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Circulatory and Lymphatic System

Anatomy & Physiology

Heart, blood vessels, lymph nodes and lymphatic organs

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Circulatory and Lymphatic System - Applied Anatomy Notes for B.Sc. Nursing

1. Introduction

The circulatory and lymphatic systems are important transport and defense systems of the human body.

- Circulatory system: Transports blood, oxygen, nutrients, hormones and waste products throughout the body.
- Lymphatic system: Returns excess tissue fluid to the bloodstream, absorbs dietary fats and helps protect the body against infection.

Both systems work together to maintain fluid balance, circulation and immunity.

2. Circulatory System

The circulatory system, also called the cardiovascular system, consists of:

1. Heart
2. Blood vessels
3. Blood

Functions of the Circulatory System

- Supplies oxygen and nutrients to body tissues.
- Transports hormones to target organs.
- Removes carbon dioxide and metabolic waste.
- Helps regulate body temperature.
- Maintains blood pressure and tissue perfusion.
- Supports immune defense and blood clotting.

3. Heart

Definition

The heart is a hollow, muscular organ that pumps blood throughout the body. It is located in the thoracic cavity, between the lungs, in the mediastinum.

Location and Position

- Lies behind the sternum and above the diaphragm.
- Approximately two-thirds of the heart lies to the left of the midline.
- Its apex points downward, forward and to the left.

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- The apex is usually located in the left fifth intercostal space near the midclavicular line.

Size and Weight

- Approximately the size of a closed fist.
- Average adult weight is about 250-350 g, with variation according to body size and sex.

Coverings of the Heart - Pericardium

The heart is enclosed in a protective sac called the pericardium.

It consists of:

1. Fibrous pericardium: Tough outer layer that protects the heart and prevents excessive stretching.
2. Serous pericardium: Thin inner membrane divided into:Parietal layerVisceral layer (epicardium)

The pericardial cavity contains a small amount of fluid that reduces friction during heart movements.

Layers of the Heart Wall

Layer

Description

Epicardium

Outer layer; also the visceral layer of serous pericardium

Myocardium

Middle muscular layer responsible for pumping

Endocardium

Inner smooth lining of chambers and valves

Chambers of the Heart

The heart has four chambers:

1. Right Atrium
   - Receives deoxygenated blood from the superior vena cava, inferior vena cava and coronary sinus.
   - Passes blood into the right ventricle.
2. Right Ventricle
   - Receives blood from the right atrium.
   - Pumps deoxygenated blood to the lungs through the pulmonary trunk.
3. Left Atrium
   - Receives oxygenated blood from the four pulmonary veins.
   - Passes blood into the left ventricle.
4. Left Ventricle
   - Receives oxygenated blood from the left atrium.
   - Pumps blood into the aorta for distribution to the body.

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- Has the thickest muscular wall because it pumps blood at high pressure.

Valves of the Heart

Heart valves maintain one-way blood flow and prevent backflow.

Valve

Location

Tricuspid valve

Between right atrium and right ventricle

Pulmonary valve

Between right ventricle and pulmonary trunk

Mitral (bicuspid) valve

Between left atrium and left ventricle

Aortic valve

Between left ventricle and aorta

Blood Flow Through the Heart

1. Body tissues -> Superior and inferior vena cava
2. Venae cavae -> Right atrium
3. Right atrium -> Tricuspid valve
4. Tricuspid valve -> Right ventricle
5. Right ventricle -> Pulmonary valve -> Pulmonary trunk
6. Pulmonary arteries -> Lungs
7. Lungs -> Pulmonary veins
8. Pulmonary veins -> Left atrium
9. Left atrium -> Mitral valve
10. Mitral valve -> Left ventricle
11. Left ventricle -> Aortic valve -> Aorta
12. Aorta -> Whole body

Important: Pulmonary arteries carry deoxygenated blood, while pulmonary veins carry oxygenated blood.

Blood Supply of the Heart

The heart receives its blood supply through the coronary arteries.

- Right coronary artery (RCA): Supplies much of the right side of the heart and commonly parts of the conduction system.

- Left coronary artery (LCA): Divides mainly into the left anterior descending artery (LAD) and circumflex artery; supplies much of the left heart.

Venous blood from the heart muscle is mainly collected by the coronary veins and drains into the coronary sinus,

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which opens into the right atrium.

Conducting System of the Heart

The conducting system generates and transmits electrical impulses that coordinate heartbeats.

Structure

Function

SA node

Natural pacemaker; initiates the heartbeat

AV node

Delays the impulse before ventricular contraction

Bundle of His

Conducts impulses into the interventricular septum

Right and left bundle branches

Carry impulses towards the ventricles

Purkinje fibres

Spread impulses through ventricular muscle

Heart Sounds

- First heart sound (S1 - "Lub"): Mainly due to closure of the mitral and tricuspid valves.
- Second heart sound (S2 - "Dub"): Mainly due to closure of the aortic and pulmonary valves.

Cardiac Cycle

The cardiac cycle is the sequence of events occurring during one heartbeat.

It has three main phases:

1. Atrial systole: Atria contract and push blood into the ventricles.
2. Ventricular systole: Ventricles contract and pump blood into the pulmonary trunk and aorta.
3. Complete cardiac diastole: All four chambers relax and fill with blood.

At a resting heart rate of about 75 beats per minute, one cardiac cycle lasts approximately 0.8 seconds.

4. Blood Vessels

Blood vessels are tubes that transport blood throughout the body.

Types of Blood Vessels

1. Arteries

- Carry blood away from the heart.
- Have thick, elastic and muscular walls.
- Usually carry oxygenated blood, except pulmonary arteries and umbilical arteries.

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2. Veins

- Carry blood towards the heart.
- Have thinner walls and a wider lumen than comparable arteries.
- Many contain valves to prevent backflow.
- Usually carry deoxygenated blood, except pulmonary veins and umbilical veins.

3. Capillaries

- Microscopic blood vessels connecting arterioles and venules.
- Have walls consisting mainly of a single layer of endothelial cells.
- Allow exchange of oxygen, nutrients, gases and waste products between blood and tissues.

Comparison of Arteries, Veins and Capillaries

Feature Arteries Veins Capillaries

Direction Away from heart Towards heart Connect arterioles and ve

Wall Thick and elastic Thin One-cell-thick endothelium

Lumen Relatively narrow Relatively wide Very narrow

Valves Generally absent Present in many veins Absent

Pressure High Low Low

Main function Distribute blood Return blood Exchange substances

Layers of Blood Vessel Walls

Most arteries and veins have three layers:

1. Tunica intima: Inner endothelial lining.
2. Tunica media: Middle smooth muscle and elastic tissue layer.
3. Tunica externa (adventitia): Outer connective tissue layer.

Capillaries do not have all three layers.

Major Arteries of the Body

- Aorta
- Pulmonary arteries
- Coronary arteries
- Carotid arteries
- Subclavian arteries
- Brachial arteries
- Radial and ulnar arteries
- Renal arteries
- Common iliac arteries

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- Femoral arteries
- Popliteal arteries
- Anterior and posterior tibial arteries

Major Veins of the Body

- Superior vena cava
- Inferior vena cava
- Pulmonary veins
- Jugular veins
- Subclavian veins
- Brachiocephalic veins
- Axillary veins
- Cephalic and basilic veins
- Renal veins
- Hepatic veins
- Femoral veins
- Great and small saphenous veins

Types of Circulation

1. Pulmonary Circulation
   - Carries deoxygenated blood from the right ventricle to the lungs.
   - Returns oxygenated blood from the lungs to the left atrium.
2. Systemic Circulation
   - Carries oxygenated blood from the left ventricle to body tissues.
   - Returns deoxygenated blood to the right atrium.
3. Coronary Circulation
   - Supplies oxygen and nutrients to the heart muscle.
   - Coronary arteries supply the myocardium, and cardiac veins drain it.

5. Lymphatic System

Definition

The lymphatic system is a network of lymph, lymphatic vessels, lymph nodes and lymphatic organs that maintains fluid balance, absorbs dietary fats and supports immunity.

Functions of the Lymphatic System

- Returns excess tissue fluid to the bloodstream.
- Returns leaked plasma proteins to circulation.

- Absorbs and transports dietary fats from the small intestine.
- Produces, stores and transports lymphocytes.
- Filters lymph and helps remove microorganisms and foreign particles.
- Supports immune responses against infection.

6. Lymph and Lymphatic Vessels

Lymph

Lymph is a clear or pale-yellow fluid formed from interstitial fluid that enters lymphatic capillaries.

Composition of lymph:

- Water
- Electrolytes
- Small amounts of proteins
- Lymphocytes and other immune cells
- Absorbed fats, especially in intestinal lymph

Formation and Flow of Lymph

1. Fluid moves out of blood capillaries into tissue spaces.
2. Most fluid returns directly to blood capillaries.
3. Excess interstitial fluid enters lymphatic capillaries and becomes lymph.
4. Lymph travels through lymphatic vessels and lymph nodes.
5. It eventually returns to the bloodstream through the major lymphatic ducts.

Lymphatic Vessels

- Begin as blind-ended lymphatic capillaries in tissues.
- Join to form larger lymphatic vessels.
- Contain valves that help prevent backward flow.
- Pass through lymph nodes.
- Drain into lymphatic trunks and ducts.

Major Lymphatic Ducts

1. Right Lymphatic Duct
   - Drains lymph from the right side of the head and neck, right upper limb and right side of the thorax.
   - Opens into the junction of the right internal jugular and right subclavian veins.
2. Thoracic Duct
   - Largest lymphatic duct.
   - Drains lymph from both lower limbs, the abdomen, left side of the thorax, left upper limb and left side of the head and neck.

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- Opens into the junction of the left internal jugular and left subclavian veins.

7. Lymph Nodes

Definition

Lymph nodes are small, bean-shaped structures located along lymphatic vessels. They filter lymph and help initiate immune responses.

Location

Lymph nodes are commonly found in groups in the following regions:

- Cervical - neck
- Axillary - armpit
- Inguinal - groin
- Mediastinal - chest
- Mesenteric - abdominal region
- Pelvic - pelvis

Structure of a Lymph Node

A lymph node consists of:

1. Capsule: Outer connective tissue covering.
2. Cortex: Outer region containing lymphoid follicles, mainly with B lymphocytes.
3. Paracortex: Region rich in T lymphocytes.
4. Medulla: Inner region containing medullary cords and sinuses.
5. Hilum: Indented area through which blood vessels and the efferent lymphatic vessel pass.

Functions of Lymph Nodes

- Filter lymph.
- Trap bacteria, viruses and foreign particles.
- Support activation and multiplication of lymphocytes.
- Help produce an immune response.
- Remove cellular debris and microorganisms.

Clinical Importance

- Enlarged lymph nodes are called lymphadenopathy.
- Tender, enlarged nodes may occur during infections.
- Persistent or hard, fixed lymph nodes may require further investigation.
- Cancer cells may spread through lymphatic vessels to regional lymph nodes.

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8. Lymphatic Organs

Lymphatic organs are involved in the production, maturation and activation of immune cells.

They are divided into primary and secondary lymphatic organs.

A. Primary Lymphatic Organs

1. Bone Marrow
   - Soft tissue found inside certain bones.
   - Produces blood cells, including lymphocyte precursors.
   - B lymphocytes mature in the bone marrow.
2. Thymus
   - Located in the upper anterior mediastinum, behind the sternum.
   - Most active during childhood and gradually decreases in size after puberty.
   - Site of T-lymphocyte maturation.

B. Secondary Lymphatic Organs

1. Spleen
   - Largest lymphatic organ.
   - Located in the left upper quadrant of the abdomen, below the diaphragm and behind the stomach.
   - Filters blood rather than lymph.

Functions:

   - Removes old and damaged red blood cells.
   - Helps defend against blood-borne microorganisms.
   - Stores platelets and some blood cells.
   - Supports lymphocyte activation and immune responses.

2. Tonsils
   - Masses of lymphoid tissue located around the entrance of the pharynx.
   - Help protect against microorganisms entering through the mouth and nose.

Main groups:

   - Palatine tonsils
   - Pharyngeal tonsil (adenoids)
   - Lingual tonsils

3. Peyer's Patches
   - Collections of lymphoid tissue mainly found in the ileum of the small intestine.
   - Monitor intestinal microorganisms and support gut immunity.
4. Appendix

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- A narrow, blind-ended tube attached to the caecum.
- Contains lymphoid tissue and contributes to gut-associated immune defence.

5. Lymph Nodes
- Filter lymph and provide sites for immune-cell activation.

9. Difference Between Circulatory and Lymphatic Systems

Feature Circulatory System Lymphatic System

Main fluid Blood Lymph

Main pump Heart No central pump

Vessels Arteries, veins and capillaries Lymphatic vessels

Flow Closed circuit One-way flow towards the bloodstream

Main function Transport of blood and substances Fluid return, fat absorption and immunity

Main organs Heart and blood vessels Lymph nodes, spleen, thymus and tonsils

10. Clinical Anatomy and Common Disorders

Condition

Description

Hypertension

Persistently elevated arterial blood pressure

Atherosclerosis

Plaque formation in arterial walls

Coronary artery disease

Narrowing or blockage of coronary arteries

Myocardial infarction

Damage to heart muscle due to prolonged loss of blood supply

Heart failure

Inability of the heart to pump adequately for the body's needs

Varicose veins

Dilated, tortuous superficial veins

Deep vein thrombosis

Formation of a blood clot in a deep vein

Lymphedema

Swelling caused by impaired lymph drainage

Lymphadenopathy

Enlargement of lymph nodes

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Splenomegaly

Enlargement of the spleen

Tonsillitis

Inflammation of the tonsils

11. Nursing Importance

Knowledge of the circulatory and lymphatic systems helps nurses to:

- Assess pulse rate, rhythm and volume.
- Measure and monitor blood pressure.
- Assess peripheral circulation, skin colour and temperature.
- Check capillary refill time.
- Observe for oedema and signs of poor tissue perfusion.
- Monitor for chest pain, breathlessness and abnormal heart sounds.
- Recognize signs of deep vein thrombosis, such as unilateral leg swelling and pain.
- Assess enlarged or tender lymph nodes.
- Monitor patients for signs of fluid overload or dehydration.
- Provide patient education about cardiovascular health, physical activity and prescribed treatment.

Important nursing point: Suspected myocardial infarction, acute limb ischemia, pulmonary embolism or stroke requires urgent medical assessment.

12. Important Examination Questions

Long Answer Questions

1. Describe the structure and functions of the human heart with a labelled diagram.
2. Explain the blood circulation through the heart.
3. Describe the structure and functions of blood vessels.
4. Explain the lymphatic system and its functions.
5. Describe the structure and functions of lymph nodes.
6. Explain the lymphatic organs and their functions.

Short Answer Questions

1. Write the layers of the heart wall.
2. Name the four chambers of the heart.
3. What are the four heart valves?
4. Explain the conducting system of the heart.
5. Differentiate between arteries and veins.
6. Define pulmonary and systemic circulation.

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7. What is lymph?
8. Name the major lymphatic ducts.
9. Write the functions of the spleen.
10. What is the function of the thymus?

Very Short Answer Questions

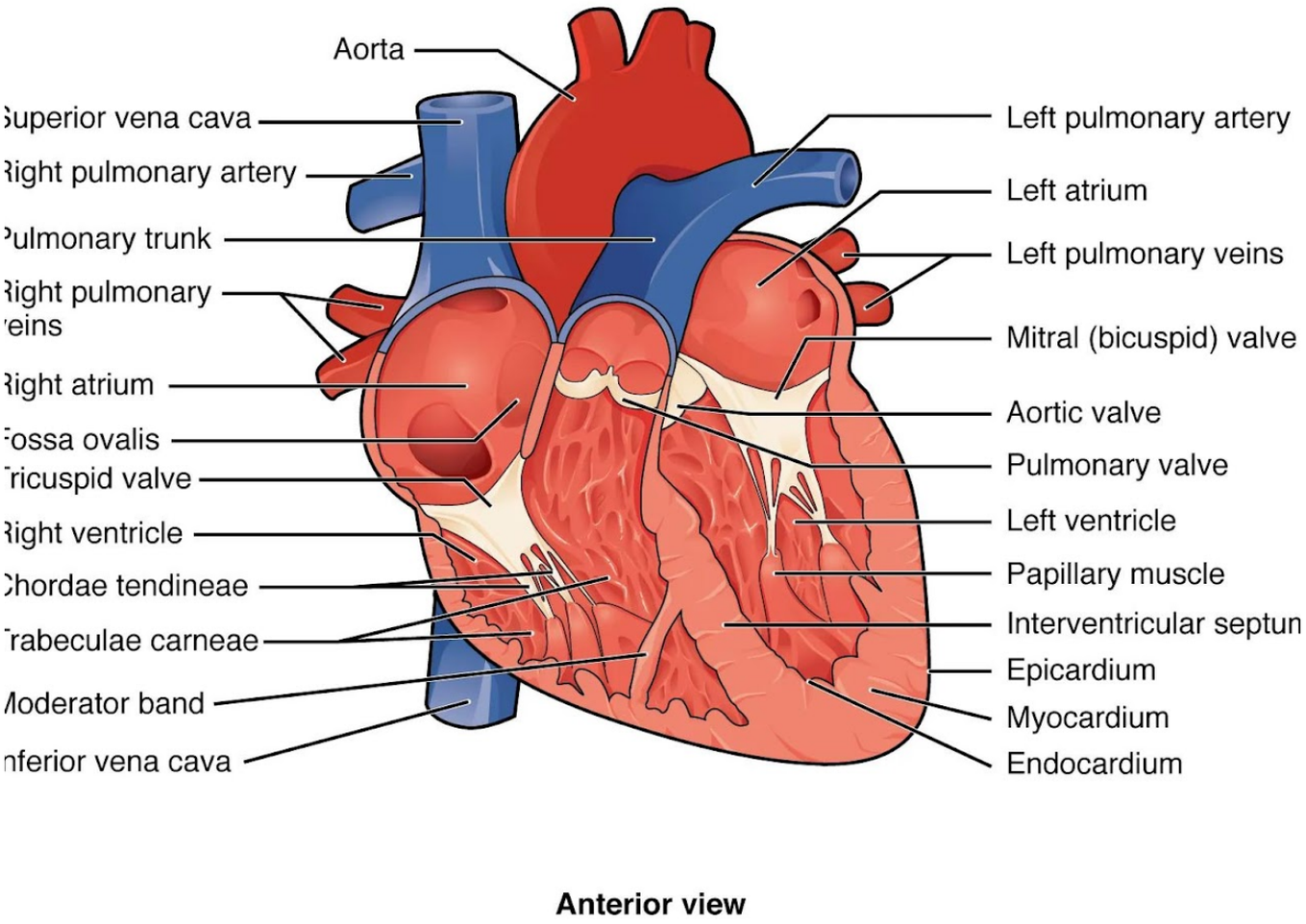
1. What is the natural pacemaker of the heart? - SA node.
2. Which chamber has the thickest wall? - Left ventricle.
3. Which blood vessels carry blood away from the heart? - Arteries.
4. Which blood vessels allow exchange of substances? - Capillaries.
5. What is the largest lymphatic organ? - Spleen.
6. Where do T lymphocytes mature? - Thymus.
7. Where do B lymphocytes mature? - Bone marrow.
8. Which is the largest lymphatic duct? - Thoracic duct.
9. Which organ filters blood? - Spleen.
10. Which organ filters lymph? - Lymph nodes.

13. Quick Revision

- The heart has four chambers: two atria and two ventricles.
- The left ventricle has the thickest wall.
- The SA node is the natural pacemaker of the heart.
- The tricuspid valve is on the right side; the mitral valve is on the left.
- Arteries carry blood away from the heart.
- Veins carry blood towards the heart.
- Capillaries are the main sites of exchange.
- Pulmonary circulation occurs between the heart and lungs.
- Systemic circulation occurs between the heart and the body.
- Lymph returns excess tissue fluid to the bloodstream.
- Lymph nodes filter lymph.
- The spleen filters blood.
- The thymus is the site of T-cell maturation.
- B cells mature in the bone marrow.
- The thoracic duct drains most of the body.

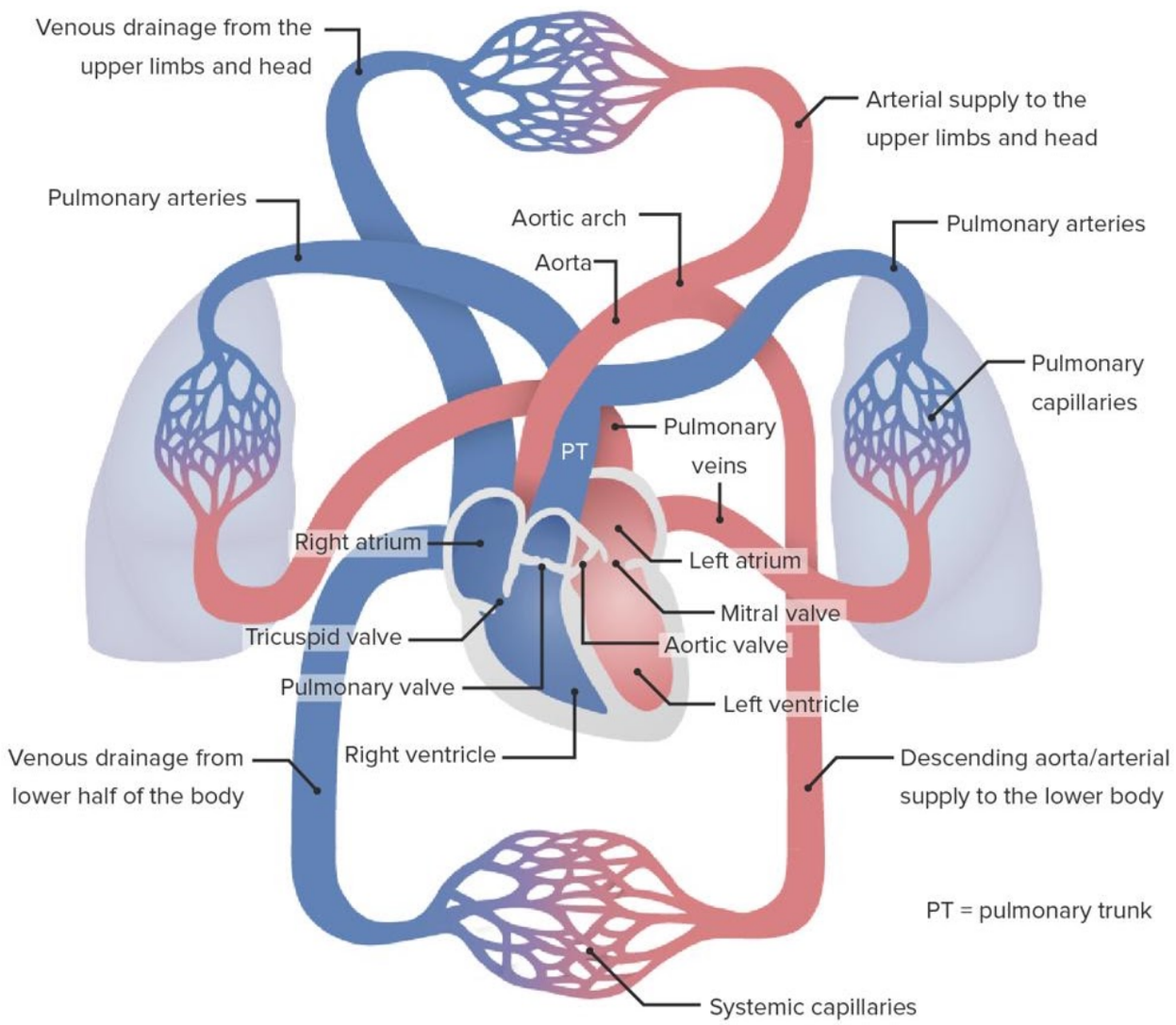
Conclusion

The circulatory system transports blood, oxygen and nutrients throughout the body, while the lymphatic system maintains fluid balance, absorbs dietary fats and supports immunity. Understanding their anatomy is essential for nursing students because it provides the foundation for cardiovascular assessment, recognition of circulatory problems and patient care.



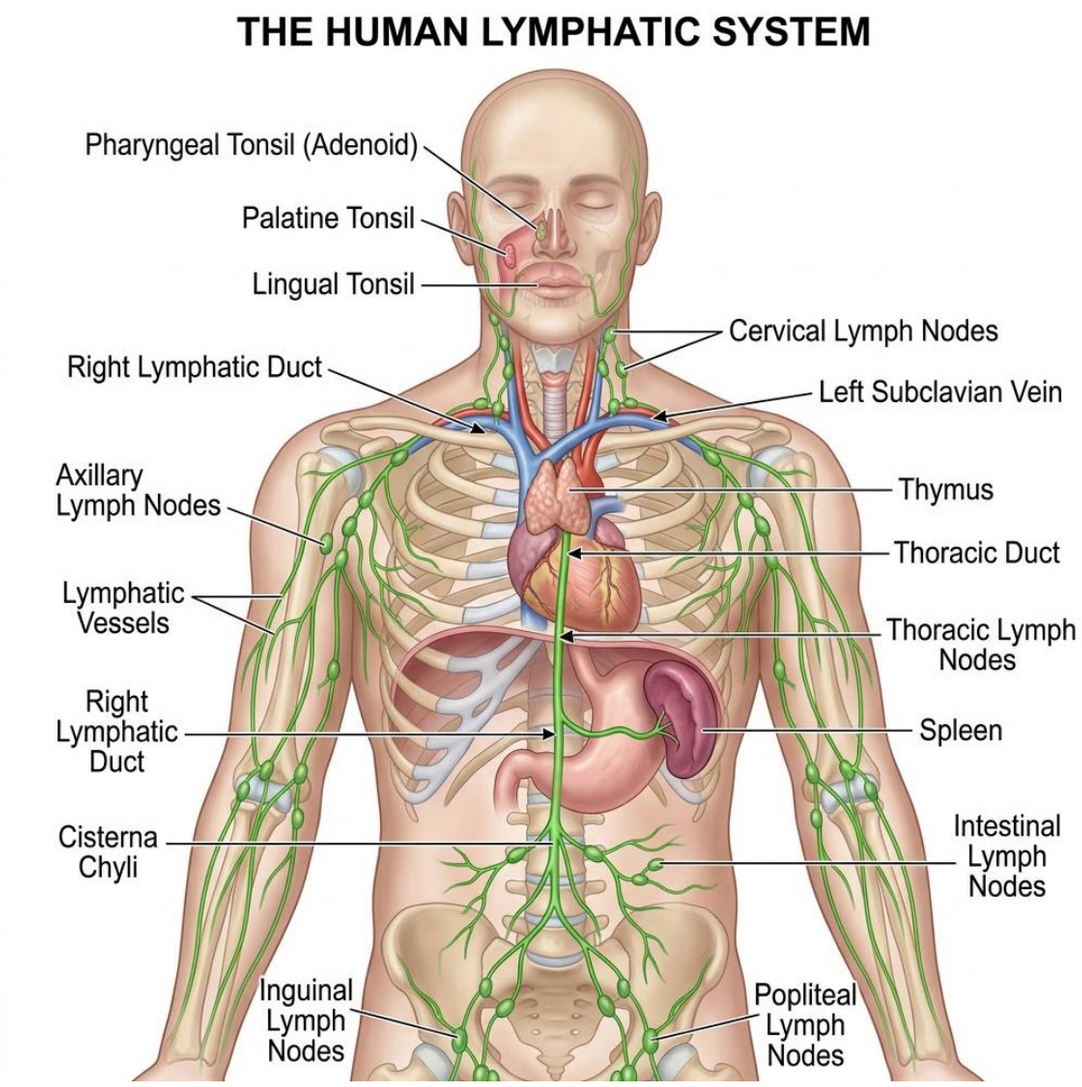
Circulatory and Lymphatic System - illustration 1

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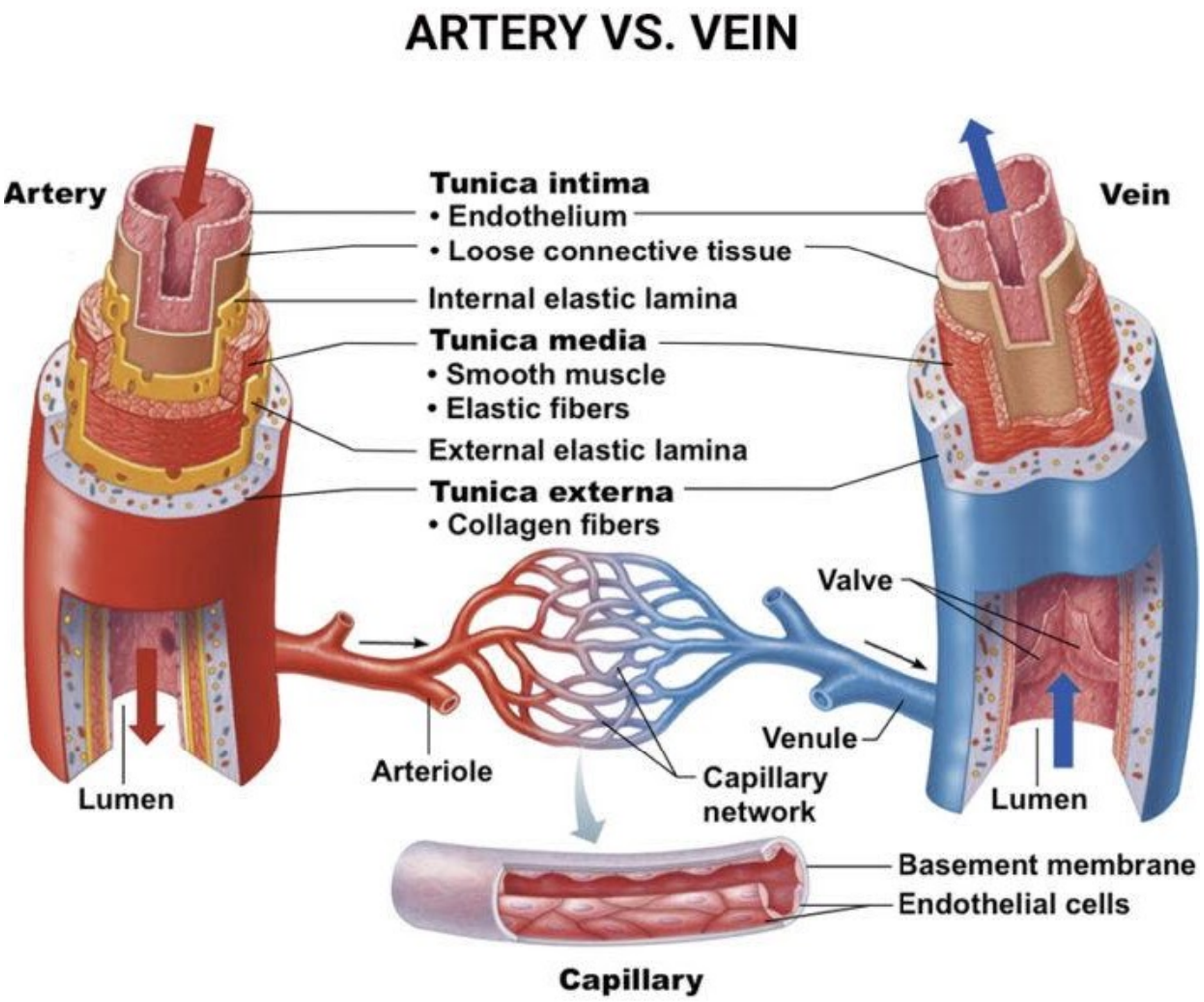
Circulatory and Lymphatic System - illustration 2

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Circulatory and Lymphatic System - illustration 3

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Circulatory and Lymphatic System - illustration 4

Quick Revision

- Heart: position & layers: The heart lies in the middle mediastinum within the pericardium. Its wall comprises epicardium, myocardium and endocardium. The left ventricular wall is thicker than the right because systemic circulation requires greater pressure.

- Chambers, valves & blood flow: Venae cavae/coronary sinus -> right atrium -> tricuspid valve -> right ventricle -> pulmonary valve -> pulmonary arteries -> lungs -> pulmonary veins -> left atrium -> mitral valve -> left ventricle -> aortic valve -> aorta.

- Blood vessels: Artery and vein are defined by direction of flow, not oxygen content. Pulmonary arteries carry deoxygenated blood; pulmonary veins carry oxygenated blood.

- Lymphatic pathways & organs: Blind-ended lymphatic capillaries collect tissue fluid. Vessels carry lymph through nodes toward venous circulation. The thoracic duct drains most of the body; the right lymphatic duct drains the right upper quadrant.

Examination questions

1. Trace a blood cell through both circulations.

2. Compare AV and semilunar valves.

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3. Distinguish lymph node and spleen functions.

Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which valve lies between left atrium and left ventricle?

A. Tricuspid
B. Pulmonary
C. Mitral
D. Aortic

2. Which organ filters blood rather than lymph?

A. Lymph node
B. Spleen
C. Tonsil
D. Thymus

3. An artery is a vessel that:

A. Always carries oxygenated blood
B. Flows away from the heart
C. Contains valves throughout
D. Flows toward the heart

4. A patient has impaired left ventricular pumping. Blood is most directly backed up into which circulation?

A. Systemic venous circulation as the first direct effect
B. Portal circulation alone
C. Lymphatic circulation alone
D. Pulmonary circulation

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Answer key and explanations

1. C - Mitral

The mitral valve is the left AV valve.

2. B - Spleen

The spleen surveys and filters circulating blood.

3. B - Flows away from the heart

Direction defines an artery; pulmonary arteries are an oxygenation exception.

4. D - Pulmonary circulation

The left ventricle receives blood through the left atrium from the pulmonary veins. Impaired left-sided pumping can increase pressure in the pulmonary circulation.

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