Chapter 6: The Circulatory System

Objectives

1. Define the key terms and abbreviations listed at the beginning of the chapter.
2. Identify the layers and other structures of the heart and describe their function.
3. Describe the cardiac cycle and how an ECG tracing relates to it; also explain the origins of heart sounds and pulse rates.
4. Describe how to take blood pressure readings and explain what they represent.

Objectives (cont’d)

5. Identify the two main divisions of the vascular system, describe the function of each, and trace the flow of blood throughout the system.
6. Identify the different types of blood vessels and describe the structure and function of each.
7. Name and locate major arm and leg veins and describe the suitability of each for venipuncture.
8. List the major constituents of blood, describe the function of each of the formed elements, and differentiate between serum, plasma, and whole blood.

Objectives (cont’d)

9. Describe how ABO and Rh blood types are determined and explain the importance of compatibility testing prior to transfusion.
10. Define hemostasis and describe basic coagulation and fibrinolysis processes.
11. Identify the structures and vessels and describe the function of the lymphatic system.
12. List the disorders and diagnostic tests of the circulatory system.
Overview: Video (How blood flows through the heart)

- **Functions of the Circulatory System**
  - Carries oxygen & food to cells of body
  - Carries carbon dioxide & other wastes away from cells to excretory organs, kidneys, lungs, & skin
  - Aids in coagulation process
  - Assists in defending body against disease
  - Aids in regulation of body temperature

- **Main Components**
  - **Cardiovascular**: heart, blood vessels, & blood
  - **Lymphatic**: lymph vessels, lymph nodes, & lymph

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The Heart

- **Structure**
  - **General**
    - 4-chambered, hollow, muscular organ
    - Size of a man’s clenched fist
    - Surrounded by pericardium (thin, fluid-filled sac)
  - **Layers**
    - ** Epicardium**: thin outer layer
    - ** Myocardium**: middle muscle layer
    - ** Endocardium**: thin inner layer

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The Heart (cont’d)

- **Structure**
  - **4 Chambers**
    - Atria, right & left
    - Ventricles, right & left
  - **4 Valves**
    - Atrioventricular (AV) located between Rt atrium & Rt ventricle (tricuspid) & left (bicupid)
    - Semilunar, right (pulmonary) & left (aortic)
  - **Septa**: partitions separating right & left sides of heart
    - Interventricular
    - Intervertebral
    - Semilunar valves: valves that exit the ventricles, crescent shaped like half moon

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The Heart (cont’d)

- **Structure**
  - **Coronary circulation**
    - The Heart receives blood supply via the right and left Coronary arteries
    - **Ischemia**: inadequate supply of oxygen to tissue, often caused by partial obstruction of coronary artery
    - **Myocardial infarction**: heart attack, caused by complete obstruction of coronary artery or prolonged ischemia
    - **Coronary veins**: return oxygen poor blood from the heart muscle back to the heart.
The Heart (cont’d)

• Function
  - Cardiac cycle
    • One complete contraction (systole) & relaxation (diastole) of heart
    • Lasts about 0.8 seconds
  - Electrical conduction system
    • Specialized cells that initiate & distribute electrical impulses throughout the myocardium to coordinate cardiac cycle
    • Sinoatrial (SA) node (pacemaker) initiates electrical impulse

The Heart (cont’d)

• Function
  - Electrocardiogram (ECG)
    • A graphic record of heart’s electrical activity during cardiac cycle
  - Origin of the heart sounds
    • First heart sound: “lubb” (ventricles contract, AV valves close)
    • Second heart sound: “dupp” (ventricles relax, semilunar valves close)
  - Heart rate & cardiac output
    • Heart rate: # of heartbeats per minute (avg. = 72 bpm)
    • Cardiac output: volume of blood pumped by heart in 1 min.

The Vascular System

• Functions
  - Pulmonary circulation
    • Carries blood from right ventricle of heart to lungs
    • Carbon dioxide is removed; oxygen is picked up
    • Oxygenated blood returns to left atrium of heart
  - Systemic circulation
    • Carries oxygenated blood & nutrients from left ventricle to body cells
    • Returns deoxygenated blood with carbon dioxide & wastes from cells to right atrium
The Vascular System (cont’d)

- *Structures: Video (Structure of blood vessels)
  - *Arteries
    - Carry oxygenated blood away from heart to tissues
    - Thick walls to withstand high pressure
    - Aorta is largest artery
  - *Arterioles: small branches of arteries that join capillaries
  - *Aorta: The largest artery in the body

- *Veins
  - Return deoxygenated blood from tissues to heart
  - Thin walls, low pressure
  - Blood is moved by skeletal muscle movement, valves that prevent backflow, & pressure changes in cavities in breathing
  - *Venules: small veins that join capillaries
  - *Capillaries
    - Microscopic, one-cell-thick vessels that connect arterioles & veins
    - Site of gas exchange between blood & body tissues

The Vascular System (cont’d)

- Blood Vessel Structure
  - *Layers
    - *Tunica adventitia: outer; connective tissue
    - *Tunica media: middle; smooth muscle & elastic fibers
    - *Tunica intima: inner; single layer endothelial cells, basement membrane, connective tissue, & elastic internal membrane
  - *Lumen
    - Internal space of a blood vessel, through which blood flows
  - *Valves
    - Thin, membranous leaflets in veins prevent backflow of blood so that it continues to flow in one direction

The Vascular System (cont’d)

- Phlebotomy-Related Vascular Anatomy
  - Antecubital fossa
    - Shallow depression in arm anterior to & below bend of elbow
    - Site of major veins, & thus first choice for venipuncture
    - Median Cubital
    - Cephalic
    - Basilic
  - H-Shaped antecubital veins (in 70% of population)
    - Median cubital, cephalic, & basilic veins
  - M-Shaped antecubital veins
    - Median, median cephalic, & median basilic veins
  - Veins on back of hand & wrist (less frequent)
The Vascular System (cont’d)

- Disorders
  - Aneurysm
  - Arteriosclerosis
  - Atherosclerosis
  - Embolism
  - Embolus
  - Hemorrhoids
  - Phlebitis
  - Thrombophlebitis
  - Thrombus

- Varicose veins

The Blood (cont’d)

- *Formed elements
  - *Erythrocytes (red blood cells), contains hemoglobin, the O2 carrying protein.
    - Most numerous cells in body
    - Carry O2 & CO2
    - Produced in bone marrow
  - *Leukocytes (white blood cells)
    - Formed in bone marrow & lymphatic tissue
    - Neutralize or destroy pathogens
    - Types: granulocytes & agranulocytes
  - *Thrombocytes (platelets): essential to coagulation

The Blood

- Blood Composition: Video (Human blood composition)
  - Plasma
    - 90% water
    - Gases (O2, CO2, N)
    - Minerals (Na, K, Ca, Mg)
    - Carbs & lipids
    - Proteins
    - Waste products
    - Vitamins, hormones, drugs

- Diagnostic Tests
  - DIC screen
  - Lipoproteins
  - Prothrombin time
  - Partial thromboplastin time
  - Triglycerides

The Blood

- 5 types of white blood cells (See study guide)
  - Neutrophils: the most numerous, comprise about 40-60% of WBC population. They are phagocytic cells (engulf and digest bacteria). Their numbers increase in bacterial infection.
  - Lymphocytes: the second most numerous, comprising about 20-40% of the WBC population. Their numbers increase in viral infection, and they play a role in immunity.
  - Monocytes: comprising 3-8% of the population, they are also the largest WBCs. Their number increases in intracellular infections and TB.
  - Eosinophils: represent 1-3% of the population, they are active against antibody-labeled foreign molecules. Numbers are increased in allergies, skin infections and parasitic infections.
  - Basophils: Account for 0-1% of WBCs. They carry histamine, which is released in allergic reactions.
Main function of WBCs is to neutralize or destroy pathogens

- **Phagocytosis**: a process in which pathogens or foreign matter is surrounded, engulfed, and destroyed by the WBCs.
- **When using Wright’s Stain to look at a blood smear**:
  - **Granulocytes**: WBCs containing easily visible granules (Neutrophils, Eosinophils, Basophils)
  - **Agranulocytes**: WBCs that lack granules or have extremely fine granules that are not easily seen (Monocytes and Lymphocytes)

The Blood (cont’d)

- **Blood Type**
  - Inherited
  - Determined by presence or absence of antigens on surface of red blood cells
  - A person’s blood either contains or has the ability to develop antibodies directed at the opposite blood type
    - Blood transfusion of the wrong type can agglutinate and hemolyze red blood cells (transfusion reaction)
  - 2 commonly used blood group systems

- **ABO blood group system** (see text Table 6-6)
  - 2 antigens (A & B)
  - 4 blood types (A, B, AB, & O)

- **Rh blood-group system**
  - Based on the “D” antigen (also called Rh factor)
  - Rh positive (Rh +)
    - RBCs have the D antigen
  - Rh negative (Rh -)
    - RBCs lack the D antigen

The Blood (cont’d)

- **Blood Specimens**
  - **Serum**
    - Fluid portion of blood remaining after clotting
    - Can be separated from clot by centrifugation
    - Does not contain fibrinogen (used up in clotting)
  - **Plasma**
    - Fluid portion of whole blood separated from the RBCs, WBCs & platelets by centrifugation
    - Contains fibrinogen
**The Blood (cont’d)**

- **Blood Specimens**
  - **Plasma (cont’d)**
    - Specimen must be collected in an anticoagulant tube
    - Used in cases when serum cannot be used
  - **Whole blood**
    - Blood in the same form as it is in the bloodstream
    - Not allowed to clot or separate
    - Specimen must be collected in an anticoagulant tube
    - Must be mixed a minimum of 2 min. just prior to test

- **Disorders**
  - Anemia
  - Leukemia
  - Leukocytosis
  - Leukopenia
  - Polycythemia
  - Thrombocytosis
  - Thrombocytopenia

- **Diagnostic Tests**
  - ABO & Rh type
  - Bone marrow
  - Complete blood count
  - Cross-match
  - Differential
  - Erythrocyte sed. rate
  - Hematocrit
  - Hemoglobin
  - Iron

**Hemostasis and Coagulation**

- *Hemostasis (See study guide)*
  - Arrest or stoppage of bleeding after injury as a body response
  - Requires coordinated interaction of endothelial cells lining blood vessels, platelets, other blood cells, plasma proteins, & clotting
  - Is ongoing daily, in conjunction with vessel repair
  - **Process** (4 interrelated responses)
    1. Vasoconstriction
    2. Formation of a primary platelet plug
    3. Progression to a stable blood clot
    4. Fibrinolysis (dissolving of clot)

- The process of hemostasis

**Primary Platelet Plug Formation**
Hemostasis and Coagulation (cont’d)

• The process of hemostasis

Hemostasis and Coagulation (cont’d)

• Coagulation Factors and Pathways (cont’d)
  - **Intrinsic Pathway**
    • **Intrinsic**: inside bloodstream
    • Produces thrombin on the surface of activated platelets
  - **Cell-based coagulation phases**
    • Initiation
    • Amplification
    • Propagation

Hemostasis and Coagulation (cont’d)

• Coagulation Pathways
  - **Extrinsic and Intrinsic Pathway**: See pg. 180 (top), also study guide.
  - **Extrinsic Pathway**
    • **Extrinsic**: outside bloodstream.
    • Initiates the coagulation process

Hemostasis and Coagulation (cont’d)

• The Role of Thrombin
  - Enzyme that plays the major role in coagulation
  - Generated at injured site from prothrombin
  - Converts fibrinogen to soluble fibrin
  - Amplifies coagulation
  - Supports platelet plug formation
  - Activates factor XIII to cross-link fibrin
  - Controls its own formation & coagulation process by activating protein C
Hemostasis and Coagulation (cont’d)

- The Hemostatic Process (See study guide)
  - 1. Vascular Phase: Vasoconstriction
    - Reduction in diameter of blood vessel due to injury. And slow flow of blood
    - Caused by contraction of smooth muscle fibers in vessel
    - Decreases blood flow past injured area & limits blood loss
  - 2. Platelet Phase: Platelet plug formation
    - Injury to endothelial lining, platelets adhere to it. Additional plts stick to the site and form a temporary plug in a process called "platelets aggregation"
  - 3. Coagulation Phase:
    - This involves a cascade of interactions of coagulation factors that convert the temporary platelet plug to a stable fibrin clot. Extrinsic and Intrinsic systems ultimately come together.

- Fibrinolysis
  - Breakdown and removal of a clot
  - As tissue repair starts, plasmin (an enzyme) starts breaking down the fibrin in the clot.
    - Dissolves clots that form in intact vessels, reopening them
    - Removes hemostatic clots from tissue as healing occurs
  - The Role of the Liver in Hemostasis
    - Synthesizes many coagulation factors: V, VIII, prothrombin, & fibrinogen
    - Produces bile salts, needed for synthesis of some factors
    - Produces heparin

Hemostasis and Coagulation (cont’d)

- Disorders
  - Deep venous thrombosis
  - Disseminated intravascular coagulation
  - Hemophilia
  - Thrombocytopenia

- Diagnostic Tests
  - Bleeding time
  - D-dimer
  - Factor assays
  - Fibrin degradation products
  - Platelet function assay
  - Prothrombin time
  - Partial thromboplastin time

Lymphatic System:

- Functions: Video
  - Returns tissue fluid to bloodstream
  - Protects body by removing microorganisms & impurities
  - Processes lymphocytes
  - Delivers fats absorbed from small intestine to bloodstream

- Structures
  - Lymph (fluid)
  - Lymphatic vessels, ducts, & nodes
The Lymphatic System (cont’d)

- **Lymph Flow**
  - **Lymph**: excess tissue fluid that filters into lymphatic capillaries
  - Capillaries join to form larger vessels that empty into terminal vessels:
    - Right lymphatic duct
    - Thoracic duct
  - These two ducts empty into large veins in upper body
  - Lymph is moved by skeletal muscle contraction
  - Lymph passes through lymph nodes that filter out impurities

- **Disorders**
  - Lymphangitis
  - Lymphadenitis
  - Lymphadenopathy
  - Splenomegaly
  - Hodgkin disease
  - Lymphosarcoma
  - Lymphoma
  - **Lymphostasis**: the obstruction or stoppage of normal lymph flow.

- **Diagnostic Tests**
  - Bone marrow biopsy
  - Complete blood count
  - Culture & sensitivity
  - Lymph node biopsy
  - Mononucleosis test

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Chapter 6 test info:

- Sac that surrounds the heart
- What does the cardiovascular system consist of?
- What are heart chambers divided by?
- Layers of the heart
- Chambers
- Valves
- Function of Pulmonary & Systemic Systems
- Major veins used for venipuncture
- Veins, capillaries, veins, arterioles, arteries, vena cava
- Layers of blood vessels
- What is essential to the clotting process?
- 4 recognized blood types
- Serum, plasma, whole blood
- Anticoagulant
- Hemostasis
- What other areas are acceptable for venipuncture?
- Veins NOT suitable for venipuncture
- Know WBCs & what each does.
- APTT and PT
- Know hemostasis: The different phases (use study guide)
- Know study questions