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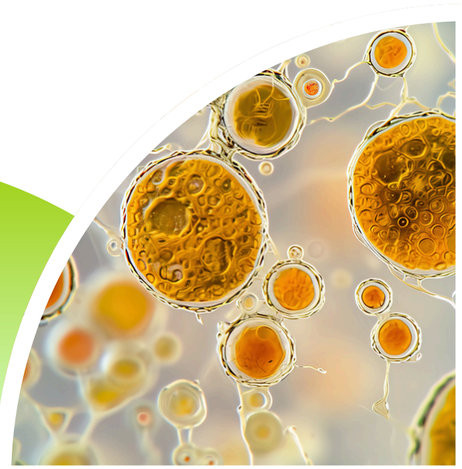

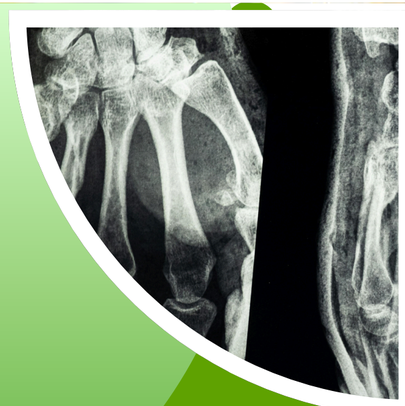


Mechanism and Illness of Human Body 2

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Disorders of the Musculoskeletal System

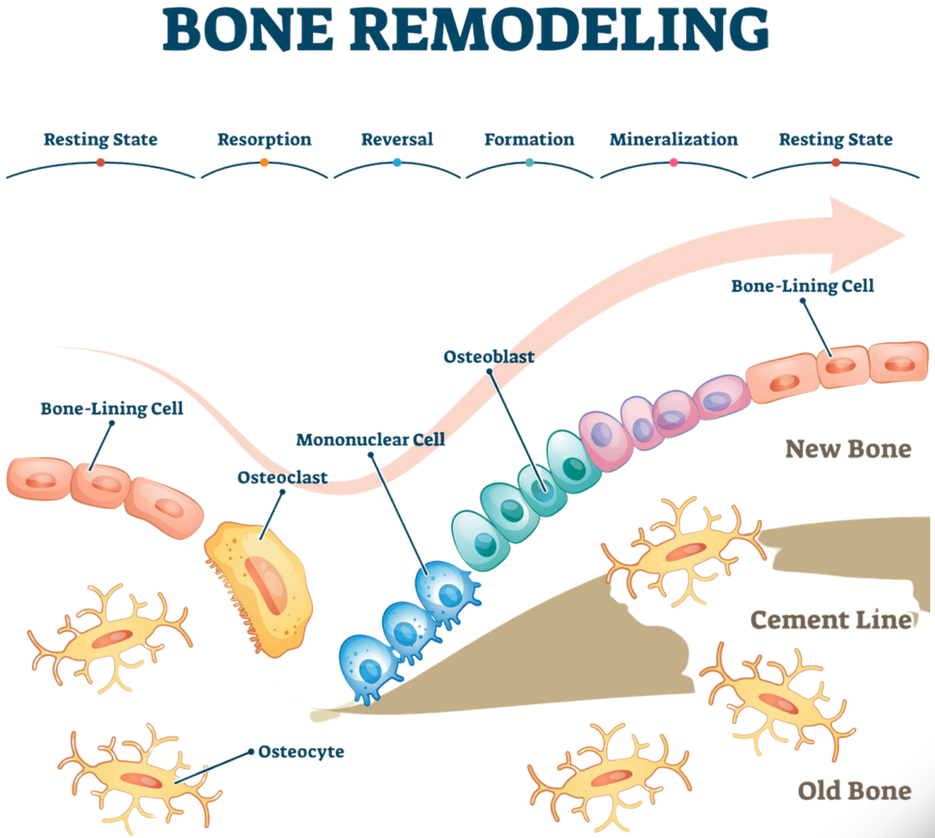
Bone Cells & Remodeling Unit

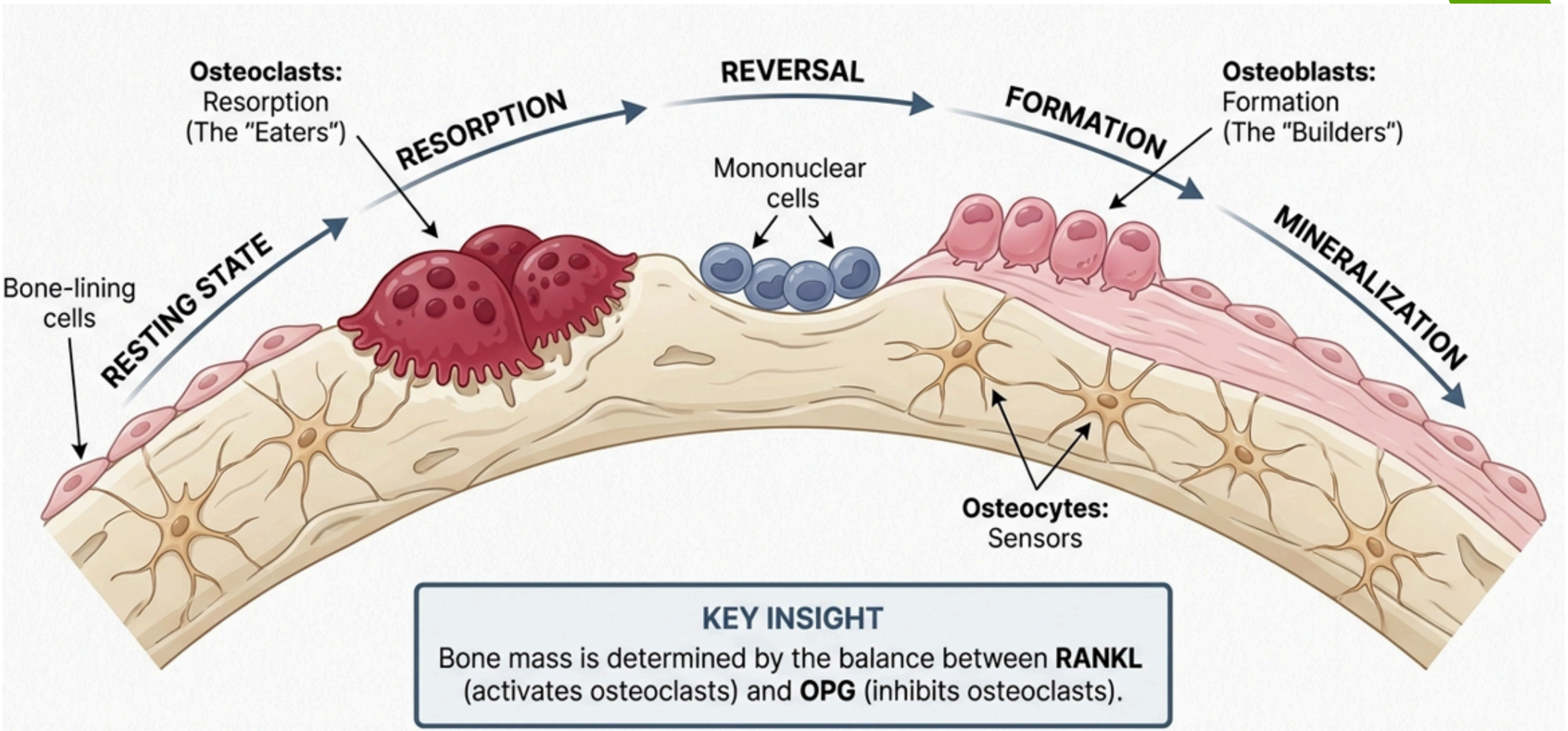
Osteoblasts: Bone formation; synthesize Collagen & Ground substance

Osteoclasts: Bone resorption; regulated by RANK-Ligand system

Osteocytes: Mature cells; regulate remodeling via mechanotransduction

Key Concept: Balance between RANKL (activates osteoclasts) and OPG (inhibits osteoclasts) determines bone mass




Osteoclasts:
Resorption
(The "Eaters")
RESORPTION
REVERSAL
FORMATION
Osteoblasts:
Formation
(The "Builders")
Mononuclear
cells
RESTING STATE
MINERALIZATION
Bone-lining
cells
Osteocytes:
Sensors
KEY INSIGHT
Bone mass is determined by the balance between RANKL
(activates osteoclasts) and OPG (inhibits osteoclasts).

Calcium Homeostasis (The Regulators)

Parathyroid Hormone (PTH):

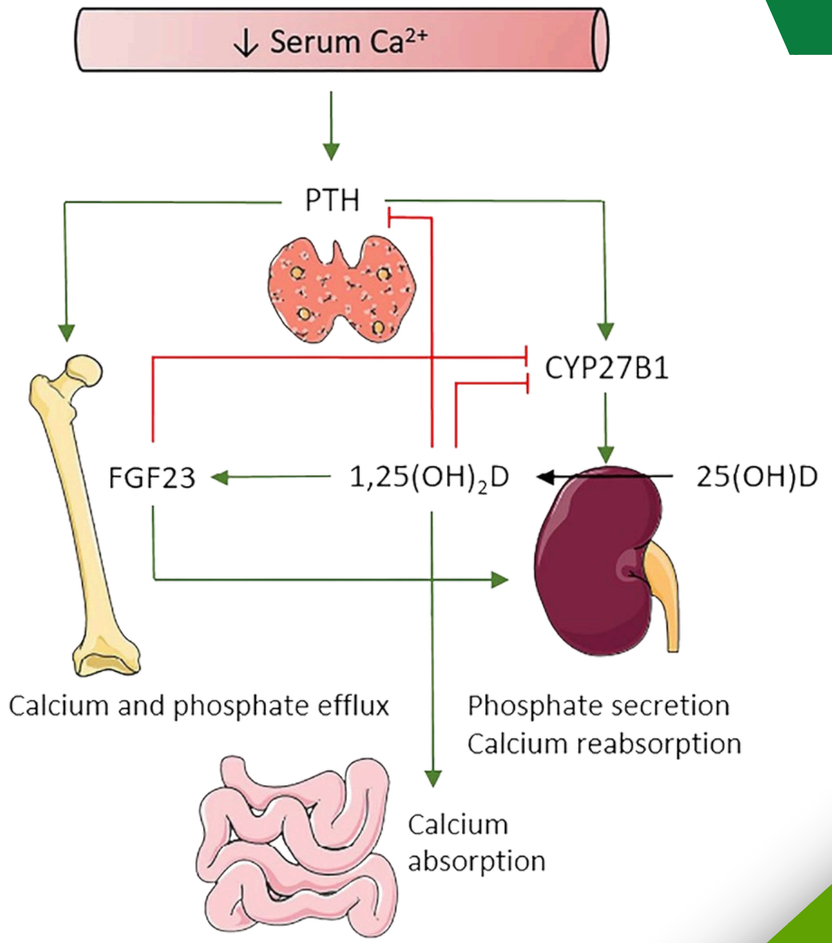
Secreted when blood Ca2+ is low

Action 1: Increases bone resorption (Osteoclast activity)

Action 2: Increases renal Ca2+ reabsorption

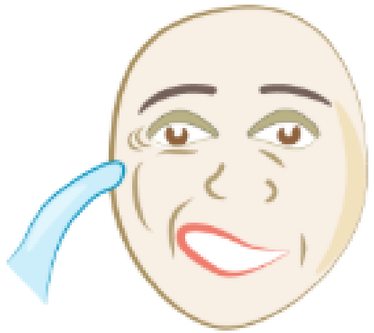
Action 3: Activates Vitamin D in kidneys

Vitamin D (Calcitriol): Increases Ca 2+ absorption from the intestine

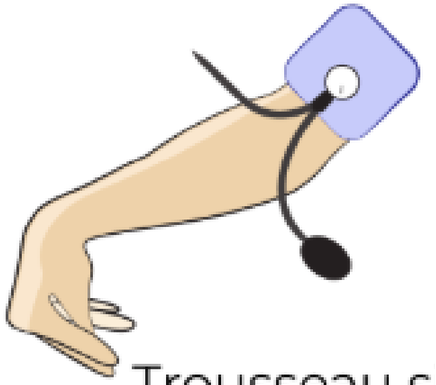


(Corbeels, et al., 2018)

Clinical Signs of Hypocalcemia



Chvostek
Sign (CN VII)



Trousseau sign

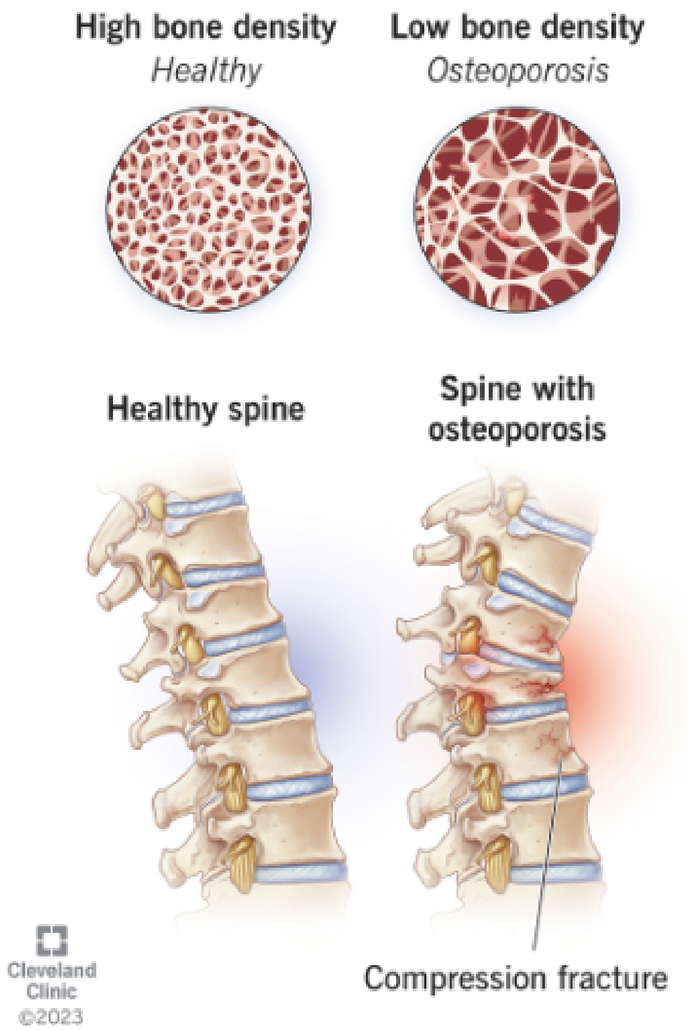
Pathophysiology: Low calcium increases neuronal excitability

Assessment:

Chvostek's Sign: Facial muscle twitching when tapping the facial nerve

Trousseau's Sign: Carpal spasm after inflating BP cuff above systolic pressure

Osteoporosis



Low bone mass & micro-architectural deterioration

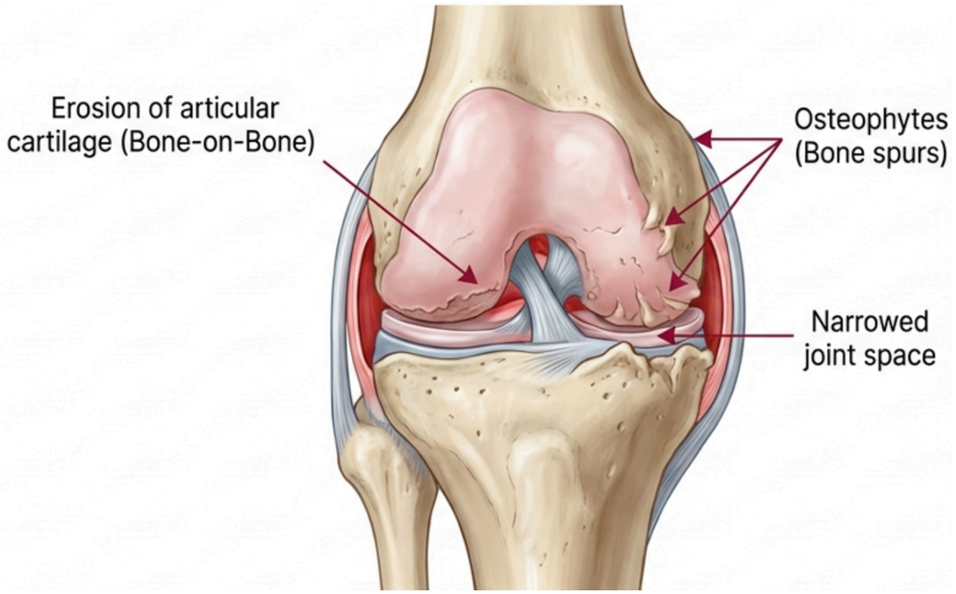
Post-Menopausal Mechanism (Type I):

Estrogen Deficiency: Leads to increased Osteoclast activity (via increased RANKL)

Bone resorption > Bone formation

Risk Factors: Low Calcium/Vit D intake, Inactivity, Steroid use

Osteoarthritis (OA)



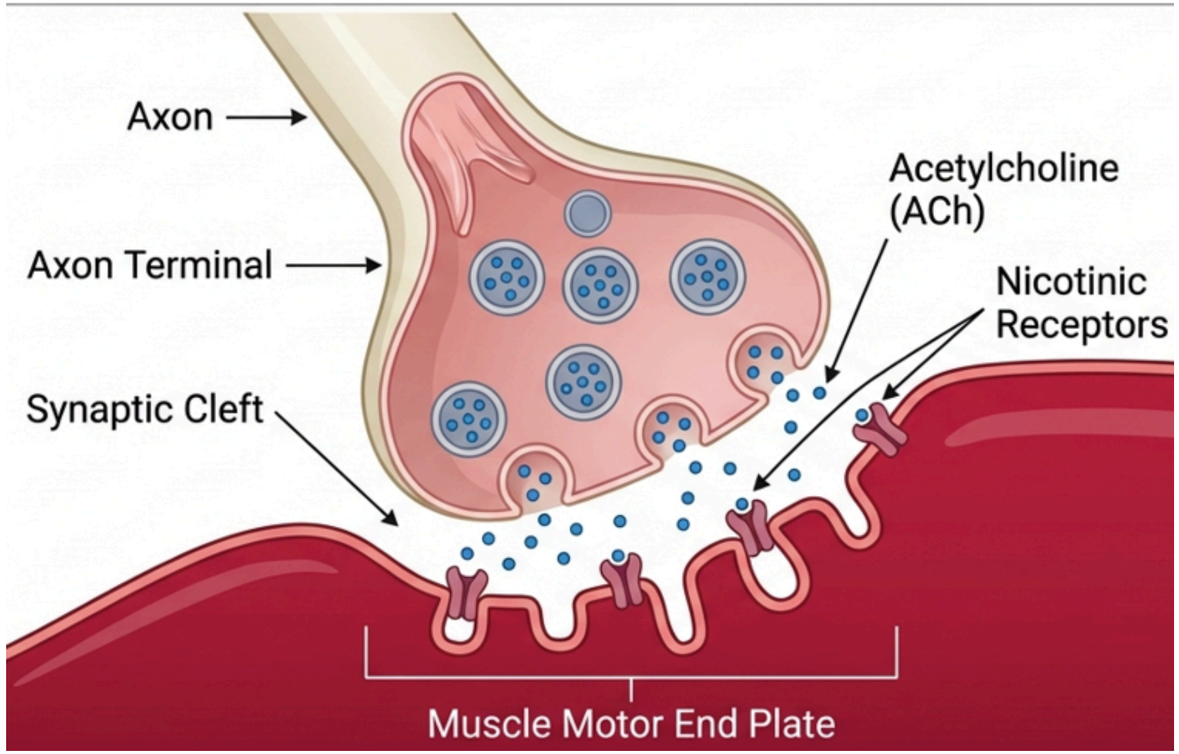
Degeneration of Articular Cartilage

Pathogenesis:

- Imbalance of cartilage synthesis/degradation
- Inflammatory cytokines (IL-1, TNF)
- Formation of Osteophytes (bone spurs) and subchondral bone sclerosis

Symptoms: Pain on weight-bearing, stiffness, Crepitus

The Neuromuscular Junction (NMJ)



Structure: Connection between Motor Neuron and Muscle Fiber.

Neurotransmitter: **Acetylcholine (ACh)**

Mechanism:

- Action potential reaches nerve terminal.
- ACh released into synaptic cleft.
- Binds to Nicotinic receptors on Motor End Plate.
- Triggers muscle action potential.

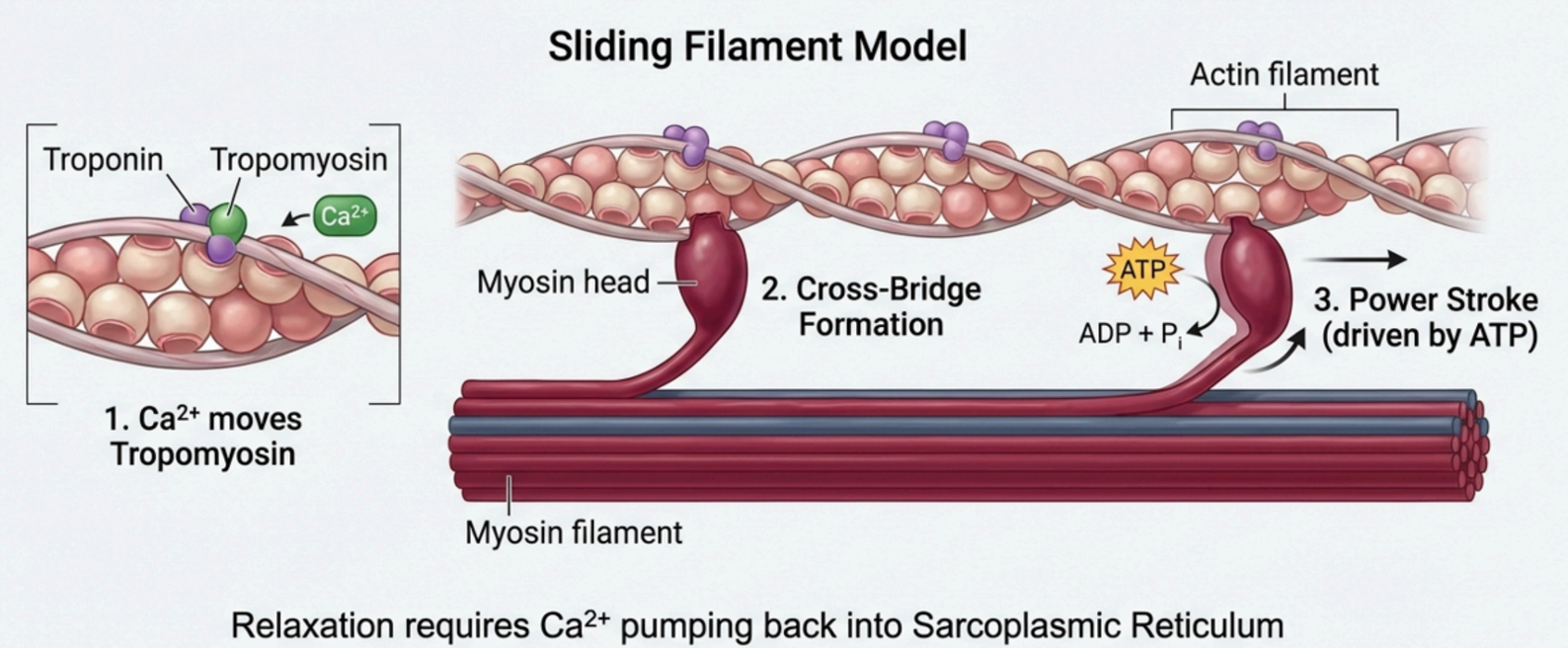
Mechanism of Muscle Contraction

Calcium (Ca2+): Binds to Troponin C moves Tropomyosin

Cross-bridge: Myosin head binds to Actin

Power Stroke: Requires ATP hydrolysis

Relaxation: Ca2+ is pumped back into Sarcoplasmic Reticulum (SR)



Energy Metabolism in Muscle

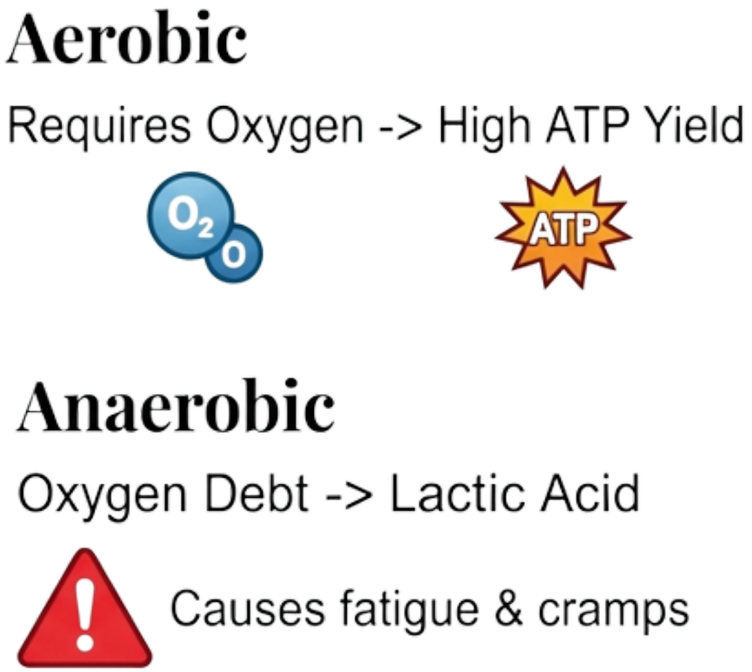
Aerobic Pathway: Requires O2; High ATP yield

Anaerobic Pathway:

Occurs during strenuous exercise /Oxygen debt

Breakdown of Glucose --> Pyruvate --> Lactic Acid

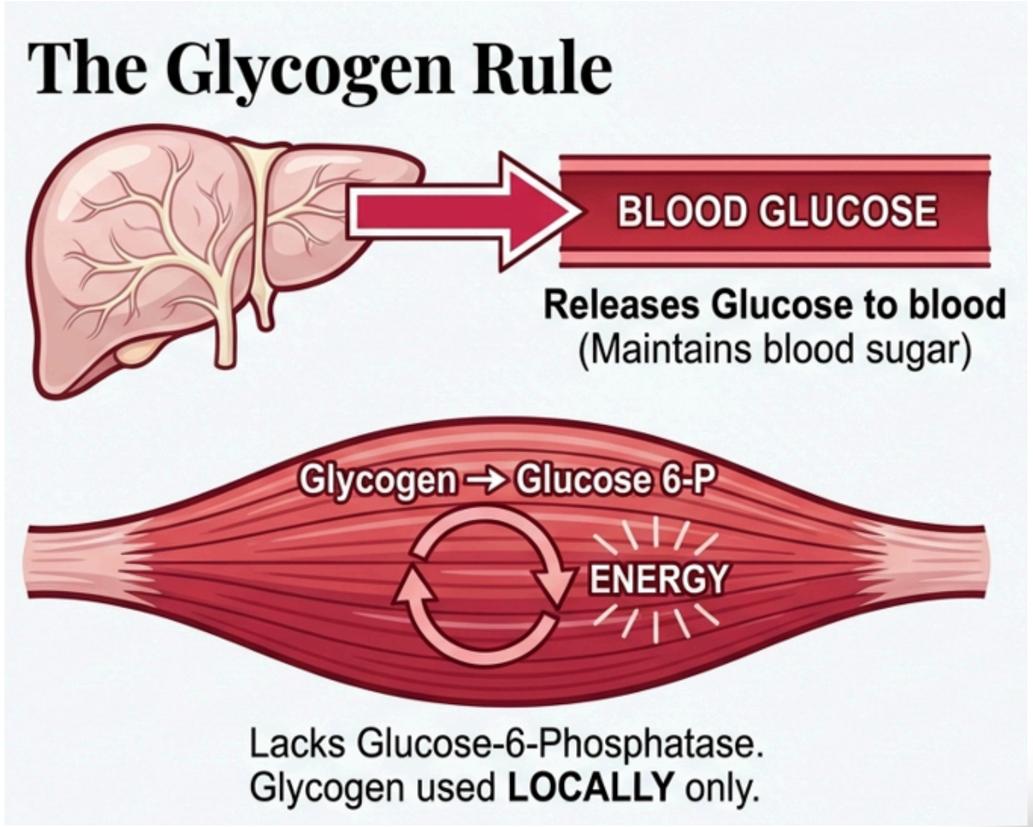
Consequence: Accumulation of Lactic Acid contributes to muscle fatigue and cramps



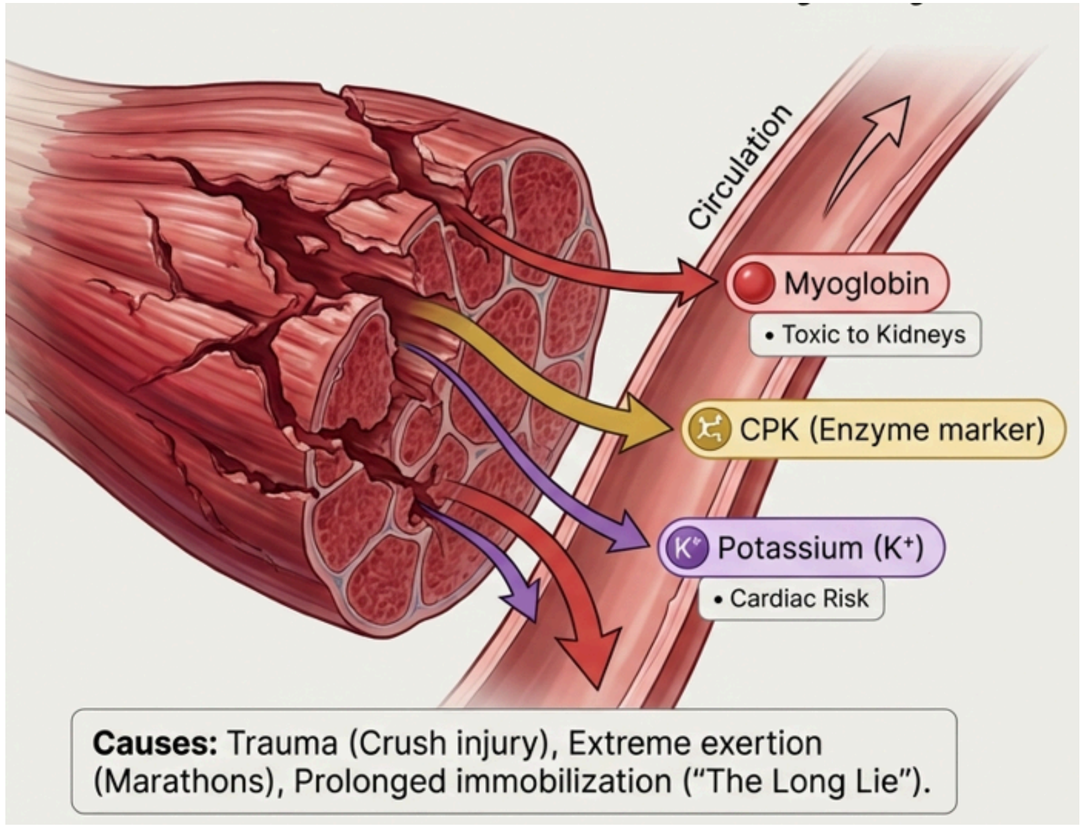
Glycogen: Liver vs. Muscle

Liver Glycogen: Can be converted to Glucose and released into blood (Maintains blood sugar)

Muscle Glycogen:
Lacks the enzyme Glucose-6-Phosphatase
Result: Muscle glycogen is used only by the muscle itself;
it cannot raise blood glucose levels



Rhabdomyolysis (Overview)



Rapid breakdown of skeletal muscle tissue

Causes:

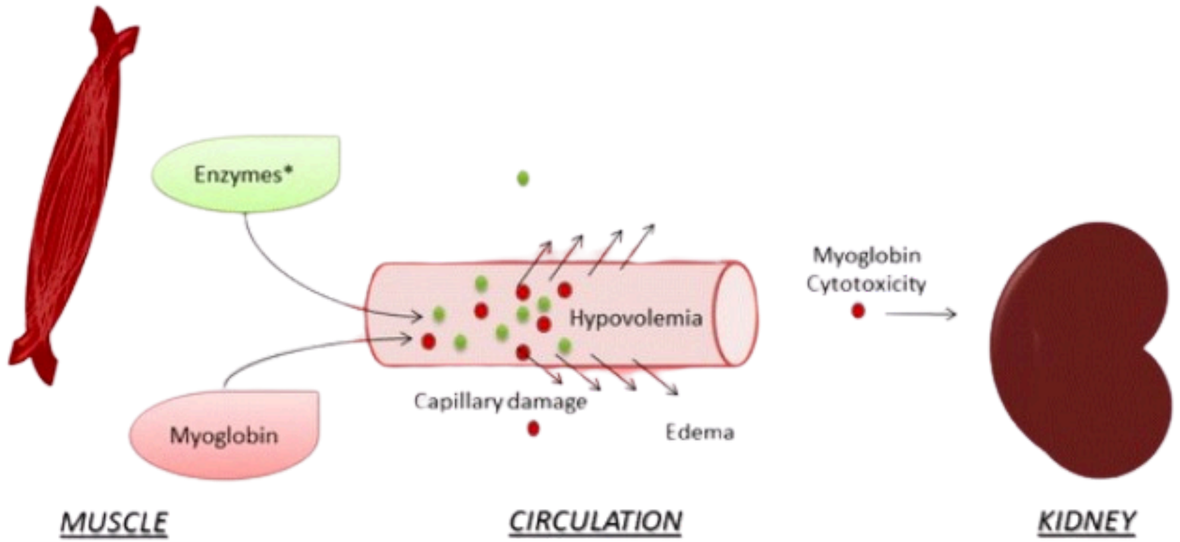
Trauma (Crush injury), Extreme exertion (e.g., Marathon)

Drugs/Toxins, Prolonged immobilization (The "Long Lie" in elderly)

Mechanism:

1. Sarcolemma damage --> Calcium influx
2. Cell necrosis
3. Release of intracellular contents:

- Myoglobin
- Creatine Phosphokinase (CPK)
- Potassium (K+)



Lab Findings:

Elevated CPK: Most sensitive marker (> 5x normal).

Hyperkalemia: Risk of cardiac arrhythmia.

Myoglobinuria: Tea-colored urine.

Urinalysis: Positive for blood (heme) but no RBCs seen.

Complication

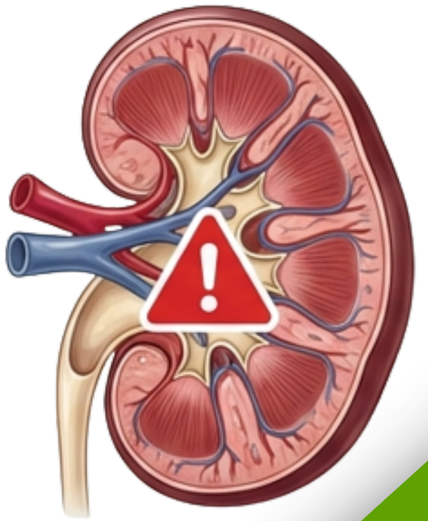
Acute Kidney Injury (AKI)

Myoglobin is nephrotoxic

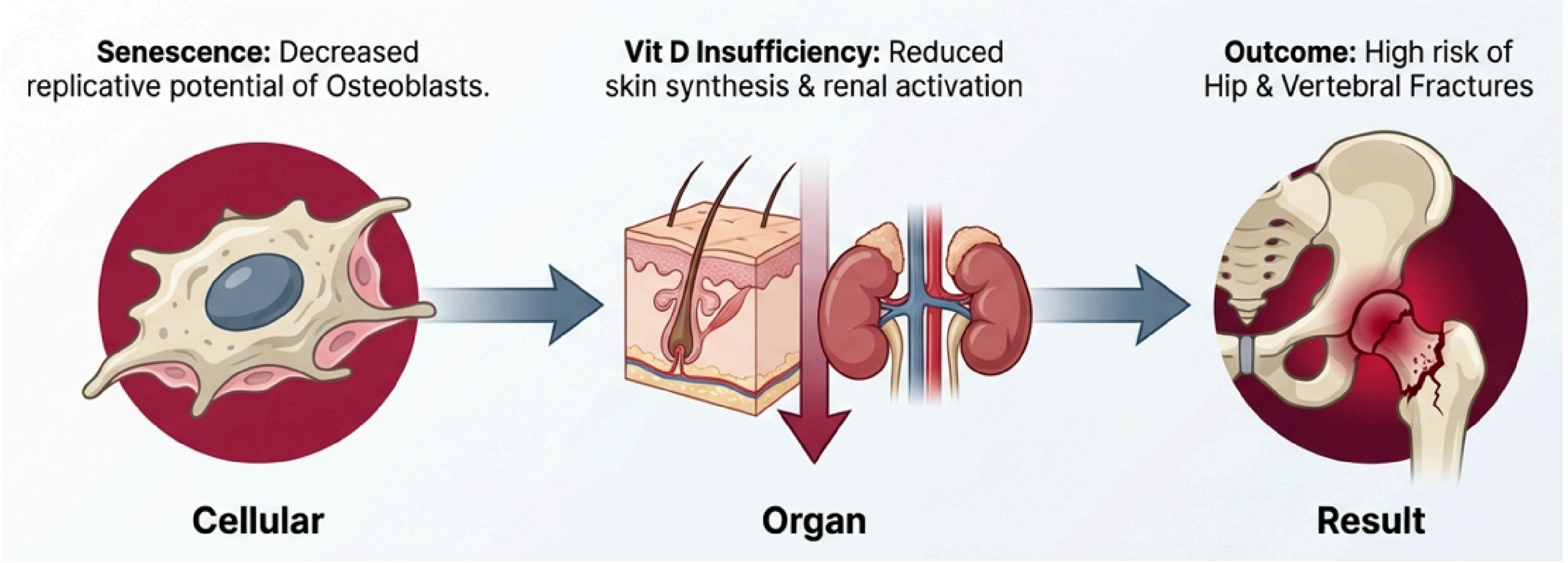
Causes tubular obstruction

Compartment Syndrome: Muscle swelling increases pressure.

Disseminated Intravascular Coagulation (DIC)



Age-Related Changes in Bone (Geriatric Osteopathology)



Age-Related Changes in Muscle (Sarcopenia & Risk of Falls)

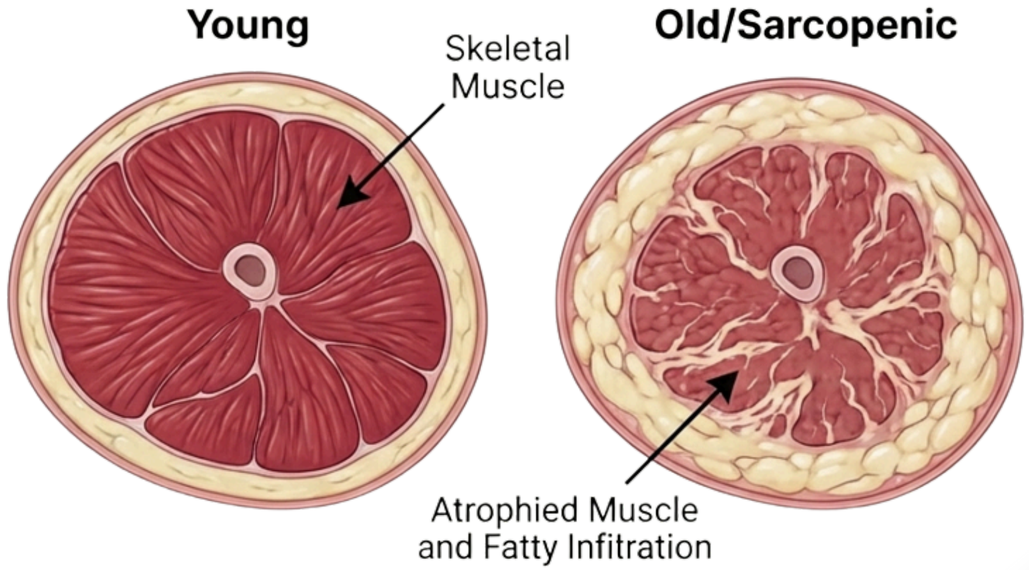
Sarcopenia:
Involuntary loss of skeletal muscle mass and function associated with aging.

Pathophysiology:

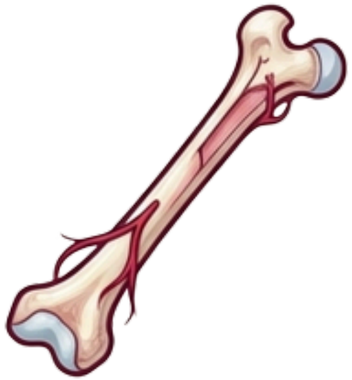
Denervation: Loss of alpha-motor neurons in the spinal cord.

Fiber Type Transformation

Mitochondrial Dysfunction: Reduced ATP production efficiency
(referencing oxidative pathway).

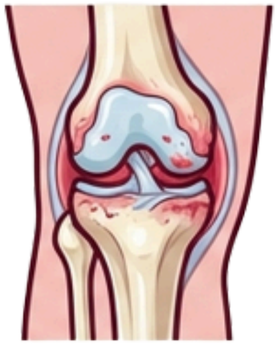


Summary of Key Points



Bone Health

Regulated by PTH & Vitamin D.
Osteoporosis occurs when Resorption > Formation.



Osteoarthritis

Not just aging. Driven by inflammatory cytokines and mechanical destruction of cartilage.

Muscle Physiology

Requires Neural input (ACh), Calcium (to unlock actin), and ATP (power stroke).

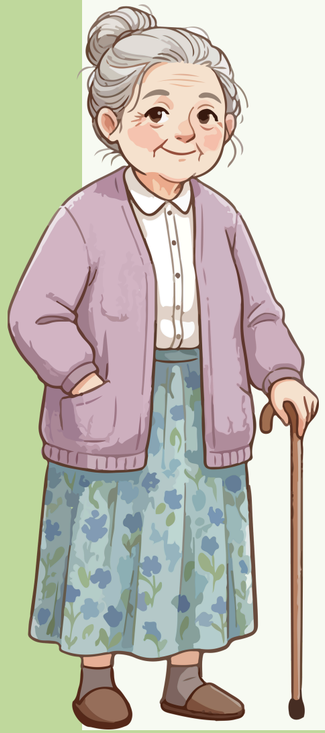
Medical Emergency

Rhabdomyolysis.
Signs: Muscle pain + Tea-colored urine.
Risk: Kidney Failure & Arrhythmia.

Case study

Mrs. G, an 82-year-old female with a history of Osteoporosis and Hypertension.

Mrs. G slipped in her bathroom and fell, sustaining a blow to her right hip. She was unable to get up due to severe pain and weakness.



Physical Examination:

- Right Leg: Shortened and externally rotated.
- Skin: Bruising noted over the right greater trochanter and sacral area.
- Neuro: confused.

Lab Results:

- Serum Creatine Phosphokinase (CPK): 5,500 U/L (High)
- Urinalysis: Dark, tea-colored urine; Positive for Heme but few RBCs seen under microscope.
- Serum Potassium (K^+): 5.8 mmol/L (Elevated)

Question

1. what complication has developed in addition to the hip fracture? Explain the pathophysiology.
2. Explain why Mrs. G's fracture presentation (Shortened and Externally Rotated leg) is classic for a femoral neck fracture, and link this to the cellular changes in her bones prior to the fall.

Answer

1

Diagnosis: Rhabdomyolysis

Pathophysiology:

Caused prolonged compression of the muscles against the hard floor, leading to muscle ischemia and cell membrane damage.

Mechanism: Breakdown of the sarcolemma allows the release of intracellular contents into the bloodstream.

Key Markers:

CPK: Released from damaged muscle cells

Hyperkalemia: Intracellular potassium is released from lysed muscle cells into the circulation.

Answer

2

Pathophysiology (Pre-fall):

- Mrs. G has Osteoporosis.
- Over time, her Osteoclast activity exceeded Osteoblast activity.
- This led to a loss of trabecular connectivity in the femoral neck (a weight-bearing area).
- The fall was likely a low-energy trauma that caused a fracture because the bone density was below the fracture threshold
- (T-score < -2.5).

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