LYMPHATIC CIRCULATION

LYMPH: FORMATION AND COMPOSITION

Formation. As discussed in capillary exchange, most (90%) of the fluid filtered at arterial end of the capillary is reabsorbed at its venous end; and the remaining 10% enters the circulation through lymphatics and is called lymph. Thus, the lymph is a transudate formed from blood in the tissue spaces, i.e. it is derived from the interstitial fluid.

Composition of lymph is similar to plasma except that its protein content is usually lower than that of plasma.

Protein content of the lymph varies with the region it drains:

- In most of the tissues, protein concentration of the interstitial fluid is 2 gm/100 ml, so lymph also has same content of protein.
- Lymph from liver has protein concentration of 6 gm/100 ml and that from the intestine 3-4 gm/100 ml.
- Since, about two third of the lymph is derived from liver and intestine, therefore, thoracic duct lymph (mixture of lymph from different areas) has usually a protein content of 3-5 gm/100 ml.

Fat content. Since, the lymphatic system also provides a route of absorption of long-chained fatty acids and cholesterol from the intestine (in the form of *chylomicrons*), so the lymph from the intestine contains these large molecules of fat. After a fatty meal these fat globules may be so numerous that lymph becomes milky and is then called *chyle*.

Cellular content. Suspended in the lymph are cells that are chiefly lymphocytes. Most of these lymphocytes are added to the lymph as it passes through lymph nodes, but some are derived from the tissues drained by the nodes.

LYMPHATIC VESSELS

The lymphatic system constitutes an accessory route for the removal of interstitial fluid. The small lymph vessels are called lymph capillaries and the large lymph vessels are called lymphatic trunks and the largest lymph vessel is thoracic duct.

Lymph capillaries

The lymph capillaries are *present* in most tissues of the body except brain, cartilage, splenic pulp, bone marrow and avascular structures (e.g. cornea, nails).

The lymph capillaries *originate* as closed endothelial tubes that are permeable to fluid and high-molecular weight compounds.

The *structure* of lymph capillaries (Fig. 4.4-28) is basically similar to that of blood capillaries with following differences:

- The basal lamina around the endothelial cells is absent or poorly developed,
- Pericytes or connective tissue are not present around the lymph capillaries,
- There are no visible fenestrations in the endothelium, and
- The junctions between endothelial cells are open, with no tight intercellular connections. In fact, the edges of the endothelial cells overlap in such a way that they form minute flap valves. So, through the lymph capillary the substances that can pass are larger molecules such as proteins, fat droplets, and particulate matter like bacteria. But once inside, the fluid particles cannot move out of capillary wall, since the tendency to backflow closes the flap valve (Fig. 4.4-28).

Larger lymph vessels

The lymphatic capillaries join to form larger lymph vessels which ultimately form lymphatic trunks and lymphatic ducts as:

Thoracic duct is the largest lymph vessel in the body. It carries lymph from both sides of the body below the diaphragm and from the left side above the diaphragm. Near its termination it receives the *left subclavian lymphatic*

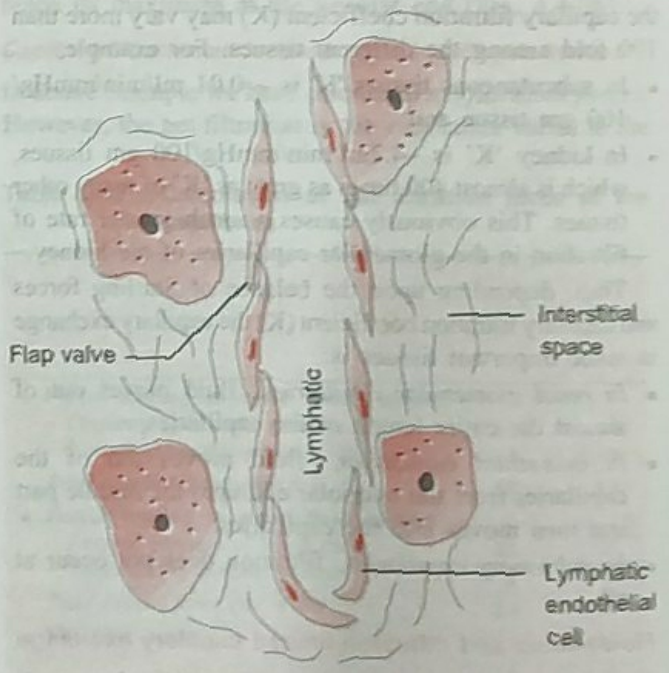

Fig. 4.4-28. Structure of lymphatic capillary.

trunks carrying lymph from left upper limb, the *left jugular lymphatic trunk* carrying lymph from left half of head and neck, and sometimes the *left brchomediastinal lymphatic trunk* carrying lymph from left half of thorax (usually this trunk enters the subclavian vein independently).

The thoracic duct ends by opening into the junction of the left subclavian vein and the internal jugular vein.

Right lymphatic duct drains lymph from the right half of the body above the diaphragm. It is formed by the *right bronchomediastinal trunk* carrying lymph from the right half of thorax, *right jugular trunk* draining lymph from the right half of head and neck, and *right subclavian trunk* carrying lymph from the right upper limb. The right lymphatic duct ends by opening into the right subclavian vein.

Structure of larger lymph vessels is similar to that of veins:

- *Three coats*, i.e. tunica intima, tunica media and tunica adventitia can be distinguished.
- *Valves* similar to those in veins are present in abundance in small as well as large lymphatic vessels. The valves often give lymph vessels a beaded appearance.

LYMPH FLOW

Functions of lymph flow

1. ***Returns proteins from tissue spaces to blood.*** Lymph flow represents the only mechanism for returning albumin and other interstitial macromolecules to the circulatory system. The lymphatic system recovers approximately 200 gm of protein daily that has been lost from the microcirculation. In addition, excess fluid is removed from the interstitium to maintain a gel state.

2. ***Absorption of nutrients,*** especially fats from the gastrointestinal tract.

3. ***Acts a transport mechanism*** to remove red blood cells that have lost into the tissues as a result of haemorrhage.

4. ***Supplies nutrients and oxygen*** to those parts where blood cannot reach.

5. ***Role in defence mechanism.*** Lymph nodes associated with lymphatic system act as efficient filters. They have sinuses lined with phagocytic cells that engulf bacteria, red cells and other particulate material.

Mechanism of lymph flow: Factors affecting:

1. ***Intrinsic lymphatic pump.*** Lymph is pumped out of the tissues by the lymphatic vessels which have valves and smooth muscles in their walls. They contract in a peristaltic fashion, propelling the lymph along the vessels. The extensive system of one-way valves present in the lymphatics maintain lymph flow towards the heart.

2. ***Pumping by external compression of the lymphatics.*** Though the contractions of lymphatics are the principal factor propelling the lymph, the lymph is also pumped by the external compression of the lymphatics by:
   - Contraction of the skeletal muscles,
   - Movements of different body parts,
   - Arterial pulsations, and
   - Compression of tissue by objects outside the body.

3. ***Negative intrathoracic pressure*** during inspiration increases the rate of lymph flow.

4. ***Suction effect of high velocity blood flow*** in the veins in which the lymphatics terminate also promotes lymph flow.

5. ***Interstitial fluid pressure.*** An increase in the interstitial fluid pressure increases the lymph flow upto a certain limit.

6. ***Increase in capillary surface area*** by capillary distension is associated with increased lymph flow under following conditions:
   - Increased capillary pressure,
   - Increase in local temperature, and
   - Infusion of fluid.

7. ***Increase in capillary permeability*** under following conditions is also associated with increased lymph flow:
   - Increase in temperature,
   - Effect of toxins, and
   - Decreased oxygen (hypoxia).

8. ***Increase in functional activity of the tissue*** also increases the lymph flow.

Normal lymph flow

Normal lymph flow is 2-4 L/day (80 to 150 ml/hour) for the entire body.

Rate of lymph flow varies in different organs and is highest in the gastrointestinal tract and the liver.

In lymphatics rate of lymph flow is 100 ml/hour through thoracic duct and about 20 ml/hour through other lymphatic channels.

Rate of formation of lymph is somewhat accelerated by regional venous obstruction (which leads to decreased absorption of tissue fluids into blood capillaries) and also by arteriolar dilatations (which leads to increased tissue fluid formation).