3.4: Lymph

3.4.1: What is Lymph?

Lymph is the name given to interstitial fluid which enters the lymphatic vessels.

Lymphatic capillaries are present in nearly all tissues. Significant exceptions are the central nervous system and bone. Small interstitial channels are present in the brain and the fluid flows into the CSF and then passes back into the circulation via the arachnoid villi.

The lymph capillaries are blind-ending and possess flap valves between adjacent lymphatic endothelial cells. These functional valves permit entry of ISF but prevent its return to the interstitium. The pressure inside the lymph capillary is about 1 mmHg at rest and the flap valves are closed. The lymph capillaries interconnect and join together to form lymph venules, and then large lymph veins which drain via lymph nodes into the thoracic duct (on the left) and the right lymphatic duct. By these two final pathways, lymph returns into the circulation.

Factors in Lymph Flow

- There is no central pump in the lymphatic system
- Forward flow is due to a pressure gradient within lymph vessels aided by one-way valves which prevent backflow
- Lymph enters lymph capillaries when the pressure in the tissue is low (up to 2 mmHg) as the flap valves between lymph capillary cells are open
- ISF enters lymphatic capillaries in the phase after the external pressure has passed as external connective tissue fibres tend to tent open the lymph capillaries, opening the flap valves
- When ISF pressure increases beyond +2 mmHg then these flap valves close (passively due to the pressure gradient)
- With flap valves closed, the increased external (ISF) pressure tends to promote forward lymph flow provided
pressure is not too high (eg \( \leq 2 \) mmHg). At higher pressures, the unevenness of the pressure tends to close proximal lymph channels and lymph does not flow (Starling resistor effect)

- The main sources of suitable levels of external pressure to promote flow are arterial pulsations and muscular contractions
- The close association of lymph channels with arteries tends to favour flow
- Larger lymph vessels have smooth muscle in their walls. 'Intrinsic contraction' of these smooth muscle cells assists forward flow
- Lymph vessels have bi-leaflet valves every few mm and these are extremely important: no forward flow is ever lost

### 3.4.2: Functions of Lymph

The three functions of the lymphatic system are:

- Return of protein and fluid from the ISF to the circulation to maintain a low interstitial fluid protein concentration and maintain the oncotic pressure gradient across the capillary membrane. Oedema will occur if ISF oncotic pressure is not kept low.
- Role in absorption and transport of fat from the small intestine.
- Immunological role - lymph glands, and circulation of immune cells such as lymphocytes and dendritic cells, removal of bacteria.

Lymph from most parts of the body usually has a low protein concentration. Liver lymph is different because:

- It normally has a high protein concentration (due to low reflection coefficient)
- It contributes more than half of all the thoracic duct lymph

Consequently, the average lymph protein concentration in thoracic duct lymph is much higher than expected based on protein concentration in lymph from other body tissues.

The thoracic duct carries about 80% of the total lymph flow. This total flow at rest is about 120 mls/hr. If interstitial hydrostatic pressure rises (ie becomes less negative) due to excess fluid filtration & accumulation, the total lymph flow can increase quite markedly.

Chyle is lymph from the intestines which has a milky-white appearance due to the presence of large numbers of chylomicrons. Chylomicrons are 100nm diameter complexes of mostly triglycerides (containing the long chain fatty acids) enclosed in a hydrophobic protein coat. Chylomicrons enter the lymphatic lacteals in the villi, travel in the lymph and then enter the circulation via the thoracic duct.

Absorption of snake venoms (for Australian elapid snakes) occurs principally via lymph channels. If the bite is on a limb, the rate of venom absorption can be very much retarded by firm external compression of the lymph channels (pressure) and by not exercising the muscles of the limb (immobilisation). The aim of this 'pressure-immobilisation technique' for bites on limbs is to minimise entry of venom into the circulation and to 'buy time' so the person can reach medical care where specific anti-venom is available. As absorption is not directly into the venous system at the bite site, a tourniquet is unnecessary and should NOT be used.