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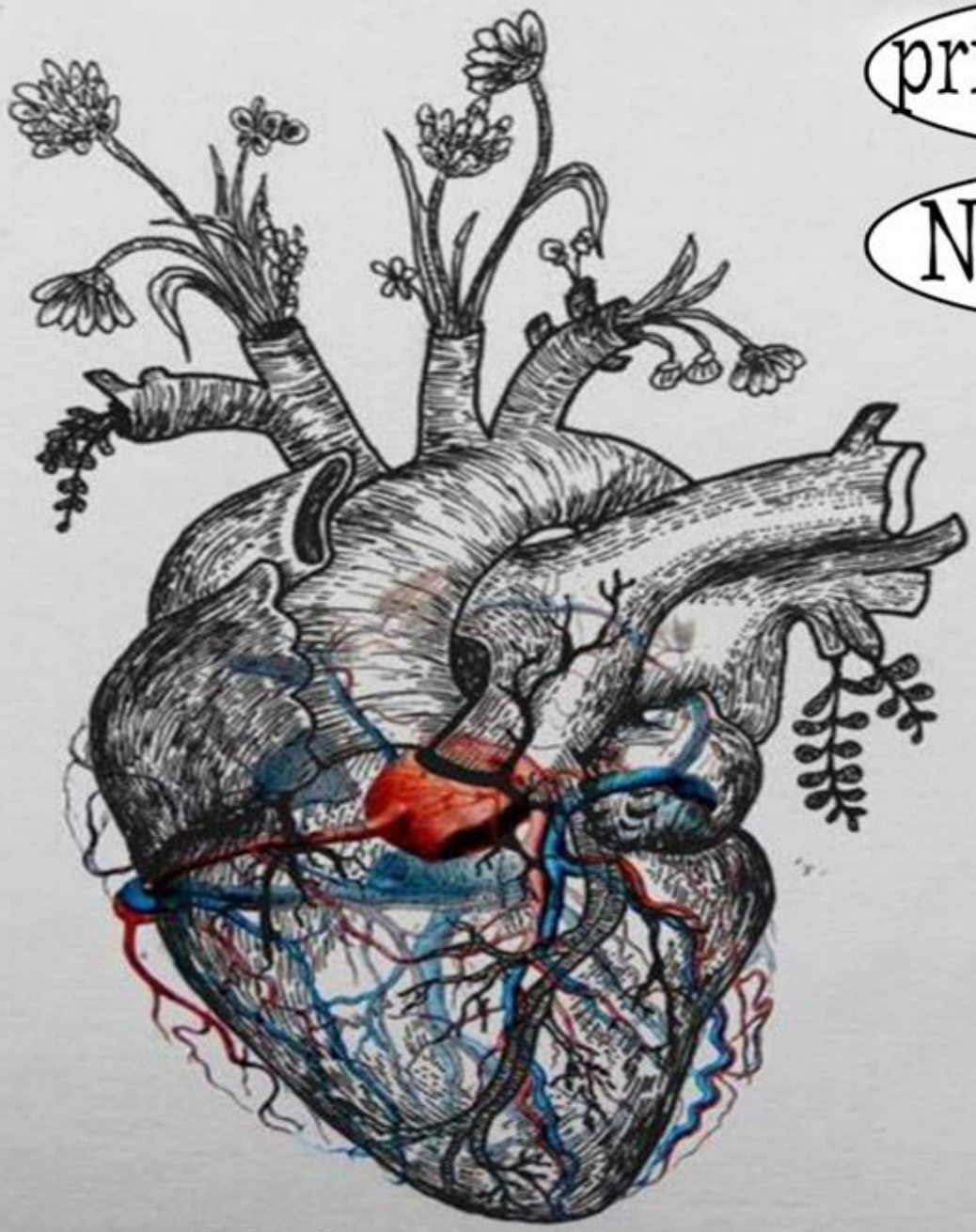


CVS

sub-system: Physiology

lecture: #07

Doctor: Dr. Mohammad Al Ja'afar

Date: 23.3.2016

Done by: Turquoise Team

Before you start please read these notes

- I rearranged this sheet while making it so you cannot follow up with the record. If you want to listen to the record my advice for you is to listen to it before or after reading the sheet.
- You may find some slides that are not included; so you can take a look at the slides while you are studying.
- If you have any notes about the sheet write them in the correction zone.
- This sheet contains some information from:
    I. Our given lecture by Dr. Mohammad al ja'afar.
    II. Guyton and hall textbook of medical physiology.
    III. Past year lecture from awn batch.

"You can never make a mistake twice because the second time you make it, it is not a mistake, it is a choice".

-Steven Denn

"If my mind can conceive it and my heart can believe it, then I can achieve it"

-Mohammad Ali

Done by: Laith Zahi

MICROCIRCULATION

INTRODUCTION

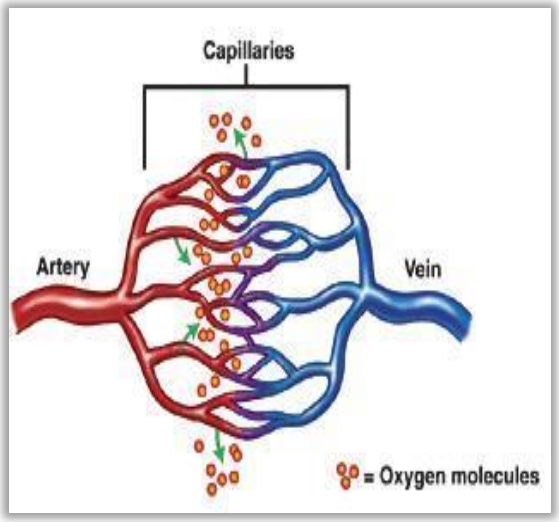
-The function of the ***cardiovascular system*** is to generate force or pressure to pump blood to the circulation.

-The function of the ***circulation*** is to transport nutrients to the tissue and remove waste products that are produced by these tissues.

> The exchange between capillaries and the tissues does not happen directly, instead the blood exchanges nutrients with the interstitial fluid and the interstitial fluid will exchange with the tissues.

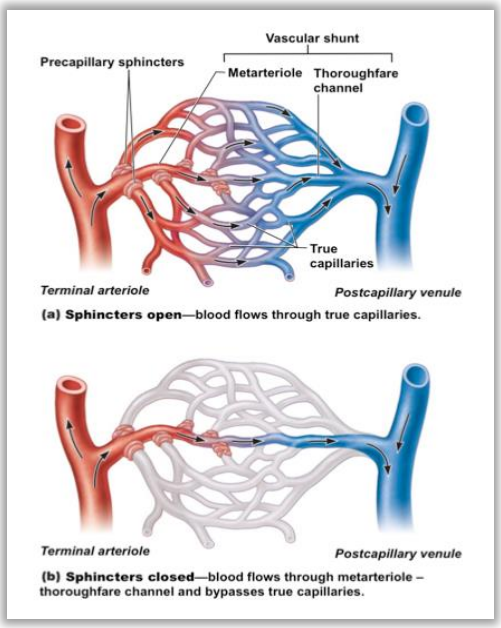
STRUCTURE OF THE CAPPILARIES

The human body contains an enormous number of capillaries about 10 billion capillaries, which have a total surface area of 500 to 700 meters squared (about 1/8 the size of a football field) which provides this function for the body.



Blood enters the Capillaries through an Arteriole and leaves through a Venule. Blood from the arteriole passes into a series of metarterioles, which are structures midway between arterioles and capillaries.

The ***metarterioles*** do not have a continuous smooth muscle coat, but smooth muscle fibers encircle the vessel at intermittent points called ***precapillary sphincters***.
Contraction of the muscle in these sphincters can open and close the entrance to the capillary.
Blood flows intermittently through capillaries, this is a phenomenon called ***"Vasomotion"*** (dynamics) related to the state of metabolism so it will keep the pre-capillary sphincter opened to allow blood to flow in or to block it.

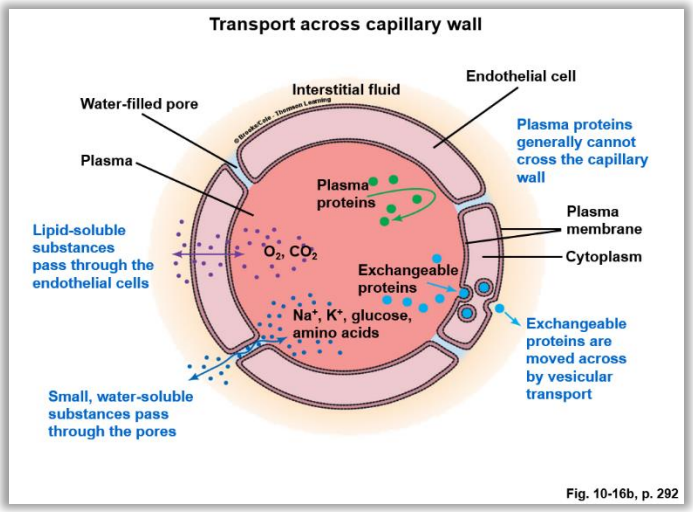


Example on Vasomotion:
In case of exercise, capillaries are widely opened in skeletal muscles because the sphincter needs oxygen to vasodilate, but in this situation all the oxygen is directed to the skeletal muscles so there is hypoxia in the vessels which leads to vasodilation. In the GI, most of the vessels are blocked by the closure of the sphincter and that's to reduce the blood flow to them; this is called **vasomotion.**

(The capillary vasmotion depends on the actual metabolic rate of the tissue, when the metabolism increases, the blood flow will increase).

This phenomenon is to reduce the load on the heart because if all of the vessels are opened, the body will need 30 liters instead of 5 liters.

The capillaries have only a single layer of highly permeable endothelial cells. They are also very porous, with several million slits or pores between the cells that make up their walls for each centimeter squared of capillary surface. Almost all dissolved substances in the plasma, except the plasma proteins, continually mix with the interstitial fluid.



There are several types of capillaries, which are related to the actual function of the tissue:

1. The capillaries in the ***liver*** have large pores so they are highly permeable for the substances that are dissolved in the plasma.
2. The capillaries in the ***intestine*** have smaller pores; the ***Heart*** capillaries are even smaller than the intestine capillaries.
3. The capillaries of the ***Central nervous system*** have no pores at all. They are called the ***Blood Brain Barrier (BBB).*** Therefore, in some cases where we

need to treat a problem in the brain with a drug, injecting it intrathecally would be the best choice for it to cross the BBB.

Factors that affects the exchange process

As we mentioned before, the function of the circulation is to exchange nutrients with the tissue by diffusion. **FIRSTLY,** the factors that are related to the **characteristics of the substances** that affect the exchange process

- ***Molecular size of the substance:*** water and electrolytes can pass through the pores rapidly. Plasma proteins, however, have large sizes, this restricts their diffusion.
- ***The concentration difference of the substance between the two sides of the membrane:*** substances diffuse from high concentration to low concentration.
- ***Solubility of the substance:***
  - Lipid soluble substances can diffuse easily through the one cell capillary **(no need for pores) s**such as alcohol, anesthesia, drugs, O_2 & CO_2. These substances do not need pores to diffuse.
  - Glucose, ions and water, pores are essential so they can diffuse through the capillary.

SECONDLY, the **Forces** that help in the exchange process either by excreting the substance from the capillary to the tissue or vice versa.

There are two forces on both sides of the membrane (**inside the capillary and outside**) and they act on both **the arterial and the venous end**:

I. Forces at the arterial end:

OUTWARD FORCES

= 30mmHg

- ***The capillary Hydrostatic pressure (PC)***: which forces fluid outwards through the capillary membrane.

= 3mmHg

- ***The interstitial fluid hydrostatic pressure (Pif):*** which forces fluid outwards into the interstitial fluid when it is negative

= 8mmHg

- ***The interstitial fluid colloid osmotic pressure (Πif):*** which tends to cause osmosis of fluid outwards through the capillary membrane

TOTAL PRESSURE = 41 mmHg outward

Note: The interstitial fluid is not a totally free fluid, it is exactly like jelly. It has this appearance due to the existence of fibroprotiens and vesicles that hold the tissue and the organ in the space. These vesicles contain negative pressure. In our body, we have so many places which have a negative pressure, mainly the joints in order to separate the bones (keeping the ends of the bones away from each other); however, if we have positive pressure there, the bones will be touching one another and we won't be able to walk!! Also, if the Pif pressure is positive, the direction of blood movement will be shifted "more blood inside than outside".

INWARD FORCES

- ***The plasma colloid osmotic pressure (Πp):*** which tends to cause osmosis of the fluid inwards through the capillary membrane.

= 28mmHg

TOTAL PRESSURE = 28 mmHg inward.

By a simple equation

(Outward – inward) = (41-28) = (13mmHg) to the interstitial fluid.

We conclude from the previous equation that the total force that pushes the blood to the outside of the capillaries equals 13 mmHg.

II. Forces at the venous end:

- **All of the forces in the venous end are the same as the arterial EXCEPT for *The capillary Hydrostatic pressure (PC)* which equals 10 mmHg.**

When we sum all of the forces:

(Outward – inward) = (21 – 28) = (7mmHg) to the blood vessel.

Starling Equilibrium

A scientist measured the pressure in all the capillaries from the arterial end to the venous end and then he took the average of the arterial and venous ends.

If we take the pressures as the following: 30mmhg in the arterial end and 10mmhg in the venous end... then the values in between from 30, 29, and 28 until you reach 10... then sum them and find the average, it will be ***= 17.3 (The average Pressure)*** which is called the **starling equilibrium**.

NOW, adding the starling equilibrium to the ***(The interstitial fluid hydrostatic pressure)*** and the ***(The interstitial fluid colloid osmotic pressure)*** we will end with a result which ***= 28.3 mmHg***

17.3 + 3 + 8 = 28.3

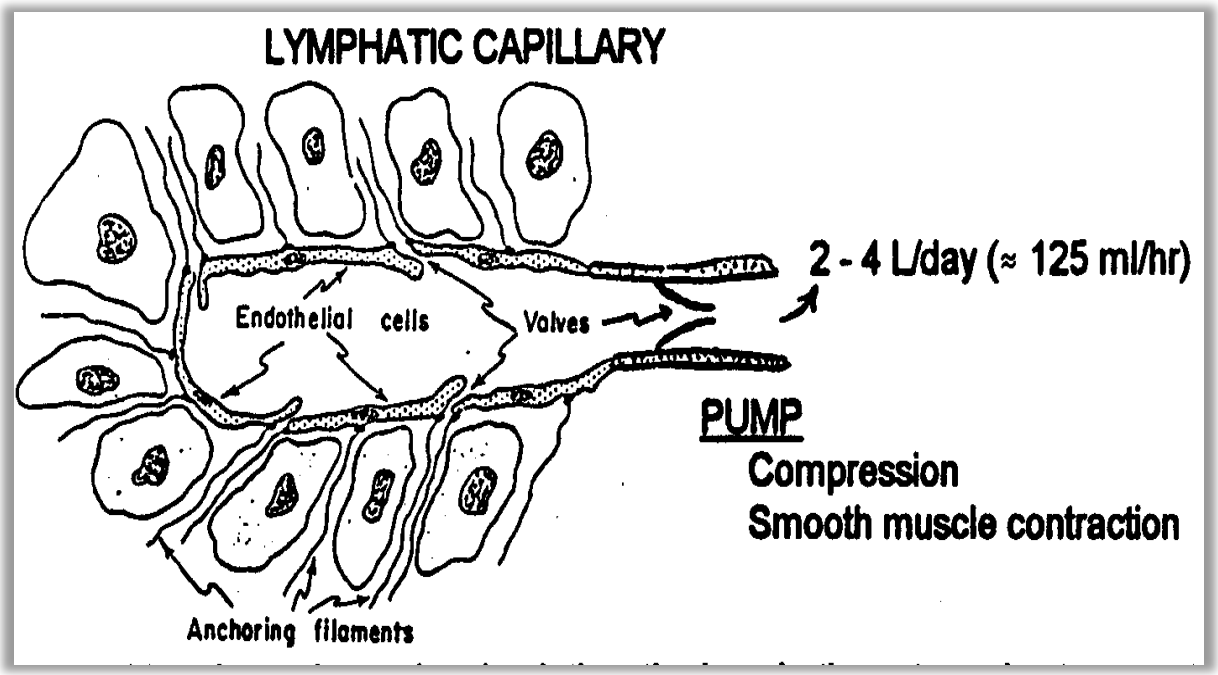
After that, adding the outward forces to the inward forces (Πp) will make us end up with a difference of 0.3 mmHg called the ***Functional force*** that will go back to the venous end by the lymphatic system.

Edema

How edema develops??

- Increased capillary Hydrostatic pressure, which will increase the filtration.
- Decreased plasma colloid osmotic pressure, which will increase the fluid to go inside the venules.
- Increased interstitial fluid colloid osmotic pressure.
- Hypertension patients, when their pressure increases the filtration rate will increase.
- Venous obstruction, when the veins are obstructed the pressure in them will increase hence the pressure will increase in the capillaries and the filtration will increase.
- Lymphatic obstruction, imagine that the 0.3 mmHg difference will not enter to the lymph vessel, this will lead to the accumulation of the fluid in the interstitial fluid.
- Increased interstitial fluid hydrostatic pressure negativity, which will cause increased suction of the interstitial fluid.

The Lymphatic system



There are many cells here, and you again see some clefts, So HOW will the fluid come to the vessels?? When substances come near the lymphatic vessels, they will push the valves and open them... So they'll go inside!!

The factors that will help the circulating fluid in the lymphatic system:

1. Fluid accumulation itself.
2. Beating of the blood vessels, which are adjacent to the lymphatic vessels, act as a force.
3. Contraction of the muscles "Muscular pump".

And the same thing happens in the venous return:

1. Muscular pump: contraction of the muscles.
2. Respiratory pump (When we inspire, the chest cavity increases, the pressure decreases and then the venous return increases).
3. Also the tissues or organs surrounding veins act as a force to push it.
4. Finally, the valves.

Edited by: Cyrine katanani