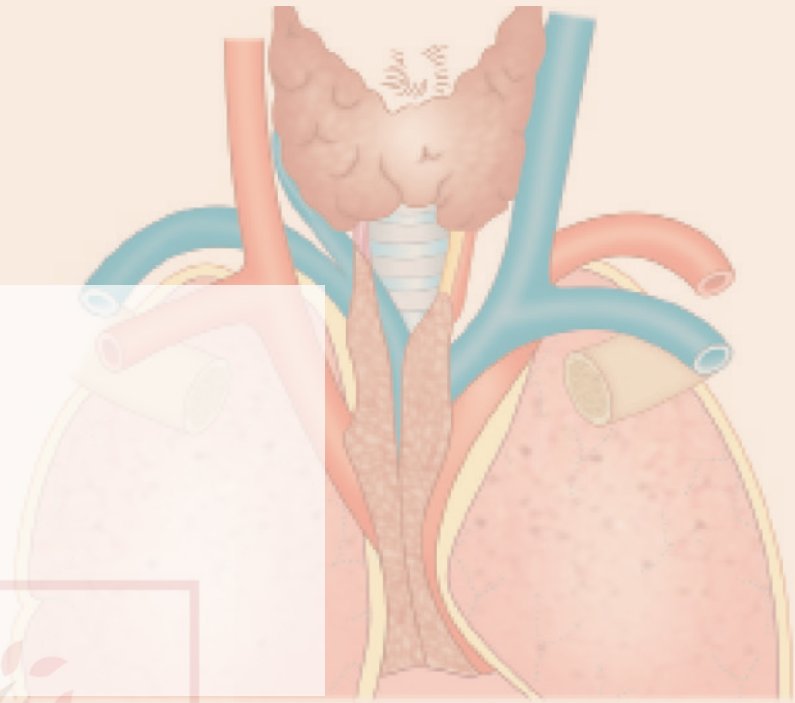


5

Lymphatic System



LEARNING OBJECTIVES

After completing the chapter, the readers will be able to:

- Describe the structure and the functions of spleen and lymph nodes.
- Describe the clinical aspects of the lymphatic system.

CHAPTER OUTLINE

- Introduction
- Lymphatic Organs
- Lymphatic Vessels
- Lymphatic Flow
- Composition of Lymph
- Functions of Lymphatic System
- Physiology

KEY TERMS

Lymph capillaries: These are minute channels starting blindly in tissue spaces. These capillaries unite to form lymph vessels.

Lymph nodes: Lymph nodes are bean-shaped structures that filter lymph fluid. These are present in neck, axilla, posterior thoracic wall, abdominal wall, and inguinal region, etc.

Lymphocytes: Lymphocytes are a type of white blood cell (WBC) that are mainly of two types: T lymphocytes (T cells) and B lymphocytes (B cells).

Right lymphatic duct: It drains the right halves of the thorax, head and neck and upper limb. It terminates into the right brachiocephalic vein in the thorax.

Thoracic duct: It is the largest lymph duct draining both lower limbs, abdomen, left halves of thorax, head and neck and upper limb. It terminates in the left brachiocephalic vein in the thorax.

INTRODUCTION

Lymphoid tissue is primarily concerned with antigen-antibody reactions and allergic mechanisms. It is the central component of the body's immune system. In conditions such as AIDS, the virus prevents proliferation of T-cells, causing the immune system to fail. It is involved in lymphoid leukemia, which results in the overproduction of lymphocytes.

LYMPHATIC ORGANS

Key lymphoid organs include lymph nodes, tonsils, spleen, and thymus. Lymphocyte clusters are also found in the gastrointestinal tract as Peyer's patches.

Lymph Nodes

- Lymph nodes are bean-shaped structures that filter lymph fluid. Lymph nodes are bean-shaped structures grouped together in neck, axilla, and inguinal region, where these are palpable if enlarged (Fig. 5.1).
- Each node contains lymphoid follicles with a germinal center that produces new lymphocytes. Macrophages within the node destroy bacteria. Cancer cells frequently spread *via* the lymphatic vessels to the lymph nodes.
- They are grouped in regions such as the neck, armpit (axilla), mediastinal (thoracic), abdominal and groin (inguinal region), where they become palpable if enlarged. They are also found throughout the thorax, abdomen, and pelvis (Fig. 5.2).
- Each node contains lymphoid follicles with a germinal center that produces new lymphocytes.

Functions of Lymph Nodes

Macrophages within the node destroy bacteria. Cancer cells frequently spread *via* the lymphatic vessels to the lymph nodes.

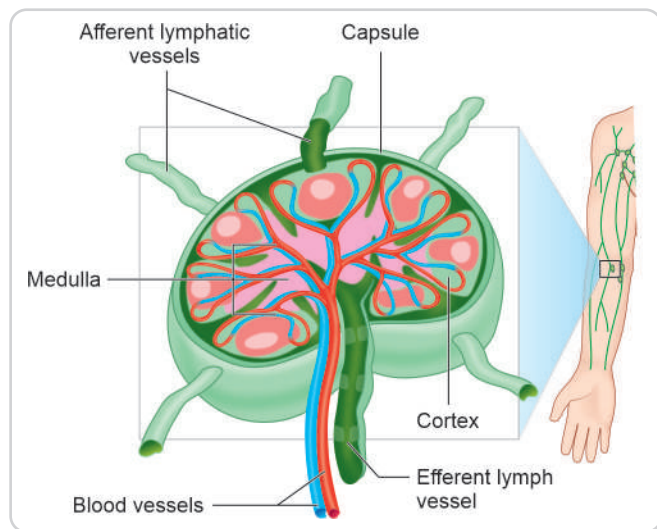


Fig. 5.1: Lymph node

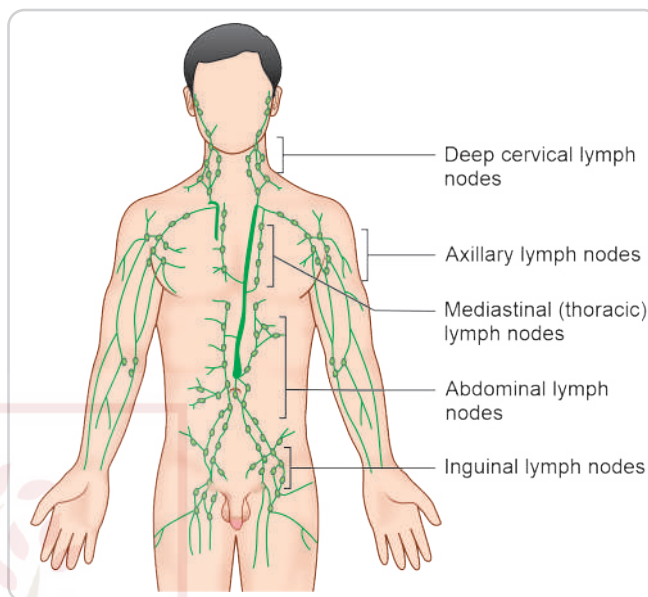


Fig. 5.2: Various groups of lymph nodes

Thymus

- Thymus lies in front of upper part of thorax, in front of heart and big blood vessels.
- It is 15 g at birth and grows up to puberty when it regresses and is replaced by fatty tissue.
- It forms 'T' lymphocytes that migrate to be in the lymphoid tissues (Figs 5.3A and B).

Relations

- **Anterior:** Sternum and upper four costal cartilages.
- **Posterior:** Arch of aorta and its branches.
- **Superior:** Structures in the root of the neck.
- **Inferior:** Heart enclosed in pericardium.
- **Lateral:** Lung enclosed in pleura on each side.

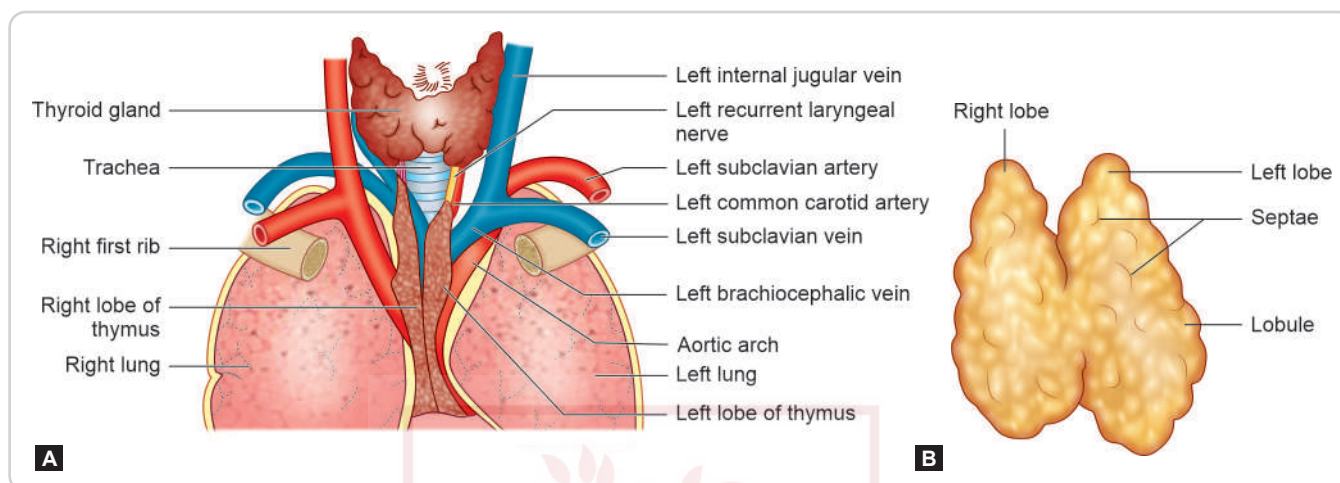
Functions of Thymus

- The thymus acts as the body's primary 'school' for T lymphocytes (T cells).
- It receives immature white blood cells from the bone marrow and programs them to identify and attack foreign pathogens.

Must Know

Thymus gland produces 'T' lymphocytes necessary for immunity of the body. In myasthenia gravis, thymus gland usually increases in size.





Figs 5.3A and B: Thymus gland showing location and its parts

Tonsils

Tonsils are collection of lymphoid tissue at oropharyngeal junction. These are as follows:

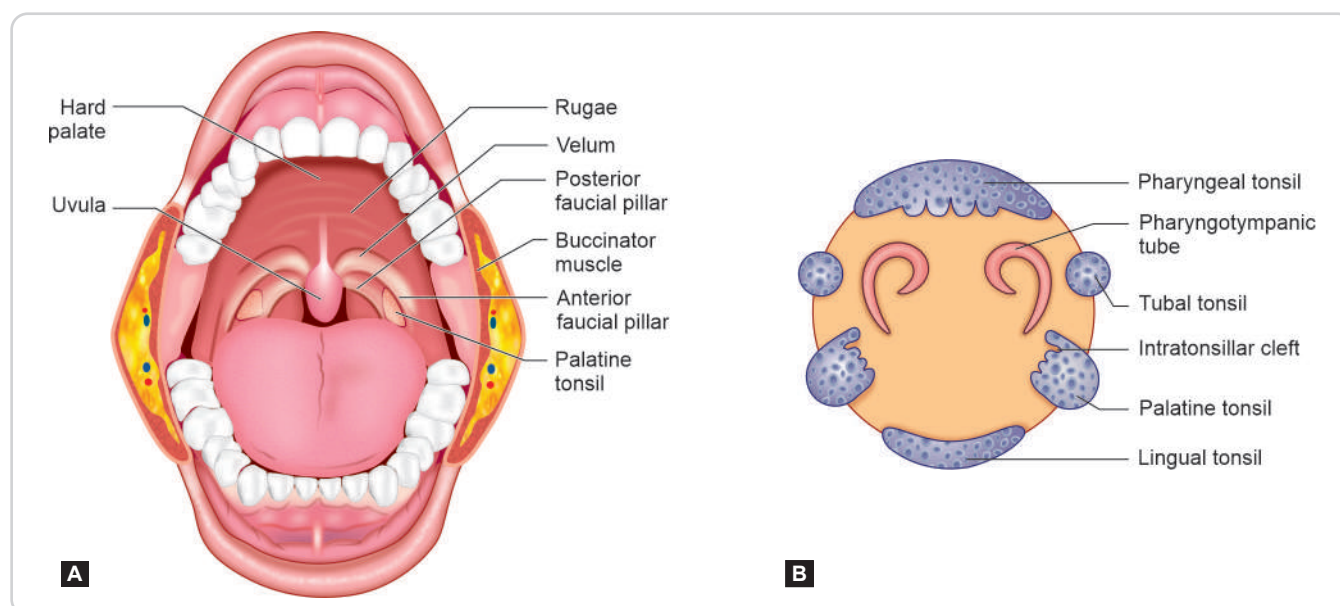
- Palatine tonsils, seen through the open mouth.
- The pharyngeal tonsils are on the posterior wall of the nasopharynx.
- Lymphoid follicles are also present in the tongue and are called lingual tonsils. Palatine tonsils are covered with stratified squamous epithelium. The rest of the structure is same as that of a lymph node.

Waldeyer's Ring

- It is also known as the Waldeyer tonsillar ring.
- At the oropharyngeal isthmus, there are several collections of lymphoid tissue that form the Waldeyer's lymphatic ring.
- It is made up of the pharyngeal tonsil above, right and left tubal tonsils, right and left palatine tonsils and the lingual tonsil below (Figs 5.4A and B).

Function of Tonsils

The tonsils act as the body's first line of defense against inhaled or ingested pathogens.

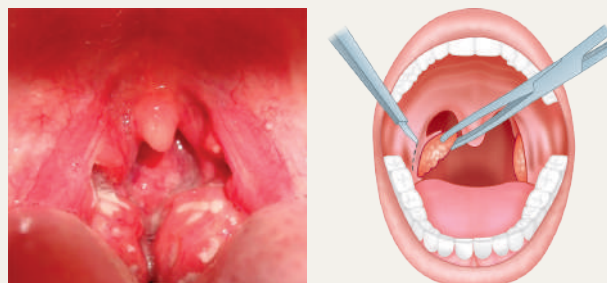


Figs 5.4A and B: A. Tonsils showing location; B. Components of Waldeyer's ring

Clinical Correlation

Tonsillitis and Tonsillectomy

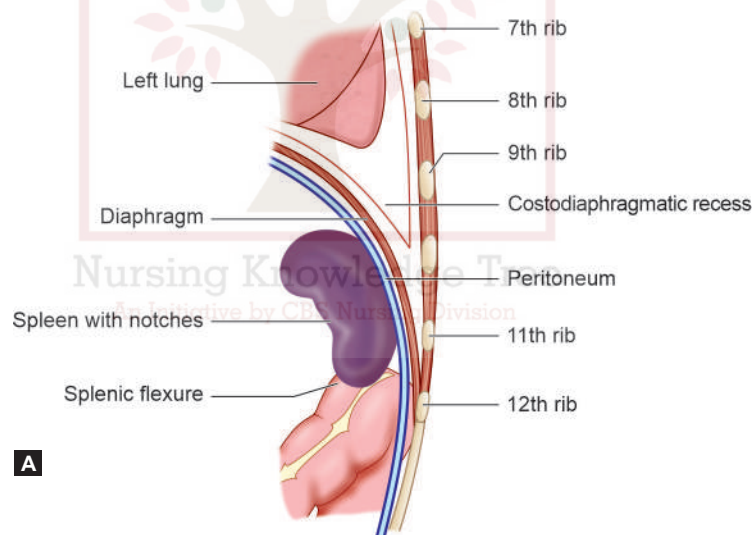
- Tonsils guard the oropharynx against antigens but can be the site of acute infection (tonsillitis).
- The tonsil gets infected and swollen due to bacterial infection.
- Sometimes surgical removal (tonsillectomy) is done, if chronically inflamed.



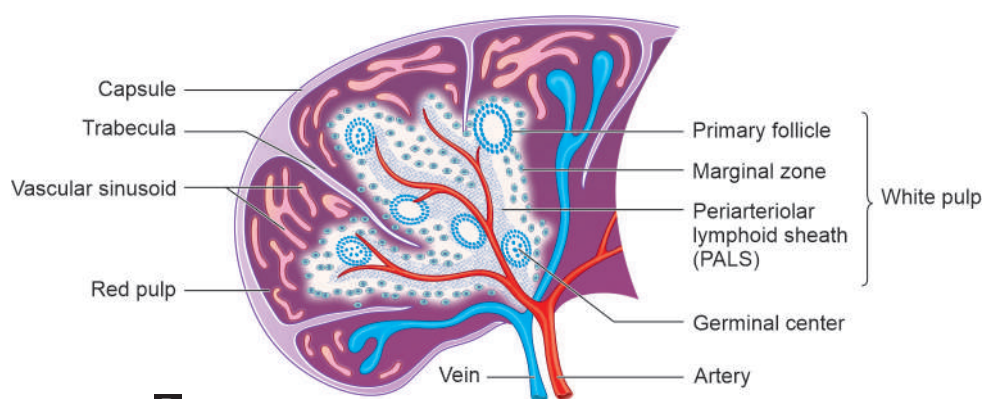
Tonsillitis and tonsillectomy

Spleen

- The spleen is a lymphoid organ located in the upper left abdomen, beneath the left lower ribs and next to the left kidney.
- It is only palpable when significantly enlarged.
- It contains numerous lymphoid follicles with a central arteriole (Figs 5.5A and B).



A

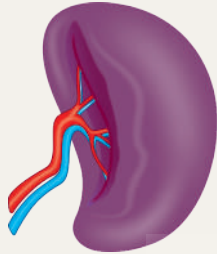


B

Figs 5.5A and B: A. Spleen showing location; B. Internal anatomy

Clinical Correlation

Splenomegaly



The spleen can become enlarged in conditions such as malaria or leukemia, extending obliquely downward. If it ruptures from injury, it must be removed, with its functions then taken over by the lymph nodes, red bone marrow, and liver.

Functions of the Spleen

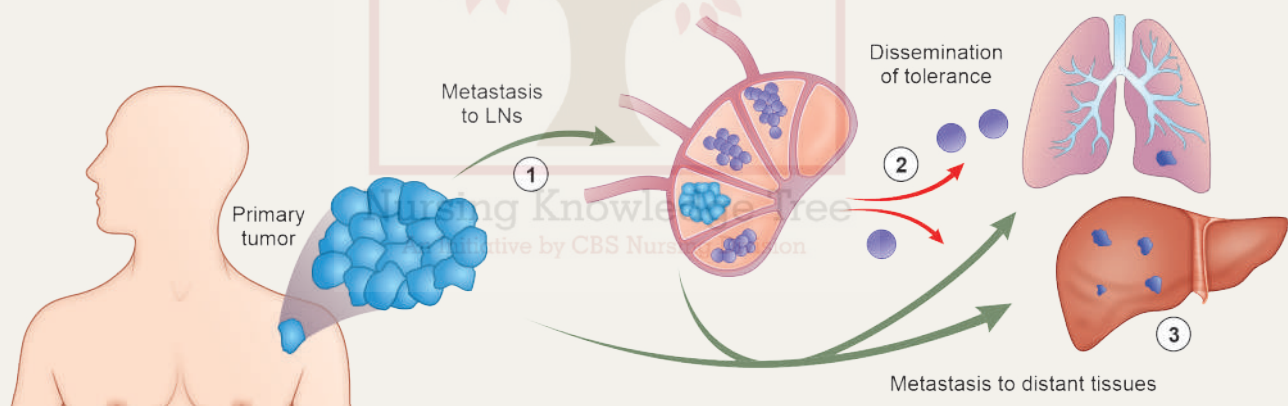
The spleen is concerned with:

- **Hematopoiesis:** Producing blood cells during fetal life.
- **Immunity:** Containing B and T lymphocytes to support the immune response.
- **Blood storage:** Acting as a reservoir for blood.
- **Phagocytosis:**
 - Removing old, abnormal, or damaged erythrocytes (red blood cells), leukocytes (white blood cells), and platelets from circulation.
 - Macrophages within the node destroy bacteria.
 - Cancer cells frequently spread *via* the lymphatic vessels to the lymph nodes.

Clinical Correlation

Metastases of the Cancer

Lymph vessels carry the cancerous cells from their site of origin to distant areas.



Peyer's Patches

In the mucous membrane of the ileum of the small intestine, the lymphocytes are aggregated. These are known as Peyer's patches (Fig. 5.6). They are the first line of defense in digestive system.

Functions of Peyer's Patches

- As part of the gut-associated lymphoid tissue (GALT), they continuously monitor intestinal contents, identify harmful pathogens, and activate targeted immune responses to maintain digestive health.
- Peyer's patches identify potential pathogens and distinguish them from commensals.

LYMPHATIC VESSELS

Lymphatic vessels drain tissue fluid, beginning as blind tubes.

- **Flow:** They drain *via* afferent lymphatics into a lymph node where the lymph filters.
- **Exit:** The filtered lymph leaves *via* efferent lymphatics.

Thoracic duct (largest): Drains the both lower limbs, abdomen, left thorax, left upper limb, and left side of head or neck. It empties into the left subclavian/internal jugular vein junction (Fig. 5.7).

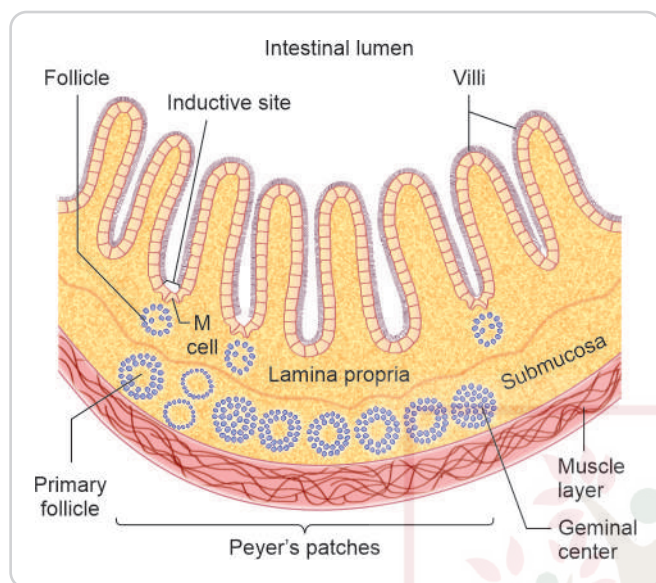


Fig. 5.6: Peyer's patches

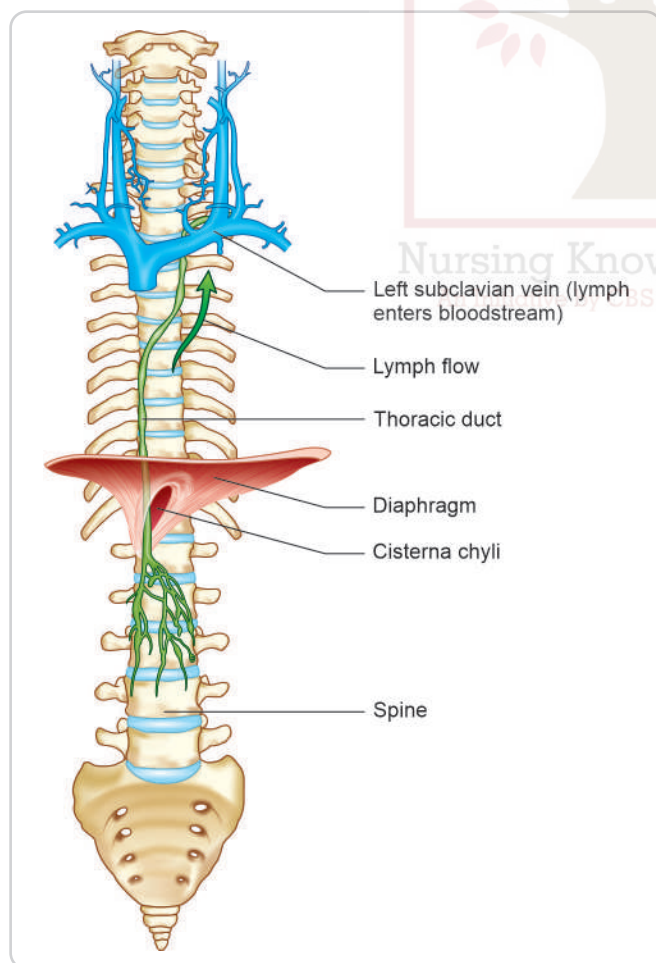


Fig. 5.7: Thoracic duct

- **Location/course:** Originates from the *cisterna chyli* in the abdominal region, travels up through the chest along the spine, and enters the root of the neck on the left side.
- **Drainage area:** Left side of the head, neck, chest, left arm, and the entire body below the diaphragm (both legs, abdomen).
- **Termination:** Empties into the junction of the left internal jugular vein and left subclavian vein.

Right lymphatic duct: Drains the right upper limb, right thorax, and right side of head/neck. It empties into the right subclavian/internal jugular vein junction.

- **Location/course:** A small vessel (1–2 cm) situated in the right cervical region, anterior to the scalene muscles.
- **Drainage area—right upper quadrant:** Right side of the head, neck, thorax, and right arm.
- **Termination:** Empties into the junction of the right subclavian and right internal jugular veins.

Must Know

Lymphatic capillaries are found in most of the places in the body except bone marrow, cartilage, CNS, cornea, nails, and spleen.

LYMPHATIC FLOW

- Lymphatic vessels are thin-walled tubes with valves for one-way flow. They lack smooth muscle; thus, lymph flow relies on pressure from surrounding structures.
- Lymphatic flow (Fig. 5.8) is the one-way, low-pressure movement of lymph fluid (carrying immune cells, waste, and excess tissue fluid) through vessels toward the heart, where it empties into the subclavian veins. Driven by muscle contractions, breathing, and valves, it acts as the body's drainage and immune system.
- Lymph flows from tissue spaces, through lymph nodes, toward the thoracic duct (left side) or right lymphatic duct, eventually returning to the bloodstream.
- Unlike blood, lymph vessels have no pump; they rely on skeletal muscle contractions, deep breathing, and the pulsation of the arteries to move.

Factors affecting lymphatic flow:

- Suction effect
- Intrinsic lymphatic pump
- Pumping by external compression
- Negative intrathoracic pressure
- Interstitial fluid pressure
- Increased capillary surface area
- Increased capillary permeability
- Increased functional activity of tissues.

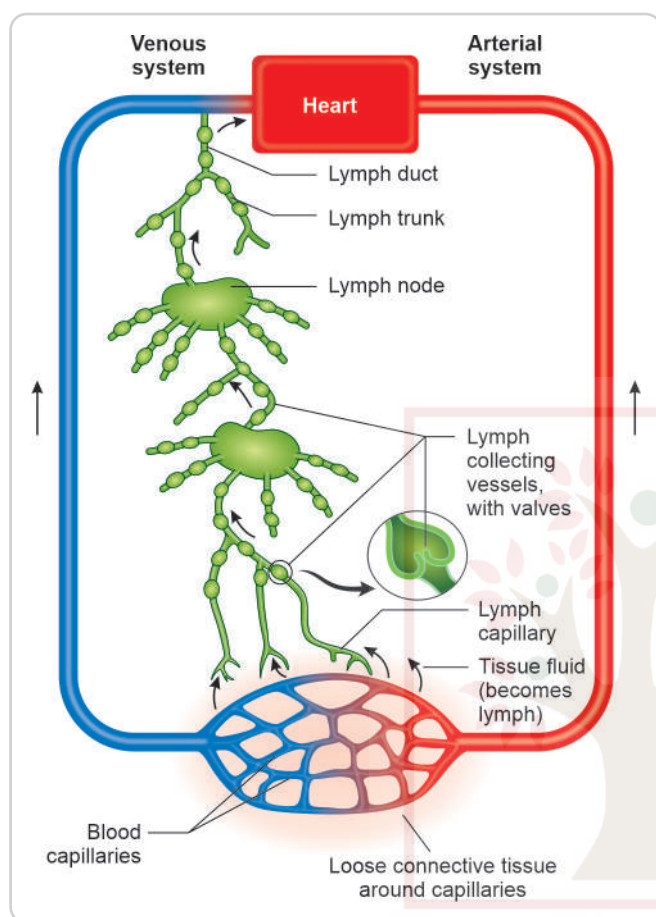


Fig. 5.8: Lymph collection from body

Collection of Fluid into Lymphatic Capillaries

The lymphatic capillaries are more permeable than blood capillaries. Because of being ultrapermeable, lymphatic capillaries allow pathogens and cancer cells to enter easily, which disseminate to other organs. They drain lymph from most tissues, connect to lymph nodes, and transport lymph and lymphocytes back into the blood circulation (Figs 5.9A to C).

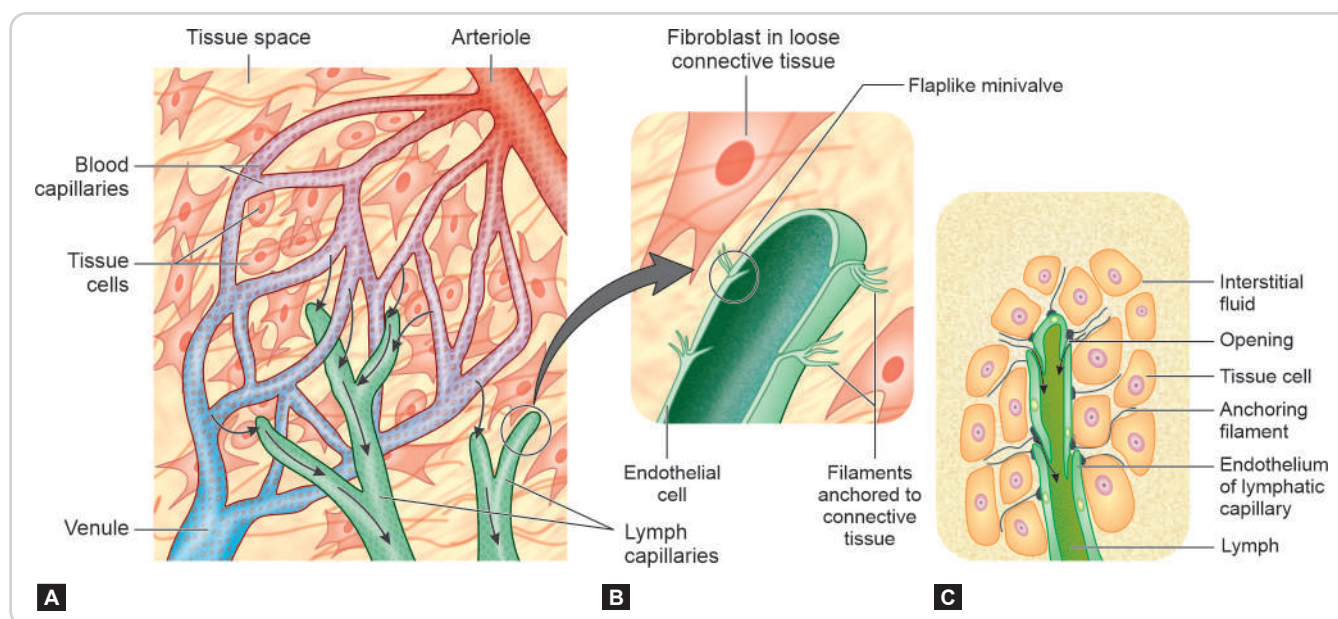
COMPOSITION OF LYMPH

Lymph is surplus tissue fluid that enters lymph capillaries, which join to form lymphatic vessels lymph is composed of:

- | | |
|--|---|
| <ul style="list-style-type: none"> • H₂O (94%) • Solids (6%) • Cells: Lymphocytes, plasma cells • Electrolytes: Same as those of plasma | <ul style="list-style-type: none"> • Urea, creatinine and amino acid • Ca⁺⁺, phosphorus • Chlorides and glucose • Clotting factors, plasma enzymes, and antibodies |
|--|---|

Must Know

- **Normal values:** 120 mL/hr or 2–4 L/day.
- **Rate of lymph flow:** 100 mL/hr in thoracic duct and 20 mL/hr in other lymphatic vessels



Figs 5.9A to C: A and B. Lymph collection from interstitial fluid; C. Diffusion of lymph from the loose connective tissue

FUNCTIONS OF LYMPHATIC SYSTEM

- Lymphatic system produces, stores and recirculates lymphocytes.
- Lymphocytes are concerned with the immune responses.
- Storehouse of macrophages.
- Drainage of surplus tissue fluid with macromolecules into the bloodstream.
- Transport of absorbed fat from intestines into the bloodstream.

PHYSIOLOGY

- The afferent lymphatics carry lymph to the lymph nodes from peripheral tissue.
- The afferent vessels deliver lymph to subcapsular region of lymph node, which contains macrophages, dendritic cells and meshwork of reticular fibers.
- The lymph flows into the outer cortex containing B cells and then it goes to the deep cortex and medullary sinuses, dominated by T cells.
- From here efferent lymphatics collect lymph from medullary sinus and send it toward the venous circulation (Fig. 5.10).

Nursing Implications

- Palpate the lymph nodes in the neck, axilla, inguinal regions to see if these are enlarged, if suspicious situation is present. If enlarged, fine-needle aspiration cytology (FNAC) is done, the diagnosis can help in the treatment at an early stage.
- **Nutrition:** Assess the patient's nutritional status, including caloric intake as well as the consumption. Adequate nutrition is essential for the optimal functioning of the immune system.
- **Infection and immunization:** Immunization status of patient is noted. A history of sexually transmitted diseases is noted along with past or present infections.
- **Treatment:** Any treatment modality that is undertaken by the patient is noted.
- **Allergy:** History of allergy, symptoms experienced due to allergens, medication used for treatment of allergy are noted.
- **Blood transfusion history:** History of blood transfusion is noted, as it may be associated with abnormal immune function.
- **Use of herbal and/or over-the-counter medicines:** History is noted regarding the herbal and/or over-the-counter medicines.
- **Lifestyle:** A detailed history of smoking, alcohol consumption, drug abuse, occupational hazards and pollutants is noted.
- **Assess the history of:** Counsel, educate and support the patients.

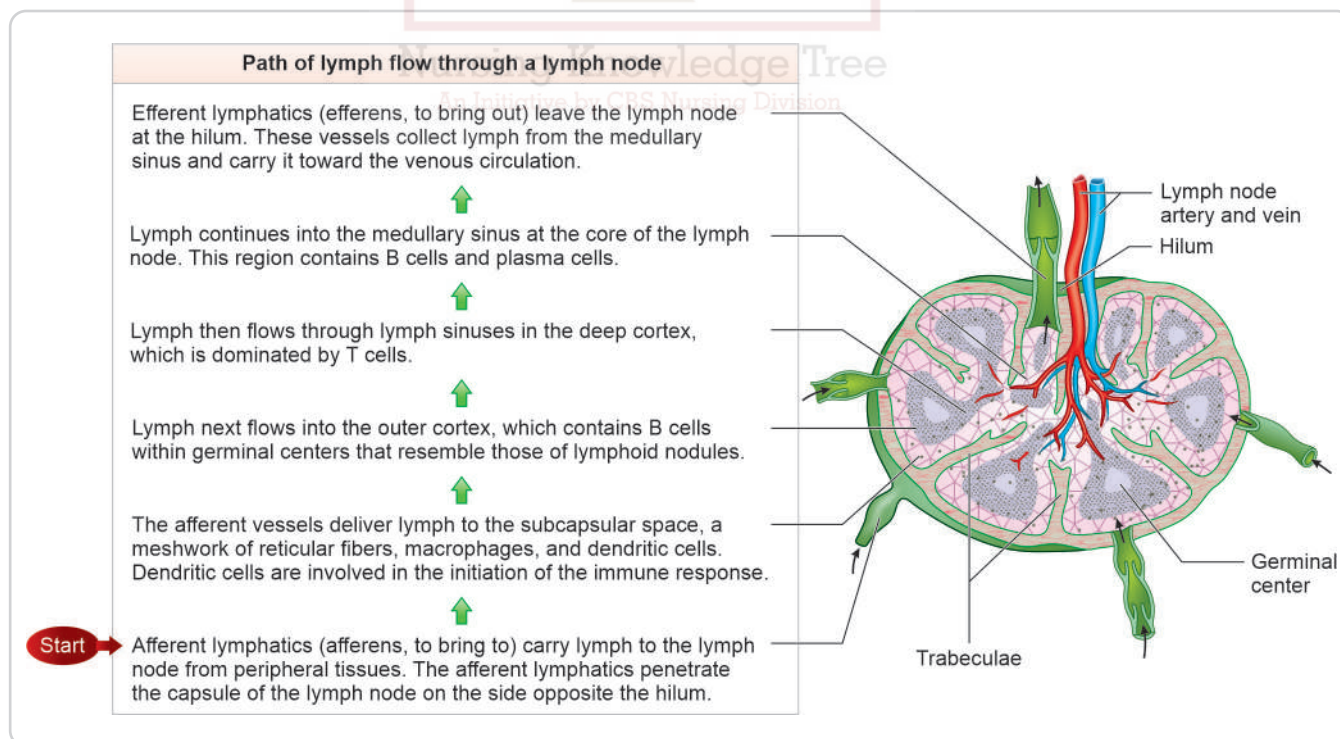


Fig. 5.10: Mechanism of lymph flow

STUDENT ASSIGNMENT

LONG ANSWER QUESTIONS

1. Enumerate the components of Waldeyer's ring. Describe the palatine tonsil.
2. Discuss the functions of lymphatic system.

SHORT ANSWER QUESTIONS

1. Write a note on clinical anatomy of 'Tonsil'.
2. Write short note on lymph and lymphatic vessels.

MULTIPLE CHOICE QUESTIONS

1. **The functions of the lymphatic system include all the following; except:**
 - a. Maintaining tissue fluid balance
 - b. Functioning as body's defense system
 - c. Absorbing fat and other substances from the digestive system
 - d. Producing red blood cells
2. **The process that assists in the transport of lymph includes:**
 - a. Gravity
 - b. Blood moving through the arteries
 - c. Blood moving through the veins
 - d. Contraction of the surrounding skeletal muscles
3. **Absence of lymph nodes is characteristic of:**
 - a. Brain
 - b. Liver
 - c. Lung
 - d. Placenta
4. **All of the following have no lymphatics; except:**
 - a. Brain
 - b. Internal ear
 - c. Cornea
 - d. Liver
5. **Which of the following is the largest lymphatic duct in the body?**
 - a. Right lymphatic duct
 - b. Thoracic duct
 - c. Cisterna chyli
 - d. Efferent lymphatic duct
6. **The thymus gland reaches its maximum size during which period of life?**
 - a. Birth
 - b. Puberty
 - c. Adulthood
 - d. Old age
7. **Which lymphoid organ is responsible for removing old or damaged red blood cells?**
 - a. Thymus
 - b. Tonsils
 - c. Spleen
 - d. Lymph nodes
8. **Waldeyer's ring is located at the:**
 - a. Inguinal region
 - b. Oropharyngeal junction
 - c. Small intestine
 - d. Mediastinum
9. **Lymphatic capillaries are absent in which of the following tissues?**
 - a. Skin
 - b. Muscles
 - c. Central nervous system
 - d. Gastrointestinal tract
10. **The thoracic duct terminates by emptying into the:**
 - a. Right brachiocephalic vein
 - b. Left brachiocephalic vein
 - c. Inferior vena cava
 - d. Portal vein

11. **What are the aggregations of lymphocytes found in the mucous membrane of the ileum called?**
 - a. Lymph nodes
 - b. Peyer's patches
 - c. Tonsils
 - d. Germinal centers
12. **The process of producing blood cells during fetal life in the spleen is known as:**
 - a. Phagocytosis
 - b. Hematopoiesis
 - c. Metastasis
 - d. Hemolysis
13. **Which cell types are primarily involved in antigen-antibody reactions in the lymphoid tissue?**
 - a. Erythrocytes
 - b. Lymphocytes
 - c. Platelets
 - d. Neutrophils
14. **The fluid portion of lymph is composed of approximately how much water?**
 - a. 50%
 - b. 75%
 - c. 94%
 - d. 99%
15. **Which condition is characterized by an increase in the size of the thymus gland and muscle weakness?**
 - a. Malaria
 - b. Leukemia
 - c. Myasthenia gravis
 - d. Tuberculosis
16. **Lymph enters a lymph node through which vessels?**
 - a. Efferent lymphatics
 - b. Afferent lymphatics
 - c. Lymph capillaries
 - d. Thoracic duct
17. **The normal rate of lymph flow in the thoracic duct is:**
 - a. 20 mL/hr
 - b. 50 mL/hr
 - c. 100 mL/hr
 - d. 120 mL/hr
18. **Which of the following does NOT assist in the movement of lymph?**
 - a. Skeletal muscle contraction
 - b. Deep breathing
 - c. Heart as a central pump
 - d. Pulsation of arteries
19. **Tumors of the lymph nodes are specifically referred to as:**
 - a. Carcinomas
 - b. Lymphomas
 - c. Sarcomas
 - d. Adenomas

TRUE OR FALSE

1. Lymphatic vessels contain smooth muscle to pump lymph through the body.
2. The palatine tonsils are covered with stratified squamous epithelium.
3. T-lymphocytes are formed in the thymus and then migrate to other lymphoid tissues.
4. The spleen is easily palpable in a healthy individual during a routine physical exam.
5. Chronic infections of the lymph nodes, such as tuberculosis, usually require 6–8 months of treatment.
6. The right lymphatic duct is the largest lymph duct in the body.
7. Lymph contains more water than plasma.

FILL IN THE BLANKS

1. The _____ duct drains lymph from the right upper limb, right thorax, and right side of the head and neck.
2. The thymus gland is replaced by _____ tissue after it regresses following puberty.
3. The _____ tonsils are located on the posterior wall of the nasopharynx.
4. The spleen is located in the upper _____ quadrant of the abdomen.
5. Lymphatic vessels have _____ to ensure the one-way flow of fluid.
6. The central component of the body's immune system is _____ tissue.
7. The _____ is a sac-like structure in the abdomen where the thoracic duct originates.

ONE-WORD QUESTIONS

1. Name the bean-shaped structures that filter lymph fluid and produce lymphocytes.
2. Which specific lymphoid organ is located in front of the heart and regresses after puberty?
3. What is the medical term for the spread of cancer cells *via* lymphatic vessels to distant areas?
4. Which part of the lymph node contains B cells?
5. Name the surgical removal of chronically inflamed tonsils.
6. Which lymphoid organ acts as a reservoir for blood?
7. What is the term for minute channels that start blindly in tissue spaces?



ANSWER KEY

Multiple Choice Questions

- | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1. d | 2. d | 3. a | 4. d | 5. b | 6. b | 7. c | 8. b | 9. c | 10. b |
| 11. b | 12. b | 13. b | 14. c | 15. c | 16. b | 17. c | 18. c | 19. b | |

True/False Questions

- | | | | | | | |
|----------|---------|---------|----------|---------|----------|----------|
| 1. False | 2. True | 3. True | 4. False | 5. True | 6. False | 7. False |
|----------|---------|---------|----------|---------|----------|----------|

Fill in the Blanks

- | | | | | |
|--------------------|-------------------|---------------|-----------------------|-----------|
| 1. Right lymphatic | 2. Fatty | 3. Pharyngeal | 4. Left-hypochondriac | 5. Valves |
| 6. Lymphoid | 7. Cisterna chyli | | | |

One-Word Questions

- | | | | | |
|----------------|----------------------|---------------|-----------------|------------------|
| 1. Lymph nodes | 2. Thymus | 3. Metastasis | 4. Outer cortex | 5. Tonsillectomy |
| 6. Spleen | 7. Lymph capillaries | | | |