Cardiovascular System

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INTRODUCTION

- Also **circulatory system**
- A **closed system** comprises **heart and blood vessels** (arteries, veins, capillaries).
- The function of the cardiovascular system is **to deliver oxygen and nutrients and to remove carbon dioxide and other waste products**
- Heart pumps blood through blood vessels;
  - Receives deoxygenated blood through veins
  - Pumps oxygenated blood through arteries
- Blood vessels allow blood to circulate to all parts of the body
    - Carries oxygen and carbon dioxide
    - Also carries nutrients and wastes

The cardiovascular system

Blood Vessels (Vascular System)

- **Three layers (tunics)**
- **Tunica intima**: *Endothelium*
- **Tunica media**: *Smooth muscle*
- **Tunica adventita**: *Mostly fibrous connective tissue*

Blood Vessels

- Blood under high pressure leaves heart and is distrubuted to the body by **thick-walled arteries**.
- The final distrubuting vessels, **arterioles**, deliver oxygen-rich blood to **capillaries**.
- Capillaries form a **capillary bed**, where the interchange of oxygen, nutrients, waste products with extracelular fluid occurs.
- Blood from the capillary bed passes into **thin-walled venules**, which resemble wide capillaries.
- Venules drain into **small veins** that open into **larger veins**.
- Largest veins, **superior** and **inferior venae cavae**, return low-oxygen blood to the heart

Types of Blood Vessels

- **Artery** – carries oxygenated blood away from the heart (under high pressure) (distributors)

- Large elastic arteries, Medium muscular arteries, Arterioles: small arteries

- Anastomoses (communications); important to form alternate channels (collateral circulation)

Types of Blood Vessels

- **Vein** – carries deoxygenated blood towards the heart (exception; pulmanary veins)

Great ability to stretch (capacitance)

Function as reservoirs: blood pools in the valves then is pushed forward from the pumping pressure

Veins tend to be double or multible. Those that accompany deep arteries called as accompanying veins

Venules: small veins (drain capillary beds), Medium, Large veins

Medium veins; drain venus plexus and accompany medium arteries, have one-way valves (prevent reflux of blood distally, also break columns of blood in the veins into shorter segments….musculovenous pump!)

Musculovenous pump and arteriovenous pump (‘Milks’ blood in veins toward the heart)

Veins

- Deep Veins (Accompany arteries and bear similar names)
- Superficial Veins
- Valves
- Normal direction;
  - Superficial → Deep
  - Distal → Proximal

PERFORATING VEINS

- *Penetrate the deep fascia close to their origin from the* ***superficial veins. They contain valves which normally allow the blood to flow from the superficial to the deep veins.***

- Connects Superficial to Deep vv.

Types of Blood Vessels

- **Capillaries** – arterial system switches to venous system
- Speed of blood flow decreases to increase contact time
- Microcirculation: blood flow between arterioles, capillaries and venules

Movement of Blood Through Vessels

- Most **arterial** blood is **pumped** by the heart
- **Veins** use the **milking action of muscles** to help move blood

Pulse

Pulse – pressure wave of blood

Monitored at “pressure points” where pulse is easily palpated

Thoracic Cavities

- The thoracic cavity contains the heart and lungs.
- The thoracic cavity is subdivided into:
  - Left and right pleural cavities (each pleural cavity contains one lung)
  - The mediastinum lies between the two pleural cavities and contains heart and other thoracic viscera except the lungs

HEART

- Heart is a **four chambered**, hollow muscular organ
- **Location:**
  - Thorax (in the **mediastinum**) between the lungs
  - Superior surface of diaphragm
  - **Left** of the midline
  - Anterior to the vertebral column, posterior to the sternum
  - Pointed **apex** directed toward left hip

FUNCTIONS OF THE HEART

- **Generating blood pressure**
- **Routing blood**
  - Heart separates pulmonary and systemic circulations
- **Ensuring one-way blood flow**
  - Heart valves ensure one-way flow
- **Regulating blood supply**
  - Changes in contraction rate and force match blood delivery to changing metabolic needs

Coverings of the Heart

- **Pericardium** – a double serous membrane , loose fitting sac surrounding the heart
  - ❑ **Fibrous pericardium** – tough, loose-fitting, inelastic
  - ❑ **Serous pericardium**
    - ➢ Parietal layer: lines the inside of the fibrous pericardium
    - ➢ Visceral layer: adheres to outside of the heart
  - ❑ **Pericardial space**: between parietal and visceral layer
- Filled with 10-15mL of pericardial fluid
- Decreases friction

The Function of the Pericardium:

- Protects and anchors the heart
- Prevents overfilling of the heart with blood
- Allows for the heart to work in a relatively friction-free environment

Walls of the Heart

- **Epicardium** – outer layer
  - Epicardium = serous pericardium

- **Myocardium** – thick, contractile layer composed of cardiac muscle cells
  - Allow cardiac muscle cells to function as a single unit

- **Endocaridium** – interior of cardiac wall
  - Endothelial tissue
  - Covers projections of myocardial tissue called trabeculae

Chambers of the Heart

- **Atria** – two superior chambers
  - ➢ "**Receiving chambers**"
  - ➢ Blood from veins enters atria

- **Ventricles** – two inferior chambers
  - ➢ "**pumping chambers**"
  - ➢ Thick muscular walls to increase force of pumping action, Left > right
  - ➢ Separated by **interventricular septum**

Myocardial Thickness and Function

Thickness of myocardium varies according to the function of the chamber

Atria are thin walled, deliver blood to adjacent ventricles

Ventricle walls are much thicker and stronger

- **Right ventricle** supplies blood to the lungs (little flow resistance)
- **Left ventricle** wall is the thickest to supply systemic circulation

!!!Myocardium of left ventricle is much thicker than the right

Valves of the Heart

- Heart valves separate each chamber and prevent a backflow of the blood (Permit blood flow in one direction during circulation)
- Held in place by chordae tendineae (“heart strings”) (**Chordae tendineae** anchor AV valves to papillary muscles)

- **Atrioventricular valves (AV valves)**
  - Also cuspid valves
  - Between atria and ventricles
- **Semilunar (SL valves)**
  - Between R ventricle and pulmonary arteries and L ventricle and aorta

Atrioventricular Valves

- AV valves prevent backflow into the atria when ventricles contract

- **Tricuspid valve**
  - Between R atrium and ventricle
  - 3 flaps of endocardium
  - Connected to ventricular papillary muscle via chordae tendinae

Bicuspid valve (Mitral)

- Between L atrium and ventricle
- Also called **mitral valve**
- Two flaps of endocardium

Semilunar Valves

- **Pulmonary semilunar valve**
  - Between R ventricle and pulmonary trunk
- **Aorta semilunar valve**
  - Between L ventricle and aorta

Pathway of Blood Through the Heart and Lungs

- Right atrium → tricuspid valve → right ventricle
- Right ventricle → pulmonary arteries → lungs
- Lungs → pulmonary veins → left atrium
- Left atrium → bicuspid(mitral) valve → left ventricle
- Left ventricle → aorta
- Aorta → systemic circulation

The Heart's Cardiac Cycle

- **Cardiac cycle** – events of one complete heart beat

- **Systole** = contraction
- **Diastole** = relaxation

- Atria contract simultaneously
- Atria relax, then ventricles contract

The Heart: Associated Great Vessels

- **Aorta** - leaves left ventricle
- **Pulmonary arteries** - leave right ventricle
- **Vena cava (superior/inferior)-** enters right atrium
- **Pulmonary veins (four)** - enter left atrium

Major Vessels of the Heart

- Vessels **returning blood to the heart** include:

  1-Superior and inferior venae cavae

  2-Right and left pulmonary veins

- Vessels conveying **blood away from the heart** include:

  1-Pulmonary trunk, which splits into right and left pulmonary arteries

  2-Aorta

- **Superior vena cava;**
  - Receives venous blood from **head, neck, thorax and upper limb**
- **Inferior vena cava;**
  - Venous blood from **abdomen and lower limb drain here**

- **Superior Vena Cava**
- **Internal jugular vein**; head and neck
- **Subclavian vein**; upper limb
- Union of internal jugular and subclavian form **Brachiocephalic vein**
- Union of the Brachiocephalic Veins forms **Superior Vena Cava**

Circulatory Routes

- **Systemic Circulation** – blood flow from the L ventricle to the body & back to the R atrium
  - Systemic circulation – the flow of blood between the heart and the cells of the body.

- **Pulmonary Circulation** – blood flow from the R ventricle to the lungs and back to the L atrium
  - Pulmonary circulation – the flow of blood between the heart and lungs.

How does the blood flow through the Heart?

RİGHT SİDE OF HEART

- Blood enters the heart through two large veins, the inferior and superior vena cava, emptying oxygen-poor blood from the body into the right atrium of the heart.

- As the atrium contracts, blood flows from your right atrium into your right ventricle through the open tricuspid valve.

- *When the ventricle is full, the tricuspid valve shuts. This prevents blood from flowing backward into the atria while the ventricle contracts.*

- As the ventricle contracts, blood leaves the heart through the pulmonic valve, into the pulmonary artery and to the lungs, where it is oxygenated and then returns to the left atrium through the pulmonary veins.

How does the blood flow through the Heart?

LEFT SİDE OF HEART

- The pulmonary veins empty oxygen-rich blood from the lungs into the left atrium of the heart.
  - As the atrium contracts, blood flows from your left atrium into left ventricle through the open mitral (bicuspid) valve.
  - *When the ventricle is full, the mitral valve shuts. This prevents blood from flowing backward into the atrium while the ventricle contracts.*
  - As the ventricle contracts, blood leaves the heart through the aortic valve, into the aorta and to the body.

Pathway of Blood Through the Heart and Lungs

- Right atrium → tricuspid valve → right ventricle
- Right ventricle → pulmonary arteries → lungs
- Lungs → pulmonary veins → left atrium
- Left atrium → bicuspid(mitral) valve → left ventricle
- Left ventricle → aorta
- Aorta → systemic circulation

The Heart: Conduction System

- **Intrinsic conduction system (nodal system)**
  - Heart muscle cells contract, without nerve impulses, in a regular, continuous way

- **<u>Special tissue sets the pace</u>**
  - ***Sinoatrial node (SA) -*** ***Pacemaker***
  - *Atrioventricular node (AV)*
  - *Atrioventricular bundle*
  - *Bundle branches*
  - *Purkinje fibers*

Conduction System of the Heart

- Four structures composed of modified cardiac muscle
- **Sinoatrial Node (SA Node)**
  - **Pacemaker of the heart**
  - 100s of cells **in the R atrium near the opening of the superior vena cava**
- **Atrioventricular Node (AV Node)**
  - Small mass of cardiac muscle tissue
  - Left lower border of R atrium
- **Atrioventricular Bundle**
  - Also **Bundle of His**
  - Bundle of specialized cardiac muscle fibers originating in the AV node
  - Branches into R and L branches eventually becoming **Purkinje fibers**
  - Extend into the walls of the **ventricles and papillary muscles**

Heart Contractions

- Contraction is initiated by the sinoatrial node
- Sequential stimulation occurs at other autorhythmic cells

The Aorta

After originating from **left ventricle**, it **ascends** for a short distance, **arches** backward and to the left side, **descends** within the thorax, pass through diaphragm, reaches abdomen.

Portions of aorta

Ascending aorta

Arch of the aorta and

Descending aorta (thoracic and abdominal aorta)

AORTA

1-Ascending aorta; coronary arteries

2-Arch of the aorta;

- Brachiocephalic trunk (Innominate artery);
  - Right common carotid artery
  - Right subclavian artery
- Left common carotid artery; head&neck
- Left subclavian artery; upper limb

3-Descending aorta (thoracic and abdominal aorta)

Ascending Aorta (Aorta Ascendens)

- Only branches of the ascending aorta are the two **coronary arteries** which supply the heart

Blood Supply to the Heart

- Blood in the heart chambers does not nourish the myocardium
- The heart has its **own nourishing circulatory system (coronary circulation)**
  - Coronary arteries
  - Cardiac veins; blood empties into the right atrium via the coronary sinus
- **Right and left coronary arteries**
  - First branches off aorta
  - Most of the blood goes to the L ventricle
  - In 50% of the population, the R coronary artery is dominant

Coronary circulation is the functional blood supply to the **heart muscle itself**

Collateral routes ensure blood delivery to heart even if major **vessels are occluded-HEART ATTACK!**

Arch of the Aorta

Branches;

- **Brachiocephalic artery** (Innominate artery)
- **Left common carotid artery**
- **Left subclavian artery**

Descending Aorta;

- Has two parts;
  - **Thoracic Aorta**
  - **Abdominal Aorta**
- DescendS in front of the vertebral column
- **Ends on L4 , bifurcates (bifurcation of aorta) into common iliac arteries (R/L)**

Common Iliac Arteries

- Gives 2 branches ;

  - **External Iliac Artery**; supply lower limb
  - **Internal Iliac Artery (Hypogastric Artery)**; supply pelvic wall and pelvic organs

Blood Supply of Lower Limb

Femoral Artery

➢ **It is the continuation of the External Iliac artery.**

Femoral Vein

- ➢ Continue proximally as external iliac veins
- ➢ External+Internal iliac veins= Common iliac veins (R/L)
- ➢ Common iliac veins (R+L)= **Inferior vena cava**

Blood supply of Head

- The arterial supply of the head is derived from the common carotid arteries.
- The right common carotid arises from the brachiocephalic trunk.
- The left common carotid arises from the aortic arch directly.

Blood supply of Head

The common carotid runs upwards in the neck and divides into external and internal carotid arteries.

Blood supply of Head

I The external carotid artery provides the major blood supply for the face and neck

II The internal carotid artery supplies brain(not all segments), the optic nerve, eye, orbit and scalp.

- Veins;
- Internal jugular vein; drains head and neck region

Blood Supply of Upper Limb

Axillary artery

- Continuation of subclavian artery
- Becomes brachial artery which supply arm
- Brachial artery divides into radial and ulnar arteries; supply forearm and hand

Veins;

Ulnar/Radial veins…Brachial vein….Axillary vein…..Subclavian vein

LYMPH

- What is lymph ?

Tissue fluid (interstitial fluid) that enters the lymphatic vessels

- The main function; collect excess large particles and tissue fluid

LYMPHATIC SYSTEM

- **Essentially a drainage system accessory to venous system**
- **Larger particles that escape into tissue fluid can only be removed via lymphatic system**

LYMPHOID SYSTEM

The important components of the lymphoid system;

- **Lymph** (clear, watery, slightly yellow tissue fluid)
- **Lymphocytes** (circulating cells of the immun system)
- **Lymphoid organs** (part of body that produce lymphocytes; spleen, tonsils, thymus, lymph nodes)
- **Lymphatic capillaries** (orginate blindly in the intercelular space and forms Lymphatic plexuses)
- **Lymphatic vessels** (thin walled vessels with valves)
- **Lymph nodes** (small masses of lymphatic tissue located along the course of lymphatic vessels)
- **Lymphatic trunks** (large collecting vessels)- Lymphatic ducts

- **Superficial lymphatic vessels…Deep lympahic vessels…traverse lymph nodes….reach Lympahatic ducts**;

✓ **Right lymphatic duct**…drains right subclavian veins (right side of head, neck, and thorax plus the right upper limb)

✓ **Thoracic duct**….drains left subclavian veins (remainder of body)

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