PASSION ACADEMIC TEAM

YU - MEDICINE

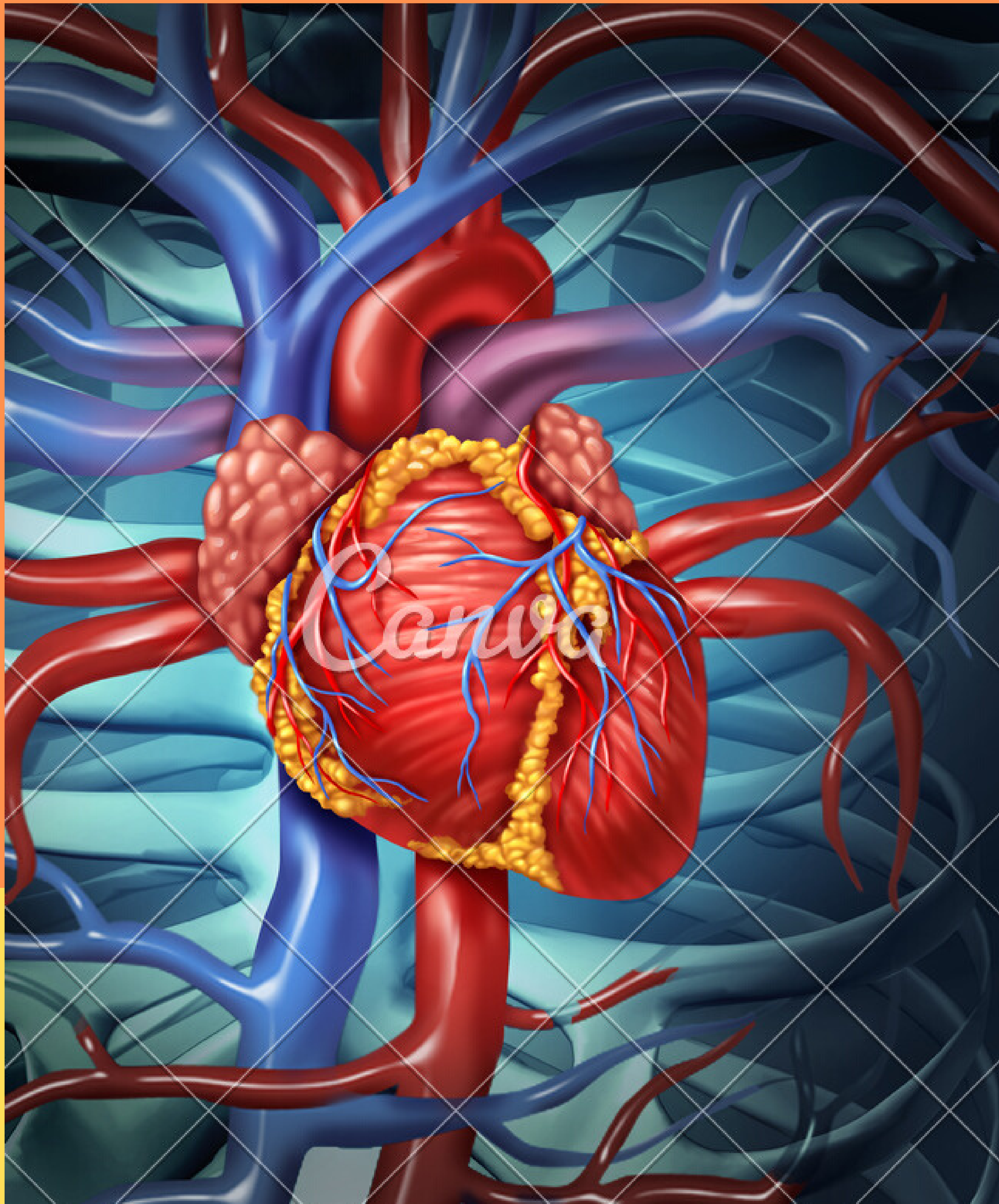
Cardiovascular System

Sheet# 9 (Part 1)

Lec. Date :

Lec. Title : Hemodynamics II

Written By : Abdallah Malkawi

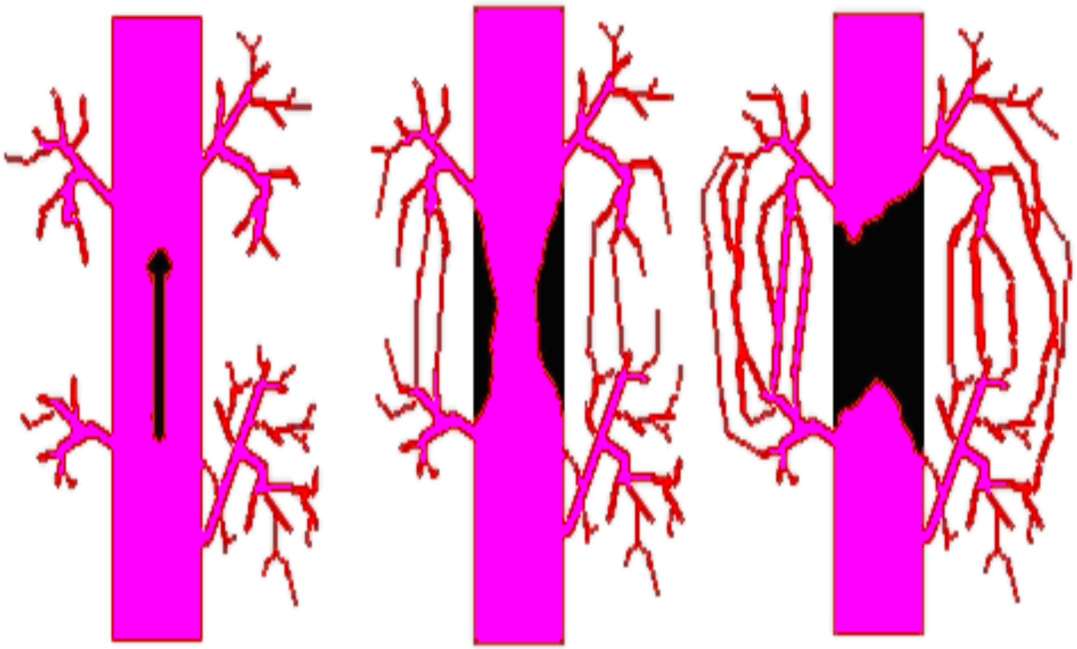


If you come by any mistake , please kindly report it to shaghafbatch@gmail.com

MECHANISM INVOLVED IN LONG-TERM BLOOD FLOW REGULATION

- Long-term blood flow regulation is required by:
  - Ischaemic tissues,
  - Tissues that are growing rapidly and
  - Tissues that become chronically hyperactive.

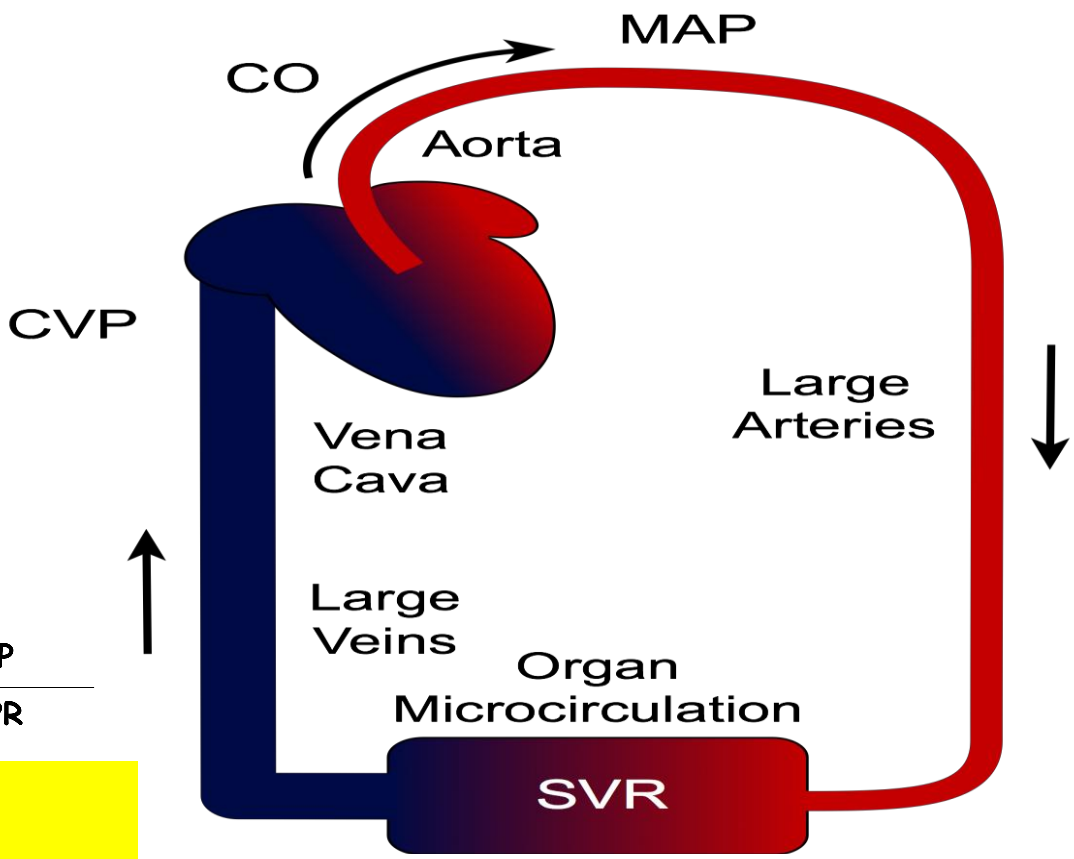
- The long-term blood flow regulation is brought by an increase in the physiological size of the vessels in a tissue and in certain circumstances even by an increase in the number of blood vessels (angiogenesis).
- Angiogenic factors:
  - Vascular endothelial growth factor,
  - Fibroblast growth factor and
  - Angiogenin.



Development of collateral circulation to compensate for vessels occluded by atherosclerosis

Extrinsic sympathetic control of arteriolar radius is important in regulating blood pressure.

- Extrinsic control of arteriolar radius includes:
  - Neural influences
  - Hormonal influences
- the effects of the sympathetic nervous system being the most important.



$$Q = \frac{MABP-RAP}{TPR}$$

Since Rt. Atrial pressure = 0 then $Q = \frac{MABP}{TPR}$

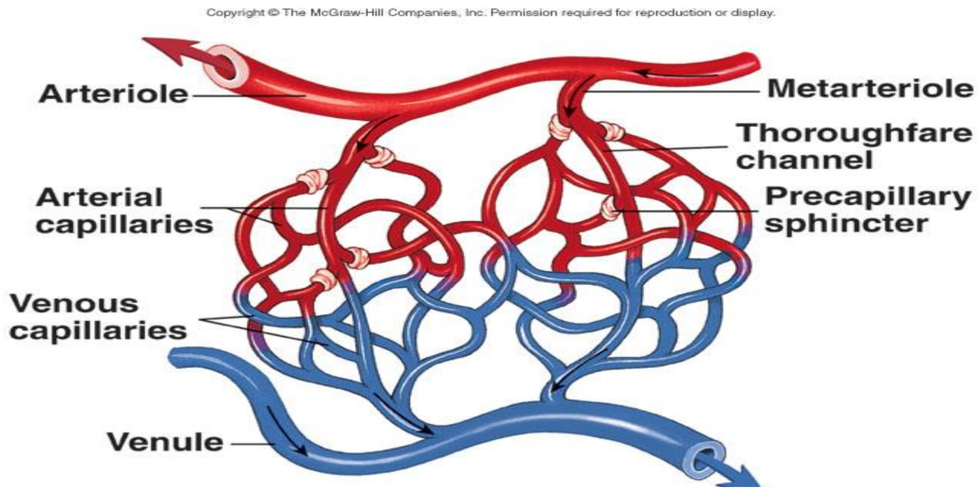
MABP= cardiac output (Q) × total peripheral resistance (TPR)

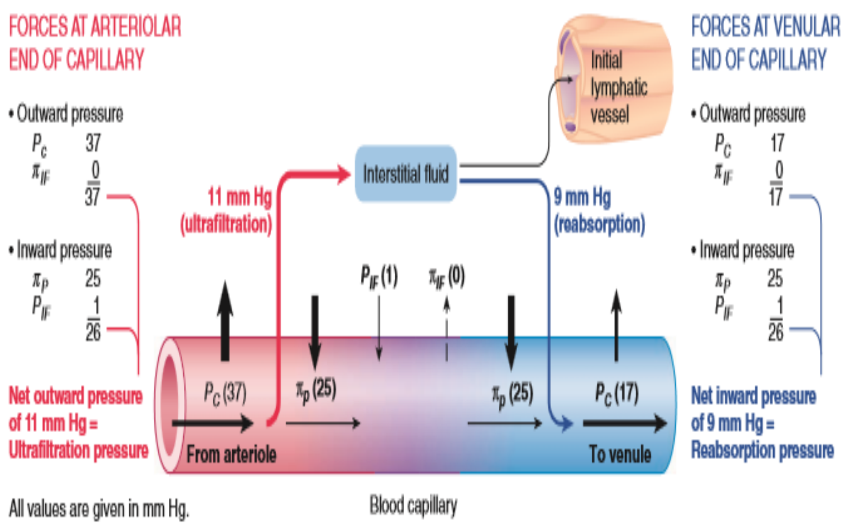
capillary network:
the terminal portion of arteriole but at the junction between arteriole &capillary the metarteriole will be formed which drains in capillary
smooth muscle of arterioles,metarterioles &precapillary sphincter will regulate blood flow
the upstream side of capillaries contains the precapillary sphincter (which is regulated mainly by local mediators)
if they contract they will decrease blood flow &vise versa
the largest surface area we can found is in capillaries
because of this large total surface area ,the velocity of blood flow is the lowest in capillaries ,beacuse there is an inverse relationship between surface area and velocity (which makes the acpillary an ideal palce for materials exchange)
so now we have 3 factors that help the capillaries to do their functions:
1-large surface area
2-thin-walled
3-slow velocity of blood flow
slide blow pic below on right says:
that we have many mechanisms for transporting substances between blood &ISF:
Some substances cross capillary wall by vesicular transportation (means to be transported into capillaries from outside or from
inside to outside these substances need vesicles to be transported we called it vesicular transportation and this type of
transportation involved exocytosis and endocytosis)
endocytosis means from outside to inside
exocytosis from inside to outside
Relatively little materials transported by vesicle transportation

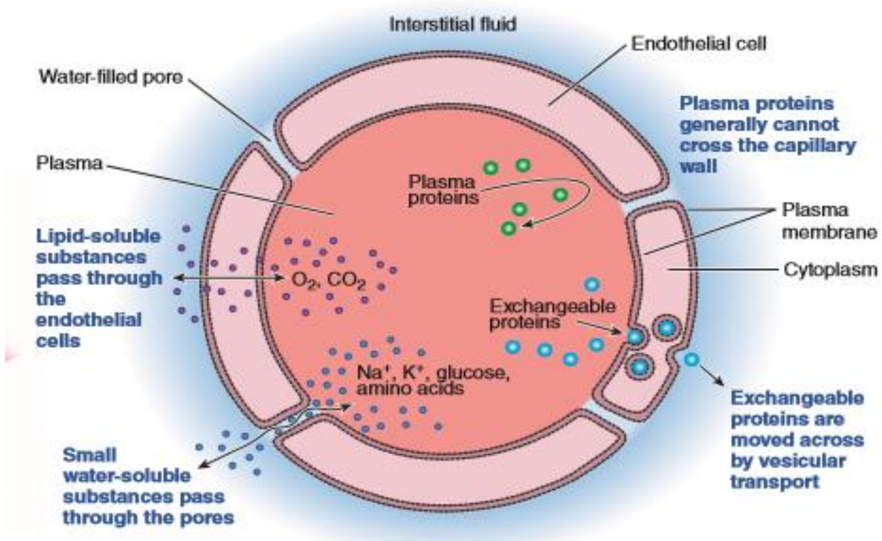
The most common mechanism to exchange salt and fluid by the junction between endothelial cells
sinusoid : large junction between endothelial cells found in the liver and endocrine glands especially anteriorpitutry gland
(not all endocrine gland)
in endocrine tissue, small intestine and the kidney the transportation happens in capillaries called fenestrated capillaries à
endothelial cells contain fenestrations so substances exchange throw these fenestrations à (substances which exchange here
are about 600nm in diameter)
* in skeletal muscle , cardiac muscle , there is no fenestration but there is small passages between endothelial cells (substances
here up to 10 nm)
in brain there is no spaces between endothelial cells that constitute the brain capillaries (they from tight junction)which allows very little passive diffusion(these tight junctions constitute an important part of the blood brain barrier)
(water,co2,other gases)can enter easily but other molecules may need a specialized transporter to transport them
now we will talk about pic below on left:
it talks about the bulk flow(the movement of solution (with solutes within it)from capillaries ti ISF (filtration) or reversible from ISF to capillaries called reabsorption)
this process also called the capillary fluid shift (regulated mainly by two forces:
the hydrostatic pressure &the osmotic colloid pressure))
at the arterial end there will be filtraton
at the venous end there will be reabsorption
typically the fluid that is filtered=that is reabsorbed
but if there is a net filtration this amount of fluid will return to circulation via the lymphatic system

Capillary Network

- Blood flows from arterioles through metarterioles, then through capillary network
- smooth muscle in arterioles, metarterioles, precapillary sphincters regulates blood flow

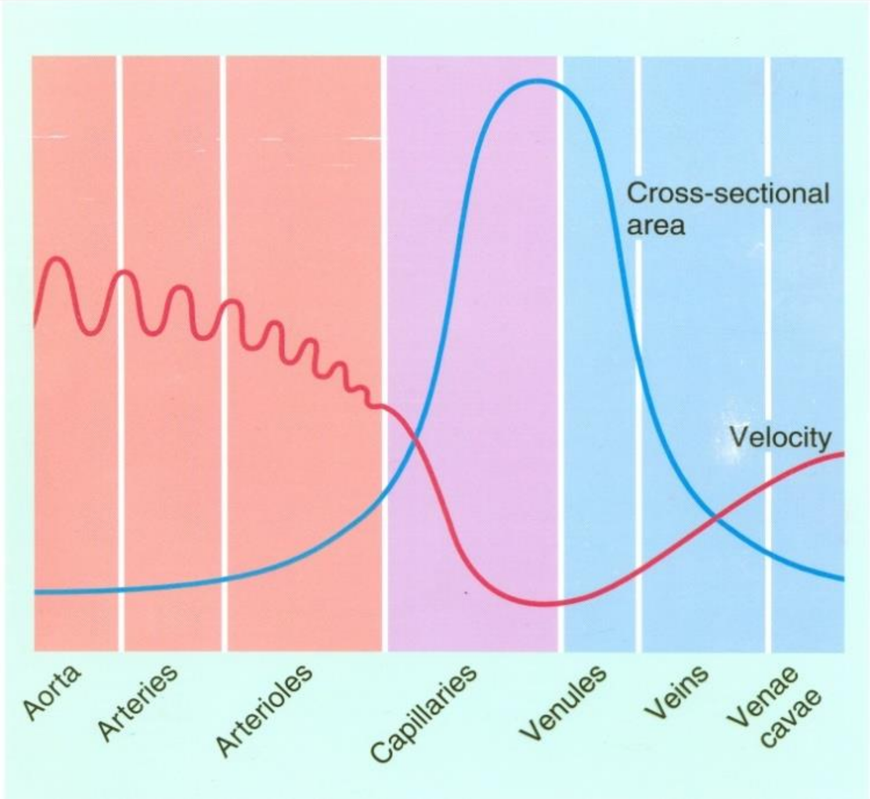






now we will talk about the relationship between the surface area &velocity :
we said that there is an inverse relationship
slide below pic on left:
note the surface area of aorta is the least (2.5cm2)so the velocity is the largest as we go further to the periphery the velocity will decrease becasue of increasing surface area &branching
what is the difference between the flow rate &velocity of flow:
flow rate is the volume of blood per unit of time so measured by L\min or ml\sec etc
while velocity is the spedd (distance per time) so measured cm\sec etc
remember that blood flow usually is constant through different points in circulation (blood flow of aorta =that of arteriole=that of capillary etc..)
as Q is constant the most important factor in determining velocity is the surface area
now we will talk about veins (venules is very similar to veins:)
veins have special features to produce specific functions:
1-storage of blood(because the complinace in veins is very high they called capacitance vessels because the contain a large amount of blood without a significant increase in BP (BP may be constant or with small increase)
walls of veins are easily distended
also the arteries (but veins more)so they can hold large amount of blood without increasing intravascular BP
capacitance because they hace a thinn-walled with less smooth muscle &elastic tissue , but they contain more collagen
veins are stretchable vessels with a very low elastic recoil (because of low elastic fibers)
collagen is present to prevent injury due to excessive dilation as possible
also they have a little inherent myogenic tone compared to arterioles
veins are innervated by sympathetic fibers they contain alpha 1 adrenergic receptors
sympathetic stimulation will cause venoconstriction so decrease the compliance &pushes the blood toward the heart

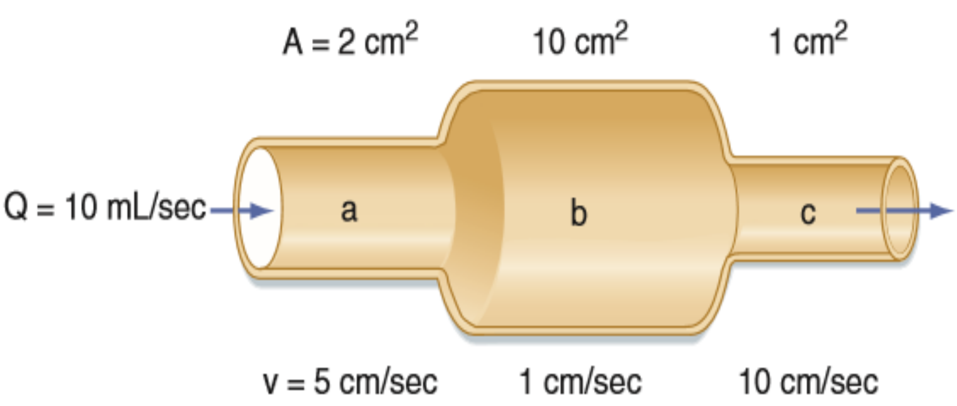
Slow Velocity of Flow Through Capillaries



- Aorta= 2.5cm^2
- Small Arterioles= 20cm^2
- Arterioles= 40cm^2
- Capillaries= 2500cm^2
- Venules= 250cm^2
- Small Veins= 80cm^2
- Venae Cavae= 8cm^2

$$v = Q/A$$

note this pic

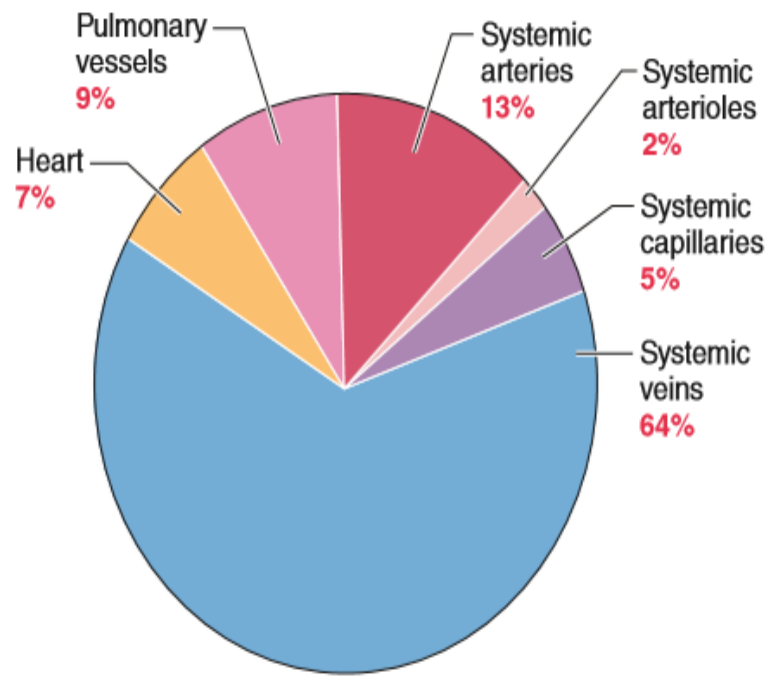


the intima of veins (mainly veins of limb)are folded at interval forming venous valves to prevent retrograde flow of blood

veins

Functions of Veins:

1. Venous system transports deoxygenated blood from tissues to the heart. From heart, blood is pumped into the lungs where carbon dioxide is removed from it.
2. Veins are capacitance vessels as they can accommodate a large volume of blood. They act as reservoir of blood. In fact, more than 60% of the total blood is present in the venous compartment.



compliance of blood vessels:
compliance =delta v\delta p(defined as the ability of blood vessels to distend as the trans mural pressure increase)
if low pressure lead to high increase in volume (this means that the slope is large so the compliance is large
pic below said:
at low pressure (veins have a greater compliance than arteries)(beacuse veins can accomodate a large changes in blood volume with a small changes in pressure)
at low pressure (vein compliance is 10-20times greater than artery compliance)
at high pressure (compliance is similar in both but volume is considerably larger in veins)
because at high pressure&volume vessels become stiffer with low compliance
this characteristic makes veins suitable for use as arterial bypass grafts

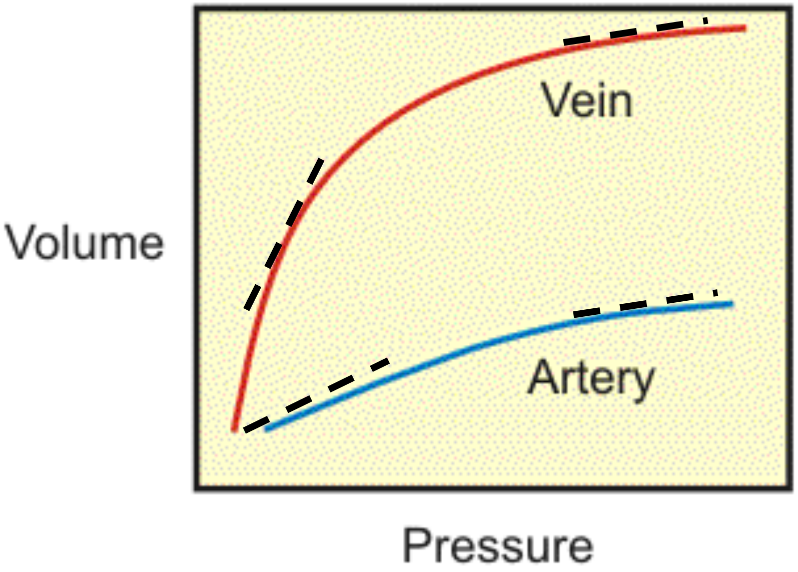
now we will talk about wall tension :according to laplace law:
in small diameter blood vessels like capillaries less wall tension is required to balance the distended pressure .(T=P*r)
that's why small vessels dont rupture due to high BP
it can be applied also to heart (when the heart is dilated the radius will increase so more wall tension is required to balance the high BP)

also that's why large blood vessels have a much thicker walls than small arteries (inorder to withstand the level of tension (stress)

Compliance of blood vessels

- At low pressures, veins have a greater compliance than arteries, Therefore, veins can accommodate a large changes in blood volume with only a small change in pressure.

- At high pressures, compliance is similar in veins and arteries (but volume is much greater in veins)
- This characteristic makes veins suitable for use as arterial by-pass grafts.



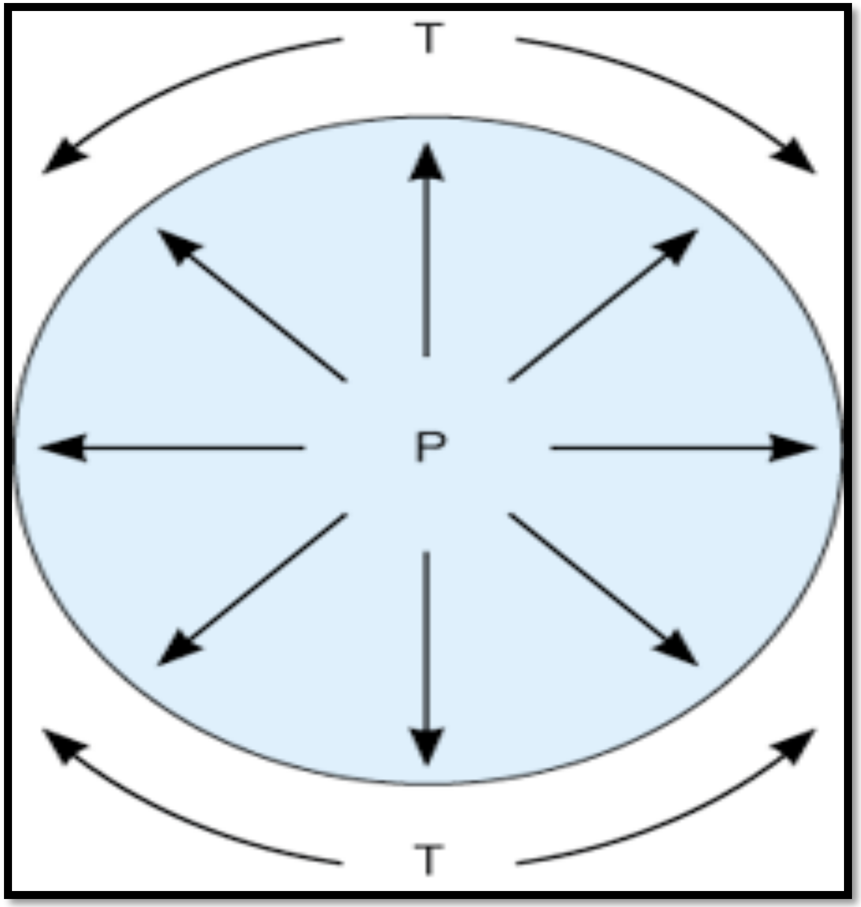
WALL TENSION

- the relationship between the distending pressure (P), the tension (T) in the wall of a structure and its radius (r) is explained by the law of Laplace
- It states that the wall tension (T) in a hollow organ is equal to the product of distending (P) and the radius (r); divided by the thickness of the wall (w):

$$T = \frac{Pr}{W}$$

- In thin-walled structures, wall thickness is negligible

$$P = \frac{T}{r} \quad \text{or} \quad T = P \times r$$



WALL TENSION

- This implies that large arteries must have thicker walls than small arteries in order to withstand the level of tension (Aneurysm).
- Arteries must have thicker walls than veins because they carry much higher blood pressure.