

The Cardiovascular System: The Heart

Objectives

Heart Anatomy

1. Describe the size, location, and orientation of the heart.
2. Identify structures of the pericardium.
3. Define the endocardium, myocardium, and epicardium.
4. Compare the function of the atria and the ventricles, and describe the difference between the function of the right and left ventricles.
5. Discuss the need for coronary circulation, and name the vessels that play a role in it.
6. Indicate the function and location of the atrioventricular valves and aortic and pulmonary valves.

Properties of Cardiac Muscle Fibers

7. Describe the microscopic anatomy and control of cardiac muscle cells, and compare to skeletal muscle cells.
8. Name the energetic requirements of cardiac muscle and how these requirements are met.

Heart Physiology

9. Describe the structures and activities of the intrinsic conduction system.
10. Draw a typical ECG. Label and define the three phases.
11. Discuss the cardiac cycle in terms of relative pressure in each set of chambers.
12. Explain the normal heart sounds and how the sounds relate to closure of specific valves and systole or diastole of the ventricles.
13. Define cardiac output, stroke volume, and heart rate. Calculate cardiac output and cardiac reserve.
14. List the factors that affect stroke volume of the heart.
15. Describe the effects of the divisions of the autonomic nervous system on the heart.

Developmental Aspects of the Heart

16. Describe the events of development of the heart from two separate tubes to a fin-ished structure.
17. Explain age-related changes that occur in the heart. Discuss possible changes in heart function due to these changes.

Lecture Outline

I. Heart Anatomy (pp. 678–689; Figs. 18.1–18.10)

- A. Size, Location, and Orientation (p. 678; Fig. 18.1)
 1. The heart is the size of a fist and weighs 250–300 grams.
 2. The heart is found in mediastinum and two-thirds lies left of the midsternal line.
 3. The base is directed toward the right shoulder and the apex points toward the left hip.
- B. Coverings of the Heart (p. 678; Fig. 18.2)
 1. The heart is enclosed in a doubled-walled sac called the pericardium.

2. Deep to pericardium is the serous pericardium.
 3. The parietal pericardium lines the inside of the pericardium.
 4. The visceral pericardium, or epicardium, covers the surface of the heart.
- C. Layers of the Heart Wall (pp. 678–680; Fig. 18.3)
1. The myocardium is composed mainly of cardiac muscle and forms the bulk of the heart.
 2. The endocardium lines the chambers of the heart.
- D. Chambers and Associated Great Vessels (pp. 680–684; Fig. 18.4)
1. The right and left atria are the receiving chambers of the heart.
 2. The right ventricle pumps blood into the pulmonary trunk; the left ventricle pumps blood into the aorta.
- E. Pathway of Blood Through the Heart (pp. 684–685; Fig. 18.5)
1. The right side of the heart pumps blood into the pulmonary circuit; the left side of the heart pumps blood into the systemic circuit.
- F. Coronary Circulation (pp. 685–686; Fig. 18.7)
1. The heart receives no nourishment from the blood as it passes through the chamber.
 2. The coronary circulation provides the blood supply for the heart cells.
 3. In a myocardial infarction, there is prolonged coronary blockage that leads to cell death.
- G. Heart Valves (pp. 686–689; Figs. 18.8–18.10)
1. The tricuspid and bicuspid valves prevent backflow into the atria when the ventricles contract.
 2. When the heart is relaxed the AV valves are open, and when the heart contracts the AV valves close.
 3. The aortic and pulmonary valves are found in the major arteries leaving the heart. They prevent backflow of blood into the ventricles.
 4. When the heart is relaxed the aortic and pulmonary valves are closed, and when the heart contracts they are open.

II. Properties of Cardiac Muscle Fibers (pp. 689–692; Figs. 18.11–18.12)

- A. Microscopic Anatomy (pp. 689–690; Fig. 18.11)
1. Cardiac muscle is striated and contraction occurs via the sliding filament mechanism.
 2. The cells are short, fat, branched, and interconnected by intercalated discs.
- B. Mechanism and Events of Contraction (pp. 690–692; Fig. 18.12)
1. Some cardiac muscle cells are self-excitabile.
 2. The heart contracts as unit or not at all.
 3. The heart's absolute refractory period is longer than a skeletal muscle's, preventing tetanic contractions.
- C. Energy Requirements (p. 692)
1. The heart relies exclusively on aerobic respiration for its energy demands.
 2. Cardiac muscle is capable of switching nutrient pathways to use whatever nutrient supply is available.

III. Heart Physiology (pp. 692–705; Figs. 18.13–18.23)

- A. Electrical Events (pp. 692–697; Figs. 18.13–18.18)

1. Intrinsic conduction system is made up of specialized cardiac cells that initiate and distribute impulses, ensuring that the heart depolarizes in an orderly fashion.
 2. The autorhythmic cells have an unstable resting potential, called pacemaker potentials, that continuously depolarizes.
 3. Impulses pass through the autorhythmic cardiac cells in the following order: sinoatrial node, atrioventricular node, atrioventricular bundle, right and left bundle branches, and Purkinje fibers.
 4. The autonomic nervous system modifies the heartbeat: the sympathetic center increases rate and depth of the heartbeat, and the parasympathetic center slows the heartbeat.
 5. An electrocardiograph monitors and amplifies the electrical signals of the heart and records it as an electrocardiogram (ECG).
- B. Heart Sounds (pp. 697–698; Fig. 18.19)
1. Normal
 - a. The first heart sound, lub, corresponds to closure of the AV valves, and occurs during ventricular systole.
 - b. The second heart sound, dup, corresponds to the closure of the aortic and pulmonary valves, and occurs during ventricular diastole.
 2. Abnormal
 - a. Heart murmurs are extraneous heart sounds due to turbulent backflow of blood through a valve that does not close tightly.
- C. Mechanical Events: The Cardiac Cycle (pp. 698–700; Fig. 18.20)
1. Systole is the contractile phase of the cardiac cycle and diastole is the relaxation phase of the cardiac cycle.
 2. Cardiac Cycle
 - a. Ventricular Filling: Mid-to-Late Diastole
 - b. Ventricular Systole
 - c. Isovolumetric Relaxation: Early Diastole
- D. Cardiac Output (pp. 700–705; Figs. 18.21–18.23)
1. Cardiac output is defined as the amount of blood pumped out of a ventricle per beat, and is calculated as the product of stroke volume and heart rate.
 2. Regulation of Stroke Volume
 - a. Preload: the Frank-Starling law of the heart states that the critical factor controlling stroke volume is the degree of stretch of cardiac muscle cells immediately before they contract.
 - b. Contractility: contractile strength increases if there is an increase in cytoplasmic calcium ion concentration.
 - c. Afterload: ventricular pressure that must be overcome before blood can be ejected from the heart.
 3. Regulation of Heart Rate
 - a. Sympathetic stimulation of pacemaker cells increases heart rate and contractility, while parasympathetic inhibition of cardiac pacemaker cells decreases heart rate.
 - b. Epinephrine, thyroxine, and calcium influence heart rate.
 - c. Age, gender, exercise, and body temperature all influence heart rate.
 4. Homeostatic Imbalance of Cardiac Output
 - a. Congestive heart failure occurs when the pumping efficiency of the heart is so low that blood circulation cannot meet tissue needs.

- b. Pulmonary congestion occurs when one side of the heart fails, resulting in pulmonary edema.

IV. Developmental Aspects of the Heart (pp. 705–709; Figs. 18.24–18.25)

- A. Embryological Development (pp. 705–708; Figs. 18.24–18.25)
 1. The heart begins as a pair of endothelial tubes that fuse to make a single heart tube with four bulges representing the four chambers.
 2. The foramen ovale is an opening in the interatrial septum that allows blood returning to the pulmonary circuit to be directed into the atrium of the systemic circuit.
 3. The ductus arteriosus is a vessel extending between the pulmonary trunk to the aortic arch that allows blood in the pulmonary trunk to be shunted to the aorta.
- B. Aging Aspects of the Heart (pp. 708–709)
 1. Sclerosis and thickening of the valve flaps occurs over time, in response to constant pressure of the blood against the valve flaps.
 2. Decline in cardiac reserve occurs due to a decline in efficiency of sympathetic stimulation.
 3. Fibrosis of cardiac muscle may occur in the nodes of the intrinsic conduction system, resulting in arrhythmias.
 4. Atherosclerosis is the gradual deposit of fatty plaques in the walls of the systemic vessels.

Cross References

Additional information on topics covered in Chapter 18 can be found in the chapters listed below.

1. Chapter 1: Ventral body cavity; mediastinum
2. Chapter 3: Cell junctions
3. Chapter 4: Serous membranes; cardiac muscle; squamous epithelium; collagen
4. Chapter 9: Sliding filament mechanisms
5. Chapter 11: Membrane potential
6. Chapter 12: Medullary control of cardiac rate
7. Chapter 13: Vagus nerve
8. Chapter 14: Neurotransmitters and cardiac rate; general sympathetic and parasympathetic function
9. Chapter 19: Atherosclerosis; hydrostatic pressure and fluid movement; cardiac output and regulation of blood pressure; vasomotor centers and control of blood pressure; function of baroreceptors and chemoreceptors in blood pressure control; blood volume and pressure control; blood flow to the heart
10. Chapter 22: Function of pulmonary arteries and veins
11. Chapter 28: Fetal circulation and modifications that occur during birth

Laboratory Correlations

1. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Cat and Fetal Pig Versions*. Eighth Edition Updates. Benjamin Cummings, 2006.
Exercise 30: Anatomy of the Heart
Exercise 31: Conduction System of the Heart and Electrocardiography
2. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Main Version*. Seventh Edition Update. Benjamin Cummings, 2006.
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Vane, John R. "Back to an Aspirin a Day?" *Science* 296 (5567) (April 2002): 474–475.