Chapter 14

The Heart and Heart Disease
Overview

Heart structure

Function

Heart studies
- Stethoscope
- ECG
- Echocardiograph
- Angiography

Diseases
- Inflammation
- Arrhythmia
- Congenital disorders
- Valve disorders
- Coronary artery disease
- Heart failure
  - Atherosclerosis
  - Angina pectoris
  - Myocardial infarction
    - Treatment
    - Prevention

Heart sounds
- Normal
- Abnormal

Layers
- Endocardium
- Myocardium
- Pericardium

Divisions
- Chambers
- Valves

Blood supply
- Coronary arteries
- Coronary veins

Heart rate control
- ANS
- Hormones
- Ions

Cardiac cycle
- Systole
- Diastole

Cardiac output
- Stroke volume
- Heart rate

Conduction system

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<table>
<thead>
<tr>
<th>Key Terms</th>
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<td>myocardium</td>
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</table>
Structure of the Heart

Learning Objectives

1. Describe the three tissue layers of the heart wall.

2. Describe the location and structure of the pericardium, and cite its functions.
Structure of the Heart (cont.)

Learning Objectives

3. Compare the functions of the right and left chambers of the heart.

4. Name the valves at the entrance and exit of each ventricle, and identify the function of each.

5. Briefly describe blood circulation through the myocardium.
Heart Function

Learning Objectives

6. Briefly describe the cardiac cycle.

7. Name and locate the components of the heart’s conduction system.

8. Explain the effects of the autonomic nervous system (ANS) on the heart rate.

9. List and define several terms that describe variations in heart rates.

10. Explain what produces each of the two normal heart sounds, and identify the usual cause of a murmur.
Heart Disease

Learning Objective

11. Briefly describe five methods used to study the heart.
Heart Disease (cont.)

Learning Objectives

12. Describe six types of heart disease.

13. List four risk factors for coronary artery disease that cannot be modified.

14. List seven risk factors for coronary artery disease that can be modified.

15. Describe three approaches to the treatment of heart disease.
Effects of Aging

Learning Objective

16. List four changes that may occur in the heart with age.
Case Study

Learning Objective

17. Referring to the case study, list the emergency and surgical procedures commonly performed following a myocardial infarction, and explain why they are done.
Learning Objective

18. Show how word parts are used to build words related to the heart.
Structure of the Heart

Learning Objectives

1. Describe the three tissue layers of the heart wall.

2. Describe the location and structure of the pericardium, and cite its functions.
Circulation and the Heart

- The circulatory system is a continuous one-way circuit of blood vessels, through which blood is pumped by the heart.
Location of the Heart

- Between the lungs
- Left of the midline of the body
- In mediastinum
- Apex pointed toward left
Why is the left lung smaller than the right lung?
Structure of the Heart

Tissue Layers of the Heart Wall

- The endocardium lines the heart’s interior.
- The myocardium is the thickest layer; the heart muscle.
- The epicardium is the thin outermost layer.
Structure of the Heart (cont.)

Figure 14-2 Layers of the heart wall and pericardium.

Which layer of the heart wall is the thickest?
The Pericardium

- The sac that encloses the heart
  - Outer fibrous pericardium holds the heart in place.
  - Serous pericardium:
    - Parietal layer fused to fibrous pericardium
    - Visceral layer (epicardium) fused to myocardium
  - Pericardial cavity is the space between serous layers.
Special Features of the Myocardium

- Composed of cardiac muscle cells
  - Are lightly striated (striped)
  - Have single nucleus
  - Are controlled involuntarily
  - Have intercalated disks
  - Have branching fibers
Structure of the Heart (cont.)

Figure 14-3 Cardiac muscle tissue viewed under the microscope (× 540).

![Image of cardiac muscle tissue with labeled structures: Intercalated disk and Nucleus.]
Structure of the Heart (cont.)

Learning Objectives

3. Compare the functions of the right and left chambers of the heart.

4. Name the valves at the entrance and exit of each ventricle, and identify the function of each.

5. Briefly describe blood circulation through the myocardium.
Divisions of the Heart

- Double pump
  - Right side pumps blood low in oxygen to the lungs via pulmonary circuit.
  - Left side pumps oxygenated blood to remainder of body via systemic circuit.
**Structure of the Heart (cont.)**

**Four Chambers**

- **Right atrium**
  - Receives low-oxygen blood returning from body tissue through superior vena cava and inferior vena cava
- **Left atrium**
  - Receives high-oxygen blood from lungs
- **Right ventricle**
  - Pumps blood from right atrium to lungs
- **Left ventricle**
  - Pumps oxygenated blood to body
Which heart chamber has the thickest wall?
Structure of the Heart (cont.)

Four Valves

- Atrioventricular valves
  - Entrance valves
    - Right atrioventricular (AV) valve (tricuspid valve)
    - Left atrioventricular (AV) valve (bicuspid valve)

- Semilunar valves
  - Exit valves
    - Pulmonary valve
    - Aortic valve
How many cusps does the right AV valve have? The left?
Blood Supply to the Myocardium

- Coronary arteries
  - Right coronary artery
  - Left coronary artery
- Cardiac veins
Structure of the Heart (cont.)

Figure 14-6 Blood vessels that supply the myocardium.

What is the largest cardiac vein, and where does it lead?
Structure of the Heart (cont.)

Figure 14-7 Opening of coronary arteries in the aortic valve (anterior view).

A Ventricular contraction (aortic valve open)

B Ventricular relaxation (aortic valve closed)

When the ventricle relaxes, backflow of blood closes valve and causes filling of coronary arteries.

Blood flow

To heart muscle (myocardium)
Structure of the Heart (cont.)

Checkpoints

14-1 What are the names of the innermost, middle, and outermost layers of the heart wall?

14-2 What is the name of the sac that encloses the heart?

14-3 What is the heart’s upper receiving chamber on each side called? What is the lower pumping chamber called?

14-4 What is the purpose of the valves in the heart?

14-5 What is the name of the system that supplies blood to the myocardium?
Heart Function

Learning Objectives

6. Briefly describe the cardiac cycle.

7. Name and locate the components of the heart’s conduction system.

8. Explain the effects of the autonomic nervous system (ANS) on the heart rate.

9. List and define several terms that describe variations in heart rates.

10. Explain what produces each of the two normal heart sounds, and identify the usual cause of a murmur.
Heart Function (cont.)

Cardiac Cycle

- Series of events occurring in the heart during one heartbeat
  - Systole (active phase, contraction)
  - Diastole (resting phase)
Heart Function (cont.)

Figure 14-8 The cardiac cycle.

Atrial systole
Contraction of atria pumps additional blood into the ventricles.

Ventricular systole
Contraction of ventricles pumps blood into aorta and pulmonary arteries.

Complete diastole
Atria fill with blood, which flows directly into the relaxed ventricles.

When the ventricles contract, what valves close? What valves open?
Heart Function (cont.)

Cardiac Output (CO)

- The volume of blood pumped by the heart per minute

- Calculation of cardiac output
  - Stroke volume (SV): The volume of blood pumped by the heart per heartbeat
  - Heart rate (HR): The number of heartbeats per minute

\[ \text{CO} = \text{SV} \times \text{HR} \]
\[ \text{CO} = \text{mL/min} \]
Heart Function (cont.)

The Heart’s Conduction System

- Produces electrical energy, which stimulates cardiac muscle
- Components
  - Sinoatrial (SA) node (pacemaker)
  - Internodal pathways
  - Atrioventricular (AV) node
  - Atrioventricular bundle (bundle of His)
  - Purkinje fibers (conduction myofibers)
What parts of the conduction system do the internodal pathways connect?
Although the SA node sets the heart’s pace, the nervous and endocrine systems can influence the heart and allow it to adapt rapidly to changing needs.

- **Autonomic nervous system (ANS)**
  - The sympathetic nervous system speeds the heart up.
  - The parasympathetic system (CN X) slows the heart down.

- **Endocrine system**
  - Epinephrine speeds the heart up.
  - Thyroxine speeds the heart up.
Figure 14-10 Autonomic nervous system (ANS) regulation of the heart.

Which cranial nerve carries parasympathetic impulses to the heart?
Heart Function (cont.)

Variations in Heart Rates

- Bradycardia
- Tachycardia
- Sinus arrhythmia
- Premature ventricular contraction (PVC)
Normal and Abnormal Heart Sounds

- Normal
  - Lub
  - Dup

- Abnormal
  - Organic murmur

- Functional murmur
  - Normal sounds heard as the heart works
Heart Function (cont.)

Checkpoints

14-6 What name is given to the contraction phase of the cardiac cycle? To the relaxation phase?

14-7 What is cardiac output? What two factors determine cardiac output?

14-8 What is the scientific name of the heart’s pacemaker?

14-9 What system exerts the main influence on the rate and strength of heart contractions?

14-10 What is a heart murmur?
Learning Objective

11. Briefly describe five methods used to study the heart.
Heart Studies (cont.)

Methods of Studying the Heart

- Stethoscope
- Electrocardiograph (ECG or EKG)
  - Electrodes
- Catheterization
  - Fluoroscope
  - Coronary angiography
- Coronary computed tomography angiography (CTA)
- Echocardiography
What is the length of the cardiac cycle shown in this diagram?
Heart Studies (cont.)

Figure 14-12 Coronary angiography.
Heart Studies (cont.)

Checkpoints

14-11 What do ECG and EKG stand for?

14-12 What is the general term for using a thin tube threaded through a vessel for diagnosis or repair?

14-13 What techniques use a dye and x-rays to visualize the coronary arteries?
Heart Disease

Learning Objectives

12. Describe six types of heart disease.

13. List four risk factors for coronary artery disease that cannot be modified.

14. List seven risk factors for coronary artery disease that can be modified.

15. Describe three approaches to the treatment of heart disease.
Heart Disease (cont.)

- The most common cause of death in industrialized countries is heart and circulatory system disease.
Heart Disease (cont.)

Classifications of Heart Disease

• Inflammatory heart disease
  – Endocarditis
  – Myocarditis
  – Pericarditis

• Abnormalities of heart rhythm
  – Arrhythmia
  – Heart block
Heart Disease (cont.)

Classifications of Heart Disease (cont.)

- Congenital heart disease
  - Atrial septal defect
  - Patent ductus arteriosus
  - Ventricular septal defect
  - Coarctation of the aorta
  - Tetralogy of Fallot
Heart Disease (cont.)

Figure 14-13 Congenital heart defects.
Heart Disease (cont.)

Classification of Heart Disease (cont.)

- Valve disorders
  - Rheumatic heart disease
- Coronary artery disease
  - Atherosclerosis
    - Ischemia
    - Thrombosis
  - Angina pectoris
  - Myocardial infarction
    - Coronary thrombosis
    - Occlusion
- Congestive heart failure
Heart Disease (cont.)

Figure 14-14 Coronary atherosclerosis.

A  Fat deposits (plaque)
B  Blockage (occlusion)
C  Blood clot (thrombus)
Heart Disease (cont.)

Figure 14-15 Myocardial infarction (MI).
Treatment of Myocardial Infarction

- Depends on extent and location of the damage
- Cardiopulmonary resuscitation (CPR)
- Defibrillation
  - Automated external defibrillator (AED)
- Thrombolytic drugs
- Surgical treatment
  - Angioplasty
  - Coronary artery bypass surgery
  - Pacemakers
- Supportive care
  - Morphine
  - Oxygen
## Prevention of Coronary Artery Disease

### Risk Factors for Coronary Artery Disease

<table>
<thead>
<tr>
<th>Risk Factors That Cannot Be Modified</th>
<th>Risk Factors That Can Be Modified</th>
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<tr>
<td>Age</td>
<td>Smoking and other forms of tobacco use</td>
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<tr>
<td>Gender</td>
<td>Physical inactivity</td>
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<tr>
<td>Heredity</td>
<td>Overweight</td>
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<td>Body type</td>
<td>Saturated fat in diet</td>
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<td>Hypertension</td>
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<td>Type 2 diabetes</td>
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<td>Sleep apnea</td>
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Prevention of Coronary Artery Disease (cont.)

- Regular physical examinations
- Control of risk factors
- Monitor “markers”
  - C-reactive protein (CRP)
  - Homocysteine
  - Lipoprotein
Heart Disease (cont.)

- Congestive heart failure
  - The heart is unable to pump sufficient blood.
  - Heart chambers enlarge.
  - Blood backs up into lungs.
  - Ventricular muscles have decreased ability to contract.
  - Fluid accumulates in the lungs, liver, abdomen, legs.
Heart Disease (cont.)

Checkpoints

14-14  What are the three types of heart inflammation?
14-15  What is an abnormal heart rhythm called?
14-16  What is congenital heart disease?
14-17  What types of organisms cause rheumatic fever?
14-18  What degenerative process commonly causes narrowing of the vessels in coronary artery disease?
14-19  What is the medical term for a “heart attack?”
14-20  What is the general name for a device that restores a normal heart rhythm?
Treatment of Heart Disease

- Lifestyle changes
- Medications
  - Statins
  - Anticoagulants
    - Aspirin
    - Warfarin
  - Digitalis
  - Beta-adrenergic blockers
  - Antiarrhythmic agents
  - Slow calcium channel blockers
Treatment of Heart Disease (cont.)

- Pacemakers
- Heart surgery
  - Coronary artery bypass graft (CABG)
  - Angioplasty
  - Coronary atherectomy
  - Cardiac ablation
  - Surgical transplantation
Figure 14-16 Placement of an artificial pacemaker.

- Pacemaker lead enters external jugular vein
- Tip of lead lodged in apex of right ventricle
- Pacemaker placed beneath skin in pectoral region
Treatment of Heart Disease (cont.)

Figure 14-17 Coronary artery bypass graft (CABG).
Treatment of Heart Disease (cont.)

Figure 14-18 Coronary angioplasty.
Figure 14-19 Arterial stent.

A
- Deflated balloon
- Closed stent
- Plaque
- Catheter

B
- Inflated balloon
- Open stent

C
- Plaque
- Open stent
Treatment of Heart Disease (cont.)

Checkpoints

14-21 How do aspirin and warfarin act to prevent heart attacks?

14-22 What is the name for a device that is wired to the heart to regulate the heartbeat?

14-23 What does CABG stand for?
Effects of Aging

Learning Objective

16. List four changes that may occur in the heart with age.
Effects of Aging on the Heart

- Heart chambers become smaller.
- Myocardial tissue atrophies.
- Less flexible valves.
- Less responsive conduction system.
  - Abnormal rhythms
- Decreases contraction strength.
- Decreased cardiac output.
17. Referring to the case study, list the emergency and surgical procedures commonly performed following a myocardial infarction and explain why they are done.
Emergency and Surgical Procedures Commonly Performed following a Myocardial Infarction

- Cardiopulmonary resuscitation
- Defibrillation
- Administration of thrombolytic medication and nitroglycerine
- Administration of oxygen
- Administration of morphine
- Monitor assays of specific substances in the blood, that is, cardiac enzymes
- Monitor the cardiac muscle’s electrical activity
Case Study (cont.)

Emergency and Surgical Procedures Commonly Performed following a Myocardial Infarction (cont.)

- Coronary bypass surgery
  - Harvest saphenous vein from Jim’s leg, which would be used as the grafts for the diseased coronary arteries.
  - Connect Jim to the heart–lung machine, which oxygenates the body while the heart is stopped to allow the surgeon to perform the bypass on the diseased arteries.
  - Following the completion of the bypassed vessels, Jim was disconnected from the heart–lung machine, and his heart was restarted.
18. Show how word parts are used to build words related to the heart.
## Word Anatomy (cont.)

<table>
<thead>
<tr>
<th>Word Part</th>
<th>Meaning</th>
<th>Example</th>
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<td><strong>Structure of the Heart</strong></td>
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<tr>
<td>cardi/o</td>
<td>heart</td>
<td>The <em>myocardium</em> is the heart muscle.</td>
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<td>pulmon/o</td>
<td>lung</td>
<td>The <em>pulmonary</em> circuit carries blood to the lungs.</td>
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<td>slow</td>
<td><em>Bradycardia</em> is a slow heart rate.</td>
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<td>The <em>sinoatrial</em> node is in a space (sinus) in the wall of the right atrium.</td>
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<td>rapid</td>
<td><em>Tachycardia</em> is a rapid heart rate.</td>
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<td>angi/o</td>
<td>vessel</td>
<td><em>Angiography</em> is radiographic study of vessels.</td>
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<td>A <em>stethoscope</em> is used to listen to body sounds.</td>
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<td><em>Cyanosis</em> is a bluish discoloration of the skin caused by lack of oxygen.</td>
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<td>suppression</td>
<td>Narrowing of blood vessels leads to <em>ischemia</em>, a lack of blood (emia) supply to tissues.</td>
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<td>hard</td>
<td>In <em>atherosclerosis</em>, vessels harden with fatty, gruel-like (ather/o) material that deposits on vessel walls.</td>
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### Word Anatomy (cont.)

<table>
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<td>sten/o</td>
<td>narrowing, closure</td>
<td><em>Stenosis</em> is a narrowing of a structure, such as a valve.</td>
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</table>

**Treatment of Heart Disease**

| -ectomy   | surgical removal | *Atherectomy* is removal of atherosclerotic (ecto [out] + tom/o [cut]) plaque from a vessel. |
| -plasty   | molding, surgical formation | *Angioplasty* is used to reshape vessels that are narrowed by disease. |