Osteology – Healing of Fractures

- 5 histologic stages of fracture healing:
  1. Fracture
  2. Formation of granulation tissue around fractured bone ends
  3. Replacement of granulation tissue by callus
  4. Replacement of callus by lamellar bone
  5. Remodeling of bone to normal contour
Osteology – Healing of Fractures

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Reactive phase

Reparative phase

Remodeling phase
Osteology – Healing of Fractures

- Fracture causes haemorrhage and tissue destruction; blood clot forms (hours)
- Proliferating fibroblasts and capillary sprouts grow into blood clot in injured area, forming granulation tissue, in response to cytokines released by tissue damage (days)
Fracture Healing

Haemorrhage

Tissue destruction

Proliferating fibroblasts and capillary sprouts grow into blood clot in injured area, forming granulation tissue

Modified from Junqueira
Fracture Healing

Invaded by neutrophils, macrophages which phagocytize debris

Granulation tissue becomes denser

Cartilage forms

Modified from Junqueira
Fracture Healing

Connective tissue
+ Cartilage tissue
= Callus

Callus temporarily binds and stabilizes bone

Dormant osteogenic cells of periosteum enlarge, become osteoblasts, deposit osseous material on outside of bone centripetally

Modified from Junqueira
Fracture Healing

Sheath of bone is formed over fibrocartilaginous callus; osteogenic buds invade this callus and replace it with bony callus; in replacement of this callus, cartilage undergoes calcification and absorption same as in intracartilaginous bone formation

Modified from Junqueira
Summary diagram of bone healing

**Fig. 12-43.** Summary diagram of healing rib fracture. New cancellous bone is shown in black; cartilage is indicated in light stipple. Arrowheads indicate the direction of growth of trabeculae of new bone in the external and internal callus. For details, see text.

From Cormack
Fracture Healing

Figure 8-17. Repair of a fractured bone by formation of new bone tissue through periosteal and endosteal cell proliferation.

From Junqueira
Factors Affecting Fracture Healing

- Both local and systemic variables influence the rate and degree of fracture healing. When normal healing occurs, but at a slower rate than usual, it is termed delayed union. A complete cessation of the healing process, in which fibrous tissue is never replaced by bony matrix, is termed non-union.
Systemic Factors Affecting Fracture Healing

- **Age:** Young patients heal rapidly and have a remarkable ability to remodel and correct angulation deformities. These abilities decrease once skeletal maturity is reached.

- **Nutrition:** A substantial amount of energy is needed for fracture healing to occur. An adequate metabolic stage with sufficient carbohydrates and protein is necessary.
Systemic Factors..cont

- **Systemic Diseases**: Diseases like osteoporosis, diabetes, and those causing an immunocompromised state will likely delay healing. Illnesses like Marfan’s syndrome and Ehlers-Danlos syndrome cause abnormal musculoskeletal healing.

- **Hormones**: Thyroid hormone, growth hormone, calcitonin, and others play significant roles in bone healing. Corticosteroids impede healing through many mechanisms.
Local Variables Affecting Fracture Healing

- Type of bone: Cancellous (spongy) bone fractures are usually more stable, involve greater surface areas, and have a better blood supply than do cortical (compact) bone fractures. Cancellous bone heals faster than cortical bone.

- Degree of Trauma: The more extensive the injury to bone and surrounding soft tissue, the poorer the outcome. Mild contusions with local bone trauma will heal easily, whereas severely comminuted injuries with extensive soft tissue damage heal poorly.
Local Variables..cont

- Vascular Injury: Inadequate blood supply impairs healing. Especially vulnerable areas are the femoral head, talus, and scaphoid bones.
- Degree of Immobilization: The fracture site must be immobilized for vascular ingrowth and bone healing to occur. Repeated disruptions of repair tissue, especially to areas with marginal blood supply or heavy soft tissue damage, will impair healing.
Intraarticular Fractures: These fractures communicate with synovial fluid, which contains collagenases that retard bone healing. Joint movement will cause the fracture fragments to more, further impairing union. When intraarticular fractures are comminuted, the fragments tend to float apart owing to loss of soft tissue support.

Separation of Bone Ends: Normal apposition of fracture fragments is needed for union to occur. Inadequate reduction, excessive traction, or interposition of soft tissue will prevent healing.
Local Variables..cont

- Infection: Infections cause necrosis and oedema, take energy away from the healing process, and may increase the mobility of the fracture site.

- Local Pathology: Any disease process that weakens the musculoskeletal tissue, like osteoporosis or osteomalacia, may impair union.
Thank you