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MSS

Musculoskeletal System

Microbiology

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Osteomyelitis (OM)

• Osteomyelitis is an **infection of bone** that leads to tissue destruction, loss of function, debility and formation of sequestra (dead necrotic bone).

• It's usually caused by a **wide variety of bacteria (including mycobacteria).** However, it can also be caused by fungi and may be associated with viral infections.

- What does it mean for viruses to be associated with OM? It means that viruses do NOT cause osteomyelitis because viruses do NOT cause direct invasion of bone, but the surrounding inflammation caused by viruses can spread to bone.

• Management is tailored for each individual.

• Tailored management depends on many factors that include:

1) Causative organism
2) Which bone is involved (Different bones have different location, shape, and structure, so they will also have different infections)
3) State of the vascular supply (if it's intact or not)
4) State of nerve function
5) Presence of foreign bodies
6) Recent injury
7) The status of the host and if the patient has any associated comorbidities

- All of these factors contribute into a wide spectrum of illnesses that fall under the umbrella of osteomyelitis.

• The spectrum of osteomyelitis can range from **extensive** (such as tibial or vertebral osteomyelitis) to **localized** (such as bone invasion following a tooth abscess) (localized spectrum could be self-limiting).

• Due to the many factors mentioned above, the syndrome is **identified as a spectrum**. The two major classification systems used (mainly to making therapeutic decisions) are:

1) Lee and Waldvogel system: uses three main criteria:
    a) Acute or chronic
    b) Route of infection: Hematogenous or contiguous (=local)
    c) With or without vascular compromise

2) The Cierny and Mader system: used for **long bone** osteomyelitis and it takes into account the location and extent of infection (+other factors).

MICROORGANISMS THAT CAUSE OSTEOMYELITIS

ORGANISM	COMMENT
Frequently Encountered Bacteria	
Staphylococcus aureus	Most likely bacterial pathogen Aggressive, invasive Often metastatic foci with bacteremia Consider surgery early
Staphylococci other than *S. aureus* (coagulase-negative)	Usually associated with foreign material or implants Biofilm production
Streptococci	May spread rapidly through soft tissues
Enterobacteriaceae (*Escherichia coli*, *Klebsiella*, others)	Considerable variation in antibiotic susceptibility Increasing antibiotic resistance with overuse May become resistant to antibiotics during therapy
Pseudomonas aeruginosa	Increasingly resistant to antibiotics Frequent successor to other bacteria when initial therapy fails May be related to contamination

Unusual Organisms	
Anaerobic bacteria	Usually mixed with aerobic bacteria May be synergistic Survival dependent on devitalized tissue
Bartonella henselae	Associated with cat scratches and probably with fleas
Brucella species	Prominent in developing countries, especially with unpasteurized milk
Fungi	*Candida* the most likely genus Considerable variation in susceptibility, depending on species Surgery may be helpful if infection is invasive.
Mycobacterium tuberculosis	May involve any bone Vertebral osteomyelitis common in some countries
Mycobacteria other than *M. tuberculosis*	Need special culture media to recover
Viruses	Associated with some viral infections, including varicella and Variola

These tables are very important, read through them carefully. Some extra notes not mentioned in the tables are:

1- Recall: Bacteria are the microorganisms mostly implicated with osteomyelitis, followed by fungi, and the least are viruses.

2- S. aureus:

- Why is it the MOST likely bacterial pathogen? It is because it has invasive enzymes that can destroy the local tissue, including collagen and other structural proteins.

S. aureus is the **most successful** in causing osteomyelitis

- It is also the most invasive and aggressive. This could be good for the patient because this aggressiveness means that the patient will develop symptoms faster which will lead him/her to seek medical attention.
- It can leave metastatic foci in the areas it infects which helps in wider spreading.
- Surgery should be considered early to prevent further spread and destruction of tissue.

3- Coagulase-negative Staphylococci (CoNS): It is characterized with biofilm formation and can be found on foreign bodies. So, the prosthetic devices in bones are highly prone to get infected with CoNS (one of the complications of

surgery). Once biofilm forms, the infection is resistant to treatment and the prosthetic device must be removed.

4- **S. aureus and CoNS** are responsible for **more than 50% of OM cases**. The rest of the microorganism are responsible for < 50% of cases.

5- Streptococci:

- It spreads rapidly through soft tissue →so it's more likely to spread from soft tissue into bone (contiguous).
- It is highly found in the mouth (normal flora) and is very close to the bone (<5 mm) → so any dental surgery will increase the risk of infection and the development of bone abscess and osteomyelitis.

6- Enterobacteriaceae: Keep in mind that bones already have low perfusion and with the development of OM, this perfusion will stop. We give antibiotics for at least a month to treat OM, and only low, suboptimal doses are reaching the area. So, if Enterobacteriaceae are found in the infected area → they will develop **de novo resistance** (resistance that develops **during therapy** and didn't exist before).

7- P. aeruginosa (gram -ve): = **biofilm formation + resistance** (so it's very difficult to treat)

8- Anaerobic bacteria: They are associated with necrosis (devitalized tissue). They may be synergistic with aerobic bacteria and facultative anaerobes (which help remove the O_2 forming an optimal environment for these anaerobes)

9- Fungi: Candida behaves like bacteria (it replicates fast) and has the additional benefit of being a eukaryote (it sticks on tissue and has more defenses against our immune system).
-Note: immunocompromised patients are more likely to get infected with candida

10- M. tuberculosis: It mainly involves vertebral bones. Vertebral OM is more common in poor countries.

11- Viruses are associated, NOT committed, with OM.

Pathogenesis:

• It is usually due to three main routes:

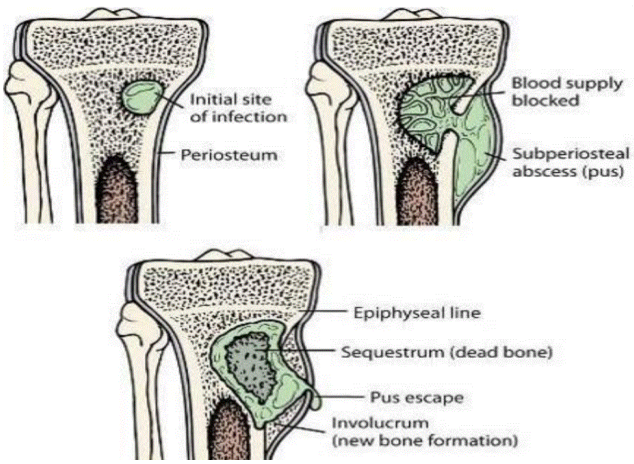
a) **Hematogenous** seeding (while in the blood, the bacteria will infect any bone with problems).
b) **Contiguous** spread from adjacent infected tissues (it spreads gradually from top to bottom (the infection from the skin will eventually reach the bone). For example, an infection may become cellulitis, then fasciitis, then it enters the

muscle and finally reaches the bone. An example we took is diabetic foot, which can cause contiguous spread to the bone).

c) **Traumatic** or surgical inoculation of microorganisms.

• Collection of **inflammatory exudates** in the bone marrow leads to **increased medullary (bone medulla) pressure** →extension of the exudate to bone cortex → **rupture** through the periosteum.

• If this periosteal exudate ruptures, the blood and nerve supply (found in periosteum) are **interrupted** → Blockage of the blood supply leads to **necrosis** and separation of dead bone (sequestrum).



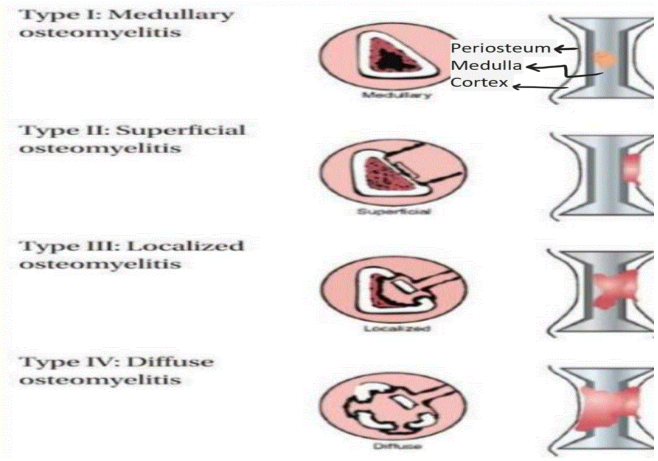
• The **site of periosteal damage** then becomes site for **new bone formation (involucrum)** (as you keep on standing, your bone tries to adapt by building new bone, but it can NOT form bone in the area of the sequestrum so it builds the bone around it forming an **involucrum**)

• The symptoms are not continuous; the patient might feel pain sometimes, and then feel nothing. It's more conspicuous in the beginning but then becomes more pronounced (like fasciitis).

Classification:

• The Cierny–Mader system is a **functional classification**, based on the affected portion of bone and physiological status of the host, and is useful in guiding therapy. It's only for long bones. There are four anatomical types:

a) stage 1 = medullary osteomyelitis (still in the medulla)
b) stage 2 = superficial osteomyelitis (only superficial or in cortex)
c) stage 3 = localized osteomyelitis (between stages 1 and 2)
d) stage 4 = diffuse osteomyelitis (diffused everywhere).



• There are three physiological classes:

A = normal host

B = host with local (BL) or systemic (Bs) compromise

C = treatment worse than disease.

Etiology:

• Hematogenous osteomyelitis →usually **monomicrobial** (Why? blood is sterile and has many defenses so the breach will most likely be by just one microbe. It is very difficult for the bacteria to be able to enter the blood, survive, and then seed into the tissue).

• Contiguous osteomyelitis →**monomicrobial or polymicrobial** (Since the microorganisms are coming from an adjacent infected tissue, it provides an easy pathway for many microbes to pass, especially when it's from the skin.)

• In patients with sinuses (occurs when the pressure breaks through to the skin), the superficial flora may not represent the true pathogen.

•The most common bacterial (>50%) cause of osteomyelitis are Staphylococcus aureus and CoNS.

• **Gram-ve** organisms such as Pseudomonas aeruginosa, Escherichia coli, enterococci, and Propionibacterium may also be found.

• **Mycobacterium tuberculosis is a common cause in countries with limited medical resources** (other mycobacterial species that infect bone include M. marinum, M. chelonei , and M. fortuitum).

• Fungi may include Candida, Coccidioides, Histoplasma, and Aspergillus species.

• The precipitating factors can vary according to route of infection:

1) Prosthetic joint implants and stabilization devices (all foreign objects) are being used more frequently in orthopedic surgery and are **associated with complex infections.**
2) Trauma: if a wound is involved with trauma, that leads to contamination of bone or surrounding tissue - with significant tissue damage or destruction (For ex. if the wound is healing, but the patient is diabetic →more likely to have circulating bacteria (ex. bacteremia) → hematogenous spread)

• **Not necessary to have an open wound or a compound fracture**. In a similar fashion to what is seen in pyomyositis: damaged tissue and internal bleeding slows down the circulation which creates favorable conditions for bacterial growth.

• In these damaged tissues, bacteria from peripheral veins or lymphatic channel (low level bacteremia) may be sufficient to cause infection – in other, normal situations, circulation would prevent that from occurring.

Bacteremia:

• Bacteremia is a frequent cause of osteomyelitis, and may arise **from endocarditis or from seeding of other infection sites** (abscess, boils...etc)

- Note: If you see osteomyelitis in someone that does NOT have a wound, then you need to find the underlying source (ex. endocarditis).

a) Prosthetic joints and S. aureus: Studies show that S. aureus bacteremia causes a rate of metastatic osteomyelitis approaching 28% if there is a prosthetic joint in place. It can be **complicated by** the involvement of methicillin-resistant strains (**MRSA**), which are progressively replacing strains that are more susceptible to antibiotics.

b) Urinary tract circulation: The overlapping circulations of the **urinary tract and the spine** is suggested to be the source of vertebral osteomyelitis especially due to **UTI causing pathogens (E. coli and Klebsiella).**

- Lower lumbar and sacral vertebrae are close to the urinary tract and share the circulation with it. Vertebral OM is commonly caused by E. coli and Klebsiella (found in urinary tract). So, UTI → short trip through shared circulation → E. coli and Klebsiella will reach the vertebrae→ Vertebral OM

c) Limited vascular supply: other predisposing factors →limited arterial and venous blood supply →limited perfusion to bone to the point of an inadequate response and poor healing.

d) Diabetes and other host factors contribute significantly to the development of osteomyelitis through impaired immunity with hyperglycemia, loss of sensation, vascular disease, and renal failure.

Epidemiology:

• In the United States, acute osteomyelitis affects ~0.1–1.8% of the otherwise **healthy adult population**.

• After a foot puncture/wound, **30–40% of adults with diabetes develop osteomyelitis**.

• MRSA has been steadily replacing MSSA over the last few decades.

• The morbidity and economic burden are greater for MRSA osteomyelitis than that caused by MSSA. (MSSA itself needs weeks of treatment due to difficulty in reaching the bone. MRSA adds even more difficulty to the treatment).

• Is MRSA more aggressive because it can evade antimicrobials so has more time to cause damage? Or is it because their bugs survive longer and get more virulence factors? Both (note: MRSA doubles the time of therapy)

• Certain countries that have more **aging populations and / or populations with more DM, obesity, and osteoarthritis** all contribute to the increase in frequency of osteomyelitis in these areas.

• Any type of instrumentation through the bone (such as implants, fixation, joint replacements, and needles in aspiration of bone marrow) may lead to infection in a small proportion of cases.

• Richer countries have more orthopedic related osteomyelitis, whereas poorer countries have more TB and brucella or significant wounds in the society (wars, accidents) →less healthcare services (micro labs, Abx..etc).

Pathogenesis: (can be applied to all pathogens mentioned in this module)

• The most common predisposing factor for osteomyelitis is an area of bone (or contiguous surrounding tissue) that is **defective** in viability, blood supply, and sensation (devitalized area).

• This damaged tissue suffers from reduced oxygenated arterial supply and **hindered venous and lymph out flow (less in, less out = stagnation of blood flow)**. These are the prime factors that **provide bacteria with optimal growth conditions** (O2, nutrients, less inflammatory cytokines and WBC...etc).

• **Host factors such as poor nutrition and immunosuppression may also be relevant**.

• As mentioned, diabetes in adults poses the most significant risk (and further accentuates the above factors).

• Diabetic neuropathy makes progression of the disease much worse, as the patient would be unaware of any symptoms (pain sensation reduced) →makes DM a significant cause for many amputations due to OM.

• In a similar fashion, other causes of immunosuppression will predispose to serious and frequent infections and OM is no exception.

• Bacterial pathogens that cause OM **perpetuate** themselves (they maintain their presence) →they do this by secreting toxins that continually damage surrounding tissue.

• S. aureus is especially strong in this respect, where it colonizes the nasal area in about one-third of the healthy populace and can produce a variety of cytokines, enzymes, and **toxins that destroy tissue and affect neutrophil response.**

- OM is **NOT** a granuloma, but its growth is very similar to the granuloma of TB. How? There are **active bacteria on the sides**, and less active bacteria as you go towards the center. In the **center, nutrition and oxygenation are at their lowest levels** → you can find bacteria that are least active and **dormant** in the center. (Note: all bacteria have a dormant form. Their dormant form behaves like spores but is NOT a spore. How? They both have resistance because there is no metabolic activity (so antibiotics don't affect them). The difference between them is that spores have a keratin layer surrounding them).
- The first dose of antibiotics will be able to kill the active bacteria but **not** the dormant ones. In addition, the blood supply is already compromised so antimicrobials can hardly reach the bone.
- These bacteria will also allow the neutrophils to sequester/ capture them and will then **escape** being destroyed inside the neutrophil
- In conclusion, there are 2 populations that can perpetuate the bacteria in the bone: **{the bacteria found in the neutrophils + extracellular active population}** →so when extracellular active bacteria decrease in number due to antibiotics, they will be replenished by the bacteria found inside the neutrophils.
- Because of this, osteomyelitis can never be self-limiting.

• Certain strains of S. aureus can survive uptake into the phagocytic vacuoles of macrophages, this enables them to keep causing tissue damage by consistently evading host defenses.

• Basically → two populations of S. aureus, intra- and extracellular, where intracellular keeps replenishing the extracellular pathogens.

• S. aureus has the **capacity to remain dormant** (sometimes called NCBV-viable but not culturable form) → These are resistant forms that hibernate and remain inactive for decades before infection erupts at sites of old injuries (especially penetrating wounds, shrapnel…).

• Although CoNS are typically less virulent than S. aureus, but they have been found **to persist** by producing **biofilm** (in which the bacteria communicate together like a community) that protects them from the host and is thought to be the mechanism that allows them to persist for many years on, especially, prosthetic joints, with minimal symptoms.

• In CoNS, it is not uncommon for prosthetic joints to show no symptoms and suddenly show **infection a year or even more later**.

• How much other organisms use their biofilm to their advantage is not fully understood, but biofilm production probably plays an important role in osteomyelitis, **especially in chronic forms.**

• Multiple bacteria may be recovered from cultures, especially when there is an entry wound.

- This makes the decision of which one to target in antibiotic therapy difficult.
- At this point → **Typically common skin flora and colonizing bacteria are not targeted** (if they are, it might make them more aggressive and resistant).
- Anaerobic bacteria can often be recovered and can play synergistic role with other pathogens → these are **usually targeted with specific therapy**.
- Usually a culture of an entry wound is polymicrobial. (For ex., culture results show the presence E. coli, pseudomonas, S. aureus, and S. epidermidis. Do you think these staphylococci are truly inside the bone or did they come from the skin following contamination? It's difficult to decide).

Clinical features:

•Acute osteomyelitis presentation is usually in pediatric patients and due to hematogenous spread.

• Whereas subacute to chronic contiguous OM is usually in adults.

• Onset of **pain occurs around the affected site** (due to increased pressure on the nerve in the periosteum → so the surrounding tissue will start hurting. The increasing pressure will also increase the pain).

• **Local and systemic signs of inflammation** such as swelling, tenderness, warmth, and erythema **may or may NOT be present** (especially in the vertebra, hip or pelvis- **NOT IN LONG BONES**).

- Note: the deeper the infection, the less likely it is for the inflammatory signs to be present on the surface.

• Chronic osteomyelitis presentation may begin with local signs of inflammation and/or presence of a sinus tract (formation of pus that pushes its way until it reaches the skin), or even pathological fractures (An example may be seen with a man who just stands up, places pressure on his leg, and suddenly a fracture occurs. Therefore, non-traumatic fractures suggest weakened bone due to chronic OM).

• Skin ulcers that are prolonged and fail to heal with antibiotic therapy may indicate **underlying osteomyelitis,** especially for the case of diabetic foot since OM can perpetuate the bacteria.

•In such cases, if bone is felt when palpating an ulcer→this can **be sufficient to diagnose osteomyelitis**

Diagnosis:

• Usually **based on clinical suspicion**, and then confirmed by radiology. Microbiology and pathology methods can then be used.

- We confirm the diagnosis by radiology. Then, we use microbiological testing to identify the pathogen and what drug(s) to use. Microbiology is not used for diagnosis because you don't retrieve the bone specimen unless you're sure it's osteomyelitis and the specimen was taken for deciding suitable treatment.

❖ Blood tests

- White cell count may be raised but can be normal.
- Inflammatory markers (ESR and CRP) are usually high (their high levels don't confirm it's osteomyelitis but suggest a suspicion of it so they might help in the diagnosis).
- CRP changes occur earlier in bacterial infection.

- However, ESR and CRP are not specific and can be elevated in conditions other than osteomyelitis

• Blood cultures are more likely positive in vertebral infection and in hematogenous spread (clavicle, pubis), rather than long bones.

❖ Radiology

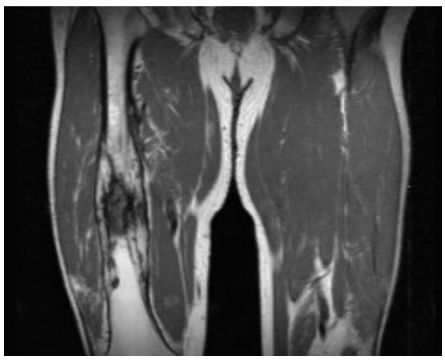
• Plain X-ray may show changes after 1-2 weeks.

• May eliminate the need for further imaging studies.

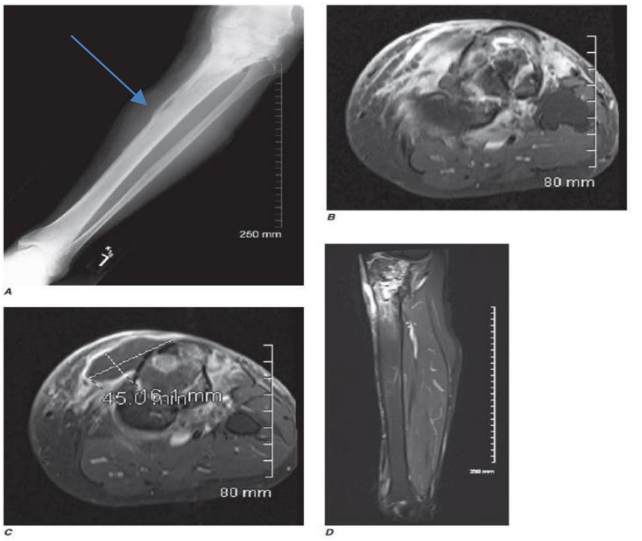
• Bone loss, sequestra, periosteal elevation or swelling (which can develop early on), and shadows around foreign bodies are hallmarks of bone infection.

• CT or MRI scans are the investigations of choice (MRI is both specific and sensitive).

• MRI may be contraindicated in patients with metal ware; which may also cause artifacts on the CT scan.



→The following x-ray shows fracture and an abscess being formed.



➔ X-ray (A) shows elevation of periosteum and an involucrum forming.

❖ Biopsy

• An open or percutaneous bone biopsy should be taken and sent to microbiology and histology labs.

• Needle aspiration of pus collection is both Rx and Dx for the pathogen.

- Because when you aspirate the fluid of the abscess, you aspirate everything. Therefore, needle aspiration is both therapeutic and diagnostic.

• Biopsy can be taken in open surgery with debridement of all necrotic tissue, which is again both Rx and Dx, as it revitalizes the tissue.

• Antibiotics should be stopped 48-72 hours prior to biopsy to improve the yield of the culture.

- Antibiotics are stopped 2 days before because you want an accurate reading of the sensitivity profile of the bacteria and to make sure that the bacteria causing OM is still there. The treatment is long and lasts from 4 to 6 weeks, so you want to make sure it is the most appropriate treatment for the case.

• Swabs from sinus tracts are of questionable value and may often just be presenting the local flora.

• PCR and sequencing technologies are becoming more standard in diagnosis to detect and identify specific organisms

- PCR shows the microorganisms' sensitivity to Abx (antibiotics) within hours instead of days or weeks.
- You can determine the sensitivity of the bacteria by using PCR since you can find the gene that is responsible for the resistance. For example, you can look for the mecA gene seen in MRSA.
- Within the next 5-10 years, a new technology (amino acid sequencer) may be replacing PCR.

Management:

• General principles:

- The aim of treatment is to eradicate the causative agent and restore (or at least preserve) the function of the bone.

- OM in adults is usually treated with a combination of surgical debridement and antibiotic therapy.

• Surgery: the principles of surgical therapy are debridement of infected tissue, removal of metal ware, management of dead space (using a flap), wound closure, and stabilization of infected fractures.

Antimicrobial therapy:

The spectrum of osteomyelitis treatment is very wide:

• Choice of Abx therapy is based on culture and sensitivity results. However, the duration is unknown and most **experts treat for 4-6 weeks IV therapy** (the treatment is prolonged because it is hard to reach the bone).

• The addition of rifampicin to β-lactams was shown to be effective in certain staphylococcal OM animal models and is often used in infections, particularly those involving prosthetic material.

• Patients are usually discharged once they are clinically stable (after debridement and any other actions needed to reach a point where the patient is stable) and treated as an **outpatient with an IV antimicrobial catheter**.

- There is a role for oral treatment, but IV treatment is superior to oral treatment, especially to increase the dose of the drug reaching the defective bone.

• Hyperbaric oxygen has been shown to be effective in animal studies (no data in humans) and can be used as adjunctive therapy.

• Negative pressure wound therapy (vacuum-assisted closure) is being increasingly used and may accelerate wound healing in complex wounds and in diabetic patients.

TABLE 23-2

ANTIBIOTICS FOR THE TREATMENT OF OSTEOMYELITIS

ORGANISM	ANTIMICROBIAL AGENT	DOSING	COMMENTS
Methicillin-susceptible *Staphylococcus aureus*	Oxacillin or nafcillin	2 g IV q6h	May be more active than cephalosporins More difficult than cephalosporins to administer for long periods
	Cephalosporins	Cefazolin: 2 g IV q8h Ceftriaxone: 1–2 g IV q24h	Ceftriaxone advantageous with OPAT
	Clindamycin[a]	600–900 mg IV q8h	Not well studied for osteomyelitis Oral form possible (300–600 mg q8h) Resistance significant and increasing Toxicity different from that of β-lactam antibiotics
Methicillin-resistant *S. aureus*	Vancomycin	15 mg/kg IV q12h	Strains with an MIC of ≥2 ug/mL may no respond well.
	Daptomycin[a]	4–6 mg/kg IV q24h	Promising, but concern about adverse effects with prolonged therapy
	Linezolid[a]	600 mg IV or PO q12h	Effectiveness and adverse effects with prolonged therapy unclear Bacteriostatic
Streptococci	Penicillin	5 mU IV q6h or 20 mU/d by continuous infusion	Not all streptococci are susceptible. Ceftriaxone (1 g/d IV or IM) and ampicilli (12 g/d IV) are alternatives.
Enterococci	Penicillin plus gentamicin	As above 5 mg/kg daily IV	If strain is susceptible
	Vancomycin	As above	If strain is susceptible
Enterobacteriaceae (*E. coli*, *Klebsiella*, other)	Ceftriaxone or another cephalosporin	As above	If strain is susceptible
	Ciprofloxacin	400 mg IV q8–12h	500–750 mg q8–12h if strain is susceptible
Pseudomonas aeruginosa	Ciprofloxacin	As above	Resistance may develop during therapy; if strain is resistant, drugs to consider include cefepime and ceftazidime.

[a]Not approved for use in osteomyelitis by the U.S. Food and Drug Administration.
Abbreviations: MIC, minimal inhibitory concentration; OPAT, outpatient parenteral antimicrobial therapy.

Some notes to know about the following table:

1- Ceftriaxone (every 24 hours) is better than Oxacillin (every 6 hours) since it will improve patient compliance. However, it may be overkill. Oxacillin may be more active than cephalosporins as well.
2- MRSA patients should take vancomycin or other forms.
3- For streptococci, penicillin works just fine.
4- Enterococci (gram positive streptococci) are very resistant because they live with enteric bacteria, so when we give them regular systemic anti-staph and strep medication, it will not work. Therefore, we have to supplement it with the drug combination mentioned in the table: vancomycin and sometimes aminoglycosides.

➢ Gentamicin: It targets proteins. Gram negative bacteria are more susceptible to it than gram positive bacteria (although gentamicin works on both). It is also bactericidal and when combined with penicillin it will have a synergistic effect.

5- Enterobacteriaceae: Ciprofloxacin is an excellent tissue penetrator, even at the bone. So, if there is a susceptibility for Ciprofloxacin, it is a good medication to use.

• There is still controversy about the optimal route and duration of therapy.

• However, a 4 to 6 week course of IV therapy remains the standard and is the usual recommended minimum.

• Although in pediatric populations, some studies are suggesting adequate treatment with **somewhat shorter duration + oral therapy.**

• Because some of the active agents reach comparable levels when given by mouth, a switch from the recommended IV administration to oral therapy may be appropriate in some situations.

• Duration is increased for more extensive disease or with patients with additional comorbidity (see previous classification-Cierny Mader) + vertebral OM (no comorbidity and local disease would require less).

Complications:

• Sinus tract formation.

• Pathological fractures→ because the sequestra make that specific area of bone less able to bear weight and is prone to fracture.

• Hematogenous **spread and sepsis**, especially in aggressive disease.

• Tumors in patients with long-standing (4–5 years).

- In rare instances, chronic inflammation and infection may lead to malignant transformation into squamous cell carcinoma or sarcoma.
- Osteomyelitis, e.g. squamous cell carcinoma (commonest), fibrosarcoma, myeloma, lymphoma, plasmacytoma, angiosarcoma, rhabdomyosarcoma, and malignant fibrous histiocytoma.

Prognosis:

• Varies based on all the factors that are included in the classification systems.

• Vertebral, immunocompromised and late Dx → poorer prognosis

• Mandible following tooth extraction, early proper treatment → better prognosis.

Prevention:

• Osteomyelitis can be prevented with better **preoperative infection and prevention measures.**

• Agents such as mupirocin and chlorhexidine (as topical agents on the skin) have been shown to be successful in preventing operative infections (which are a common cause in prosthetic joins OM).

• Early Dx and treatment of other infection routes (abscess, bacteremia, boil…etc).

• Early surgical treatment of wounds (especially extensive ones) have better outcome.

• Sacral ulcers can often be a point of infection in bed ridden patients → and easily overlooked.

Good Luck