Chapter 6

Lymphatic and Immune Systems
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Functions of Lymphatic System

• Three main functions
  – Absorption of fats and fat-soluble vitamins through lacteals of small intestine
  – Removal of waste products and tissues, and cooperation with the immune system in destroying invading pathogens
  – Returning filtered lymph to veins at the base of the neck
Absorption of Fats and Fat-Soluble Vitamins

- Villi located in small intestine contain lacteals and blood vessels
- Lacteals are specialized to absorb fats not transported by the bloodstream
- Lymphatic vessels return them to venous circulation to be used throughout the body as nutrients
Interstitial Fluid and Lymph

• Interstitial fluid
  – Plasma from arterial blood that delivers nutrients, oxygen, and hormones to cells
  – 90% of this fluid returns to the bloodstream

• Lymph
  – Remaining 10% of interstitial fluid
  – Contains electrolytes and proteins
Structures of Lymphatic System
Structures of Lymphatic System

- Lymphatic circulation
  - Depends on pumping motion of muscles to move fluid upward
  - Flows in only one direction (upward to the circulatory system at the base of the neck)
  - Vessels are not visible, since lymph is a clear fluid
Structures of Lymphatic System

• Lymphatic capillaries
  – Microscopic, blind-ended tubes near the surface of the body
  – Brief separation of cells in capillary walls allows lymph to enter capillary
  – Closing of these cells in capillary walls forces lymph to flow upward and forward
Structures of Lymphatic System

- Capillary bed
- Lymph capillary
- Tissue cells
- Venules
- Lymphatic vessel
- Arteriole
Structures of Lymphatic System

- Lymphatic vessels and ducts
  - Valves prevent backward flow of lymph
  - Larger lymphatic vessels join to form two ducts
- Right lymphatic duct collects lymph from right side of head and neck, upper right quadrant of the body, and right arm and empties into right subclavian vein
Structures of Lymphatic System

- Lymphatic vessels and ducts
  - Thoracic duct collects lymph from left side of head and neck, upper left quadrant of trunk, the left arm, lower portion of trunk, and both legs and empties into left subclavian vein
Structures of Lymphatic System

- **Lymph nodes**
  - Specialized lymphocytes capable of destroying pathogens
  - Three major groups
    - Cervical lymph nodes located along sides of neck
    - Axillary lymph nodes located under the arms
      - (axill: armpit)
    - Inguinal lymph nodes located in the inguinal area of lower abdomen
      - (inguin: groin)
Structures of Lymphatic System

• Lymphocytes
  • (lymph/o: lymph; -cytes: cells)
    – Leukocytes formed in bone marrow as stem cells
    – Assist in defending body against antigens

• Three types:
  • Natural killer cells (aid in killing cancer cells)
  • B cells (produce antibodies)
  • T cells (play a role in cell-mediated immunity)
T Cells

• Cytokines
  – Group of proteins released primarily by T cells
  – Begin the immune response
• Interferons
  – Produced in response to antigens
• Interleukins
  – Direct B and T cells to divide and proliferate
Additional Structures of Lymphatic System

- Tonsil and adenoid
- Bone marrow
- Skin
- Vermiform appendix
- Lymphatic vessels
- Thymus
- Spleen
- Lymph nodes
Additional Structures of Lymphatic System

• Some structures are made up of lymphoid tissue
• Tonsils
  • Types include adenoids, palatine tonsils, and lingual tonsils
  • Form protective ring around the back of the nose and upper throat
  • Prevent pathogens from entering respiratory system
Additional Structures of Lymphatic System

(A) Right palatine tonsil

(B) Epiglottis

Left palatine tonsil

Lingual tonsil

Adenoids

Tonsil

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Additional Structures of Lymphatic System

- **Thymus gland**
  - Located above the heart
  - Reaches greatest size at puberty and decreases in size with age
- **Vermiform appendix**
  - Hangs over lower portion of cecum
  - Exact purpose unknown, but may play role in immune system
Additional Structures of Lymphatic System

• Spleen
  – Located in left upper quadrant of the abdomen just below the diaphragm and behind the stomach
  – Numerous functions include but not limited to
    • Filtering of microorganisms and other foreign material from blood
    • Formation of lymphocytes and monocytes
Additional Structures of Lymphatic System

- Liver
- Stomach
- Large intestine
- Small intestine
- Spleen
  - Splenic artery
  - Splenic vein
Functions and Structures of Immune System

- Protects the body from pathogens, allergens, toxins, or malignant cells
- Destruction of harmful substances that enter the body
- Identification and attack on antigens
Immune System’s First Line of Defense

- Intact skin
  - Physical barrier against invading organisms
- Respiratory system
  - Nose hair and moist mucous membranes trap breathed-in foreign matter
Immune System’s First Line of Defense

- **Digestive system**
  - Uses acids/enzymes to destroy invaders that are swallowed or consumed with food
- **Lymphatic system**
  - Specialized leukocytes attack and destroy pathogens that have succeeded in entering the body
The Antigen–Antibody Reaction

- Binding of antigens to antibodies
- Labels potentially dangerous antigen so that it is recognized and destroyed
- Tolerance
  - Acquires unresponsiveness to specific antigen
- Antibody
  - Disease-fighting proteins
Immunoglobulins

- Bind with specific antigens in antigen–antibody response
- Five primary types
  - Immunoglobulin G (in blood serum and lymph)
  - Immunoglobulin A (produced against ingested antigens)
Immunoglobulins

- **Primary types**
  - Immunoglobulin M (found in circulating body fluids)
  - Immunoglobulin D (found only on the surface of B cells)
  - Immunoglobulin E (produced in lungs, skin, and mucous membranes; responsible for allergic reactions)
Phagocytes

- Specialized leukocytes acting as part of the antigen–antibody reaction
- Destroy cell debris, dust, pollen, and pathogens by phagocytosis
  - (phag/o: to eat or swallow)
- Include monocytes, macrophages (macro-: large; -phage: a cell that eats), dendritic cells
Complement System

- Group of proteins normally circulating in blood in inactive form
- Combine with antibodies to dissolve and remove pathogenic bacteria and other foreign cells when needed
• State of being resistant to a specific disease
  – Natural immunity
  • Resistance to disease is present without administration of antigen or exposure to disease
  • Present at birth or is passed from mother to child through breast milk
Immunity

- Acquired immunity
  - Obtained by
    - Having had a contagious disease
    - Being vaccinated against a contagious disease
    - Boost vaccination may be required
Medical Specialties Related to Lymphatic/Immune Systems

• **Allergist**
  – Diagnoses and treats conditions of altered immunologic reactivity, such as allergic reactions

• **Immunologist**
  • (immune: protected; -ologist: specialist)
  – Diagnoses and treats disorders of immune system
• Lymphologist
  • (lymph: lymphatic system)
    – Diagnoses and treats disorders of the lymphatic system
• Oncologist
  • (onc: tumor)
    – Diagnoses and treats malignant disorders
• **Lymphadenitis**
  - (lymphaden: lymph nodes)
    - Inflammation of lymph nodes
• **Lymphadenopathy (lymphaden/o: lymph node)**
  - Any disease affecting lymph nodes
• **Lymphangioma (lymph: lymph; angi: lymph vessel; -oma: tumor)**
  - Benign tumor; abnormal collection of lymphatic vessels; congenital malformation
• Ruptured spleen
  – Medical emergency
  – Covering of spleen is torn
• Splenorrhagia
  • (splen/o: spleen; -rrhagia: bleeding)
  – Bleeding from spleen
Pathology and Diagnostic Procedures (Lymphatic)

- **Splenomegaly**
  - (splen/o: spleen; -megaly: enlargement)
  - Abnormal enlargement of spleen
- **Lymphoscintigraphy**
  - Diagnostic test to detect damage or malformations of lymphatic vessels
Lymphedema (lymph: lymph; edema: swelling)

- Swelling of tissues due to accumulation of lymph fluid within the tissues due to inadequate draining of lymph
- Often associated with infections

- Primary lymphedema
  - Hereditary; swelling begins in feet and progresses upward along the legs

- Secondary lymphedema
  - Due to damage to lymphatic vessels
• Bioimpedance spectroscopy
  – Noninvasive method of diagnosing lymphedema
  – Measures resistance to electrical current passed along the affected limb
• **Allergic reaction**
  – Body’s immune system reacts to a harmless allergen as if it were a dangerous invader

• **Allergy**
  – Overreaction by body to particular antigen

• **Allergen**
  – Substance producing allergic reaction
• Localized allergic response
  – Redness, itching, burning where skin came into contact with allergen
• Systemic reaction
  – Severe response to allergen
  – Also known as anaphylaxis
  – Medical emergency
Pathology and Diagnostic Procedures (Immune System)

- Scratch test
  - Diagnostic test to identify common allergies
- Allergen-specific immunoglobulin
  - Blood test to determine if person is allergic to a particular substance
- Antihistamines
  - Medications to relieve or prevent symptoms of certain allergies
• Autoimmune disorders
  – Group of diseases
  – Immune system produces antibodies against its own tissues
  – May be genetic
• Immunodeficiency disorders
  – Severe combined immunodeficiency
    • Inherited
    • Increased susceptibility to infections and failure to thrive due to infections
• Immunodeficiency disorders
  – HIV (human immunodeficiency virus)
    • Blood borne infection
    • Damages T cells
    • Causes increased risk of opportunistic infections
  – Acquired immunodeficiency syndrome
    • Most advanced and fatal stage of HIV infection
    • No cure
    • Treatment: combinations of antiretroviral drugs
• Kaposi’s sarcoma
  – Opportunistic disease frequently associated with HIV
• ELISA (enzyme-linked immunosorbent assay)
  – Screens for presence of HIV antibodies
• Western blot test
  – Produces more accurate results than ELISA
Treatment of Immune System

- Immunotherapy
  - (immun/o: immune; -therapy: treatment)
    - Stimulating or repressing the immune response
      - Treatment of cancers: immune response is stimulated to fight malignancy
      - Treatment of allergies: body’s sensitivity to a particular allergen is repressed
Treatment of Immune System

- **Antibody therapy**
  - Synthetic immunoglobulins
    - Postexposure preventive measure
  - Synthetic interferon
    - Treatment of multiple sclerosis, hepatitis C, and some cancers
- **Monoclonal antibodies**
  - Antibodies produced in laboratory by identical offspring of clone of specific cells
Treatment of Immune System

- **Immunosuppression**
  - **Immunosuppressant**
    - Prevents/reduces body’s normal immune response
  - **Corticosteroid drug**
    - Hormone-like drug used as anti-inflammatory and immunosuppressant
  - **Cytotoxic drug**
    - (cyt/o: cell; tox: poison; -ic: pertaining to)
    - Medication that kills or damages cells
Pathogenic Organisms

• Bacteria
  – One-celled microscopic organism
  – Most are not pathogenic
  – Pathogenic bacteria include, but not limited to
    • Bacilli (rod-shaped spore-forming bacteria)
      – (bacilli: rod shaped)
    • Anthrax (transmitted through livestock)
    • Rickettsia (lives in lice, fleas, ticks, and mites)
    • Spirochetes (spiral-shaped bacteria; capable of movement)
Pathogenic Organisms

- Pathogenic bacteria include
  - Lyme disease (transmitted by bite of a tick)
  - Staphylococci (group of 30 species shaped like clusters)
    - (staphyl/o: clusters or bunches of grapes; -cocci: spherical bacteria)
    - Example
      - *Staphylococcus aureus* (infests wounds)
  - Streptococci (bacteria that form a chain)
    - (strept/o: twisted chain)
Antibiotic-Resistant Bacteria

• Occur when surviving bacteria become resistant to a particular drug
• Example
  – Methicillin-resistant *Staphylococcus aureus*
    • Difficult to treat; can be fatal
Fungus and Yeast Infections

- **Fungus**
  - Parasitic organism
  - Can be harmless or pathogenic

- **Yeast**
  - Infections occur on skin or mucous membranes in warm, moist area
  - Caused by pathogenic yeast *Candida albicans*
Parasites

- Plant or animal living on or within another living organism at the expense of that organism
- Malaria
  - Transferred to humans by certain mosquitoes
- Toxoplasmosis
  - Transmitted from pets to humans by contaminated animal feces
Viral Infections

- **Ebola**
  - Transmitted by contact with any bodily fluid infected with *Ebola virus*
- **Influenza**
  - Viral respiratory infections
- **Measles**
  - Transmitted by respiratory droplets of *rubeola virus*
Viral Infections

• Mumps
  – Swelling of parotid glands (salivary glands located in front of the ears)

• Rubella
  – Known as German measles or 3-day measles
  – MMR immunization can prevent measles, mumps, and rubella
Viral Infections

- **Rabies**
  - Transmitted to human through bite or saliva of infected animal
- **West Nile virus**
  - Spread to humans by the bite of an infected mosquito
Herpesviruses

- Cytomegalovirus
  - (cyt/o: cell; megal/o: large; vir: virus; -us: singular noun ending)
    - Found in most body fluids
    - May cause no symptoms, or may be serious if individual has weakened immune system

- Varicella zoster
  - Causes varicella
  - Also known as chickenpox
Herpesviruses

• Herpes zoster
  – Acute viral infection
  – Also known as shingles
  – Postherpetic neuralgia may occur if nerve fibers are damaged during the outbreak

• Epstein–Barr virus
  – Causes infectious mononucleosis
Medications to Control Infections

- **Antibiotics**
  - Inhibit growth of, or kill, pathogenic bacterial microorganisms
    - (anti-: against; bio: life; -tic: pertaining to)

- **Bactericide**
  - Causes death of bacteria
    - (bacteri: bacteria; -cide: death)
Medications to Control Infections

- **Bacteriostatic**
  - Inhibits growth of bacteria
    - (-static: causing control)
- **Antifungal**
  - (anti-: against; fung: fungus; -al: pertaining to)
  - Destroys or inhibits growth of fungi
- **Antiviral**
  - Used to treat viral infections or to provide temporary immunity
Oncology

• Study of prevention, causes, and treatment of tumors and cancer
  – (onc: tumor; -ology: study of)

• Tumors (neoplasm)
  • (neo-: new or strange; -plasm: formation)
  – Abnormal growth of body tissue
  – Benign tumor (not cancerous)
  – Malignant tumor (cancerous)
Angiogenesis
– Tumor supports its growth by creating its own blood supply
  • (angi/o: vessel; -genesis: reproduction)

Antiangiogenesis
– Treatment that disrupts the blood supply to the tumor
  • (anti-: against; angi/o: vessel)
Cancer

- Class of diseases characterized by uncontrolled division of cells and ability of these cells to invade other tissues
- Metastasis
  - Process by which cancer is spread to a new site
  - May occur in the same body system or in another body system at a distance from the primary site
Carcinomas

• (carcin: cancer; -oma: tumor)
• Malignant tumor occurring in epithelial tissue
• Tends to infiltrate and metastasize
• Carcinoma in situ remains in original position and does not invade surrounding tissue
Sarcomas

- (sarc: flesh; -oma: tumor)
- Malignant tumors arising from connective tissues
- Hard-tissue sarcomas
  - Arise from bone or cartilage
    - Osteosarcoma
      - (oste/o: bone; sarc: flesh; -oma: tumor)
Sarcomas

- Soft-tissue sarcomas
  - Occur in muscle, fat, fibrous tissue, blood, and lymphatic vessels
- Liquid-tissue sarcomas
  - Arise from blood and lymph
    - Leukemia
• Classification of tumors related to progression of disease, potential for response to therapy, and patient’s prognosis
Lymphomas

• (lymph: lymph; -oma: tumor)
• Malignancies affecting lymphoid tissue
• Two most common types
  – Hodgkin’s lymphoma
    • Cancer of immune system characterized by presence of Reed–Sternberg cells
  – Non-Hodgkin’s lymphoma
    • Category for all lymphomas other than Hodgkin’s lymphoma
    • Originate in lymphocytes
Breast Cancer

- Develops from breast cells, and may metastasize to lymph nodes and other body sites
- BRCA1 or BRCA2 genes
  - Abnormal genes carrying higher risk of breast, ovarian, and certain other cancers
- Ductal carcinoma in situ
  - Breast cancer at its earliest stage
Breast Cancer

- Inflammatory breast cancer
  - Aggressive form of breast cancer
  - Cancer cells block lymphatic vessels in the skin of the breast
  - Cannot be detected by mammography
- Male breast cancer
  - May occur in small amount of breast tissue normally present in men
Stages of Breast Cancer

- **Stage 0**
  - Cancer cells found only in one location
- **Stage I**
  - Cancer cells are beyond the duct but not in lymph nodes
- **Stage II**
  - Cancer has reached one to three axillary lymph nodes
Stages of Breast Cancer

- **Stage III**
  - Cancer has spread to cervical lymph nodes and/or tissue surrounding the breast

- **Stage IV**
  - Cancer has spread to other organs, such as brain, lungs, liver, bones
Detection of Breast Cancer

• Breast self-examination
  – Self-care procedure
• Palpation of the breast
  – Performed by health care provider for texture, size, and consistency of breast
• Mammography
  – Radiographic examination of breast
    • (mamm/o: breast; -graphy: the process of producing a picture or record)
Detection of Breast Cancer

- Molecular breast imaging
  - Nuclear medicine technique
- Ultrasound
  - May be a follow-up procedure if abnormality found by mammography
Detection of Breast Cancer

- Needle breast biopsy
  - X-ray or MRI-guided needle removes small samples of tissue for diagnosis and planning of treatment
  - (bi-: pertaining to life; -opsy: view of)
Detection of Breast Cancer

- **Surgical biopsy**
  - Removal of small amount of tissue for examination and to confirm diagnosis

- **Sentinel node biopsy**
  - Biopsy of first lymph node to come in contact with the cancer cells

- **Lymph node dissection**
  - Removal of lymph nodes to determine or slow the spread of cancer
Surgical Treatment of Breast Cancer

- **Lumpectomy**
  - Removal of only the cancerous tissue with surrounding margin of normal tissue

- **Mastectomy**
  - Removal of breast and nipple
    - (mast: breast; -ectomy: surgical removal)
  - May be radical or modified radical
Breast Reconstruction

• Immediate breast reconstruction
  – Begins during same surgery as the mastectomy

• Delayed breast reconstruction
  – Performed after completion of radiation therapy
Cancer Treatments

• Surgery
  – Removal of malignancy plus margin of surrounding tissue

• Chemotherapy
  – Use of chemical agents, such as antineoplastic or cytotoxic medications

• Radiation therapy
  – Use of brachytherapy, teletherapy, or tomotherapy
Additional Cancer Treatment Therapies

- **Targeted therapy**
  - Uses substances to identify/attack specific cancer cells without harming normal cells

- **Adjuvant therapy**
  - Used after primary treatments are completed to decrease risk of recurrence

- **Clinical trials**
  - Testing new cancer treatments not yet approved by FDA