***
- The ***extent of resection*** is important ***in B hosts*** as B hosts treated with marginal resection (i.e., with a clearance margin of <5 mm) found to have a higher rate of recurrence than normal hosts.[A]
- ***Repeated debridements*** may be required.

A.Simpson AH, Deakin M, Latham JM. Chronic osteomyelitis. The effect of the extent of surgical resection on infection-free survival. *J Bone Joint Surg Br.* 2001;83:403-7.



Sequestrectomy and curettage. **A,** Affected bone is exposed, and sequestrum is removed. **B,** All infected matter is removed. **C,** Wound is either packed open or closed loosely over drains.

When to do sequestrectomy?

Early sequestrectomy

- Eradicate infection
- Better environment for periosteum to respond

Delayed sequestrectomy

Wait till sufficient involucrum has formed before doing a sequestrectomy to mimimize the risk of fracture, deformity & segmental loss

In either case it is critical to preserve the involucrum

preferable to wait at least 3-6 months before performing a sequestrectomy

Prerequisites for Sequestrectomy

Radiological

- Well formed involucrum surrounding the discretely visible sequestrum adequately at least 2/3rd diameter of bone (3 intact walls on two views ensure 3/4th intact walls)

Clinical

- Symptomatic patient with pus discharge or chronic unreleaved disabling pain due to osteomyelitis per se and type A/B host.

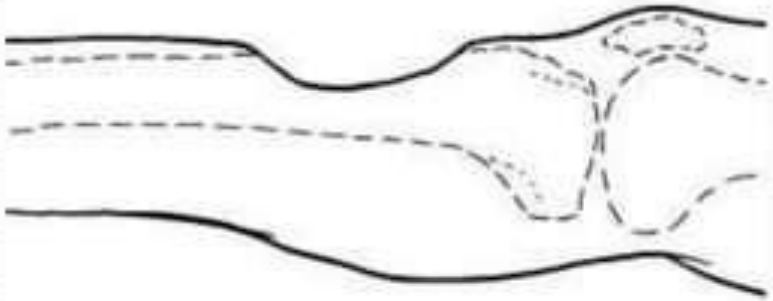
Post sequestrectomy

- *NO STABLISATION IS NECESSARY WHEN 70% OF THE ORIGINAL CORTEX REMAINS INTACT*
- If >70% cortical volume has been retained—protect by cast
- Greater bone loss-Ext fix
- Focal bone loss-open cancellous BG/conventional BG
- Seg. bone loss—BG/Bone transport/other devices

Radiologically if cortical continuity of the involucrum is 50% of the over all cortical diameter on 2 orthogonal views then the involucrum is structurally adequate

Saucerization

- Extension of surgical debridement
- Debrided wounds left open widely through excision of overhanging soft tissue and bone
  - Wounds drain freely
  - Abscesses do not form
- Limited to areas where it causes acceptable loss of function e.g. Tibia and femur
- May require stabilization

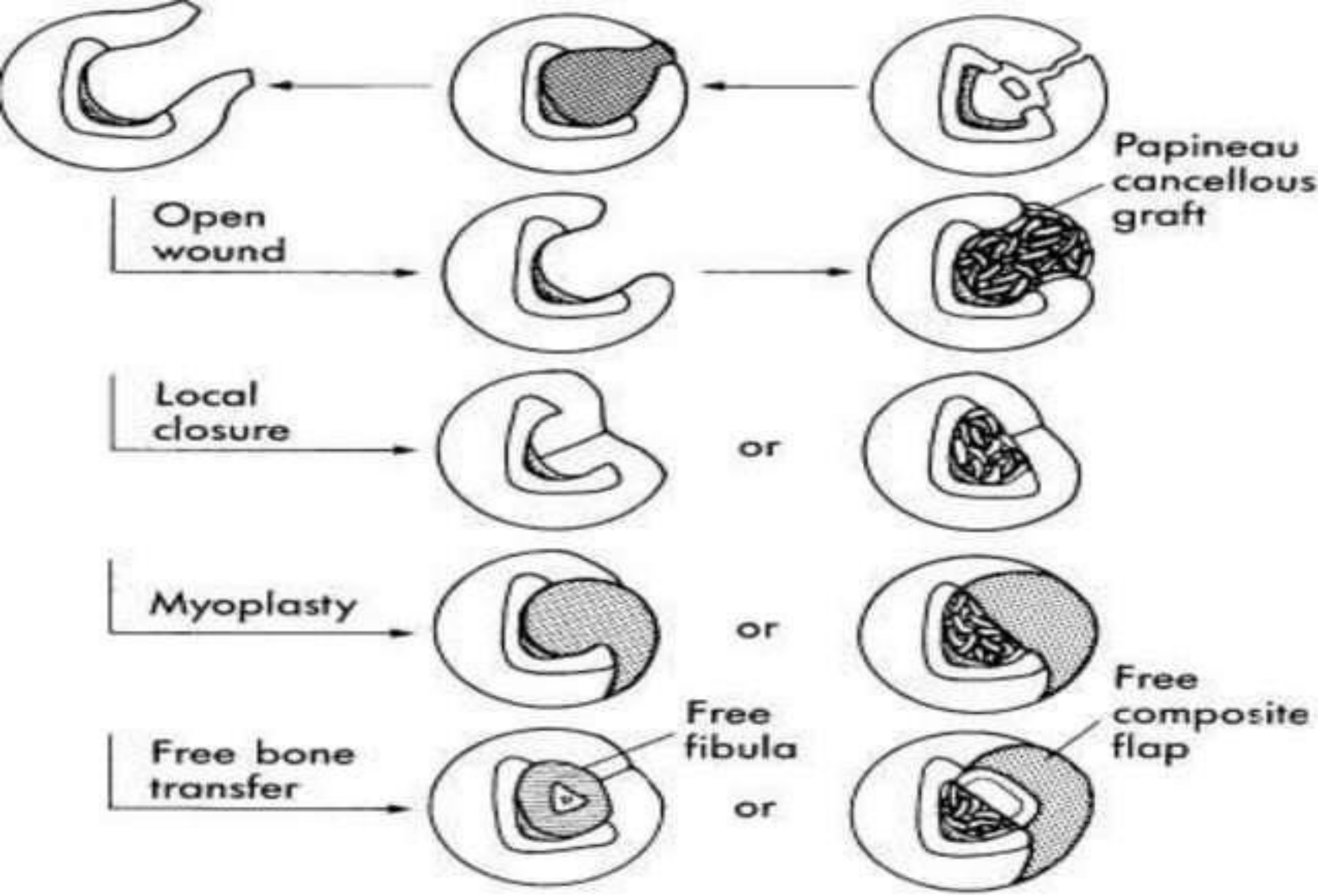


Management of Dead Space:

- Adequate debridement may leave a large bone defect, termed a *dead space.*
- It is a predisposing condition for the persistence of infection because it is poorly vascularized.
- Appropriate management of any dead space created by debridement is mandatory
  - to arrest the disease
  - to maintain the integrity of the skeletal part.
- Help improve the local biological environment by bringing in a blood supply important for
  - host defense mechanisms
  - antibiotic delivery
  - osseous and soft-tissue healing.
- The goal of dead space management is to replace dead bone and scar tissue with durable vascularized tissue.

Management of Dead Space:

- A free vascularized bone graft has been used successfully to fill dead space. e.g.the fibula or ilium.
- Local tissue flaps or free flaps can also be used to fill dead space.
- Cancellous bone grafts beneath local or transferred tissues can also be used where structural augmentation is necessary.
- Open cancellous grafts without soft-tissue coverage are useful when a free tissue transfer is not an option and local tissue flaps are inadequate.
- Careful preoperative planning is critical to the conservation of the patient's limited cancellous bone reserves.



Four basic methods of immediate, biological management of dead space using living tissue or cancellous bone grafts.

Dead space management

RHINELANDER –PAPINEAU TECHNIQUE

- 3 STAGES

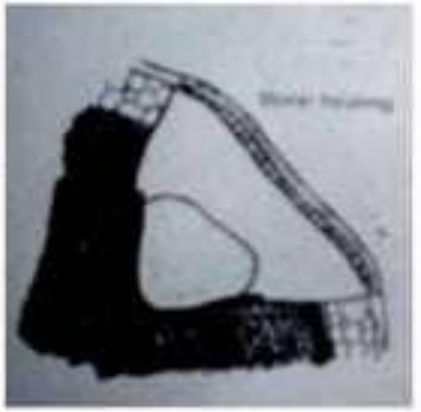
1.Debridement

- stabilization if necessary
  - ext. fixator preferable.
  - Rhinelander used cast.
  - Papineau-IM nails.

2. Cancellous bone grafting-after entire cavity is covered with granulation tissue
   - Best donor site- post. Ilium
   - others-gt. Trochanter,distal femur, proximal tibia.disadv. include pathological #
   - Cut into small pieces-3-4mm thick and 4-6cm long
   - all cortical pieces discarded
   - chips packed fingertight .
   - No dead space allowed
   - over period of several weeks ,slowly invaded by granulation tissue &become vascularized

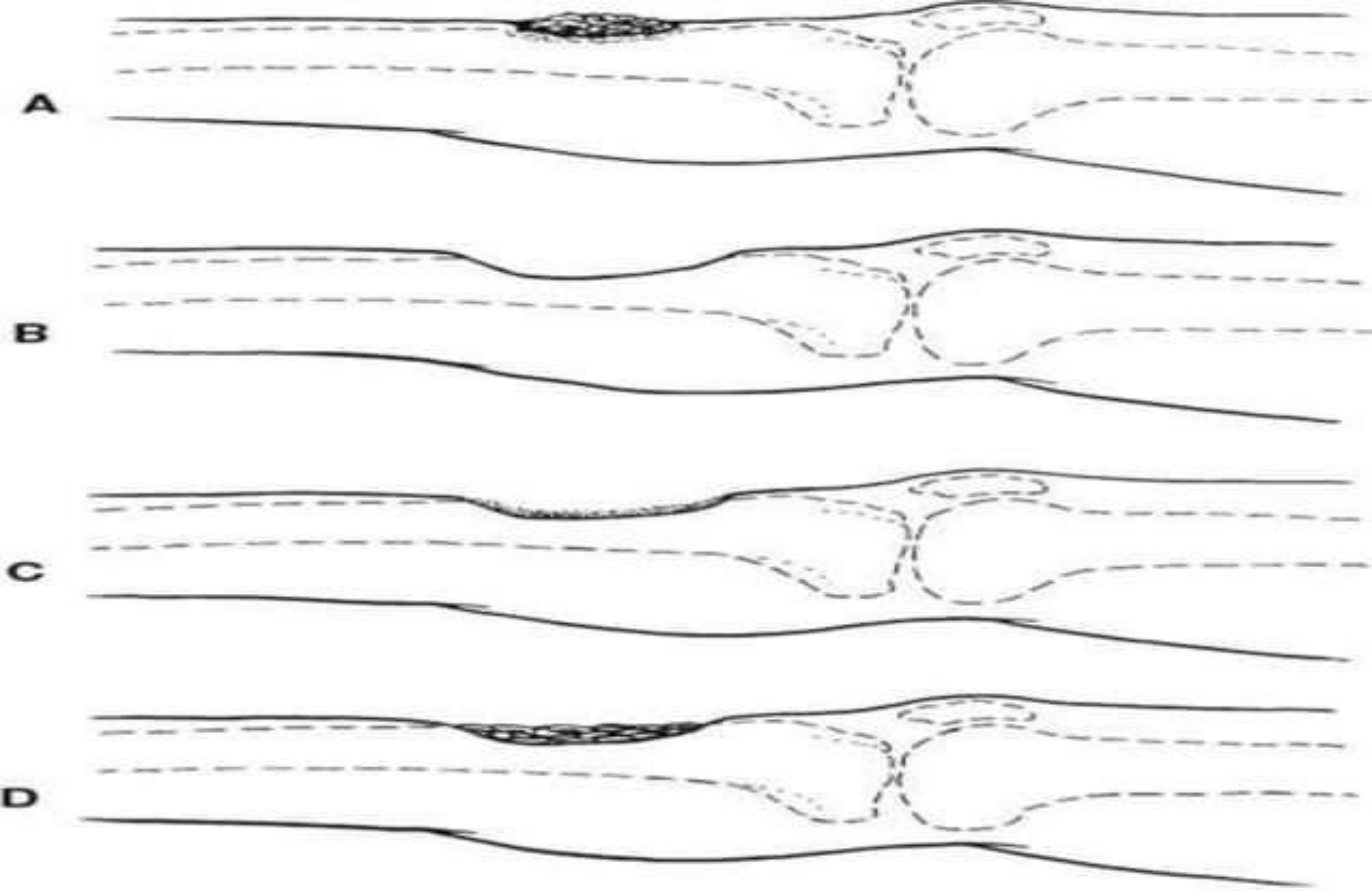
3.wound coverage

- Small wounds –spontaneous epithelizatio
- Large wound-SSG or other soft tissue procedure, usually after 8-16 wks.
- Ext. fixator removal
- Protected wt. Bearing
- Failure of granulation tissue to invade the graft with loss of surface chips-repetition of tech.(mini –papineau)



LIMITATIONS-cannot be used when:

- Segmental defect >4 cm.
- Poor quality soft tissue
- Poor vascular supply



Papineau technique:

Muscle flaps

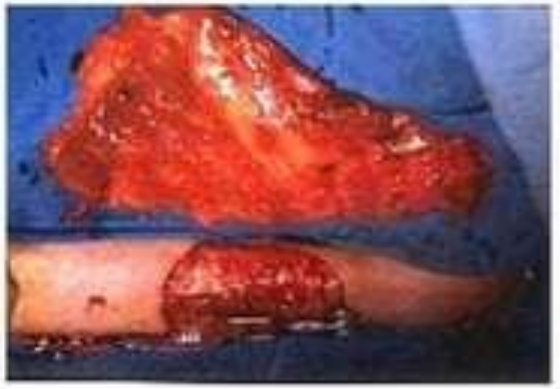
- Increases the blood supply to that area.
- Superior to skin flaps .
- Obliterates dead space in irregularly contoured osseous cavity.
- Resistance to recurrent sepsis.
- Gastocnemius most common -covers proximal 1/3 of tibia , knee, distal 1/5 of femur.
- Not used in –distal 1/3 tibia, midfoot, forefoot.
- Cross leg flaps-prolonged immobilization, exposes normal extremity to infection.

Indications :

- Adjacent soft tissue cannot cover the area.
- Area should anatomically permit transportation of a local muscle flap without compromising its neurovascular bundle.
- Debridement procedure hasn't compromised the mechanical integrity of osseous structures.
- Gross purulence has been eliminated.

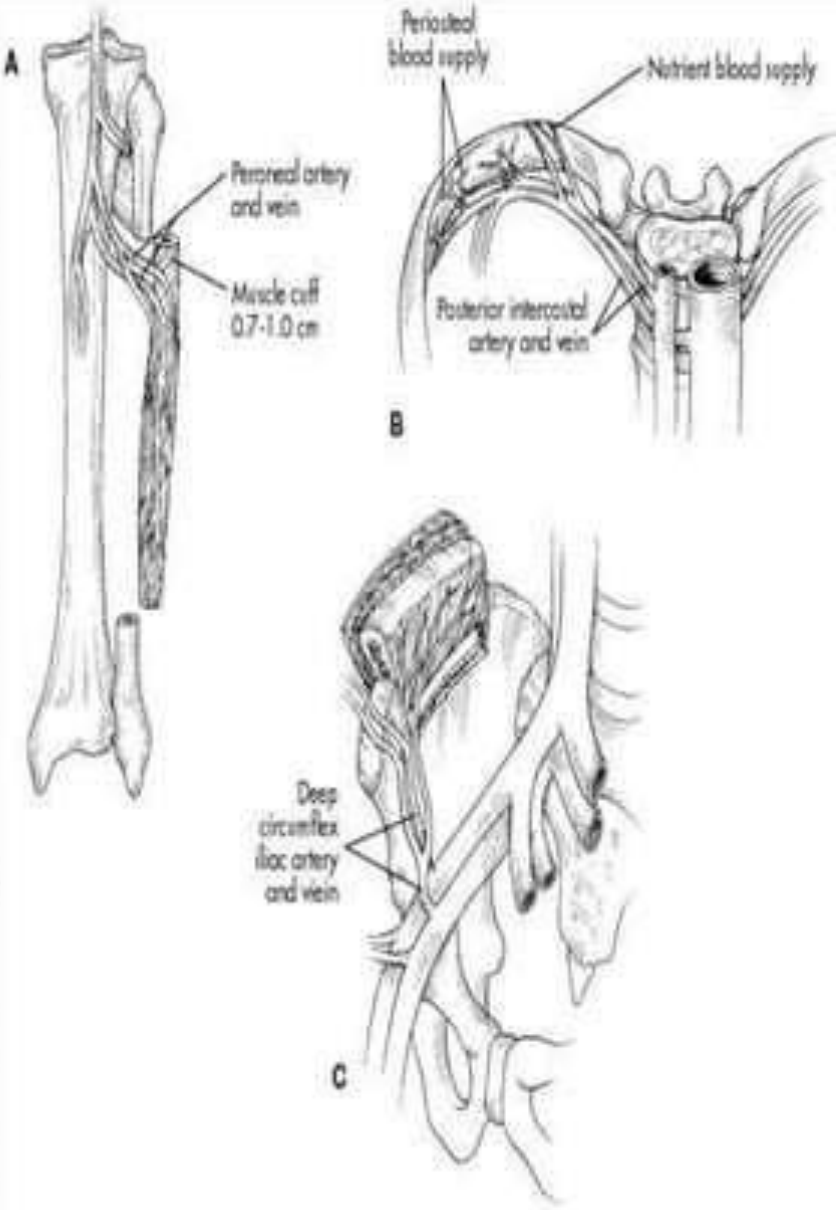
Vascularized muscular & musculocutaneous flaps

- Pedicle flap, free flap
- Assessment:
  - size of wound & muscle
  - size & length of pedicle
  - nearest good recipient vessels
  - recipient vessels- palpation, doppler-arteriogram
  - position of pt. On table.
- L. dorsi (most common), gracilis, TFL, omentum
- Omentum- flexible, covers large irregular defects, long pedicle.
  - Disadv: complications of laprotomy.



Vascularized bone segment transfer

- *Indications :*
  - restoration of bone mass with soft tissue coverage
  - >6 cm. in length
- Fibula, iliac crest, ribs, lat. Scapula, metatarsal,lat. portion of radius.
- Fibula:
  - based on 1 or more nutrient vascular perforators
  - include a flap of muscle [PB,PL,FHL]
  - most useful for defects >10 cm.
  - length-6-35 cm.
- Iliac crest:
  - based on multiple nutrient perforators from deep circumflex iliac vessels
  - useful for shorter defects<8cm.

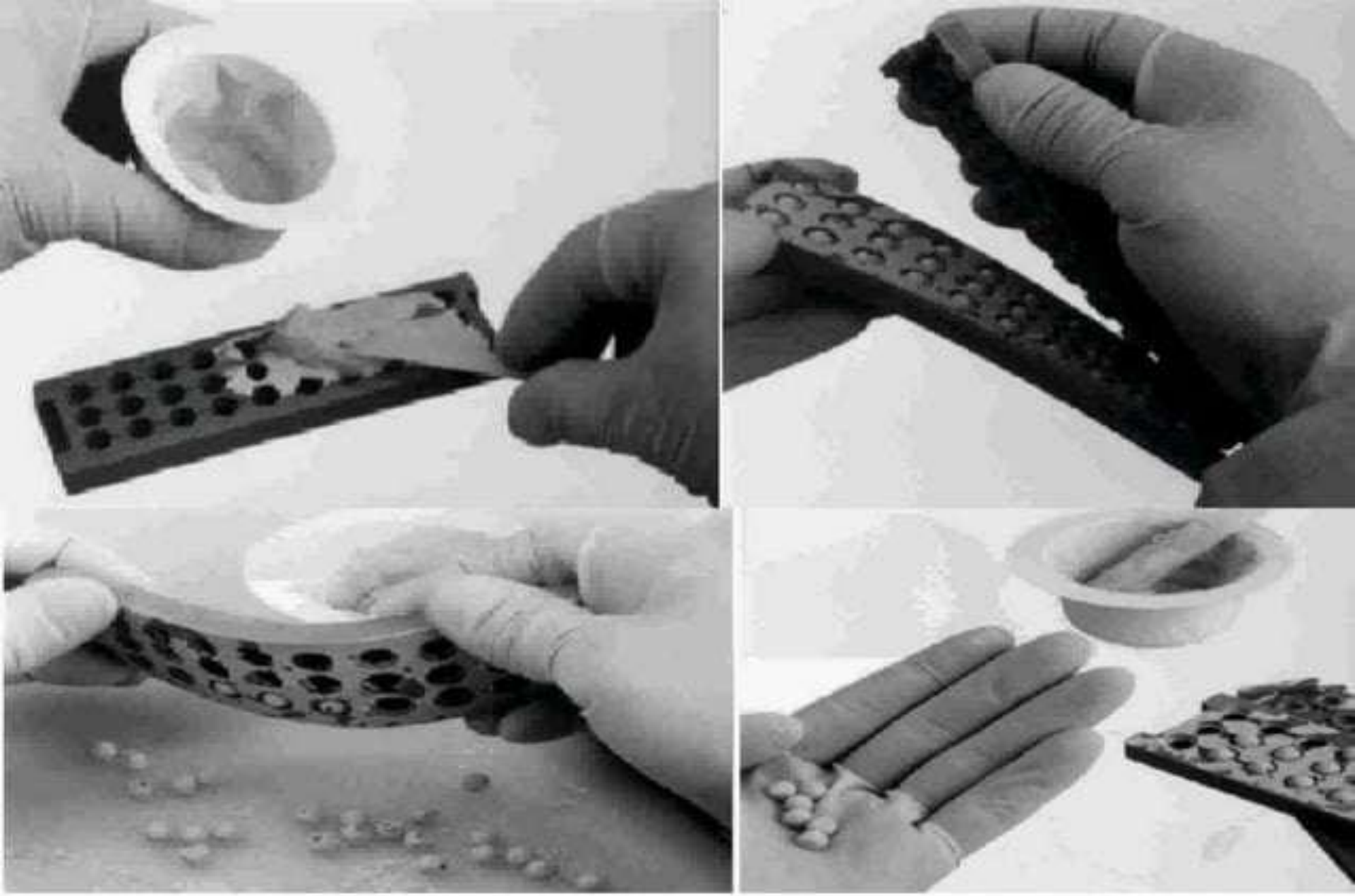


Management of Dead Space:

Antibiotic Beads

- May be used to sterilize and temporarily maintain a dead space.
- Beads are made with PMMA+ab
  - Cement -40 gm.
  - Genta- 1-2 gm. or vanco 1-2 gm.
- Other antibiotics that can be used are Tobramycin, Penicillin, cephalosporins, amikacin, vancomycin.
- The gentamycin concentration remain for 30 days after implantation.
- The shape and type of methylmethacrylate has a significant effect on the amount of antibiotic delivery, as well as duration.
- The best delivery profile was with PMMA beads impregnated with gentamicin.[a]
- Usually removed within two to four weeks and are replaced with a cancellous bone graft.

a. Patzakis MJ, Mazur K, Wilkins J, et al. Septopal beads and autogenous bone grafting for bone defects in patients with chronic osteomyelitis. Clinical Orthopaedics and Related Research 1993, 295: 112–8.



Preparation of antibiotic beads

Antibiotic beads:

- Nelson et al found the delivery of both gentamicin and tobramycin at day one ranged from 88 to 807 μg/ml respectively.
  - There was a significant dropoff in the amounts at day two, and a much more gradual decrease out to 30 days.
  - By day 30, between 1 and 28 μg/ml of antibiotic was delivered respectively.
  - The rate of arrest of osteomyelitis has ranged from 55% in a study of fifty-four patients[a] to 96% in a study of forty-six patients[b].

a. Cho SH, Song HR, Koo KH, Jeong ST, Park YJ. Antibiotic-impregnated cement beads in the treatment of chronic osteomyelitis. *Bull Hosp Jt Dis.* 1997;56:140-4.

b. Modi SP, Eppes SC, Klein JD. Cat-scratch disease presenting as multifocal osteomyelitis with thoracic abscess. *Pediatr Infect Dis J.* 2001;20:1006-7.

Antibiotic beads:

- Can act as a biomaterial surface to which bacteria preferentially adhere.
  - To avoid such a problem, biodegradable antibiotic-impregnated (calcium sulfate) beads have been employed recently and have shown favorable antibiotic release kinetics[c].
    - Elution testing of 4% by weight loaded calcium sulfate pellets revealed a maximum concentration of 828 μg/ml and undetectable levels by day 15.
  - Antibiotic-impregnated cancellous bone grafts were recently used in a clinical trial of forty-six patients, and the osteomyelitis was arrested in 95% of them[d].

c. Steven Gitelis and Gregory T. Brebach: The treatment of chronic osteomyelitis with a biodegradable antibiotic-impregnated implant *Journal of Orthopaedic Surgery 2002, 10(1): 53–60*

d. Chan YS, Ueng SW, Wang CJ, Lee SS, Chen CY, Shin CH. Antibioticimpregnated autogenic cancellous bone grafting is an effective and safe method for the management of small infected tibial defects: a comparison study. *J Trauma.* 2000;48:246-55.

Management of Dead Space:

- Antibiotics (clindamycin and amikacin) have also been delivered directly into dead spaces with an implantable pump.
- Very high local and low systemic levels of antibiotics have been achieved.

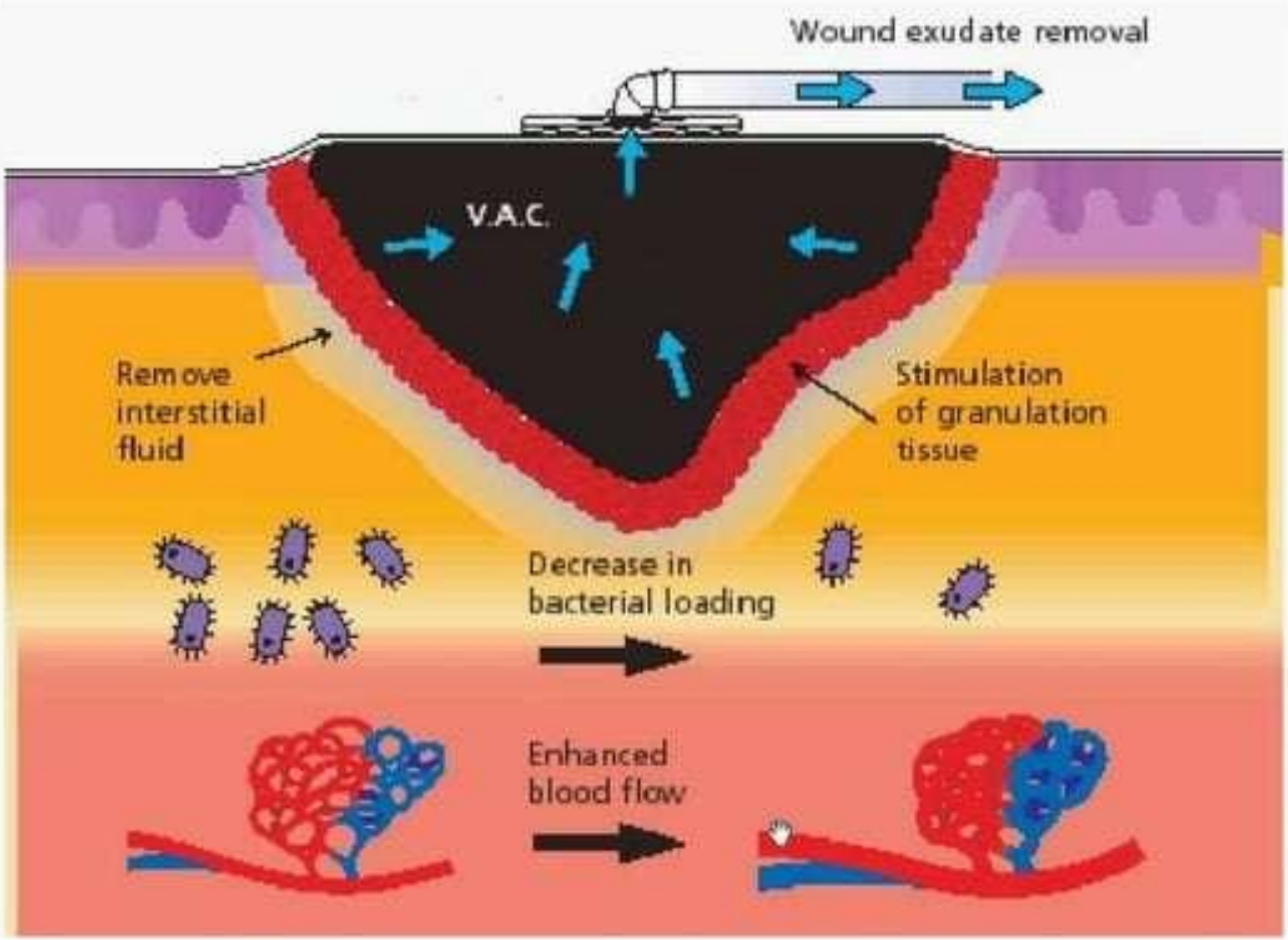
Management of Dead Space:

- Use of ***vacuum-assisted closure system***, a device that applies localized negative pressure over the surface of wounds and aids in the removal of fluids.
  - useful as an adjunct therapy for high-energy soft-tissue injuries.[a,b]

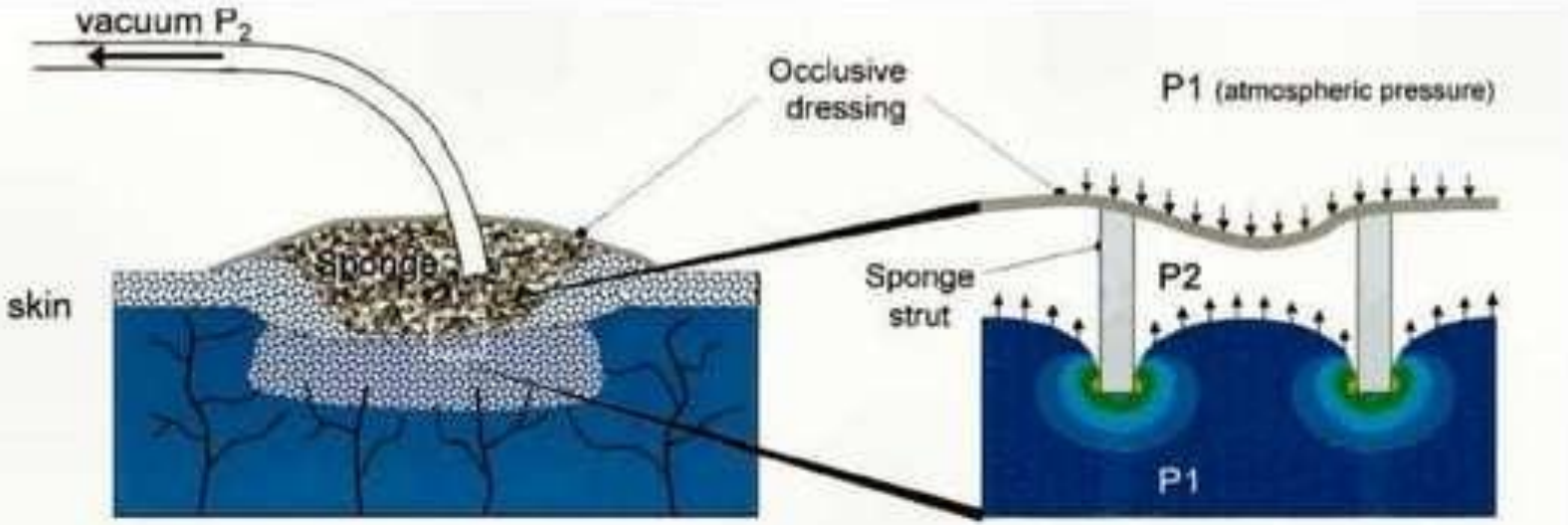
- Tigecycline-impregnated hydroxyapatite can have a potential in the treatment of chronic osteomyelitis of methicillin-resistant S. aureus origin, which may be considered as a therapeutic alternative by surgeons dealing with osteomyelitis.[c]

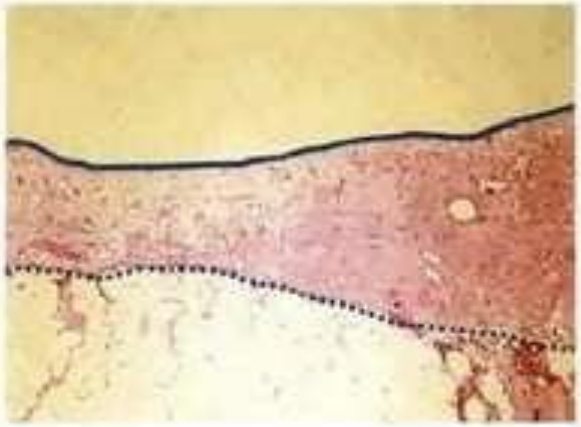
a. Mooney JF, Argenta LC, Marks MW, Morykwas MJ, DeFranzo AJ. Treatment of soft tissue defects in pediatric patients using the V.A.C. system. *Clin Orthop*. 2000;376:26-31.
b. Herscovici D Jr, Sanders RW, Scaduto JM, Infante A, DiPasquale T. Vacuum-assisted wound closure (VAC therapy) for the management of patients with high-energy soft tissue injuries. *J Orthop Trauma*. 2003;17: 683-8.
c. Kaya M, Simsek-Kaya G. Local treatment of chronic osteomyelitis with surgical debridement and tigecycline-impregnated calcium hydroxyapatite: an experimental study. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2012 Mar;113(3):340-7.

Vacuum-assisted closure system:



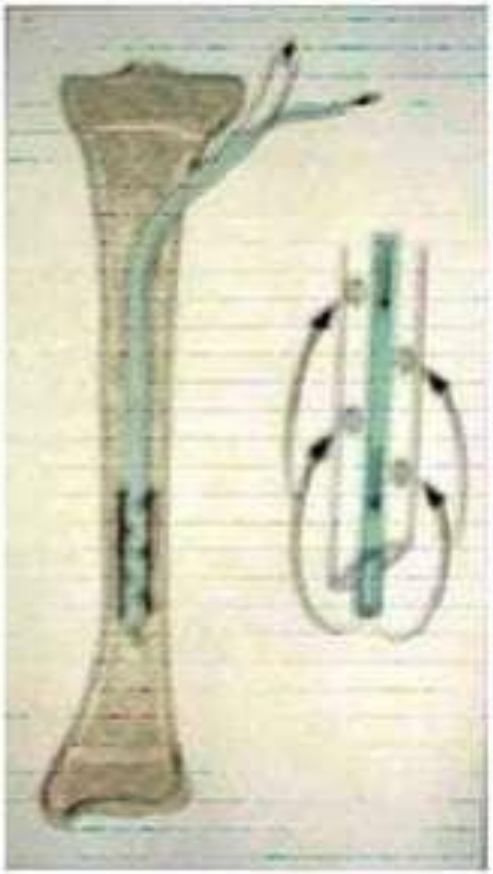
Vacuum-assisted closure system:





Closed suction drains

- DRAIN
  - Suction double lumen catheter
  - Tubes with separate stab wound
  - 4 hrly antibiotics
  - cleaned shortly before next instillation
  - More tidy than continuous suction irrigation which normally fails due to leakage.
  - Continued till effluent is sterile
  - tubes are gradually withdrawn as cavity diminishes.
  - meticulous care & supervision.
- Wound
  - closed/open
    - close if no significant cellulitis, abcess, adequately debrided wound
    - if any doubt – leave open
- Abandoned by many due to secondary contamination and infection.



Soft-Tissue Coverage:

- Three methods commonly used:
  - Primary closure- if no infection
  - Let tissue heal by *secondary intention*
  - Small soft-tissue defects may be covered with a *split-thickness skin graft.*
  - *Local muscle flaps and free vascularized muscle flaps* in the presence of a large soft-tissue defect or an inadequate soft-tissue envelope.

- Healing by so-called secondary intention should be discouraged, since the scar tissue that fills the defect may later become avascular.

Bone Stabilization:

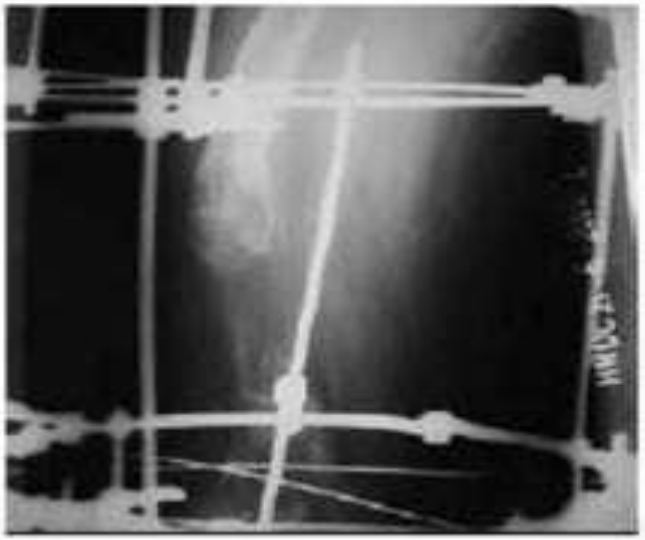
- If skeletal instability is present at the site of an infection, measures must be taken to achieve stability with
  - Plates
  - Screws
  - Rods
  - An external fixator

- *External fixation is preferred* over internal fixation because
  - of the tendency of the sites of *medullary rods to become secondarily infected* and to spread the extent of the infection.

- *Rigid fixation* helpful in union of fracture sites.

Limb reconstruction:

- Ilizarov external fixation
  - Is used for *reconstruction* of segmental defects and difficult infected nonunions.
  - Based on the technique of *distraction osteogenesis* whereby an osteotomy created in the metaphyseal region of the bone is gradually distracted to fill in the defect.
  - Used for difficult cases of osteomyelitis when stabilization and bone-lengthening are necessary.
  - May also be used to compress *nonunions* and to correct *malunions*.



Limb reconstruction:

- Disadvantages:
  - The technique is laborintensive and requires *an extended period* of treatment with the device, averaging 8.5 months.
  - In addition, the sites of the wires or pins usually become *infected* and the device is *painful*.
- In studies in which this technique was used, osteomyelitis arrest rates have ranged between *75%* in a series of twenty-eight patients[a] and *100%* in a series of thirteen patients[b].

a. Cattaneo R, Catagni M, Johnson EE. The treatment of infected nonunions and segmental defects of the tibia by the methods of Ilizarov. *Clin Orthop.* 1992;280:143-52.
b. Morandi M, Zembo MM, Ciotti M. Infected tibial pseudarthrosis. A 2-year follow up on patients treated by the Ilizarov technique. *Orthopedics.* 1989;12:497-508.

AMPUTATION:

- Infrequently performed

- INDICATIONS
  1. Malignancy
  2. Arterial insufficiency
  3. Nerve paralysis
  4. Jt. Contracture & stiffness making limb nonfunctional

Complementary therapies:

- Hyperbaric oxygen:
  - Augment host immune system
  - Allow formation of peroxides
  - Promote wound healing

- Electrical stimulation :For non unions with acceptable alignment
  - Types:
    - direct current
    - Inductive coupling
    - Capacitive coupling

- Ultrasound: low intensity

Complications :

- Acute exacerbations- most common
- Growth abnormalities
- Deformities
- Pathological #
- Jt. Stiffness
- Amylodosis
- Malignancy(0.25%) –sq. cell carcinoma most common, reticulam cell carcinoma,fibrosarcoma
- Septic arthritis- hip, ankle, shoulder ,elbow

CASE REPORT

Histoplasma Osteomyelitis Simulating Giant-Cell Tumor of the Distal Part of the Radius

The Journal of Bone and Joint Surgery (American). 2010;92:708-714.

- Barnea Y etal -the free fibula flap and its role for distal humerus reconstruction [1]
- Koort JK etal[2]
  - based on controlled ciprofloxacin release from poly (D/L-lactide).
  - therapeutic level of ciprofloxacin (>2microg/mL) was maintained between 60 and 300 days.
  - a promising option as resorbable carriers.
- Ross JJ[3]
  - described role of angiogenic gene and agents in treatment of osteomyelitis.
  - Recommended studies of various agents like vascular endothelial growth factor (VEGF) , placental growth factor , sonic hedgehog, bone morphogenetic proteins, matrixmetalloproteinase-9, secretoneurin, and pluripotent stem cells

1. Barnea Y, Amir A, Shlomo D, Cohen N, Zaretski A, Leshem D, Miller E, Meilik B, Kollender Y, Meller I, Bickels J, Gur E. Free fibula flap elbow-joint hemiarthroplasty reconstruction for chronic osteomyelitis of the distal humerus. J Reconstr Microsurg. 2006 Apr;22(3):167-71.
2. Koort JK, Suokas E, Veiranto M, Makinen TJ, Jalava J, Tormala P, Aro HT.In vitro and in vivo testing of bioabsorbable antibiotic containing bone filler for osteomyelitis treatment.J Biomed Mater Res A. 2006 Sep 1;78(3):532-40.
3. Ross JJ. Angiogenic gene therapy as a potential therapeutic agent in chronic osteomyelitis. Med Hypotheses. 2006;67(1):161-3. Epub 2006 Mar 7.

- Archdeacon MT etal described Modern papineau technique with vacuum-assisted closure.[4]
  - Results encouraging.
- Vestn Khir Im I I Grek – use of laser osteoperforation.[5]
- Hong JP etal- use of anterolateral thigh perforator flaps in chronic osteomyelitis of thelower extremity.[6]
- Di Silvio L etal[7]
  - biodegradable drug delivery system
  - the use of a degradable gelatin DDS, for the combined release of therapeutic levels of both gentamicinand growth hormone (GH)
  - a promising DDS for the management of acute and chronic bone and tissue infection

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- Hashmi MA etal[8]
  - The management of chronic osteomyelitis using the Lautenbach method

    - Involves:
      - debridement.
      - intramedullary reaming.
      - the insertion of double-lumen tubes to establish both a local antibiotic delivery system and cavity analysis for volume and culture .

- The end-point of treatment is
  - the irrigate produces three consecutive clear cultures
  - improvement in the blood indices
  - obliteration of the cavity volume.

- Recommended for long-standing complex cases.

8. Hashmi MA, Norman P, Saleh M. The management of chronic osteomyelitis using the Lautenbach method. J Bone Joint Surg Br. 2004 Mar;86(2):269-75.

THANK YOU