BONE AND JOINTS INFECTION

Lecture objectives:

1. What is bone and joint infection.
2. Why we consider bone and joint infection as a red flag.
3. Low does the presentation in children and adults differ.
4. What are the most involved organisms in children and adults.
5. How do we diagnose and confirm diagnosis of bone and joint infection.
6. Principles of management of bone and joint infection.
7. Complications of bone and joint infection.

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References: Dr's slides & 436 team, Toronto notes'2020'

INTRODUCTION

- Initial treatment → based on presumed infection type → clinical findings and symptoms. You give broad spectrum antibiotics until you can identify the organism from the final culture.
- Definitive treatment → based on final culture.
- Glycocalyx, Polysaccharides Biofilm that forms commonly around artificial joints and prevents ABx from reaching, can't be treated without removal of glycocalyx
  - o Exopolysaccharide coating
  - o Envelops bacteria
  - o Enhances bacterial adherence to biologic implants
- Terminology:
  - o Sequestrum (Dead Bone): This happens when blood supply is cut off from area of bone due to infection. click here
  - o Involucrum: New bone formed at site of infection and trapping a cavity of bone.

BONE INFECTION: OSTEOMYELITIS (TORONTO NOTES)

التهاب العظم و النقي

Infection of bone and bone marrow.

- Route of infection:
  - o Direct inoculation → Open fractures
  - o Blood-borne organisms → hematogenous

Determination of the offending organism is not a clinical diagnosis, but depends on deep culture which it is essential. The deep culture is taken from deep bone not soft tissue unless there was pus for example.

★ **Classification**: Each of them presentation is different depend on patient age

#Acute hematogenous OM. (Acute less than 3 weeks)
#Acute OM.
#Subacute (between 3-6 weeks)
#Chronic OM. (Chronic more than 6 weeks)

ACUTE HEMATOGENOUS OSTEOMYELITIS

★ **Clinical Features:**

Caused by blood-borne organisms.

More common in children.

- – Boys > girls
- – Most common in long bone metaphysis or epiphysis
- – Lower extremity >> upper extremity

o Pain, malaise, restlessness.
o Loss of function of the involved extremity. Fixed flexion deformity, contractures and stiffness
o Soft tissue abscess and swelling. Especially if the infection spread to soft tissues

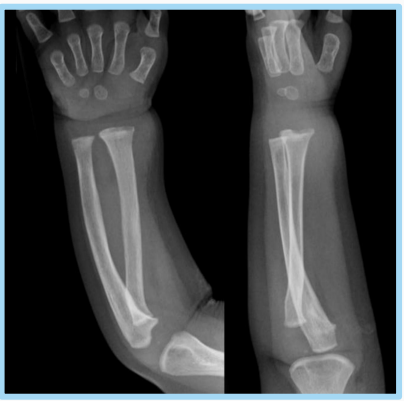
★ Radiographic Changes:

- Early: Soft tissue swelling. No changes visible on x-ray
- (10-14 days): Bone demineralization = decreases bone density.

2 weeks to see bone changes on X-ray

- Later (in chronic stage):

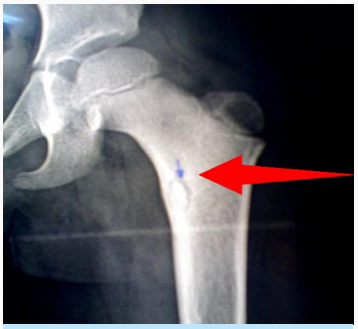
- Sequestrum (indication of OM) dead bone with surrounding granulation tissue.
- Involucrum periosteal new bone formation.



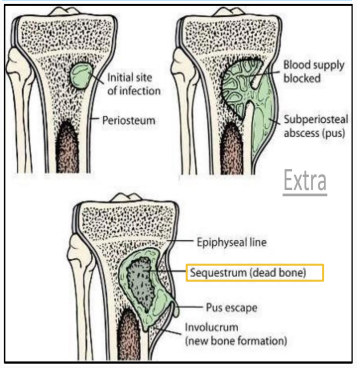
8 month old boy with soft tissue swelling only!

Early X rays may not reveal any findings except soft tissue swelling at site of infection. Bony changes take up to 10-14 days to show up. There is decreased blood supply due to it not being managed for a while which in turn causes osteopenia, (osteopenia may appear earlier not diagnostic).

REMEMBER the patient can present with symptoms without bony changes in the X ray.



SEQUESTRUM

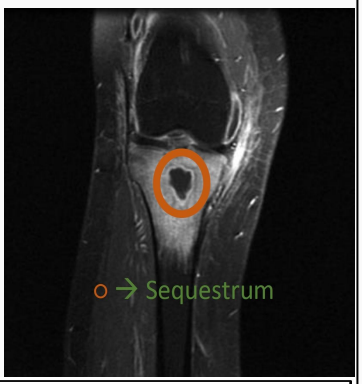


★ Diagnosis:

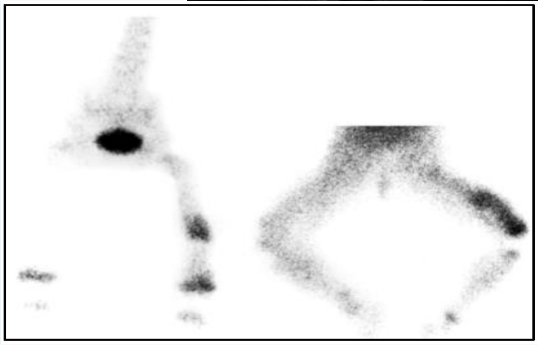
o ↑ WBC count mainly neutrophils
o ↑ ESR not specific (better in TJA infection)
o Blood cultures may be positive in children, must be done especially if patient is febrile
o C-reactive protein monitor response to treatment
- Most sensitive monitor of infection course in children. respond very fast
- Short half-life.
- Dissipates "start to reduce" in about 1 week after effective treatment.

o MRI imaging: MRI bone changes appear before x-ray "best tool for radiological diagnosis as it is sensitive and specific, but difficult in young children as they require general anesthesia"
- Shows changes in bone and bone marrow before plain films.
- Decreased T1-weighted* bone marrow signal intensity.
- Increased post-gadolinium (contrast) fat-suppressed T1-weighted signal intensity.
- Increased T2-weighted signal relative to normal fat.
- Picture: "there's no activity in this area = dead, it doesn't have any blood supply. It could be a sequestrum or Brodie's abscess"

o Nuclear medicine studies → may help when not sure of the course or source of infection.



o Bone scan > gallium scan (most imp for infections)
o WBC labeled bone scan.
o Increase uptake in femur bone, due to increase activity, so it's possibly infection, tumor or fracture we don't know
o Useful in delayed cases, when we want to check if there is more than one focus of infection "if we treated one place but the child is not improving".



o Plain X-Ray
o Ultrasound
o Isotope bone scan: Nuclear medicine isotope bone scan: Tcm99 bone scan (Technetium 99) or Gallium bone scan are diagnostic, as increased local tracer uptake; but take time to appear.
*MRI sequence.

- Confirm Diagnosis:
  1. Ultrasound guided aspiration from site of swelling or abscess.
  2. X-ray guided aspiration of suspected bone involvement (according to MRI).
  3. Open incision –drainage procedure (drilling of bone) when there is high suspicion. Aspirated or obtained materials at open incision are sent urgently for Direct Smear and C&S including anaerobic, TB and Fungal. Early results of smear don't give the exact bacteria, but it will show infection.
  4. Histopathology examinations are recommended as well. Definite Diagnosis By histopathology depends on seeing organisms at direct smear, or culturing organisms. It's important but usually result is late

★ Treatment Outline:

o Identify the organisms. (take culture)
o Select appropriate antibiotics.
o Deliver antibiotics to the infected site.
o Halt tissue destruction.

Empirical Treatment is initiated before definitive cultures become available, based on patient's age and other circumstances. (Before reach exact organism which cause the patient conduction by culture)

Empirical Treatment:

Newborn (up to 4 months of age)	Children 4 years of age or older	Adults 21 years of age or older
The most common organisms: 1. Staphylococcus aureus. Most imp, most common organism in bone infection. 2. Gram-negative bacilli. 3. Group B streptococcus. after URI Newborns: crying, pain, swelling, stiffness (loss of function) - May be afebrile. weak immunity هذه المشكلة إنهم بدون حرارة - 70% positive blood cultures. #Primary empirical therapy includes: Oxacillin (penicillin) specific for staph. for group (+) + 3rdgeneration cephalosporin for other groups. for group (-)	The most common organisms: 1. Staphylococcus aureus. 2. Group A streptococcus. 3. Coliforms (uncommon). #Empirical therapy includes: Oxacillin or cefazolin 1nd gen cephalosporins If suspecting gram-negative organisms → 3rd-generation cephalosporin. Haemophilus influenzae bone infections almost completely eliminated due to vaccination.	Organisms: Most common organism S. aureus Wide variety of other organisms has been isolated. #Initial empirical therapy: Oxacillin or cefazolin. Oxacillin is key because it is the most important in all age groups

Empirical Treatment 'Special cases':

فقر الدم المنجليSickle cell anemia	Hemodialysis and IV drug abuser
Salmonella is a characteristic organism. #The primary treatment is **fluoroquinolones** (only in adults). Can't be given to children. Alternative treatment is 3rd-generation cephalosporin	Common organisms: **1. Staphylococcus aureus** 2. S. epidermidis 3. Pseudomonas aeruginosa #Treatment of choice is penicillinase-resistant synthetic penicillins (PRSPs) + ciprofloxacin. Alternative treatment: Vancomycin **with** ciprofloxacin (for Pseudomonas)

★ Operative Treatment:

- o Started after cultures. Starting treatment beforehand masks the results
- o **Indications for operative intervention:**
- Drainage of an abscess, if we're sure there's pus (as a result of our investigations).
- Debridement of infected soft tissues to prevent further destruction. dead tissue can't respond to Abx so its removed.
- Refractory cases that show no improvement after nonoperative treatment. (we use nuclear scan for this case)

In case of presence of sequestrum it must be removed (Sequestrectomy)

ACUTE OSTEOMYELITIS

★ Common in:

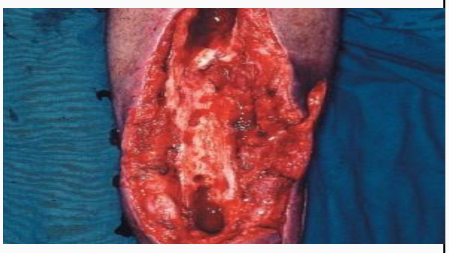
Usually comes after open fracture or closed fracture with open reduction and internal fixation (iatrogenic) Ex: Somebody have surgery then AOM.

Clinical findings similar to acute hematogenous OM "pain, swelling, loss of function and fever".

★ Most common organisms:

- o S. aureus
- o P. aeruginosa
- o Coliforms

Empirical therapy before doing culture Oxacillin + ciprofloxacin



★ Treatment:

- o Radial Incision & Drainage. "Radical means you take everything out, bone,soft tissue and even the skin "
- o Removal of orthopedic hardware "device,Screws or plates" if necessary. External fixator, screws. These FB have no communication with blood so they must be removed as they act as a good media for colonization
- o Rotational or free flaps (tissue transplant→ muscles + soft tissue + skin) for open wounds if needed.

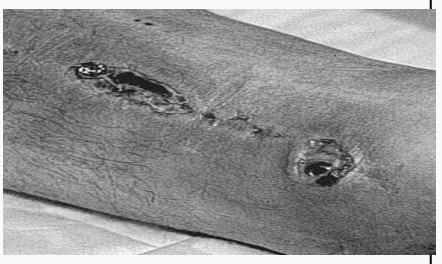
★ Complications:

1- Septicemia and distant abscesses. 2- Septic arthritis. 3- Chronic osteomyelitis.
4- Growth disturbance in skeletally immature and deformity. 5- Pathological fracture

CHRONIC OSTEOMYELITIS

★ **Common in:**

o Inappropriately treated acute OM. presences of sequestrum (requires urgent intervention) "source of bacteria" antibiotics cannot reach it.
o Trauma.
o Immunosuppressed. They will present with sinus discharging pus **without fever**
o Diabetics.
o IV drug abusers.

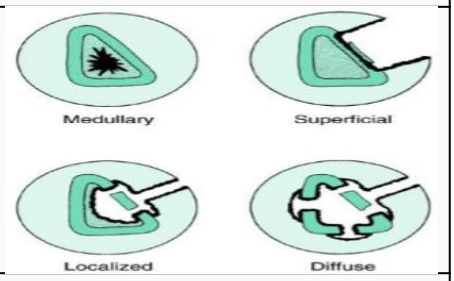


★ **Most common organisms:**

o S. aureus
o Enterobacteriaceae (mainly with IV drug abuse)
o P. aeruginosa

★ **Anatomical classification:**

4 types:
o Medullary.
o Superficial. Only surface (part of cortex and soft tissue around it)
o Localized. Sinus formation with pus "draining" between outside and medulla
o Diffuse. Whole medullary canal, the sinus has destroyed the whole bone



★ **Features:**

o Skin and soft tissues involvement.
o Sinus tract may occasionally develop squamous cell carcinoma.
o Periods of quiescence followed by → acute exacerbations.

★ **Diagnosis:**

o Nuclear medicine → activity of the disease. E.g. Bone scan, gallium scan to tell if the lesion is old, remission, reactive and show us if infection is expanded and destruction more tissue.
anything that wasn't useful in acute is useful here: plain x rays, CT scans
o **Best test** to identify the organisms → Operative sampling of deep specimens from multiple foci.

★ **Treatment:**

Empirical therapy not indicated because bone is dead. The main difference between acute and chronic is that in chronic there is no rush to start therapy because the damage has already occurred. Do culture and sampling > once you get the results you can do debridement > start treatment

Glycocalyx (the sneaky bacteria when there's a cell coming to attack them or when they sense an Abx, they form a circular shield around them. Most commonly under the plate and screws, so if it happened, we have to remove them).
This happens after surgery and after total knee replacement. exopolysaccharide coating that envelops bacteria and enhances bacterial adherence to biologic implants. What to do? Hardware has to be removed, but stability should be maintained (consider Ex-Fix)

o IV antibiotics must be **based on** deep cultures. NOT THE SUPERFICIAL CULTURE

Surgical debridement إنضار:

o Complete removal of compromised bone and soft tissue. Due to the excessive destruction of bone, soft tissue and vessels we remove all infected/unhealthy tissue to avoid much worse consequences like amputation (best to remove everything all at once than to remove small pieces one at a time, it may cause a huge scar but the results are better)

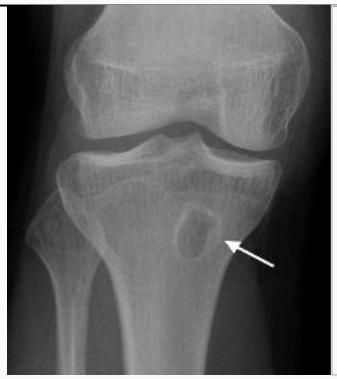
o Hardware:
Most important factor
- Almost impossible to eliminate infection without removing implant.
- Organisms grow in a glycocalyx (biofilm) around the foreign body "device" shields them from antibodies and antibiotics. We have to take out the glycocalyx

o Bone grafting and soft tissue coverage is often required. You use a flap (containing muscle, soft tissue and skin) rather than skin alone
o Amputations are still required in certain cases. Diabetes mellitus, if huge area of bone and soft tissue is destructed

SUBACUTE OSTEOMYELITIS

★ **May occure in:**
o Partially treated acute osteomyelitis.
o Occasionally in fracture hematoma.

★ **Diagnosis:**
o Painful limp. not sever like acute
o No systemic and often no local signs or symptoms.
o Signs and symptoms on plain radiograph.



Cyst surrounded by sclerotic area, hypodense in the middle. Abscess very well circumscribed. An area of osteopenia surrounded by a thick cortex which is very well localized and won't spread

Frequently normal WBC count and negative blood cultures.
● **Usually useful tests:** any infection you need to rule out tumor
o ESR not very specific could be elevated due to sore throat
o Bone cultures only a small percentage have a +ve result
o Radiographs:
Brodie's abscess → localized radiolucency seen in long bone metaphysis difficult to differentiate from **Ewing's sarcoma** (which is a differential diagnosis) You should do more investigations to differentiate between the tumor and abscess, bone scan will show a high uptake for both. You could open the area and send for culture and histopath to differentiate between infection and tumour

★ **Treatment:**
o Most commonly involves femur and tibia. lower limb, Hip and knee pain.
o It can cross the physis = growth plate even in older children.
o Metaphyseal Brodie's abscess → surgical curettage. (The only treatment for brodie's abscess)

SEPTIC ARTHRITIS (OSMOSIS) (TORONTO NOTES)

التهاب المفاصل الإنتاني

★ **Route of infection:**
o Hematogenous spread.
o Extension of metaphyseal/diaphyseal osteomyelitis in children.
o Complication of a diagnostic or therapeutic joint procedure " like aspiration, steroid injection"..
Most commonly in infants (hip) and children. "In infants & children → hip joint , in adults → knee joint"
Metaphyseal osteomyelitis can lead to septic arthritis in:
o Proximal femur → **most common** in this category. It may go up to the hip and cause septic arthritis
o Proximal humerus.
o Radial neck.
o Distal fibula.

- **Adults at risk for septic arthritis are those with:**

o Rheumatoid arthritis التهاب المفاصل الروماتويدي:
  - Tuberculosis → most characteristic because of immunosuppression
  - S. aureus most common

o IV drug abuse → Pseudomonas most characteristic.

Clinical presentation and Investigations almost like Acute Osteomyelitis.

★ **Empirical therapy** is prior to the availability of definitive cultures based on the patient's age and/or special circumstance.

Empirical therapy

Newborn (up to 3 months of age)	**Children** (3 months to 14 years of age)
Most common organisms almost same as acute OM newborn: 1. *S. aureus* 2. Group Bstreptococcus Less common organisms: 3. Enterobacteriaceae 4. *Neisseria gonorrhoeae* o 70% with adjacent bony involvement. o Blood cultures are commonly positive. #Initial **treatment:** PRSP + 3rd-generation cephalosporin.	Most common organisms: 1. *S. aureus* 2. *Streptococcus pyogenes* 3. *S. pneumoniae* 4. *H. influenzae* markedly decreased with vaccination 5. gram-negative bacilli #Initial **treatment:** PRSP + 3rd-generation cephalosporin. Alternative treatment vancomycin + 3rd-generation cephalosporin.

Acute monoarticular (One joint is involved) septic arthritis in **Adults**

The most common organisms:
1. *S. aureus*
2. Streptococci
3. Gram-negative bacilli

#Antibiotic treatment is PRSP + 3rd-generation cephalosporin
Alternative treatment PRSP **plus** ciprofloxacin

Polyarticular septic arthritis	Chronic monoarticular septic arthritis (Cartilage damage.)
Most common organisms: 1. Gonococci, 2. B. burgdorferi, 3. Acute rheumatic fever 4. Viruses.	Most common organisms: 1. Brucella most common 2. Nocardia 3. Mycobacteria 4. Fungi

★ **Surgical treatment:**

o Mainstay of treatment:

- Surgical drainage → open or arthroscopicتنظير المفصل. Clean and wash with a scope but if it's difficult you can open
- Daily aspiration.

o Tuberculosis infections lead to pannus (soft tissue granuloma) [Inflammation and proliferation of the synovium leads to formation of pannus.] similar to that of inflammatory arthritis (Rheumatoid Arthritis). Pannus "hypertrophied synoviunm" has to be removed.

o Late sequelae of septic arthritis → soft tissue contractures → may require soft tissue procedures (such as a quadricepsplasty[corrective surgical procedure on the quadriceps femoris muscle and tendon to release adhesions and improve mobility]). The quads become short and you can't extend the knees anymore so we have to do surgery to make it more elongate

INFECTED TOTAL JOINT ARTHROPLASTYترميم المفصل "TIJ"

It is very difficult problem

If joint got infected, we have to take deep aspiration of knee, remove prosthesis, treat, put new prosthesis.

★ **Most common pathogen:**

- S. epidermidis → Most common with any foreign body
- S. aureus
- Group B streptococcus

★ **Prevention:**

o Perioperative intravenous antibiotics most effective method for decreasing its incidence.

o Good operative technique. You must be very gentle with soft tissue

o Laminar flow avoiding obstruction between the air source and the operative wound.
(Video Explains Laminar Flow) air suction mechanism

o Special "space suits". Everything is sterile even the face area

o Most patients with TJA do not need prophylactic antibiotics for dental procedures. Unless they have an infection/abscess then Abx are given

o Before TKA revision knee aspiration is important to rule out infection. The culture may be -ve but it doesn't rule out an infection

Laminar flow

★ **Diagnosis:**

o ESR → most sensitive but not specific.

o Culture of the hip aspirate → sensitive and specific.

o C-RP may be helpful.

o Preoperative skin ulcerations → ↑**risk**. If the patient shaves before the operation he will cause small skin openings and ulcerations that will be a good medium for infections, all shaving must be done in the OR to avoid scratches of the skin

o Most accurate test → **tissue culture.**

★ Treatment:

o **Acute** infections **within 2-3 weeks** of arthroplasty: prosthesis has metal part and plastic part
- Prosthesis salvage stable prosthesis
- Exchange polyethylene (plastic part) components you open the joint and keep the prosthesis and cover the surface of the tibia and femur with polyethylene (don't remove the prosthesis)
- Synovectomy beneficial if synovium is infected

o **Chronic** TJA infections **>3** weeks of arthroplasty ترميم النفصل:
- Implant and cement removal
- Staged exchange arthroplasty stage 1: after removal of prosthesis, put spacer (cement and anti-biotic) and keep it there for 6 weeks, then do new culture, stage 2: put the new prosthesis.

Glycocalyx:
- Formed by polymicrobial organisms
- Difficult infection control without removing prosthesis and vigorous debridement
- Helpful steps:
  - Use of antibiotic-impregnated cement. Abx used are usually vancomycin tobramycin and gentamycin
  - Antibiotic spacers/beads. مثل السبحة وعليها مضاد
  - You could do both Abx-impregnated cement and antibiotic spacers/beads

Osteomyelitis SLIDE 2

- bone infection with progressive inflammatory destruction

Etiology
- most commonly caused by *S. aureus*
- mechanism of spread: hematogenous (most common) vs. direct-inoculation vs. contiguous focus
- risk factors: recent trauma/surgery, immunocompromised patients, DM, IV drug use, poor vascular supply, peripheral neuropathy

Plain Film Findings of Osteomyelitis
- Soft tissue swelling
- Lytic bone destruction*
- Periosteal reaction (formation of new bone, especially in response to #)*

*Generally not seen on plain films until 10-12 d after onset of infection

Clinical Features
- symptoms: pain and fever
- on exam: erythema, tenderness, edema common ± abscess/draining sinus tract; impaired function/WB

Rapid progression of signs and symptoms (over hours) necessitates need for serial examinations

Diagnosis
see Medical Imaging, MI23
- workup includes: WBC and differential, ESR, CRP, blood culture, aspirate culture/bone biopsy

Table 7. Treatment of Osteomyelitis

Acute Osteomyelitis	Chronic Osteomyelitis
IV antibiotics 4-6 wk; started empirically and adjusted after obtaining blood and aspirate cultures	Surgical debridement
± surgery (I&D) for abscess or significant involvement	Antibiotics: both local (e.g. antibiotic beads) and systemic (IV)
± hardware removal (if present)	

Acute osteomyelitis is a medical emergency which requires an early diagnosis and appropriate antimicrobial and surgical treatment

Osteomyelitis
- MRI is the imaging modality of choice for demonstrating bone, bone marrow, and soft tissue abnormalities
- ^{99m}Tc, followed by ^{111}In-labeled white cell scan or gallium radioisotope scan
- plain film changes visible 8-10 d after process has begun
  - soft tissue swelling
  - local periosteal reaction
  - pockets of air (from anaerobes) may be seen in the tissues, may also suggest necrotizing fasciitis
  - mottled and nonhomogeneous with a classic "moth-eaten" appearance
  - endosteal scalloping
  - cortical destruction
  - peripheral sclerosis (late sign)

Septic Joint SLIDE7

- joint infection with progressive destruction if left untreated

Etiology
- most commonly caused by *S. aureus* in adults
- consider coagulase-negative Staphylococcus in patients with prior joint replacement
- consider *N. gonorrhoeae* in sexually active adults and newborns
- most common route of infection is hematogenous
- risk factors: young/elderly (age >80 yr), prosthetic joint, recent joint surgery, skin infection/ulcer, IV drug use, recent intra-articular corticosteroid injection, immunocompromised (cancer, DM, alcoholism, RA)

Most commonly affected joints in descending order
knee → hip → elbow → ankle → sternoclavicular joint

Clinical Features
- inability/refusal to bear weight, localized joint pain, erythema, warmth, swelling, pain on active and passive ROM, ± fever

Plain Film Findings in a Septic Joint
- Early (0-3 d): usually normal; may show soft-tissue swelling or joint space widening from localized edema
- Late (4-6 d): joint space narrowing and destruction of cartilage

Investigations
- X-ray (to rule out fracture, tumour, metabolic bone disease), ESR, CRP, WBC, blood cultures
- joint aspirate: cloudy yellow fluid, WBC >50,000 with >90% neutrophils, protein level >4.4 mg/dL, joint glucose level <60% blood glucose level, no crystals, positive Gram stain results
- listen for heart murmur (re: concern for infective endocarditis, use Duke Criteria)

Serial C-reactive protein (CRP) can be used to monitor response to therapy

Treatment
- IV antibiotics, empiric therapy (based on age and risk factors), adjust following joint aspirate C&S results
- non-operative
  - therapeutic joint aspiration, serially if necessary

Does This Adult Patient Have Septic Arthritis?
JAMA 2007;297(13):1478-88
Purpose: To review the accuracy and precision of the clinical evaluation for the diagnosis of nongonococcal bacterial arthritis.
Methods: Review of 14 studies including 6242 patients of which 653 had positive synovial culture (gold standard diagnostic tool for septic arthritis).
Results/Conclusions: Age, diabetes mellitus, rheumatoid arthritis, joint surgery, hip or knee prosthesis, skin infection, and human immunodeficiency virus type 1 infection significantly increase the probability of septic arthritis. Joint pain, history of joint swelling, and fever are useful clinical findings in identifying patients with a monoarticular arthritis who may have septic arthritis. Laboratory findings from an arthrocentesis are also required and helpful prior to Gram stain and culture. The presence of increased WBC increases the likelihood ratio (for counts <25 000/μL: LR, 0.32; 95% CI, 0.23-0.43; for counts ≥25 000/μL: LR, 2.9; 95% CI, 2.5-3.4; for counts ≥100 000/μL: LR, 28.0; 95% CI, 12.0-66.0). A polymorphonuclear cell count of ≥90% increases the LR of septic arthritis by 3.4, while a PMN cell count of <90% reduces the LR by 0.34.

QUESTIONS

1) Which of the following is used to monitor the efficacy of the treatment in a patient with osteomyelitis?

A. WBCs count
B. ESR
C. CRP
D. US

2) What is the empirical treatment for acute hematogenous osteomyelitis in a newborn patient?

A. Oxacillin + 3rd generation cephalosporin
B. Fluoroquinolones
C. empirical therapy not indicated
D. Oxacillin or cefazolin

3) Which one of the following complications requires urgent intervention in chronic osteomyelitis patient?

A) Large sequestrum
B) Severe Osteoporosis
C) Epiphysis involvement
D) Pathological fracture

4) Diabetic patient came with gangrene in the 5th toe and controlled by oral antibiotics, which one of the following is important to manage him?

A) IV antibiotic
B) Repeated dressing
C) Local antibiotics
D) Back slap

ANSWERS: 1- C 2- A 3- A 4-A