Ashur University
College of Medicine

Grade 1
Cardiovascular Module
Cardiovascular Physiology
Lect. 7

Microcirculation & Lymphatics (Edema formation)



Ass. Professor Internal Medicine

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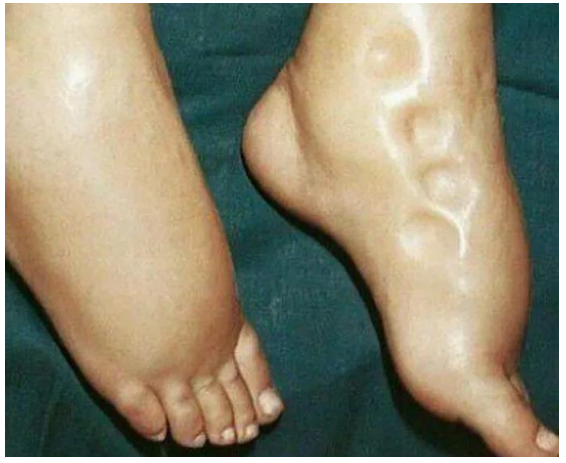
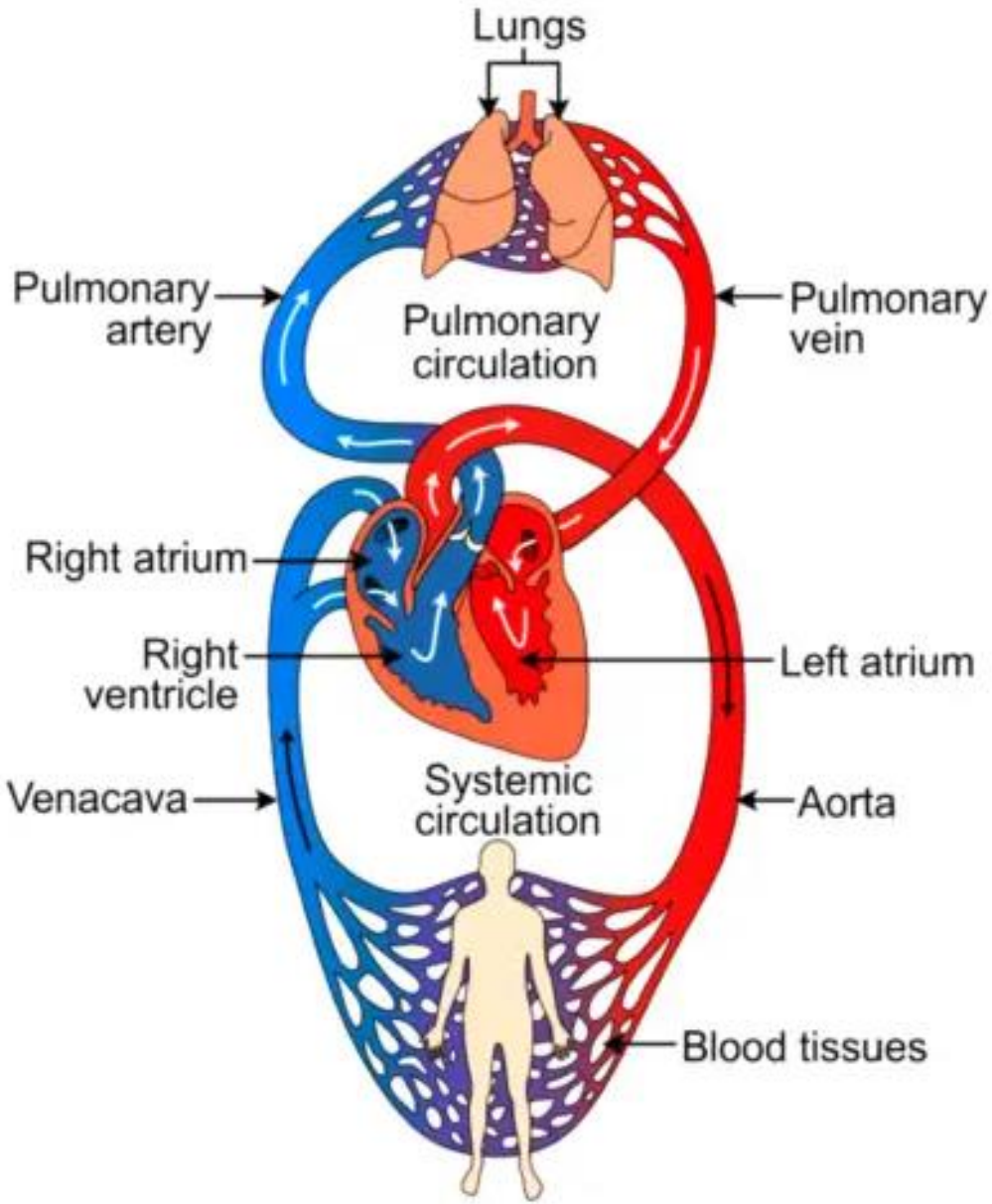
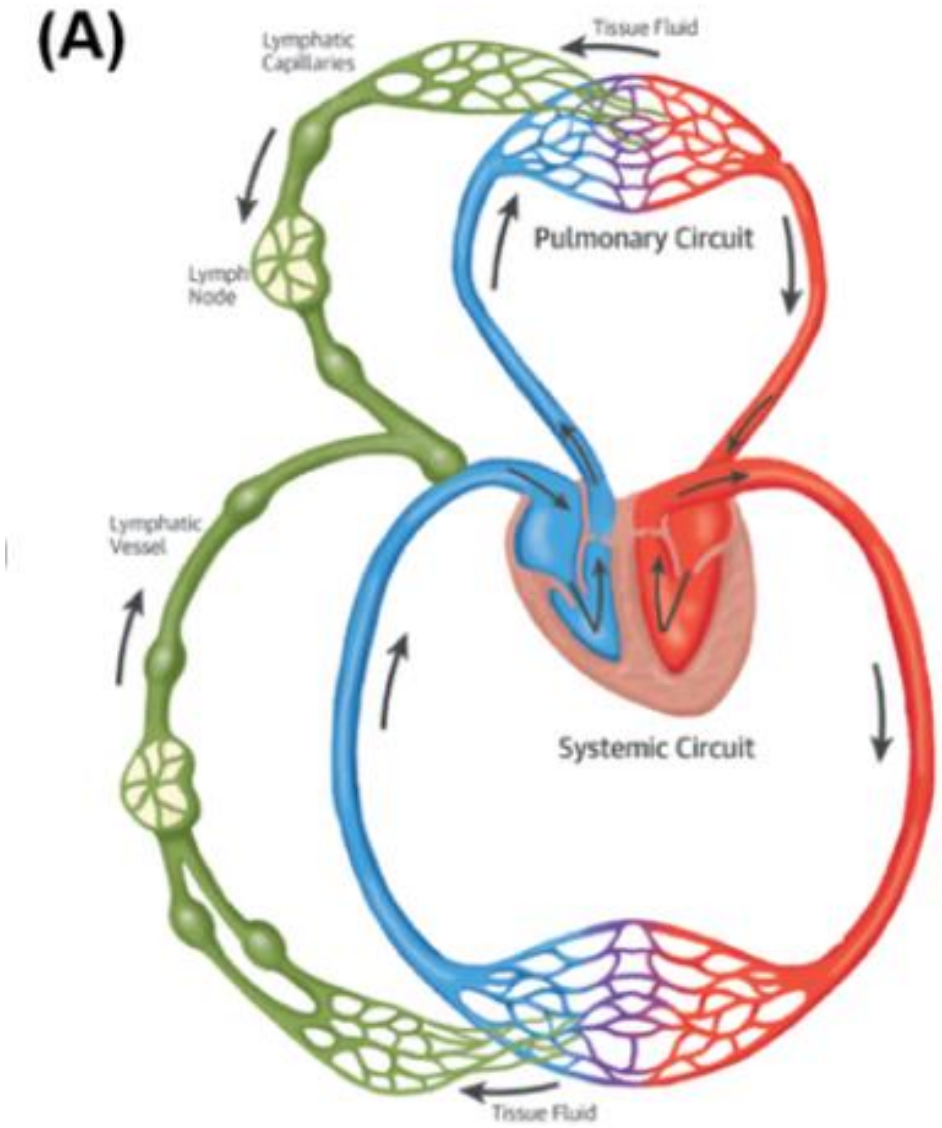
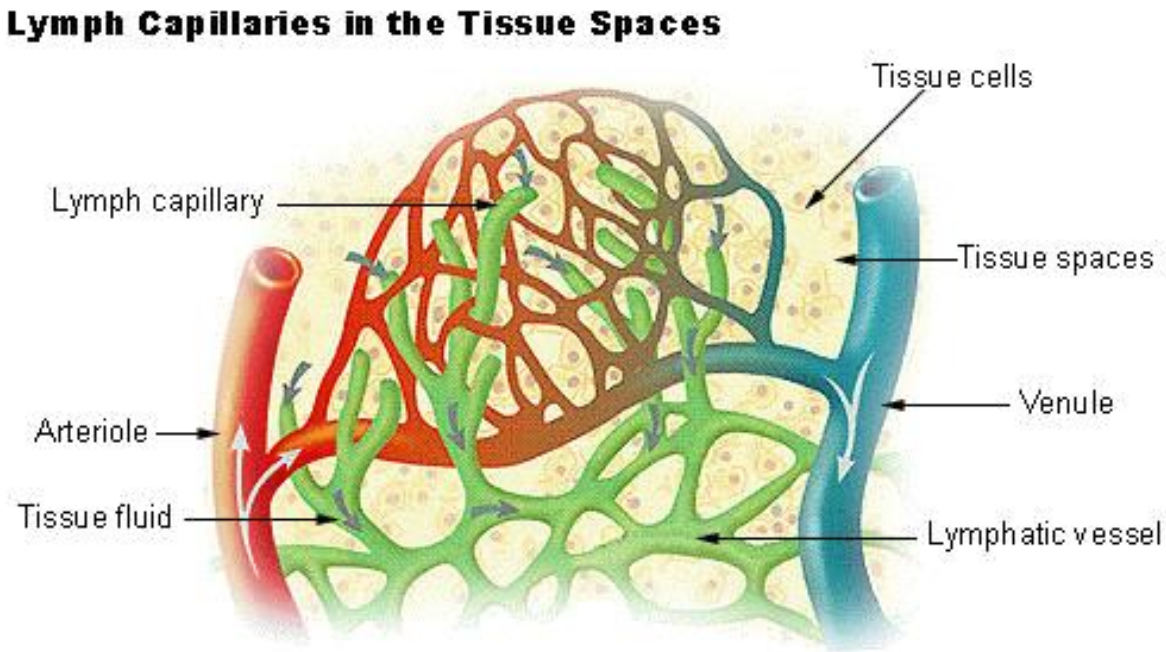
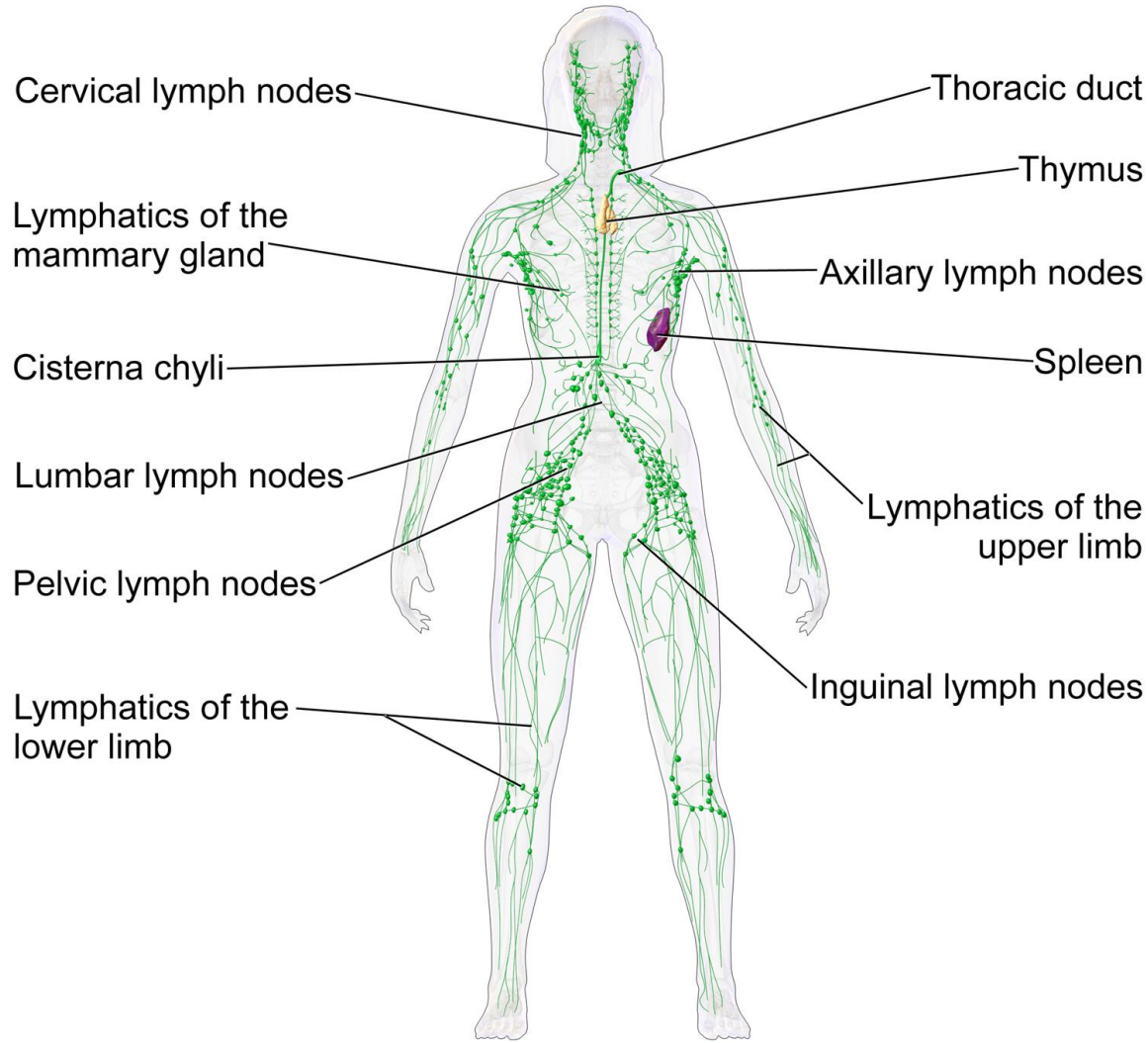


Systemic and pulmonary circulation






Lymph Capillaries in the Tissue Spaces
Tissue cells
Lymph capillary
Tissue spaces
Venule
Arteriole
Tissue fluid
Lymphatic vessel


Cervical lymph nodes
Thoracic duct
Thymus
Lymphatics of the mammary gland
Axillary lymph nodes
Cisterna chyli
Spleen
Lumbar lymph nodes
Lymphatics of the upper limb
Pelvic lymph nodes
Inguinal lymph nodes
Lymphatics of the lower limb

Microcirculation and Lymphatic system

Objectives:

1. Define the term hydrostatic and oncotic (colloid osmotic) pressures and state how it is interact in maintenance of interstitial fluid.

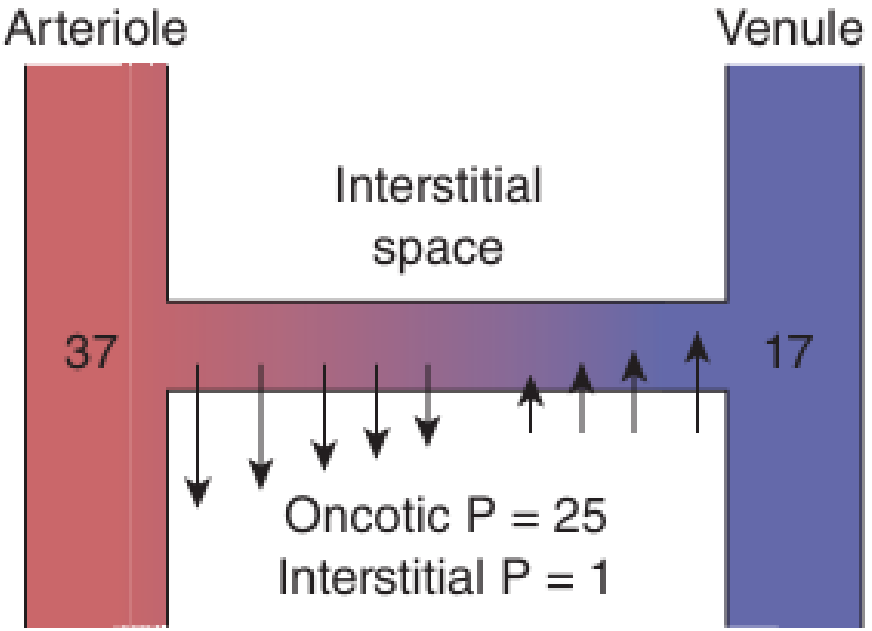
2. State and explain briefly the effects on tissue fluid formation in a vascular bed of: altered capillary hydrostatic pressure, decreased plasma protein concentration, elevated central venous pressure, increased capillary permeability, and obstruction of lymph drainage.

3. Define the term edema.

4. Explain the physiological mechanisms involved in the development of bilateral leg, and pulmonary edema.

The microcirculation and the lymphatic system

FIGURE Schematic representation of pressure gradients across the wall of a muscle capillary. The numbers at the arteriolar and venular ends of the capillary are the hydrostatic pressures in mm Hg at these locations. The arrows indicate the approximate magnitude and direction of fluid movement.



In this example, the pressure differential at the arteriolar end of the capillary is **11 mm Hg ([37 – 1] –25) outward**; at the opposite end, it is **9 mm Hg (25 – [17 – 1]) inward**.

Thus: **Fluid movement = k [(Pc – Pi) – (πc – πi)]**

where

k = capillary filtration coefficient

Pc = capillary hydrostatic pressure

P i = interstitial hydrostatic pressure

πc = capillary colloid osmotic pressure

π i i = interstitial colloid osmotic pressure

π is usually negligible, so the osmotic pressure gradient (πc − πi) usually equals the oncotic pressure

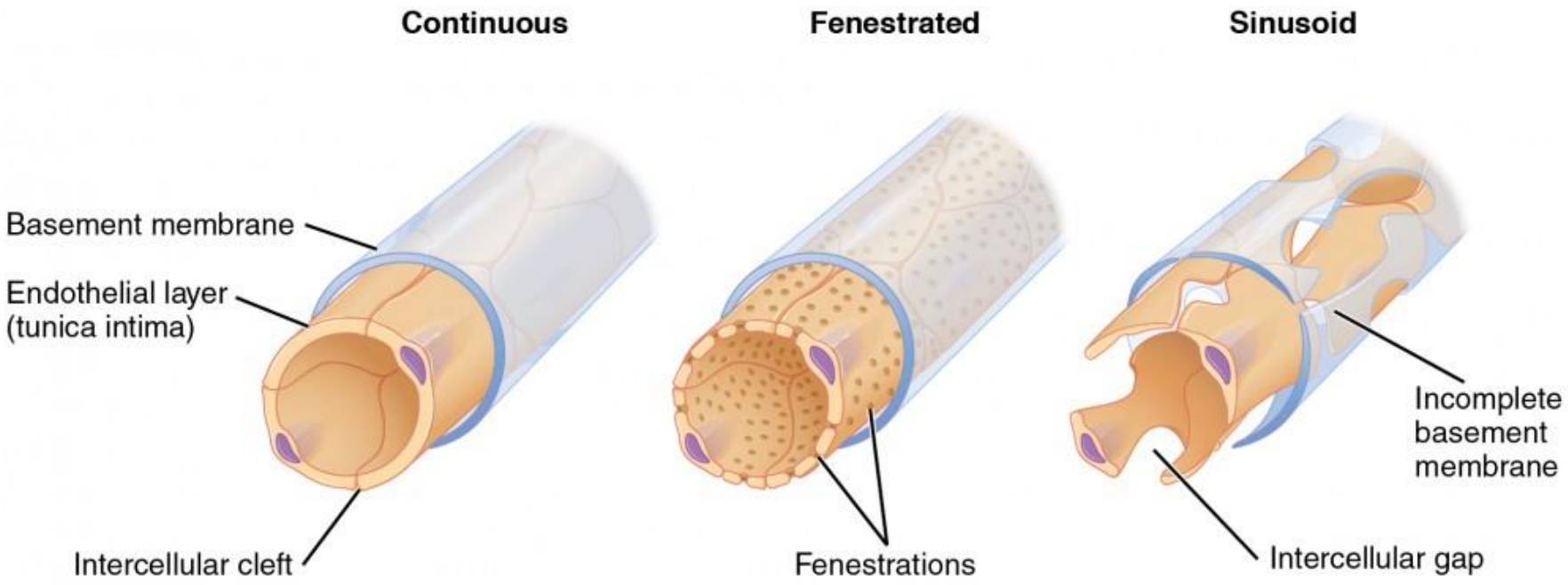
Types of Capillaries

Permits exchange of nutrients and wastes

1- Continuous: Intercellular channels or clefts.

2- Fenestrated: Intercellular pores.

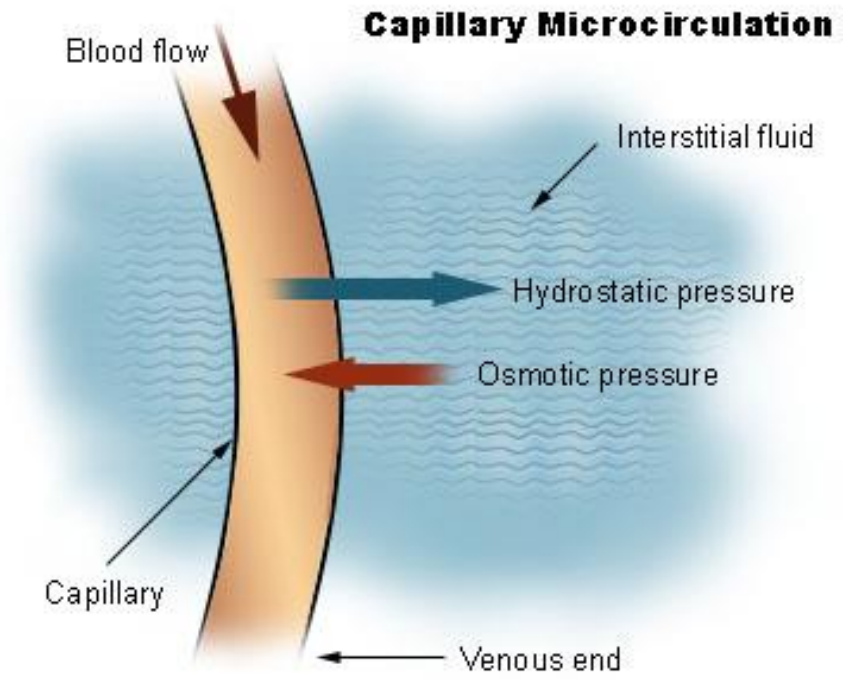
3- Discontinuous (sinusoidal): Have large, leaky capillaries.

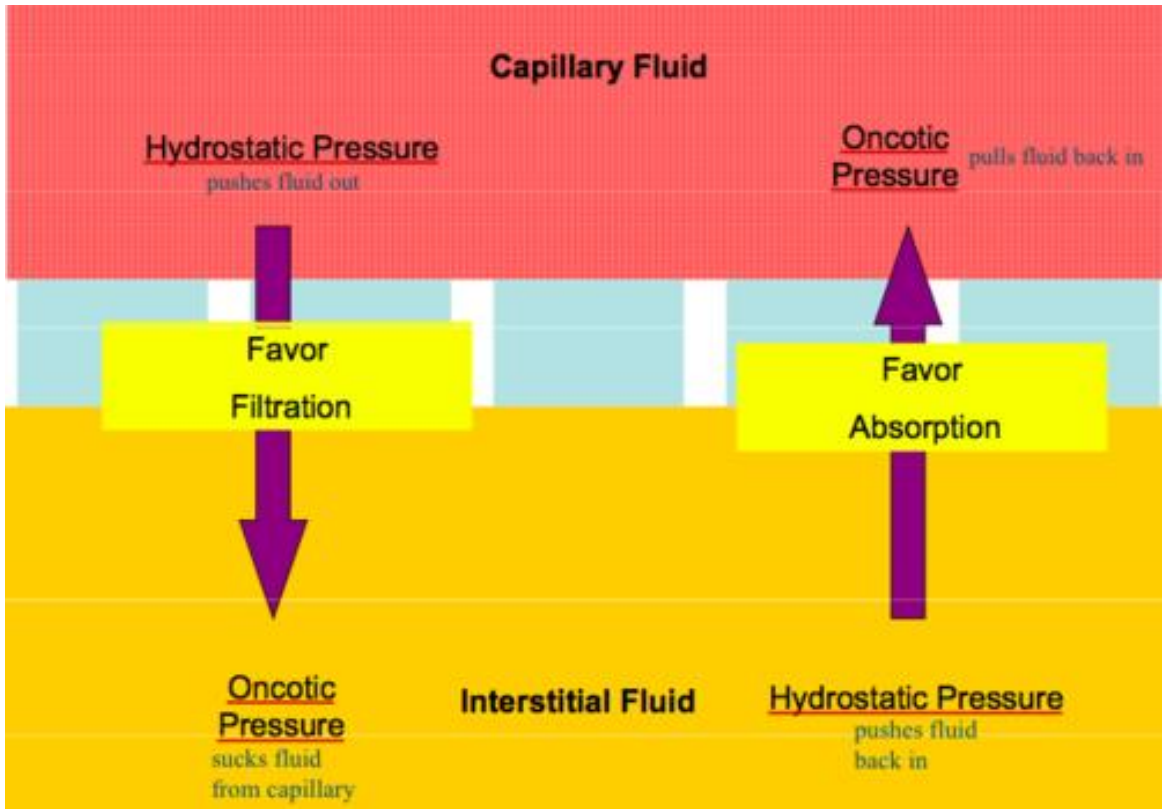


Formation and drainage of the interstitial fluid:

The interstitial fluid (IF) is continuously formed and drained by the capillaries, and it contains almost the same constituents of the plasma except the plasma proteins. Factors that affect tissue fluid formation and drainage:

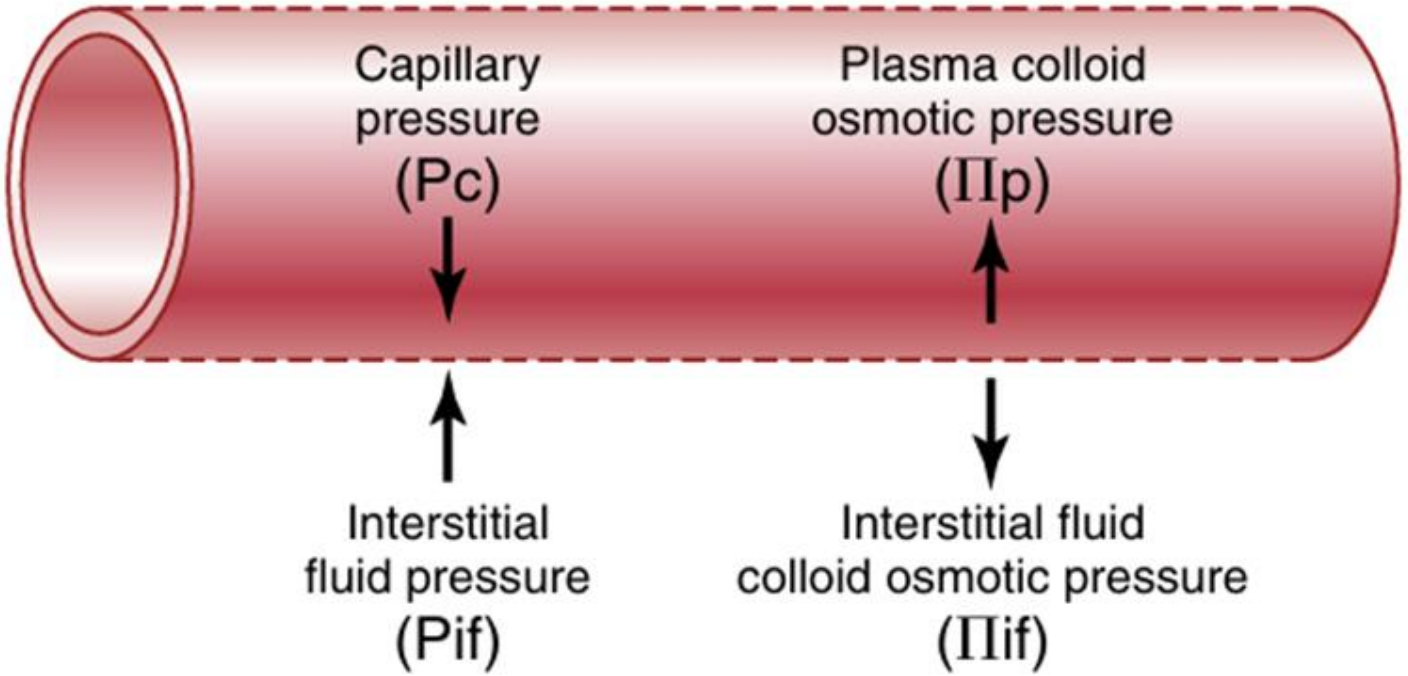
- **The Starling's forces (the hydrostatic and osmotic forces that act across the capillary walls)**
- **The capillary permeability.**





Figure

Fluid pressure and colloid osmotic pressure forces operate at the capillary membrane and tend to move fluid outward or inward through the membrane pores.



Overall Fluid Movement (Starling forces)

Pc = Hydrostatic pressure in capillary

Πi= Colloid osmotic pressure of interstitial fluid

Pi = Hydrostatic pressure in interstitial fluid

Πp= Colloid osmotic pressure of blood plasma.

Pc + Πi (fluid out) - Pi + Πp (fluid in)

Hydrostatic and Colloid Osmotic Forces Determine Fluid Movement Through the Capillary Membrane. Figure shows the **four primary forces** that deter mine whether fluid will move out of the blood into the interstitial fluid or in the opposite direction. These forces, **called Starling forces**, were named after the physiologist Ernest Starling who first demonstrated their importance:

1. The capillary hydrostatic pressure (Pc), which tends to force fluid **outward** through the capillary membrane

2. The interstitial fluid hydrostatic pressure (Pif), which tends to force fluid **inward** through the capillary membrane when Pif is positive but **outward** when Pif is negative.

3. The capillary plasma colloid osmotic pressure (Πp), which tends to cause osmosis of fluid **inward** through the capillary membrane

4. The interstitial fluid colloid osmotic pressure (Πif), which tends to cause osmosis of fluid **outward** through the capillary membrane.

If the sum of these forces—the **net filtration pressure**— **is positive**, there will be a net **fluid filtration across the capillaries**. If the sum of the Starling forces **is negative**, there will be a net **fluid absorption from the interstitial spaces into the capillaries.**

The Starling's forces:

1- The hydrostatic capillary pressure:

outwards, averages 35 mmHg (arteriolar ends) and 12 mmHg (venular ends).

2- The interstitial fluid pressure:

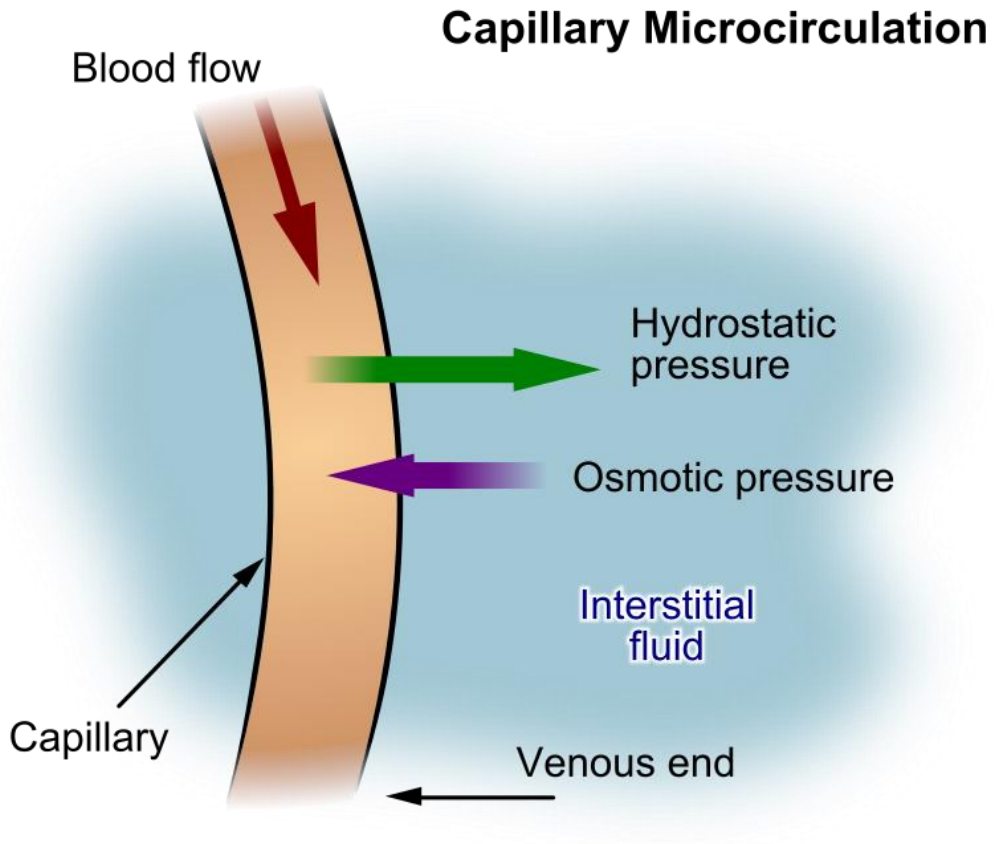
inwards, averages 1 mmHg.

3- The plasma colloid osmotic pressure or oncotic pressure:

inwards, plasma albumin. averages 25 mmHg.

4- The interstitial fluid colloid osmotic pressure:

outwards, averages 3 mmHg.



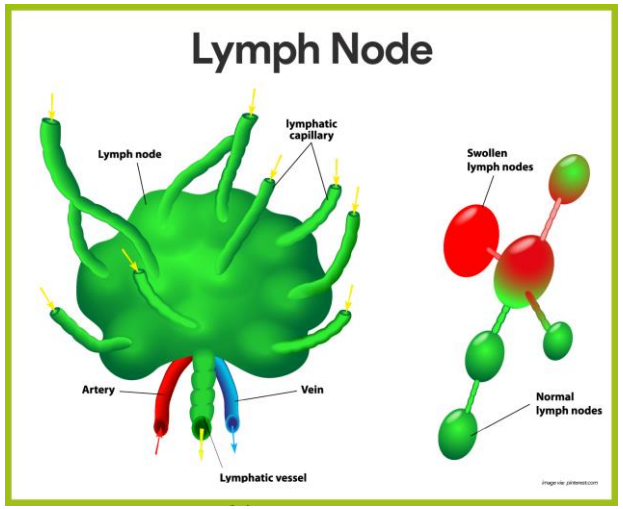
Lymphatic System

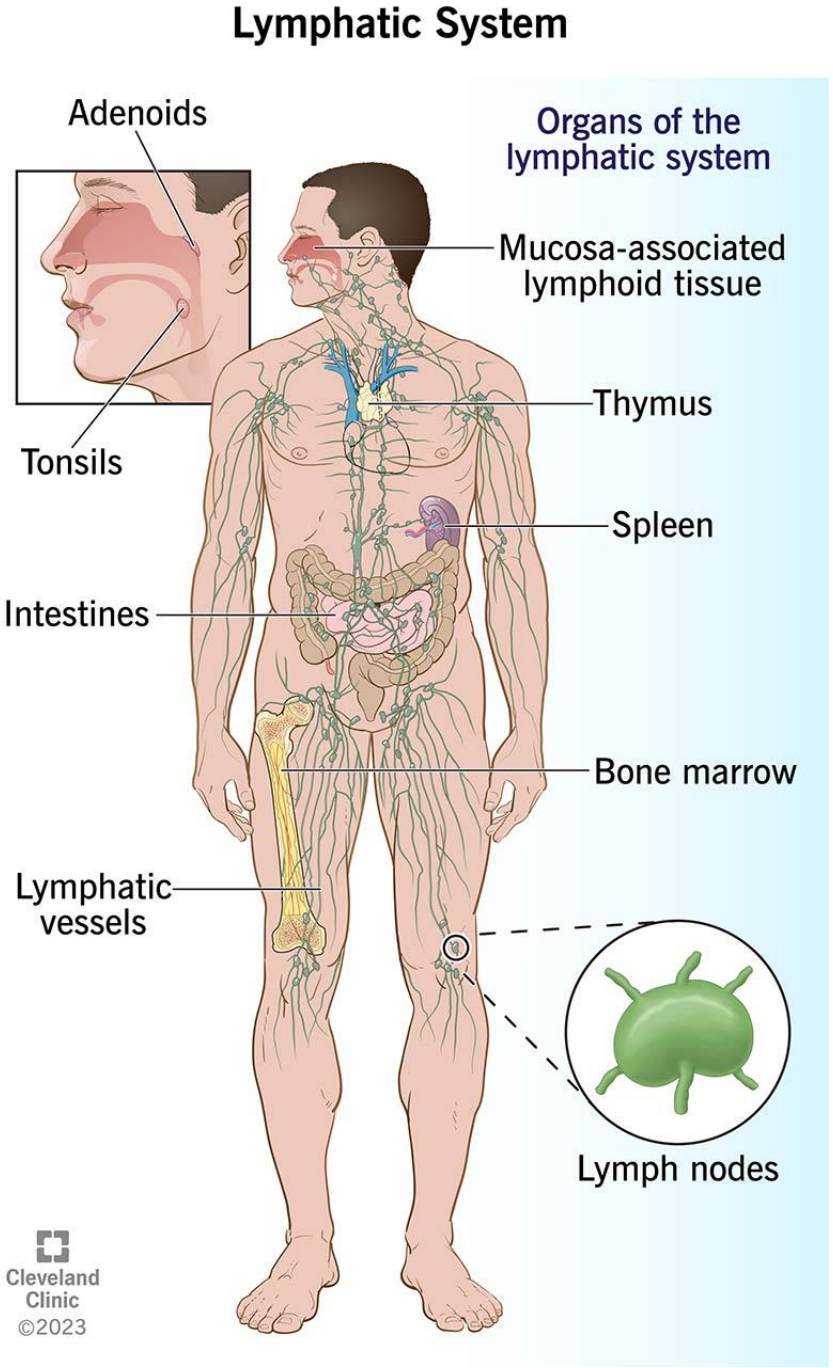
3 basic functions:

① Transports interstitial (tissue) fluid back to the blood.

② Transports absorbed fat from small intestine to the blood.

③ Helps provide immunological defenses against pathogens.





EDEMA

It is due to accumulation of excessive amounts of interstitial fluid (mostly in the dependent parts of the body by the effect of gravity), and this has

2 main causes:

① **Excessive leakage of fluid from the capillaries.**

② **Inadequate lymph drainage.**





Pitting Edema







Non Pitting Edema





EDEMA … cont.

(1) Excessive leakage of fluid from the capillaries:

- **An increase of the capillary hydrostatic pressure:**

(elevation of the venous pressure (heart failure)).

Increase in Hydrostatic Pressure due to :

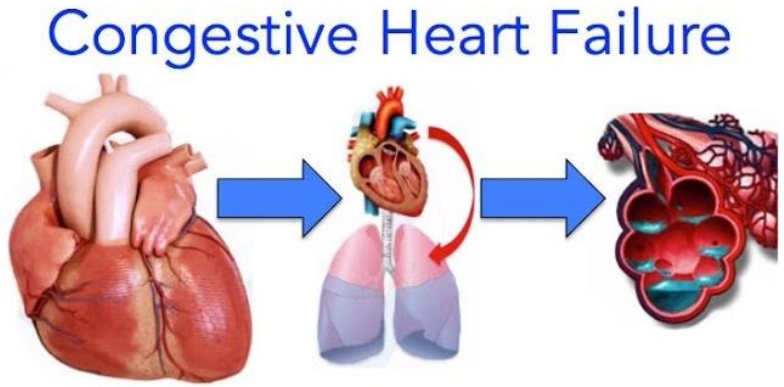
Hypertension

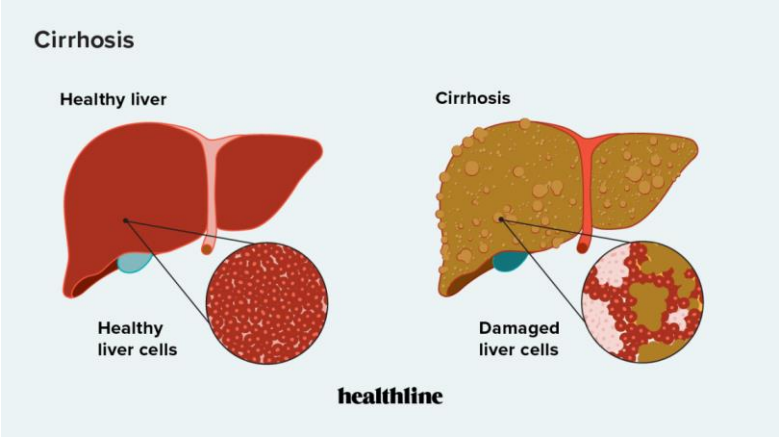
Right sided heart failure - causes peripheral edema

Left sided heart failure - pulmonary edema

- **Hypoproteinaemia:**

- decrease of synthesis of plasma proteins (severe liver disease).
- Undernutrition.
- excessive loss of plasma proteins (nephrotic syndrome, severe burns).







EDEMA … cont.



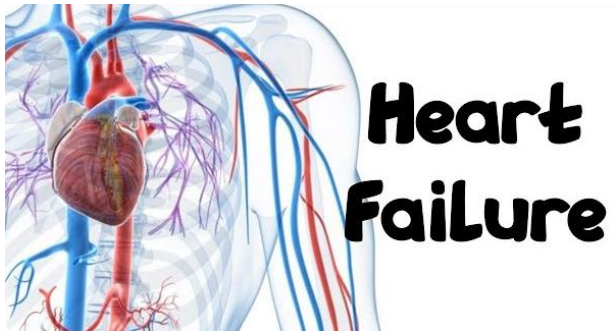


- **An increase of capillary permeability:**
- inflammation, bacterial infections, allergic reactions.
- prolonged ischemia and certain toxins.

- **Excessive retention of salt in the body:**

Renal edema →→

Cardiac edema.







EDEMA … cont.

(2) Inadequate lymph drainage.

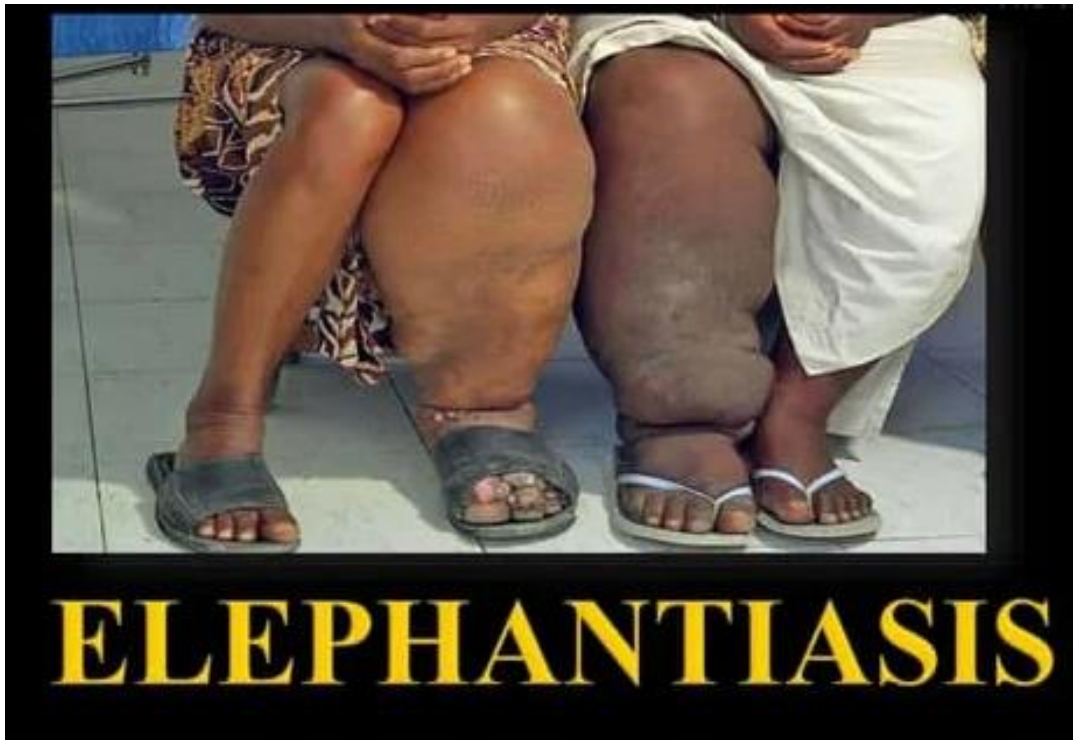
- **Blockage of the lymph vessels:** which leads to accumulation of both fluid and protein in the tissue spaces (lymphedema (non-pitting edema)).
- Cancer, after certain surgical operations (e.g. radical mastectomy).
- Infection with filaria worms which obstruct the lymphatics, causing massive swelling of the affected organ commonly the legs (elephantiasis).



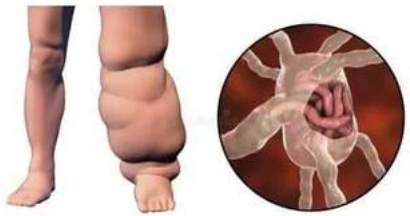


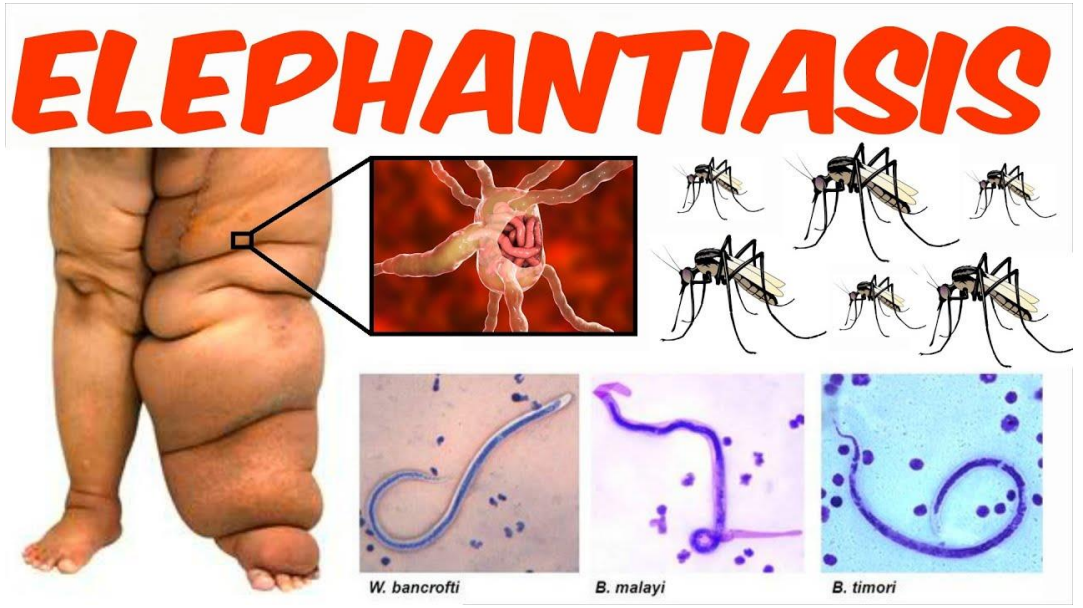
Elephantiasis (Filariasis)





Lymphatic Filariasis





Summary

Edema:

It is excessive accumulation of Extracellular fluid (ECF) resulting from:

- High blood pressure (hypertension).
- Venous obstruction or congestion (rasied systemic or pulmonary venous pressure as eg. in Heart failure).
- Leakage of plasma proteins into Extracellular fluid (ECF)
- Low plasma protein levels resulting from liver disease
- Obstruction of lymphatic drainage


Thank
You