Unit 11

Human Circulatory System

STUDENTS LEARNING OUTCOMES (SLO's)

After studying this unit, the students will be able to

- *Discuss the meaning of the terms species and speciation.*
- *Describe the classification of organisms into three domains: Archaea, Bacteria and Eukarya.*
- *Describe the clas4sification of organisms in the Eukarya domain into the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species.*
- *Outline the characteristic features of the kingdoms Monera, Protoctista, Fungi, Plantae and Animalia.*
- *Outline how viruses are classified.*
- *Define the terms ecosystem and niche.*
- *Explain the different levels at which biodiversity can be assessed.*
- *Explain the importance of random sampling in determining the biodiversity of an area.*
- *Describe and use suitable methods to assess the distribution and abundance of organisms in an area.*

INTRODUCTION

Humans have two systems for the transport of different materials in different parts of body.

1. Blood circulatory system
2. Lymphatic system.

Blood circulatory system carries out pulmonary and systemic circulation simultaneously. You know humans have a closed blood circulatory system. It consists of blood, heart, and blood vessels (arteries, capillaries and veins).

> Blood is the medium in which dissolved nutrients, gases, hormones, and wastes are transported throughout the body. It is composed of two main components **(i)** plasma and **(ii)** cells or cell-like bodies (white blood cells, red blood cells, platelets). In a healthy person, plasma constitutes about **55%** by volume of the blood, and cells or cell-like bodies about **45%** by volume of the blood.

11.1 STRUCTURE & FUNCTIONING OF HEART

Q 1. Write a detailed note on the structure & function of human heart?

Ans. A hard-working pump that moves blood through body is known as **heart**.

1. Location of Heart

It is situated in the middle of chest cavity (between the lungs). Its back surface is near vertebral column while its front surface is behind sternum and rib cartilages.

2. Pericardium

Heart is enclosed in a sac called **pericardium (Figure 11.1).** Pericardium separates heart from surrounding organs. It is composed of the following two layers.

Outer layer of pericardium is called **fibrous pericardium.**

- It is made of strong connective tissue.
- It protects heart against external pressure and shocks.
- It also prevents excessive dilation of heart.

Inner layer of pericardium is called **serous pericardium.** It is a sac, made of two layers **i.e.,**

- Outer **parietal** pericardium - present beneath fibrous pericardium.
- Inner **visceral** pericardium (also called epicardium) - closely attached to the underlying heart.

Pericardial Cavity

The space between parietal and visceral pericardium is called **pericardial cavity.**

- It contains up to 50 mL pericardial fluid.
- It lubricates heart and protects it from infections.

3. Wall of the Heart

The wall of heart is composed of three layers.

Sr.	Layer	Description
1	**Epicardium**	The inner layer of pericardium is known as **epicardium.** It makes the outer lining of heart wall.
2	**Myocardium**	Beneath epicardium, there is the thickest layer of heart wall known as **myocardium.** Myocardium is made of cardiac muscles.
3	**Endocardium**	**Endocardium** is present beneath myocardium. It is a single layer of epithelial cells and make the inner linings of heart chambers **(Figure: 12.1).**

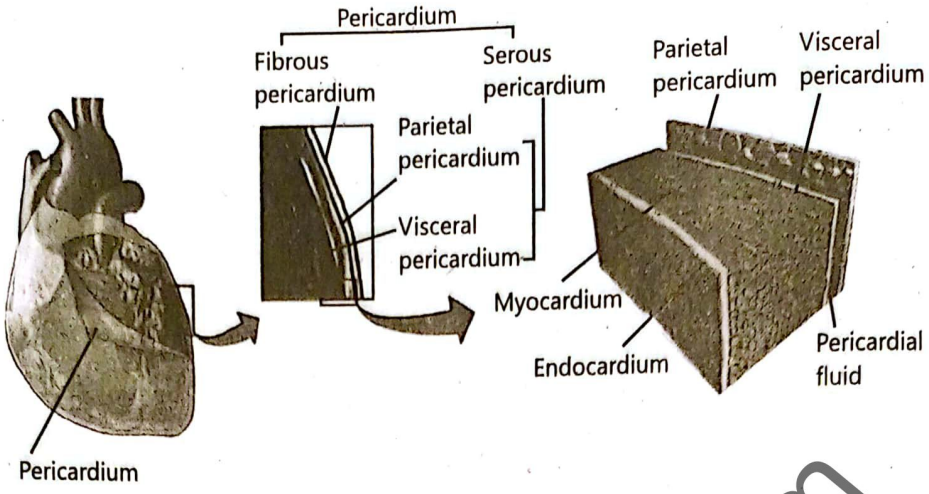

Fig. 11.1: Pericardium and heart wall

The component parts of a circulatory system are; a circulatory fluid (the blood), tubes (vessels) for the transport the circulatory fluid, and a contractile pumping device (heart).

The heart is usually felt to be on the left side because the left side of heart is stronger and larger, since it pumps to all body parts. Because the heart is between the lungs, the left lung is smaller than the right lung and has a cardiac notch in its border to accommodate the heart.

4. Chambers and valves of heart

There are four chambers of heart.

Two Upper Thin-Walled Atria	Two Lower Thick-Walled Ventricles
Atria receives blood from body and passes it to ventricles, which distribute blood to body. ➢ **Atrioventricular Septum** Atria and ventricles are separated by atrioventricular septum. ➢ **Interatrial Septum** The left and right atria are separated from each other by a septum known as interatrial septum.	**Ventricles** receive blood from the atria & distribute blood to body. ➢ **Interventricular Septum** The left and right ventricles are separated from each other by a septum known as interventricular septum. It is much thicker than the interatrial septum.

Valves

Atrioventricular Valves

At the entrance points of ventricles (in atrioventricular septum), there are two atrioventricular valves known as **tri & bicuspid valves.** When ventricles contract, tricuspid and bicuspid valves close and prevent the back flow of blood into atria **(Figure: 11.2).**

Tricuspid Valve	Bicuspid (mitral) Valve
The valve (made of three cusps) & present between right atrium and right ventricle is known as **tricuspid valve.**	**The valve** (made of two cusps) & present between left atrium and left ventricle is known as **bicuspid (mitral) valve.**

Semilunar Valves

At the exit points of ventricles, there are two valves known as **semilunar valves** (with shapes like a half-moon). These semilunar valves are called **pulmonary valve** and **aortic valve**. When ventricles relax, pulmonary and aortic valves close. So, they prevent back flow of blood from pulmonary artery and aorta into ventricles **(Figure: 11.2).**

Pulmonary Valve	Aortic Valve
Pulmonary valve is located at the base of pulmonary artery.	**Aortic valve** is present at the base of aorta.

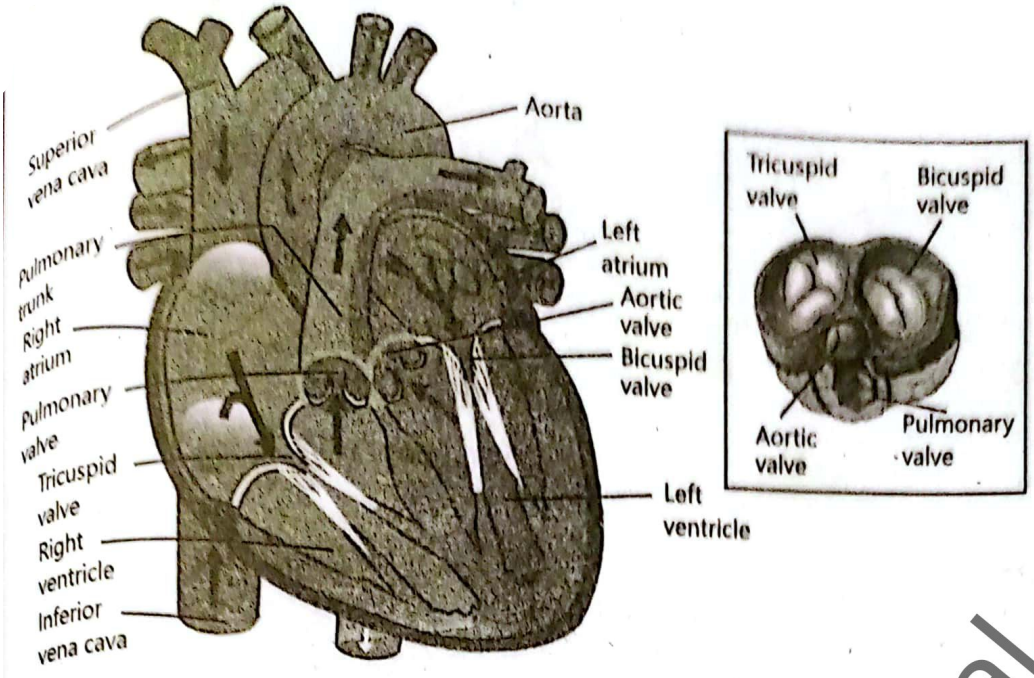

Fig. 11.2: Human Heart and valves

The wall of left ventricle is thicker (about 3 times) than that of the right ventricle because it has to push the blood to all over body.

5. Circulation of blood through Heart

Human heart functions as a **double pump**.

Types of Circulation

Pulmonary Circulation	Systemic Circulation
Circulation of blood towards lungs is known as **pulmonary circulation**. Blood is pumped towards lungs for oxygenation.	Circulation in blood towards all organs of body except lungs is known as **systemic circulation**.

Separation of Oxygenated & Deoxygenated Blood

Complete separation of deoxygenated (right side) and oxygenated (left side) blood is maintained in heart.

Fate of Deoxygenated Blood	Fate of Oxygenated Blood
The **right atrium** receives deoxygenated blood from body via two veins i.e., **superior vena cava and inferior vena cava.**	The oxygenated blood from lungs is **brought to left atrium by pulmonary veins.**
⬇	⬇
Right atrium passes this blood to **right ventricle** via tricuspid valve.	**Left atrium** passes this blood to **left ventricle** via bicuspid (or mitral) valve.
⬇	⬇
When **right ventricle** contracts, deoxygenated blood is passed to **pulmonary trunk** via semilunar pulmonary valve.	When **left ventricle** contracts, oxygenated blood is passed to **aorta** via semilunar aortic valve.
⬇	⬇
The **pulmonary trunk** divides into left and right pulmonary arteries which carry this blood to **lungs.**	**Aorta** carries this blood to all parts of **body (except lungs).**

6. Cardiac Cycle: Heartbeat

Heart works in continuous cycles. Its chambers relax and are passively filled with blood from large veins. Then, its chambers contract and propel the blood throughout body. It's alternating relaxations and contractions are collectively called a cardiac cycle or one **heartbeat (Figure: 11.3)**.

In one complete heartbeat, diastole lasts about **0.4 sec**, atrial systole takes about **0.1 sec**, and the ventricular systole lasts about **0.3 sec.** In one's life, heart beats about **2.5 billion times**, without stopping.

Diastole	Atrial Systole
While atria are relaxed and being filled with blood, the ventricles are also relaxed. This relaxed period of heart chambers is called **diastole**.	During diastole, both atria are filled with blood. As blood accumulates in atria, their blood pressure rises, due to which both of them contract. This is called **atrial systole**.
Ventricular Systole	
It passes the blood through tricuspid and bicuspid valves into the two relaxed ventricles. When ventricles are filled with blood, both of them contract. This is called **ventricular systole** and it pumps the blood to pulmonary arteries and aorta. During ventricular systole, tricuspid and bicuspid valves close while pulmonary and aortic valves open.	

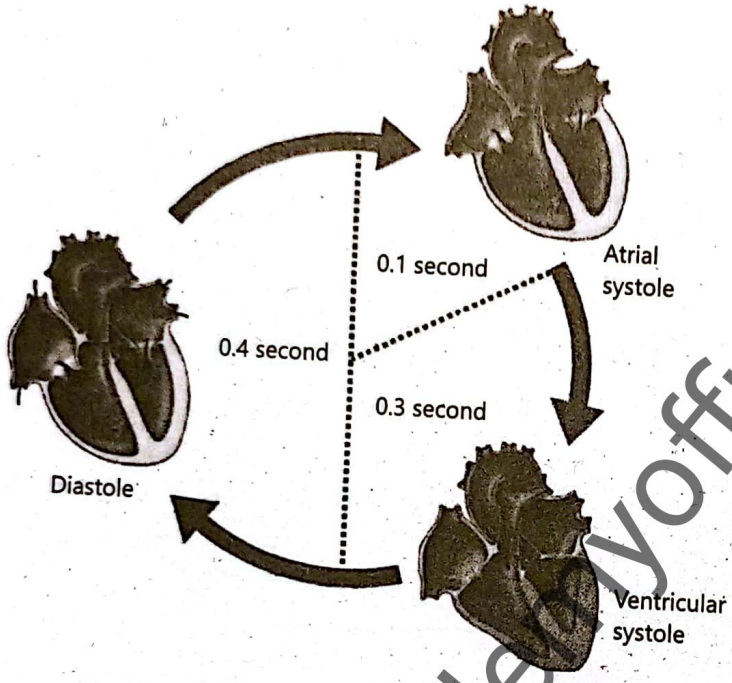

Fig. 11.3: Cardiac cycle (one heartbeat)

Most cases of heart murmurs are not serious, and those that prove serious can be corrected by replacing the damaged valves with artificial ones or with valves taken from an organ donor.

7. Sounds of a Heartbeat

Sounds of heart beat "**Lubb-dubb**" can be heard with the help of a stethoscope. If the valves are not closing fully, or if they open narrowly, turbulence is created within the heart. This turbulence can be heard as a heart murmur. A murmur sounds like a hiss.

Lubb	Dubb
When both ventricles contract simultaneously to pump the blood to pulmonary arteries and aorta, the tricuspid and bicuspid valves close and **"lubb"** sound is made.	When ventricular systole ends and both ventricles relax simultaneously, the pulmonary and aortic semilunar valves close and **"dubb"** sound is made.

8. Control of heartbeat (Heart Excitation and Contraction)

Sinoatrial (SA) Node

The pumping of heart consists of a well-arranged series of contractions and relaxations. It is initiated by the **Sinoatrial Node** (SA node) or **pacemaker**.

- The sinoatrial node consists of a small cluster of cardiac muscle cells.
- It is embedded in the upper wall of right atrium.
- Heartbeat starts when SA node sends electrical impulses to the walls of atria.
- It causes both atria to contract simultaneously.

Atrioventricular (AV) Node

Impulses form the SA node travel to an **atrioventricular node** (AV node).

- It is also made of small cluster of cardiac muscle cells.

- It lies at the lower portion of interatrial septum.

Atrioventricular (AV) Bundle / Bundle of His

From AV node, the impulses are handed over to an **atrioventricular bundle** or **bundle of His**.

- It is a network of fibres present in interventricular septum.

Purkinje Fibres

AV bundle divides into left and right branches, which end at the **Purkinje fibres** in the walls of the ventricles. Stimulation of these fibres causes the ventricles to contract almost simultaneously **(Figure: 11.4).** There is a delay of about **0.15** second in conductance of impulses from the SA node to AV node, permitting atrial systole to be completed before ventricular systole begins.

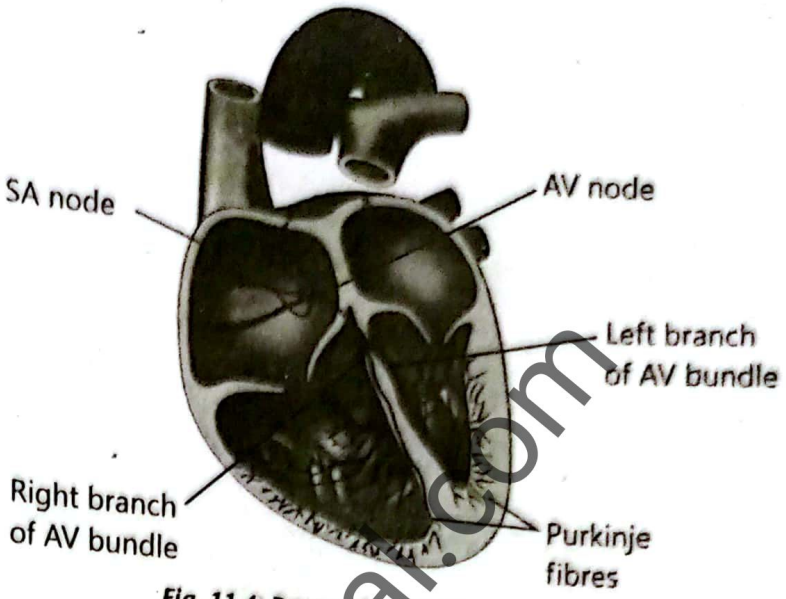

Fig. 11.4: Pacemaker and its connections

Artificial Pacemaker

If there is some block in the flow of the electrical impulses, or if the impulses initiated by SA node are weak; it may delay the rhythmicity of heartbeat or stop it. In such patients of weak SA node, **artificial pacemaker** is used. It is a battery- operated device that is surgically transplanted near the AV node. It emits electrical signals that trigger normal heartbeats.

8. Rate of Heartbeat

The heart of an average adult beats about **70 times** per minute. It pumps the entire blood volume (about 5 litres) every minute.

How Rate of Heartbeat is Maintained

The normal speed of heartbeat is made and maintained by pacemaker and AV node. Brain also exerts some influence on heart rate.

For Example,

During fever and exercise, the control centre in brain sends nerve signals to both the pacemaker and the AV node, making them to increase the heart rate. It is to cope with the situation. In contrast, when we are asleep or at rest, the brain's control centre slows down the activity of pacemaker and AV node.

For Board Exam & MDCAT MCQs

1. **Which two systems are involved in the transport of materials in the human body?**
   A. Respiratory and nervous systems
   B. Digestive and lymphatic systems
   C. Blood circulatory and lymphatic systems ✓
   D. Endocrine and excretory systems

2. **What type of circulatory system does humans possess?**
   A. Open circulatory system B. Partially open system
   C. Closed circulatory system ✓
   D. Single circulatory system

3. **Which components are part of the human closed circulatory system?**
   A. Blood, lymph, and neurons
   B. Heart, blood, and blood vessels ✓
   C. Lymph, blood vessels, and brain
   D. Blood, liver, and spleen

4. **Where is the human heart located?**
   A. In the right side of chest cavity
   B. In the left side of chest cavity
   C. In the middle of chest cavity ✓
   D. Below the diaphragm

5. **What separates the heart from surrounding organs?**
   A. Sternum B. Pericardium ✓
   C. Diaphragm D. Rib cage

6. **Which structure encloses the human heart?**
   A. Endocardium B. Myocardium
   C. Pericardium ✓ D. Pleura

7. **What is the name of the outer layer of the pericardium?**
   A. Serous pericardium B. Fibrous pericardium ✓
   C. Visceral pericardium D. Endocardium

8. **The back surface of the heart is near which structure?**
   A. Lungs B. Sternum

C. Rib cage D. Vertebral column ✓

9. The front surface of the heart lies behind:
A. Diaphragm
B. Rib cartilages and sternum ✓
C. Vertebral column D. Lungs

10. The blood circulatory system in humans is classified as:
A. Open and incomplete B. Closed and complete ✓
C. Partially open D. Dual and open

11. Which of the following is NOT a component of blood vessels?
A. Arteries B. Veins
C. Capillaries D. Bronchi ✓

12. Which of the following best describes the function of the circulatory systems in humans?
A. Removal of undigested food
B. Transport of materials ✓
C. Production of hormones D. Digestion of nutrients

13. Which organ system is responsible for immune defense and transport of lymph?
A. Nervous system B. Digestive system
C. Lymphatic system ✓ D. Endocrine system

14. What protects the heart from mechanical shocks and friction?
A. Blood vessels B. Pericardial sac ✓
C. Lung tissue D. Diaphragm

15. Which layer of the pericardium is directly attached to surrounding organs?
A. Serous layer B. Fibrous layer ✓
C. Myocardial layer D. Visceral layer

16. Which system includes lymph, lymph nodes, and lymphatic vessels?
A. Nervous system B. Lymphatic system ✓
C. Excretory system D. Muscular system

17. Which part of the pericardium is made of tough connective tissue?
A. Serous pericardium B. Endocardium
C. Fibrous pericardium ✓ D. Visceral pericardium

18. What lies anterior to the heart?
A. Vertebral column
B. Rib cartilages and sternum ✓
C. Lungs D. Peritoneum

19. Which structure lies at the back of the heart?
A. Ribs B. Sternum
C. Vertebral column ✓ D. Diaphragm

20. Which body cavity contains the heart?
A. Abdominal cavity B. Pelvic cavity
C. Chest cavity ✓ D. Cranial cavity

SQ

1. What are the two systems for the transport of different materials in the human body?

Ans. Humans have two systems for the transport of different materials in different parts of the body:
1. Blood circulatory system
2. Lymphatic system.

2. What is the nature of the human blood circulatory system and what are its components?

Ans. Humans have a closed blood circulatory system. It consists of blood, heart, and blood vessels (arteries, capillaries and veins).

3. Where is the human heart located?

Ans. It is situated in the middle of the chest cavity (between the lungs). Its back surface is near the vertebral column while its front surface is behind the sternum and rib cartilages.

4. What is pericardium and what are its layers?

Ans. Heart is enclosed in a sac called pericardium. It is composed of two layers:
1. Outer fibrous pericardium (made of strong connective tissue; protects heart against external pressure and shocks; prevents excessive dilation of heart).
2. Inner serous pericardium (a sac made of two layers: outer parietal pericardium and inner visceral pericardium or epicardium).

5. What is pericardial cavity and what is its function?

Ans. The space between parietal and visceral pericardium is called pericardial cavity. It contains up to 50 mL pericardial fluid. It lubricates heart and protects it from infections.

6. What are the three layers of the heart wall?

Ans. **1. Epicardium:** The inner layer of pericardium, makes the outer lining of heart wall.
2. Myocardium: The thickest layer, made of cardiac muscles.
3. Endocardium: Present beneath myocardium, a single layer of epithelial cells making the inner linings of heart chambers.

7. How many chambers are there in the human heart and what is their function?

Ans. There are four chambers of heart:
- Two upper thin-walled atria (receive blood from body and pass it to ventricles).
- Two lower thick-walled ventricles (distribute blood to body).

8. **What separates the different chambers of the heart?**

Ans.
- Atrioventricular septum separates atria from ventricles.
- Interatrial septum separates left and right atria.
- Interventricular septum separates left and right ventricles; it is thicker than the interatrial septum.

9. **What are atrioventricular valves and what is their function?**

Ans. Atrioventricular valves are located at the entrance points of ventricles. These include:
- Tricuspid valve (between right atrium and right ventricle; has three cusps).
- Bicuspid/mitral valve (between left atrium and left ventricle; has two cusps).
- These valves prevent the backflow of blood into atria when ventricles contract.

10. **What are semilunar valves and where are they located?**

Ans. Semilunar valves (shaped like a half-moon) are present at the exit points of ventricles:
- Pulmonary valve is located at the base of the pulmonary artery.
- Aortic valve is present at the base of the aorta.
- They prevent backflow of blood into ventricles when ventricles relax.

11. **How does the human heart function as a double pump?**

Ans. Human heart functions as a double pump:
- Pulmonary circulation: blood is pumped towards lungs for oxygenation.
- Systemic circulation: blood is circulated to all organs of the body except lungs.

12. **How is oxygenated and deoxygenated blood separated in the heart?**

Ans. Complete separation of deoxygenated (right side) and oxygenated (left side) blood is maintained in the heart.

13. **What is the pathway of deoxygenated blood through the heart?**

Ans. The right atrium receives deoxygenated blood via superior and inferior vena cava, passes it to right ventricle via tricuspid valve, which then pumps it to pulmonary trunk via semilunar pulmonary valve. The pulmonary trunk divides into left and right pulmonary arteries that carry the blood to lungs.

14. **What is the pathway of oxygenated blood through the heart?**

Ans. Oxygenated blood from lungs is brought to left atrium by pulmonary veins, passed to left ventricle via bicuspid (mitral) valve, and then pumped to aorta via semilunar aortic valve. Aorta carries this blood to all parts of body (except lungs).

15. **What is a cardiac cycle or heartbeat?**

Ans. Heart chambers relax and fill with blood, then contract to propel it. These alternating relaxations and contractions are collectively called a cardiac cycle or one heartbeat.

16. **What are the phases of the cardiac cycle and their durations?**

Ans. In one complete heartbeat:
- Diastole lasts about 0.4 sec.
- Atrial systole takes about 0.1 sec.
- Ventricular systole lasts about 0.3 sec.

17. **What causes the sounds of a heartbeat and what are they called?**

Ans. Sounds of heartbeat "Lubb-dubb" are caused by valve closures:
- "Lubb" is made when tricuspid and bicuspid valves close during ventricular contraction.
- "Dubb" is made when pulmonary and aortic valves close when ventricles relax.

18. **What is the SA node and what is its role in heart excitation?**

Ans. Sinoatrial node (SA node or pacemaker) is a small cluster of cardiac muscle cells embedded in the upper wall of right atrium. It initiates heartbeat by sending electrical impulses to atrial walls, causing both atria to contract simultaneously.

19. **How do impulses travel from the SA node to cause heart contraction?**

Ans. Impulses from SA node travel to AV node (in lower interatrial septum), then to atrioventricular bundle (Bundle of His), which runs in the interventricular septum and divides into left and right branches ending in Purkinje fibres. These fibres stimulate the ventricles to contract almost simultaneously.

20. What is an artificial pacemaker and when is it used?

Ans. If SA node impulses are weak or blocked, rhythmicity may be delayed or stopped. In such cases, an artificial pacemaker is surgically transplanted near AV node. It is a battery-operated device that emits electrical signals triggering normal heartbeats.

2. Write a note on Electrocardiogram (ECG)?

Ans. Electrocardiogram

The recording of electrical potentials, generated by the currents of cardiac impulses, is known as **electrocardiogram (ECG).**

How ECG Works

When cardiac impulse passes over the surface of heart, a minute electrical current is generated. This current spreads into the tissues surrounding heart. This minute electrical current also travels to the surface of body. In ECG, the electrical potentials generated by this current are measured and recorded. For this purpose, electrodes are placed on skin on the opposite sides of heart. The electrodes are attached to a machine called **electrocardiograph** that records electrical potentials generated by this current. ECG helps to diagnose the abnormalities in conduction system of heart.

Waves of ECG

ECG shows the following waves of electrical impulses produced at specific events of cardiac cycle **(Fig. 11.5).**

Sr.	Wave	Description
1	P wave	It shows beginning of atrial depolarization, initiated by SA node. It causes atrial contraction. Irregular or absent P waves may indicate arrhythmia (lack of rhythmicity).
2	PR segment	It shows the completion of atrial depolarization. It is usually 0.12 to 0.20 seconds. A prolonged PR indicates a first-degree heart block.
3	QRS	It shows the beginning of depolarization of ventricles. Atrial re-polarization also occurs during this phase. Abnormalities in the QRS complex may indicate bundle branch block, ventricular tachycardia (faster rate of contraction), or other ventricular abnormalities.
4	ST segment	It shows the completion of depolarization of ventricles. It can be depressed in ischemia (decreased flow of blood and oxygen to heart 5muscles) and elevated in myocardial infarction. This segment ordinarily lasts about 0.08 second.
5	T wave	It represents the beginning of repolarization of ventricles. T wave abnormalities may indicate electrolyte disturbance. The hyper-acute T wave shows the earliest findings of acute myocardial infarction.
6	QT interval	The QT interval is from the beginning of the QRS complex to the end of the T wave. A normal QT interval is usually about 0.40 seconds.

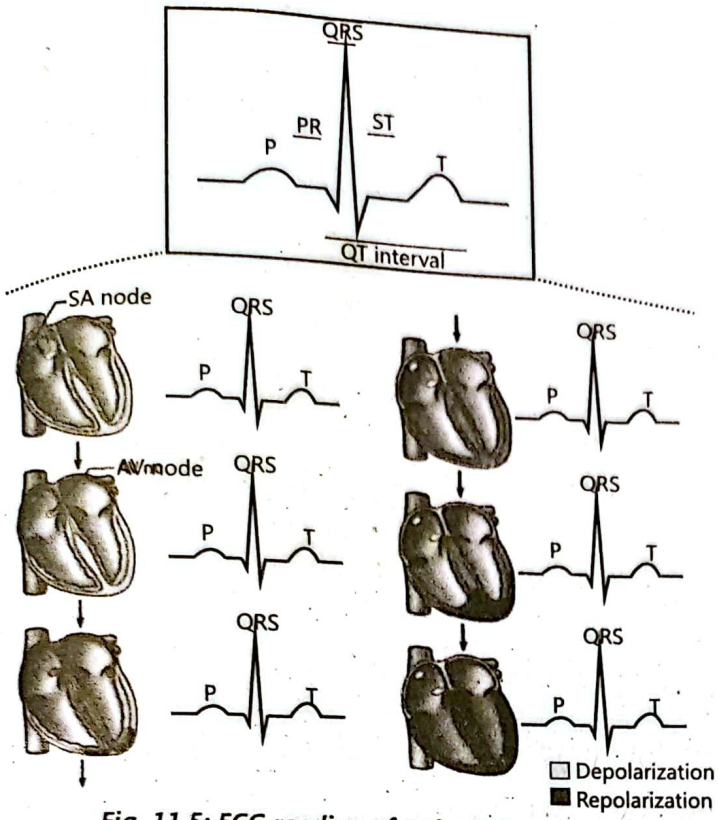

Fig. 11.5: ECG reading of a single heartbeat

Some abnormal babies may have blueness (cyanosis) of skin. They are called blue babies. It is due to the mixing of oxygenated and deoxygenated blood between two atria. Mixed blood is supplied to the body of new born babies resulting in blueness of skin. Cyanosis results due to the failure of **interatrial foramen** to close, during development. Interatrial foramen is a temporary opening in the embryonic heart between right and left atria. Normally, it is closed during development. Cyanosis may also happen due to failure of **ductus arteriosus** to fully constrict, during development. Ductus arteriosus is a temporary channel between the embryonic pulmonary artery and aorta. Normally, it constricts during development.

For Board Exam & MDCAT

MCQs

1. What does the P wave in an ECG represent?
A. Ventricular depolarization
B. Atrial depolarization ✓
C. Ventricular repolarization
D. Atrial repolarization

2. Which ECG segment is prolonged in a first-degree heart block?
A. ST segment
B. QT interval
C. PR segment ✓
D. QRS complex

3. What does the QRS complex represent in an ECG?
A. Atrial repolarization
B. Ventricular repolarization
C. Atrial depolarization
D. Ventricular depolarization ✓

4. In which condition is the ST segment elevated?
A. Arrhythmia
B. Electrolyte imbalance
C. Myocardial infarction ✓
D. Ischemia

5. What is the normal duration of the QT interval in an ECG?
A. 0.08 seconds
B. 0.12 to 0.20 seconds
C. About 0.40 seconds ✓
D. About 0.60 seconds

6. Which wave in the ECG may show abnormalities in case of electrolyte disturbance?
A. P wave
B. QRS complex
C. T wave ✓
D. PR segment

SQ

1. What does the P wave represent in an ECG?
Ans. It represents the beginning of atrial depolarization, initiated by the SA node.

2. Which ECG segment indicates the completion of atrial depolarization?
Ans. PR segment.

3. What does a prolonged PR segment suggest?
Ans. A first-degree heart block.

4. Which wave or segment shows the beginning of ventricular repolarization?
Ans. T wave.

5. What is the normal duration of the QT interval in an ECG?
Ans. About 0.40 seconds.

Q 3. Write a comprehensive note on the arteries, capillaries & veins?

Ans. Arteries

The blood vessels which carry blood away from heart to different parts of body are known as **arteries (Figure: 11.6).**

➢ **Transport**

All arteries carry oxygenated blood, except pulmonary arteries.

➢ **Structure**

(i) Lumen

The central core of artery is **lumen**.

(ii) Walls

The walls of arteries are made up of three layers.

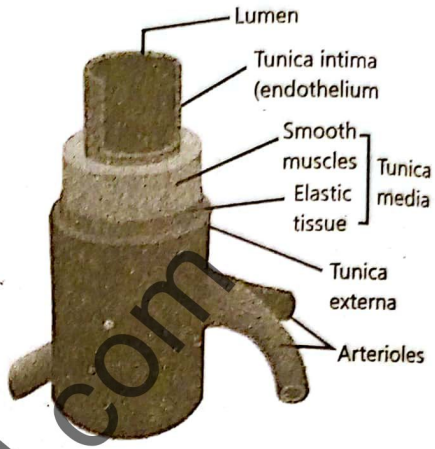

Fig. 11.6: Structure of artery

Sr.	Layer	Description
1	**Tunica Externa**	Outer layer of arterial walls is known as **tunica externa** or **adventitia.** • **Structure** It is made of connective and elastic tissue.
2	**Tunica Media**	Middle layer of arterial walls is known as tunica media. • **Structure** It is made of thick muscular tissue and elastic fibres. • **Function** Middle layer is important and it can withstand higher blood pressure during ventricular systole.
3	**Tunica Intima**	Inner layer of arterial walls is known as **tunica intima.** • **Structure** It is made of thin layer of endothelial cells.

Fate of Arteries

(i) Arterioles

Arteries divide into smaller vessels called **arterioles**.

(ii) Capillaries

Arterioles divide repeatedly until they form a dense network of very fine branches called **capillaries.**

Capillaries

Capillaries are formed by the division of arterioles **(Fig. 11.7).**

Structure

Endothelial Cells

The walls of capillaries are made of a single layer of **endothelial** cells.

Diameter

The internal diameter of a capillary is about **8** micrometres.

Functions

- Capillaries penetrate all tissues and have approach to the cellular level.
- Capillaries are the sites where materials are exchanged between blood and body tissues by diffusion or active transport.
- Water and diffusible substances can pass through capillary walls. Materials pass through the endothelial cells or through the intercellular spaces of capillary wall.
- Some materials are also taken up by capillary wall cells by endocytosis. The

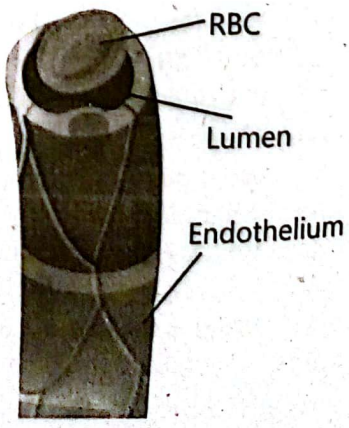

Fig. 11.7: Structure of capillary

capillary wall cells then pass these materials to the other side by exocytosis.

Interstitial Fluid

The pressure within capillaries causes a continuousleakage of fluid from the blood plasma into tissues. This fluid, known as **interstitial fluid**.

Composition of Interstitial Fluid

Interstitial fluid consists of water with dissolved nutrients, hormones, gases, wastes and small proteins. Large proteins, RBCs and platelets remain within capillaries. But some WBCs can squeeze out through the intercellular spaces of capillary wall.

> No cell of the body is more than **100 micrometres** away from a capillary. Capillaries are so narrow that RBCs must pass through them in single line.
> It is estimated that the total length of capillaries in an adult human is over **80, 600** kilometers, enough to encircle the globe twice!

Veins

The blood vessels that carry blood from different parts of the body towards heart are known as **veins (Figure: 11.8).**

Transport

All veins carry deoxygenated blood, except pulmonary veins.

Structure

The wall of veins has same three layers as are present in arteries.

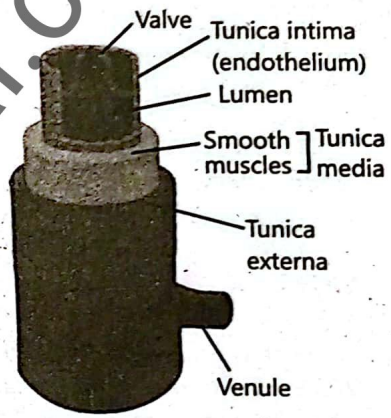

Fig. 11.8: Structure of vein

Sr.	Layer	Description
1	**Tunica Externa**	Outer layer of venial walls is known as **tunica externa** or **adventitia.** • **Structure** It is made of connective and elastic tissue.
2	**Tunica Media**	Middle layer of venial walls is known as tunica media. • **Structure** It is relatively thin and only slightly muscular, with few elastic fibres. The middle layer of veins is relatively thinner than that of arteries because veins do not have to withstand high blood pressure. An empty artery is still a hollow tube but an empty vein collapses like an empty balloon.
3	**Tunica Intima**	Inner layer of venial walls is known as **tunica intima.** • **Structure** It is made of thin layer of endothelial cells.

Semilunar Valves

Semilunar valves are present in veins to prevent the back flow of blood, as it is moving towards heart.

The pressure generated by the contraction of surrounding muscles presses veins and assists in the return of blood towards heart.

Fate of Veins

Superior & Inferior Vena Cava

Smaller veins join to form larger veins and ultimately from **vena cavae (inferior vena cava and superior vena cava)**, which pour blood into the right atrium of heart. Pulmonary veins from lungs empty in left atrium.

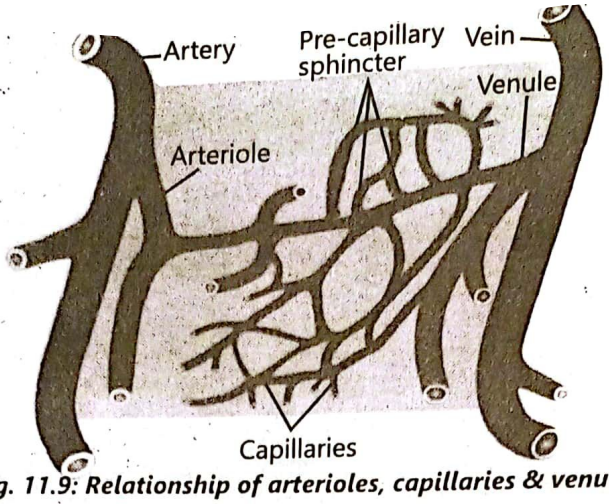

Fig. 11.9: Relationship of arterioles, capillaries & venules

For Board Exam & MDCAT

MCQs

1. **Which blood vessels carry blood away from the heart to various body parts?**
   A. Veins B. Arteries ✓
   C. Capillaries D. Vena cava
2. **Which arteries do NOT carry oxygenated blood?**
   A. Coronary arteries B. Pulmonary arteries ✓
   C. Carotid arteries D. Aortic arteries
3. **What is the central core of an artery called?**
   A. Tunica media B. Intima
   C. Lumen ✓ D. Sinus
4. **What is the tunica externa of an artery composed of?**
   A. Muscular tissue only B. Epithelial cells
   C. Connective and elastic tissue ✓ D. Cartilage
5. **What is the main function of tunica media in arteries?**
   A. Absorb nutrients
   B. Withstand high blood pressure during ventricular systole ✓
   C. Store red blood cells D. Assist in digestion
6. **The inner layer of artery walls is called:**
   A. Tunica extern B. Tunica media
   C. Tunica intima D. Endothelium ✓
7. **Arterioles further divide to form:**
   A. Venules B. Veins
   C. Capillaries ✓ D. Aorta
8. **What is the internal diameter of a capillary?**
   A. 5 micrometres B. 10 micrometres
   C. 8 micrometres ✓ D. 15 micrometres
9. **Capillaries allow exchange of materials through:**
   A. Osmosis only B. Filtration only
   C. Diffusion and active transport ✓
   D. Conduction
10. **Which type of fluid leaks out from capillaries into tissues?**
    A. Plasma B. Interstitial fluid ✓
    C. Cytoplasm D. Lymph
11. **What does interstitial fluid contain?**
    A. Only water and salts B. Only hormones
    C. Water, nutrients, gases, hormones, wastes, small proteins ✓
    D. Only glucose and RBCs
12. **Which blood vessels return blood towards the heart?**
    A. Arteries B. Veins ✓
    C. Capillaries D. Arterioles
13. **Why is the tunica media of veins thinner than that of arteries?**
    A. Veins carry more blood
    B. Veins do not withstand high pressure ✓
    C. Veins are made of bone
    D. Veins do not need walls
14. **What prevents backflow of blood in veins?**
    A. Arterial pressure B. Gravity
    C. Semilunar valves ✓ D. Pulmonary action
15. **Which veins bring blood into the right atrium of the heart?**
    A. Pulmonary veins
    B. Superior and inferior vena cava ✓
    C. Coronary veins D. Jugular veins

SQ

1. What are arteries and what is their primary function?

Ans. Arteries are blood vessels that carry blood away from the heart to different parts of the body. They generally carry oxygenated blood, except pulmonary arteries. They have thick muscular walls to withstand high pressure.

2. Describe the structure and function of the tunica media in arteries.

Ans. The tunica media is the middle layer of the artery wall. It is composed of thick muscular tissue and elastic fibres. This layer helps arteries withstand high blood pressure during ventricular systole.

3. What happens to arteries as they branch out in the body?

Ans. Arteries divide into smaller vessels called arterioles. Arterioles further divide repeatedly to form capillaries. This branching helps in delivering blood to even the smallest tissues.

4. What are capillaries and what is their structure?

Ans. Capillaries are the smallest blood vessels formed by division of arterioles. They are made of a single layer of endothelial cells. Their walls are thin to allow exchange of substances between blood and tissues.

5. Explain the process of material exchange in capillaries.

Ans. Capillaries allow diffusion and active transport of materials between blood and tissues. Water and other substances pass through endothelial cells or intercellular spaces. Some materials are also moved via endocytosis and exocytosis.

6. What is interstitial fluid and what is its composition?

Ans. Interstitial fluid is the fluid that leaks out of capillaries into tissues. It consists of water, dissolved nutrients, gases, hormones, wastes, and small proteins. Large proteins, RBCs, and platelets remain in the capillaries, but some WBCs can pass out.

7. How do veins differ structurally from arteries?

Ans. Veins have the same three layers as arteries but with key differences. Their tunica media is thinner and has fewer muscle and elastic fibres. Unlike arteries, empty veins collapse due to their thinner walls.

8. What are semilunar valves and what is their function in veins?

Ans. Semilunar valves are structures found in veins. They prevent the backflow of blood as it moves towards the heart. They ensure unidirectional flow even under low pressure conditions.

9. How is blood returned to the heart through veins?

Ans. Blood is returned to the heart through smaller veins joining to form larger ones. Ultimately, they form the superior and inferior vena cava. These large veins pour deoxygenated blood into the right atrium.

10. What is the exception to the oxygenation rule in arteries and veins?

Ans. Pulmonary arteries carry deoxygenated blood from the heart to the lungs. Pulmonary veins carry oxygenated blood from the lungs to the heart. These are exceptions to the general rule of arteries carrying oxygenated and veins deoxygenated blood.

Q 4. How Blood Flow in Capillaries is regulated. Explain?

Ans. Ways of Blood Regulation:

1. Constriction &Dilation of Capillaries

The amount of blood flowing in capillaries is controlled by constricting or dilating the capillaries.

2. Nervous Stimulation

Nervous stimulation can constrict capillaries and certain chemicals such as histamine can dilate them.

3. Pre-Capillary Sphincter

Some capillaries are connected with arterioles and venules through loops of other capillaries. The entry of each loop is guarded by a ring of muscles called a **pre-capillary sphincter**. These sphincters regulate the amount of blood flowing through capillaries **(Figure: 11.10)**.

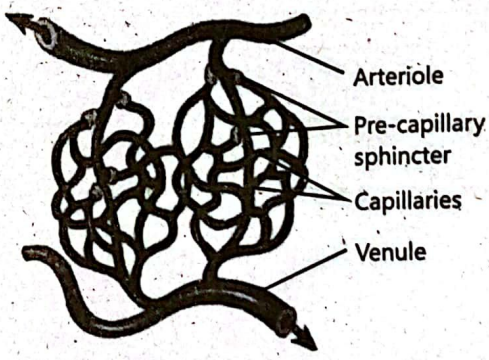

Fig. 11.10: Pre-capillary sphincters

Q 5. Discuss Vasoconstriction & Vasodilation in detail?

Ans. In the walls of arterioles, there are more circular muscles than elastic tissue.

Vasoconstriction

The contraction of the circular muscles of arterioles is under the control of nervous and endocrine systems. When these muscles contract, arterioles are constricted. It is called **vasoconstriction.**

Importance of Vasoconstriction

Vasoconstriction reduces the flow of blood in arterioles.

Vasodilation

When the circular muscles of arterioles are relaxed, arterioles are dilated & this is known as **vasodilation (Figure: 11.11).**

Importance of Vasodilation

Vasodilation increases the blood flow in the arterioles.

When Vasodilation or Vasoconstriction Happens?

Vasoconstriction and vasodilation happen in response to changes in metabolic activity of tissues.

For Example,

- When metabolic activity in a tissue rises, oxygen decreases and carbon dioxide increases in its interstitial fluid. In its response, the circular muscles of the arterioles in that tissue relax (vasodilation). Vasodilation increases blood flow in these arterioles and also in capillaries. The increased blood flow supplies more oxygen and removes more carbon dioxide.
- Similarly, decreased metabolic activity causes vasoconstriction of arterioles.

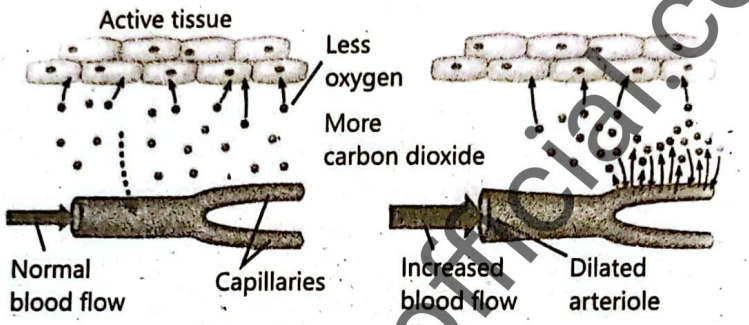

Fig. 11.11: Vasodilation

Q 6. Write a detailed note on the rates of blood flow?

Ans. The velocity of blood flow is different in different vessels. Changes in the velocity of blood result from changes in the total cross section of the vessel system **(Figure: 11.12).**

Sr.	Vessel	Velocity of Blood Flow
1	**Aorta**	Velocity of blood is highest in aorta (450-500 mm/sec)
2	**Capillaries**	Velocity of blood tends to fall along the network of arteries, arterioles and becomes lowest in capillaries (01 mm/sec).
3	**Venules, Veins & Vena Cava**	Velocity of blood rises again in venules, veins and vena cava (250-300 mm/sec).

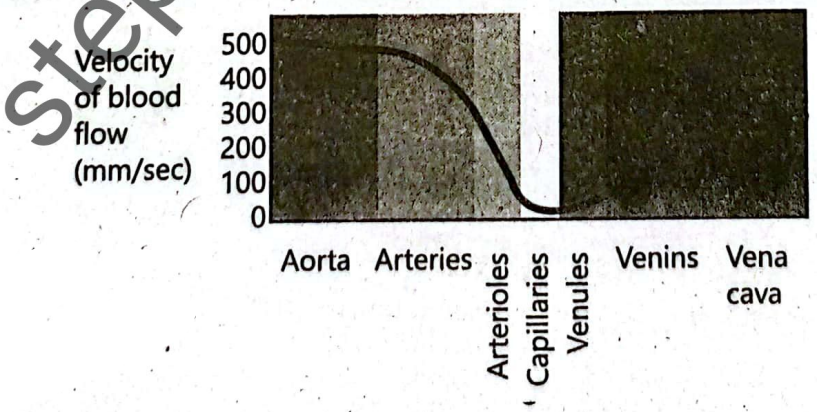

Fig. 11.12: Velocity of blood, movin g in different vessels

MCQs

1. **What regulates blood flow in capillaries?**
   A. Only nervous stimulation
   B. Constriction and dilation, nervous stimulation, and pre-capillary sphincters
   C. Heart rate only ✓
   D. Venous pressure

2. **What effect does constriction of capillaries have on blood flow?**
   A. Increases blood flow
   B. Decreases blood flow
   C. Has no effect ✓
   D. Stops blood flow completely

3. **Which chemical can cause dilation of capillaries?**
   A. Adrenaline
   B. Histamine ✓
   C. Acetylcholine
   D. Dopamine

4. **What is the pre-capillary sphincter?**
   A. A valve in veins
   B. A ring of muscle controlling blood entry into capillary loops
   C. An elastic tissue in arteries ✓
   D. A nerve ending near capillaries

5. **Which muscle type is abundant in arteriole walls?**
   A. Longitudinal muscles
   B. Circular muscles ✓
   C. Skeletal muscles
   D. Smooth muscles only in veins

6. **What does vasoconstriction cause?**
   A. Dilation of arterioles
   B. Contraction of circular muscles in arterioles
   C. Increased blood flow
   D. Relaxation of muscles in veins ✓

7. **Vasodilation is the:**
   A. Contraction of arteriole muscles
   B. Relaxation of circular muscles in arterioles ✓
   C. Narrowing of veins
   D. Increase in blood pressure only

8. **What triggers vasodilation in tissues?**
   A. Increased oxygen and decreased carbon dioxide
   B. Decreased oxygen and increased carbon dioxide
   C. Increased adrenaline ✓
   D. Increased nervous stimulation

9. **When metabolic activity decreases, what happens to arterioles?**
   A. They dilate
   B. They constrict ✓
   C. They burst
   D. No change occurs

10. **Where is the velocity of blood flow the slowest?**
    A. Aorta
    B. Capillaries ✓
    C. Venules
    D. Vena cava

SQ

1. How is blood flow regulated in capillaries?
Ans. Blood flow in capillaries is regulated by constriction and dilation of capillaries, nervous stimulation, and pre-capillary sphincters.

2. What role does constriction and dilation play in capillary blood flow?
Ans. Constriction reduces blood flow, while dilation increases blood flow through the capillaries.

3. How does nervous stimulation affect capillaries?
Ans. Nervous stimulation can cause capillaries to constrict, whereas certain chemicals like histamine can cause them to dilate.

4. What is the function of the pre-capillary sphincter?
Ans. The pre-capillary sphincter is a ring of muscle that controls the entry of blood into capillary loops, regulating blood flow through capillaries.

5. Which type of muscles are more abundant in arteriole walls?
Ans. Circular muscles are more abundant than elastic tissue in the walls of arterioles.

6. Define vasoconstriction.
Ans. Vasoconstriction is the contraction of circular muscles in arterioles, causing the arterioles to constrict and reduce blood flow.

7. What happens to blood flow during vasoconstriction?
Ans. Blood flow in arterioles decreases during vasoconstriction.

8. Define vasodilation.
Ans. Vasodilation is the relaxation of circular muscles in arterioles, causing them to dilate and increase blood flow.

9. How does metabolic activity affect vasodilation and vasoconstriction?
Ans. Increased metabolic activity causes vasodilation to increase blood flow, while decreased metabolic activity causes vasoconstriction to reduce blood flow.

10. Where is the velocity of blood flow the highest in the circulatory system?
Ans. The velocity of blood flow is highest in the aorta (450-500 mm/sec).

Q 7. Write a detailed note on the pathways of circulation?

Ans. Circulatory Pathways

In the humans (and in all mammals and birds), blood circulates throughout body in two main pathways (Fig. 11.13).

1. Pulmonary circulation (to and from lungs)
2. Systemic circulation (to and from the other body parts).

1. Pulmonary Circulation

Circulation which supplies deoxygenated blood to lungs and returns oxygenated blood to heart is known as **pulmonary circulation**.

Pulmonary Trunk

A big artery i.e., **pulmonary trunk** carries deoxygenated blood from the right ventricle of heart. Pulmonary trunk divides into right and left pulmonary arteries, which carry deoxygenated blood to the right and left lungs.

Pulmonary Vein

Inside each lung, the pulmonary artery divides and makes pulmonary arterioles and lung capillaries. In lung capillaries, blood is oxygenated. Lung capillaries join to form pulmonary venules, which join to form **pulmonary vein.** Left and right pulmonary veins from lungs open in left atrium.

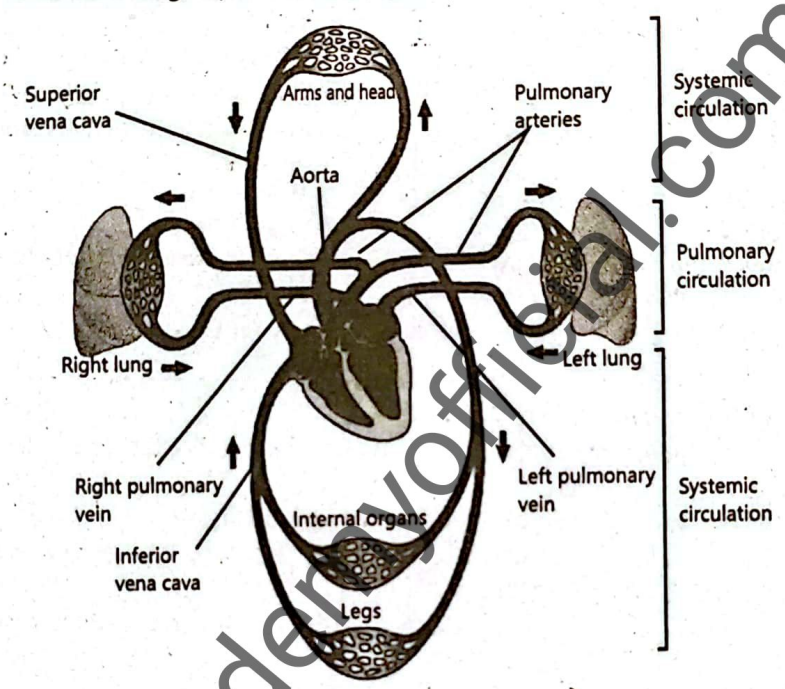

Fig. 11.13: Pulmonary and systemic circulations

Systemic Circulation

The circulation which supplies oxygenated blood to all the cells, tissues, and organs of the body (except lungs) and returns deoxygenated blood to heart is known as **systemic circulation.**

Components of Systemic Circulation

1. Coronary Circulation

The heart walls are supplied with blood through a small portion of the systemic circulation, known as **coronary circulation (Figure: 11.14).**

Sr.	Vessels	Description
1	**Coronary Arteries**	In the coronary circulation. Two **coronary arteries** i.e., right and left coronary arteries arise from aorta, near its origin. These arteries divide into many smaller arteries, arterioles and then into capillaries.
2	**Coronary Veins**	In the coronary circulation, after supplying oxygenated blood to heart muscles, the capillaries unite to form venules which make many **coronary veins.**
3	**Coronary Sinus**	In the coronary circulation, the coronary veins join to form a **coronary sinus,** which opens in right atrium. Small coronary veins drain directly into right atrium.

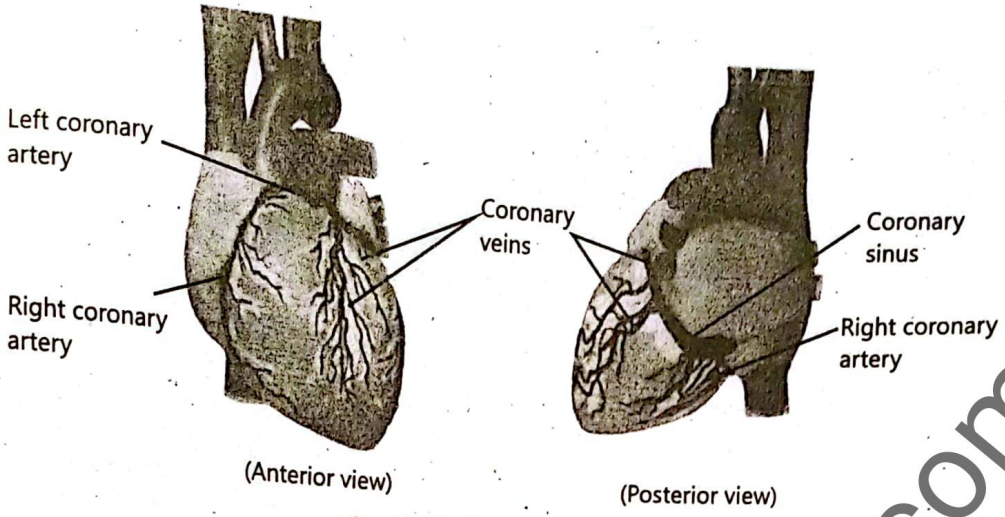

Fig. 11.14: Coronary circulation

2. Hepatic Portal Circulation

A portal system is a circulation in which veins end in capillaries. In hepatic portal system, a large **hepatic portal vein** collects blood from spleen and alimentary canal and take it to liver. The blood from liver is taken to heart through **hepatic veins (Figure: 11.15)**.

Significance of Hepatic Portal Circulation

The blood that comes from alimentary canal to liver contains substances that are absorbed from small intestine. These substances pass through liver before going to heart. Liver removes harmful substances from blood and absorbs nutrients for storage before sending this blood to heart.

Coverage Area of Hepatic Portal Circulation

Hepatic portal system extends from the lower portion of oesophagus to the upper part of anal canal.

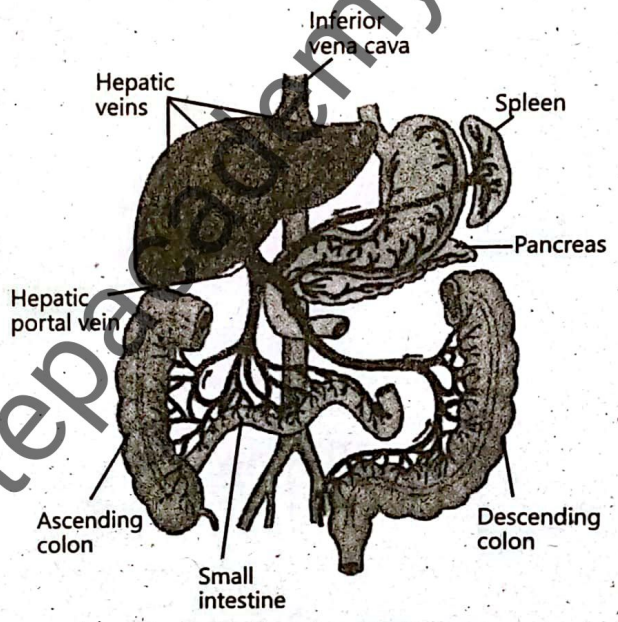

Fig. 11.15: Hepatic portal system

3. Renal Circulation

Renal circulation is important component of the systemic circulation just like coronary & hepatic portal circulation. Right and left renal arteries carry oxygenated blood to the right and left kidneys **(Figure: 11.16).**

Fate of Renal Artery

Sr.	Vessels	Description
1	**Afferent Arterioles**	In the renal circulation, inside the kidney, each renal artery divides repeatedly to make smaller arteries. The smaller arteries branch into several arterioles known as **afferent arterioles.**

		➢ **Function** Afferent arterioles supply blood to nephrons (units of kidney).
2	**Capillaries of Glomeruli**	In the renal circulation, each afferent arteriole divides to make the capillaries of **glomeruli**.
3	**Efferent Arteriole**	In the renal circulation, the capillaries of glomeruli unite to make **efferent arteriole**, which divides to make two sets of capillaries like. **(i) Peri-Tubular Capillaries** Peri-tubular capillaries are found around nephron tubule in cortical portion of kidney. **(ii) Vasa Recta Capillaries** Vasa recta capillaries are found around nephron tubule in the medulla of kidney.
4	**Renal Vein**	In the renal circulation, the capillaries formed by the division of efferent arterioles **(Peri-tubular capillaries + Vasa recta capillaries)** unite to form venules that converge and make smaller veins. The smaller veins unit to form a **renal vein**.

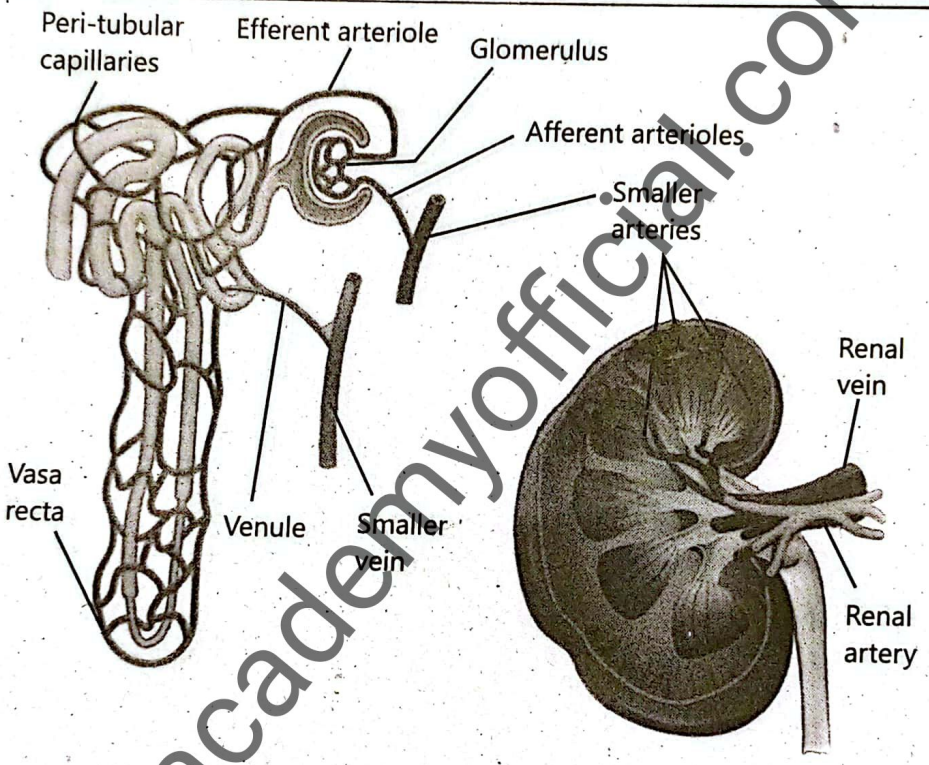

Fig. 11.16: Renal portal system

For Board Exam & MDCAT

MCQs

1. **Pulmonary circulation carries _____ blood to the lungs.**
   (a) Oxygenated (b) Deoxygenated ✓
   (c) Both oxygenated and deoxygenated
   (d) None of the above
2. **The pulmonary trunk arises from which chamber of the heart?**
   (a) Left atrium (b) Right atrium
   (c) Left ventricle (d) Right ventricle ✓
3. **The pulmonary arteries carry blood to the:**
   (a) Heart (b) Brain
   (c) Lungs ✓ (d) Liver
4. **Pulmonary veins open into the:**
   (a) Right atrium (b) Left atrium ✓
   (c) Right ventricle (d) Left ventricle
5. **Coronary arteries arise from which major artery?**
   (a) Pulmonary artery (b) Aorta ✓
   (c) Vena cava (d) Renal artery
6. **The coronary sinus drains blood into the:**
   (a) Left atrium (b) Right atrium ✓
   (c) Left ventricle (d) Right ventricle
7. **Hepatic portal circulation carries blood from the alimentary canal to the:**
   (a) Heart (b) Kidneys
   (c) Liver ✓ (d) Lungs

8. **What is the main function of the hepatic portal circulation?**
(a) Supply oxygen to liver
(b) Remove harmful substances and store nutrients ✓
(c) Supply oxygenated blood to the brain
(d) Regulate blood pressure

9. **In renal circulation, afferent arterioles supply blood to:**
(a) Liver (b) Nephrons ✓
(c) Heart muscles (d) Lungs

10. **Vasa recta capillaries are found around nephron tubules in the:**
(a) Cortex of kidney (b) Medulla of kidney ✓
(c) Liver (d) Heart

1. What are the two main circulatory pathways in humans?
Ans. The two main circulatory pathways are pulmonary circulation and systemic circulation. Pulmonary circulation carries blood between the heart and lungs, while systemic circulation supplies blood to the rest of the body tissues and organs.

2. What type of blood does the pulmonary circulation carry to the lungs?
Ans. Pulmonary circulation carries deoxygenated blood from the right ventricle of the heart to the lungs. In the lungs, blood gets oxygenated before returning to the heart through the pulmonary veins.

3. From which part of the heart does the pulmonary trunk carry blood?
Ans. The pulmonary trunk carries deoxygenated blood from the right ventricle of the heart. It then divides into right and left pulmonary arteries that take blood to the corresponding lungs for oxygenation.

4. Where do the left and right pulmonary veins open in the heart?
Ans. The left and right pulmonary veins open into the left atrium of the heart. They carry oxygenated blood from the lungs back to the heart for circulation throughout the body.

5. What is the role of coronary circulation?
Ans. Coronary circulation supplies oxygenated blood to the heart muscles through the coronary arteries. It also collects deoxygenated blood via coronary veins, which empty into the coronary sinus and then into the right atrium.

6. What is the significance of the hepatic portal circulation?
Ans. Hepatic portal circulation carries blood from the alimentary canal and spleen to the liver. This blood contains nutrients and harmful substances absorbed from the intestines; the liver processes these substances before the blood reaches the heart.

7. What do afferent arterioles supply blood to in the kidney?
Ans. Afferent arterioles carry oxygenated blood into the nephrons of the kidney. They branch into capillaries of the glomeruli where filtration of blood begins as part of urine formation.

11.3 BLOOD PRESSURE

8. Write a detailed note on the types of blood pressure & its regulation?

Ans. Blood Pressure

The measure of force exerted by blood against the inner walls of blood vessels is known as **blood pressure**. This force keeps blood flowing from heart to the entirecapillary network in body.

Systemic Arterial Blood Pressure

Although the blood pressure occurs throughout the vascular system, the term blood pressure most commonly refers to **systemic arterial blood pressure**. Arterial blood pressure rises and falls corresponding to the phases of cardiac cycle.

Blood pressure is highest in aorta and then gradually reduces in systemic arteries. The walls of arteries are elastic.

Pulse

The flow of blood creates rhythmical throbbing of arteries, which is called as **pulse.**

Types

1. Systolic Pressure

When ventricles contract (ventricular systole), heart forces blood into pulmonary arteries and aorta. As a result, the pressure in these arteries rises sharply. The maximum pressure during ventricular systole is called **systolic pressure (Figure: 11.17)**.

Systolic pressure in a normal young adult is **120 mm Hg**.

2. Diastolic Pressure

When ventricles relax (diastole), the arterial pressure drops. The lowest pressure that remains in arteries before the next ventricular contraction is called **diastolic pressure (Figure: 11.17)**.

Diastolic pressure in a normal young adult is **75-85 mm Hg**.

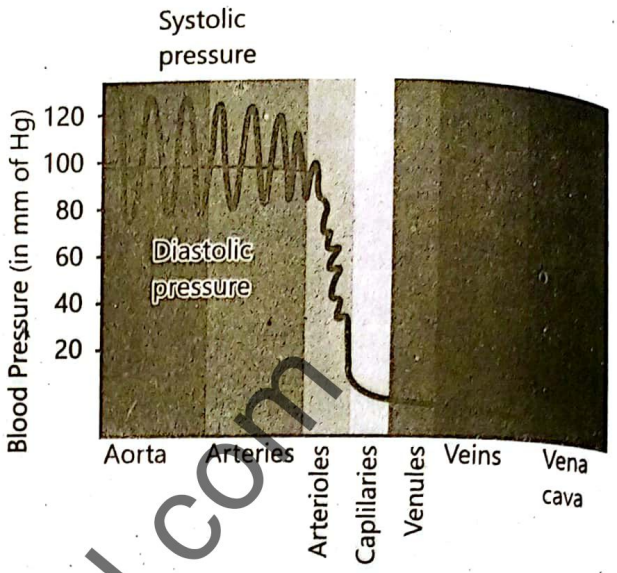

Fig. 11.17: Systolic & diastolic blood pressures

How Readings are taken

Conventionally, the readings of blood pressure are expressed as 120/80. The instrument **sphygmomanometer is used** for the manual measurement of systolic and diastolic blood pressures. In this instrument, rise and fall in mercury column shows the readings of blood pressure.

Regulation of Blood Pressure

Role of Baroreceptors

Pressure receptors (baroreceptors) are present in carotid arteries (arteries that supply blood to the head region and brain) and aortic arch (portion of artery that bends between the ascending and descending aorta). When blood pressure falls, baroreceptors activate sensory neurons that send (بھیجنا) information to brain. The control centre in brain reacts by increasing the rate and force of contraction of heart, and by causing vasoconstriction in arterioles. Both these changes restore blood pressure to normal.

Role of Hormones

(i). Antidiuretic Hormone

The long-term regulation of blood pressure is done through hormones. Certain hormones regulate the volume of blood by effecting the reabsorption of water and salt in kidneys. When there is a decrease in blood volume and blood pressure, special receptors present in brain create thirst. They also stimulate posterior pituitary gland to secrete **antidiuretic hormone (ADH)**. ADH stimulates kidneys to retain (رکھنا) more water in blood, excreting less in urine. It restores the blood volume and ultimately blood pressure. ADH also constricts arterioles, which raises arterial blood pressure.

(ii). Arterial Natriuretic Hormone (ANH)

The walls of right atrium contain endocrine cells that secrete **atrial natriuretic hormone (ANH)**. When there is stretching of the atrium by an increased blood volume, the right atrium secretes ANH. It speeds up the excretion of salts and water through urine, which lowers the blood volume and pressure.

For Board Exam & MDCAT MCQs

1. **What does the term "blood pressure" usually refer to?**
   A) Pulmonary vein pressure
   B) Systemic venous pressure
   C) Systemic arterial pressure ✓
   D) Pressure in heart chambers

2. **The maximum pressure during ventricular contraction is called:**
   A) Diastolic pressure B) Pulse pressure
   C) Mean arterial pressure D) Systolic pressure ✓

3. **What is the normal systolic pressure in a healthy young adult?**
   A) 110 mm Hg B) 120 mm Hg ✓
   C) 130 mm Hg D) 140 mm Hg

4. **Which of the following statements is true about diastolic pressure?**
   A) It occurs during ventricular contraction
   B) It is higher than systolic pressure
   C) It is the lowest pressure in arteries ✓
   D) It is measured during atrial systole

5. **Which instrument is used for manual blood pressure measurement?**
A) Barometer B) Thermometer
C) Spirometer D) Sphygmomanometer ✓

6. **Where are baroreceptors located?**
A) In lungs and liver B) In kidneys and ureters
C) In carotid arteries and aortic arch ✓
D) In brain and spinal cord

7. **What triggers the release of ADH in the body?**
A) Increase in blood pressure
B) Increase in urine output
C) Decrease in blood volume and pressure ✓
D) High salt intake

8. **What is the function of antidiuretic hormone (ADH)?**
A) Increases urine output B) Lowers blood pressure
C) Causes vasoconstriction and water retention ✓
D) Inhibits thirst center

9. **Atrial natriuretic hormone (ANH) is released in response to:**
A) Low blood pressure B) Dehydration
C) Stretching of right atrium due to increased blood volume ✓
D) Low salt levels in blood

10. **Which hormone promotes excretion of salts and water to reduce blood pressure?**
A) ADH B) Insulin
C) ANH ✓ D) Epinephrine

1. What is blood pressure and where is it highest?

Ans. Blood pressure is the force exerted by blood against the inner walls of blood vessels. It is highest in the aorta and gradually decreases as it moves through systemic arteries.

2. Differentiate between systolic and diastolic pressure.

Ans. Systolic pressure is the maximum pressure during ventricular contraction, normally 120 mm Hg. Diastolic pressure is the lowest pressure during ventricular relaxation, normally 75–85 mm Hg.

3. What is the function of baroreceptors in blood pressure regulation?

Ans. Baroreceptors in the carotid arteries and aortic arch sense low blood pressure. They send signals to the brain, which increases heart rate and causes vasoconstriction to restore blood pressure.

4. How does antidiuretic hormone (ADH) help in blood pressure regulation?

Ans. ADH is secreted by the posterior pituitary in response to low blood volume. It promotes water retention in kidneys and vasoconstriction, both of which increase blood pressure.

5. What is the role of atrial natriuretic hormone (ANH)?

Ans. ANH is released by the right atrium when stretched by excess blood volume. It promotes salt and water excretion in urine, reducing blood volume and lowering blood pressure.

11.4 CARDIOVASCULAR DISORDERS

9. Write a detailed note on the cardiovascular disorders, their diagnosis & treatments?

Ans. Cardiovascular Disorders

Cardiovascular disorders are the leading cause of death in developed and developing countries. These involve the disorders of blood vessels and heart. Atherosclerosis and arteriosclerosis are the major contributors to cardiovascular disorders.

Major Contributors of Cardiovascular Disorders

Atherosclerosis

Atherosclerosis means "deposition within arteries".

Causes

Various materials may accumulate in arteries like.

- Fatty Materials
- Abnormal amounts of smooth muscle cells
- Cholesterol
- Fibrin
- Cellular debris of various kinds

The accumulation of cholesterol is thought to be the prime contributor to atherosclerosis.

Effects

Atherosclerosis can lead to heart attacks, because it causes the narrowing of arteries and increases the risk of the formation of thrombus.

Arteriosclerosis

Arteriosclerosis means "hardening of arterial walls".

Causes

- Arteriosclerosis occurs when calcium is deposited in arterial walls. The blood flow through these arteries is restricted and arteries cannot expand normally. This forces the heart to work harder.
- Severe atherosclerosis usually leads to arteriosclerosis.

Diagnosis of Cardiovascular Disorders

Various diagnostic tests are performed on cardiovascular patients to locate the exact problem and to measure the severity of disease. The important tests are ECG and angiography.

1. Angiography

Coronary angiography is an X-ray examination of blood vessels or chambers of heart.

Technique

Use of Catheter

In order to create the X-ray pictures, a physician guides a small tube-like device called **catheter** through the large arteries of body.

Contrast Medium

In the angiography when the tip of catheter reaches the opening of coronary arteries, a special fluid (called a **contrast medium** or dye) is injected in catheter. This fluid is visible in X-ray machine. Pictures (**angiograms**) of fluid in coronary artery are obtained.

Analysing of Angiograms

If clots are present in the lumen of a coronary artery, the artery appears narrow.

Treatment

By changing the **diagnostic catheter** to a **guiding catheter;** physicians can also pass an instrument into coronary artery through the catheter. The most commonly used instruments are guiding wires and balloon dilation catheters (see angioplasty).

2. Thrombosis

Thrombosis is the formation of thrombus. Thrombus is a solid mass or plug of blood constituents (clot) in a blood vessel. This mass may block (wholly or only in part) the vessel.

Thromboembolism

Formation of thrombus in a blood vessel and then its carriage to any other location is called **thromboembolism**.

Causes

Thrombus formation may be due to

- Irritation or infection of lining of blood vessels
- Reduced rate of blood flow, due to long periods of inactivity
- Pneumonia, tuberculosis, emphysema etc.

Effects

- Thrombosis blocks the blood flow to organs.
- A thrombosis in coronary arteries causes heart attack.
- Similarly, a thrombus in the vessels of brain causes stroke.
- **A thrombus may be dislodged and carried to some other locations in the circulatory system. Such a thrombus is called embolus.**

Hypertension

A chronic (long lasting) elevation in blood pressure is called **hypertension**. It occurs when blood pressure consistently remains above **140/90.**

Causes

Any abnormality in nervous or hormonal mechanisms of blood pressure regulation may cause hypertension. Other causes of hypertension include.

- Stress
- Obesity
- High salt intake
- Smoking

- There may also be hereditary reasons of hypertension

Effects of Hypertension

(i). Brain Haemorrhage

Whenever blood pressure is chronically elevated in hypertension, there is an increased chance of the rupture of blood vessels. When this occurs in brain, it is called **brain haemorrhage**. It damages the delicate structure of brain.

(ii). Congestive Heart Failure

Hypertension weakens cardiac muscles. If hypertension is prolonged, heart is unable to pump effectively and blood flow cannot be maintained to meet needs of tissues. In such conditions, blood may be retained in heart and lungs. It is called **congestive heart failure**. Chest pain, including angina, does not occur during congestive heart failure.

(iii). Damage of Nephrons

Hypertension can also damage the nephrons of kidneys. It leads to further retention of salts and water in blood and therefore further hypertension.

Heart Problems and Treatments

1. Myocardial Infarction

Coronary arteries supply oxygen and nutrients to cardiac muscles. If blood flow is blocked in coronary arteries, it results in insufficient supply of blood to one or more parts of cardiac muscle. If heart muscles die due to no supply of oxygen and nutrients, the condition is known as **myocardial infarction (heart attack)**.

Causes

Blockage of coronary arteries is usually due to gradual build-up of lipids (especially **cholesterol**) in the inner wall of coronary artery.

Angina Pectoris

If the conditions of myocardial infarction persist, chest pain, called **angina pectoris**, can result during periods of stress or physical exertion. Angina indicates that oxygen demands are greater than its delivery and a heart attack may occur in future.

Treatment

If lifestyle changes and medication haven't relieved the symptoms or if the narrowed coronary arteries are at imminent risk of a heart attack, coronary bypass surgery or angioplasty is performed.

Recovery from a heart attack is possible if the damaged portion of heart is small enough that the other blood vessels in heart can enlarge their capacity and resupply the damaged tissues.

Heart disease and coronary artery disease are the leading causes of death in developed countries.

2. Coronary Bypass Surgery

Coronary bypass surgery is one of the most common and effective procedures to compensate the blockage of blood to cardiac muscles **(Figure: 11.18)**.

Procedure

In this surgery, surgeon takes a healthy blood vessel from leg, arm, chest or abdomen of the patient. He attaches the ends of blood vessel above and below the blocked coronary artery. So, blood is bypassed around the damaged or blocked area. Coronary bypass surgery doesn't cure the underlying disease process **i.e.,** atherosclerosis or coronary artery disease. The open or beating-heart surgery is done when heart is still beating.

Prevention

Lifestyle changes — especially smoking cessation — are crucial to reduce the chance of future blockages and heart attacks, even after successful bypass surgery.

In addition, patients need to make other lifestyle changes, such as reducing certain types of fat in diet, increasing physical activity, and controlling high blood pressure, diabetes and other risk factors for heart disease.

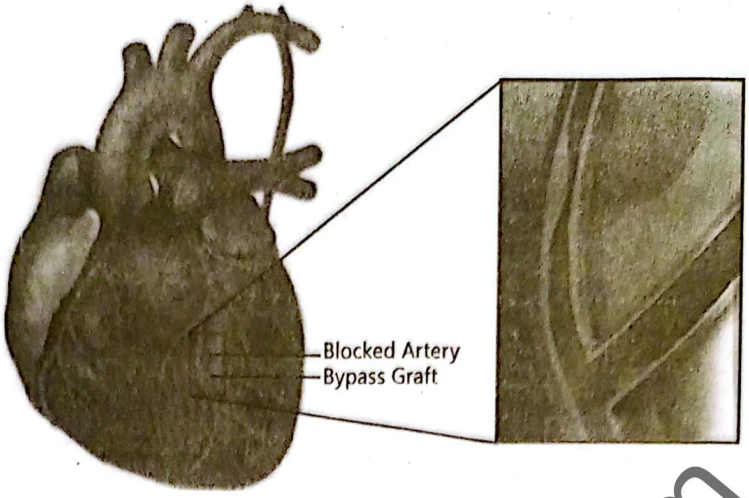

Fig. 11.19: Coronary bypass

3. Angioplasty & Stenting

Angioplasty is a procedure that opens a blocked or narrowed artery **(Figure: 11.19).**

Procedure

During an angioplasty, a small wire called a catheter, under x-ray guidance, is passed through the narrowed coronary artery. A small sausage-shaped balloon is then advanced over the wire into the narrowed section of artery. The balloon is then inflated to dilate the narrowed section of the artery. Once the artery is dilated, a small amount of dye is injected to confirm the successful dilatation.

Stenting

Stenting may also be done during angioplasty. A **stent** is an expandable stainless steel mesh tube, mounted on a balloon catheter.

Procedure

When the stent/balloon is positioned within the narrowed artery, the balloon is inflated. The inflated balloon expands the stent and the artery. The balloon is removed and the stent remains in place. The stent supports the artery walls and keeps the artery open and dilated.

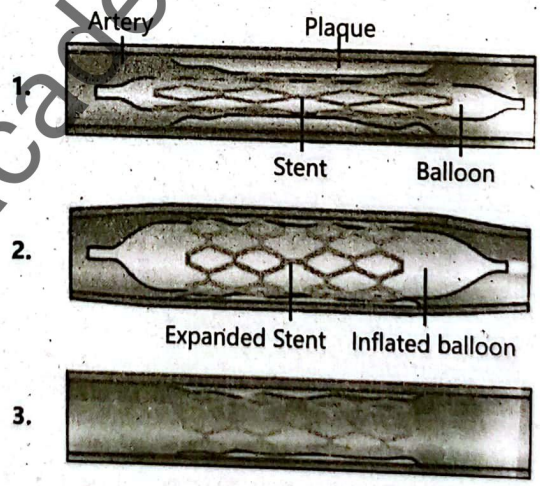

Fig. 11.20: Angioplasty and stenting

MCQs

1. **Atherosclerosis primarily involves the deposition of which substance in arteries?**
   A) Calcium
   B) Uric acid
   C) Cholesterol ✓
   D) Glucose
2. **The term "arteriosclerosis" refers to:**
   A) Narrowing of veins
   B) Hardening of arterial walls ✓
   C) Blockage in lymph vessels
   D) Enlargement of the heart
3. **Which of the following diagnostic tools is used to detect blockages in coronary arteries?**
   A) MRI
   B) Angiography ✓

C) CT scan D) Ultrasound

4. **In angiography, the contrast medium is injected into the:**
A) Veins of the arm
B) Coronary artery openings ✓
C) Pulmonary artery D) Jugular vein

5. **What does the term "angioplasty" refer to?**
A) Removal of a blood clot
B) Surgery for heart valve replacement
C) Opening a blocked artery with instruments ✓
D) Bypass surgery

6. **Which of the following can lead to thrombus formation?**
A) High protein diet B) Reduced blood flow ✓
C) Regular exercise D) Low salt intake

7. **A thrombus that detaches and circulates in the bloodstream is called a:**
A) Clot B) Embolus ✓
C) Plaque D) Nephron

8. **A heart attack is medically known as:**
A) Myocarditis B) Angina
C) Myocardial infarction ✓ D) Aneurysm

9. **Hypertension is defined when blood pressure consistently stays above:**
A) 110/70 mm Hg B) 120/80 mm Hg
C) 130/85 mm Hg D) 140/90 mm Hg ✓

10. **Chronic hypertension can result in:**
A) Increased oxygen in blood B) Faster digestion
C) Congestive heart failure ✓
D) Stronger immune response

11. **A stroke caused by blood vessel rupture in the brain is known as:**
A) Brain hemorrhage ✓ B) Coronary occlusion
C) Cardiac arrest D) Neural thrombosis

12. **Hypertension can damage kidneys by affecting:**
A) Glomeruli B) Nephrons ✓
C) Renal veins D) Ureters

13. **The major contributor to atherosclerosis is:**
A) Carbohydrates B) Proteins
C) Cholesterol ✓ D) Sodium

14. **Arteriosclerosis commonly results from deposition of:**
A) Potassium B) Iron
C) Calcium ✓ D) Magnesium

15. **In coronary bypass surgery, the new vessel is usually taken from:**
A) Another person B) Artificial graft
C) The patient's own body ✓ D) Donated kidney

SQ

1. **What are cardiovascular disorders, and which two conditions contribute to them most?**
Ans. Cardiovascular disorders involve diseases of the heart and blood vessels and are the leading cause of death globally. Atherosclerosis and arteriosclerosis are the major contributors. These conditions affect the structure and function of arteries.

2. **Define atherosclerosis and mention its key cause?**
Ans. Atherosclerosis means "deposition within arteries." It involves the accumulation of materials like cholesterol, fatty substances, smooth muscle cells, and debris. Cholesterol is considered the prime contributor to this condition.

3. **What are the harmful effects of atherosclerosis?**
Ans. Atherosclerosis narrows the arteries, reducing blood flow and increasing the risk of thrombus (clot) formation. This can lead to serious conditions like heart attacks or strokes if arteries become blocked.

4. **What is arteriosclerosis and what leads to it?**
Ans. Arteriosclerosis refers to the "hardening of arterial walls" caused by calcium deposits. It restricts the blood flow and prevents normal arterial expansion, making the heart work harder. Severe atherosclerosis often leads to arteriosclerosis.

5. **What is the purpose of diagnostic tests in cardiovascular disorders?**
Ans. Diagnostic tests help identify the specific cardiovascular issue and assess the severity of the disease. Important tests include ECG and angiography, which are essential in forming an effective treatment plan.

6. **Describe how coronary angiography is performed?**
Ans. In angiography, a catheter is guided through large arteries to the coronary openings. A contrast medium is injected, which appears on X-rays, helping doctors obtain angiograms that show the blood flow and detect blockages.

7. **How is a blocked artery treated during angiography?**
Ans. If a clot is detected, the diagnostic catheter is replaced with a guiding catheter. Instruments like balloon catheters or guide wires are passed to open the blocked artery, a process known as angioplasty.

8. **What is thrombosis, and what causes it?**
Ans. Thrombosis is the formation of a thrombus (clot) in a blood vessel, which may partially or completely block it. Causes include irritation or infection of vessel linings, reduced blood flow, and diseases like pneumonia or tuberculosis.

9. What are the possible effects of thrombosis?

Ans. Thrombosis can block blood flow to vital organs. If it occurs in coronary arteries, it causes a heart attack; in brain vessels, it results in a stroke. A dislodged thrombus can become an embolus and block other areas.

10. Define hypertension and its normal threshold?

Ans. Hypertension is a chronic elevation in blood pressure that consistently remains above 140/90 mm Hg. It can result from hormonal or nervous system imbalances, stress, obesity, smoking, or genetic factors.

11. What is brain haemorrhage, and how is it related to hypertension?

Ans. Brain haemorrhage is the rupture of blood vessels in the brain, often caused by prolonged high blood pressure. It damages delicate brain structures and can lead to permanent neurological issues.

12. Explain congestive heart failure in the context of hypertension?

Ans. Chronic hypertension weakens cardiac muscles, making the heart unable to pump blood effectively. This leads to blood retention in the heart and lungs, causing a condition called congestive heart failure, often without chest pain.

13. How does hypertension affect the kidneys?

Ans. Hypertension can damage the nephrons in kidneys, leading to reduced filtration ability. This causes salt and water retention in blood, which further increases blood pressure, creating a harmful cycle.

14. What is myocardial infarction, and how does it develop?

Ans. Myocardial infarction, or heart attack, occurs when blood flow in coronary arteries is blocked, depriving cardiac muscles of oxygen. This leads to the death of heart tissue, often due to cholesterol buildup in arteries.

15. Describe the procedure and purpose of coronary bypass surgery?

Ans. In bypass surgery, a healthy vessel is taken from the patient's body and connected above and below the blocked coronary artery. This allows blood to bypass the blockage. The procedure restores blood flow but doesn't cure the underlying disease.

11.5 LYMPHATIC SYSTEM OF HUMAN

10. Write a detailed note on the lymphatic system of Humans?

Ans. In the humans, in addition to the blood circulatory system, there is another system responsible for the transport of materials. It also returns the materials from tissues to blood. This system is called **lymphatic system (Figure 11.20).**

Components of Lymphatic System

- Lymph vessels
- Lymphoid masses
- Lymph nodes
- Lymph-the fluid which flows in the system

Lymph vessels and lymph

Sr.	Lymph Vessels & Lymph	Description
1	**Lymph Capillaries**	Lymphatic system begins with small vessels called **lymph capillaries**, which have blind endings in extracellular fluid (interstitial fluid). • Pressure of the interstitial fluid forces it to enter into lymph capillaries. • Lymph capillaries are more permeable than blood capillaries. So, larger molecules can also enter lymph capillaries.
2	**Lymph**	When interstitial fluid enters lymph capillaries, it is called **lymph**.
3	**Lymphatic Vessels**	Lymph capillaries join to form larger **lymphatic vessels** (or lymphatics or lymph vessels).
4	**Lymph Ducts**	Lymph vessels join to form larger lymph ducts. There are two main lymph ducts like. **1. Right Lymphatic Duct** **2. Thoracic Duct** These ducts open into right and left subclavian veins (veins that drain blood from the arms and shoulders to the heart), respectively.

Flow of Lymph

The **flow of lymph** is always from body tissues towards thoracic duct. It is maintained by the activity of skeletal muscles, movement of viscera and breathing movements. The valves present in lymph vessels prevent the back flow of lymph.

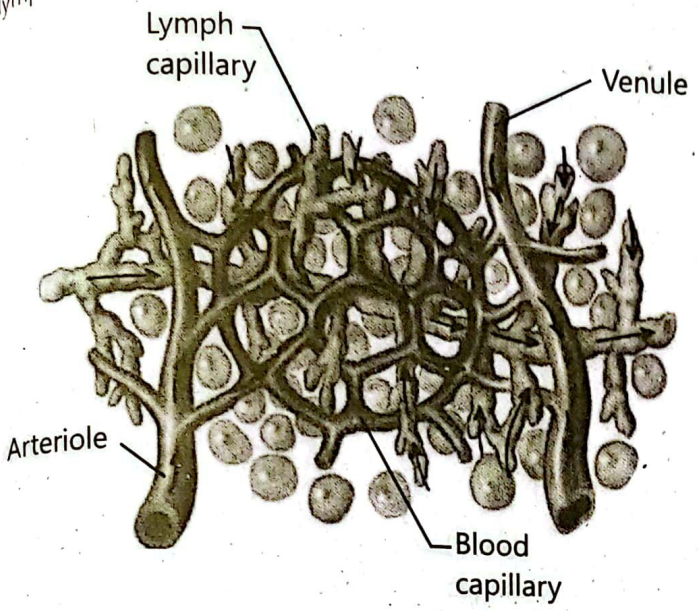

Fig. 11.21: Formation of lymph

The branches of lymph capillaries in villi, are called lacteals. Fatty acids and glycerol are absorbed into the epithelial cells of villi where they form triglycerides. The triglycerides are coated with proteins to form chylomicrons, which enter the lacteals of villi.

The painful swelling of lymph nodes in certain diseases (e.g. mumps) is largely a result of the accumulation of dead lymphocytes and macrophages.

Functions of the lymphatic system

Return of excessive interstitial fluid to blood

Lymphatic system returns the excess fluid and dissolved proteins and other substances to blood. In an average person, about three litres more fluid leaves blood capillaries daily. But it is absorbed by lymphatic capillaries and returned to bloodstream, before the blood enters heart.

Defence of Body against Foreign Invaders

Lymphatic system also helps to defend body against foreign invaders. Lymph nodes filter lymph. They have lymphocytes and macrophages that destroy bacteria and viruses present in lymph. Spleen filters blood through its macrophages and lymphocytes that destroy foreign particles and aged RBCs. Spleen also functions to store **RBCs.**

Lymph nodes and lymphoid masses

Lymph Nodes

At certain spots, the lymph vessels have masses of connective tissue where lymphocytes are present. These are **lymph nodes (Figure: 11.21)**.

- Several afferent lymph vessels enter a lymph node and the lymph is drained by a single efferent lymph vessel.
- Lymph nodes are present in the neck region, axilla and groin areas of man.
- In addition to lymph nodes, several **lymphoid masses** are present in different areas e.g., in the mucosa and submucosa of alimentary canal. The larger lymphoid masses are spleen, thymus, tonsils and adenoids. These produce lymphocytes.

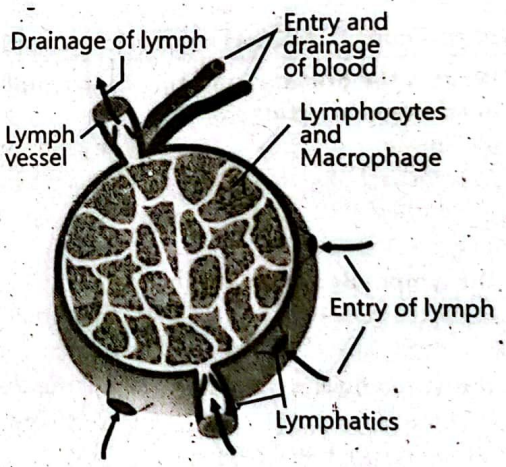

Fig. 11.23: A lymph node

Human Lymphatic System

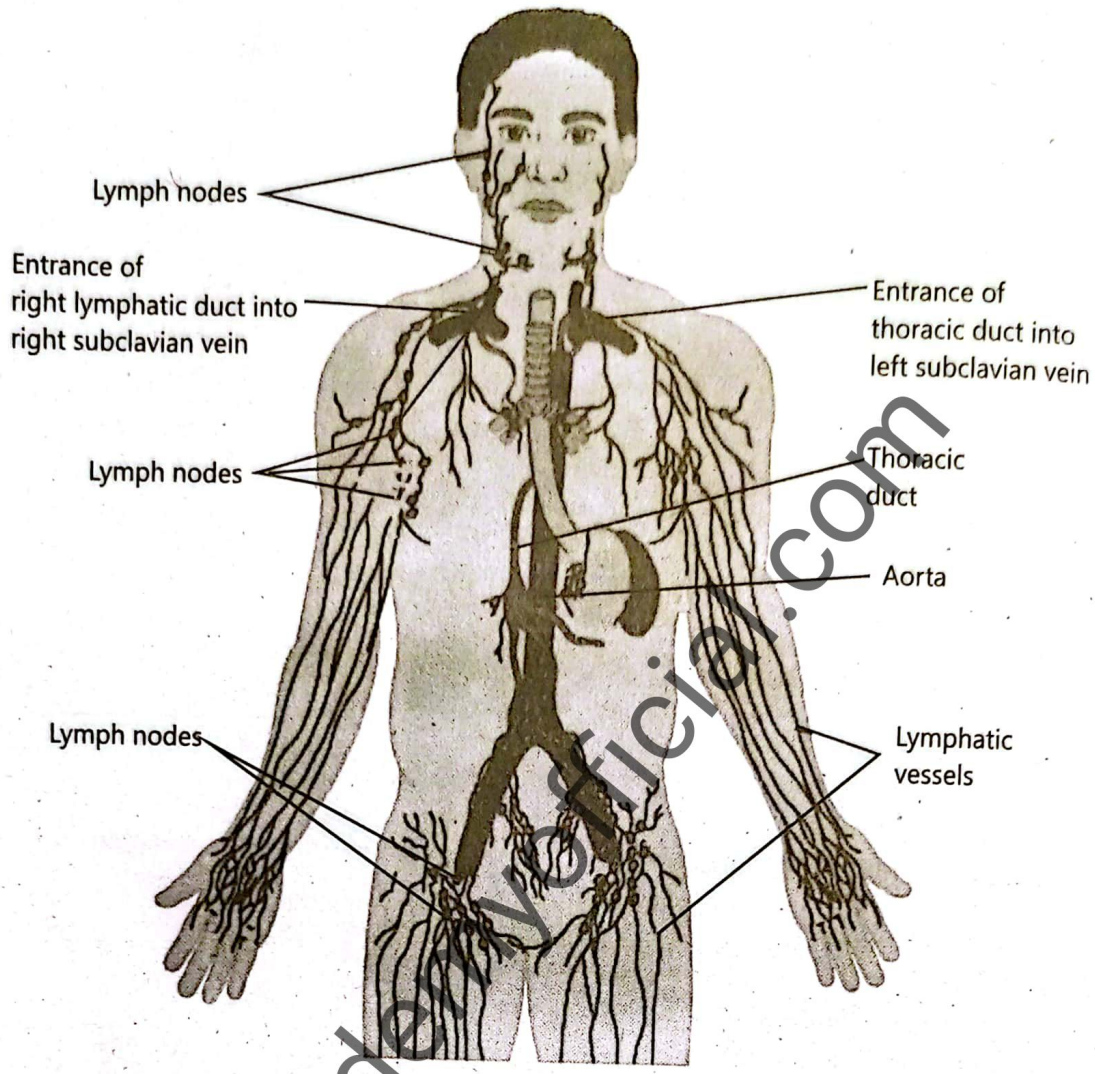

Fig. 11.22: Human lymphatic system

For Board Exam & MDCAT

MCQs ✓

1. **What is the primary function of the lymphatic system in addition to circulation?**
   A) Digestion B) Respiration
   C) Transport of materials and return from tissues to blood ✓
   D) Hormone production
2. **The lymphatic system begins with:**
   A) Lymph nodes B) Lymph ducts
   C) Lymph capillaries ✓ D) Subclavian veins
3. **Interstitial fluid enters lymph capillaries due to:**
   A) Osmotic pressure B) Muscle contraction
   C) Pressure of interstitial fluid ✓
   D) Negative blood pressure
4. **Lymph capillaries are more permeable than:**
   A) Lymph nodes B) Veins
   C) Arteries ✓ D) Blood capillaries
5. **When interstitial fluid enters lymph capillaries, it is called:**
   A) Serum B) Blood plasma
   C) Lymph ✓ D) Tissue fluid
6. **Lymphatic vessels are formed by joining of:**
   A) Veins B) Lymph capillaries ✓
   C) Arteries D) Lymph ducts
7. **The two main lymph ducts are:**
   A) Jugular and carotid
   B) Right lymphatic and thoracic ducts ✓
   C) Subclavian and hepatic ducts
   D) Aortic and pulmonary ducts
8. **The lymphatic ducts drain into the:**
   A) Aorta B) Vena cava
   C) Subclavian veins ✓ D) Pulmonary arteries
9. **Which of the following maintains lymph flow?**
   A) Blood pressure B) Gland secretion
   C) Skeletal muscle and breathing movements ✓
   D) Peristalsis only
10. **Valves in lymph vessels function to:**
    A) Absorb oxygen B) Increase blood pressure
    C) Prevent backflow of lymph ✓ D) Filter lymph

11. **On average, how much excess fluid is returned to blood by lymphatic capillaries daily?**
A) 1 liter B) 2 liters
C) 3 liters ✓ D) 5 liters

12. **Lymph nodes are rich in:**
A) Neurons and glial cells
B) Lymphocytes and macrophages ✓
C) Platelets and enzymes
D) Red blood cells

13. **The spleen filters blood and destroys:**
A) Healthy RBCs
B) Aged RBCs and foreign particles ✓
C) White blood cells D) Nerve cells

14. **Lymph nodes are present in all of the following regions except:**
A) Neck B) Axilla
C) Groin D) Stomach ✓

15. **Which of the following is NOT a lymphoid mass?**
A) Spleen B) Liver ✓
C) Tonsils D) Thymus

1. What is the function of the lymphatic system besides blood circulation?
Ans. The lymphatic system transports materials and returns them from tissues to the blood. It begins with lymph capillaries and ends at lymph ducts that drain into subclavian veins. It also plays a role in immune defence.

2. What is lymph and how is it formed?
Ans. When interstitial fluid enters lymph capillaries, it is called lymph. This fluid is forced into capillaries due to pressure in the extracellular space. It contains larger molecules and waste products.

3. How do lymph capillaries differ from blood capillaries?
Ans. Lymph capillaries have blind ends and are more permeable than blood capillaries. They allow the entry of larger molecules. They absorb excess interstitial fluid from tissues.

4. What are the major components of the lymphatic system?
Ans. The major components include lymph vessels, lymph nodes, lymphoid masses, and lymph. These work together to transport fluid and support immune defence.

5. How is the flow of lymph maintained in the body?
Ans. Lymph flows from body tissues toward the thoracic duct. Its flow is maintained by skeletal muscle movement, breathing, and movement of internal organs.Valves prevent backflow of lymph.

6. What is the function of lymphatic vessels and ducts?
Ans. Lymphatic vessels carry lymph and join to form larger ducts. The right lymphatic duct and thoracic duct drain lymph into the right and left subclavian veins, respectively.

7. What happens to the 3 litres of excess fluid that leaves blood capillaries daily?
Ans. This fluid is absorbed by lymphatic capillaries. The lymphatic system returns it to the bloodstream before the blood enters the heart, preventing tissue swelling.

8. What is the role of lymph nodes in the immune system?
Ans. Lymph nodes filter lymph and contain lymphocytes and macrophages. These cells destroy bacteria and viruses, defending the body against foreign invaders.

9. Where are lymph nodes commonly found in the human body?
Ans. Lymph nodes are present in the neck, axilla (armpits), and groin. They are masses of connective tissue with immune cells like lymphocytes.

10. Name some larger lymphoid masses and their function.
Ans. Spleen, thymus, tonsils, and adenoids are larger lymphoid masses. They produce lymphocytes and help in immune defence. The spleen also stores and filters red blood cells.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

1. **Compared to vein, an artery?**
   a) Has thinner walls
   b) Is located more superficially
   c) Carries blood away from an organ✓
   d) Has no internal valves

2. **Bicuspid valve guards the opening between?**
   a) Stomach and intestine
   b) Pulmonary vein and left atrium
   c) Right atrium and right ventricle
   d) Left atrium and left ventricle✓

3. **What is the state of bicuspid and tricuspid valves at the end of the first heart sound?**
   a) Bicuspid is closed, tricuspid is open
   b) Bicuspid is open, tricuspid is closed
   c) Both are open
   d) Both are closed✓

4. **By beating at normal speed, our heart pumps how much blood per minute?**
   a) 2 litres
   b) 3 litres
   c) 5 litres✓
   d) 8 litres

5. **Closure of tricuspid and bicuspid valves produces sound?**
   a) "Lubb"✓
   b) "Dubb"
   c) First Lubb" then "Dubb"
   d) None of these but "murmurs"

6. **SA-node initiates heartbeat in?**
   a) Right atrium only✓
   b) Right atrium and partially left also
   c) Right and left both
   d) Left atrium and partially right also

7. **Systolic pressure in young man is?**
   a) 60 mm of Hg
   b) 80 mm of Hg
   c) 100 mm of Hg
   d) 120 mm of Hg✓

8. **Blood pressure is highest in ____ and blood moves most slowly in?**
   a) Veins, capillaries
   b) Arteries, capillaries✓
   c) Capillaries, arteries
   d) Veins, arteries

9. **Instead of normal "lub-dubb" sound, a "lub-hiss, lub-hiss" sound indicates?**
   a) Blocked coronary artery
   b) Damaged pacemaker
   c) Defective semilunar valve✓
   d) High blood pressure

10. **In humans which one is the other system for the transport of materials, than blood circulatory system?**
    a) Lymphatic system✓
    b) Digestive system
    c) Nervous system
    d) Respiratory system

SHORT ANSWER QUESTIONS

1. **What is the main difference between the walls of an artery and a vein?**

Ans.

Sr.	Artery	Vein
1	Distributing Vessel	Collecting Vessel
2	Pink in Colour	Red in Colour
3	Deep Location	Superficial in Location
4	Blood Flow With High Pressure	Blood Flow With Low Pressure
5	Wall of Artery is Strong, Thick & Elastic	Wall of Vein is Weak, Thin & Non-Elastic
6	All Arteries Carry Oxygenated Blood Except Pulmonary Artery	All Veins Carry Deoxygenated Blood Except Pulmonary Veins
7	Internal Valves Are Absent	Internal Valves Are Present

2. Enlist the four valves present in heart and also state their locations?

Ans.

Sr.	Valve	Location
1	Tricuspid Valve	Tricuspid valve is located between the right atrium and the right ventricle.
2	Pulmonary Valve	Pulmonary Valve is located between the right ventricle and the pulmonary artery.
3	Mitral / Bicuspid Valve	Mitral / Bicuspid valve is located between the left atrium and the left ventricle.
4	Aortic Valve	Aortic valve is located between the left ventricle and the aorta.

3. State the phases of heartbeat?

Ans. Every single heartbeat includes three major phases: atrial systole, ventricular systole, and complete cardiac diastole.

Sr.	Phase	Description
1	Atrial Systole	Atrial systole is the contraction of the atria that causes ventricular filling.
2	Ventricular Systole	Ventricular systole is the contraction of the ventricles in which blood is ejected into the pulmonary artery or aorta, depending on side.
3	Complete Cardiac Diastole	Complete cardiac diastole occurs after systole. The blood chambers of the heart relax and fill with blood once more, continuing the cycle.

4. List the principles and uses of Electrocardiogram?

Ans.

Principle

The basic principle of the ECG is that stimulation of a muscle alters the electrical potential of the muscle fibres. Cardiac cells, unlike other cells, have a property known as automaticity, which is the capacity to spontaneously initiate impulses.

Uses

An electrocardiogram (ECG) is a simple test that can be used to check your heart's rhythm and electrical activity. Sensors attached to the skin are used to detect the electrical signals produced by your heart each time it beats.

5. Define angiography and angioplasty?

Ans.

Angiography

Coronary angiography is an X-ray examination of blood vessels or chambers of heart.

The X-rays provided by an angiography are called angiograms. This test is used to study narrow, blocked, enlarged, or malformed arteries or veins in many parts of your body, including your brain, heart, abdomen, and legs.

Angioplasty

Angioplasty is a procedure that opens a blocked or narrowed artery. It restores blood flow to the heart muscles.

6. What is meant by Purkinje fibres?

Ans. The Purkinje fibers are specialized conducting fibers composed of electrically excitable cells. Purkinje fibers allow the heart's conduction system to create synchronized contractions of its ventricles, and are essential for maintaining a consistent heart rhythm.

7. What do you mean by vasoconstriction and vasodilation?

Ans. **Vasoconstriction**

Vasoconstriction is the narrowing (constriction) of blood vessels by small muscles in their walls. When blood vessels constrict, blood flow is slowed or blocked. Vasoconstriction may be slight or severe. It may result from disease, drugs, or psychological conditions.

Vasodilation

Vasodilation is the widening of blood vessels as a result of the relaxation of the blood vessel's muscular walls. Vasodilation is a mechanism to enhance blood flow to areas of the body that are lacking oxygen and/or nutrients.

8. What is the rate of blood flow in different types of blood vessels?

Ans. The rate, or velocity, of blood flow varies inversely with the total cross-sectional area of the blood vessels. As the total cross-sectional area of the vessels increases, the velocity of flow decreases. Blood flow is slowest in the capillaries, which allows time for exchange of gases and nutrients while blood flow is highest in the arteries.

9. State the role of baroreceptors and volume receptors in regulating the blood pressure?

Ans. Role of Baroreceptors

Pressure receptors (baroreceptors) are present in carotid arteries (arteries that supply blood to the head region and brain) and aortic arch (portion of artery that bends between the ascending and descending aorta). When blood pressure falls, baroreceptors activate sensory neurons that send information to brain. The control centre in brain reacts by increasing the rate and force of contraction of heart, and by causing vasoconstriction in arterioles. Both these changes restore blood pressure to normal.

Role of Volume Receptors

As blood volume decreases, it is detected by volume receptors & pressure and flow decrease. As blood volume increases, it is detected by volume receptors & pressure and flow increase. Under normal circumstances, blood volume varies little.

10. Differentiate between thrombus and embolus?

Ans. Thrombosis

Thrombosis is the formation of thrombus. Thrombus is a solid mass or plug of blood constituents (clot) in a blood vessel. This mass may block (wholly or only in part) the vessel.

Thromboembolism

Formation of thrombus in a blood vessel and then its carriage to any other location is called **thromboembolism**.

Embolus

A thrombus may be dislodged and carried to some other locations in the circulatory system. Such a thrombus is called embolus.

LONG QUESTIONS

Q1. Describe the structure of the walls of heart and rationalize the thickness of the walls of each chamber?
Ans: See Long Question No. 01

Q2. Describe the flow of blood through heart as regulated by the valves?
Ans: See Long Question No. 01

Q3. Explain how a heartbeat is initiated and controlled?
Ans: See Long Question No. 01

Q4. Describe the detailed structure of arteries, veins and capillaries?
Ans: See Long Question No. 03

Q5. Describe the role of precapillary sphincters in regulating the flow of blood through capillaries?
Ans: See Long Question No. 04

Q6. Write the components of pulmonary circulation?
Ans: See Long Question No. 07

Q7. What are the main components of coronary, hepatic-portal and renal circulation?
Ans: See Long Question No. 07

Q8. Define blood pressure and explain systolic and diastolic pressure?
Ans: See Long Question No. 08

Q9. Define the term thrombus and differentiate between thrombus and embolus?
Ans: See Long Question No. 09

Q10. Identify the factors causing atherosclerosis and arteriosclerosis?
Ans: See Long Question No. 09

Q11. Write notes on *Angina pectoris*, heart attack, and heart failure?
Ans: See Long Question No. 09

Q12. Outline the main principles of coronary bypass and angioplasty?

Ans: See Long Question No. 09

Q13. **Define hypertension and describe the factors that regulate blood pressure and can lead to hypertension and hypotension?**

Ans: See Long Question No. 09

Q14. **List the changes in life styles that can protect man from hypertension and cardiac problems?**

Ans: See Long Question No. 09

15. **Describe the structure and role of lymph capillaries, lymph vessels and lymph ducts.**

Ans: See Long Question No. 10

INQUISITIVE QUESTIONS

1. **Why is the pressure in the pulmonary circulation lower than in the systemic circulation?**

Ans. Pulmonary circulation is a short loop from the heart to the lungs and back, requiring less force to pump blood. The lung capillaries are thin and delicate, so lower pressure prevents damage and allows efficient gas exchange.

2. **Why is it so important for the human heart to develop early and begin functioning within the developing embryo?**

Ans. The heart forms early to ensure delivery of oxygen and nutrients to the rapidly growing tissues of the embryo. Early circulation also removes waste products essential for normal development.

3. **Justify how vasoconstriction or vasodilation is reflective of emotions.**

Ans. Emotions trigger the autonomic nervous system, which affects blood vessels. For example, fear causes vasoconstriction (pale skin), while embarrassment causes vasodilation (blushing).

4. **Justify in what way the blood circulatory system is dependent on the lymphatic system.**

Ans. The lymphatic system returns excess interstitial fluid and proteins to the bloodstream. It maintains blood volume and pressure, supporting the function of the circulatory system.

5. **Interpret why the swelling of the lymph nodes is a cause of concern.**

Ans. Swollen lymph nodes indicate that they are actively fighting infections or abnormal cells. Persistent swelling may signal infections, immune disorders, or cancers requiring medical attention.

6. **Trace the path of lymph from a lymph capillary until it is returned to the blood.**

Ans. Lymph enters lymph capillaries, travels through larger lymph vessels, passes through lymph nodes, and drains into the lymph ducts (right lymphatic or thoracic). These ducts empty lymph into the subclavian veins, returning it to the bloodstream.

Self-Assessment Unit 11

Max. Marks: 28 **Time allowed 60 Mins**

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. Compared to veins, arteries typically:

(a) Have thinner wallsz (b) Are located closer to the skin surface

(c) Transport blood away from organs (d) Lack internal valves

2. The bicuspid (mitral) valve controls the passage of blood between:

(a) Stomach and small intestine (b) Pulmonary vein and the left atrium

(c) Right atrium and right ventricle (d) Left atrium and left ventricle

3. At the conclusion of the first heart sound, the bicuspid and tricuspid valves are:

(a) Bicuspid shut, tricuspid open (b) Bicuspid open, tricuspid shut

(c) Both open (d) Both closed

4. Under resting conditions, the human heart pumps approximately how much blood per minute?

(a) 2 liters (b) 3 liters (c) 5 liters (d) 8 liters

5. The sound "lubb" during the cardiac cycle is caused by:

(a) Closing of the tricuspid and bicuspid valves (b) Closing of the semilunar valves

(c) First "lubb" then "dubb" sequence (d) Abnormal heart murmurs

6. The SA node triggers heart contractions in the:

(a) Right atrium only (b) Right atrium and partially left atrium

(c) Both atria (d) Left atrium and partly right atrium

7. What is the average systolic pressure in a healthy young adult?

(a) 60 mm Hg (b) 80 mm Hg (c) 100 mm Hg (d) 120 mm Hg

8. Blood pressure is greatest in ____, while blood flows slowest in the:

(a) Veins; capillaries (b) Arteries; capillaries (c) Capillaries; arteries (d) Veins; arteries

9. A "lub-hiss, lub-hiss" heart sound instead of the normal "lub-dubb" may suggest:

(a) A blocked coronary artery (b) Malfunctioning pacemaker

(c) Faulty semilunar valve (d) Elevated blood pressure

10. Besides the circulatory system, which other system in humans aids in material transport?

(a) Lymphatic system (b) Digestive system (c) Nervous system (d) Respiratory system

Q2. Write short answers to the following questions **(5x2=10)**

1. What is the main difference between the walls of an artery and a vein?
2. Enlist the four valves present in heart and also state their locations.
3. Define angiography and angioplasty.
4. What is meant by Purkinje fibres?
5. What do you mean by vasoconstriction and vasodilation?

Q3. Write detailed answer to the following question **(4+4=8)**

1. Describe the flow of blood through heart as regulated by the valves.
2. Describe the structure and role of lymph capillaries, lymph vessels and lymph ducts.`1