Cardiovascular System

11

Subject	Physiology
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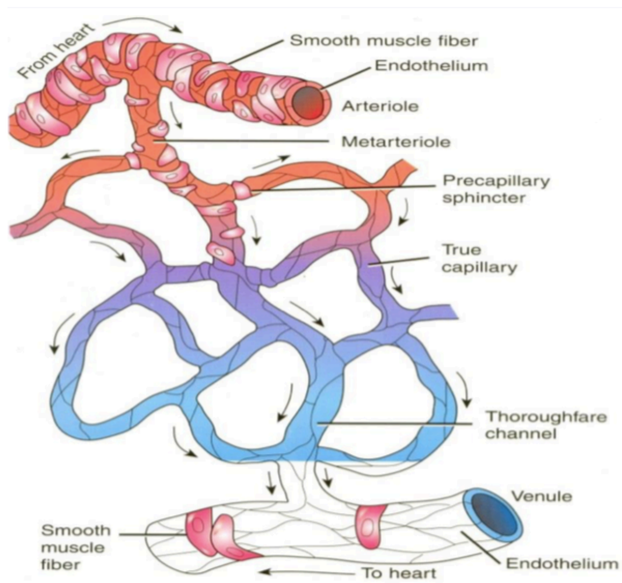
Starting with the first part of the physiology of circulation (ending "cardio" part and starting "vascular" part) we will talk about physical law.
(ohm's law is a basic law , $F=\Delta p/R$)

Functions of circulation or blood flow to tissues :

-Delivery of O2 and removal of CO2 from tissue cells. -Gas exchange in lungs.
-Absorption of nutrients from GIT.
-Urine formation in kidneys.

Systemic circulation starts from Aorta > large then medium then small sized arteries > then arterioles > metarterioles-> capillaries > veniules etc...

In capillaries we have microcirculation - where we have arterial and venous sides where filtration and reabsorption happen respectively, and we won't talk about it because we talked about it in first year .

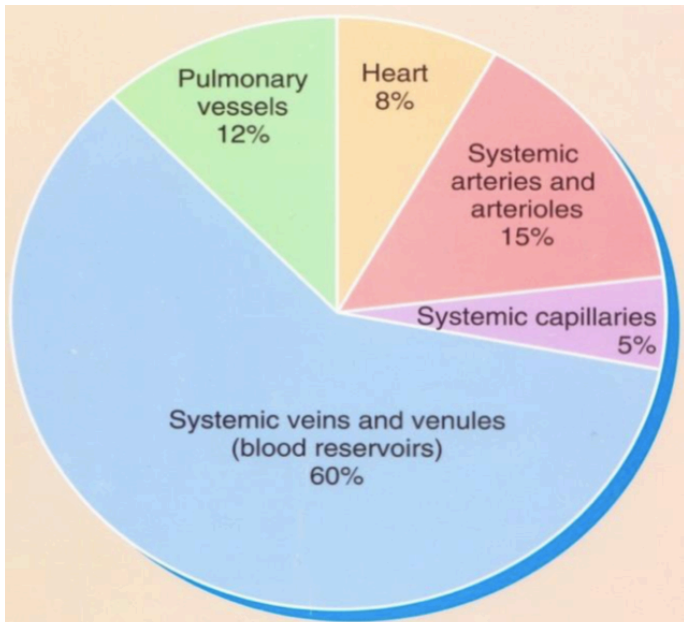


(a) Details of a capillary network

Distribution of blood volume :

Around 2/3 of our blood volume lies in veins (the largest amount of blood compared to other components) that's why we call veins the **capacitance vessels** (because they have the largest capacity)

Doctor faisal read what is written in this figure:



-Total peripheral resistance (TPR) lies in arterioles and if you constrict them they aren't going to affect the MSFP .

- Spleen is a reservoir of blood (we need it in case of hemorrhage).

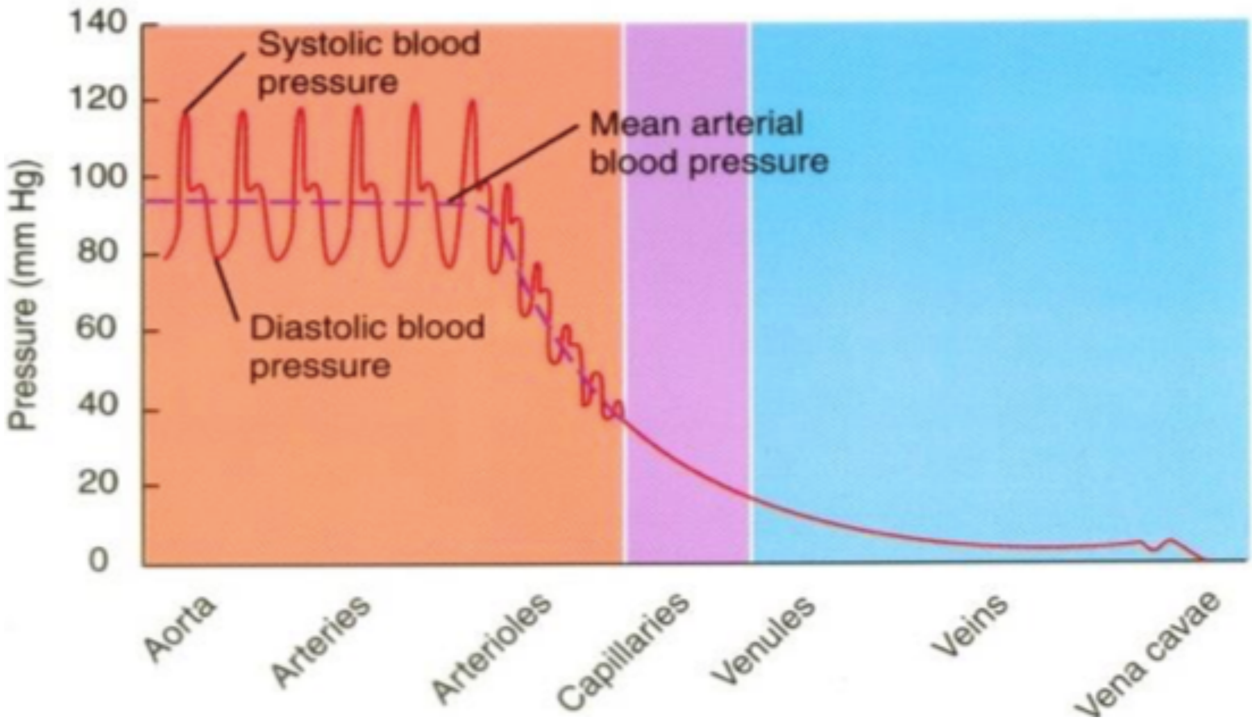
- Blood flow to tissues is controlled in relation to tissue needs. So more need, brings more blood to the tissue (auto-regulation) .

-Cardiac output is the sum of blood flow to the tissues .
-Arterial pressure is affected by many factors that's why it is almost kept constant.

Now look at this figure below and note that we take the components of each part together, for example large arteries (we talk about all large arteries as one unit) and this is applied on capillaries, arterioles ... etc

(where the flow in 12 billion capillaries = cardiac output)

- Blood pressure in Aorta is **pulsatile** (ranges between systolic and diastolic 120/80), and between them we have mean arterial pressure. **(which causes blood to move through the aorta).**
  (MAP= 1/3 systolic p. + 2/3 diastolic p.) note that the MAP is closer to the diastolic p.



- **Cardiac output** (CO) at all these areas is the same.

- **Flow** through each part (arteries or capillaries or...) = **CO**

- **WE ARE NOT TALKING ABOUT ONE ARTRY ALONE**, but about all arteries together.
  CO= flow = Δp / R

- *Now keep your eyes with the curve above - the upcoming numbers are approximate numbers:*

Let's assume that the MAP in Aorta = 100 (actually it's not 100 , 120/80 gives MAP = 93-95) And if the MAP in arteries is 95 -for example- the Δp will be 5 , then to keep a constant CO (to say 1 L/min) , resistance (R) must be 5 in order to maintain the same CO . We can see that the drop in pressure isn't high because there is **no high resistance in arteries .**

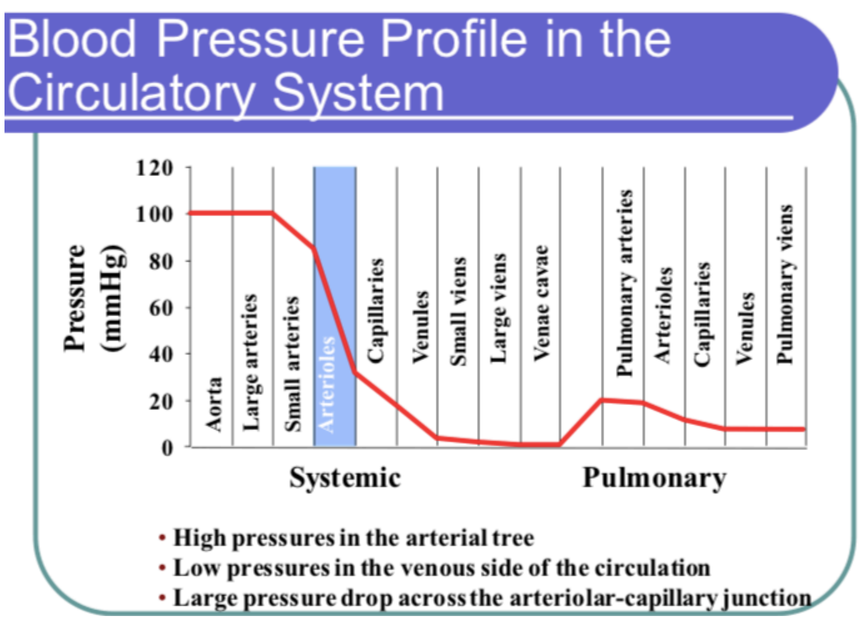
At the beginning of arterioles the MAP = 85 and at the end = 35 , then Δp = 50 and R must be 50 to have CO=1, we have too much pressure drop in arterioles because we have the largest resistance (**so arterioles are called major resistance vessels) .**
**** The resistance of the arterioles contributes to more than 50% of the total peripheral resistance.**

Another difference is that **at the end of the arterioles, no pulsation is found;** because of the very high resistance (damping of pulsation occurs), so pulsation in capillaries will be considered abnormal.

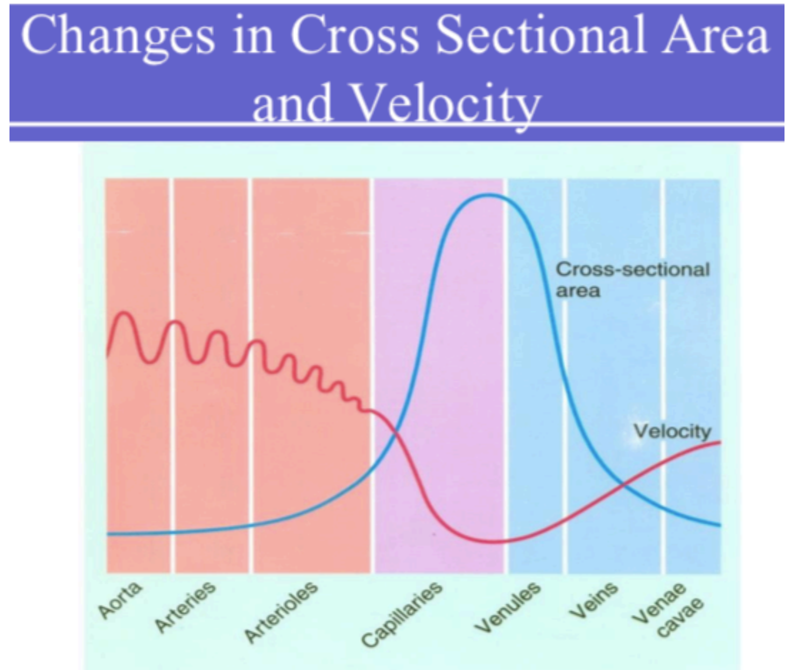
In capillaries, at the beginning MAP is 35 and at the end 15, why is it lower at the end ? We must have lower p so that blood would flow according to the difference in pressure (Δp) .

We have Continues pressure drop (pressure gradient) as we go from Aorta to right atrium. **Main pressure drop is in the arterioles** (arteriolar capillary junction) .

Does vasoconstriction in arterioles cause hypertension? Yes , vasoconstriction of arterioles could lead to hypertension , if it increased resistance, MAP would increase (MAP = CO*TPR)



In any vessel, **flow = area * velocity = πR2 * velocity**
<u>Flow through each part is constant and equals = **CO .**</u>
Remember Boyle's Law that states V1*p1=V2*p2, which describes the pressure-volume relationship of a gas (where V stands for volume and p stands for pressure), a similar law that concerns us here is the continuity equation which states that at a fixed volume flow rate through a certain tube, an increase in cross sectional area results in decreased velocity to maintain the constant flow and vice versa, i.e A1*v1= A2*v2 (where A stands for cross sectional area, and v stands for velocity).



Here in flow we have the same concept, flow is constant and (area* velocity) must be constant , so if we have increase in area then velocity will be decrease , and vice versa ...

Just like when you're watering the plants with a hose (او تشطفي/ي) and the water isn't "strong" enough, you put your finger on the tip of the hose and the water becomes faster, so we basically decrease the cross sectional area to increase the velocity)

We have Higher velocity in Aorta and lower in arteries because of **lower area in aorta.**

In capillaries, **large area** causes **slow velocity** so the <u>flow and the CO will still be constant</u>. ***(Again, don't forget that we are talking about all capillaries in the body. Not just one)***

Slow flow gives capillaries an advantage, so they have enough time for **exchange of gases and nutrients**, also the large area increases the exchange (faster and higher diffusion)

Velocity in vena cava is **lower** than velocity in Aorta **because we have 2 vena cava** (larger area) and because its **more flexible** than Aorta.

The Capillaries Have the Largest Total Cross-sectional Area of the Circulation

	cm
Aorta	**2.5**
Small Arterioles	**20**
Arterioles	**40**
Capillaries	**2500**
Venules	**250**
Small Veins	**80**
Venae Cavae	**8**

capillaries have the largest total cross sectional area in the circulation .

$$\textit{Velocity}\ \text{of Blood Flow} = \frac{\text{Blood Flow}}{\text{Cross sectional area}}$$

Flow= A*V

A= Area , V= Velocity

flow is constant and inversely related to cross sectional Area.

Aorta >Arterioles > Small veins >Capillaries

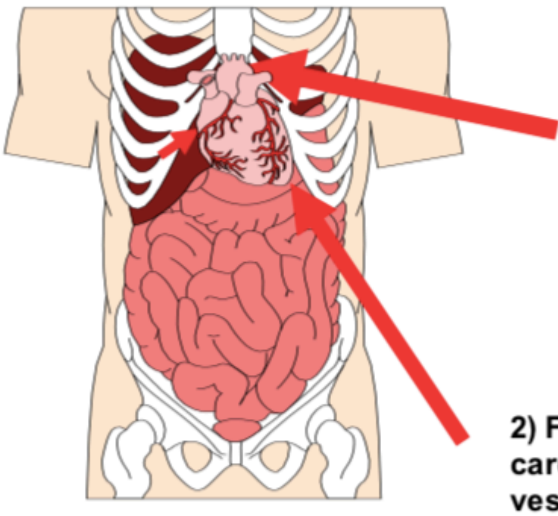
Blood flow or "F" means simply the quantity of blood that passes a given point in the circulation in a given period of time (mL/Sec)

$$F = \frac{\Delta P}{R}$$

In the systemic circulation

***(F) = cardiac output (CO),**

*** the pressure gradient = (difference between mean arterial blood pressure and atrial pressure which is around zero) = mean systemic arterial B.P.**



1) Pressure gradient produced by heart pumping moves blood in the system from the arterial to the venous side, 5 l/min

2) Fluid pressure expands cardiac chambers and blood vessels.

The doctor only read this slide

$$CO(F) = \frac{\textit{mean systemic arterial blood pressure}}{\textit{total peripheral resistance}}$$

Velocity (V) is proportionate to flow (F) divided by cross sectional area of the blood vessel (A) : **F=A*V V=F/A**

The laws of flow and velocity are **only** applied on **laminar flow** (or stream line flow), in which blood flows in layers. On the other hand, Turbulent flow occurs when we have constriction and it's not an efficient flow **(only laminar is efficient)**

Note that we talked previously about **"turbulence"** in heart sounds , where S1&S2 are caused by turbulence of blood around closed valves, AV and semilunar respectively

Blood **doesn't flow as plugs (A)**. Instead, the blood in the center has the highest velocity that decreases at the sides because of increasing resistance near the wall. This gives a *"**parabolic**" shape of flow.* **(B)**
* turbulent flow **(C)**