Lecture Outline: The Cardiovascular System, Perfusion, and Circulation

I. **Introduction to the Cardiovascular System**

A. Relationship to Circulatory System

1. Cardiovascular system: **heart and vessels**
2. Circulatory system: **heart, vessels, and blood**

B. Location of the Heart

1. Between the two lungs, in the **mediastinum**
2. Situated diagonally, **apex points to lower left**
3. More to the **left of the midline**, making the left lung smaller

C. Membranes Surrounding the Heart

1. **Pericardium** (serous membrane)
    a. Features two layers with **pericardial fluid** between them
    b. Allows for slippage and movement without abrasion
2. Pericardium Layers
    a. **Parietal layer** (more superficial)
    b. **Visceral layer** (in direct contact with heart)
        (1) Also called **epicardium** (part of heart wall)
    d. **Fibrous layer** (superficial to serous pericardium)

II. **Heart Anatomy and Function**

A. Heart as a Pump: **Two Pumps in One**

1. Four chambers: **two atria** (superior), **two ventricles** (inferior)
    a. Right atrium and right ventricle
    b. Left atrium and left ventricle
2. Blood **does not mix** between right and left sides

B. Heart Wall Layers (from superficial to deep)

1. **Epicardium** (visceral layer of serous pericardium)
2. **Myocardium** (thickest, cardiac muscle tissue)
3. **Endocardium** (inner lining, in direct contact with blood)

C. Atria vs. Ventricles (Wall Thickness)

1. Atria are much **thinner-walled** and less muscular (pump to adjacent ventricles)
2. Ventricles are much **thicker-walled** and more muscular (pump blood through longer distances)
3. **Left ventricle is much thicker than right ventricle**
    a. Pumps blood to the **systemic circuit** (rest of body)
    b. Right ventricle pumps blood to the **pulmonary circuit** (lungs)

D. Heart Valves: **Ensure One-Way Blood Flow**

1. **Atrioventricular (AV) Valves**
    a. Located between an atrium and a ventricle
    b. Open **downward** (inferiorly)
    c. Anchored by **chordae tendineae** to ventricular wall (prevent backward flow)
    d. Types:
        (1) **Right AV valve** (**Tricuspid valve**): between right atrium and right ventricle (3 cusps)
        (2) **Left AV valve** (**Bicuspid valve**): between left atrium and left ventricle (2 cusps)
2. **Semilunar Valves** (half-moon shaped)
    a. Located between a ventricle and its major artery
    b. Open **upward** (superiorly)
    c. **No chordae tendineae**
    d. Types:
        (1) **Right semilunar valve** (**Pulmonary semilunar valve**): between right ventricle and pulmonary trunk
        (2) **Left semilunar valve** (**Aortic semilunar valve**): between

left ventricle and aorta

III. **Blood Flow Circuits**

A. **Pulmonary Circuit**

1. Involves the **right side of the heart**
2. **Deoxygenated blood** from body enters **right atrium**, then **right ventricle**
3. Right ventricle pumps blood through **pulmonary semilunar valve** into **pulmonary trunk**
4. Pulmonary trunk splits into **pulmonary arteries**, then arterioles, then **capillaries in lungs**
5. Gas exchange in lung capillaries: CO2 released, **O2 picked up** (blood becomes oxygenated)
6. **Oxygenated blood** returns to heart via venules, then larger veins, then **pulmonary veins**
7. Pulmonary veins empty into the **left atrium**

B. **Systemic Circuit**

1. Involves the **left side of the heart**
2. **Oxygenated blood** from lungs enters **left atrium**, then **left ventricle**
3. Left ventricle pumps blood through **aortic semilunar valve** into the **aorta**
4. Aorta branches into arteries, then arterioles, then **capillaries throughout the body**
5. Gas exchange in body capillaries: O2 delivered to cells, **CO2 picked up** (blood becomes deoxygenated)
6. **Deoxygenated blood** returns to heart via venules, then larger veins
7. **Superior Vena Cava** (from upper body) and **Inferior Vena Cava** (from lower body) empty into the **right atrium**

C. **Coronary Circuit** (Blood supply to the heart muscle itself)

1. Heart muscle (myocardium) is too thick for direct diffusion of oxygen from blood in chambers
2. **Coronary arteries** branch off the aorta, deliver oxygenated blood to

heart muscle

3. **Coronary veins** drain deoxygenated blood from heart muscle, dump into the **right atrium**

IV. **Electrical System of the Heart**

A. Composed of **specialized excitable tissues**

B. Generates and transmits **action potentials** for rhythmic beating

C. Components and Sequence of Operation:

1. **Sinoatrial (SA) Node**
    a. "**Pacemaker of the heart**"
    b. Located in the **right atrium**
    c. Creates initial action potentials, causing both atria to contract almost simultaneously
2. **Atrioventricular (AV) Node**
    a. Located near the junction of atrium and ventricle
    b. Transmits signal from SA node to ventricles
    c. **Delays signal** to allow atria to fully empty into ventricles
3. **Atrioventricular (AV) Bundle**
    a. Located in the **interventricular septum**
    b. Rapidly transmits signal after AV node delay
4. **Bundle Branches** (two major branches, one for each ventricle)
    a. Send signals down toward the **apex** of the heart
5. **Purkinje Fibers**
    a. Distribute signals to muscle cells in ventricular walls
    b. Ensure ventricles contract from **bottom upward**, efficiently ejecting blood

V. **Cardiac Cycle** (One cycle of the pump)

A. **Diastole** (**Relaxation**)

1. Atrial Diastole: All four chambers relaxed, blood passively enters atria and spills into ventricles

B. **Systole** (**Contraction**)

1. Atrial Systole: Only atria contract, squeezing remaining blood into ventricles
2. Ventricular Systole: Ventricles contract
    a. **Isovolumetric Contraction**: Initial phase, pressure builds, volume doesn't change
    b. **Ejection Phase**: Pressure opens semilunar valves, blood is forced into major arteries, ventricular volume decreases

C. **Isovolumetric Relaxation**: Ventricles relax, ending the cycle

VI. **Blood Vessels (Beyond the Heart)**

A. Categories of Blood Vessels

1. **Arteries**: Carry blood **away from the heart**
    a. Much **thicker, more muscular walls** than veins
    b. Can **vasoconstrict** (decrease diameter) or **vasodilate** (increase diameter) to adjust blood flow
    c. **Do not have internal valves**
    d. Three layers (tunics): tunica intima, **tunica media (thickest)**, tunica externa
2. **Arterioles**: Smaller arteries
3. **Capillaries**: **Smallest blood vessels**
    a. Site of **gas exchange** between blood and tissues
    b. Walls are **one cell thick** (endothelium)
    c. **No tunics** (layers)
    d. Blood pressure is **continuous** (zero pulse pressure)
4. **Venules**: Small veins
5. **Veins**: Carry blood **toward the heart**
    a. Much **thinner, less muscular walls** than arteries
    b. Have **internal valves** to prevent backflow due to lower pressure
    c. **Skeletal muscle contractions** squeeze veins, acting as a pump to push blood toward heart
    d. Three tunics: tunica intima, tunica media (thinner), tunica externa

B. Control of Blood Flow to Tissues (**Perfusion**)

1. **Capillary beds**: Network of capillaries
2. **Pre-capillary sphincters**: Rings of muscle at capillary branch points
    a. Contract to **shut off blood flow** to specific capillaries
    b. Relax to allow perfusion (blood flow through tissue)
3. **Vascular shunt**: Direct connection from arteriole to venule, bypassing capillary bed when sphincters are contracted
4. **Not all tissues are perfused at once** to prevent drastic blood pressure drop (shock)

C. Blood Flow to the Brain

1. Brain requires **continuous supply of oxygen and glucose**
2. Supplied by **carotid arteries**
3. **Circle of Willis**: Circular arterial arrangement at base of brain
    a. Provides collateral circulation; helps maintain blood flow if one carotid artery is blocked

VII. **Blood Pressure Dynamics**

A. Highest in the **aorta** (first artery from left ventricle)

B. **Systolic pressure**: Pressure during ventricular contraction

C. **Diastolic pressure**: Pressure during ventricular relaxation

D. **Pulse pressure**: Systolic pressure minus diastolic pressure (height of pressure curve)

1. High in arteries, decreases further from heart
2. **Zero in capillaries** (continuous flow needed for gas exchange)
3. Lowest in veins (requires valves and muscle pumps to return blood to heart)

VIII. **Portal Systems**

A. Definition: **Two capillary beds in series** before blood returns to the heart

B. **Hepatic Portal System** (Liver)

1. **First capillary bed**: surrounds digestive system (e.g., small intestine, stomach)

    a. Absorbs nutrients and toxins
2. Blood collects into veins (e.g., **hepatic portal vein**) which then **branch**
3. **Second capillary bed**: surrounds **liver cells (hepatocytes)**
    a. Liver processes nutrients and removes toxins
4. Blood then returns to the heart via other veins

IX. **Major Arteries and Veins (General Overview)**

A. **Arteries** (carrying blood away from heart)

1. **Aorta**: Main artery from left ventricle
    a. **Aortic arch**: U-turn portion
    b. Ascending aorta, Descending aorta
    c. Branches supply lower appendages (iliac arteries), kidneys (renal arteries), and upper body (subclavian, axillary, brachial, radial, ulnar arteries)
2. **Pulmonary arteries**: From right ventricle to lungs (carry deoxygenated blood)

B. **Veins** (carrying blood toward heart)

1. **Superior Vena Cava (SVC)**: Collects deoxygenated blood from upper body
2. **Inferior Vena Cava (IVC)**: Collects deoxygenated blood from lower body
3. Both SVC and IVC empty into the **right atrium**
4. **Pulmonary veins**: From lungs to left atrium (carry oxygenated blood)
5. Other veins often named similarly to arteries (e.g., brachial vein, subclavian veins)

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