MSS

pathology

LEC no.3

Writer: زين مالك وصهيب زعيتر

Corrector: شـهد الأحمـد

Doctor: طارق العديلي

MUSCULOSKELETAL PATHOLOGY-3

OSTEONECROSIS, OSTEOMYELITIS, FRACTURE

Professor Tariq Aladily

Department of Pathology

The University of Jordan

tnaladily@ju.edu.jo

We have 3 topics in this lecture.

OSTEONECROSIS

There are many type of necrosis as ischemic, infectious, caseous...
But here the osteonecrosis means ischemic necrosis (Caused by a lack of blood supply to the tissue, leading to cell death)

- Also known as: 1) avascular necrosis
- 2) Ischemic infarction of bone and bone marrow
- Most patients are middle-age adults

Caused by:

- Vascular injury (surgery, trauma, vasculitis means damage of blood vessels by inflammation)
- Drugs (corticosteroids the most common one)
- Radiation (for many causes of use as radiotherapy)
- Thrombosis (sickle cell disease the most effected people)

Additional information: here's video's link which illustrate this point :
Sickle anemia and thrombosis

Note: thrombosis involves the abnormal formation of a clot within a blood vessel so, no blood supply to the bone .
Here's an additional pic --------->

TYPES: MEDULLARY AND SUBCHONDRAL

The type of osteonecrosis depends on **the site of bone infarction**

Is spared = لا يتأثر

- **Medullary**: infarction of trabecular bone and bone marrow, the cortical bone is spared due to presence of collateral circulation there because they have their own blood vessels . (clarification in next slide)

- **Subchondral**: appears triangular (wedge)- shape, results in collapse of bone, fracture and sloughing of articular cartilage

- The overlying articular cartilage is intact due to nutrients in synovial fluid

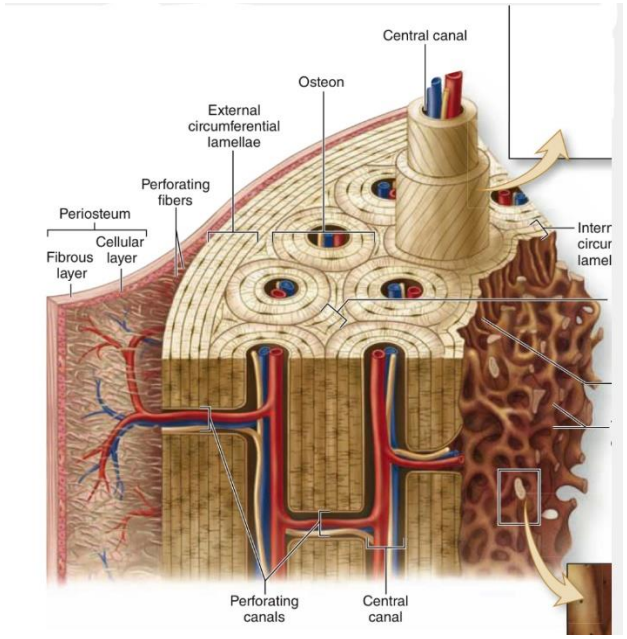
- Repair of subchondral infarction is slow

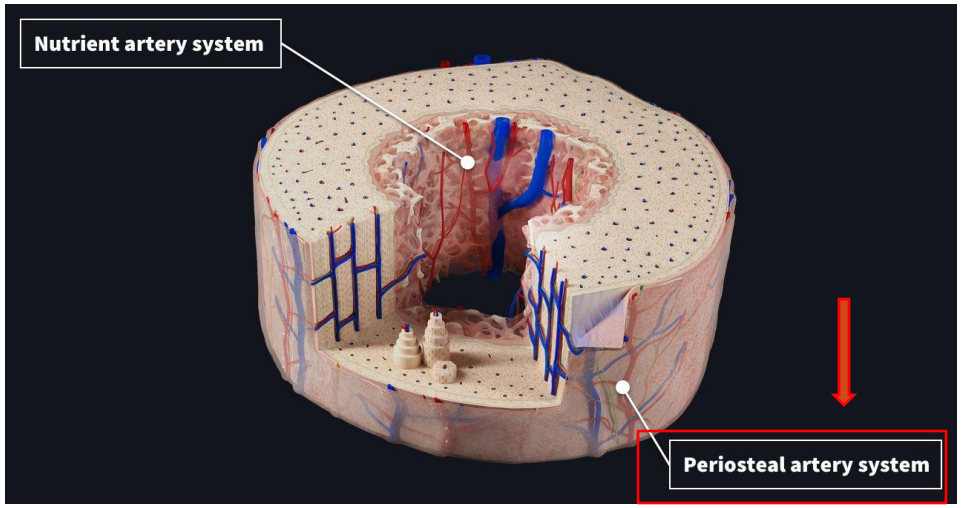
The cartilage may undergo sloughing or physical displacement due to movement, but it remains viable and intact because of presence of synovial fluid.

- For both types: Microscopically: no visible osteocytes (empty lacunae)
  Osteoclasts from adjacent viable area start resorption of dead bone

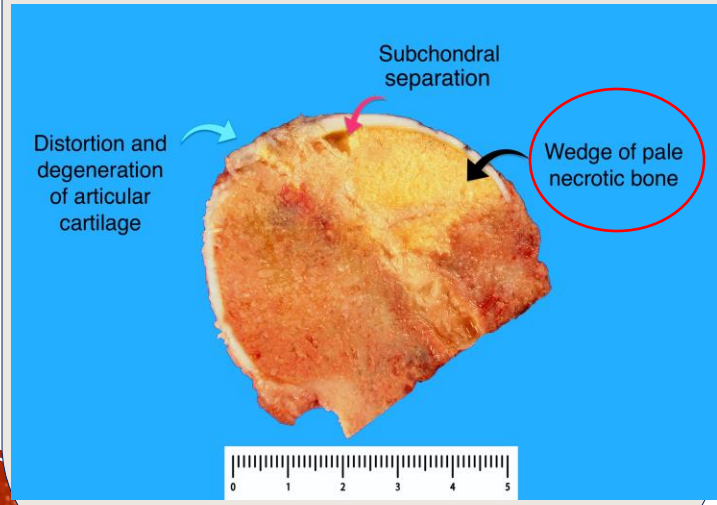
Additional note about collateral circulation to supply the cortical bone: (Additional Slide)

the collateral circulation refers to the network of additional blood vessels that supply blood to the bone tissue when the primary arteries are compromised. The specific term used to describe this phenomenon is "periosteal arterial plexus." This arterial network runs along the surface (periosteum) of the bone and provides an alternate blood supply to the bone tissue, particularly the cortical bone. **(in summary, It is an alternative way to deliver nutrition in case it is cut off from the bone, such as in the case of osteonecrosis)**





This is "wedge" shape for subchondral type



SYMPTOMS

- Pain, begins in association with activity, then becomes constant and more severe.
- If articular cartilage is sloughed, secondary osteoarthritis develop

OSTEOMYELITIS

- Inflammation of bone and bone marrow
- Almost always is infectious in origin
- Can be caused by bacteria, viruses and fungi

Inflammation can be caused by many factors, may be infectious or non infectious, but here in osteomyelitis it is always infectious.

PYOGENIC OSTEOMYELITIS

Pyo= Pus
Genic = Forming
It's "pus forming" inflammation

Additional note
Pus is a thick, yellowish or greenish fluid that forms at the site of infection in the body. It consists of dead white blood cells, bacteria, tissue debris, and fluid

- Caused by bacterial infection
- Organisms reach bone either by:
- A) Hematogenous route
- B) Extension from adjacent site (joint, soft tissue as lung and T.B infection)
- C) Direct implantation (open fracture, surgery)
- In children: most commonly hematogenous and affect long bones
- In adults: most commonly secondary to fractures, surgery or diabetes (diabetic foot)

Additional Note : u can watch this Vid :
Watch this about Osteomyelitis

PYOGENIC OSTEOMYELITIS

- **Staph Aureus** is overall the most common microorganism, it binds easily to collagen in osteoid matrix so they can easily bind to the bone.
- In neonates, group B-streptococci and E. Coli are the most common (maternal origin, so during birth they can affect bone)
- Mixed bacteria is seen in open fracture and surgery
- Salmonella and gram-negative bacteria are the most common in patients with sickle-cell anemia

MORPHOLOGY

- Acute phase: neutrophilic inflammation, liquefactive necrosis
- Infection then spread radially means in all directions vertically… horizontally in bone, reaching the periosteum the outer most layer of the bone .
- In children, the periosteum is loosely attached to cortical bone, so it detaches, sub-periosteal abscess forms, dissecting it, compressing blood supply and causing necrosis of bone.
- Bone abscess may spread to adjacent soft tissue, ultimately reaching skin through a sinus tract
- Epiphyseal infection may spread to joint structures, causing septic arthritis and cartilage destruction (disability)

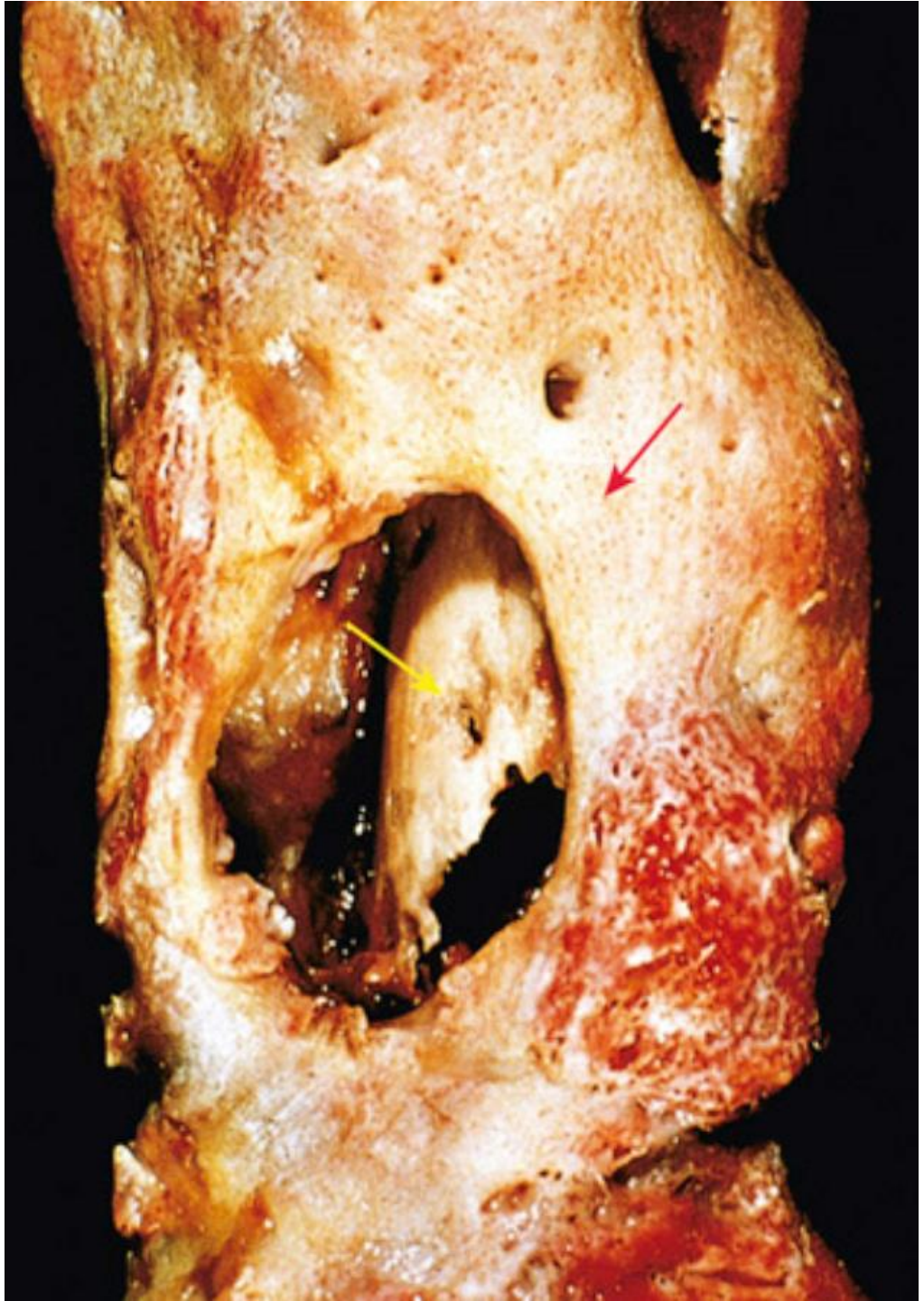
remember from our last semester.. **liquefactive necrosis** is partial or complete dissolution of dead tissue and transformation into a liquid, viscous mass

The pus or abscess forms under the periosteum and start pushing it

If the abscess spread to cartilage tissue in growth plate of children, this will cause permanent damage and short limbs.

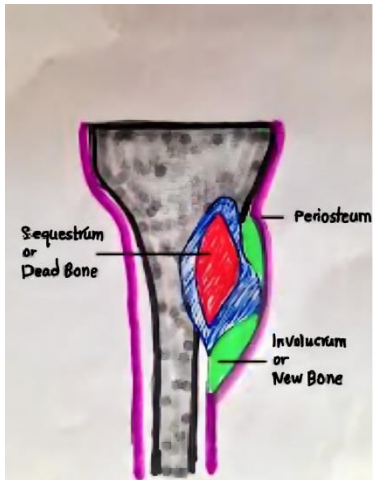
MORPHOLOGY

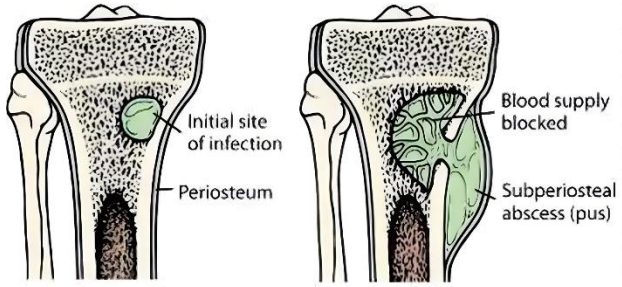
- After one week of bone infection, chronic inflammatory cells appear (lymphocytes and plasma cells)
- Secreted cytokines cause bone resorption, growth of fibrous tissue and new bone formation (so cytokines affect both osteoblasts and osteoclasts)
- Dead bone is called sequestrum وشيظ
- Newly formed bone is called involucrum result of osteoblasts activation كساء عظمي, appears as a shell around dead tissue

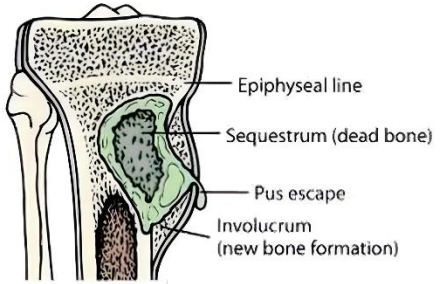


- Resected femur in a patient with draining osteomyelitis. The drainage tract in the subperiosteal shell of viable new bone (involucrum, yellow arrow) shows the original cortex (sequestrum, red arrow), which is necrotic.

Additional pics:







CLINICAL FEATURES

Osteomyelitis causes:

- Severe Throbbing pain over affected area
- Fever, leukocytosis (increased WBC count in peripheral blood)

Due to inflammation

- Unexplained fever in infants (it does not come with typical symptoms such as sore throat)
- X-ray and MRI show bone changes (give good findings that help in diagnosis)
- 5-25% of acute osteomyelitis cases persist, transform to chronic osteomyelitis, manifest as recurrent flares and dormancy

*Note: In chronic osteomyelitis, the symptoms tend to be milder, yet the hallmark of this condition is its episodic flare-ups followed by periods of dormancy. بتيجي وبتروح

Complications of chronic osteomyelitis: pathologic fracture, amyloidosis, squamous cell carcinoma in sinus tract(due to inflammation), sarcoma in bone (rare)

Amyloidosis: deposition of light chain in tissue due to antibodies that are secreted from plasma cells, this deposition make physical damage to the bone.

Treatment of osteomyelitis is hard even with antibiotics (patients have to receive antibiotic I.V for a long time and it might not work)

MYCOBACTERIAL OSTEOMYELITIS

Type of chronic osteomyelitis.

- Affects 1-3% of patients with TB (tuberculosis osteomyelitis)
- Hematogenous spread(blood born), or direct extension from lung (ribs, spine)

Means if I take all the bones that have TB, 40% of them might be vertebrae.

- Pott disease(important): vertebral infection, occurs in 40% of osseus TB, affects multiple vertebral bones(severe damage), destruction to intervertebral discs causing deformity and spinal cord damage(neurologic disease either by deformity itself or fracture or by infection), may spread to soft tissue and psoas muscle (out of vertebrae into pelvis)

FRACTURE

This symbol (#) means Fracture.

- Fracture is: Loss of bone integrity
- Results from physical force and/or decreased bone strength
- Pathologic fracture (#): called when the bone is weak secondary to disease
- Simple #: skin is intact (vs. compound #(if I have damage in the skin))
- Comminuted #: bone is fragmented (shattering to the bone) more **severe** than compound #.
- Displaced #: distal ends of bones are mal-aligned

  Note: The alignment is disrupted, similar to what happens with a humerus fracture, where the proximal and distal parts have shifted away from each other. Essentially, they are no longer aligned or on the same axis.
- Stress #(minor): repetitive small forces cause # (not sudden ones)
- Greenstick #: part of the bone width is fractured, common in infants and children " شُعر"

Pathologic means it is preceded by a disease that causes bone weakness (much important)

Babies have bones that are still growing and are softer than adult bones. So, if a baby's bone gets broken, the fracture might look like it's part of the bone's width.

HEALING PROCESS

- Fracture causes disruption of blood vessels, a hematoma forms (blood collection that forms a mass)

Formation of hematoma in the bone is the first change in healing process.

- Hematoma contains fibrin network(solid part), which guide inflammatory cells, fibroblasts and new capillaries

- Inflammatory cells and platelets secrete platelets-derived growth factor (PDGF), transforming growth factor-β (TGF-β) and fibroblast growth factor (FGF), activating osteoprogenitor cells (mesenchymal cells to differentiate into other cells) and stimulate osteoblasts and osteoclasts.

CALLUS

Means fracture or term that we use in fractures.

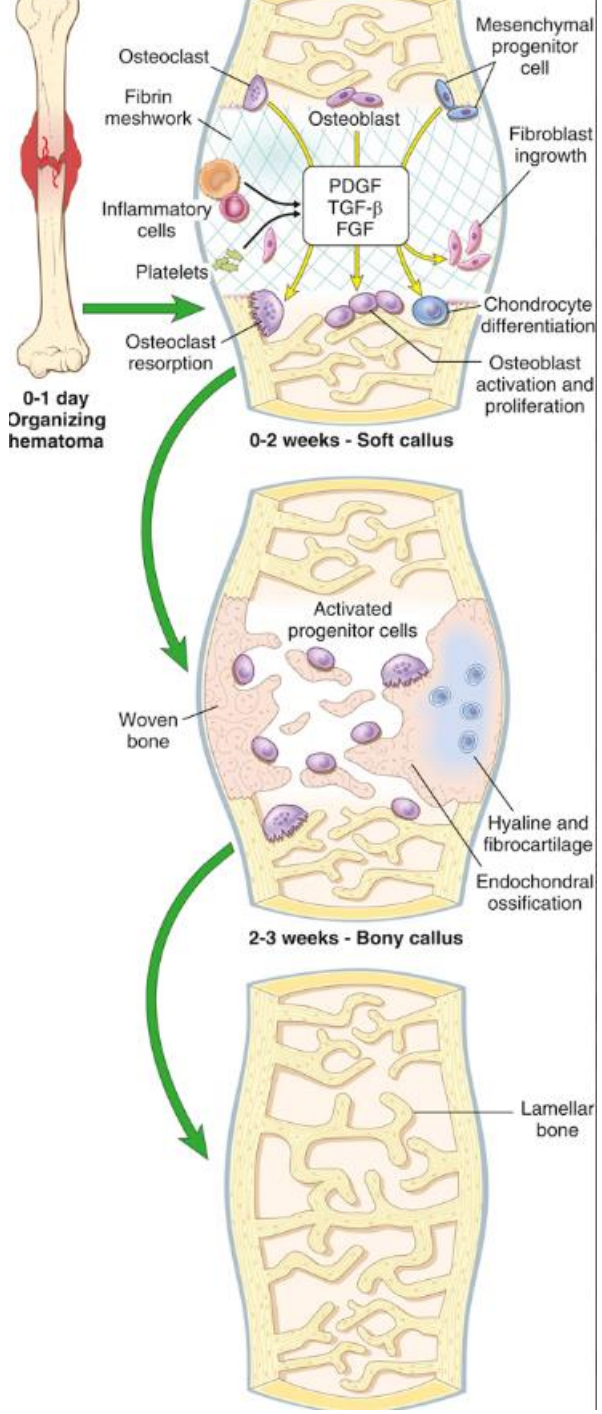
- After one week, a soft callus دُشبذ (procallus) is formed, which is composed of uncalcified new tissue that fills the cavity

soft callus is newly synthesized osteoid without calcium.

- After two weeks, soft callus is converted to bony callus by deposition of woven bone.

mineralization happens and conversion into woven bone takes place.

- In some cases, fracture site shows new cartilage formation, which undergoes endochondral ossification.like normal growth pattern (in some cases)
- Callus undergoes remodeling according to weight-bearing forces, reduces in size and shape and it fills the cavity.
- Contour of new bone is re-established and shows lamellar bone. (after remodeling)
- Formation of medullary cavity (the site of bone marrow or trabecular bone) is the last step in bone healing.



- The reaction to a fracture begins with an organizing hematoma. Within 2 weeks, the two ends of the bone are bridged by a fibrin meshwork in which osteoclasts, osteoblasts, and chondrocytes differentiate from precursors. These cells produce cartilage and bone matrix, which, with adequate immobilization, remodels into normal lamellar bone. FGF, Fibroblast growth factor; PDGF, platelet-derived growth factor; TGF-β, transforming growth factor-β.

Little summary:Cytokines affect both cells osteoclast and osteoblast ---> woven bone formation (soft callus then hard callus) ---> remodeling.

hard callus = bony callus

just to remember: (not required)

Woven Bone: This is the initial, disorganized form of bone tissue that appears during the healing process

Lamellar Bone: This mature type of bone tissue replaces woven bone during the remodeling stage

U can watch this about healing :)

bone healing

means Fracture.

SUBOPTIMAL HEALING OF BONE

Or impaired healing

We'll talk here about what things prevent optimal healing of a fracture:

- Comminuted # causes deformity (Severe)
- Inadequate immobilization (بضل يتحرك): movement of callus causes delayed union of bone or non-union. Non-union results in cystic degeneration and a false joint formation

عشان هيك بنطلب من الشخص يحط جبيرة (cast) لأنه اذا تأخر ممكن يصير deformity

- Infection of fracture site (compound open #)
- Malnutrition
- Diabetes (as we take in wound healing).
- Pathologic fracture (needs surgical immobilization(to prevent movement))

Because it is a weak bone.

Osteonecrosis

Definition

OSTEONECROSIS → cell dead

- Also known as: avascular necrosis
- Ischemic infarction of bone and bone marrow
- Most patients are middle-age adults

Caused by:

- Vascular injury (surgery, trauma, vasculitis) — inflammation of a blood vessel
- Drugs (corticosteroids)
- Radiation
- Thrombosis (sickle cell disease)

thrombosis involves the abnormal formation of a clot within a blood vessel

Types

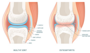
TYPES: MEDULLARY AND SUBCHONDRAL (cartilage)

- Medullary: infarction of trabecular bone and bone marrow, the cortical bone is spared due to presence of collateral circulation there
- Subchondral: appears triangular (wedge)- shape, results in collapse of bone, fracture and sloughing of articular cartilage
- The overlying articular cartilage is intact due to nutrients in synovial fluid
- Microscopically: no visible osteocytes (empty lacunae)
- Osteoclasts from adjacent viable area start resorption of dead bone
- Repair of subchondral infarction is slow

Symptoms

SYMPTOMS

- Pain, begins in association with activity, then becomes constant
- If articular cartilage is sloughed, secondary osteoarthritis develop



Osteomyelitis

Definition

OSTEOMYELITIS

- Inflammation of bone and bone marrow
- Almost always is infectious in origin
- Can be caused by bacteria, viruses and fungi

Pyogenic Osteomyelitis — causes

Pus is a thick, yellowish or greenish fluid that forms at the site of infection in the body. It consists of dead white blood cells, bacteria, tissue debris, and fluid. It is often produced as a response to infection or inflammation

PYOGENIC OSTEOMYELITIS

- Caused by bacterial infection
- Organisms reach bone either by:
- A) Hematogenous route
- B) Extension from adjacent site (joint, soft tissue)
- C) Direct implantation (open fracture, surgery)
- In children: most commonly hematogenous and affect long bones
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PYOGENIC OSTEOMYELITIS

- Staph Aureus is overall the most common microorganism, it binds easily to collagen in osteoid matrix
- In neonates, group B-streptococci and E. Coli are the most common (maternal origin)
- Mixed bacteria is seen in open fracture and surgery
- Salmonella and gram-negative bacteria are the most common in patients with sickle-cell anemia

Morphology

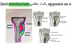
steps of development

MORPHOLOGY

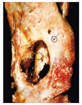
- Acute phase: neutrophilic inflammation, liquefactive necrosis
- Infection then spread radially, reaching the periosteum
- In children, the periosteum is loosely attached to cortical bone, so it detaches, sub-periosteal abscess forms, dissecting it, compressing blood supply and causing necrosis of bone.
- Bone abscess may spread to adjacent soft tissue, ultimately reaching skin through a sinus tract
- Epiphyseal infection may spread to joint structures, causing septic arthritis and cartilage destruction (disability)

MORPHOLOGY

- After one week of bone infection, chronic inflammatory cells appear (lymphocytes and plasma cells)
- Secreted cytokines cause bone resorption, growth of fibrous tissue and new bone formation
- Dead bone is called sequestrum
- Newly formed bone is called involucrum, appears as a shell around dead tissue



The shape of bone



- Resected femur in a patient with draining osteomyelitis. The drainage tract in the subperiosteal shell of viable new bone (involucrum, yellow arrow) shows the original cortex (sequestrum, red arrow), which is necrotic.

Clinical features — To diagnosis

CLINICAL FEATURES (for diagnosis)

- Throbbing pain over affected area
- Fever, leukocytosis — an increase in the number of white cells in the blood, especially during an infection.
- Unexplained fever in infants
- X-ray and MRI show bone changes
- 5-25% of acute osteomyelitis cases persist, transform to chronic osteomyelitis, manifest as recurrent flares and dormancy
- Complications of chronic osteomyelitis: pathologic fracture, amyloidosis, squamous cell carcinoma in sinus tract, sarcoma in bone (rare)

Acute osteomyelitis is a severe bone infection caused by bacteria entering the bone tissue, often through an open wound or during surgery. While many cases of acute osteomyelitis can be successfully treated with antibiotics and proper wound care, a portion of cases—approximately 5-25%—can persist and transform into chronic osteomyelitis.

Chronic osteomyelitis develops when the initial infection is not completely eradicated or when the bone tissue fails to heal properly. In chronic osteomyelitis, the infection can linger within the bone, causing recurrent flares of symptoms such as pain, swelling, redness, and fever. Between these flares, the infection may enter a dormant phase, during which symptoms may subside but the bacteria remain present within the bone.

Amyloidosis is a rare but serious condition characterized by the abnormal buildup of proteins called amyloids in various organs and tissues throughout the body. These amyloid proteins can accumulate in organs such as the heart, kidneys, liver, spleen, nervous system, and digestive tract, interfering with their normal function.

Special type of infection cause Osteomyelitis (TB)

MYCOBACTERIAL OSTEOMYELITIS

- Affects 1-3% of patients with TB
- Hematogenous spread, or direct extension from lung (ribs, spine)
- Pott disease: vertebral infection, occurs in 40% of osseus TB, affects multiple vertebral bones, destruction to intervertebral discs causing deformity and spinal cord damage, may spread to soft tissue and psoas muscle

Tubercular osteomyelitis of the vertebra — so they can not move the spine

Fracture

Definition

FRACTURE (3rd Pobic)

- Loss of bone integrity
- Results from physical force and/or decreased bone strength
- Pathologic fracture (#): called when the bone is weak secondary to disease (because of infection or other infectious disease)
- Simple #: skin is intact (vs. compound #)
- Comminuted #: bone is fragmented
- Displaced #: distal ends of bones are mal-aligned
- Stress #: repetitive small forces cause #
- Greenstick #: part of the bone width is fractured, common in infants and children

Healing

The process of Healing

HEALING PROCESS

- Fracture causes disruption of blood vessels, a hematoma forms (Blood collection that form a mass in the bone.)
- Hematoma contains fibrin network, which guide inflammatory cells, fibroblasts and new capillaries
- Inflammatory cells and platelets secrete platelets-derived growth factor (PDGF), transforming growth factor-β (TGF-β) and fibroblast growth factor (FGF), activating osteoprogenitor cells and stimulate osteoblasts and osteoclasts. (Cytokines)

Then

CALLUS (for fracture)

a thickened and hardened part of the skin or soft tissue, especially in an area that has been subjected to friction.

- After one week, a soft callus (procallus) is formed, which is composed of uncalcified new tissue that fills the cavity
- After two weeks, soft callus is converted to bony callus by deposition of woven bone.
- In some cases, fracture site shows new cartilage formation, which undergoes endochondral ossification: as normal growth pattern
- Callus undergoes remodeling according to weight-bearing forces, reduces in size and shape
- Contour of new bone is re-established and shows lamellar bone
- Formation of medullary cavity is the last step in bone healing

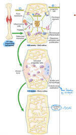
Some fracture can not be Complete Healing — Why or Like what?

SUBOPTIMAL HEALING OF BONE

of less than the highest standard or quality

- Comminuted # causes deformity → it is difficult to back as normal bone
- Inadequate immobilization: movement of callus causes delayed union of bone or non-union. Non-union results in cystic degeneration and a false joint formation
- Infection of fracture site (compound open #)
- Malnutrition
- Diabetes
- Pathologic fracture (needs surgical immobilization) → Because the bone is weak in origin so they need to recover the optimal quality of the bone

The summary of Healing



- The reaction to a fracture begins with an organizing hematoma. Within 2 weeks, the two ends of the bone are bridged by a fibrin meshwork in which osteoclasts, osteoblasts, and chondrocytes differentiate from precursors. These cells produce cartilage and bone matrix, which, with adequate immobilization, remodels into normal lamellar bone. FGF, Fibroblast growth factor; PDGF, platelet-derived growth factor; TGF-β, transforming growth factor-β.