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Physiology sheet

Doctor 2022 -أثر- | medicine | MU

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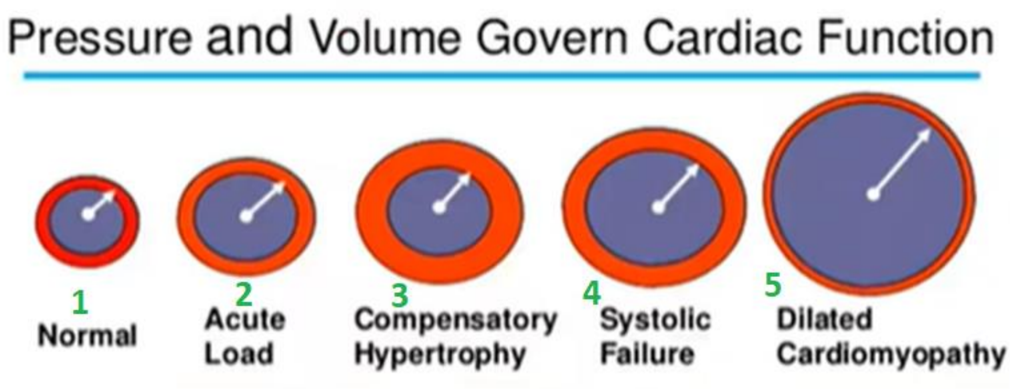
Blood Pressure

La Place Law of the Heart:

- Blood pressure (BP) could be simply defined as: **blood pressure is the pressure exerted by circulating blood on the wall of arteries** or blood vessels (BVs) generally. When a pressure ↑→ tension (stretching) ↑→ radius (of BVs lumen) ↑. That is a general rule, now to the details:
- In the following figure (track the numbers (#)):



1. In Normal Heart: pressure, tension and radius all are normal. The size of wall tension is commensurate (in proportion) with the needs of the oxygen (O2)

2. In acute load (as in exercising person): preload (or left ventricular end diastolic pressure, LVEDP) ↑ → ↑blood pumped → ↑ the need for more O2 → ↑ venous return (VR, the flow of blood from the periphery [all body parts] back to the R atrium)→ radius will ↑ → ↑ in pressure. O2 here is adequate with metabolic activity.

3. In compensatory hypertrophy (a disease): (hypertrophy) enlargement in walls of ventricles → ↑ radius (in either eccentric or concentric hypertrophy) →↑ in pressure and tension (stretching) → O2 demand ↑ (A lot of pressure compared to volume and a lot of O2 demand).

4. Another disease is heart failure (HF). Before getting into its classifications, remember that blood takes the following path:

- All body parts (periphery) → Superior and inferior Vena Cava (SVC& IVC) veins → R atrium → R ventricle → Pulmonary artery → R and L lungs → Pulmonary vein → L atrium → L ventricle → Aorta artery → back to the periphery. When a chamber of the heart is not working properly (dysfunctional) → blood will pool (accumulate) in this chamber and the 1st one or two structures before it, where the signs and symptoms can be related. That being said, classification can be done according to:
  - The side of chambers affected: it's divided to:

a. <u>Left- side heart failure:</u> where L ventricular dysfunction → ↑ in blood in pulmonary vein → ↑ fluids in lung tissues → lung related sings & symptoms (coughing, shortness of breath [SOB] and/ or trouble breathing) → pulmonary edema.

b. <u>Right- side heart failure:</u> where R ventricular dysfunction → ↑ blood in SVC& IVC → ↑ in interstium in all the periphery → generalized (systemic) edema or fluids build- ups, moslty in legs, genitals, different organs and/ or abdomen.

c. <u>Biventricular heart failure:</u> where both the ventricles are dysfunctional → sings & symptoms of both R and L sides heart failure types.

- <u>The values of ejection fraction (EF),</u> all this classification subtypes go <u>under left- side heart failure,</u> where it is subdivided to:

  a. <u>HF with preserved EF (HFpEF) or Diastolic HF;</u> the EF is normal (preserved) and the problem is that LV can't relax between heartbeats (in diastole).

  b. <u>Hf with reduced EF (HFrEF) or Systolic HF;</u> the EF is below normal (reduced) and the problem is that LV can't efficiently contract with each heartbeat (in systole).

- In <u>systolic failure;</u> ventricles can't pump enough blood (like fibrillation) → No heart rate and no breathing. Pre-load (LV end diastolic volume in this case) → aggregates in ventricles → no pumping volume of blood in large amount. So, (a lot) of pressure ↑ and radius will ↑ (not a lot) and definitely with ↑ in O2 demand.

<u>5.</u> <u>Dilated cardiomyopathy</u>: dilation in walls of ventricle → very thin walls → volume, pressure and tension (stretching) will ↑→ with radius and O2 demand of a lot ↑ (when there will be thinning in walls → the tension will ↑ a lot and pressure and radius would ↑ accordingly). The patient can do activities that do not affect the heart and do not significantly increase tension.

- **To sum up:**
  - **In <u>La Place Law for myocardial O2 demand</u> there is a direct relationship between VO2 (volume of O2 your body consumes) and wall tension; where:**

$$\text{Laplace's Law: Wall stress} = \frac{\text{Pressure} \times \text{Radius}}{2 \times \text{Wall Thickness}} = \frac{\text{Pressure} \times \text{Volume}}{\text{LV Mass}}$$

Wall Stress

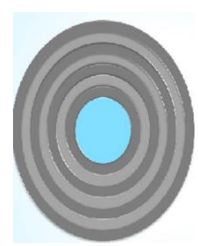
  - **Primary target for heart failure therapy: reduce left ventricle (LV) wall stress.**

What Blood Pressure is and Factors Determining Blood Pressure:

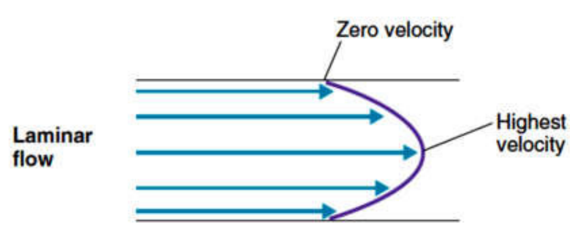
- **Blood pressure is the pressure exerted by circulating blood on the wall of arteries**
- **One of the most physiological parameters of the body which is why including in the <u>five vital signs</u> along with 1) <u>temperature</u>, 2) <u>heart rate</u> (rate of heart beat), 3) <u>respiratory rate</u> (rate of breathing), 4) <u>oxygen saturation</u> (measure of how much hemoglobin is bound to O2 related to how much is not bound; this percentage [%] reflects the amount of O2 circulating in our bloods and it is measured by fingertip oximeter) and 5) <u>blood pressure.</u> Those five vital signs are routinely done to every patient to indicate any malfunctions.**
- **Factors affecting blood pressure:**
  1. **Heart rate**
  2. **Myocardia contractility; refers to how hard the heart is squeezing**
  3. **Vascular tone; which refers to how much the arteries are constricted or relaxed**
  4. **Blood volume**
  5. **Blood viscosity**
  6. **Arterial compliance; refers how much give or elasticity the arteries have**

Blood Flow:

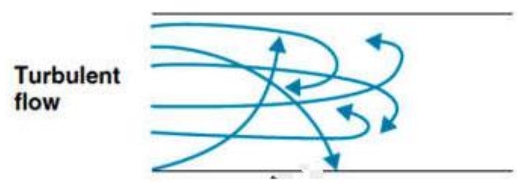
- **<u>Laminar flow: normal blood flow in the blood vessels (physiological):</u>**
  - ♦ **As you go toward the edges the velocity the blood is going to be slower and the velocity in the middle is highest**
  - ♦ **So, imagine you are looking to blood vessels as a circle, and you are looking at the flow from the back you are going to notice that is flow is very concentric and this type of flow is silent**



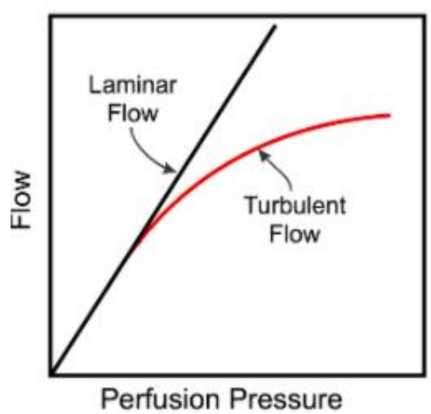
  - ♦ **blood flows inside vessels in parallel lines → no friction (laminar or smooth flow) → no abnormal sounds in this type. When number of lines of blood flow ↑ → friction with walls of blood vessel ↑ → there will be sounds and this is not normal, it is called the (<u>turbulent flow</u>) → ↑ in both pressure and volume.**

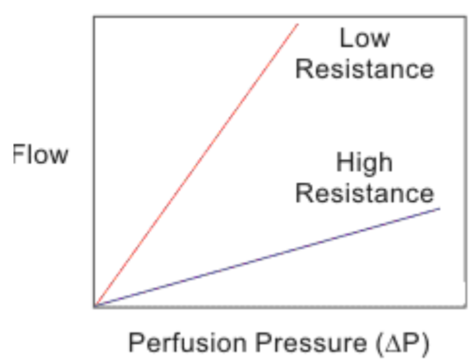


- **<u>Turbulent flow: pathological and physiological one</u>:**
    - **Inside our heart you have a valves mitral valve and aortic valve whenever blood is being pumped upward right it can hit mitral valve as it hits mitral valve it can develop turbulent flow (mostly due to ↑ in blood viscosity).**
    - **Imagine a blood vessels and plaques inside ; as the normal flow gets to the occlusion it start developing a turbulence and that gives a lot of heat and changes the action of perfusion pressure and produce what called brutes and can be heard at carotid artery so if you take a stethoscope and put it over carotid artery you can hear it as actual sounds that caused by turbulent flow. It also can produce murmurs.**



- **Prefusion (or perfusion pressure) is the rate at (@) which blood is delivered to a tissue. In other words, it resembles how much pressure it takes to push blood through all BVs in a specific area. Simply, it is blood flow per unit mass of tissue → it is not the same as blood flow.**
- **If you look at the graph here; as you increase the pressure the flow is increasing in laminar or turbulent flow, but you get to the point where the flow veers off and the flow start decreasing as the perfusion pressure start increasing**
- **If there is a turbulent flow it decreases the actual flow the volume of blood that circulating through an area of blood vessel per a minute and increase the perfusion pressure and the resistance is going to be very high**

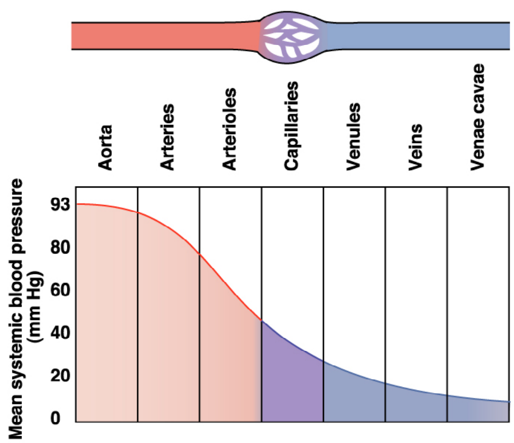


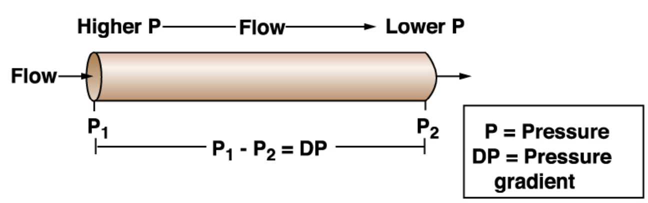


- **To sum up:**
    - **<u>Resistance</u>: in laminar flow is normal, but it ↑ in turbulent flow.**
    - **<u>Perfusion pressure (or perfusion):</u> is normal in laminar flow, but ↓ in turbulent flow.**
    - **The heart sounds are a basic indicator of the condition of the heart: is it normal or not?**

Perfusion Pressure:

- <u>How can we measure perfusion pressure?</u> By one of two ways:
  1. Perfusion pressure (Δp) = Mean arterial pressure (MAP) which normally equals 90- 93 mmHg – (minus) the central venous pressure (CVP) which normally equals 3-8 mmHg. The central venous pressure (CVP) determines the right atrial pressure (RAP). The volume of blood pumped toward heart is your central venous pressure which is the same as the venous pressure that affects your right atrium pressure and it is about 3-8 mmHg; it is small → we don't even consider it often (negligible value) → you can put a zero in its place in the equation above → So what we say that: the perfusion pressure (Δp) = Mean arterial pressure (MAP) – zero = 93 – zero = 93 mmHg, <u>what does that mean???</u> MAP is the average arterial pressure throughout one cardiac cycle, systole, and diastole and it has a significance in measuring the pressure necessary for adequate perfusion of the organs of the body. Specifically, we need to maintain an arterial pressure of 93 mmHg to ensure the perfusion process to all the periphery.
  2. Perfusion pressure (Δp) = pressure @ highest point (Aorta) - pressure @ lowest point (vena cava). Check the following figures:





- <u>Systolic pressure:</u>
  - Whenever the heart contracting it pumping the blood outside the heart; the force at which we are trying to push the blood out of the heart and into the actual major arteries is the <u>systolic pressure</u> (left ventricles to aorta) and on average it is about 120 mmHg
  - Whenever the blood comes into the aorta it stretches the wall of the aorta so the wall of the aorta is going to be stretched now this is not that is stretching the walls is the systolic pressure but what happens is eventually; the actual aorta is very elastic and wants to recoil and squeeze the blood downwards or upwards to the head and the neck
  - Systole means how much contraction during highest point of pumping.

- **Diastolic blood pressure:**
  - Whenever the aorta is coming back to it is natural size the point when is relaxing and going back to its normal size original size; this is called the diastolic blood pressure and on average it is about 80 mmHg
  - Diastole means relaxation in walls of ventricles and consequently aorta→ doing stretching and it is the lowest point.
- Blood pressure is resembled as systole / diastole. Then we have the following readings:
  1. BP= 120/80 NORMAL, If the pressure changes from this limit, it does not necessarily have to be a problem, because there are many factors that play a role, such as height, age, and weight (directly proportional with height and weight but can vary with age).
  2. BP= 90/60 HYPOTENSION.
  3. BP= 140/90 HYPERTENSION.

Mean Arterial Pressure:

- Can be calculated by one of two ways:
  1. $MAP = diastolic\, pressure + 1/3\, pulse\, pressure = 93mmHg$ where pulse pressure is the difference between systolic and diastolic pressure which is 40 mmHg on average. Note that heart rate is one cardiac cycle and it resembles the beats of the heart, but pulse pressure is from the aortic arch of heart→ it resembles vibrations from the artery→ those are the ones heard.
  2. To calculate a mean arterial pressure, double the diastolic blood pressure and add the sum to the systolic blood pressure. Then divide by 3. For example, if a patient's blood pressure is 83 mm Hg/50 mm Hg, his MAP would be 61 mm Hg. Here are the steps for this calculation:

     $$MAP = \frac{SBP + 2\,(DBP)}{3} \text{ or } 2/3\,(DPB) + 1/3\,(SBP)$$

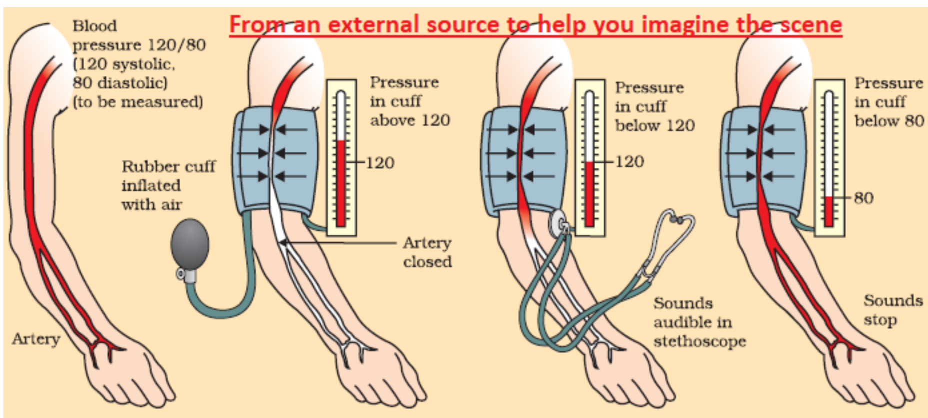
     Why different thirds? the ventricles spend approximately one-third (1/3) of their time in systole, and two-thirds (2/3) in diastole (filling the chambers takes more time than emptying them).
- MAP is so important because it determines the actual pressure by which will propel the substances out of the capillary beds into the tissues.

Korotkoff Sounds:

- They are the sounds that medical personnel listen for when they are taking blood pressure using a non-invasive procedure.

- **The following figure is from an external source. However, the doctor almost mentioned all the tips in it.**

- **Steps in measuring blood pressure:**
  1. **Put the blood pressure cuff on you start pumping the blood pressure cuff**
  2. **As you start pumping the cuff usually put around the brachial area, so you are compressing the brachial artery as you compressing the brachial area you are going to decreasing and slowing the blood flow to that area**
  3. **Keep pumping it until you hear no sounds like hit it 30-50 mmHg above 120, this is done to avoid having an auscultatory gap related problems in measuring BP (it will be explained briefly below).**
  4. **Once you get to a decently high point Then start slowly letting go and you going to hearing tapping sound and it is like swishing sound and this Korotkoff sound**
  5. **After those sounds go away it leads into the first sound is the systolic pressure**
  6. **Those sounds of systolic pressure is going to continue and continue until the sound completely dissipate that last point at which the sounds disappear is called the diastolic pressure**

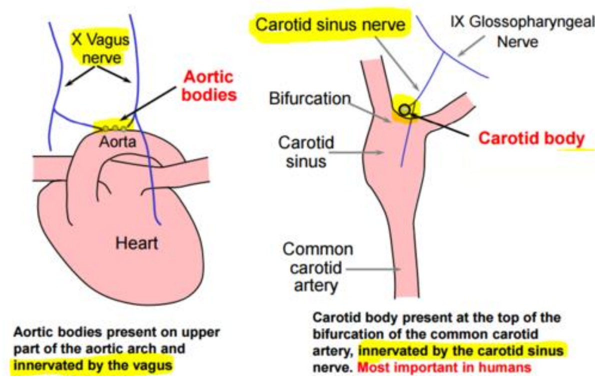


- **Notes regarding BP measurements:**
  - **If the measurement of pressure was done to a person while he is standing → he will be afraid → it will ↑ his heartbeat → ↑ his blood pressure. That is why the person must sit in a state of relaxation and take the reading from brachial artery. Moreover, the thrilled status yield more BP → be relaxed.**
  - **In order to feel the pulse more clearly, we press on the patient's hand, and the first time we hear the sound, this means that the blood is pumping from aorta to brachial artery.**
  - **In abnormal pressure → sounds will be unstable.**
  - **An auscultatory gap (the silent gap): is a period of diminished or absent Korotkoff sounds during the manual measurement of blood pressure. Example: The patient's actual systolic pressure is 200 with a gap from 170 to 140 and a diastolic of 110. You inflate the cuff to 170 and hear nothing until the manometer reaches 140, which you presume is the systolic pressure. Auscultatory gap is age independent and it is thought atherosclerosis is one of the possible causes. To avoid it we always inflate the cuff 30- 50 mmHg above the suspected value of systole → to ensure hearing all the sounds.**

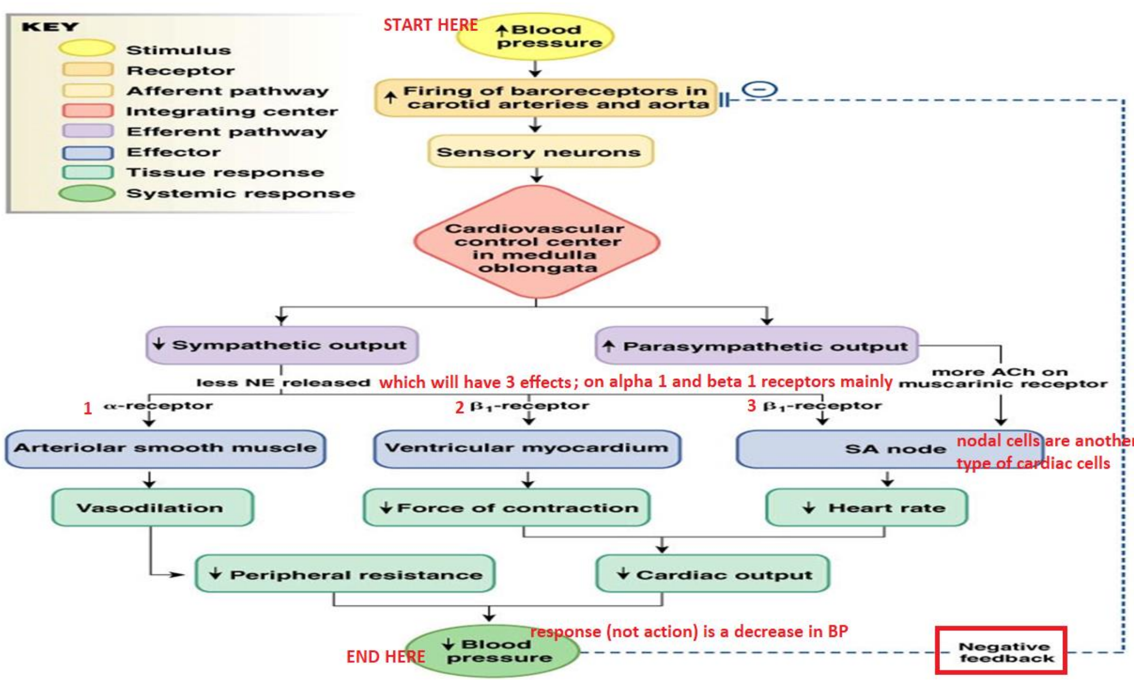
- ➢ **In old age difference between systole and diastole is more → higher pulse pressures.**

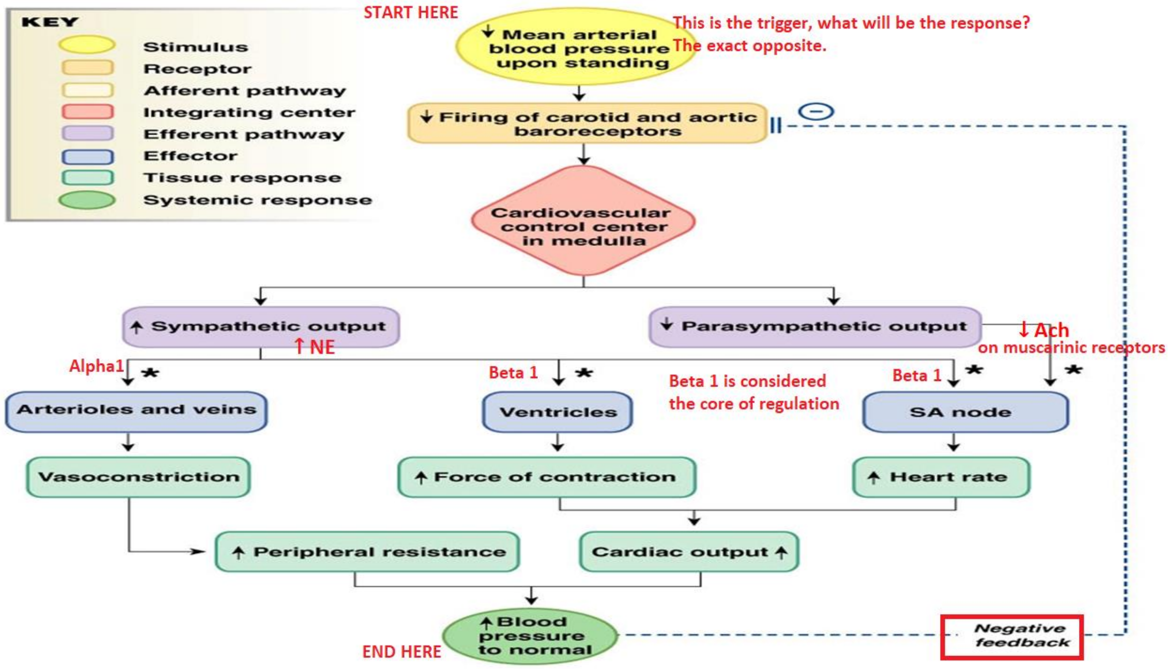
Regulation of Blood Pressure (regulation of Cardiac Output [CO]):

- **Regulation of blood pressure (to maintain dynamic homeostasis) can be done either by:**
  1. **Chemical regulation: using hormones such as: epinephrine (adrenaline), norepinephrine (noradrenaline), aldosterone ..etc.**
  2. **Mechanical regulation: by mechanical baroreceptors; which are:**
     a. **Aortic bodies: that present on upper part of aortic arch and innervated by the Vagus nerve (cranial nerve # 10) which will go then to medullary oblongata (a part of brainstem).**
     b. **Carotid body: present @the top of the bifurcation of the common carotid artery (or sinus)and it is innervated by the Glossopharyngeal nerve (cranial nerve # 9) which will go to medullary oblongata.Most important in humans.**



- **The following two figures are important with its notes:**





- **To sum up:**
  - NE and Ach work on opposite ways.
  - In ↓ BP: ↑ NE and ↓ ach.
  - In ↑ BP: ↓ NE and ↑ ach.
  - Alpha 1 receptors stimulation has a vasoconstrictive effect on smooth muscles of BVs → ↑ vasoconstriction on BVs → ↑ Total peripheral resistance (TPR) and as BP= CO x TPR → ↑ BP. That being said; alpha 1 blockers cause vasodilation → ↓ BP (a type of drugs used to treat HTN).
  - Beta 1 receptors stimulation has two effects: 1) ↑ ventricles force of contraction (positive [+ve] inotropy) and 2) stimulates SA nodes → ↑ HR (+ve chronotropy). Both the effects will lead to ↑ing CO → ↑ BP. Beta 1 blockers (or antagonists) → they ↓ BP → used to treat HTN, too.

" لقد تعبنا من المسير، ومللنا، وسئمنا، لكننا نريد الوصل، ويجب أن نصل،

ومن أجل الوجهة تهن عذابات المسير!"