L-6  Lymphatic System and Defense Mechanism (Immune Response)

Dr Than Kyaw
12 March 2011
Lymphatic system

Includes:

1. lymphatic vessels

2. Lymphoid tissues
   - lymph node
     - nodules
   - lymph patches of mucosa of intestinal, respiratory, reproductive systems; also k/s mucosa-associated lymphoid tissue (MALT)
     - e.g. Payer’s patches
   - spleen
   - thymus
   - tonsils
Lymphatic system of the cow
Clinical examination of lymphatic system

- Procrural lymph node
- Retropharyngeal lymph node
- Parotid lymph node
- Supramammary lymph node
- Submandibular lymph node
- Prescapular lymph node

Clinician’s hand lifting udder to facilitate palpation of supramammary lymph node

Locations of palpable lymph nodes in cattle showing placement of the clinician’s hand
Lymphatic system of cat

- Submandibular Nodes
- Thoracic Duct
- Cervical Nodes
- Inguinal Node
- Popliteal Node
- Axillary Node

Lymph Node (cross section)
The main lymph nodes and lymphatic ducts of the dog

- Parotid lymph node
- Retropharyngeal lymph nodes
- Tracheal duct
- Thoracic duct
- Cisterna chyli
- Submandibular lymph nodes
- Prescapular lymph node
- Axillary lymph node
- Bronchial lymph nodes
- Mesenteric lymph nodes
- Superficial inguinal lymph nodes
- Popliteal lymph node
Characteristics of Lymphatic vessels

- Distributed throughout the body
- Have **blind beginnings** (lymph capillaries)
- In interstitial spaces (between the cells and outside of the blood vessels)
- Similar structure to blood capillaries and veins
Characteristics of Lymphatic vessels

- One way system toward the heart (unidirectional flow)
- No pump
- Lymph moves toward the heart by
  - Contraction of surrounding skeletal muscles
  - Rhythmic contraction of smooth muscle in the lymphatic vessel walls
  - Pressure changes in the thoracic cavity during respiration

-- Largest lymphatic vessels join with the large veins just cranial to the heart
-- no lymph vessels in the brain (CSF)
Lymph Capillaries in the Tissue Spaces

- Lymph capillary
- Arteriole
- Tissue fluid
- Tissue cells
- Tissue spaces
- Venule
- Lymphatic vessel
Lymph

- Lymph is usually a clear, colorless fluid, similar to blood plasma but low in protein.
- Its composition varies from place to place; e.g. - after a meal, lymph draining from the small intestine, milky lymph (chyle), due to lipid content.
- Lymph may contain numerous lymphocytes, macrophages, inorganic salts, glucose, and other nitrogenous substances.
- May also contain viruses, bacteria, cellular debris and even traveling cancer cells.
- Neutrophils – not normally present in large numbers except during acute infections.
Lymph node

- Various sizes; along lymph v/s
- Surrounded by connective tissue **capsule** which sends fine vascular fibrous **trabeculae** into the substance of the node.
- Roughly divided into
  1. Cortex
  2. Paracortex
  3. Medulla

Each with large number of lymphocytes and macrophages

1. **Cortex**  --  Lymphocytes arranged in **nodules**
   -- **primary nodules**  --  dark staining
   -- **secondary nodules**  --  light staining
     - Germinal center
     - rapid **B cell proliferation**
2. Paracortex
   -- Deep to the cortex
   -- Primarily *T lymphocytes* and *dendritic* cells (a type of phagocyte and a type of antigen-presenting cell (APC))

3. Medulla
   -- Lymphocytes arranged in medullary cord
   -- primarily – accumulation of *plasma cells*

*Dendritic* cell: A special type of immune cell that is found in tissues, such as the skin, and boosts immune responses by showing antigens on its surface to other cells of the immune system.

*Plasma* cell: A type of immune cell that makes large amounts of a specific antibody. Plasma cells develop from B cells that have been activated.
Structure of a typical lymph node

- Subcapsular sinus
- Lymphocyte accumulation in deep cortex
- Afferent lymphatics
- Lymphatic capillary
- Post capillary capsule
- Lymphatic nodules
- Medullary cord
- Medullary sinus
- Medullary trabecula
- Efferent lymphatics
A lymph node showing nodular and diffuse lymphatic tissue.
Lymph node dog

1 = Capsule
2 = Cortical sinus
4 = Deep cortex
7 = Lymph nodule
8 = Medullary cord
9 = Medullary sinus
12 = Subcapsular sinus
13 = Trabeculae

GC = Germinal center
A Lymph node of **Pig**

What are the differences?

A Lymph node of **cow**
Lymph node

Subcapsular sinus

-- space immediately deep to the capsule
-- communicate with other sinuses of cortex and medulla
-- lymph delivered by afferent lymph vessels enters subcapsular sinus and slowly filtered through the cortex and medulla
-- finally emerge at the hilus of the node
Lymphocytes of the lymph node

- **T Cells (T lymphocytes)**
  - attack foreign cells or body cells infected by viruses; T cells mature and divide in the **thymus**
  - responsible for **cell-mediated immunity** (protection directly from living cells)

- **B Cells (B lymphocytes)**
  responsible for **antibody-mediated immunity** (=**humoral immunity**); a percentage of circulating B lymphocytes mature into **plasma cells**; plasma cells produce and secrete **antibodies** (immunoglobulins) which destroy antigens

- **NK Cells (natural killer cells)** - attack foreign cells and cells infected with viruses and cancer cells; also abnormal cells of body
LYMPHOCYTE and MEMORY

- Some B and T cells have what is called “memory”.
- Memory Cells have the ability to divide on short notice to produce more of all of the B and T cells.
- **This is the basis of acquired immunity.**
- B and T cells amplified in response to antigen are reserved and circulate in lymphatic system..for years or even life.
- If same antigen enters body again immune response will take place rapidly and *without* full-blown illness.
Lymph node and infection

-- A LN may reflect local health condition
-- E.g. LN of infected area -- enlarged
  -- Germinal centers produce additional lymphocytes in response to **antigens** (bacteria, virus) delivered to the node
  -- Frequently associated with pain on palpation
  -- An enlargement of LN indicates infection
  -- at least 99% of the pathogens in the lymph are removed

** Neoplastic (cancerous) cells may spread through the lymphatic channels.
Five classes immunoglobulin (Ig)

IgG - active in blood against bacteria and viruses
    helps activate complement
    helps phagocytes eliminate antigens
    most common antibody in the blood
    can pass v/s and placenta

IgM - reacts with certain antigens, usually on first exposure

IgA - most common in mucosa

IgD -- rare in blood
    usually found on B cells (not released)
    may be involved in B cell activation

IgE -- rare in blood
    involved in allergic reactions
    sticks to mast cells, which release inflammatory substances
Hemal node

- Small dark red or black nodes in cattle and sheep
- Usually located in the dorsal parts of the abdominal and thoracic cavities
- Resembles LN but re found on the course of blood vessels and contains only blood.
Functions of lymphatic system

Has multiple interrelated functions:
- responsible for the removal of interstitial fluid from tissues
- absorbs and transports fatty acids and fats as chyle from the digestive system
- transports WBCs to and from the lymph nodes into the bones
- transports antigen-presenting cells (APCs), such as dendritic cells, to the lymph nodes where an immune response is stimulated.
  - body’s most important defence mechanism against invasion by pathogens
  - production of immunoglobulin
- filters lymph and blood
Spleen

- Largest lymphoid organ

Functions
- Contractile – expresses RBCs into the blood vessels
- The only organ to filter the blood
- An active destruction site for RBCs (MPS – mononuclear phagocytic system)
- Storage of iron
- Initiation of immune responses by B cells and T cells in response to antigens in circulating blood
- Acts as a blood reservoir

• Not essential for life
• Splenectomy - bone marrow takes place its function
Spleen

**RED PULP vs. WHITE PULP:**

**Red pulp**
- Area containing a large number of RBCs
- Structurally consists of a network of reticular fibers rich in macrophages
- mainly concerned with disposing of worn-out red blood cells and bloodborn pathogens

**White pulp**
- Area that resembles lymphoid nodules
- Composed mostly of lymphocytes suspended on reticular fibers and involved with the immune functions of the spleen
Thymus

- An organ of immature animal
- Undergo involution at puberty
- Lies cranial to the heart
- Accumulation of lymphocytes (k/s thymocytes)
- Embryonic lymphocyte undergo differentiation and leave to populate many other lymphatic tissues of the body
TONSILS

-- Unencapsulated aggregate of lymphoid nodules associated with the pharyngeal mucosa
-- Lack afferent lymphatic vessels
-- rely on the proximity of epithelial surface to make contact with antigens
-- have crypts that increase surface area
PEYER’S PATCHES

-- Peyer's patches are clusters of lymphoid nodules deep to the epithelial lining of the small intestine
-- Contain lymphocytes and macrophages which remove microorganisms, debris, and antigens from the digestive tract

**Note:** Although the terms tonsils and Peyer’s patches for pharynx and small intestine respectively used, identical histological structures are found in the mucous membranes of prepuce and vagina etc.
Chicken

-- no lymph nodes
-- Bursa of Fabricius: a sac like dorsal diverticulum of the proctodeum
  -- unique to birds.
    -- characterized by tall, thick mucosal folds (plicae) filled with numerous polyhedral follicles.
    -- Each follicle, composed of lymphatic tissue, is divided into a cortex and medulla.
Filtration and edema

• Recall lecture on flow
• The balance between pressure changes between arterioles and veinules (tissue space)
Edema

- Increased venous pressure leads to increased interstitial fluid volume (edema).

- **3 counteracting effects** (*Negative feedback*) against edema.

1. An increase in interstitial fluid hydrostatic pressure reduces the rate of filtration back toward normal.
2. An increase in lymph flow reduces interstitial fluid volume back toward normal.
3. A decrease in interstitial fluid protein concentration reduces the rate of filtration back toward normal.
Lymphatic obstruction

↑ Venous pressure

↓ Lymph flow

↑ Interstitial protein concentration

↓ Capillary filtration

↑ Interstitial fluid volume

↑ Interstitial fluid pressure

(−) Negative feedback

↑ Capillary hydrostatic pressure

↑ Filtration

↑ Interstitial fluid volume (edema)

↑ Interstitial fluid pressure

↓ Lymph flow

↓ Interstitial protein concentration

(−) Negative feedback
# CIRCULATORY SYSTEMS

<table>
<thead>
<tr>
<th>Cardiovascular</th>
<th>Lymphatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derived from mesoderm</td>
<td>Derived from mesoderm</td>
</tr>
<tr>
<td>Transport System</td>
<td>Transport System</td>
</tr>
<tr>
<td>Has a pump (heart)</td>
<td>No pump</td>
</tr>
<tr>
<td>Arteries</td>
<td>No equivalent</td>
</tr>
<tr>
<td>Veins for return</td>
<td>Lymph vessels for return</td>
</tr>
<tr>
<td>Veins have valves</td>
<td>Lymph vessels have valves</td>
</tr>
<tr>
<td>Carries RC, WBC, plasma</td>
<td>Carries WBC, plasma</td>
</tr>
</tbody>
</table>