THE CARDIOVASCULAR SYSTEM

2ND SEMESTER | S.Y. 2025-2026 | PROF. DOC UMLAS
Trans: CUESTA

TOPIC OUTLINE

★ **The Cardiovascular System**
- The cardiovascular system is a closed system composed of the heart and the blood vascular system
- The heart is the hollow muscular organ that pumps the blood through the blood vascular system
- The blood vascular system is composed of the different types of blood vessels
- Main function: to deliver blood (plasma and formed elements), oxygen and carbon dioxide, and waste products [to liver and kidneys]

BLOOD VESSELS

- Arteries: carry oxygenated blood away from the heart → to the systemic circulation
- Veins: carry deoxygenated blood from the systemic circulation → back to the hear
- Capillaries: smallest blood vessels → site of gas (oxygen and carbon dioxide), nutrient, and waste exchange between blood and tissues
  - Perfusion: flow or passage of blood through the capillaries (supplying blood to the tissues)

➢ ***REFERENCE BOOK BY: PHLEBOTOMY ESSENTIALS FIFTH EDITION (RUTH E. McCALL)***

✓ Arteries and veins are composed of three main layers. The thickness of the layers varies with the size and type of blood vessel. Figure 6-7 shows a cross-section of an artery and a vein as seen through a microscope. Capillaries are composed of a single layer of endothelial cells enclosed in a basement membrane. (See Fig. 6-8 for a comparison diagram of artery, vein, and capillary structure.)

✓ Layers

• Tunica (tu'ni-ka) adventitia (ad'ven-tish'e-a): the outer layer of a blood vessel, sometimes called the tunica externa. It is made up of connective tissue and is thicker in arteries than in veins.

• Tunica media: the middle layer of a blood vessel. It is made up of smooth muscle tissue and some elastic fi bers. It is much thicker in arteries than in veins.

• Tunica intima (in'ti-ma): the inner layer or lining of a blood vessel, sometimes called the tunica interna. It is made up of a single layer of endothelial cells with an underlying basement membrane, a connective tissue layer, and an elastic internal membrane.

❖ *FYI: TUNICA (LATIN FOR "COAT" OR "SHEATH" MEANS A COAT OR LAYER OF TISSUE.*

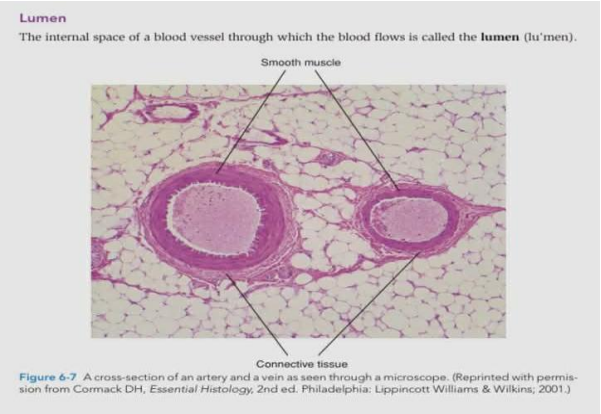

Figure 6-7 A cross-section of an artery and a vein as seen through a microscope. (Reprinted with permission from Cormack DH, *Essential Histology*, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2001.)

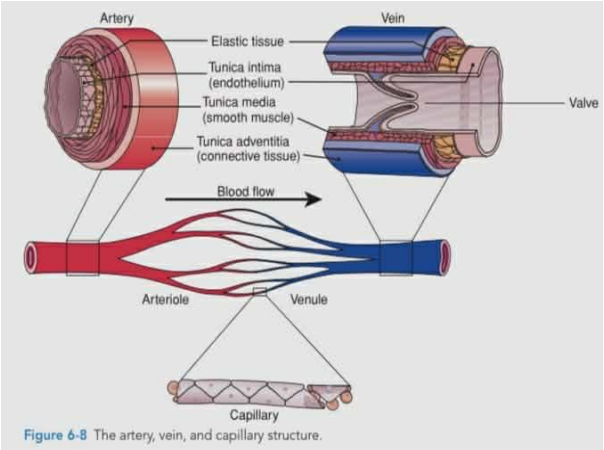

Figure 6-8 The artery, vein, and capillary structure.

PHYSIOLOGY:

PULSE RATE

- ★ Pulse- pressure wave of blood
- ★ Monitored at "pressure points" where pulse is easily palpated
- ★ Normal range (when not being active):
- ★ Adults: 60-100bpm
- ★ Children: 70-100bpm

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✓ The pulse is the palpable rhythmic throbbing caused by the alternating expansion and contraction of an artery as a wave of blood passes through it. It is created as the ventricles contract and blood is forced out of the heart and through the arteries. In normal individuals, the pulse rate is the same as the heart rate. The pulse is most easily felt by compressing the radial artery on the thumb side of the wrist.

PATHOLOGY: THE BLOOD VASCULAR SYSTEM

- ★ Atherosclerosis refers to the buildup of fats, cholesterol and other substances in and on your artery walls (plaque), which can restrict blood flow.
- ★ The plaque can burst, triggering a blood clot.
- ★ Although atherosclerosis is often considered a heart problem, it can affect arteries anywhere in your body.
- ★ **Varicose veins** are enlarged, swollen, and twisting veins, often appearing blue or dark purple. They happen when faulty valves in the veins allow blood to flow in the wrong direction or to pool.
- ★ A stroke is a sudden interruption in the blood supply of the brain.
- ★ Most strokes are caused by an abrupt blockage of arteries leading to the brain (ischemic stroke).
- ★ Other strokes are caused by bleeding into brain tissue when a blood vessel bursts (hemorrhagic stroke).

ARTERIES

- Transport oxygenated blood away from the heart
- Thicker tunica media
- Smaller lumen
- No valves
- Most arterial blood

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✓ Arteries Fig. 6-4) are blood vessels that carry blood away from the heart. They have thick walls because the blood that moves through them is under pressure from the contraction of the ventricles. This pressure creates a pulse that can be felt, distinguishing the arteries from the veins.

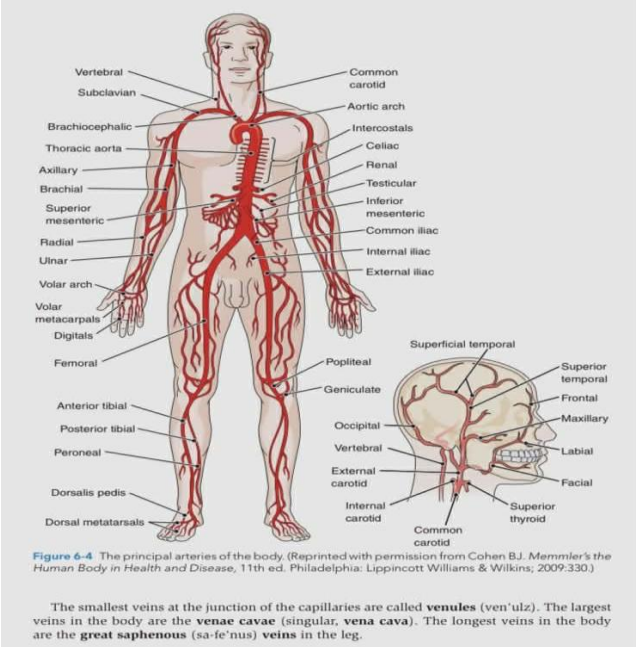

Figure 6-4 The principal arteries of the body. (Reprinted with permission from Cohen BJ. *Memmler's the Human Body in Health and Disease*, 11th ed. Philadelphia: Lippincott Williams & Wilkins; 2009:330.)

The smallest veins at the junction of the capillaries are called **venules** (ven'ulz). The largest veins in the body are the **venae cavae** (singular, **vena cava**). The longest veins in the body are the **great saphenous** (sa-fe'nus) **veins** in the leg.

❖ KEY POINT When arterial blood is collected by syringe, the pressure normally causes the blood to "pump" or pulse into the syringe under its own power

✓ Systemic arteries carry oxygenated (oxygen-rich) blood away from the heart to the tissues. Because it is oxygen-rich, or full of oxygen, normal systemic arterial blood is bright red.

❖ KEY POINT The pulmonary artery is the only artery that carries deoxygenated, or oxygen-poor, blood. It is part of the pulmonary circulation and carries deoxygenated blood from the heart to the lungs. It is classified as an artery because it carries blood away from the heart.

✓ The smallest branches of arteries that join with the capillaries are called arterioles (ar-te're-olz). The largest artery in the body is the aorta. It is approximately 1 inch (2.5 cm) in diameter.

VEINS

- Transport deoxygenated blood back to the heart
- Thicker tunica adventitia
- Larger lumen
- Have valves (folded tunica intima forms the valves)

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✓ Veins (Fig. 6-5) are blood vessels that return blood to the heart. Veins carry blood that is low in oxygen (deoxygenated or oxygen-poor) except for the pulmonary vein, which carries oxygenated blood from the lungs back to the heart. Because systemic venous blood is oxygen poor, it is much darker and more bluish-red than normal arterial blood. The walls of veins are thinner than those of arteries because the blood is under less pressure than arterial blood. Since the walls are thinner, veins can collapse more easily than arteries. Blood is kept moving through veins by skeletal muscle movement, valves that prevent the backflow of blood, and pressure changes in the abdominal and thoracic cavities during breathing.

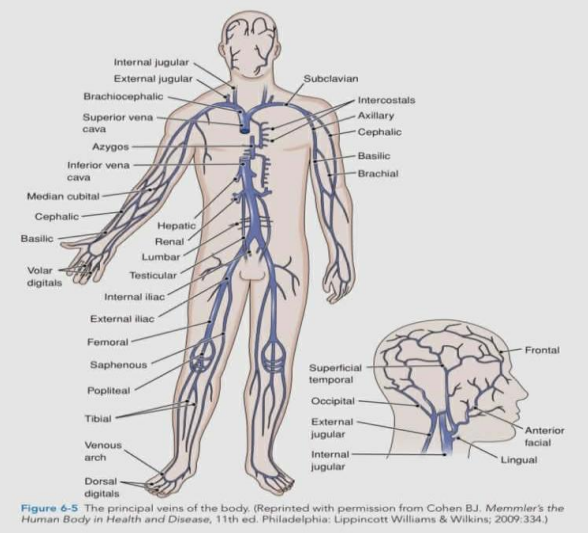

Figure 6-5 The principal veins of the body. (Reprinted with permission from Cohen BJ. *Memmler's the Human Body in Health and Disease*, 11th ed. Philadelphia: Lippincott Williams & Wilkins; 2009:334.)

Capillaries

- Exchange of gases, nutrients, and wastes between tissues
- Only have an endothelium
- No other tunics or subendothelial layer
- Have two types of vessels: true capillaries

➢ ***REFERENCE BOOK BY: PHLEBOTOMY ESSENTIALS FIFTH EDITION (RUTH E. McCALL)***

✓ Capillaries are microscopic, one-cell-thick vessels that connect the arterioles and venules, forming a bridge between the arterial and venous circulation. Blood in the capillaries is a mixture of both venous and arterial blood. In the systemic circulation, arterial blood delivers oxygen and nutrients to the capillaries. The thin capillary walls allow the exchange of oxygen for carbon dioxide and nutrients for wastes between the cells and the blood (Fig. 6-6). Carbon dioxide and wastes are carried away in the venous blood. In the pulmonary circulation, carbon dioxide is delivered to the capillaries in the lungs and exchanged for oxygen.

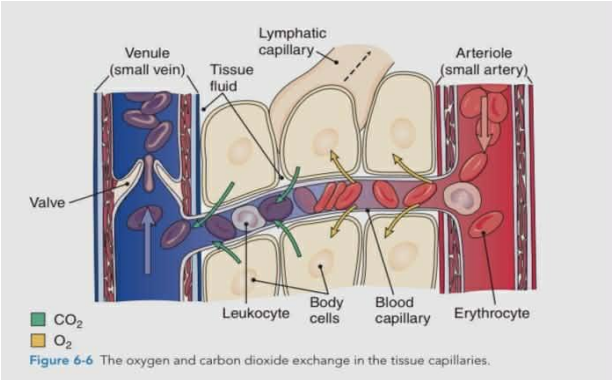

Figure 6-6 The oxygen and carbon dioxide exchange in the tissue capillaries.

HEART ATTACK

- A myocardial infraction (MI), also known as a heart attack, occurs when blood flow decreases or stops to a part of the heart, causing damage to the heart muscle.
- The most common symptom is chest pain or discomfort which travel into the shoulder, arm, back, neck or jaw.
- This usually happens because one or more of the heart's arteries is narrowed or blocked, also called ischemia.
- Damage to AV node= release of ventricles from control= slower heart beat
- Slower heart beat can lead to fibrillation

- Fibrillation= lack of blood flow to the heart (ventricular)
- Tachycardia= more than 100 beats/min
- Bradychardia= less than 60 beats/min

✓ BLOOD CIRCULATION:

- Taking blood to the tissues and back
  - Arteries
  - Arterioles
  - Capillaries
  - Venules
  - Veins

INTERNAL STRUCTURE OF THE HEART:

✓ HEART VALVES:

- Allows the unidirectional flow of blood (allows blood to flow in one direction); valves open as blood is pumped through
- ATRIOVENTRICULAR VALVES: found between atria and ventricles
  - Bicuspid valve: has two cusps; aka mitral valve; left atrioventricular valve
  - Tricuspid: has three cusps; right atrioventricular valve
- SEMILUNAR VALVES: found between ventricle and artery
  - Pulmonary semilunar: found between right ventricle; entrance to pulmonary artery
  - Aotic semilunar: found between left ventricle; entrance to aorta

✓ CONDUCTING SYSTEM

Generates and propagates waves of electrical signals through the myocardium to stimulate rhythmic contractions

- Sinoatrial node (SA node or pacemaker)
- Atrioventricular node (AV node)
- AV bundle of His
- Subendocardial conducting network (Purkinje fibers)

✓ CARDIAC SKELETON

- Compound of dense fibrous connective tissue
- Forms part of the septa of the heart (singular-septum), surrounds the heart valves, and extends to the valve cusps and chordae tendineae
- Functions:
  - Anchors and supports the heart valves
  - Provides firm points of insertion of caridac muscles
  - Helps in coordination of heartbeat by acting as electrical insulation between chambers

EXTERNAL ANATOMY; THE HEART

- ***Brachiocephalic artery:*** **supplies blood to the right arm, the head and**
- ***Superior vena cava:*** **returns blood from systemic circulation to the right atrium**
- ***Right pulmonary artery:*** **supplies deoxygenated blood to the right**
- ***Ascending aorta:*** **regulates blood pressure throughout the cardiovascular**
- ***Pulmonary trunk*****: transports blood from the right ventricle to the**
- ***Right pulmonary veins:*** **returns oxygenated blood from left lung to left**
- ***Right atrium:*** **the first chamber to receive deoxygenated blood from the systemic circulation**
- ***Right coronary artery:*** **supplies blood to the right ventricle, SA and AV**
- ***Anterior cardiac vein:*** **drains blood from upper anterior portion of myocardium to the right atrium**
- ***Right ventricle:*** **receives deoxygenated blood from right atrium and pumps it to the**
- ***Marginal artery*****: supplies blood to the right ventricle**
- ***Small cardiac vein:*** **drains the right ventricle**
- ***Inferior vena cava:*** **carries deoxygenated blood from the lower and middle body into the right atrium**
- ***Left common carotid artery:*** **supplies blood to the head and neck**
- ***Left subclavian artery:*** **supplies blood to the left**
- ***Aortic arch:*** **distributes blood to upper extremities**
- ***Ligamentum arteriosum:*** **holds aorta and pulmonary artery close to each**
- ***Left pulmonary artery:*** **supplies deoxygenated blood to the left lung**
- ***Left pulmonary veins:*** **returns oxygenated blood from left lung to left**
- ***Left atrium:*** **receives blood from pulmonary veins**
- ***Auricle:*** **flap of heart wall on anterior surface of left**
- ***Circumflex artery:*** **supplies blood to left atrium**
- ***Left coronary artery:*** **supplies blood to left atrium and left ventricle**
- ***Left ventricle:*** **pumps oxygenated blood through the aorta**

- ***Great cardiac vein:*** **returns deoxygenated blood from anterior surface of left**
- ***Anterior interventricular artery:*** **supplies blood to interventricular septum and left ventricle**
- ***Apex:*** **the tip of the left ventricle, regulates contraction of the ventricles**

PATHOLOGY OF THE HEART

A **premature ventricular contraction (PVC)** is a relatively common event where the heartbeat is initiated by Purkinje fibers in the ventricles rather than by the sinoatrial node.

PVCs may cause no symptoms or may be perceived as a **"skipped beat"** or felt as palpitations in the chest.

Congestive Heart Failure (CHF)

- Chronic progressive condition
- Decline in pumping efficiency of heart
- May result in inadequate circulation, also coronary atherosclerosis, high blood pressure and history of multiple myocardial infractions →impairment of blood flow can damage the heart
- Left side falls= pulmonary congestion and suffocation
- Right side fails= peripheral congestion and edema

➢ ***REFERENCE BOOK BY: PHLEBOTOMY ESSENTIALS FIFTH EDITION (RUTH E. McCALL)***

✓ The heart is a four-chambered, hollow, muscular organ that is slightly larger than a man's closed fist. It is surrounded by a thin fluid-filled sac called the pericardium (per'i-kar'de-um), and its walls have three distinct layers. The heart has two sides, a right and a left. Each side has two chambers, an upper and a lower. One-way valves between the chambers help prevent the backflow of blood and keep it moving through the heart in the right direction. The right and left chambers are separated from each other by partitions called septa (singular, septum).

✓ Layers The three layers of the heart (Table 6-1) are the epicardium (ep'-i-kar'de-um), the thin outer layer; the myocardium (mi-o-kar'de-um), the middle muscle layer; and endocardium (en' do-kar'de-um), the thin inner layer.

✓ Chambers The upper chambers on each side of the heart are called atria (a'tre-a), and the lower chambers are called ventricles (ven'trik-ls). The atria (singular, atrium) are receiving chambers, and the ventricles are pumping or delivering chambers. The

TABLE 6-1 Layers of the Heart

Layer	Location	Description	Function
Epicardium	Outer layer of the heart	Thin, serous (watery) membrane that is continuous with the lining of the pericardium	Covers the heart and attaches to the pericardium
Myocardium	Middle layer of the heart	Thick layer of cardiac muscle	Contracts to pump blood into the arteries
Endocardium	Inner layer of the heart	Thin layer of epithelial cells that is continuous with the lining of the blood vessels	Lines the interior chambers and valves

location and function of the chambers of the heart are described in Table 6-2.

TABLE 6-2 Chambers of the Heart

Chamber	Location	Function
Right atrium	Upper right chamber	Receives deoxygenated blood from the body via both the **superior (upper) vena cava** (ve'na ka'va) and **inferior (lower) vena cava** (plural, venae cavae) and pumps it into the right ventricle.
Right ventricle	Lower right chamber	Receives blood from the right atrium and pumps it into the **pulmonary artery,** which carries it to the lungs to be oxygenated.
Left atrium	Upper left chamber	Receives oxygenated blood from the lungs via the **pulmonary veins** and pumps it into the left ventricle.
Left ventricle	Lower left chamber	Receives blood from the left atrium and pumps it into the **aorta** (a-or'ta). The walls of the left ventricle are nearly three times as thick as those of the right ventricle owing to the force required to pump the blood into the arterial system.

✓ Valves The valves at the entrance to the ventricles are called atrioventricular (a'tre-o-ven-trik'u-lar) (AV) valves

✓ Septa There are two partitions separating the right and left sides of the heart. The partition that separates the right and left atria is called the interatrial (in-ter-a'tre-al) septum. The partition that separates the right and left ventricles is called the interventricular (in-ter-ven-trik'u-lar) septum. Each septum consists mostly of myocardium.

✓ Coronary Circulation The heart muscle does not receive nourishment or oxygen from blood passing through the heart. It receives its blood supply via the right and left coronary (also called cardiac) arteries, which branch off of the aorta, just beyond the aortic semilunar valve.

✓ Origin of the Heart Sounds (Heartbeat) As the ventricles contract (systole), the atrioventricular valves close, resulting in the first heart sound: a long, low-pitched sound commonly described as a "lubb." The second heart sound comes at the beginning of ventricular relaxation (diastole) and is due to the closing of the semilunar valves. It is shorter and sharper and described as a "dupp." Abnormal heart sounds are called murmurs and are often due to faulty valve action.

✓ Heart Rate and Cardiac Output The heart rate is the number of heartbeats per minute. The normal adult

heart rate averages 72 beats per minute. The volume of blood pumped by the heart in 1 minute is called the cardiac output and averages 5 liters per minute. An irregularity in the heart's rate, rhythm, or beat is called an arrhythmia (ah-rith'me-ah). A slow rate, less than 60 beats per minute, is called bradycardia (brad'e-kar'de-ah). A fast rate, over 100 beats per minute, is called tachycardia (tak'e-kar'de-ah). Extra beats before the normal beat are called extrasystoles. Rapid, uncoordinated contractions are called fibrillations and can result in lack of pumping action.

- ✓ HEART FUNCTION Cardiac Cycle One complete contraction and subsequent relaxation of the heart lasts about 0.8 seconds and is called a cardiac cycle. The contracting phase of the cardiac cycle is called systole (sis'to-le), and the relaxing phase is called diastole (di-as'to-le).
- ✓ Blood pressure is the force (pressure) or tension exerted by the blood on the walls of blood vessels. It is commonly measured in a large artery (such as the brachial artery in the upper arm) using a sphygmomanometer (sfig'mo-mah-nom'e-ter), more commonly known as a blood pressure cuff. Blood pressure results are expressed in millimeters of mercury (mm Hg) and are read from a manometer that is either a gauge or a mercury column, depending upon the type of blood pressure cuff used. The two components of blood pressure measured are:
  • Systolic (sis-tol'ik) pressure: the pressure in the arteries during contraction of the ventricles
  • Diastolic (di-as-tol'ik) pressure: the arterial pressure during relaxation of the ventricles

❖ *FYI A blood pressure reading is expressed as the systolic pressure over the diastolic pressure. The American Heart Association defines normal blood pressure as less than 120 over 80 mm Hg, which is written 120/80 mm Hg.*