Bone Injury and Inflammatory Bone Diseases

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Bone necrosis. Cross section.

Note the large area of necrosis (N) seen as pale discolored bone (beneath physeal cartilage).

The texture of the necrotic bone is also changed. Necrotic bone becomes friable (rather than hard) as demonstrated by scratching the bone with a sharp object. For another example of bone necrosis see figure 10-23 Thomson's book.
Bone Necrosis.

Normal bone typically shows osteocytes inside the bone lacunae. These osteocytes appear as dark cells (arrows). In contrast, note the lack of visible osteocytes in the necrotic bone (arrowheads) where the lacunae appear empty. Also, note in the necrotic bone the lack of bone marrow cells.

Aseptic necrosis of bone occurs as a result of ischemia or trauma. As long as the blood circulation has not been compromised, necrotic bone is reabsorbed by osteoclastic activity.
Necrosis → resorption → woven bone → mature bone

Fractured bone spicule

Note the woven bone joining and replacing an old fractured spicule of mature lamellar bone.

Mature lamellar bone (lb) appears as pink and well organized in which collagen fibers are compacted and arranged in a parallel fashion. In contrast, woven bone (wb) is less compacted and the collagen fibers are organized in a crisscross fashion.

Eventually, woven bone (w) would be replaced by mature lamellar bone (l).
Necrosis → resorption → woven bone → scar (callus)

Bone Necrosis.

A fractured rib with callus formation.

If the size of the necrosis is large like in this fractured rib, repair occurs but leaves a visible scar known as callus. Note the enlargement of the rib at the site of the callus.

A healing fracture starts with hemorrhage and the formation of a hematoma at the site of fracture. This hematoma is rapidly invaded by fibrous connective tissue forming a temporary fibrous bridge between the edges of the fracture. With time, the fibrous connective tissue becomes infiltrated with osteoblasts which lay down osteoid. The osteoid and the osteoblasts form woven (immature) bone. Finally, woven bone is reabsorbed and replaced by mature (lamellar) bone forming a secondary callus.

See figure 10-13 Thomson's book.
Necrosis → resorption → woven bone → scar (callus)

Bone Calluses.

Old Rib Fractures.

Note the multiple bone calluses (arrows) in the fractured rib cage.

Passing through the birth canal is sometime traumatic enough to cause multiple rib fractures in neonates.

Acquired trauma such as kicking or being hit by a car other common causes of multiple rib fractures.
**Necrosis → NO resorption → bone sequestrum**

**Bone Sequestrum.**

**Spine**

Note the large **sequestrum** (asterisk) in the vertebral body.

A bone sequestrum is formed when a large piece of necrotic bone becomes isolated from circulation and cannot be reached by osteoclasts.

Although it is not visible in this slide, a band of connective tissue known as **involucrum** generally surrounds the sequestered dead bone.
Necrosis → resorption → inflammation → proliferation

Chronic, proliferative osteomyelitis.
Distal part of large bone.

Note the extensive Osteophyte proliferation resulting from chronic arthritis and osteomyelitis.

Chronic and persistent inflammation and necrosis of bone induces abnormal remodeling characterized by the growth of bone nodules known as Osteophytes. In severe cases, these Osteophytes cover large portions of the periosteal bone or joint.

As shown in this case, proliferation and formation of Osteophytes obliterate the entire diaphysis of the femur in this pig.
Suppurative (pyogenic)

Osteomyelitis resulting from bacteremia in a young animal.

In the bone shown here there is good evidence of suppurative (neutrophilic) inflammation and osteolysis which appear as a large pale area of discolored bone. Note that there is exudate in the diaphysis (below the growth cartilage) and metaphysis (above of the growth cartilage) of this bone.

Remember that in osteomyelitis, the suffix *myelitis* means inflammation of bone marrow. It should not be confused with *myelitis* as in inflammation of the spinal cord (i.e., encephalomyelitis).

Metaphyseal blood vessels are commonly the site of septic osteomyelitis in farm animals and foals.
Suppurative (pyogenic).

Osteomyelitis from neonatal bacteremia in a young calf.

Another view of suppurative osteomyelitis. Note the purulent exudate and dissolution of bone tissue (asterisk). In most cases if septic inflammation, neutrophils induce extensive lysis of the bone which often results in pathological fractures.

An aspirate of this type of lesion would reveal large numbers of neutrophils some of which may contain bacteria.
Osteomyelitis. Histopathology

Note the large cluster of leukocytes in the bone. Also note the bone trabecula in this area has already been reabsorbed by ostoclastic activity and replaced by fibrotic tissue as a first step for repair. Assuming that the infection is controlled, new woven bone will replace this localized area of fibrosis.

Bone infections occur commonly as a sequel of bacteremia. Compared to other tissues, bone infections are difficult to treat.
**Actinocycosis - Lumpy Jaw**

Note the swelling of the jaw due to localized osteomyelitis with exudate in the ulcerated skin (fistula). The pathogenesis of this lesion generally involves soft tissue trauma of the oral cavity with penetration of opportunistic *Actinomyces bovis*.

The macerated jaw reveals exuberant exostosis. Pyogranulomatous inflammation of the mandible in Actinomycosis is generally unilateral. Bone deformation and severe exostosis occur following episodes of bone necrosis and repair as is the case with chronic inflammation.

(See figure 10-29 Thomson's book).
Spinal Abscess

This pig was unable to stand due to spinal cord injury resulting from a spinal abscess.

Abscesses in the vertebrae are common in pigs and cattle. It is postulated that "tail bite" skin infections often result in bacterial emboli lodging in the vertebral bodies (spondylitis). If several animals are affected in a herd, it indicates poor health management. Vertebral inflammation often extends to the meninges and causes meningitis.

Note the large vertebral abscess (asterisk) with compression of the spinal cord (arrows).

Compression of the spinal cord could lead to pathological fractures in the vertebrae.
Chronic osteomyelitis
*Rhodococcus equi* / foal

Note the lytic lesion in the x-ray and in the corresponding hemisection of vertebra. This foal had been previously diagnosed with sepsis and ataxia.

*Rhodococcus equi* was isolated from the exudate in a vertebra. Omphalophlebitis is a common source of bacterial embolisms in neonates.

Bacterial embolisms lodge primarily in the epiphyseal vessels of long bones. These infections are important in young foals where 70% of foals with *joint-ill* also have septic osteomyelitis.

The inflammation in this foal extended into the spinal canal causing meningitis.
Chronic mycotic osteomyelitis / Canine pelvis, femur, and vertebra.

Blastomycosis.

Bone inflammation and with notable exostosis are commonly seen in infections caused by systemic mycoses. These fungal diseases commonly cause chronic disseminated osteomyelitis that is part of a multi-systemic infection involving other tissues such as lymph nodes, spleen, skin, liver, brain, eyes, etc.

**Systemic (deep) mycoses** as their name implies, are disseminated fungal infections caused by dimorphic fungi such as *Blastomyces dermatitides, Coccidioides immitis* and *Cryptococcus neoformans*. These fungi disseminate, through the blood and lymphatic systems, to many tissues including bones.

Note the chronic granulomatous osteomyelitis characterized by proliferative lesions (exostosis) in the skeleton of this dog.

A microscopic view is shown in the next slide.
Chronic osteomyelitis / Canine Blastomycosis. Histopathology

A tissue section (PAS stain) of a lytic bone lesion in the leg of a mature dog with a history of weight loss, cough and lameness. The dog also exhibited ulcerated skin lesions and a disseminated lymphadenomegaly (enlargement of lymph nodes). Many organs had multiple pyogranulomas.

Note the several PAS-positive yeasts (*Blastomyces dermatitides*) inside a multinucleated giant cell. Because of a high carbohydrate contents, the walls of yeast stain positive with PAS stain.
Pulmonary hypertrophic osteoarthropathy. Dog

Pulmonary hypertrophic osteoarthropathy is a disease of convoluted pathogenesis characterized by extensive proliferation of osteophytes along the entire appendicular skeleton. In humans this condition is called Marie's Disease.

The pathogenesis is still controversial but a space-occupying mass in the thorax such as large abscesses or tumors is often incriminated. If the thoracic mass is removed, bone lesions tend to regress.

Megakarocytes released into circulation are normally trapped in the pulmonary capillaries. When there is a space occupying mass in the thorax, pulmonary hypertension induces vascular anastomosis that allows for magakaryocytes to reach the periosteal bone.

Note the severe hyperostosis along the entire periosteal surface of these bones.
Craniomandibular osteopathy (Lion's jaw). Canine.

Craniomandibular osteopathy is a localized bone disease in dogs of unknown etiology that results in extensive periosteal proliferation of the mandible and cranial bones. It is mainly seen in West Highland White and Scottish Terriers.

Lesions affect only the head, are bilaterally symmetrical, and self-limiting. The tympanic bullae are severely affected in most cases. Clinically, there is painful swelling and enlargement of the temporal-maxillary region. Grossly and radiographically, there are proliferative changes in the temporal and maxillary bones causing bony bridging on the periosteal surface.