Cardiovascular Structure and Function
Pathology 2 - Dr. Gary Mumaugh

Circulatory System - Heart
- Right heart
  - Pulmonary circulation - Pumps blood through the lungs
- Left heart
  - Systemic circulation - Pumps blood through the body
- Mediastinum
- Heart wall
  - Pericardium
    - Parietal and visceral
    - Pericardial cavity and fluid
  - Myocardium
  - Endocardium
The Valves of the Heart
- Atroventricular valves:
  - Tricuspid valve
  - Mitral valve
- Semilunar valves:
  - Pulmonic semilunar valve
  - Aortic semilunar valve

The Great Vessels
- Superior and inferior venae cavae
- Pulmonary artery (trunk)
  - Right and left pulmonary arteries
- Pulmonary veins
- Aorta
The Coronary Vessels
- Right coronary artery
  - Right marginal branch
  - Posterior descending branch
- Left coronary artery
  - Left anterior descending artery
  - Circumflex artery
- The Coronary Vessels
- Coronary capillaries
- Coronary veins:
  - Coronary sinus
  - Great cardiac vein
  - Posterior vein of the left ventricle
- Coronary lymphatic vessels

Structures That Control Heart Action
- Cardiac action potentials
- Conduction system
  - Sinoatrial node (SA)
  - Atrioventricular node (AV)
  - Bundle of His (AV bundle)
  - Right and left bundle branches
  - Purkinje fibers
Structures That Control Heart Action

- Propagation of cardiac action potentials
  - Resting membrane potential
  - Depolarization
  - Repolarization
  - Hyperpolarization
  - Refractory period
- Electrocardiogram
- Automaticity
- Rhythmicity

Structures That Control Heart Action

- Cardiac innervation
  - Sympathetic nerves
  - Parasympathetic nerves
- Adrenergic receptor function
  - Beta-adrenergic receptors
  - Norepinephrine or epinephrine

Cardiac Performance

- Cardiac output
  - Preload
    - Left ventricular end-diastolic volume
    - Laplace law
    - Frank-Starling law of the heart
  - Afterload
    - Load muscle must move after it starts to contract
    - Determined by system vascular resistance in aorta, arteries, and arterioles

Heart rate

- Cardiovascular control center
  - Cardioexcitatory and cardioinhibitory centers
- Neural reflexes
  - Bainbridge and baroreceptor reflexes
- Atrial receptors
- Hormones and biochemicals
Cardiac Performance
- Myocardial contractility
  - Stroke volume
  - Inotropic agents
  - Oxygen and carbon dioxide levels
- Cardiac output
  - Volume of blood flowing through either the systemic or pulmonary circuit in liters per minute
- Ejection fraction
Systemic Circulation
- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

Structure of Blood Vessels
- Lumen
- Tunica intima
- Tunica media
- Tunica externa (adventitia)

Factors Affecting Blood Flow
- Pressure
  - Force exerted on a liquid per unit area
- Resistance
  - Opposition to force
  - Diameter and length of the blood vessels contribute to resistance
- Poiseuille law
- Factors Affecting Blood Flow
- Neural control of total peripheral resistance
  - Change in diameter of the vessels
  - Baroreceptors
  - Arterial chemoreceptors
- Velocity
- Laminar vs. turbulent flow
- Vascular compliance

Laminar vs. Turbulent Flow
Regulation of Blood Pressure
- Arterial pressure
  - Mean arterial pressure (MAP)
  - Effects of cardiac output
  - Effects of total peripheral resistance
  - Effect of hyperemia
  - Effects of hormones
    - Epinephrine and norepinephrine
    - Antidiuretic hormone, renin-angiotensin system, and natriuretic peptides

Regulation of Blood Pressure
- Adrenomedullin
- Insulin
- Venous pressure

Regulation of Coronary Circulation
- Coronary perfusion pressure
- Autoregulation
- Autonomic regulation
Lymphatic System
- Special vascular system that picks up excess fluid and returns it to the bloodstream
- Lymphatic fluid
- Lymphatic veins and venules
- Right lymphatic duct
- Thoracic duct
- Afferent and efferent lymphatic vessels
Diseases of the Veins

**Varicose veins**
- A vein in which blood has pooled
- Distended, tortuous, and palpable veins
- Caused by trauma or gradual venous distention
- Risk factors:
  - Age, Female gender, Family history, Obesity
  - Pregnancy, Deep Vein Thrombosis, Prior leg injury

**Chronic venous insufficiency**
- Inadequate venous return over a long period due to varicose veins or valvular incompetence
- Venous stasis ulcers

**Deep venous thrombosis**
- Obstruction of venous flow leading to increased venous pressure
- Factors:
  - Triad of Virchow
    - Venous stasis
    - Venous endothelial damage
    - Hypercoagulable states
  - Other (cancer, orthopedic surgery/trauma, heart failure, immobility)

**Superior vena cava syndrome**
- Progressive occlusion of the superior vena cava that leads to venous distention of upper extremities and head
- Oncologic emergency
Diseases of the Arteries and Veins

Hypertension
- Isolated systolic hypertension—becoming prevalent in all age groups
  - Elevations of systolic pressure are caused by increases in cardiac output, total peripheral vascular resistance, or both

Primary hypertension
- Essential or idiopathic hypertension
- Genetic and environmental factors
- Affects 92% to 95% of individuals with hypertension
- Risk factors:
  - High sodium intake
  - Obesity
  - Insulin resistance

Secondary hypertension
- Caused by a systemic disease process that raises peripheral vascular resistance or cardiac output
- Renal artery stenosis, renal parenchymal disease, pheochromocytosis, drugs

Complicated hypertension
- Chronic hypertensive damage to the walls of systemic blood vessels
- Smooth muscle cells undergo hypertrophy and hyperplasia with fibrosis of the tunica intima and media
- Affects heart, kidneys, retina
- Can result in transient ischemic attack/stroke, cerebral thrombosis, aneurysm, dementia

Malignant hypertension
- Rapidly progressive hypertension
- Diastolic pressure is usually >140 mm Hg
- Life-threatening organ damage

Orthostatic (postural) hypotension
- Decrease in both systolic and diastolic blood pressure upon standing
- Lack of normal blood pressure compensation in response to gravitational changes on the circulation
- Acute orthostatic hypotension
- Chronic orthostatic hypotension
Aneurysm
- Local dilation or outpouching of a vessel wall or cardiac chamber
- True aneurysms
  - Fusiform aneurysms
  - Circumferential aneurysms
- False aneurysms
  - Saccular aneurysms
- Aorta most susceptible, especially abdominal
  - Causes include atherosclerosis, hypertension
  - Can lead to aortic dissection or rupture

Thrombus formation
- Blood clot that remains attached to the vessel wall
- Risk factors include intimal injury/inflammation, obstruction of flow, pooling (stasis)
- Thromboembolus
- Thrombophlebitis
- Arterial thrombi
- Venous thrombi

Embolism
- Bolus of matter that is circulating in the bloodstream
  - Dislodged thrombus
  - Air bubble
  - Amniotic fluid
  - Aggregate of fat
  - Bacteria
  - Cancer cells
  - Foreign substance
**Thromboangiitis obliterans (Buerger disease)**
- Occurs mainly in young men who smoke
- Inflammatory disease of peripheral arteries resulting in the formation of nonatherosclerotic lesions
  - Digital, tibial, plantar, ulnar, and palmar arteries
- Obliterates the small and medium-sized arteries
- Causes pain, tenderness, and hair loss in the affected area
- Symptoms are caused by slow, sluggish blood flow
- Can often lead to gangrenous lesions

**Raynaud phenomenon and Raynaud disease**
- Episodic vasospasm in arteries and arterioles of the fingers, less commonly the toes
- Raynaud disease is a primary vasospastic disorder of unknown origin
- Raynaud phenomenon is secondary to other systemic diseases or conditions:
  - Collagen vascular disease
  - Smoking
  - Pulmonary hypertension
  - Myxedema
  - Cold environment
- Manifestations include pallor, cyanosis, cold, pain

**Arteriosclerosis**
- Chronic disease of the arterial system
  - Abnormal thickening and hardening of the vessel walls
  - Smooth muscle cells and collagen fibers migrate to the tunica intima
- Form of arteriosclerosis
- Thickening and hardening caused by accumulation of lipid-laden macrophages in the arterial wall
- Plaque development
- Progression
  - Inflammation of endothelium
  - Cellular proliferation
  - Macrophage migration and adherence
  - LDL oxidation (foam cell formation)
  - Fatty streak
  - Fibrous plaque
  - Complicated plaque
- Risk factors include hyperlipidemia/dyslipidemia, diabetes, smoking, hypertension
- Result in—inadequate perfusion, ischemia, necrosis
Peripheral Arterial Disease
- Atherosclerotic disease of arteries that perfuse limbs
- Intermittent claudication

Coronary Artery Disease
- Any vascular disorder that narrows or occludes the coronary arteries leading to myocardial ischemia
- Atherosclerosis is the most common cause
- Risk Factors
  - Major:
    - Increased age
    - Family history
    - Male gender or female gender post menopause
  - Modifiable:
    - Dyslipidemia
    - Hypertension
    - Cigarette smoking
    - Diabetes mellitus
    - Obesity/sedentary lifestyle
    - Atherogenic diet
  - Nontraditional risk factors:
    - Markers of inflammation and thrombosis
      - High density C-reactive protein, erythrocyte sedimentation rate, von Willebrand factor concentration, interleukin-6, interleukin-18, tumor necrosis factor, fibrinogen, and CD 40 ligand
      - Hyperhomocysteinemia
      - Adipokines
      - Infection

Myocardial ischemia
- Local, temporary deprivation of the coronary blood supply
- Stable angina
- Prinzmetal angina
- Silent ischemia

Acute coronary syndromes:
- Transient ischemia
- Unstable angina
- Sustained ischemia
- Myocardial infarction
  - STEMI or non-STEMI
- Myocardial inflammation and necrosis
Myocardial infarction
- Sudden and extended obstruction of the myocardial blood supply
- Subendocardial infarction
- Transmural infarction
- Cellular injury
- Cellular death
- Structural and functional changes:
  - Myocardial stunning
  - Hibernating myocardium
  - Myocardial remodeling
  - Repair
- Manifestations:
  - Sudden severe chest pain; may radiate
  - Nausea, vomiting
  - Diaphoresis
  - Dyspnea
- Complications:
  - Sudden cardiac arrest due to ischemia, left ventricular dysfunction, and electrical instability

Disorders of the Heart Wall
Disorders of the Pericardium:
- Acute pericarditis
- Pericardial effusion
  - Tamponade
- Constrictive pericarditis

Disorders of the Myocardium
- Cardiomyopathies:
  - Dilated cardiomyopathy (congestive cardiomyopathy)
  - Hypertrophic cardiomyopathy
    - Asymmetrical septal hypertrophy
    - Hypertensive (valvular hypertrophic) cardiomyopathy
  - Restrictive cardiomyopathy
Disorders of the Endocardium

- Valvular dysfunctions:
  - Valvular stenosis
    - Aortic stenosis
    - Mitral stenosis
  - Valvular regurgitation
    - Aortic regurgitation
    - Mitral regurgitation
    - Tricuspid regurgitation
  - Mitral valve prolapse syndrome (MVPS)

Acute Rheumatic Fever and Rheumatic Heart Disease

Rheumatic fever

- Systemic, inflammatory disease caused by a delayed immune response to pharyngeal infection by the group A beta-hemolytic streptococci
- Febrile illness
  - Inflammation of the joints, skin, nervous system, and heart
- If left untreated, rheumatic fever causes rheumatic heart disease
Acute Rheumatic Fever and Rheumatic Heart Disease

- Common manifestations:
  - Fever
  - Lymphadenopathy
  - Arthralgia
  - Nausea/vomiting
  - Tachycardia
  - Abdominal pain
  - Epistaxis

- Major clinical manifestations:
  - Carditis
  - Polyarthritis
  - Chorea
  - Erythema marginatum

Infective Endocarditis

- Inflammation of the endocardium
- Agents:
  - Bacteria, Viruses, Fungi, Rickettsiae, Parasites
- Pathogenesis
  - Damaged (prepared) endocardium
  - Blood-borne microorganism adherence
  - Proliferation of the microorganism (vegetations)
- Manifestations:
  - Classic finding:s
    - Fever
    - New or changed cardiac murmur
    - Petechial lesions of the skin, conjunctiva, and oral mucosa
  - Characteristic physical findings:
    - Osler nodes (painful erythematous nodules on the pads of the fingers and toes)
    - Janeway lesions (nonpainful hemorrhagic lesions on the palms and soles)
  - Other: weight loss, back pain, night sweats, and heart failure
Cardiac Complications of AIDS

- Myocarditis
- Endocarditis
- Pericarditis
- Cardiomyopathy
- Pericardial effusion
- Pulmonary hypertension
- Antiviral drug-related cardiotoxicity

Dysrhythmias (Arrhythmias)

- Disturbance of the heart rhythm
- Range from occasional “missed” or rapid beats to severe disturbances that affect the pumping ability of the heart
- Can be caused by an abnormal rate of impulse generation or abnormal impulse conduction
- Examples:
  - Tachycardia
  - Flutter
  - Fibrillation
  - Bradycardia
  - Premature ventricular contractions (PVCs)
  - Premature atrial contractions (PACs)
  - Asystole

Heart Failure

- General term used to describe several types of cardiac dysfunction that result in inadequate perfusion of tissues with blood-borne nutrients

Left heart failure (Congestive heart failure)

- Systolic heart failure
  - Inability of the heart to generate adequate cardiac output to perfuse tissues
  - Ventricular remodeling
  - Causes include myocardial infarction, myocarditis, cardiomyopathy
- Diastolic heart failure
  - Pulmonary congestion despite normal stroke volume and cardiac output
  - Causes include myocardial hypertrophy and ischemia, diabetes, valvular and pericardial disease
- Manifestations of left heart failure:
  - Result of pulmonary vascular congestion and inadequate perfusion of the systemic circulation
  - Include dyspnea, orthopnea, cough of frothy sputum, fatigue, decreased urine output, and edema
  - Physical examination often reveals pulmonary edema (cyanosis, inspiratory crackles, pleural effusions), hypotension or hypertension, an S₃ gallop, and evidence of underlying CAD or hypertension
Right heart failure
- Most commonly caused by a diffuse hypoxic pulmonary disease
- Can result from an increase in left ventricular filling pressure that is reflected back into the pulmonary circulation

High-output failure
- Inability of the heart to supply the body with blood-borne nutrients, despite adequate blood volume and normal or elevated myocardial contractility
- Causes include anemia, hyperthyroidism, septicemia

Shock
- Cardiovascular system fails to perfuse the tissues adequately
- Leads to impaired cellular metabolism
  - Impaired oxygen use
  - Impaired glucose use
- Manifestations vary based on stage but often include hypotension, tachycardia, increased respiratory rate
- Types of Shock
  - Cardiogenic
  - Hypovolemic
  - Neurogenic
  - Anaphylactic
  - Septic

Multiple Organ Dysfunction Syndrome
- Causes:
  - Most common: sepsis, septic shock
  - Other: any severe injury (trauma, burns, major surgery)
- Manifestations:
  - Respiratory
  - Hepatic
  - Renal
  - GI
  - Myocardial failure
Pediatric Cardiovascular Pathology
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Congenital Heart Defects
• Major cause of death in the first year of life other than prematurity
• Prenatal, environmental, and genetic risk factors:
  o Maternal rubella or increased age, type 1 diabetes, alcoholism, PKU, drugs, and hypercalcemia
  o Prematurity
  o Chromosome aberrations
• Heart defects
• Hemodynamic alterations
  o Right-to-left shunt, left-to-right shunt
• Status of tissue oxygenation
  o Cyanotic defects
  o Acyanotic defects

Obstructive Defects
• Coarctation of the aorta
  o Narrowing of the lumen of the aorta that impedes blood flow
  o Almost always in a juxtaductal position
  o Manifestations:
    ▪ If severe decreased CO, acidosis, hypotension at birth
    ▪ If mild, no manifestations until find hypertension in upper extremities at older age
• Aortic stenosis
  o Narrowing of the aortic outflow tract
  o Caused by malformation or fusion of the cusps
  o Causes increased workload on left ventricle and left ventricular hypertrophy
  o Various types
  o Manifestations:
    ▪ Infant: if significant faint pulses, hypotension, tachycardia, and poor feeding
    ▪ Older children: may have complaints of exercise intolerance
    ▪ Risk for bacterial endocarditis
Obstructive Defects - continued

- Valvular aortic stenosis
  - Malformed or fused cusps
  - Progressive obstruction with episodes of ischemia
  - Strenuous activity limited
- Subvalvular aortic stenosis
  - Stricture caused by a fibrous ring below a valve
- Pulmonic stenosis
  - Narrowing of the pulmonary outflow tract
  - Abnormal thickening of the valve leaflets
  - Narrowing of the valve with resistance to flow from right ventricle to pulmonary artery
  - Right ventricular hypertrophy
  - Pulmonary semilunar valve atresia
  - Manifestations:
    - If severe: cyanosis from right-to-left shunt through atrial septal defect; decreased CO

Defects Increasing Pulmonary Blood Flow

- Patent ductus arteriosus (PDA)
  - Failure of the ductus arteriosus to close
  - PDA allows blood to shunt from the aorta to pulmonary artery causing left-to-right shunt
  - Manifestations:
    - Asymptomatic or pulmonary overcirculation (dyspnea, fatigue, poor feeding)
  - Complications:
    - Risk for bacterial endocarditis
- Atrial septal defect
  - Abnormal opening between the atria; blood flows from left atria to right atria
  - Manifestations:
    - Asymptomatic at early age
    - Pulmonary symptoms on exertion at later age
Defects Increasing Pulmonary Blood Flow - continued

- Ventricular septal defect (VSD)
  - Abnormal communication between the ventricles
  - Most common type of congenital heart lesion
  - Two types
  - Manifestations:
    - May be asymptomatic
    - If severe: increased pulmonary blood flow from left-to-right shunt; pulmonary hypertension

- Tetralogy of Fallot
  - Syndrome represented by four defects:
    - Ventricular septal defect (VSD)
    - Overriding aorta
    - Pulmonary valve stenosis
    - Right ventricle hypertrophy
  - Manifestations:
    - Acute cyanosis at birth or gradual cyanosis
    - Gradual clubbing, poor growth; Tet spells
    - If untreated, emboli, stroke, brain abscess, seizures

- Tricuspid atresia
  - Imperforate tricuspid valve
  - Lack of communication between the right atrium and right ventricle
  - Additional defects:
    - Atrial septal defect
    - Hypoplastic or absent right ventricle
    - Enlarged mitral valve and left ventricle
    - Pulmonic stenosis
  - Manifestations:
    - In newborn, cyanosis, tachycardia, dyspnea, poor feeding
    - In older child, signs of chronic hypoxemia
Mixed Defects
* Transposition of the great arteries
  o Aorta arises from the right ventricle and the pulmonary artery arises from the left ventricle
  o Results in two separate, parallel circuits
    ▪ Unoxygenated blood circulates continuously through the systemic circulation
    ▪ Oxygenated blood circulates continuously through the pulmonary circulation
  o Extrauterine survival requires communication between the two circuit
  o Manifestation: Depends on size and associated defects
* Truncus arteriosus
  o Failure of the embryonic artery and the truncus arteriosus to divide into the pulmonary artery and the aorta
  o The trunk straddles an always present VSD

Obstructive Defects
* Hypoplastic left heart syndrome
  o Abnormal development of the left-sided cardiac structures
    ▪ Obstruction to blood flow from the left ventricular outflow tract
  o Underdevelopment of the left ventricle, aorta and aortic arch; mitral atresia or stenosis; coarctation of the aorta
  o Manifestations occur early in newborn (cyanosis, tachypnea, decreased CO)
  o Fatal in early life if untreated
Heart Failure
- Heart is not able to maintain cardiac output at level that meets demands of body
- Result from poor ventricular function
- Complication of many congenital heart defects

Acquired Cardiovascular Disorders
- Systemic hypertension
  - In children defined as systolic and diastolic pressure that is over the 95\textsuperscript{th} percentile for age and gender on at least three occasions
    - Hypertension in children differs from adults:
      - Often has an underlying disease
      - Renal disease or coarctation of aorta
      - A cause of the hypertension in children is almost always found
  - Children commonly asymptomatic
  - Seeing increased incidence of primary hypertension in older children related to obesity

Acquired Cardiovascular Disorders
- Childhood obesity
  - Multivariable and multidimensional
  - Risks:
    - Insulin resistance, diabetes, cardiovascular disease
    - Childhood nutrition, level of physical activity, and engagement of sedentary activities (TV, computer use, etc.)
  - Association with parental obesity
  - Epidemic in the USA
Respiratory System AP Review
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Major Functions of the Respiratory System
• To supply the body with oxygen and dispose of CO2
• Respiration – four distinct processes must happen
  o Pulmonary ventilation – moving air into and out of the lungs
  o External respiration – gas exchange between the lungs and the blood
  o Transport – transport of oxygen and carbon dioxide between the lungs and tissues
  o Internal respiration – gas exchange between systemic blood vessels and tissues

Respiratory System
• Consists of the respiratory and conducting zones
• Respiratory zone
  o Site of gas exchange
  o Consists of bronchioles, alveolar ducts, and alveoli
• Conducting zone
  o Provides rigid conduits for air to reach the sites of gas exchange
  o Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)
• Respiratory muscles – diaphragm and other muscles that promote ventilation
Function of the Nose
- The only externally visible part of the respiratory system that functions by:
  - Providing an airway for respiration
  - Moistening and warming the entering air
  - Filtering inspired air and cleaning it of foreign matter
  - Serving as a resonating chamber for speech
  - Housing the olfactory receptors

Nasal Cavity
- Olfactory mucosa
  - Lines the superior nasal cavity
  - Contains smell receptors
- Respiratory mucosa
  - Lines the balance of the nasal cavity
  - Glands secrete mucus containing lysozyme and defensins to help destroy bacteria

Nasal Cavity
- Inspired air is:
  - Humidified by the high water content in the nasal cavity
  - Warmed by rich plexuses of capillaries
- Ciliated mucosal cells remove contaminated mucus
- Superior, medial, and inferior conchae:
  - Increase mucosal area
  - Enhance air turbulence and help filter air
  - Sensitive mucosa triggers sneezing when stimulated by irritating particles

Functions of the Nasal Mucosa and Conchae
- During inhalation the conchae and nasal mucosa:
  - Filter, heat, and moisten air
- During exhalation these structures:
  - Reclaim heat and moisture
  - Minimize heat and moisture loss

Pharynx
- Funnel-shaped tube of skeletal muscle that connects to:
  - Nasal cavity and mouth superiorly
  - Larynx and esophagus inferiorly
- Extends from the base of the skull to the level of the sixth cervical vertebra
Larynx (Voice Box)
- Superiorly attaches to the hyoid bone. Inferiorly attaches to the trachea
- The three functions of the larynx are:
  - To provide a patent airway
  - To act as a switching mechanism to route air and food into the proper channels
  - To function in voice production
- Epiglottis – elastic cartilage that covers the laryngeal inlet during swallowing

Trachea
- Flexible and mobile tube extending from the larynx into the mediastinum
- Composed of three layers
  - Mucosa – made up of goblet cells and ciliated epithelium
  - Submucosa – connective tissue deep to the mucosa
  - Adventitia – outermost layer made of C-shaped rings of hyaline cartilage

Conducting Zone: Bronchi
- The carina of the last tracheal cartilage marks the end of the trachea and the beginning of the right and left bronchi
- Air reaching the bronchi is:
  - Warm and cleansed of impurities
  - Saturated with water vapor
- Bronchi subdivide into secondary bronchi, each supplying a lobe of the lungs
- Air passages undergo 23 orders of branching in the lungs

Respiratory Zone
- Defined by the presence of alveoli; begins as terminal bronchioles feed into respiratory bronchioles
- Respiratory bronchioles lead to alveolar ducts, then to terminal clusters of alveolar sacs composed of alveoli
- Approximately 300 million alveoli:
  - Account for most of the lungs’ volume
  - Provide tremendous surface area for gas exchange
Gross Anatomy of the Lungs
- Lungs occupy all of the thoracic cavity except the mediastinum
  - Root – site of vascular and bronchial attachments
  - Costal surface – anterior, lateral, and posterior surfaces in contact with the ribs
  - Apex – narrow superior tip
  - Base – inferior surface that rests on the diaphragm
  - Hilus – indentation that contains pulmonary and systemic blood vessel
  - Cardiac notch (impression) – cavity that accommodates the heart
  - Left lung – separated into upper and lower lobes by the oblique fissure
  - Right lung – separated into three lobes by the oblique and horizontal fissures
  - There are 10 bronchopulmonary segments in each lung

Pleurae
- Thin, double-layered serosa
- Parietal pleura
  - Covers the thoracic wall and superior face of the diaphragm
  - Continues around heart and between lungs
- Visceral, or pulmonary, pleura
  - Covers the external lung surface
  - Divides the thoracic cavity into three chambers
    - The central mediastinum
    - Two lateral compartments, each containing a lung

Breathing
- Breathing, or pulmonary ventilation, consists of two phases
  - Inspiration – air flows into the lungs
  - Expiration – gases exit the lungs

Pressure Relationships in the Thoracic Cavity
- Respiratory pressure is always described relative to atmospheric pressure
- Atmospheric pressure
  - Pressure exerted by the air surrounding the body
- Intrapulmonary pressure – pressure within the alveoli
- Intrapleural pressure – pressure within the pleural cavity
- Two forces act to pull the lungs away from the thoracic wall, promoting lung collapse
  - Elasticity of lungs causes them to assume smallest possible size
  - Surface tension of alveolar fluid draws alveoli to their smallest possible size
- Opposing force – elasticity of the chest wall pulls the thorax outward to enlarge the lungs

**Airway Resistance**
- As airway resistance rises, breathing movements become more strenuous
- Severely constricted or obstructed bronchioles:
  - Can prevent life-sustaining ventilation
  - Can occur during acute asthma attacks which stops ventilation
- Epinephrine release via the sympathetic nervous system dilates bronchioles and reduces air resistance

**Alveolar Surface Tension**
- Surface tension – the attraction of liquid molecules to one another at a liquid-gas interface
- The liquid coating the alveolar surface is always acting to reduce the alveoli to the smallest possible size
- Surfactant, a detergent-like complex, reduces surface tension and helps keep the alveoli from collapsing

**Lung Compliance**
- The ease with which lungs can be expanded
- Determined by two main factors
  - Distensibility of the lung tissue and surrounding thoracic cage
  - Surface tension of the alveoli

**Factors That Diminish Lung Compliance**
- Scar tissue or fibrosis that reduces the natural resilience of the lungs
- Blockage of the smaller respiratory passages with mucus or fluid
- Reduced production of surfactant
- Decreased flexibility of the thoracic cage or its decreased ability to expand
- Examples include:
  - Deformities of thorax
  - Ossification of the costal cartilage
  - Paralysis of intercostal muscles

**Respiratory Volumes**
- *Tidal volume* - Air that moves into and out of the lungs with each breath (approximately 500 ml)
- *Inspiratory reserve volume* - Air that can be inspired forcibly beyond the tidal volume (2100–3200 ml)
- *Expiratory reserve volume* - Air that can be evacuated from the lungs after a tidal expiration (1000–1200 ml)
- **Residual volume** - Air left in the lungs after strenuous expiration (1200 ml)

**Respiratory Capacities**
- **Inspiratory capacity** - Total amount of air that can be inspired after a tidal expiration
- **Functional residual capacity** - Amount of air remaining in the lungs after a tidal expiration
- **Vital capacity** - The total amount of exchangeable air
- **Total lung capacity** - Sum of all lung volumes

**Oxygen Transport**
- Molecular oxygen is carried in the blood:
  - Bound to hemoglobin (Hb) within red blood cells
  - Dissolved in plasma

**Carbon Dioxide Transport**
- CO2 is transported in the blood in three forms
  - Dissolved in plasma – 7 to 10%
  - Chemically bound to hemoglobin – 20% is carried in RBCs
  - Bicarbonate ion in plasma – 70% is transported as bicarbonate

**Control of Respiration: Medullary Respiratory Centers**
- The dorsal respiratory group or inspiratory center
  - Appears to be the pacesetting respiratory center
  - Excites the inspiratory muscles and sets breath rates (12-15 breaths/minute)
  - Becomes dormant during expiration
- The ventral respiratory group is involved in forced inspiration and expiration

**Depth and Rate of Breathing: Higher Brain Centers**
- Hypothalamic controls act through the limbic system to modify rate and depth of respiration
  - Example: breath holding that occurs in anger
- A rise in body temperature acts to increase respiratory rate
- Cortical controls are direct signals from the cerebral motor cortex that bypass medullary controls
  - Examples: voluntary breath holding, taking a deep breath

**Lifespan Changes**
- By the 28th week, a baby born prematurely can breathe on its own
- During fetal life, the lungs are filled with fluid and blood bypasses the lungs
- Gas exchange takes place via the placenta
- At birth, respiratory centers are activated, alveoli inflate, and lungs begin to function
- Respiratory rate is highest in newborns and slows until adulthood
- Lungs continue to mature and more alveoli are formed until young adulthood
- Respiratory efficiency decreases in old age
Lifespan changes reflect an accumulation of environmental influences and the effects of aging in other organ systems, and may include:

- The cilia become less active
- Mucous thickening
- Swallowing, gagging, and coughing reflexes slowing
- Macrophages in the lungs lose efficiency
- An increased susceptibility to respiratory infections
- A "barrel chest" may develop
- Bronchial walls thin and collapse
- Dead space increasing
Signs and Symptoms of Pulmonary Disease

Dyspnea
- Subjective sensation of uncomfortable breathing
- Orthopnea
  - Dyspnea when a person is lying down
- Paroxysmal nocturnal dyspnea (PND)

Cough
- Acute cough
- Chronic cough

Abnormal sputum

Hemoptysis

Abnormal breathing patterns:
- Kussmaul respirations (hyperpnea)
- Cheyne-Stokes respirations

Hypoventilation
- Hypercapnia

Hyperventilation
- Hypocapnia

Cyanosis

Clubbing
- Finger clubbing is characterized by enlarged fingertips and a loss of the normal angle at the nail bed.

Pain
Conditions Caused by Pulmonary Disease or Injury

Hypercapnia
Hypoxemia
  • Hypoxemia versus hypoxia
  • Ventilation-perfusion abnormalities
    o Shunting

Acute respiratory failure

Chest Wall Disorders
Chest wall restriction
  • Compromised chest wall
    o Deformation, immobilization, and/or obesity

Flail chest
  • Instability of a portion of the chest wall

Pleural Abnormalities
Pneumothorax
  • Open pneumothorax
  • Tension pneumothorax
  • Spontaneous pneumothorax
  • Secondary pneumothorax
Pleural Abnormalities
- Pleural effusion
  - Transudative effusion
  - Exudative effusion
  - Hemothorax
  - Empyema
    - Infected pleural effusion
  - Chylothorax
Pulmonary Disorders - Restrictive Lung Diseases

Aspiration
- Passage of fluid and solid particles into the lungs

Atelectasis
- Compression atelectasis
- Absorption atelectasis

Bronchiectasis
- Persistent abnormal dilation of the bronchi

Bronchiolitis
- Inflammatory obstruction of the small airways
- Most common in children
- Occurs in adults with chronic bronchitis, in association with a viral infection, or with inhalation of toxic gases

Pulmonary fibrosis
- Ideopathic
Inhalation Disorders

Toxic gases

Pneumoconiosis
- Silica
- Asbestos
- Coal

Allergic alveolitis
- Extrinsic allergic alveolitis (hypersensitivity pneumonitis)

Pulmonary edema
- Excess water in the lungs

Acute respiratory distress syndrome (ARDS)
- Fulminant form of respiratory failure characterized by acute lung inflammation and diffuse alveolocapillary injury
- Injury to the pulmonary capillary endothelium
- Inflammation and platelet activation
- Surfactant inactivation
- Atelectasis

Manifestations:
  - Hyperventilation
  - Respiratory alkalosis
  - Dyspnea and hypoxemia
  - Metabolic acidosis
  - Hypoventilation
  - Respiratory acidosis
  - Further hypoxemia
  - Hypotension, decreased cardiac output, death

Evaluation and treatment
  - Physical examination, blood gases, and radiologic examination
  - Supportive therapy with oxygenation and ventilation and prevention of infection
  - Surfactant to improve compliance
Pulmonary Disorders - Obstructive Lung Diseases

- Airway obstruction that is worse with expiration
- Common signs and symptoms
  - Dyspnea and wheezing
- Common obstructive disorders:
  - Asthma
  - COPD
  - Emphysema
  - Chronic bronchitis

Obstructive lung diseases: Asthma

- Chronic inflammatory disorder of the airways
- Inflammation results from hyperresponsiveness of the airways
- Can lead to obstruction and status asthmaticus
- Symptoms include expiratory wheezing, dyspnea, and tachypnea
- Peak flow meters, oral corticosteroids, inhaled beta-agonists, and anti-inflammatory agents used to treat
Obstructive lung diseases: chronic bronchitis
- Hypersecretion of mucus and chronic productive cough that lasts for at least 3 months of the year and for at least 2 consecutive years
- Inspired irritants increase mucus production and the size and number of mucous glands
- The mucus is thicker than normal
- Bronchodilators, expectorants, and chest physical therapy used to treat

Obstructive lung diseases: emphysema
- Abnormal permanent enlargement of the gas-exchange airways accompanied by destruction of alveolar walls without obvious fibrosis
- Loss of elastic recoil
- Centriacinar emphysema
- Panacinar emphysema
How COPD develops

- Smoking causes increased mucus production and bronchial inflammation
- Nicotine paralyzes the mucociliary escalator
  - Mucociliary escalator traps mucus, bacteria, irritants
- Nicotine blocks protein inhibitors which will eventually dissolve the alveoli
- Pathophysiology
  - Involves all four parts of the respiratory tract
    - Bronchi
    - Bronchioles
    - Alveoli
    - Parenchyma
  - Specific Pathophysiology
    - Increased resistance to airflow
    - Loss of elastic recoil
    - Decreased expiratory flow rate
    - Alveolar walls frequently break because of the increased resistance of air flows
    - The hyper inflated lungs flatten the curvature of the diaphragm and enlarge the rib cage
    - The altered configuration of the chest cavity places the respiratory muscles, including the diaphragm, at a mechanical disadvantage and impairs their force-generating capacity
    - Consequently, the metabolic work of breathing increases, and dyspnea increases

Two types of COPD

- Type A – Pink Puffers
  - Have mostly emphysema
  - Need to breathe rapidly to exchange O2 and CO2
  - Have prominent dyspnea, the fast puffing keeps them from becoming cyanotic
  - Most of the lung is perfused with blood exchange is not efficient because of fewer alveoli
- Type B – Blue Bloaters
  - Have mostly chronic bronchitis with bronchiolar obstruction and non-ventilated alveoli
  - Results in shunting of cyanotic blood away from the area where there is no air in the lungs
  - Results in pulmonary hypertension which leads to heart failure with peripheral swelling
  - Severe dyspnea with any exertion
- Diagnosis
  - Smoker with hacking cough, sputum and dyspnea
    - Type A – thin, dorsal kyphosis, clubbing, pigeon breast (pectus carinatum) or funnel chest (pectus excavatum)
    - Type B – obese, swollen appearance, cyanotic
- X-ray finding
  - Large lung volumes hyperlucent, flat diaphragm, increased AP diameter
- Pulmonary function tests
  - Airway obstruction and decrease, air trapping
- Blood gases
  - Type A – normal blood gases
  - Type B – marked hypoxemia and CO2 retention
- Treatment of COPD
  - Bronchodilators
  - Antibiotics
  - Corticosteroids
  - Supplemental oxygen therapy
  - Chest physiotherapy to lose secretions
  - Surgery to remove diseased lung tissue
  - Lung transplantation

Respiratory tract infections

Tuberculosis
- *Mycobacterium tuberculosis*
- Acid-fast bacillus
- Airborne transmission
- Tubercle formation
- Caseous necrosis
- Positive tuberculin skin test (PPD)
Acute bronchitis
- Acute infection or inflammation of the airways or bronchi
- Commonly follows a viral illness
- Acute bronchitis causes similar symptoms to pneumonia but does not demonstrate pulmonary consolidation and chest infiltrates
- Abscess formation and cavitation
  - Abscess
  - Consolidation
  - Cavitation

Pulmonary embolus
- Occlusion of a portion of the pulmonary vascular bed by a thrombus, embolus, tissue fragment, lipids, or an air bubble
- Pulmonary emboli commonly arise from the deep veins in the thigh
- Virchow triad
  - Venous stasis, hypercoagulability, and injuries to the endothelial cells that line the vessels
- Occurs when a blood clot is from the deep venous system travels to the lungs
  - Usually involves veins of legs, arms and pelvis (pregnancy)
- Three conditions are put you at risk
  - Increased coagulation of blood
    - Stress, surgery, injury, heart attack, severe illness
  - Stasis or stagnation of blood flow
    - Seen in conditions of immobility such as prolonged bed rest long car rides of plane flights in cramped position
  - Damage to vessel wall or venous valves
    - Stasis-induced phlebitis, soft-tissue injury, bad ankle sprain
- Pathophysiology
  - Pulmonary infarction of distal tissues occurs in a small number of cases
  - Hemorrhage and edema of tissues distal to the clot is more common
  - Vasoconstriction of pulmonary blood vessels occurs
    - This causes a release of serotonin an vasoconstrictive amines which cause more constriction
  - Low blood pH causes even more constriction
  - Right sided heart failure followed by left sided blood flow followed by syncope and sudden death
- S & S
  - Sudden dyspnea
  - Pleuritic chest pain with hemoptysis
  - Can have syncope followed by death
- Diagnosis
  - Normal chest x-ray
  - Perfusion lung scan shows absence of perfusion to involved arteries
  - Pulmonary arteriography – “gold standard”
  - Contrast CT
  - Decreased blood gases and increased pH
- Treatment
  - tPA – tissue plasminogen activator if potentially life threatening embolism
  - Complete bed rest
  - Anticoagulation with heparin in ICU
  - Coumadin anticoagulation for six months
  - Vena caval filter surgery
- PE prophylaxis
  - Most common secondary cause of hospital deaths
  - Lower extremity anti-embolism device with compression during surgery are after heart attack or severe illness
  - Low dose heparin during surgery
  - Graduated compression support hose for patients with deep venous insufficiency

**Pulmonary vascular disorders: Pulmonary hypertension**
- Mean pulmonary artery pressure 5 to 10 mm Hg above normal or above 20 mm Hg
- Primary pulmonary hypertension
  - Idiopathic
- Diseases of the respiratory system and hypoxemia are more common causes
- Classifications:
  - Pulmonary arterial hypertension
  - Pulmonary venous hypertension
  - Pulmonary hypertension due to a respiratory disease or hypoxemia
  - Pulmonary hypertension due to thrombotic or embolic disease
  - Pulmonary hypertension due to diseases of the pulmonary vasculature

**Pulmonary vascular disorders: Cor pulmonale**
- Pulmonary heart disease
  - Right ventricular enlargement
  - Secondary to pulmonary hypertension
  - Pulmonary hypertension creates chronic pressure overload in the right ventricle
Malignancies of the Respiratory Tract

- Lip
  - Most common form—exophytic
  - Stages

- Laryngeal
  - Carcinoma of the true vocal cords (most common)
  - Supraglottic
  - Subglottic

- Lung (bronchogenic)
  - Most common cause is cigarette smoking
  - Heavy smokers have a 20 times’ greater chance of developing lung cancer than nonsmokers
  - Smoking is related to cancers of the larynx, oral cavity, esophagus, and urinary bladder
  - Environmental or occupational risk factors are also associated
  - Lung Types:
    - Non-small cell cancer:
      - Squamous cell carcinoma
      - Adenocarcinoma
      - Large cell carcinoma
    - Small cell cancer—from neuroendocrine tissue so see ectopic hormone secretion (paraneoplastic); large size
Disorders of the Upper Airways
- Croup
- Tonsilar infections
- Aspiration of foreign bodies
- Obstructive sleep apnea syndrome

Disorders of the Lower Respiratory System
- Respiratory distress syndrome (RDS) of newborn
- Bronchopulmonary dysplasia
- Bronchiolitis
- Pneumonia
- Aspiration pneumonitis
- Bronchiolitis obliterans
- Asthma
- Acute respiratory distress syndrome (ARDS)
- Cystic fibrosis
- Sudden Infant Death Syndrome (SIDS)

Disorders of the Upper Airways
Croup
- Acute laryngotracheobronchitis
- Common in children from 6 months to 5 years
- Commonly caused by a virus
  - Causes subglottic edema
- Spasmodic croup
  - Older children; sudden night onset without prior illness
- Bacterial laryngotracheitis
  - Most common life-threatening form
  - High fever
- Usually occurs after an episode of rhinorrhea, sore throat, low-grade fever, inspiratory stridor, and hoarse voice
- Causes seal-like barking cough
  - Self-limiting condition
- Most resolve within 24-48 hours
- Severe cases are treated with nebulized epinephrine
Disorders of the Upper Airways - continued

Acute epiglottitis

- Severe, rapidly progressive, life-threatening infection of the epiglottis and surrounding area
- Historically caused by Haemophilus influenzae type B
  - 80%-90% decreased incidence due to HIB vaccination
- Manifestations:
  - High fever
  - Irritability
  - Sore throat
  - Inspiratory stridor
  - Muffled voice
  - Severe respiratory distress
- Treatment
  - Emergency airway and antibiotics

Tonsilar infections

- Incidence of tonsillitis secondary to GABHS (group A strep) and MRSA has risen in the past 15 years
- Complication of infectious mononucleosis
- Can lead to upper airway obstruction

Aspiration of foreign bodies

- Foreign body aspiration in children occurs frequently between the ages of 1 and 3
- Manifestations:
  - Coughing
  - Choking
  - Gagging
  - Wheezing
  - Symptoms depend on foreign body size
- Aspirated foreign bodies can be removed by bronchoscopy

Obstructive sleep apnea syndrome

- Partial or complete upper airway obstruction during sleep
  - Obstructive sleep apnea disrupts normal ventilation and sleep patterns
    - The most common cause for childhood obstructive sleep apnea is adenotonsillar hypertrophy
    - Likely in children who have had a clinically significant episode of RSV bronchiolitis in infancy
  - Manifestations:
    - Snoring and labored breathing during sleep
    - Daytime sleepiness
    - Chronic mouth breathing
  - Treatment: tonsillectomy and adenoidectomy, or CPAP
Disorders of the Lower Respiratory System
Respiratory Distress Syndrome (RDS) of Newborn
- Also known as hyaline membrane disease (HMD)
  - Poor lung structure and lack of adequate surfactant
  - Primarily a disease of preterm infants
  - Causes widespread atelectasis, respiratory distress, and pulmonary hypertension
- Pulmonary hypertension causes continued shunting of blood away from the lungs (ductus arteriosus)
- Symptoms:
  - Tachypnea
  - Expiratory grunting
  - Nasal flaring
  - Dusky skin
- Treatment
  - Prevention of preterm birth
  - Mechanical ventilation, surfactant administration, glucocorticoid administration to women in preterm labor
Disorders of the Lower Respiratory System - continued

**Bronchopulmonary dysplasia**

- Chronic disease; result of acute respiratory disease in the neonatal period
- Caused by premature birth, immature lungs, infections, genetics, poor formation of alveoli, ventilatory support at birth, etc.
- Manifestations:
  - Hypoxemia
  - Hypercapnia
  - Elevated work of breathing
  - Bronchospasm
  - Mucus plugging
  - Pulmonary hypertension
- Bronchopulmonary dysplasia is not as common because of the availability of exogenous surfactant and antenatal glucocorticoids

**Bronchiolitis**

- Most common associated pathogen is respiratory syncytial virus (RSV)
- Major reason for hospitalization of infants and young children
- Manifestations
  - Rhinorrhea
  - Tight cough
  - Decreased appetite, lethargy, and fever
  - Wheezing
Disorders of the Lower Respiratory System - continued

**Pneumonia**
- **Bacterial pneumonia**
  - Most common: streptococci and staphylococci
  - Pneumococcal (*Streptococcus pneumoniae*) pneumonia is the most common cause of community-acquired bacterial pneumonia
  - May follow viral illness or viral pneumonia
- **Viral pneumonia**
  - Most common viral pneumonia in young children is RSV (respiratory syncytial virus)
  - Also parainfluenza, influenza, and adenovirus
- **Atypical (*Mycoplasma pneumoniae*)**
  - Most common cause of community-acquired pneumonia for school age and young adults
  - Onset is usually gradual, resembling a typical upper respiratory infection but with low-grade fever and prominent cough
  - Usually not severe and self-limiting

**Aspiration pneumonitis**
- Caused by a foreign substance, such as food, meconium, secretions (saliva or gastric), or environmental compounds, entering the lung and resulting in inflammation of the lung tissue
- Leading cause of death in children who are neurologically compromised
- Lung damage depends on volume and pH of aspirate

**Bronchiolitis obliterans**
- Fibrotic obstruction of the respiratory bronchioles and alveolar ducts secondary to intense inflammation
- Most often occurs as a sequelae of a severe viral pulmonary infection
- Progression of disease demonstrates:
  - Increasing tachypnea
  - Dyspnea
  - Cough
  - Sputum production
  - Crackles
  - Wheezing
  - Increased APD
  - Hypoxemia
Disorders of the Lower Respiratory Track - continued

Asthma
- Characterized by bronchial hyperreactivity and reversible airflow obstruction, usually in response to an allergen (Type I hypersensitivity reaction)
- Most prevalent chronic disease in childhood
- Results from a complex interaction between genetic susceptibility and environmental factors (e.g., allergens including air pollution, dust mites, cockroach antigen, cat exposure, tobacco smoke) and infections, particularly viral (e.g., rhinovirus and RSV)
- Manifestations:
  - Cough
  - Expiratory wheeze
  - Shortness of breath, tachypnea
  - Nasal flaring
  - Use of accessory muscles
  - Exercise intolerance

Acute Respiratory Distress Syndrome (ARDS)
- Life-threatening condition resulting from a direct pulmonary insult (pneumonia, aspiration, near drowning, smoke inhalation) or a systemic insult (sepsis or multiple trauma)
- Inflammatory response activation causes alveolocapillary injury
- Hallmark is lung inflammation leading to fluid in air spaces and alveolar collapse
- Manifestations:
  - Develops acutely after the initial insult, usually within 24 hours
  - Progressive respiratory distress, severe hypoxemia, decreased pulmonary compliance
  - Hyperventilation
- Treatment:
  - Mechanical ventilation
  - Supportive care

Cystic fibrosis
- Autosomal recessive multisystem disease
- Exocrine or mucus-producing glands secrete abnormally thick mucus because of defective epithelial ion transport
- In the lungs, thick secretions obstruct the bronchioles and predispose the lungs to chronic infections
- Chronic inflammation leads to hyperplasia of goblet cells, bronchiectasis, pneumonia, hypoxia, fibrosis, etc.
Disorders of the Lower Respiratory Track - continued

Sudden Infant Death Syndrome (SIDS)

- Defined as “sudden death of an infant under 1 year of age which remains unexplained”
- Incidence
  - Lower during first month of life, increases in the second month, and peaks at 3 to 4 months
  - More common in male infants
- Seasonal variation
  - Possible relationship to respiratory infections
- Wide range of risk factors
- Etiology unknown
Urinary Tract Obstruction
- Urinary tract obstruction is an interference with the flow of urine at any site along the urinary tract
- The obstruction can be caused by an anatomic or functional defect
- Severity based on:
  - Location
  - Completeness
  - Involvement of one or both upper urinary tracts
  - Duration
  - Cause
- Compensatory hypertrophy
  - Obligatory growth
  - Compensatory growth
- Post-obstructive diuresis
Kidney stones
- Calculi or urinary stones
  - Masses of crystals, protein, or other substances that form within and may obstruct the urinary tract
- Risk factors
  - Gender, race, geographic location, seasonal factors, fluid intake, diet, and occupation
- Kidney stones are classified according to the minerals comprising the stones
- Pathophysiology
  - 80% of kidney stones are composed of calcium with oxalate or phosphate
  - Kidney stones are the result of crystallization of stone-forming salts that separate from the urine
  - Affects 5% of the population
  - Stones vary in size from microscopic to one-inch
- Kidney Stone Formation
  - Supersaturation of one or more salts
    - Presence of a salt in a higher concentration than the volume able to dissolve the salt
  - Precipitation of a salt from liquid to solid state
    - Temperature and pH
  - Growth into a stone via crystallization or aggregation
  - Other factors affecting stone formation
    - Crystal growth-inhibiting substances
    - Particle retention
    - Matrix
- Stones
  - Calcium oxalate or calcium phosphate
  - Struvite stones and Uric acid stones
- Manifestation
  - Renal colic
- Evaluation
  - Stone and urine analysis
  - Intravenous pyelogram (IVP) or kidney, ureter, bladder x-ray (KUB)
  - Spiral abdominal CT
- Treatment
  - High fluid intake, decreasing dietary intake of stone-forming substances, stone removal

Lower Urinary Tract Obstruction
- Neurogenic bladder
- Dyssynergia
  - Detrusor hyperreflexia
  - Detrusor areflexia
- Obstruction
- Low bladder wall compliance
Tumors
- Renal tumors
  - Renal adenomas
  - Renal cell carcinoma (RCC)
- Bladder tumors
  - Transitional cell carcinoma
  - Gross, painless hematuria
  - Most common in males older than 60 years

Urinary Tract Infection (UTI)
- UTI is inflammation of the urinary epithelium caused by bacteria
- Acute cystitis
- Painful bladder syndrome/interstitial cystitis
- Interstitial cystitis
- Acute and chronic pyelonephritis
- Most common pathogens
  - *Escherichia coli*
- Virulence of uropathogens
  - Host defense mechanisms

Acute cystitis
- Cystitis is an inflammation of the bladder
- Manifestations
  - Frequency, dysuria, urgency, and lower abdominal and/or suprapubic pain
- Treatment
  - Antimicrobial therapy, increased fluid intake, avoidance of bladder irritants, and urinary analgesics

Interstitial cystitis
- Nonbacterial infectious cystitis
- Manifestations
  - Most common in women 20 to 30 years old
  - Bladder fullness, frequency, small urine volume, chronic pelvic pain
- Treatment
  - No single treatment effective, symptom relief

Pyelonephritis
- Acute pyelonephritis
  - Acute infection of the renal pelvis interstitium
    - Vesicoureteral reflux, *E. coli*, Proteus, *Pseudomonas*
- Chronic pyelonephritis
  - Persistent or recurring episodes of acute pyelonephritis that leads to scarring
  - Risk of chronic pyelonephritis increases in individuals with renal infections and some type of obstructive pathologic condition
Glomerular Disorders
- The glomerulopathies are disorders that directly affect the glomerulus
- Urinary sediment changes
  - Nephrotic sediment
  - Nephritic sediment
  - Sediment of chronic glomerular disease
- Glomerular disease demonstrates a sudden or insidious onset of hypertension, edema, and an elevated blood urea nitrogen (BUN)
- Decreased glomerular filtration rate
  - Elevated plasma creatinine, urea, and reduced creatinine clearance
- Glomerular damage causes a decreased glomerular membrane surface area, glomerular capillary blood flow, and blood hydrostatic pressure
- Increased glomerular capillary permeability and loss of negative ionic charge barrier result in passage of plasma proteins into the urine
- Resulting hypoalbuminemia encourages plasma fluid to move into the interstitial spaces
  - Edema

Glomerulonephritis
- Inflammation of the glomerulus
  - Immunologic abnormalities (most common)
  - Drugs or toxins
  - Vascular disorders
  - Systemic diseases
  - Viral causes
- Most common cause of end-stage renal failure
- Mechanisms of injury
  - Deposition of circulating soluble antigen-antibody complexes, often with complement fragments
  - Formation of antibodies against the glomerular basement membrane
Acute poststreptococcal glomerulonephritis
- Rapidly progressing glomerulonephritis
  - Antiglomerular basement membrane disease (Goodpasture syndrome)
- Chronic glomerulonephritis

Nephrotic Syndrome
- Excretion of 3.5 g or more of protein in the urine per day
- The protein excretion is caused by glomerular injury
- Findings
  - Hypoalbuminemia, edema, hyperlipidemia, and lipiduria, and vitamin D deficiency
- Membranous glomerulonephritis
- Focal glomerulosclerosis
- Minimal change disease (lipoid nephrosis)

Acute Renal Failure (ARF)
- Prerenal acute renal failure
  - Most common cause of ARF
  - Caused by impaired renal blood flow
  - GFR declines because of the decrease in filtration pressure
- Intrarenal acute renal failure
  - Acute tubular necrosis (ATN) is the most common cause of intrarenal renal failure
    - Postischemic or nephrotoxic
    - Oliguria
- Postrenal acute renal failure
  - Occurs with urinary tract obstructions that affect the kidneys bilaterally
  - Oliguria phase
  - Diuretic phase
  - Recovery phase
Chronic Renal Failure

- Chronic renal failure is the irreversible loss of renal function that affects nearly all organ systems
- Stages
  - Chronic renal insufficiency
  - Chronic renal failure
  - End-stage renal failure
- Proteinuria and uremia
- Creatinine and urea clearance
- Fluid and electrolyte balance
  - Sodium and water balance
  - Phosphate and calcium balance
  - Potassium balance
  - Acid-base balance
- Alterations seen in following systems:
  - Musculoskeletal
  - Cardiovascular and pulmonary
  - Hematologic
  - Immune
  - Neurologic
- Gastrointestinal
  - Alteration in protein, carbohydrate, and lipid metabolism
- Endocrine and reproduction
- Integumentary
Assessment of pediatric renal function
- Signs and symptoms
- Laboratory tests
- Radiological tests
- Nursing considerations
- Psychosocial and developmental considerations

GU Disorders and Defects
- Urinary Tract Infection (UTI)
- Vesicoureteral Reflux
- Hypospadias
- Nephrotic Syndrome
- Acute Glomerular Nephritis
- Hemolytic Uremic Syndrome
- Wilm’s Tumor

Renal Failure
- Acute
- Chronic
- Kidney transplantation

Urinary Tract Disorders Signs and Symptoms
- Newborn
  - Poor feeding
  - Vomiting
  - Poor weight gain
  - Rapid respirations
  - Respiratory distress
  - Frequent voiding
  - Crying w/voiding
  - Jaundice
  - Spontaneous pneumothorax
  - Seizures
  - Dehydration
  - Other anomalies
  - Enlarged kidneys or bladder
- Infant & toddler
  - Poor feeding, vomiting
  - Poor weight gain
  - Increased thirst
  - Frequent voiding
  - Crying with voiding
Urinary Tract Disorders Signs and Symptoms - continued

- Infant & toddler
  - Foul-smelling urine
  - Pallor
  - Fever
  - Persistent diaper rash
  - Seizures
  - Dehydration
  - Enlarged kidneys or bladder

- Childhood
  - Poor appetite
  - Vomiting
  - Growth failure
  - Excessive thirst
  - Enuresis, incontinence, frequent urination
  - Painful urination
  - Swelling of the face
  - Seizures or tetany
  - Pallor
  - Fatigue
  - Blood in urine
  - Abdominal or back pain
  - Edema
  - Hypertension

Urinary Tract Infection

- Infection in the upper or lower tract
- Females 10-30x risk of males
- Urinalysis
  - Leukocyte esterase, nitrites, WBC and RBC counts, bacteria
- Culture and Sensitivity
  - E. coli – 80% of cases
- Anatomic and Physical Factors
  - Shorter urethra in females
    - 2 – 6 years of age
    - Adolescents
  - Urinary stasis
    - Reflux
    - Anatomic abnormalities
    - Bladder compression
    - Dysfunctional voiding
**Vesicoureteral Reflux**
- Retrograde flow of urine from the bladder up the ureters
- Conservative management - prophylactic antibiotics, routine urine cultures
- Surgical management – reimplants

**Hypospadias/Epispadias**
- Location of the urinary meatus behind the glans penis or anywhere on the penile shaft
- Circumcision delayed
- Surgical correction by 1 year old
  - To enable voiding in standing position
  - Improve physical appearance
  - Sexual adequacy

**Nephrotic Syndrome**
- Primary - Minimal Change Nephrotic Syndrome
  - 80% of all cases
  - Good prognosis
- Secondary to another disorder
- Congenital
- Goals
  - Reduce urinary protein excretion
  - Reduce tissue fluid retention
  - Prevent infection
  - Minimize complication
- Therapeutic Management
  - Low salt diet
  - Corticosteroids
  - Albumin and Lasix
  - Immunosuppressants
**Acute Glomerulonephritis**
- Clinical Manifestations
  - Orbital edema (worse in AM)
  - Loss of appetite
  - Decreased urine output
  - Tea-colored urine
  - Antecedent streptococcal infection
  - Hypertension
  - Proteinuria
- Nursing Interventions
  - No added salt diet
  - Fluid restriction
  - Daily weights
  - Close follow-up

**Hemolytic Uremic Syndrome**
- Age 6 months – 5 years
- Presents as viral illness followed by sudden onset of hemolysis and anemia
- Anemia, thrombocytopenia and renal failure = HUS
- 95% recovery rate with prompt treatment
- Can progress to chronic renal failure

**Wilm’s Tumor**
- Abdominal swelling or mass
- Usually 1 kidney (favors left)
- Encapsulated for long period
- Can become quite large
- Treatment: surgical removal and chemotherapy
- Wilm’s Tumor Post-op Care Monitor for:
  - Edema
  - Bowel sounds and Bowel movements
  - Abdominal distention
  - Vomiting
  - Pain
  - Blood pressure
  - Urine output
  - Signs of infection

**Acute Renal Failure**
- Symptoms
  - Oliguria
  - Nausea
  - Vomiting
  - Drowsiness
  - Edema
  - Hypertension
• Acute Renal Failure Resulting from:
  o Severe dehydration
  o Poor renal perfusion
  o Acute renal injury
  o Glomerulonephritis

**Chronic Renal Failure**

• Uremia
  o Retention of waste products
  o Water and sodium restriction
  o Hyperkalemia
  o Metabolic acidosis
  o Anemia
  o Calcium & phosphorus disturbances
  o Growth disturbance

• Chronic Renal Failure Meds
  o Calcium and Vitamin D
  o Antihypertensives
  o Diuretics
  o Bicarbonate
  o Antiepileptics
  o Antihistamines

• Treatment of CRF
  o Peritoneal Dialysis
    CAPD – continuous
    ambulatory
    CCPD – continuous cyclic

• Treatment of CRF - Kidney Transplantation
  o LRD – living related donor
  o CAD – cadaver donor

• Renal Transplantation - Watch for
  o Fever
  o Swelling and tenderness over graft area
  o Decreased urine output
  o Elevated blood pressure
Reproductive Pathology and Sexually Transmitted Infections
Pathology 2 – Dr. Gary Mumaugh

Alterations of Sexual Maturation

Delayed puberty
- Secondary sex characteristics have not appeared in girls by age 13
- Secondary sex characteristics have not appeared in boys by age 14
- 95% of cases are simply a constitutional delay
- 5% are caused by some type of disruption of the hypothalamic-pituitary-gonadal axis

Precocious puberty
- Sexual maturation before age 6 in black girls and age 7 in white girls
- Sexual maturation before age 9 in boys
- Forms:
  - Isosexual precocious puberty
  - Heterosexual precocious puberty
  - Incomplete precocious puberty

Hormonal Alterations
- Primary dysmenorrhea
  - Painful menstruation associated with prostaglandin release in ovulatory cycles
  - Related to the duration and amount of menstrual flow
- Secondary dysmenorrhea
  - Painful menstruation related to pelvic pathology
  - Can occur any time in the menstrual cycle
- Primary amenorrhea
  - Absence of menstruation by age 14
  - Causes:
    - Congenital defects of gonadotropin production
    - Genetic disorders
    - Congenital central nervous system defects
    - Congenital anatomic malformations
    - Acquired CNS lesions
- Secondary amenorrhea
  - Absence of menstruation for a time equivalent to three or more cycles or 6 months in women who have previously menstruated
  - Causes:
    - Pregnancy
    - Dramatic weight loss
    - Malnutrition or excessive exercise
    - Anovulation
    - Hyperprolactinemia
    - Hirsutism
Menstrual Alterations

- Abnormal uterine bleeding
  - Menstrual irregularity
  - Dysfunctional uterine bleeding
- Polycystic ovarian syndrome
  - Oligo-ovulation or anovulation
  - Elevated levels of androgens or clinical signs of hyperandrogenism and polycystic ovaries
  - Leading cause of infertility in the United States
  - Multifactorial
    - Hyperinsulinism
    - Hypertension
    - Dyslipidemia
  - Dysfunction of follicle development
- Premenstrual Syndrome (PMS)
  - Cyclic physical, psychological, or behavioral changes that impair interpersonal relationships or interfere with usual activities
  - Premenstrual dysphoric disorder (PMDD) in 3% to 8% of women
  - Greater than 200 physical, emotional, and behavioral signs and symptoms
Infection and Inflammation

- Pelvic inflammatory disease (PID)
  - Acute inflammatory disease caused by infection
  - May involve any organ of the reproductive tract
    - Salpingitis
    - Oophoritis
  - Sexually transmitted diseases migrate from the vagina to the upper genital tract
  - Polymicrobial infection

- Vaginitis
  - Infection of the vagina
  - Sexually transmitted pathogens, bacterial vaginosis, and *Candida albicans*
  - Acidic nature of the vagina provides some protection
    - Maintained by cervical secretions, normal flora, and lactobacillus acidophilus

- Cervicitis
  - Inflammation or infection of the cervix
  - Mucopurulent cervicitis (MPC)

- Vulvitis
  - Inflammation of the female external genitalia
  - Causes:
    - Contact with soaps, detergents, lotions, hygienic sprays, shaving, menstrual pads, perfumed toilet paper, or nonabsorbing or tight-fitting clothing
    - Vaginal infections that spread to the labia

Infection and Inflammation

- Bartholinitis
  - Inflammation of one or both ducts that lead from the vaginal opening to the Bartholin glands
  - Caused by microorganisms that infect the lower female reproductive tract
  - Inflammation narrows the distal portion of the ducts
  - Leads to obstruction and stasis of glandular secretions
Pelvic Relaxation Disorders

- The bladder, urethra, and rectum are supported by the endopelvic fascia and perineal muscles
- The muscular and fascial tissue loses tone and strength with aging
- Fails to maintain organs in proper position
- Pelvic Relaxation Disorders
  - Cystocele and rectocele
  - Urethrocele
  - Cystourethrocele
  - Enterocele
  - Vaginal prolapse
  - Uterine prolapse

Benign Growths

- Benign ovarian cysts
  - Unilateral
  - Produced when a follicle or number of follicles are stimulated but no dominant follicle develops and reaches maturity
    - Follicular cysts
    - Corpus luteum cysts
    - Dermoid cysts
  - Cysts can cause ovarian torsion
- Endometrial polyps
  - Benign mass of endometrial tissue
  - Intermenstrual; excessive bleeding can occur
- Leiomyomas
  - Commonly called uterine fibroids
  - Benign tumors of smooth muscle cells in the myometrium
  - Cause abnormal uterine bleeding, pain, and symptoms related to pressure on nearby structures
- Adenomyosis
  - Islands of endometrial glands surrounded by benign endometrial stroma within the myometrium
  - Asymptomatic, or abnormal bleeding, dysmenorrhea, uterine enlargement, and tenderness
Proliferative Conditions
- Endometriosis
  - Presence of functioning endometrial tissue or implants outside the uterus
  - Responds to hormone fluctuations of the menstrual cycle
  - Possible causes:
    - Retrograde menstruation
    - Spread through vascular or lymphatic systems
    - Stimulation of multipotential epithelial cells on reproductive organs
    - Genetic predisposition

Female Reproductive Cancer
- Cervical cancer
  - Cervical dysplasia (CIN)
  - Cervical carcinoma in situ
  - Invasive carcinoma of the cervix
  - Risk factors:
    - HPV and HIV
    - Multiple sexual partners
- Vaginal cancer
- Vulvar cancer
- Endometrial cancer
- Ovarian cancer
Impaired Fertility
- Infertility
  - Inability to conceive after 1 year of unprotected intercourse with the same partner
  - Fertility can be impaired by factors in the man, woman, or both
  - Fertility tests:
    - Structural
    - Hormonal

Disorders of the Male Reproductive System
Disorders of the Urethra:
- Urethritis
  - Inflammation of the urethra usually, but not always, caused by a sexually transmitted disease
  - Nonsexual origins can be caused by urologic procedures, insertion of foreign objects, anatomic abnormalities, or trauma
- Urethral strictures
  - Fibrotic narrowing of the urethra caused by scarring
  - Commonly a result of trauma or untreated or severe urethral infections

Disorders of the Penis:
- Phimosis
  - Inability to retract foreskin from the glans of the penis (distal to proximal)
- Paraphimosis
  - Inability to replace or cover the glans with the foreskin (proximal to distal)
  - Frequently caused by poor hygiene or chronic infections
- Peyronie disease
  - "Bent nail syndrome"
  - Slow development of fibrous plaques (thickening) in the erectile tissue of the corpus cavernosa, causing a lateral curvature of the penis during erection
  - Occurs in middle-aged men and causes painful erections and intercourse
- Priapism
  - Condition of prolonged penile erection
  - Urologic emergency
- Penile cancer
  - Carcinoma of the penis is rare
  - Mostly squamous cell carcinomas
  - Requires surgery, radiation, or chemotherapy
  - 5-year survival rate 50%
- Balanitis - Inflammation of the glans penis
  - Usually associated with foreskin inflammation (posthitis)
  - Accumulation under the foreskin (smegma) causes irritation of the glans
Disorders of the Scrotum

- **Varicocele**
  - Inflammation/dilation of veins in the spermatic cord
  - Caused by inadequate or absent valves in the spermatic veins

- **Hydrocele**
  - Scrotal swelling caused by collection of fluid within the tunica vaginalis
  - Imbalance between fluid secretion and reabsorption

- **Spermatocele**
  - Painless diverticulum of the epididymis located between the head of the epididymis and the testis
  - Contains milky fluid that contains sperm and does not cover the entire anterior scrotal surface

Disorders of the Testis

- **Cryptorchidism**
  - Failure of one or more of the testes to descend from the abdominal cavity into the scrotum
  - Treatment
    - Hormone therapy or surgery (orchiopexy)

- **Orchitis**
  - Acute inflammation of the testis
  - Complication of a systemic disease or related to epididymitis
  - Mumps most common cause

- **Torsion of the testis**
  - Rotation of the testis
  - The rotation causes the twisting of the blood vessels in the spermatic cord
  - Painful and swollen testis
  - Condition may be spontaneous or follow physical exertion or trauma
  - Surgical emergency

- **Cancer of the testis**
  - Among the most curable of cancers
  - Common in men between ages 15 and 35
  - Causes painless testicular enlargement

Impairment of Sperm Production and Quality

- **Hormone and growth factors**
  - FSH, LH, and testosterone
  - Androgen-binding protein, inhibin B, and other peptides
  - Adequate spermatogonia - Sperm count >20 million/mL

- **Sperm motility**
- **Antisperm antibodies**
- **Drugs and toxins in the semen**
Disorders of the Epididymis
- Epididymitis
  - Inflammation of the epididymis
  - Common in sexually active young men
  - The pathogenic microorganism reaches the epididymis by ascending the vas deferens from an already infected bladder or urethra

Disorders of the Prostate Gland
- Benign prostatic hyperplasia
  - Enlargement of the prostate gland
  - Symptoms associated with urethral compression
  - Relationship to aging
  - Evaluation
    - Digital rectal exams
    - Prostate-specific antigen (PSA) monitoring
- Prostatitis
  - Inflammation of the prostate
  - Normal protective barriers:
    - Urethral length
    - Micturition
    - Ejaculation
    - Antimicrobials in prostatic fluid (PAF)
  - Similar symptoms to BPH
    - Acute bacterial
    - Chronic bacterial
    - Nonbacterial
  - Prostatodynia
- Cancer of the prostate
  - Accounts for 29% of all cancers in males
  - Prostatic cancer is asymptomatic until its advanced stages
  - Symptoms are similar to BPH
  - Dietary factors
  - Hormones
  - Vasectomy
  - Chronic inflammation
  - Familial factors
Male Sexual Dysfunction
- Vascular, endocrine, and neurologic disorders
- Chronic diseases
  - Renal failure and diabetes mellitus
- Penile diseases and penile trauma
- Iatrogenic factors
  - Surgery and pharmaceuticals
- Treatment both medical and surgical
  - Viagra

Disorders of the Breast
- Galactorrhea
  - Persistent and sometimes excessive secretion of milky fluid from the breasts of a woman who is not pregnant or nursing
  - Galactorrhea also can occur in men
  - Nonpuerperal hyperprolactinemia
  - Women with galactorrhea also experience menstrual abnormalities

Benign Breast Lesions
- Nonproliferative breast lesions
  - Fibrocystic changes (FCC)
- Proliferative breast lesions without atypia:
  - Epithelial hyperplasia
  - Florid hyperplasia
  - Sclerosing adenosis
  - Complex sclerosing lesion
  - Papillomas
  - Atypical hyperplasia
  - Ductal hyperplasia
  - Lobar hyperplasia

Breast Cancer
- Most common cancer in American women
- Leading cause of death from ages 40 to 44
- Second most common killer after lung cancer
- Black women more likely to die from it
- Reproductive factors
- Hormonal factors
- Environmental factors and lifestyle
  - Radiation
  - Diet
  - Chemicals (xenoestrogens)
- Physical activity
- Familial factors and tumor-related genes
Breast Cancer (cont’d)
- Manifestations:
  - Painless lump
  - Dimpling of skin
  - Edema
- Treatment:
  - Surgery
  - Radiation
  - Chemotherapy
  - Hormone therapy
  - Biologic therapy
  - Bone marrow transplantation
  - Based on stage of cancer

Disorders of the Male Breast
- Gynecomastia
  - Overdevelopment of the breast tissue in a male
  - Results from hormone alterations
    - Idiopathic and system disorders, drugs, or neoplasms
- Male breast cancer
  - Most commonly seen after age 60
  - Tumors resemble carcinomas of the breast in women
  - Crusting and nipple discharge are common clinical manifestations

Sexually Transmitted Infections (STIs)
- Reportable infections do not include some of the most prevalent sexually transmitted infections
- Complications: pelvic inflammatory disease (PID), infertility, ectopic pregnancy, chronic pelvic pain, neonatal morbidity and mortality, genital cancer, and epidemiologic synergy with HIV transmission
- Although the majority of STIs can be treated, viral-induced STIs are considered incurable
- Bacterial vaginosis
  - Sexually associated condition, but not always an STI
  - Caused by *Gardnerella vaginalis* and various other anaerobes
  - Characterized by increased, thin, grey-white vaginal discharge with a strong “fishy” odor
- Chancroid
  - Incidence is low in United States; women are generally asymptomatic, whereas men develop inflamed, painful genital ulcer
  - Secondary infections can occur
Sexually Transmitted Bacterial Infections (cont’d)

- **Chlamydia**
  - Infections caused by *Chlamydia trachomatis*
  - Most common STI in the United States
  - Untreated or undertreated chlamydial infections are the primary cause of preventable infertility and ectopic pregnancy
  - Leading cause of blindness worldwide
  - Often asymptomatic
  - Adolescents 15–19 years at highest risk
  - Transmitted by:
    - Oral, anal, or vaginal intercourse
    - Mother-to-child transmission during vaginal delivery
  - Manifestations:
    - Urethral, renal, vaginal, and oral infections
    - Vaginal discharge
    - Bleeding or spotting and heavy menses
    - Painful urination
    - Asymptomatic in up to 50%

- **Gonorrhea**
  - Caused by microorganisms of the species *Neisseria gonorrhoeae*
    - Aerobic, non-spore-forming, gram-negative diplococcus

- **Lymphogranuloma venereum**
  - Often confused with syphilis, herpes, or chancroid
  - Begins as skin lesion, spreads to lymphatic tissue
  - Appears as multivesicular ulcer on penis or scrotum in men and appears on vaginal wall, cervix, or labia in women
  - Anorectal lesions, from anal intercourse, can appear in both men and women

- **Syphilis**
  - Caused by *Treponema pallidum*
  - Higher incidence among men who have sex with men; in urban and poverty-stricken areas and prison population
  - Transmitted during first few years of infection
  - Can be transmitted to fetus during pregnancy
  - Syphilis Stages:
    - Primary syphilis
      - Local manifestations:
        - Granulomatous tissue reaction—hard chancre
        - Microorganisms drain with the lymphatic fluid
    - Secondary syphilis
      - Systemic manifestations:
        - Fever, malaise, sore throat, hoarseness, anorexia, joint pain, skin rash, and lesions (condylomata lata)
Sexually Transmitted Bacterial Infections (cont’d)

- Syphilis stages: (cont’d)
  - Latent syphilis
    - Medical evidence of the infection, but patient is asymptomatic
  - Tertiary syphilis
    - Usually asymptomatic
    - Destructive systemic manifestations

Sexually Transmitted Viral Infections
- Human papillomavirus (HPV)
  - Most common viral STI in United States
  - Risk factors include multiple sexual partners, early onset of sexual activity (16–25 years of age)
  - Associated with cervical and vulvar cancer in females and anorectal and squamous cell carcinoma of the penis in men
  - Infants can be infected during delivery
  - Frequently asymptomatic
  - Warts are soft, skin-colored, whitish pink to reddish brown; may occur singly or in clusters

- Genital herpes
  - Two serotypes:
    - Herpes simplex virus type 1
    - Herpes simplex virus type 2
      - 80% of initial and 98% of recurrent infections are type 2
  - Most common cause of genital ulceration in United States; reaching epidemic status
  - Neonatal infections can occur primarily intrapartum and postpartum
  - Virus undergoes local replication in dermis and epidermis leading to vesicles
  - Can remain in latent stage until reactivated; cause of reactivation unknown but may be related to stress, sun exposure, hormonal fluctuations, or illness
  - Small, scattered vesicles are quite painful, lasting 5–21 days
  - Transmitted through contact with a person who is shedding the virus in a secretion or from a peripheral lesion or mucosal surface

Sexually Transmitted Parasitic Infections
- Pediculosis pubis
  - Caused by the crab louse *Pthirus pubis*
  - Transmitted primarily by intimate sexual contact or contact with infected bed linens or clothing
  - Primarily transmitted sexually, causes “crabs;” most common in single persons ages 15–25 years
  - Ranges from mild itching to severe, intolerable itching in the pubic area
  - Lice and nits are visible to the naked eye
Sexually Transmitted Parasitic Infections (cont'd)

- **Scabies**
  - Caused by the adult female itch mite, *Sarcoptes scabiei*
  - Transmission of scabies requires prolonged, close skin-to-skin contact
    - Typically occurs between family members or sexual partners
  - Primary symptom is intense itching

- **Trichomoniasis**
  - Caused by *T. vaginalis*
    - Anaerobic, unicellular, flagellated, parasitic protozoan
  - Common cause of lower genital tract infection; found in both partners; urethra most common site of infection in men, primarily involves vagina in women
  - Manifestations range from none to severe, including pain on intercourse, dysuria, copious frothy vaginal discharge, and internal pruritis; most men remain asymptomatic
Clinical Manifestations of Gastrointestinal Dysfunction

Anorexia
- A lack of a desire to eat despite physiologic stimuli that would normally produce hunger

Vomiting
- The forceful emptying of the stomach and intestinal contents through the mouth
- Several types of stimuli initiate the vomiting reflex

Nausea
- A subjective experience that is associated with a number of conditions
- The common symptoms of vomiting are hypersalivation and tachycardia

Retching
- Nonproductive vomiting

Projectile vomiting
- Projectile vomiting is spontaneous vomiting that does not follow nausea or retching

Constipation
- Constipation is defined as infrequent or difficult defecation
- Pathophysiology
  - Neurogenic disorders
  - Functional or mechanical conditions
  - Low-residue diet
  - Sedentary lifestyle
  - Excessive use of antacids
  - Changes in bowel habits

Diarrhea
- Increased frequency of bowel movements
- Increased volume, fluidity, weight of the feces
- Major mechanisms of diarrhea:
  - Osmotic diarrhea
  - Secretory diarrhea
  - Motility diarrhea
- Associated with malabsorption syndromes

Abdominal pain
- Abdominal pain is a symptom of a number of gastrointestinal disorders
- Parietal pain and visceral pain
- Referred pain
Clinical Manifestations of Gastrointestinal Dysfunction

**Gastrointestinal bleeding**
- Upper gastrointestinal bleeding
  - Esophagus, stomach, or duodenum
- Lower gastrointestinal bleeding
  - Bleeding from the jejunum, ileum, colon, or rectum
- Hematemesis
- Hematochezia
- Melena
- Occult bleeding

**Disorders of Motility**

**Dysphagia**
- Dysphagia is difficulty swallowing
- Types:
  - Mechanical obstructions
  - Functional obstructions
- Achalasia:
  - Denervation of smooth muscle in the esophagus and lower esophageal sphincter relaxation

**Gastroesophageal reflux disease (GERD)**
- GERD is the reflux of chyme from the stomach to the esophagus
- If GERD causes inflammation of the esophagus, it is called reflex esophagitis
- A normal functioning lower esophageal sphincter maintains a zone of high pressure to prevent chyme reflux
- Conditions that increase abdominal pressure can contribute to GERD
- Manifestations:
  - Heartburn
  - Regurgitation of chyme
  - Mid-epigastric pain within 1 hour of eating

**Hiatal hernia**
- Sliding hiatal hernia (A)
- Paraesophageal hiatal hernia (B)
Disorders of Motility

Pyloric obstruction
- The blocking or narrowing of the opening between the stomach and the duodenum
- Can be acquired or congenital
- Manifestations:
  - Epigastric pain and fullness
  - Nausea
  - Vomiting
  - With a prolonged obstruction, malnutrition, dehydration, and extreme debilitation

Intestinal obstruction and paralytic ileus
- An intestinal obstruction is any condition that prevents the flow of chyme through the intestinal lumen or failure of normal intestinal motility in the absence of an obstructing lesion
- An ileus is an obstruction of the intestines
- Simple obstruction
- Functional obstruction

Gastritis
- Inflammatory disorder of the gastric mucosa
- Acute gastritis
- Chronic gastritis

Peptic Ulcer Disease
- A break or ulceration in the protective mucosal lining of the lower esophagus, stomach, or duodenum
- Acute and chronic ulcers
- Superficial
  - Erosions
- Deep
  - True ulcers
- Duodenal ulcers
  - Most common of the peptic ulcers
  - Developmental factors:
    - *Helicobacter pylori* infection
      - Toxins and enzymes that promote inflammation and ulceration
    - Hypersecretion of stomach acid and pepsin
    - Use of NSAIDs
    - High gastrin levels
    - Acid production by cigarette smoking
Gastric Ulcer
- Gastric ulcers tend to develop in the antral region of the stomach, adjacent to the acid-secreting mucosa of the body
- Pathophysiology
  - The primary defect is an increased mucosal permeability to hydrogen ions
  - Gastric secretion tends to be normal or less than normal

Stress Ulcer
- A stress ulcer is a peptic ulcer that is related to severe illness, neural injury, or systemic trauma
  - Ischemic ulcers
    - Within hours of trauma, burns, hemorrhage, sepsis
  - Cushing ulcers
    - Ulcers that develop as a result of a head/brain injury

Dumping Syndrome
- Dumping syndrome is the rapid emptying of chyme from a surgically created residual stomach into the small intestine
- Dumping syndrome is a clinical complication of partial gastrectomy or pyloroplasty surgery
- Developmental factors:
  - Loss of gastric capacity
  - Loss of emptying control
  - Loss of feedback control by the duodenum when it is removed
- Late dumping syndrome

Malabsorption Syndromes
Maldigestion
- Failure of the chemical processes of digestion

Malabsorption
- Failure of the intestinal mucosa to absorb digested nutrients
- Maldigestion and malabsorption frequently occur together
**Malabsorption Syndromes**

**Pancreatic insufficiency**
- Insufficient pancreatic enzyme production
  - Lipase, amylase, trypsin, or chymotrypsin
- Causes:
  - Pancreatitis
  - Pancreatic carcinoma
  - Pancreatic resection
  - Cystic fibrosis
- Fat maldigestion is the main problem, so the patient will exhibit fatty stools and weight loss

**Lactase deficiency**
- Inability to break down lactose into monosaccharides and therefore prevent lactose digestion and monosaccharide absorption
- Fermentation of lactose by bacteria causes gas (cramping pain, flatulence, etc.) and osmotic diarrhea

**Bile salt deficiency**
- Conjugated bile salts needed to emulsify and absorb fats
- Conjugated bile salts are synthesized from cholesterol in the liver
- Can result from liver disease and bile obstructions
- Poor intestinal absorption of lipids causes fatty stools, diarrhea, and loss of fat-soluble vitamins (A, D, E, K)

**Fat-soluble vitamin deficiencies:**
- Vitamin A
  - Night blindness
- Vitamin D
  - Decreased calcium absorption
  - Bone pain
  - Osteoporosis
  - Fractures
- Vitamin K
  - Prolonged prothrombin time
  - Purpura
  - Petechiae
- Vitamin E
  - Uncertain

**Inflammatory Bowel Diseases**
- Chronic, relapsing inflammatory bowel disorders of unknown origin
  - Genetics
  - Alterations of epithelial barrier functions
  - Immune reactions to intestinal flora
  - Abnormal T cell responses
Ulcerative Colitis
- Chronic inflammatory disease that causes ulceration of the colonic mucosa
  - Sigmoid colon and rectum
- Suggested causes:
  - Infectious
  - Immunologic (anticolon antibodies)
  - Dietary
  - Genetic (supported by family studies and identical twin studies)
- Symptoms:
  - Diarrhea (10 to 20/day)
  - Bloody stools
  - Cramping
- Treatment:
  - Broad-spectrum antibiotics and steroids
  - Immunosuppressive agents
  - Surgery
- An increased colon cancer risk demonstrated

Crohn Disease
- Granulomatous colitis, ileocolitis, or regional enteritis
- Idiopathic inflammatory disorder; affects any part of the digestive tract, from mouth to anus
- Difficult to differentiate from ulcerative colitis
  - Similar risk factors and theories of causation as ulcerative colitis
- Causes “skip lesions”
- Ulcerations can produce longitudinal and transverse inflammatory fissures that extend into the lymphatics
- Anemia may result from malabsorption of vitamin $B_{12}$ and folic acid
- Treatment similar to ulcerative colitis

Diverticular Disease of the Colon
- Diverticula
  - Herniations of mucosa through the muscle layers of the colon wall, especially the sigmoid colon
- Diverticulosis
  - Asymptomatic diverticular disease
- Diverticulitis
  - The inflammatory stage of diverticulosis
Appendicitis
- Inflammation of the vermiform appendix
- Possible causes:
  - Obstruction, ischemia, increased intraluminal pressure, infection, ulceration, etc.
- Epigastric and RLQ pain
  - Rebound tenderness
- The most serious complication is peritonitis

Irritable Bowel Syndrome
- A functional gastrointestinal disorder with no specific structural or biochemical alterations as a cause of disease
- Characterized by recurrent abdominal pain and discomfort associated with altered bowel habits that present as diarrhea or constipation or both
- Associated with anxiety, depression, and chronic fatigue syndrome
- Cause unknown but mechanisms proposed:
  - Visceral hypersensitivity
  - Abnormal intestinal motility and secretion
  - Intestinal infection
  - Overgrowth of small intestinal flora
  - Food allergy/intolerance
  - Psychosocial factors
- Manifestations:
  - Can be diarrhea-predominant or constipation-predominant
  - Alternating diarrhea/constipation, gas, bloating, and nausea
- Symptoms are usually relieved with defecation and do not interfere with sleep

Vascular Insufficiency
- Blood supply to the stomach and intestine
  - Celiac axis
  - Superior and inferior mesenteric arteries
  - Two of three must be compromised to cause ischemia
- Mesenteric venous thrombosis
- Acute occlusion of mesenteric artery blood flow
- Chronic mesenteric arterial insufficiency

Obesity
- An increase in body fat mass
  - Body mass index greater than 30
- A major cause of morbidity, death, and increased health care costs
- Risk factor for many diseases and conditions
- Hypothalamus
- Hormones that control appetite and weight:
  - Insulin
  - Ghrelin
Obesity
- Peptide YY
- Leptin
- Adiponectin
- Resistin
- Leptin resistance
- Hyperleptinemia

Anorexia Nervosa and Bulimia Nervosa
- Characteristics:
  - Abnormal eating behavior
  - Weight regulation
  - Disturbed attitudes toward body weight, body shape, and size
- Anorexia nervosa
  - A person has poor body image disorder and refuses to eat
  - Anorexic patients can lose 25% to 30% of their ideal body weight as a result of fat and muscle depletion
  - Can lead to starvation-induced cardiac failure
  - In women and girls, anorexia is characterized by the absence of three consecutive menstrual periods
  - Binge eating/purging anorexia nervosa
- Bulimia nervosa
  - Body weight remains near normal but with aspirations for weight loss
  - Findings
    - Recurrent episodes of binge eating
    - Self-induced vomiting
    - Two binge-eating episodes per week for at least 3 months
    - Fasting to oppose the effect of binge eating, or excessive exercise
  - Continual vomiting of acidic chyme can cause:
    - Pitted teeth
    - Pharyngeal and esophageal inflammation
    - Tracheoesophageal fistulas
  - Overuse of laxative can cause rectal bleeding

Malnutrition and Starvation
- Starvation
  - Decreased caloric intake leading to weight loss
  - Cachexia
  - Short-term starvation
    - Glycogenolysis
    - Gluconeogenesis
  - Long-term starvation
    - Marasmus
    - Kwashiorkor
Liver Disorders

Portal hypertension

- Abnormally high blood pressure in the portal venous system caused by resistance to portal blood flow
  - Prehepatic
  - Intrahepatic
  - Posthepatic
- Consequences:
  - Varices:
    - Lower esophagus
    - Stomach
    - Rectum
  - Splenomegaly
  - Ascites
  - Hepatic encephalopathy

Hepatic encephalopathy

- A neurologic syndrome of impaired cognitive function, flapping tremor, and EEG changes
- The condition develops rapidly during fulminant hepatitis or slowly during chronic liver disease
- Cells in the nervous system are vulnerable to neurotoxins absorbed from the GI tract that, because of liver dysfunction circulate to the brain

Jaundice (icterus)

- Obstructive jaundice
  - Extrahepatic obstruction
  - Intrahepatic obstruction
- Hemolytic jaundice
  - Prehepatic jaundice
  - Excessive hemolysis of red blood cells or absorption of a hematoma

Viral Hepatitis

- Systemic viral disease that primarily affects the liver
  - Hepatitis A
    - Formally known as infectious hepatitis
  - Hepatitis B
    - Formally known as serum hepatitis
  - Hepatitis C, D, E, and G

Hepatitis A

- Hepatitis A can be found in the feces, bile, and sera of infected individuals
- Usually transmitted by the fecal-oral route
- Risk factors:
  - Crowded, unsanitary conditions
  - Food and water contamination
Hepatitis B
- Transmitted through contact with infected blood, body fluids, or contaminated needles
- Maternal transmission can occur if the mother is infected during the third trimester
- The hepatitis B vaccine prevents transmission and development of hepatitis B

Hepatitis C
- Hepatitis C is responsible for most cases of post-transfusion hepatitis
- Also implicated in infections related to IV drug use
- 50% to 80% of hepatitis C cases result in chronic hepatitis

Hepatitis
- Hepatitis D
  - Depends on hepatitis B for replication
- Hepatitis E
  - Fecal-oral transmission
  - Developing countries
- Hepatitis G
  - Recently discovered
  - Parentally and sexually transmitted
- Sequence:
  - Incubation phase
  - Prodromal (preicteric) phase
  - Icteric phase
  - Recovery phase
- Chronic active hepatitis
- Fulminant hepatitis
  - Results from impairment or necrosis of hepatocytes

Cirrhosis
- Irreversible inflammatory disease that disrupts liver function and even structure
- Decreased hepatic function caused by nodular and fibrotic tissue synthesis (fibrosis)
- Biliary channels become obstructed and cause portal hypertension
- Because of the hypertension, blood can be shunted away from the liver, and a hypoxic necrosis develops
- Alcoholic
  - The oxidation of alcohol damages hepatocytes
- Biliary (bile canaliculi)
  - Cirrhosis begins in the bile canaliculi and ducts
  - Primary biliary cirrhosis (autoimmune)
  - Secondary biliary cirrhosis (obstruction)
Disorders of the Gallbladder

- Obstruction or inflammation (cholecystitis) is the most common cause of gallbladder problems
- Cholelithiasis—gallstone formation
  - Types:
    - Cholesterol (most common)
    - Pigmented (cirrhosis)
  - Risks:
    - Obesity
    - Middle age
    - Female
    - Native American ancestry
    - Gallbladder, pancreas, or ileal disease

Gallstones

- Obstruction or inflammation (cholecystitis) is the most common cause of gallbladder problems
- Cholesterol stones form in bile that is supersaturated with cholesterol
- Theories:
  - Enzyme defect increases cholesterol synthesis
  - Decreased secretion of bile acids to emulsify fats
  - Decreased resorption of bile acids from ileum
  - Gallbladder smooth muscle hypomotility and stasis
  - Genetic predisposition
  - Combination of any or all of the above

Disorders of the Pancreas

- Pancreatitis
  - Inflammation of the pancreas
  - Associated with several other clinical disorders
    - Caused by an injury or damage to pancreatic cells and ducts, causing a leakage of pancreatic enzymes into the pancreatic tissue
  - These enzymes cause autodigestion of pancreatic tissue and leak into the bloodstream to cause injury to blood vessels and other organs
    - Manifestations and evaluation:
      - Epigastric pain radiating to the back
      - Fever and leukocytosis
      - Hypotension and hypovolemia
      - Enzymes increase vascular permeability
      - Characterized by an increase in a patient’s serum amylase level
  - Chronic pancreatitis
    - Related to chronic alcohol abuse
Cancer of the Gastrointestinal Tract
- Esophagus
- Stomach
- Colon and rectum
- Liver
- Gallbladder
- Pancreas

Typical location of carcinomas

Transverse colon (15%)
- Pain, obstruction, change in bowel habits, anemia

Ascending colon (25%)
- Pain, mass, change in bowel habits, anemia

Descending colon (15%)
- Pain, change in bowel habits, bright red blood in stool, obstruction

Rectum (45%)
- Blood in stool, change in bowel habits, rectal discomfort
Alterations of Digestive Function in Children
Pathology 2 – Dr. Gary Mumaugh

Cleft Lip and Cleft Palate
- Developmental anomalies
- Both disorders are caused by multifactorial inheritance
  - Maternal alcohol and tobacco use, maternal diabetes mellitus, and vitamin B deficiencies
  - These factors reduce the amount of neural crest mesenchyme that migrates into the area that will develop into the face of the embryo
- Cleft lip
  - Caused by the incomplete fusion of the nasomedial or intermaxillary process during the second month of development
  - Commonly occurs under one nostril, but the defect can be bilateral and symmetric or asymmetric
- Cleft palate
  - Commonly associated with cleft lip, but can occur without it
  - Results from an incomplete fusion of the primary palatal shelves during the third month of gestation
- Clinical manifestations:
  - Feeding difficulties
  - Repeat infections of paranasal sinuses
- Evaluation and treatment:
  - 3D ultrasound and facial x-rays
  - Surgical correction
  - Speech training
  - Prosthodontist and orthodontist follow-up

Esophageal Malformations
- Esophageal atresia
  - Condition in which the esophagus ends in a blind pouch
- Tracheoesophageal fistula (TEF)
  - Abnormal connection between the trachea and the esophagus
- Clinical manifestations:
  - Pulmonary complications
  - Cardiovascular anomalies
- Evaluation and treatment:
  - Inability to pass catheter into stomach at birth
  - X-rays
  - Surgery
**Pyloric Stenosis**
- Obstruction of the pylorus because of hypertrophy of the pyloric sphincter muscle
- More frequent in full-term, white male babies
- Child begins projectile vomiting (3-4 feet) at 2 to 3 weeks of age
- Vomiting causes weight loss, electrolyte imbalances, and dehydration
- Infant irritable as a result of hunger and esophageal discomfort
- Evaluation and treatment:
  - On examination, the hypertrophic pylorus is palpable in the RUQ
  - Pyloromyotomy and fluid administration are often necessary for treatment
  - Antispasmodic drugs
  - Endoscopic balloon dilation with oral atropine sulfate

**Intestinal Malrotation**
- During embryonic development, the developing ileum and cecum normally rotate, so the cecum is in the right lower quadrant and fixed to the abdomen by the mesentery
- Malrotation
  - Condition in which normal rotation does not occur
  - The malrotated intestine can easily twist because of a poor connection
- Clinical manifestations:
  - Intermittent or persistent bile-stained vomiting
  - Dehydration and electrolyte imbalances
  - Fever, pain, scanty stools, diarrhea, and bloody stools
- Evaluation and treatment:
  - Clinical manifestations and x-rays
  - Laparoscopic or open surgery to reduce volvulus
Meconium Ileus
- Meconium is a substance that fills the intestine before birth
- Meconium is a collection of intestinal gland secretions and amniotic fluid
- A meconium ileus is a meconium-caused intestinal obstruction in a newborn
- Usually caused by a lack of digestive enzymes during fetal life
- Usually treated with hyperosmolar enemas done using fluoroscopy

Distal Intestinal Obstruction Syndrome (DIOS)
- With the syndrome, intestinal contents become abnormally thick and impact the intestinal lumen
  - Impactions frequently occur after periods of dehydration and lack of pancreatic enzymes
- Child shows signs of intestinal obstruction and is treated with hypertonic enemas

Obstructions of the Duodenum, Jejunum, and Ileum
- Ileal or jejunal atresia
  - The intestine ends blindly, proximal and distal to an interruption in its continuity, with or without a gap in the mesentery
  - Stenosis (narrowing of the lumen) causes dilation proximal to the obstruction and luminal collapse distal to it

Meckel Diverticulum
- Outpouching of all layers of the small intestinal wall (usually in the ileum)
- The most common congenital malformation of the gastrointestinal tract
- Most asymptomatic
- Most common symptom is painless rectal bleeding
- Intestinal obstruction, intussusception and volvulus can occur

Congenital Aganglionic Megacolon - Hirschsprung Disease
- Caused by the failure of the parasympathetic nervous system to form intramural ganglion cells in the enteric nerve plexuses
- The aganglionic section of colon is immotile and an obstruction will likely occur
- The intestinal segment proximal to the segment lacking ganglion cells is dilated and hypertrophied
- Clinical manifestations
  - Mild to severe constipation
  - Diarrhea
  - Enterocolitis, sepsis, death
- Evaluation and treatment
  - Rectal biopsy, x-rays
  - Resection, enemas, stool softeners
Anorectal Malformations
- Anal or rectal agenesis, atresia, and fistula
- Imperforate anus
- 40% of infants born with anorectal malformations have other developmental anomalies
- Detected by rectal tube insertion and X-rays
- Treated with dilations or surgery

Intussusception
- Intussusception is a telescoping or invagination of one part of the intestine to another, which causes an obstruction of the intestine
- The most common scenario is the ileum invaginating into the cecum
- 80% to 90% of intestinal obstructions in infants and children are intussusception
- Similar to megacolon, the blockage can cause an obstruction of blood and lymphatic flow
- Clinical manifestations
  - Abdominal pain, irritability, vomiting and “currant jelly” stools
- Evaluation and treatment
  - Clinical manifestations and ultrasonography
  - Reduction with fluoroscopy
  - Surgical reduction
Gastroesophageal Reflux (GER)
- Related to dilation of the esophagus and reflux of stomach contents
- In newborns, reflux is normal because neuromuscular control of the gastroesophageal sphincter is not fully developed
- Contributing cause of sudden infant death syndrome
- Clinical manifestations:
  - Excessive vomiting
  - Aspiration pneumonia, inadequate retention of nutrients, esophagitis, iron-deficiency anemia
- Evaluation and treatment:
  - Barium swallow and esophageal pH
  - Feeding and sleeping positions
  - Oral medications
  - Surgical correction

Cystic Fibrosis
- Autosomal recessive disease that involves many organs
- In the digestive tract it causes a deficiency of pancreatic enzymes
- Triad:
  - Pancreatic enzyme deficiency
  - Overproduction of mucus in the respiratory tract
  - Abnormally elevated sodium and chloride concentrations

Gluten-Sensitive Enteropathy - Celiac Disease
- Gluten is the protein component in cereal grains (wheat, rye, barley, oats, malt)
- The patient loses villous epithelium in the intestinal tract; gluten protein acts as a toxin
- The disease appears to be caused by dietary, genetic, and immunologic factors
- Children will fail to grow and thrive; patients will also exhibit malabsorption symptoms (rickets, bleeding, or anemia)
- Confirmation is done by performing a tissue biopsy
- The patient is put on a restrictive diet, and vitamin D, iron, and folic acid supplements are given
- Celiac crisis results in severe diarrhea, dehydration, malabsorption, and protein loss
**Kwashiorkor and Marasmus**
- Both are types of malnutrition associated with long-term starvation
- Kwashiorkor and marasmus are known collectively as protein energy malnutrition (PEM)
- Kwashiorkor is a severe protein deficiency
- The presence of subcutaneous fat, hepatomegaly, and a fatty liver (kwashiorkor) differentiates kwashiorkor from marasmus
- Marasmus is a deficiency of all nutrients
- Stunted physical and mental development of children
- Liver function:
  - In kwashiorkor, the lack of proteins causes the liver to swell because of the inability to produce lipoproteins for cholesterol synthesis
  - In marasmus, liver function still continues, but the overall caloric intake is too low to support cellular protein synthesis

**Necrotizing Enterocolitis**
- Most common gastrointestinal emergency of the newborn
- The cause of necrotizing enterocolitis is thought to be reduced mucosal blood flow
  - Ischemia leads to inflammation and necrosis of the intestinal segments
- Contributing factors:
  - Infections
  - Immature immunity
  - Maternal age >35 years
  - Perinatal stress
  - Effects of medications and feeding practices
- Clinical manifestations:
  - Mild abdominal distention to bowel perforation
  - Grossly bloody stools and septicemia
- Evaluation and treatment:
  - Clinical manifestations, laboratory results, and plain films of abdomen
  - Cessation of feeding, gastric suction, antibiotics, and surgery
Diarrhea
- Prolonged diarrhea in children is very dangerous
- Children have lower fluid reserves than adults
- Infant diarrhea
- Infectious diarrhea
- Acute diarrhea - Rotavirus
- Chronic diarrhea
- Chronic nonspecific diarrhea

Primary Lactose Intolerance
- The inability to digest milk sugar
- Caused by the inadequate production of lactase, the enzyme that catabolizes lactose
- Malabsorbed lactose causes:
  - Osmotic diarrhea
  - Abdominal pain
  - Bloating
  - Flatulence

Neonatal Jaundice
- A benign, transient icterus that occurs during the first week of life in otherwise healthy full-term infants
- Mild unconjugated hyperbilirubinemia
- Kernicterus
- Usually treated by phototherapy or exchange transfusion

Biliary Atresia
- Congenital malformation characterized by the absence or obstruction of the intrahepatic or extrahepatic bile ducts
  - Plugging, inflammation, and fibrosis of the bile canaliculi, and cholestasis
- Jaundice is the primary clinical manifestation
- Liver transplant long-term therapy
- 80% die before 3 years if untreated

Hepatitis
- Hepatitis A
  - 20% to 30% of hepatitis A infections occur in children
- Hepatitis B
  - 90% of newborns infected with hepatitis B from their mothers develop chronic hepatitis and become carriers
- Hepatitis C
  - Associated primarily with blood transfusions
- Chronic hepatitis
**Cirrhosis**

- Chronic liver diseases in children can progress to cirrhosis, but it is infrequent
- The complications for cirrhosis in children are the same as adults
- Children may also experience:
  - Growth failure
  - Nutritional deficits
  - Developmental delay
Congenital Defects - Clubfoot (congenital equinovarus)
- Forefoot is adducted and supinated
  - Positional equinovarus
  - Idiopathic congenital equinovarus
  - Teratologic equinovarus

Congenital Defects - Developmental Dysplasia of the Hip (DDH)
- Abnormality of the hip that can affect the femoral head, acetabulum, or both
  - Risk factors:
    - Female sex
    - Positive family history
    - Breech presentation
  - The hip can present as subluxated, dislocated, or acetabular dysplasia
  - Manifestations:
    - Asymmetry of skinfolds at groin crease
    - Galeazzi sign
    - Limitation of hip abduction
    - Positive Ortolani sign
    - Positive Barlow test
  - Clinical management
    - Outcome becomes poorer with age
    - Pavlik harness
    - Closed reduction with spica casting
    - Surgery

Osteogenesis Imperfecta - “Brittle bone disease”
- Defect in type I collagen production
  - Bone and vessel collagen
- Clinical manifestations:
  - Osteopenia
  - Increased rate of fractures
  - Bone deformity (bowing)
  - Short stature
  - Blue sclera and poor dentition
  - Aortic aneurysm
- Clinical management:
  - Surgical
    - Intramedullary and telescoping rod placement
  - Medical
    - Increased calcium and vitamin D
    - Biphosphates

Osteomyelitis
- Bone infection from bacteria or tuberculosis (granulomatous)
- Acute hematogenous osteomyelitis in children frequently begins as a blood abscess in the metaphysis of the bone
- The abscess ruptures under the periosteum and spreads along the bone shaft or into the bone marrow
- Clinical manifestations:
  - Pain, swelling, warmth, fever
  - Elevated white blood cells, C-reactive protein, and erythrocyte sedimentation rate
- Clinical management:
  - Antibiotics for 6-week regimen
  - Surgical debridement

Septic Arthritis
- Caused by bacteria or granulomatous
- Surgical emergency
- Occurs primarily or secondary to osteomyelitis
- Lysosomes destroy articular cartilage and interrupt blood supply
- Clinical manifestations:
  - Pseudoparalysis
  - Inability to bear weight
  - Guarded motion of the joint
  - Malaise
  - Anorexia
- Clinical management:
  - Staphylococcus aureus most common bacteria
  - Surgical debridement
  - Antibiotic therapy
  - Long-term follow-up
Juvenile Rheumatoid Arthritis (JRA)
- Childhood form of rheumatoid arthritis
- The basic pathophysiology of JRA is the same as the adult form
- Three distinct modes of onset:
  - Oligoarthritis
  - Polyarthritis
  - Still's disease
- Differences in JRA and adult RA:
  - Large joints are affected
  - Chronic uveitis
  - Low detection of rheumatoid factor
  - Subluxation and ankylosis of the cervical spine
- Treatment
  - Supportive with anti-inflammatories and methotrexate

Osteochondrosis
- Avascular diseases of the bone
- Decrease blood supply
  - Trauma
  - Change in clotting sensitivity
  - Vascular injury
- Legg-Calvé-Perthes disease
  - Interrupted blood supply to the femoral head
  - Deformation due to ischemia is permanent
  - Clinical manifestations:
    - Spasm on rotation of hip
    - Limited internal rotation or abduction of hip
    - Trendelenburg gait
  - Clinical management:
    - Anti-inflammatories
    - Serial radiographs
    - Surgery
- Osgood-Schlatter disease
  - Tendinitis of the anterior patellar tendon and osteochondrosis of the tubercle of the tibia
  - One of the most common ailments in children involved in sports
  - Clinical manifestations:
    - Pain
    - Swelling
  - Clinical management:
    - Restricted activity
    - Bracing and knee immobilizer

**Scoliosis**
- Scoliosis is a curvature of the spine that involves both lateral curvature and rotation
  - Idiopathic (80% of cases)
  - Congenital
  - Teratogen
- Medical management:
  - Bracing
  - Surgery

**Muscular Dystrophies**
- Group of inherited disorders that cause degeneration of skeletal muscle fibers
- The muscular dystrophies cause progressive, symmetric weakness and wasting of skeletal muscle groups

**Duchenne Muscular Dystrophy**
- Most common of the muscular dystrophies
- X-linked recessive inheritance
  - Deletion of a segment of DNA or a single gene defect on the short arm of the X-chromosome
- Generally affects boys
- Duchenne muscular dystrophy gene
  - Encodes for the dystrophin protein
  - Dystrophin maintains the structural integrity of the cytoskeleton
- Manifestations of the disorder begin to appear by approximately 3 years of age:
  - Slow motor development
  - Progressive weakness
  - Muscle wasting
  - Sitting and standing are delayed
  - The child is clumsy, falls frequently, and has difficulty climbing stairs
Musculoskeletal Tumors

- Benign bone tumors
- Osteochondroma
  - Inherited syndrome of hereditary multiple exostoses
- Nonossifying fibroma
  - Sharply demarcated, cortically based lesions of fibrocytes

Malignant bone tumors

- Osteosarcoma
  - Most common tumor in childhood
  - Originates in mesenchymal cells - Linked to deletion of genetic material
  - Bulky tumor extending into soft tissue
  - Clinical manifestations:
    - Night pain, swelling, warmth,
    - Cough, dyspnea, and chest pain if lung metastasis
  - Clinical management:
    - Graded according to malignancy
    - Surgery and chemotherapy

- Ewing sarcoma
  - Most lethal bone tumor
  - Translocation of chromosome
  - Breaks through bone to form soft tissue mass
  - Metastasizes to nearly every organ
  - Clinical manifestations:
    - Pain that increases in severity
    - Fever, Malaise, Anorexia
  - Clinical management:
    - Radiation and chemotherapy
    - Surgical debridement

Nonaccidental Trauma

- “Corner” metaphyseal fractures
  - Long bone fractures caused by a twisting force
  - Transverse tibial fractures are the most common
  - Associated with child abuse, but osteogenesis imperfecta must be ruled out

- Legally mandated to report child abuse
Acne Vulgaris

- Most common skin disease
- Affects 85% of the population between ages 12 and 25 years
- Develops at sebaceous follicles located primarily on the face and upper parts of the chest and back
- Non-inflammatory acne
  - Blackheads
  - Whiteheads
- Inflammatory acne
  - Caused by follicular wall rupture in closed comedones
  - Cystic nodules develop when inflammation is deeper
- Physiologic factors:
  - Follicular hyperkeratinization
  - Excessive sebum production
  - Colonization of *Propionibacterium acnes*
  - Inflammation secondary to the action of inflammatory products produced by *P. acnes*
  - The excessive production of sebum is related to androgenic hormones
- Clinical management:
  - Topical treatments
  - Systemic therapies
  - Surgery
  - Scarring treated with dermabrasion, lasers, and resurfacing techniques

Acne Vulgaris

- Acne conglobata
  - Highly inflammatory form of severe acne
  - Characterized by the formation of communication cysts and abscesses beneath the skin

Atopic Dermatitis

- Most common form of eczema in children
- The cause is unknown, but 80% of individuals demonstrate a personal or family history of asthma or allergic rhinitis
- Manifestations:
  - Increased IgE levels
  - Elevated interleukin-4
  - Positive allergen skin tests
  - Eosinophilia
Clinical manifestations:
- Severe pruritus, eczematoid appearance and age-dependent distribution of skin lesions
  - Young: rash to face, scalp, trunk, arms and legs
  - Older: rash to neck, antecubital and popliteal fossae, hands and feet

Clinical management:
- Accurate diagnosis and identification
- Elimination of exacerbating factors
- Reduction of emotional stresses
- Hydration of skin
- Anti-inflammatory agents
- Immunomodulator and systemic therapies

Diaper Dermatitis
- Group of inflammatory disorders affecting the lower abdomen, genitalia, buttocks, and upper thigh
- Diaper dermatitis is an irritant contact dermatitis
  - Inflammation encouraged by prolonged exposure to irritation by urine and feces, maceration by wet diapers, airtight plastic diaper covers, and possible association with intercurrent illness and early introduction of cereals
- Clinical manifestations:
  - Vary from mild erythema to erythematous papular lesions
- Treatment:
  - Frequent diaper changes to keep area clean and dry
  - Frequent exposure of perineal area to air
  - Topical antifungal medications
  - Short-term topical steroids
  - Barrier creams or pastes

Infections of the Skin - Bacterial Infections
- Impetigo contagiosum
  - Superficial skin infection usually caused by Staphylococcus or group A streptococci
  - High incidence in hot, humid climates
- Bullous impetigo
- Vesicular impetigo
- Staphylococcal scalded-skin syndrome (SSSS)
  - Serious skin infection caused by exfoliative toxin producing group II staphylococci
  - The exfoliative toxin causes separation of the skin just below the granular layer of the epidermis
Manifestations:
- Fever, malaise, rhinorrhea, and generalized erythema and skin tenderness, skin sloughing, and secondary infections
- Treatment with oral and intravenous antibiotics, and aseptic technique to prevent infection

Infections of the Skin - Fungal Infections
- Tinea capitis (scalp)
  - Most common fungal infection of childhood
  - Causative organisms found on cats, dogs, and rodents
  - Lesions circular and manifested by broken hairs at site, scaling and raised borders
- Tinea corporis (ringworm)
  - Kittens and puppies common source
  - Lesions erythematous, round scaling patches that spread peripherally with clearing in the center
  - Treatment with antifungals
- Thrush
  - The presence of Candida in the mucous membranes of the mouths of infants, and less commonly in adults
  - Characteristics:
    - White plaques or spots in the mouth that lead to shallow ulcers
    - Tongue appears to have white covering
  - Thrush can spread to the groin, buttocks, and other parts of the body
  - Treatment with oral antifungal suspension

Infections of the Skin - Viral Infections
- Molluscum contagiosum
  - Highly contagious viral infection of the skin
  - Transmission is skin to skin and contact with contaminated items
  - The virus encourages epidermal cell proliferation
  - Lesions slightly umbilicated dome-shaped papules primarily on the face, trunk, and extremities
  - No specific treatment but self-limiting and clears in 6 to 9 months
• Rubella (German measles or 3-day measles)
  o RNA virus
  o The disease is mild in most children
  o Manifestations:
    ▪ Enlarged cervical and postauricular lymph nodes, low-grade fever, headache, sore throat, runny nose, cough
    ▪ Faint pink to red maculopapular rash caused by virus dissemination to the skin
  o Vaccination for rubella combined with mumps and rubeola (measles) (MMR)

• Rubeola
  o RNA paramyxovirus
  o High fever, malaise, enlarged lymph nodes, runny nose, conjunctivitis, barking cough
  o Koplik spots over buccal mucosa

• Roseola
  o Characterized by fever and an erythematous macular rash that lasts about 24 hours

Infections of the Skin - Viral Infections
• Herpes zoster (shingles)
  o Occurs mainly in adults
  o Varicella virus persists for life in sensory nerve ganglia and reactivates
  o Lesions consist of groups of vesicles situated on an inflammatory base and follow the course of a sensory nerve
  o Therapy similar to that for chickenpox
- **Chickenpox (varicella)**
  - Highly contagious DNA virus
  - Spread by close person-to-person contact and airborne droplets
  - First signs of illness include fever, itching, and appearance of vesicles on face, trunk, and scalp
  - Uncomplicated infection requires no therapy
  - Vaccine available

- **Smallpox**
  - Highly contagious and deadly
  - Caused by poxvirus variolae
  - Eradicated in 1977 and vaccines discontinued in 1972
  - Concern that bioterrorists have virus led to implementation of vaccination and isolation criteria by the CDC

**Insect Bites and Parasites - Scabies**
- Contagious disease caused by the itch mite *Sarcoptes scabiei*
- Transmitted by personal contact and infected clothing and bedding
- Female mite tunnels millimeters to 1 cm into the stratum corneum, deposits eggs, and over a 3-week period the eggs mature into adult mites
- The primary lesions are burrows, papules, and vesicular lesions with severe itching
- Patient is at risk for secondary infections from scratching
- Treated with application of scabicide and linen cleaning
Insect Bites and Parasites - Pediculosis
- Pediculus capitis (head), pediculus corporis (body), and Phthirus pubis (crab or pubic)
- Highly contagious parasite that survives by sucking blood
  - Acquired through personal contact and shared clothing, combs, or brushes
- Treated with pediculicides; all clothes, towels, bedding, and brushes should be washed in hot water

Insect Bites and Parasites - Flea Bites
- Cat, dog, and human fleas
- Bites occur in clusters along the arms and legs
- The characteristic lesion is an urticarial wheal with a central hemorrhagic puncture
- Treatment includes:
  - Spraying home
  - Treating infected animals
  - Washing clothing and bedding in hot water

Insect Bites and Parasites - Lyme Disease
- Multisystem inflammatory disease
- Spirochete, Borrelia burgdorferi causative agent transmitted by tick bite
- Occurs in stages:
  - Localized infection
  - Disseminated infection 9 months after bite
  - Late persistent infection continuing for years
- Treatment with antibiotics

Insect Bites and Parasites - Bedbugs
- Cimex lectularius
- Live in the crevices and cracks of floors, walls, and furniture and in bedding or furniture stuffing
- 3 to 5 mm long and reddish brown
- Bedbugs feed in the darkness
  - Attach to the skin, suck blood, and leave
- Lesions are red macules that develop into nodules

Hemangiomas
- Strawberry hemangiomas
  - Raised vascular lesions that usually emerge 3 to 5 weeks after birth
  - The lesions proliferate, become bright red, and elevate with small capillary projections
- Cavernous hemangiomas
  - Present at birth
  - Cavernous hemangiomas involve larger and more mature vessels than strawberry hemangiomas
Vascular Malformations
- Port-wine stains
  - Congenital malformation of dermal capillaries
  - Flat, pink, to dark reddish purple lesions
- Salmon patches
  - Macular, pink lesions resulting from distended dermal capillaries
    - Usually fade by 1 year of age
  - Common on the nape of the neck, forehead, upper eyelids, or nasolabial folds

Miliaria
- Vesicular eruption after prolonged exposure to perspiration, with subsequent obstruction of eccrine ducts
- Miliaria crystallina
  - Ductal rupture within the stratum corneum
  - Clear vesicles without erythema
- Miliaria rubra (prickly heat)
  - Erythematous papules and papulovesicles

Port Wine Stain  Strawberry Hemangioma  Salmon Patch