Chapter 18: The Cardiovascular System: The Heart

Objectives:
1. Describe the size, shape, location and orientation of the heart in the thorax.
2. Name the coverings of the heart.
3. Describe the structure and function of each of the three layers of the heart wall.
4. Describe the structure and functions of the four heart chambers. Name each chamber and provide the name and general route of its associated great vessel(s).
5. Trace the pathway of blood through the heart.
6. Name the major branches and describe the distribution of the coronary arteries.
7. Name the heart valves and describe their location, function and mechanism of operation.
8. Describe the structural and functional properties of cardiac muscle, and explain how it differs from skeletal muscle.
9. Briefly describe the events of cardiac muscle contraction.
10. Name the components of the conduction system of the heart, and trace the conduction pathway.
11. Draw a diagram of a normal electrocardiogram tracing, name the intervals, and indicate what each represents. Name some abnormalities that can be detected on an ECG tracing.
12. Describe the timing and events of the cardiac cycle.
13. Describe normal heart sounds, and explain how heart murmurs differ.
14. Name and explain the effects of various factors regulating stroke volume and heart rate.
15. Explain the role of the autonomic nervous system in regulating cardiac output.
16. Describe fetal heart formation, and indicate how the fetal heart differs from the adult heart.
17. Provide examples of age-related changes in heart function.

I. Heart Anatomy
   A. Approximately the size of your fist
   B. Location
      1. Superior surface of diaphragm
      2. Left of the midline
3. Anterior to the vertebral column, posterior to the sternum

C. Coverings of the Heart
   1. Pericardium – a double-walled sac around the heart
      a. Protects and anchors the heart
      b. Prevents overfilling of the heart with blood
      c. Allows for the heart to work in a relatively friction-free environment
   2. Visceral Pericardium (Epicardium)
      a. On the heart itself
      b. Forms outer surface of the heart

D. Heart Wall
   1. Epicardium – visceral layer of the serous pericardium
   2. Myocardium – cardiac muscle layer forming the bulk of the heart
   3. Endocardium – endothelial layer of the inner myocardial surface

Skeleton
   Pectinate muscle
   Chordae Tendinae
   Tracebulae Carneae
   Papillary muscle

   Fibrous trigone
   Fibrous Ring
   Septim Membranaceum
   Epicardium
   Myocardium
   Endocardium

   Interventricular Septum

II. Major Vessels of the Heart
   A. Vessels returning blood to the heart include:
      1. Superior and inferior venae cava
      2. Right and left pulmonary veins
   B. Vessels conveying blood away from the heart:
      1. Pulmonary trunk, splits into
         a. right and left pulmonary arteries
      2. Ascending aorta (three branches)
         a. brachiocephalic
         b. left common carotid
c. subclavian arteries

III. Regions and Branches of the Aorta

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<tr>
<td>a. Ascending Aorta</td>
<td>Coronary aa.</td>
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<td>B. Aortic Arch</td>
<td>Brachiocephalic</td>
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<td>Subclavian</td>
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<td>c. Descending Aorta (Thoracic)</td>
<td>Intercostals</td>
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<td>d. Descending Aorta (Abdominal)</td>
<td>Inferior Phrenic</td>
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<td>Celiac Trunk</td>
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<td>Middle Sacral</td>
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IV. Vessels that Supply/Drain the Heart

A. Arteries
   1. right and left coronary
   2. marginal
   3. circumflex
   4. anterior interventricular
B. Veins
   1. small cardiac
   2. anterior cardiac
   3. great cardiac

V. Atria of the Heart
A. Atria are the receiving chambers of the heart
B. Pectinate muscles mark atrial walls
C. Blood enters right atria from superior and inferior venae cavae and coronary sinus
D. Blood enters left atria from pulmonary veins

VI. Ventricles of the Heart
A. Ventricles are the discharging chambers of the heart
B. Papillary muscles and trabeculae carneae muscles mark ventricular walls
C. Right ventricle pumps blood into the pulmonary trunk
D. Left ventricle pumps blood into the aorta

VII. Pathway of Blood Through the Heart and Lungs

Superior Vena Cava  |  
Inferior Vena Cava  |  → Right Atrium
Coronary Sinus  |  |
  |  Tricuspid (Right A-V Valve)
  |  |
  |  Right Ventricle
  |  |  Pulmonary Semilunar Valve
  |  |  |
  |  |  Pulmonary Trunk
  |  |  |  Right
  |  |  |  Left Pulmonary Arteries
  |  |  |  |  Right
  |  |  |  |  Left Pulmonary Veins
  |  |  |  |
  |  |  Left Atrium
  |  |
  |  Bicuspid (Mitral or Left A-V Valve)
  |  |
  |  Left Ventricle
  |  |
  |  Aortic Semilunar Valve
  |  |
  |  Ascending Aorta
VIII. Coronary Circulation
   A. Coronary circulation is the functional blood supply to the heart muscle itself
   B. Collateral routes ensure blood delivery to heart even if major vessels are occluded

-------------------------------------------Ascending Aorta-------------------------------------------

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IX. Heart Valves
   A. Heart valves ensure unidirectional blood flow through the heart
   B. Atrioventricular (AV) valves lie between the atria and the ventricles
   C. AV valves prevent backflow into the atria when ventricles contract
   D. Chordae tendineae anchor AV valves to papillary muscles
   E. Aortic semilunar valve lies between the left ventricle and the aorta
   F. Pulmonary semilunar valve lies between the right ventricle and pulmonary trunk
   G. Semilunar valves prevent backflow of blood into the ventricles
X. Microscopic Anatomy of Heart Muscle
   A. Cardiac muscle is striated, short, fat, branched, and interconnected
   B. The connective tissue endomysium acts as both tendon and insertion
   C. Intercalated discs anchor cardiac cells together and allow free passage of ions
   D. Heart muscle behaves as a functional syncytium

XI. Cardiac Muscle Contraction
   A. Heart muscle:
      1. Is stimulated by nerves and is self-excitable (automaticity)
      2. Contracts as a unit
   B. Cardiac muscle contraction is similar to skeletal muscle contraction
   C. Sequence of Excitation
      1. Sinoatrial (SA) node (pacemaker) generates impulses about 75 times/minute
      2. Atrioventricular (AV) node delays the impulse approximately 0.1 second
      3. Impulse passes from atria to ventricles via the atrioventricular bundle (bundle of His)
      4. AV bundle splits into two pathways in the interventricular septum (bundle branches)
         a. Bundle branches carry the impulse toward the apex of the heart
         b. Purkinje fibers carry the impulse to the heart apex and ventricular walls
      5. Extrinsic Innervation of the Heart
         a. Heart is stimulated by the sympathetic cardioacceleratory center
         b. Heart is inhibited by the parasympathetic cardioinhibitory center

XII. Electrocardiography
   A. Electrical activity is recorded by electrocardiogram (ECG)
   B. P wave corresponds to depolarization of SA node
   C. QRS complex corresponds to ventricular depolarization
   D. T wave corresponds to ventricular repolarization
   E. Atrial repolarization record is masked by the larger QRS complex

XIII. Heart Sounds
A. Heart sounds (lub-dup) are associated with closing of heart valves
   1. First sound occurs as AV valves close and signifies beginning of systole
   2. Second sound occurs when SL valves close at the beginning of ventricular diastole

XIV. Cardiac Cycle
A. Cardiac cycle refers to all events associated with blood flow through the heart
   1. Systole – contraction of heart muscle
   2. Diastole – relaxation of heart muscle

XV. Regulation of Heart Rate: Autonomic Nervous System
A. Sympathetic nervous system (SNS) stimulation is activated by stress, anxiety, excitement, or exercise
B. Parasympathetic nervous system (PNS) stimulation is mediated by acetylcholine and opposes the SNS
C. PNS dominates the autonomic stimulation, slowing heart rate and causing vagal tone

XVI. Chemical Regulation of the Heart
A. The hormones epinephrine and thyroxine increase heart rate
B. Intra- and extracellular ion concentrations must be maintained for normal heart function

XVII. Congestive Heart Failure (CHF)
A. Congestive heart failure (CHF) is caused by:
   1. Coronary atherosclerosis
   2. Persistent high blood pressure
   3. Multiple myocardial infarcts
   4. Dilated cardiomyopathy (DCM)

Chapter 19: The Cardiovascular System: Blood Vessels

Objectives:

1. Define vasoconstriction and vasodilation.
2. Compare and contrast the structure and function of the three types of arteries.
3. Describe the structure and function of a capillary bed.
4. Describe the structure and function of veins, and explain how veins differ from arteries.
5. Define blood flow and blood pressure and explain the relationships between these factors.
6. List and explain the factors that influence blood pressure, and describe how blood pressure is regulated.
7. Define hypertension. Describe its manifestations and consequences.
8. Explain how blood flow is regulated in the body in general and in its specific organs.
9. Outline factors involved in capillary dynamics, and explain the significance of each.
10. Trace the pathway of blood through the pulmonary circuit, and state the importance of this special circulation.
11. Describe the general functions of the systemic circuit name and give the location of the major arteries and veins in the systemic circulation.

I. Blood Vessels
   A. Blood is carried in a closed system of vessels that begins and ends at the heart
   B. Three major types of vessels
      1. arteries
      2. capillaries
      3. veins
   C. Arteries carry blood away from the heart
   D. Veins carry blood toward the heart
   E. Capillaries contact tissue cells and directly serve cellular needs

II. Muscular (Distributing) Arteries and Arterioles
    A. Muscular arteries
       1. Deliver blood to body organs
    B. Arterioles
       1. Smallest arteries
       2. Lead to capillary beds
       3. Control flow into capillary beds via vasodilation and constriction
    C. Capillaries
1. Capillaries are the smallest blood vessels
   a. Walls one cell thick
   b. Allow only a single RBC to pass at a time
2. There are three structural types of capillaries:
   a. continuous
   b. fenestrated
   c. sinusoids
3. Continuous Capillaries
   a. Continuous capillaries are abundant in the skin and muscles
4. Fenestrated Capillaries
   a. Found wherever active capillary absorption or filtrate formation occurs (e.g., small intestines, endocrine glands, and kidneys)
   b. Greater permeability than other capillaries
5. Sinusoids
   a. Highly modified, leaky, fenestrated capillaries with large lumens
   b. Found in the liver, bone marrow, lymphoid tissue, and in some endocrine organs
   c. Allow large molecules (proteins and blood cells) to pass between the blood and surrounding tissues
   d. Blood flows sluggishly, allowing for modification in various ways
6. Capillary Beds
   a. A microcirculation of interwoven networks of capillaries
7. Blood Flow Through Capillary Beds
   a. Blood flow is regulated by vasomotor nerves and local chemical conditions

III. Venous System: Venules
A. Venules are formed when capillary beds unite
   1. Allow fluids and WBCs to pass from the bloodstream to tissues
B. Veins
   1. Formed when venules converge
   2. Capacitance vessels (blood reservoirs) that contain 65% of the blood supply
   3. Have much lower blood pressure and thinner walls than arteries
   4. To return blood to the heart, veins have special adaptations
      a. Large-diameter lumens, which offer little resistance to flow
      b. Valves (resembling semilunar heart valves), which prevent backflow of blood

IV. Blood Flow
A. Actual volume of blood flowing through a vessel, an organ, or the entire circulation in a given period:
   1. Is measured in ml per min.
   2. Is equivalent to cardiac output (CO), considering the entire vascular system
   3. Is relatively constant when at rest
   4. Varies widely through individual organs

V. Blood Pressure (BP)
   A. Force per unit area exerted on the wall of a blood vessel by its contained blood
      1. Expressed in millimeters of mercury (mm Hg)
      2. Measured in reference to systemic arterial BP in large arteries near the heart
   B. The differences in BP within the vascular system provide the driving force that keeps blood moving from higher to lower pressure areas
   C. Systemic Blood Pressure
      1. The pumping action of the heart generates blood flow through the vessels along a pressure gradient, always moving from higher- to lower-pressure areas
      2. Pressure results when flow is opposed by resistance
   D. Arterial Blood Pressure
      1. Systolic pressure – pressure exerted on arterial walls during ventricular contraction
      2. Diastolic pressure – lowest level of arterial pressure during a ventricular cycle
      3. Pulse pressure – the difference between systolic and diastolic pressure
      4. Mean arterial pressure (MAP) – pressure that propels the blood to the tissues
   E. Maintaining Blood Pressure
      1. Requires:
         a. Cooperation of the heart, blood vessels, and kidneys
         b. Supervision of the brain
      2. The main factors influencing blood pressure are:
         a. Cardiac output (CO)
         b. Peripheral resistance (PR)
         c. Blood volume
   F. Cardiac Output (CO)
1. Cardiac output is determined by venous return and neural and hormonal controls
2. Resting heart rate is controlled by the cardioinhibitory center via the vagus nerves

G. Controls of Blood Pressure
1. Short-term controls:
   a. Are mediated by the nervous system and bloodborne chemicals
   b. Counteract moment-to-moment fluctuations in blood pressure by altering peripheral resistance
2. Long-term controls regulate blood volume

H. Short-Term Mechanisms: Vasomotor Center
1. Vasomotor center – a cluster of sympathetic neurons in the medulla that oversees changes in blood vessel diameter
   a. Maintains blood vessel tone by innervating smooth muscles of blood vessels, especially arterioles
2. Cardiovascular center – vasomotor center plus the cardiac centers that integrate blood pressure control by altering cardiac output and blood vessel diameter

I. Measuring Blood Pressure
1. Systemic arterial BP is measured indirectly with the auscultatory method
   a. A sphygmomanometer is placed on the arm superior to the elbow
   b. Pressure is increased in the cuff until it is greater than systolic pressure in the brachial artery
   c. Pressure is released slowly and the examiner listens with a stethoscope
   d. The first sound heard is recorded as the systolic pressure
   e. The pressure when sound disappears is recorded as the diastolic pressure
2. Variations in Blood Pressure
   a. Blood pressure cycles over a 24-hour period
   b. BP peaks in the morning due to waxing and waning levels of retinoic acid
   c. Extrinsic factors such as age, sex, weight, race, mood, posture, socioeconomic status, and physical activity may also cause BP to vary
3. Alterations in Blood Pressure
   a. Hypotension – low BP in which systolic pressure is below
100 mm Hg
b. Hypertension – condition of sustained elevated arterial pressure of 140/90 or higher
1) Transient elevations are normal and can be caused by fever, physical exertion, and emotional upset
2) Chronic elevation is a major cause of heart failure, vascular disease, renal failure, and stroke