

## Unit VII – Problem 4 – Pathology: Osteonecrosis and osteoporosis

### - Osteonecrosis is also known as: avascular bone necrosis (because of insufficient blood supply) or aseptic necrosis (not occurring in relation to an infection).

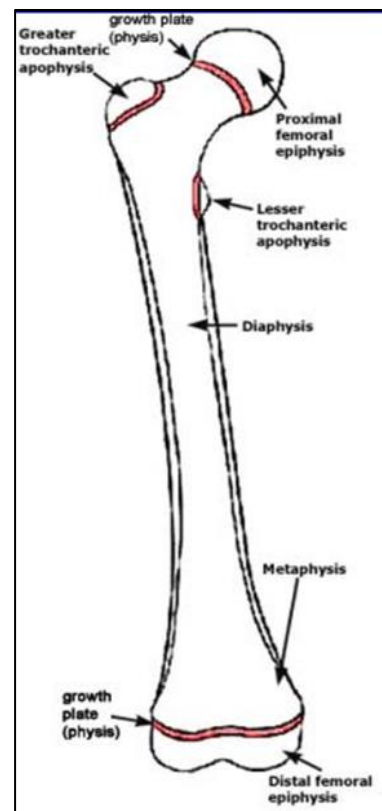
- **Definition of osteonecrosis:** the death of bone and bone marrow due to insufficient blood supply (without the presence of an infection).
- **Causes:**
  - ✓ Emboli: producing focal bone infarction.
  - ✓ Systemic diseases such as polycythemia (in which there is increased blood viscosity) or sickle-cell disease (in which the crescent-shaped RBCs lead to microinfarcts in the capillaries).
  - ✓ Thrombosis of local vessels.
  - ✓ Osteochondritis dissecans: a condition of unknown etiology in which a piece of articular cartilage and subchondral bone breaks off into a joint. It is thought that a focal area of bone necrosis occurs and eventually detaches.
- **Idiopathic osteonecrosis:**
  - ✓ Osteonecrosis in the head of the femur among adults.
  - ✓ Legg-Calve-Perthes disease: osteonecrosis in the head of the femur among children (it is bilateral in 10% of cases).
- **The image below:** shows the head of the femur with an intact articular cartilage. There is an infarct below the articular cartilage (appearing as a white plaque). This infarct is surrounded by congested bone tissue (due to the formation of granulation tissue).



- **Healing process:**
  - ✓ Healing of a cortical bone: occurs by “cutting cones” in which osteoclasts will remove the dead bone and then osteoblasts will form new bone.
  - ✓ Healing of a cancellous bone: occurs by “creeping substitution” in which the dead part with necrotic marrow will be invaded by new blood vessels carrying with them osteoclasts for resorption & osteoblasts for new bone formation.
- Osteoporosis:
  - **Bone composition/structure:** mineralized matrix with organic (type-I collagen) and inorganic (Ca) and other components.
  - **Organization of the bone:**
    - ✓ Cortical (compact) bone: for integrity and strength.
    - ✓ Cancellous (trabecular) bone: sites of turnover.
    - ✓ Woven (reparative/reactive) bone: found during callus formation.
  - **Modifying factors of bone remodeling:**
    - ✓ Role of bone homeostasis: the bone is a major store of calcium & proteins (collagen type-I). These are released by osteoclasts when they are needed in the blood. With time, they must be replaced again otherwise this will lead to bone weakness.
    - ✓ Genetic and local growth factors.
    - ✓ Number of stem cells and vascular proliferation.

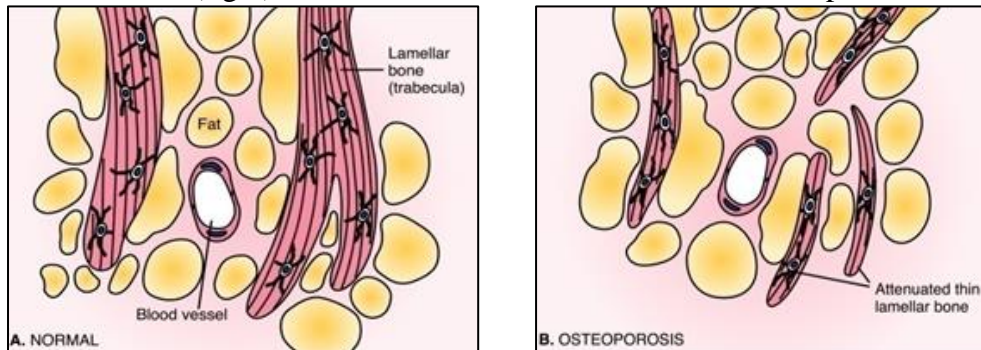
- **Bone growth:**

- ✓ Bones of the hand are composed of: carpals (arranged in two rows), metacarpals and phalanges (proximal, middle and distal except for the thumb which only has proximal and distal phalanges).
- ✓ The growth plate: is a cartilage made of 1 or 2 layers of stem cells → during growth, this cartilage is replaced by the formation of strong bone and this will give the bone its length.
- ✓ Why can't the distal phalanx be as long as the femur?
  - ❖ Because the growth plate is capable to differentiate to a strong bone for a certain number of divisions throughout life → this is why epiphysis of different bones will close at certain ages.
- ✓ There are 4 growth plates in the femur bone (see the figure). The first 3 growth plates are responsible for the shape of the head of femur.



- **Definition of osteoporosis:** skeletal lesions in which the normal mineralized bone mass is reduced → no maintenance of integrity.

- **The image below:** normal (left): bone trabeculae surrounded by fat. Abnormal (right): trabeculae are reduced in number in osteoporosis.



- **Causes of osteoporosis:** normally, there is a balance between osteoblastic and osteoclastic activities.

- ✓ Excess bone removal over normal bone formation.
- ✓ Excess bone removal over decreased bone formation.
- ✓ Normal resorption with decreased bone formation.

- **Types of osteoporosis:**

- ✓ Physiological-pathological:
  - ❖ Physiological osteoporosis is normal in elderly and post-menopausal females.
  - ❖ Pathological osteoporosis: mechanical fail when weight bearing bones become susceptible to stress and fracture (vertebral crush fracture, neck of the femur, neck of the humerus and colle's fracture in the distal end of the radius).
- ✓ Primary-secondary:
  - ❖ Type-1 primary (post-menopausal) osteoporosis: ↓estrogen will lead to ↑osteoclastic activity (through the action of cytokines).
  - ❖ Type-2 primary (senile) osteoporosis: found in males > 70 yrs and reflects attenuated osteoblastic activity (there is no increase in osteoclastic activity).

**Note:** causes and modifying factors of primary osteoporosis:

- ✚ Genetic/ethnic factors.
- ✚ Calcium intake + calcium/ vitamin D metabolism.
- ✚ Physical activity.
- ✚ Environmental factors (ex. Alcohol and smoking).



- ❖ Secondary osteoporosis:
  - ✚ Endocrine causes:
    - **Corticosteroids:** inhibiting osteoblastic activity – catabolic effects on protein leading to loss of collagen – impair vitamin D-dependent intestinal absorption which increase the secretion of PTH.
    - **Estrogen:** cytokines act on both osteoclasts and osteoblasts via mediation by estrogen receptors.
    - **↑PTH:** it might be secondary to calcium malabsorption and leads to increased osteoclastic activity.
    - **↑thyroid hormone:** leading to increased bone turnover and increased osteoclastic activity.
    - **Hypogonadism:** it is associated with deficiency of anabolic androgens in males and estrogen deficiency in females.
  - ✚ Malignancy:
    - **Multiple myeloma:** malignant plasma cells secrete osteoclast activating factors.
    - Some **leukemias** and **lymphomas**.
    - **Systemic mastocytosis:** due to local release of heparin which leads to increased resorption.
    - **Metastatic bone deposits** from cancers of thyroid, GIT, kidney and neuroblastomas produce lytic lesions by stimulating osteoclasts.
  - ✚ Others:
    - **Malabsorption:** impaired absorption of calcium, phosphate and vitamin D (ex. In hepatic and GIT diseases).
    - **Alcoholism:** direct inhibition of osteoblasts and calcium absorption.

✓ Localized-generalized.



**Vertebral osteoporosis.** [A] Lower thoracic vertebrae showing small protrusions of the intervertebral disc into the osteoporotic bone (arrowed). [B] Lumbar spine. The vertebral body in the centre has collapsed ►► typical biconcave shape deformity.