12: Alterations of the Musculoskeletal and Integumentary Systems

Learning Objectives

- Review clinical manifestations of musculoskeletal diseases
- Explain the pathophysiology of bone fractures & osteoporosis
- Explain the pathophysiology *osteomyelitis*
- Explain the pathophysiology and types of *osteoarthritis*
- Explain the pathophysiology of *impaired uric acid metabolism* and *gout*
- Explain the pathophysiology of *fibromyalgia*
- Explain the pathophysiology of *various skin lesions*
- Explain the pathophysiology of *pressure ulcers*
- Explain the pathophysiology of *scleroderma*
- Explain the pathophysiology of *burn*
- Explain the pathophysiology of *common inflammatory disorders of the skin* and *psoriasis*
- Explain the pathophysiology of *common skin cancers*

Review: Anatomy and Physiology of the Musculoskeletal and Integumentary Systems

- Bone tissue is a solid connective tissue (review anatomy and physiology of bone tissue)
    - Cartilage is avascular while bone is very vascular
        - This is why intraosseous access can be effectively used for emergency vascular access in emergency and trauma situations where vascular access is not possible
    - The osteocyte is the "Mother Cell" for bone tissue
- Review of anatomy and physiology of the Integumentary System

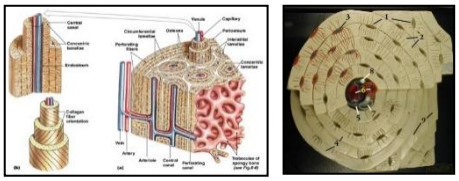


Figure 1: Compact and spongy bone

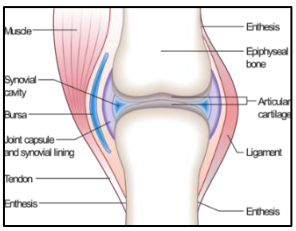


Figure 2: Synovial joint

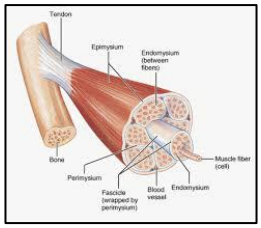


Figure 3: Muscle structure

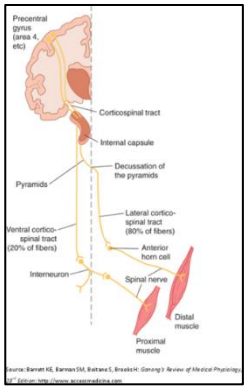
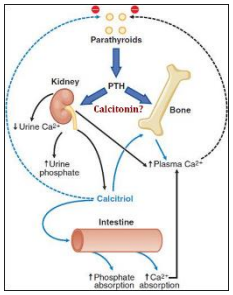


Figure 4: Corticospinal tract



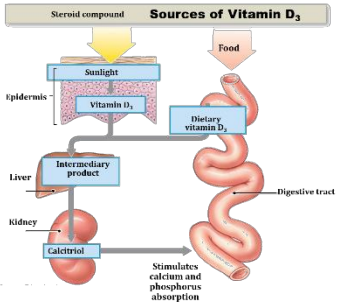


Figure 5: Vitamin D Synthesis

Bone Fractures

- A fracture is a break in the continuity of a bone

Classifications:

- Complete or incomplete
- Closed or open
- Comminuted
- Linear
- Oblique
- Spiral
- Transverse
- Greenstick – children (just a bend)
- Pathologic

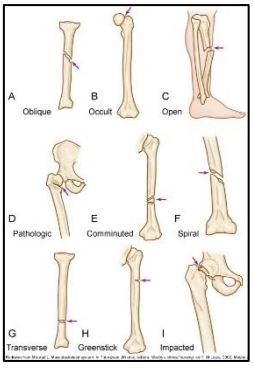


Figure 6: Classifications of bone fractures

Pathophysiology:

- Broken bone causes damage to surrounding tissue, periosteum, and blood vessels with hematoma formation
    - Inflammation process begins
- Bone tissue destruction triggers an inflammatory response and repair (callus formation)

Clinical manifestations:

- Numbness up to 20 minutes following injury
- Swelling, tenderness, pain, impaired sensation, muscle spasms, malalignment

Osteoporosis

- Porous poorly mineralized bone

Etiology:

- Decreased levels of estrogen and testosterone. Common in postmenopausal women (estrogen is an anabolic hormone)
- Inadequate levels of vitamin D (osteomalacia)
- Decreased physical activity level (age-related)
- Excess intake of caffeine, phosphorus, alcohol, nicotine
- Drug-induced eg glucocorticoids

Clinical manifestations:

- Bone aches, weakness & deformities, fractures

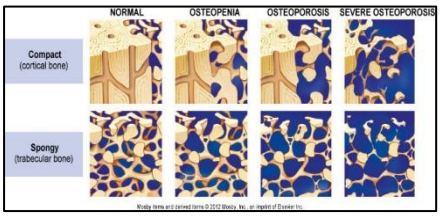


Figure 7: Comparison bone density in stages of osteoporosis to normal bone

Pathophysiology:

- Reduced bone mass/density and an imbalance of bone resorption and formation
  - Normal bone density = >833mg/cm^2
  - Osteopenic bone = 833-648 mg/cm^2
  - *Bone density <648 mg/cm^2 = osteoporosis

Diagnostic Evaluation and Testing

- **Bone histology**:
  - Usually normal but lacks structural integrity
  - Thinning and perforations
- **Bone densitometry** (dual-energy x-ray absorptiometry [DXA, DEXA])
  - Simple imaging test for determining bone density
  - Common in the diagnosis of osteoporosis

Osteomyelitis

- Bone infection with progressive inflammatory destruction, usually from **bacteria**
- Very serious

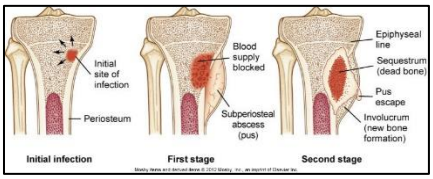


Figure 8: Progression of osteomyelitis

Etiology:

- **Staphylococcal infection**:
  - Open wound (exogenous)
  - Blood-borne (endogenous)

Risk factors:

- Trauma/surgery
- Immunocompromised patients
- Diabetes mellitus
- Poor vascular supply

- Peripheral neuropathy

Pathophysiology and clinical manifestations

- Acute or chronic inflammation
- Necrotic bone
- Pain, erythema, tenderness, swelling± abscess
- Fever
    - Can be a cause for fever of unknown origin (FUO)

Osteoarthritis

- Inflammatory/degenerative joint disease

Etiology:

- Primary disease is idiopathic
- Genetic, biochemical, and biomechanical factors

Risk factors:

- Joint trauma, long-term mechanical stress
- Endocrine disorders (hyperparathyroidism)
- Obesity, aging

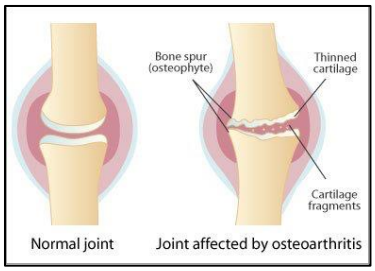


Figure 9: Normal versus osteoarthritic joint

Pathophysiology:

- Local areas of degeneration and loss of articular cartilage
- Increased production of pro-inflammatory cytokines
- Tissue catabolism exceeds repair
- Thickening of the joint capsule
- Formation of bone spurs (**osteophytes**)
- Variable degrees of synovitis (inflammation of the synovial membrane)

Clinical manifestations:

- Pain (worsens with activity)
- Stiffness (diminishes with activity)
- Swelling of the joint
- Tenderness
- Limited mobility
- Deformity

Rheumatoid Arthritis

- Systemic inflammatory/autoimmune disease primarily affecting joints

Etiology:

- Multifactorial with strong genetic predisposition
- Association with **HLA-DR4**
  - **HLA** (Human Leukocyte antigen) OR **MHC** (major histocompatibility complex):
    - Group of proteins coded for by genes on chromosome 6 that makes for our tissue identity.
  - There are 6 sets of genes in HLA forming two classes HLA I and II the pattern of which make us each unique.
    - Class 1 = A, B, C.
    - Class 2 = DR, DQ and DP.
  - HLA typing/matching is required in organ transplantation to avoid/ reduce graft rejection

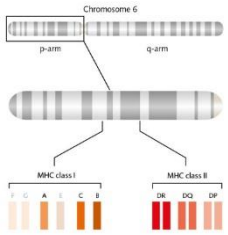


Figure 10: Genetics of rheumatoid arthritis

Pathophysiology:

- Primary site is synovial membrane
- Antibodies formed against joint tissue
- **Type IV hypersensitivity** (T cell mediated)
- Inflammatory cells, exudate & cytokines (TNF-α) leading to destruction of cartilage/bone
- Abnormal layer of granulation tissue (pannus)
  - **Pannus** = granulation tissue that replaces the gaps on destroyed tissue.

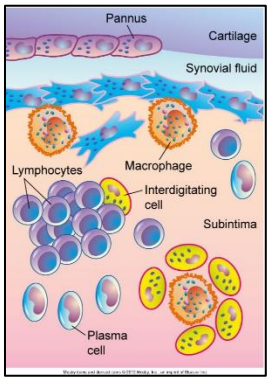


Figure 11: Pathophysiology of rheumatoid arthritis

Clinical manifestations:

- Insidious onset
- **Affected joints**: initially Wrists, MCPs, MTPs
- Symmetric joint involvement
- Morning stiffness
- Constitutional symptoms
- Joint deformities
- Subcutaneous nodules
- Presence of RF (rheumatoid factor) and ANA (antinuclear antibody) in serum

- *Specific criteria for diagnosis, published in the Journal of Arthritis and Rheumatology ("2010 Rheumatoid arthritis classification criteria" can be found at https://onlinelibrary.wiley.com/doi/full/10.1002/art.27584

Ankylosing Spondylitis

- Inflammatory joint disease of the spine or sacroiliac joints causing stiffening and fusion of joints (**LOSE CURVATURE IN SPINE**)

Etiology:

- Unknown
- Strong association with **HLA-B27 antigen**

Pathophysiology:

- Inflammation of fibrocartilage
- Inflammatory cells and fibrocartilage erosion
- Repair and scar tissue
- Calcification leading to joint fusion

Clinical manifestations:

- **Early symptoms:**
  - Low back pain that begins in early 20s and progresses over time
  - Stiffness
  - Pain
  - Restricted motion
- Loss of normal lumbar curvature (lordosis)
- Increased concavity of upper spine (kyphosis)

Gout

- Metabolic disorder that disrupts the body's control of uric acid production or excretion

Etiology and Pathophysiology:

- Accelerated purine breakdown OR poor uric acid secretion in the kidneys
  - Purines (nitrogenous bases) are required in DNA synthesis which is needed for cell division.
  - With cell damage/death, there is breakdown of purines → increase in uric acid production
  - Uric acid buildup is also caused by cancer chemotherapy
  - Uric acid transforms into urea in order to be excreted via the kidney
  - Uric acid buildup → hyperuricemia → deposition in various tissue

- High levels of uric acid in blood (hyperuricemisa)
- Uric acid crystals deposition in connective tissue including joints, also in the kidney causing uric acid stones

Sites:

- MTP (Metatarsophalangeal) joint of big toe (50% of initial attacks)
- Heel, ankle, instep of the foot, knee, wrist, or elbow

Risk factors:

- Male gender
- Increasing age
- High intake of alcohol, red meat, and fructose
- Drugs

Clinical manifestations:

- Recurrent attacks of monoarticular arthritis
- **Tophi**: deposits of urate crystals in and around joints
- **Renal disease**: glomerular, tubular, interstitial, vascular
- Renal stones
- **Acute gouty attack**:
    - Severe pain, especially at night, with hot, red, tender joint & signs of systemic acute inflammation

Figure 12: Tophi deposits of the metacarpal joints

Fibromyalgia

- Chronic widespread diffuse **non-articular** pain associated with fatigue and characteristic tender points. No joint pain.

Pathophysiology/clinical features:

- 80% to 90% are women, ages 25-45 yr, some adolescents
- Genetic predisposition: defective serotonin, catecholamines, and dopamine genes
- CNS sensitization
- Autoimmune disorders often coexist
- Overlaps with chronic fatigue syndrome and myofascial pain syndrome

Clinical manifestations:

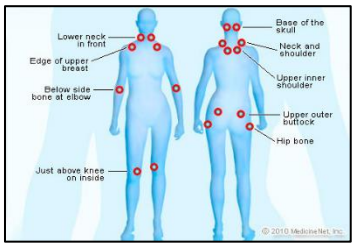


Figure 13: Multiple pain sites of fibromyalgia

- Diffuse, chronic (>3 mo) pain (burning/gnawing)
- Pain often begins in one location, especially neck and shoulders, then becomes more generalized
- Profound fatigue
- Increased sensitivity to touch
- Absence of inflammation
- Sleep disturbances / non-restorative sleep

Diagnosis

- Tenderness in eleven pairs of tender points along with a history of diffuse pain
- Diagnostic criteria*

Bone Tumors

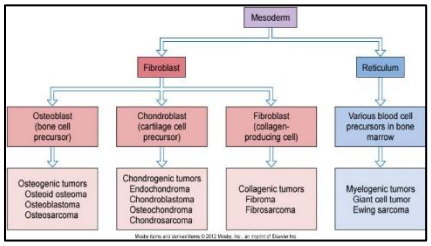


Figure 14: Cellular/ tissue origins of bone tumors

- Can have different origins:
  - **Osteogenic**: from bone cells
  - **Chondrogenic**: from cartilage (chondroblast)
  - **Collagenic**: from fibrous tissue (fibroblast)
  - **Myelogenic**: from vascular tissue/marrow

Osteosarcoma

- Adolescents and young adults
- 38% of bone tumors
- Seniors with a history of radiation therapy
- Metaphysis of long bones
- Masses of osteoid

Chondrosarcoma

- Middle-aged and older adults
- Infiltrates trabeculae in spongy bone
- Metaphysis or diaphysis of long bones
- Lobules of hyaline cartilage

Fibrosarcoma

- Firm, fibrous mass of collagen, fibroblasts, and osteoclast-like cells
- Metaphysis of femur or tibia
- Lung metastasis is common

Myelogenic tumors

- Giant cell tumor
    - Extensive bone resorption because of the osteoclastic origin of the giant cells
    - Epiphyses of the femur, tibia, radius, or humerus
    - Slow growth rate

Multiple Myeloma*

Muscle Tumors

Rhabdomyosarcoma

- Malignant tumor of striated muscle
- Usually muscles and CT in the eye, tongue, neck, larynx, nasal cavity, axilla, vulva, and heart
- Highly malignant with rapid metastasis

12: Disorders of the Integument

Clinical Manifestations/ Lesions of Skin Dysfunction

Table: Describing Skin Alterations and Lesions *(Poonawalla & Diven, 2008)*	
Macule	Telangiectasia
Papule	Keloid
Vesicle	Atrophy
Bulla	Sclerosis
Pustule	Scar
Plaque	Erosion
Nodule	Scale
Cyst	Ulcer
Erythema	Vesicle

Pressure Ulcers

- Ulcers result from any unrelieved pressure on the skin, causing underlying tissue damage
    - Pressure
    - Shearing forces

- Friction
- Moisture

Stages:

I. Non-blanchable erythema of intact skin
II. Partial-thickness skin loss (epidermis or dermis)
III. Full-thickness skin loss with damage/loss of SC tissue
IV. Full-thickness skin loss with damage to muscle, bone

Pathophysiology:

- Over bony prominences; 95% on lower body
- **Hyperemia**: early sign
- **Ischemia**: can start 2-6 h of pressure
- **Necrosis**: can start as early as 6 h of constant pressure
- **Ulcer**: necrotic area breaks down (like tip of an iceberg)

Patient care:

- Reposition patient every 2 hours

Keloids

- Elevated, rounded, and firm
- Claw-like margins that extend beyond the original site of injury
- Excessive collagen formation during dermal connective tissue repair
- Common in dark skin types and burn scars
- Type III collagen is increased

Inflammatory Disorders of the Skin

- Most common are:
  - **Dermatitis**; various types
  - Eczema
- The disorders are generally characterized by:
  - Pruritus
  - Distinct lesions
  - Epidermal changes

Allergic contact dermatitis

- Type IV hypersensitivity
- Erythema, swelling, pruritus, vesicular lesions

Atopic dermatitis

- Type I hypersensitivity
- Red, weeping crusts, chronic inflammation, lichenification

Irritant contact dermatitis

- Non-immunologic inflammation of the skin
- Prolonged exposure to irritating substances
- Symptoms similar to allergic contact dermatitis

Seborrheic dermatitis

- Inflammation; scalp, eyebrows, eyelids, nasolabial folds, and ear canals
- Scaly, white, or yellowish plaques

Psoriasis

- A chronic, relapsing, proliferative skin disorder

Etiology:

- Not fully understood, genetic and immunologic factors

Pathophysiology and clinical manifestations:

- Shortened keratinocyte cell cycle
- High rate of mitosis in the basal skin layer. Cells do not have time to mature or adequately keratinize
- T cell immune- mediated inflammatory response
- Scaly, thick, silvery, itchy elevated lesions
- Sites: scalp, elbows, or knees
- Dermal and epidermal thickening

Scleroderma

- Sclerosis (hardening) of skin/ CT, can progress to internal organs

Pathophysiology:

- Increased synthesis, deposition of collagen with inflammation
- Altered connective tissues, damage to small blood vessels
- T lymphocytes activation
- 50% of patients die within 5 years

Clinical manifestations:

- **Skin**: hard, hypopigmented, tightly connected to underlying tissue
    - Facial skin becomes tight, mouth may not open completely
- Fingers become tapered and flexed; nails and fingertips can be lost from atrophy

Burns

Etiology:

- Fire, chemical, electrical
- **Assessment of burn**:
  - Degree (1st, 2nd, 3rd)
  - % body surface area (Rule of 9's)
  - **Parklands formula** (calculation for fluid administration)

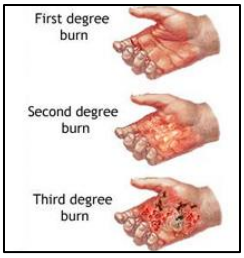


Figure 15: Degree of burn (1st, 2nd, 3rd)

Pathophysiology:

- Heat disturbs protein 3D structure → dysfunctional proteins
- Disruption of skin sensation
- Tissue/endothelial injury and inflammation
- Increased capillary permeability → edema
- Loss of water and plasma causing dehydration
- Electrolytes imbalance → lose everything from intravascular space
- Hypovolemia, multiorgan damage

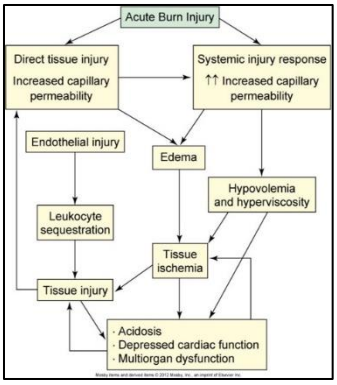


Figure 16: Pathophysiology of burns

Rule of nines

- Method for estimating percentage of body surface area impacted by burn

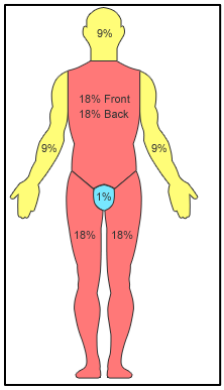


Figure 17: Rule of Nines (Adult)

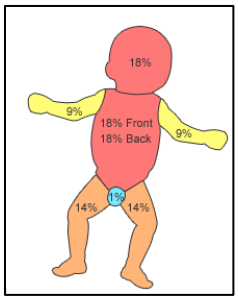


Figure 18: Rule of Nines (Child)

Clinical manifestations:

- Edema
- Manifestations of dehydration
- Manifestations of hypovolemia
- Organ failure
- Death results from dehydration, poor organ perfusion and renal failure