LYMPHATIC SYSTEM
LECTURE OUTLINE

• What is the lymphatic system?
• Functions of the lymphatic system
• Components of the lymphatic system
• Classification of lymphoid organs
• Formation and flow of lymph
• Structure and function of lymphoid tissues and organs
Definition

• ‘The lymphatic system consists of groups of cells, tissues and organs that monitor body surfaces and internal fluid compartments and react to the presence of potentially harmful substances’
Functions of the lymphatic system

1. Drainage of fluid:
   - One of the main functions of the lymphatic system is to collect and return tissue fluid from intercellular spaces in all the tissues of the body back to systemic circulation.
   - Plasma proteins contained in the lymph is also returned to circulation via this means.
2. Absorption and transportation of fat

- Lymphatic vessels located in the villi of the gastrointestinal tract (GIT) known as lacteals are responsible for absorption and transport of ingested lipids.
- Fat soluble vitamins are also absorbed with the lipids via the same means.
3. **Immune function**

- The lymphatic system is associated with cells originating from the bone marrow which mount specific responses in the presence of an antigen or foreign body.
- The B and T lymphocytes recognize foreign cells, toxins, microbes and cancer cells. Their response are specific to a particular antigen or foreign cell.
- Other cells like macrophages, neutrophils, eosinophils etc are also found in the lymphatic system and participate in the immune system. Their response may be however less specific.
Functions of the lymphatic system continued-

4. **Production and maturation of immune cells** - the bone marrow and thymus are responsible for the production and maturation of the B and T lymphocytes.

5. **Filtration of lymph** - the lymph nodes perform filtration function of lymph and trap particles that may be contained in the lymph before it is returned to circulation.

6. Large molecular compounds e.g. enzymes and hormones are also transported through the lymphatic system.

- Intimately related and works synergistically with the immune system and the circulatory system.
- The end result is to ensure immunity and return of lymphatic fluid back to circulation.
COMPONENTS OF THE LYMPHATIC SYSTEM

- Lymph fluid
- Lymphatic vessels
- Immune cells e.g. lymphocytes, macrophages, neutrophils, eosinophils, antigen presenting cells etc.
- Lymphatic tissue/organs
FORMATION OF LYMPH

• Lymph is ultrafiltrate of blood
• Interstitial fluid is formed at the arterial end of capillaries and reabsorbed at the venous end.
• About 10-20% of this fluid is not reabsorbed in the venous end- lymph fluid.
• This fluid enters the lymphatic system via the lymph vessels.
• There is a difference between the composition of plasma and lymph fluid.

Filtration at the capillary bed
Table showing differences between blood, tissue fluid and lymph.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Blood</th>
<th>Tissue Fluid</th>
<th>Lymph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells</td>
<td>Erythrocytes, leucocytes and platelets</td>
<td>Some leucocytes</td>
<td>Lymphocytes</td>
</tr>
<tr>
<td>Proteins</td>
<td>Hormones and plasma proteins</td>
<td>Some hormones and proteins secreted by body cells</td>
<td>Few proteins</td>
</tr>
<tr>
<td>Glucose</td>
<td>More (80-120mg/dl)</td>
<td>None</td>
<td>Less</td>
</tr>
<tr>
<td>Amino acids</td>
<td>More</td>
<td>Less (absorbed by body cells)</td>
<td>Less</td>
</tr>
<tr>
<td>Oxygen</td>
<td>More</td>
<td>Less</td>
<td>Less</td>
</tr>
<tr>
<td>Carbondioxide</td>
<td>More</td>
<td>More (released by body cells)</td>
<td>Less</td>
</tr>
</tbody>
</table>
Lymph Flow

- Rate of flow is generally slow.
- An increase in pressure of interstitial fluid causes increased flow into the lymph vessels.
- Valves in lymph vessels prevent retrograde flow.
- Skeletal muscle contraction and pulses generated by arteries help to propel lymph through the lymphatic channels.
- Absent in areas like brain, bone marrow and cartilages.
Unidirectional flow of lymph in lymphatic vessels ensured by valves
Lymph Circulation

Lymphatic capillaries
- Lymphatic vessels
- Lymph nodes
- Lymph trunks
- Cisterna Chyli
- Lymph ducts
- Blood

(b) Areas drained by right lymphatic and thoracic ducts

- Orange: Area drained by right lymphatic duct
- Green: Area drained by thoracic duct
Classification/components of the lymphatic system

1. **LYMPHOID TISSUE** *(POSSES NO CONNECTIVE TISSUE CAPSULE)*
   a. Diffuse Lymphoid Tissue
   b. Nodular Lymphoid Tissue
      - solitary nodules
      - aggregate nodules

2. **LYMPHOID ORGANS** *(POSSES CONNECTIVE TISSUE CAPSULE)*
   a. Primary Lymphoid Organs:
      - bone marrow
      - thymus
   b. Secondary Lymphoid Organs:
      - lymph node
      - spleen
Lymphoid tissue

• Lymphocytes

• **Cells of reticular meshwork**
  - Reticular cells (produce reticular fibers)
  - APCs-antigen presenting cells
  - Macrophages
Diffuse Lymphoid Tissue:

- Loose cells
- No capsule
- Example:
  - MALT (mucosa assoc. lymphoid tissue)
  - GALT (Gut associated lymphoid tissue)

Nodular Lymphoid tissue

- Contained in meshwork of reticular fibers
- Walls of GIT, Genitourinary tract, Respiratory tract
- No capsule
• **Nodular Lymphoid Tissue:**
  - Characterized by **nodules / follicles**
  - **Primary nodule** – mainly consists of small lymphocytes
  - Indicate that there is no antigen exposure

Primary lymphoid nodule
Secondary nodule

- Lymphatic nodule with a **germinal center (GC)** - area where lymphocytes undergo active proliferation

- Germinal center mainly contains:
  - lymphoblasts
  - plasmoblasts

- Germinal center indicates active immunological response to antigen

- Mantle zone or corona- consists of small lymphocytes around GC
Lymphoid organs

- **THYMUS**
  - it is embryologically derived from the third pharyngeal pouch
  - located in the superior mediastinum
  - location for the proliferation and maturation of T cells (originate from the bone marrow)
  - it is well developed in early childhood
  - thymus begins involution at puberty
  - by adulthood, most of the thymus has atrophied and replaced by adipose tissue
Thymus

- **Origin**: mainly 3rd pharyngeal pouch
- **Primary lymphoid organ**
- Multipotent lymphoid stem cells invade epithelial rudiment to differentiate as T lymphocytes
- Immature T lymphocytes are called thymocytes
- **Epithelial component-ERCs (EPITHELIORETICULAR CELLS)**
- ERCs establish a protective blood-thymus barrier that prevents the developing thymocytes from coming in contact with antigens.
• Covered by a thin connective tissue capsule.
• Trabeculae from the connective tissue divide it into lobules.
• Each lobule contains a cortex and a medulla.

**Thymus - cortex**
• Cortex contains mainly thymocytes, is darker staining (due to tightly packed lymphocytes) and also epithelioreticular cells (ERCs).
**Thymus - medulla**

- Blood vessels in medulla lose ERC covering
- Lymphocyte differentiate and enlarge
- Mature T cells migrate into medullary blood vessels and **efferent** lymphatics
- ERC’s contract into spherical, degenerative masses – Hassall Corpuscle
RED BONE MARROW

• Is a primary lymphoid organ

• Site of production of T and B lymphocytes

• Immature T lymphocytes exit the bone marrow to the thymus for maturation and differentiation

• B lymphocytes develop, mature and differentiate in the bone marrow
LYMPH NODE

- Kidney or bean shaped
- Encapsulated – dense connective tissue
- Trabeculae divides nodes into compartments
- Efferent and afferent lymphatic vessels
- Subdivisions- cortex and medulla
- Filters lymph and mounts immune response via recirculation of lymphocytes
- Has a Hilum where arteries and veins & efferent lymphatics exit
- Afferent lymphatic vessels drain lymph through the convex margin
**Cortex:**
Outer cortex: lymph nodules, B cells
Inner cortex (paracortex): T cells, dendritic cells

**Medulla:** B cells, reticular cells, reticular fibers
Sinuses and cords: reticular fibers, lymphocytes, macrophages
Circulation of lymph in the lymph node

Diagram of a lymph node
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Flow of lymph

- Lymph from afferent lymphatic vessels
- Drain into subcapsular sinuses
- From the subcapsular sinuses, lymph flow into the trabecular sinuses
- Then to the medullary sinuses
- And finally exit via the efferent lymphatics in the hilum of the lymph node.
SPLEEN

- The spleen is a secondary lymphoid organ

- The major function of the spleen is to filter blood

- Located at the left-posterior abdominal wall under cover of ribs 9-11

- Largest lymphoid organ

- It is covered by a dense connective tissue capsule which continues as trabeculae in the parenchyma of the organ

- Unlike the lymph nodes, contains no cortex or medulla
SPLEEN

- Consists of **red pulp and white pulp**

- **RED PULP**
  - contains capillary sinusoids
  - splenic cords (of Billroth): laced with lymphocytes, macrophages, plasma cells, granulocytes, etc.

- **WHITE PULP**
  - consists of focal accumulation of lymphocytes with macrophages
  - central artery located in the white pulp is ensheathed by T lymphocytes & macrophages
SPLENIC PARENCHYMA

WHITE PULP: Lymphocytes, macrophages, central artery

RED PULP: venous sinuses, splenic cords: lymphocytes, macrophages, plasma cells, granulocytes, RBCs
**WHITE PULP:**
- B cells and T cells carry out immune functions.
- Macrophages destroy blood-borne pathogens by phagocytosis.

**RED PULP**
- Removal by macrophages of ruptured, worn out, or defective blood cells and platelets.
- Storage of platelets, up to one-third of the body’s supply.
- Production of blood cells during fetal life.
TONSILS

• Tonsils are lymphoid tissues

• Part of gut associated lymphoid tissue (GALT)

• Process antigens that may attack the body via the oral or nasal cavity

• Are partially encapsulated

• Include the pharyngeal tonsil, palatine tonsils and lingual tonsils

• Together they form a lymphoid ring at the back of the oral cavity called Waldeyer’s ring
PHARYNGEAL TONSILS

• Located at the posterior wall of the pharynx

• Called adenoids when enlarged by inflammation

• Contains many lymph nodules
LINGUAL TONSILS

• Found at the posterior aspect of the tongue

• Also contains crypts (shallow)

• Associated with mucus glands
PALANTINE TONSILS

• Paired tonsil found on either side of the mouth posteriorly

• Contains deep crypts formed by epithelial invagination

• Mainly secondary nodules are found in this region
Tonsillitis

Inflammation of the Tonsils

Common causes
Virus
Bacteria

Symptoms
Headache, fever, malaise
enlarged lymph nodes in the neck, dysphagia.
LYMPH NODES IN THE HEAD AND NECK

- Posterior auricular
- Occipital
- Preauricular
- Parotid
- Tonsillar (Jugulodigastric)
- Submental
  - Lower lip, floor of mouth, apex of tongue
- Submandibular
  - Cheek, side of nose, lower lip, gums, anterior tongue
- Supraclavicular
  - Thorax and abdomen
- Deep cervical
  - Other nodes of head and neck, occipital scalp, ear, back of neck, tongue, trachea, nasopharynx, nasal cavities, palate, esophagus
- Superficial cervical
  - Lower ear and parotid
LYMPHATIC DRAINAGE OF THE THORACIC WALL
LYMPH NODES OF THE UPPER LIMB
LYMPH NODES OF THE LOWER LIMB
RIGHT LYMPHATIC DUCT

Drains lymph from the following parts of the body:

• Upper right side of the trunk above the diaphragm (via the right bronchomediastinal trunk)

• Right upper limb (via right subclavian trunk)

• Right side of the head and neck (via right jugular trunk)

The right lymphatic duct usually drains into the right subclavian, at its junction with the right internal jugular vein.
Thoracic duct is the largest lymphatic vessel in the human body. It usually starts at the level of the 2\textsuperscript{nd} lumbar vertebra and extends to the neck.

- Collects and drains lymph from the lower part of the body below the diaphragm, left side of the trunk above the diaphragm, the left upper limb and the left side of the head and neck.

- It drains/empties into the left brachiocephalic vein.
LYMPHEDEMA

ELEPHANTIASIS....... Caused by filarial worms obstructing lymphatic vessels
Lymphedema secondary to surgical removal of lymph nodes