Physiology lecture 15
Hemodynamic

- **Dispensability (D)** :
  - proportional change in volume per unit change in pressure
    D = ΔV/ΔP*V
  - It is proportional (divided by the original volume).
- **Compliance (C)** :
  - total change in volume per unit change in pressure
    C = (ΔV/ΔP) = D*V
  - It is not proportional.

Example:

- If the blood volume changed by 20 ml, the original vulome was 200 ml, and that changes the pressure by 1 mmHg;
  D = 20 / 1*200 = 10%
  C = 20/1 = 20

- Notice that:
  - Since Veins contains 60% of blood volume, while arteries contain only 15% → Volume of the veins is 4 times more than that of arteries.
  - The dispensability of the veins is 6 times (6-8 times) more than the arteries.
  → **Compliance/Capacitance of the Veins is 24 times more than the arteries.**

- **Pulse pressure (PP)**:
  - Equals the difference between the Systolic and Diastolic pressure
    PP = Systolic pressure – Diastolic pressure
  - Around 40 mmHg (if we consider that the Systolic pressure= 120, Diastolic pressure =80 mmHg)
  - Affected by 2 factors :
    1. Stroke volume (SV): ↑ **SV** → ↑ **PP**
       - ↑ SV → ↑ blood that goes to the Aorta → it distends more but it has a fixed Compliance, so the pressure will increase → ↑ Systolic pressure → ↑ PP
    2. Compliance (C) : ↓ **C** → ↑ **PP**
       - ↓ C → vessel becomes rigid →when volume is increased ↑ Systolic pressure → ↑ PP

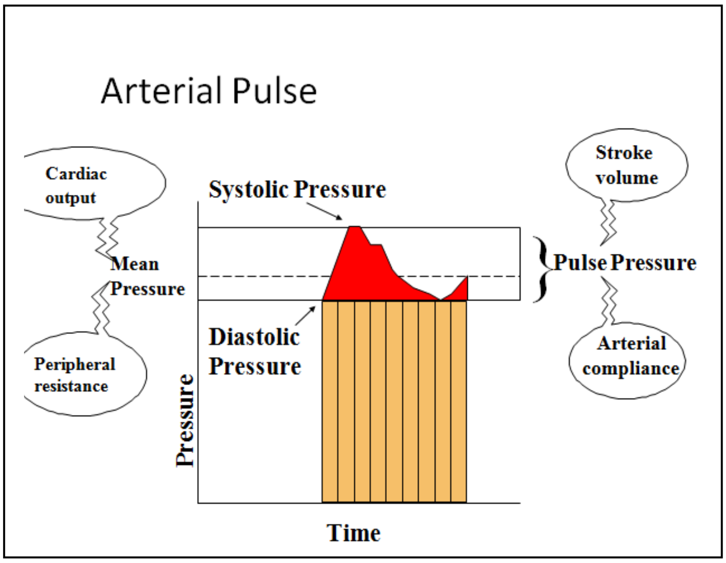
$$PP \approx \frac{SV}{C}$$

PP is affected by the ratio of SV to C. So, you can change both SV and C without changing PP.

- When we measure pulsation, <u>the pulse we feel is *the wave*</u> that moves through the wall of the artery NOT the blood flow.
- ↓ C → ↑ speed of the movement of the pulse wave.

Compliance: in Aorta > Medium sizes arteries > small arteries and arterioles
Speed of the wave: 5m/s 10m/s 40m/s

- Movement of the pulsation wave need blood flow to move in front of it.
- Damping of pulse in arterioles is due to the very high resistance.
- First heart sound almost coincide (happens at the same time) with the pulsation, and flow can't move that fast from the valve to place we pulse – to the wrist as an example- , which insures that it is the wave that we feel that moves through the arterial wall not the blood flow.



- In the diagram :
  1. PP = Systolic P – Diastolic P
  2. PP is affected by SV and C.
  3. MAP is affected by CO and peripheral resistance. (Remember it equals CO * TPR).

- Abnormal pressure pulse:
  1. ***Arteriosclerosis*** : ↓ Compliance →↑ PP

  2. ***Patent ductus arteriosus*** :

     - in this case there is a connection between the Aorta and the pulmonary artery; so blood flows from the Aorta to the Pulmonary A. during the systole, and blood goes back to the Lt. ventricle → ↑ EDV → ↑ SV ↑ Systolic P & since part of the blood goes from the aorta to the pulmonary artery (where the resistance is lower) → ↓ Diastolic P →↑ PP

  3. ***Aortic regurgitation*** :

     –condition associated with backward flow of blood through the aortic valve to the Lt. ventricle → ↑ EDV → ↑ SV ↑ Systolic P & since the blood goes to the Lt. Ventricle instead of going to the systemic circulation through the aorta→ ↓ Diastolic P →↑ PP

- Incisura might disappear in this condition.

- **Volume – Pressure relationship in circulation**:
  - When we plot a V – P curve (in a graph in which the volume is on the Y axis, and pressure on X axis) any change in the volume over the change in the pressure is the <u>compliance.</u>
  - Any given change in volume within the arterial tree results in larger increases in pressure than in veins.

The End of Midterm Exam Material.

Good luck. ☺

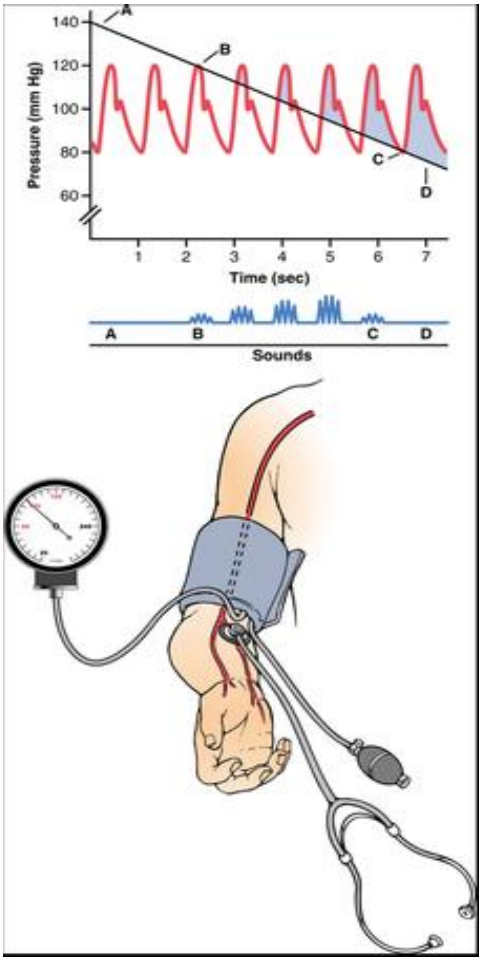
Blood Pressure Regulation-1

❖ **Objectives:**

- Outline the short term and long term regulators of BP.
  If you were sleeping and then you get up, according to the gravity law your blood pressure should fall → decrease blood flow → you will fall down (coma) BUT that doesn't happen because in terms of seconds the blood pressure is raised and the blood flow to the brain won't decrease. Also, if you were standing and then you sleep, pressure has to increase by gravity, the pressure might break the capillaries → bleeding BUT that doesn't happen because blood pressure is regulated right away and brought down to its normal value. How does that happen?
- Know how baroreceptors and chemoreceptors work. – Know function of the atrial reflex.
- Know function of CNS ischemic reflex. – Know the role of Epinephrine, Antidiuretic hormone (ADH), Renin-Angiotensin-Aldosterone and Atrial Natriuretic Peptide (ANP) in BP regulation.
- Know the role of Kidney-body fluid system in long term regulation of BP.

❖ **Blood pressure measurement:**

- By Sphygmomanometer (mercury or digital):
- **Auscultatory method**, which is the most commonly used:
  - Wrap the cuff around the upper arm at the level of the heart.
  - Press the stethoscope's bell over the brachial artery just below the cuff's edge.
  - Inflate the cuff to a level higher than the systolic pressure (> 120 mmHg). Thus the artery is completely compressed, there is no blood flow, and no sounds are heard.
  - Release air from the cuff, the pressure is slowly decreased. At the point where the systolic pressure exceeds the cuff pressure, the Korotkoff sounds are first heard and blood passes in <u>turbulent</u> flow through the partially constricted artery. Korotkoff sounds will continue to be heard as the cuff pressure is further lowered. However, when the cuff pressure reaches diastolic pressure, the sounds disappear and the blood flow is stream line/laminar (<80 mmHg, free flow).



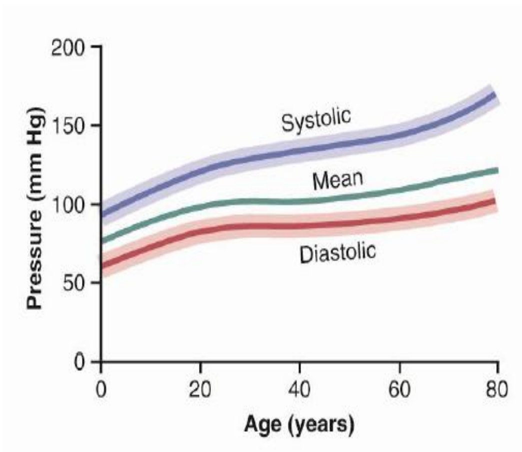
Auscaltatory method for measuring systolic and diastolic arterial pressure.

(Point A: pressure is higher than the systolic pressure and no sounds are heard; point B: as soon as the pressure in the cuff is below the systolic one begins to hear **tapping** sounds; point C: as the cuff pressure reaches the diastolic pressure, one hears **muffled** sounds; point D: as the cuff pressure falls a few mm Hg the sound disappears entirely.

– **Palpatory method:**
If you don't have a stethoscope, you can use the pulse method to measure the systolic pressure ONLY; the first pulse you feel is the <u>systolic</u>.
Korotkoff sounds are named after *Nikolia korotkoff*, a Russian physician who first described them.

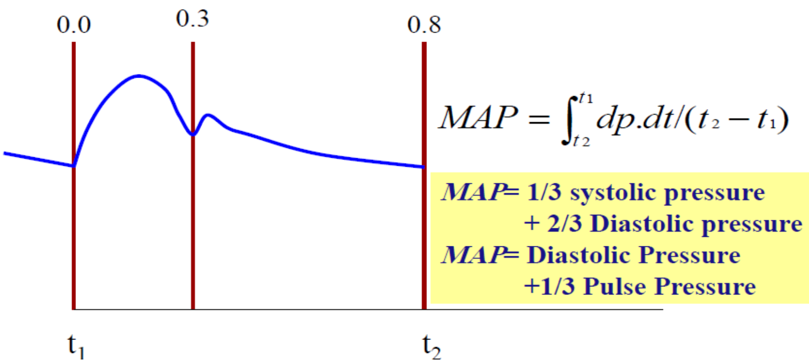
❖ **Mean Arterial Pressure:**

- What we are talking about in blood pressure regulation is the Mean Arterial Pressure which moves the blood in the circulation.
- In diagram no.1; you can notice that the MAP is closer to the diastolic because it equals 1/3 of systolic pressure + 2/3 of diastolic pressure.



#1

- In diagram no 2; area under the curve is the pressure; to calculate the mean you divide it by t_2-t_1. (Remember: pulse pressure = systolic pressure – diastolic pressure).



#2

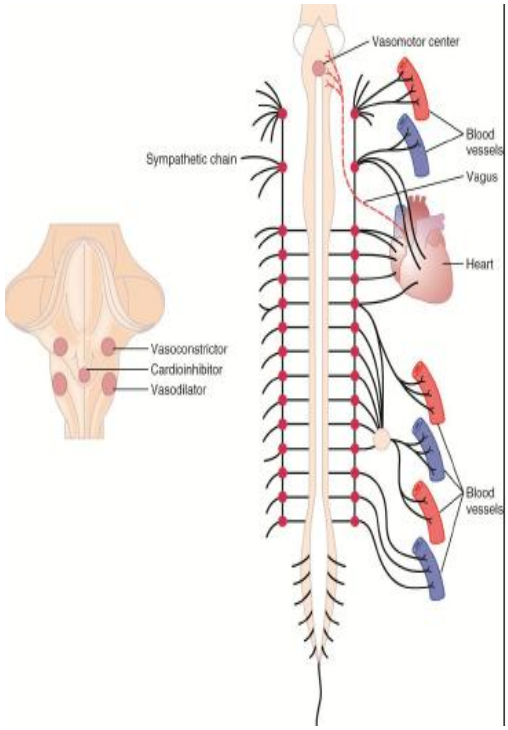
- According to Ohm's law; CO = MAP / TPR → MAP = CO * TPR
So any time you would like to change MAP either you change the CO (by changing Stroke volume or Heart rate) or the total peripheral resistance that is changed by vasodilation or vasoconstriction.

❖ **There are three time sequence of regulation:**

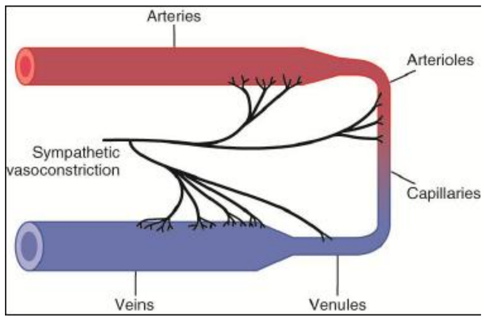
1. Short term, occurring within of seconds (neural)
2. Intermediate term (hormonal/ chemicals)
3. Long term (fluids/ renal system)

❖ **Nervous regulation of the circulation:**

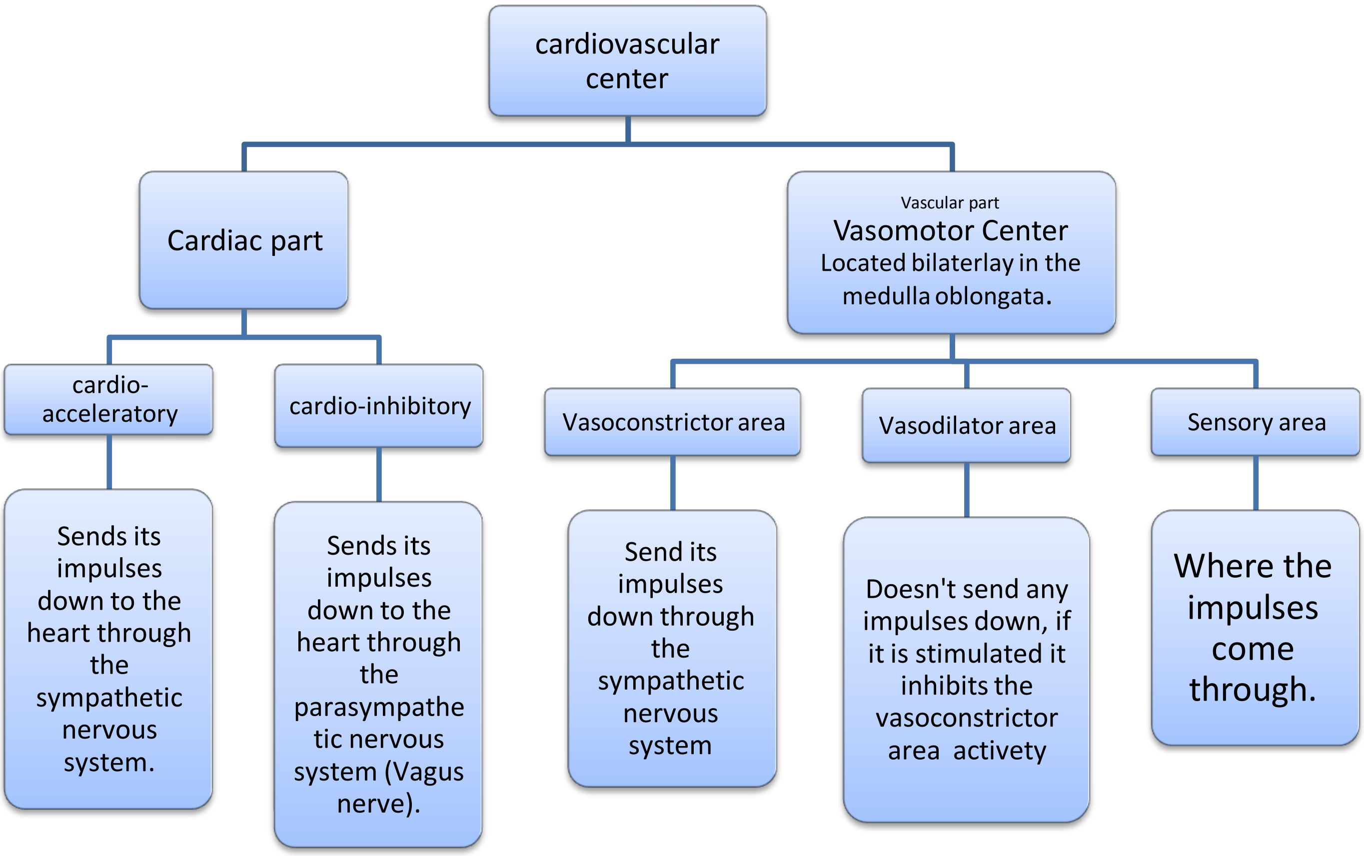
- ANS supplies the cardiovascular system; Sympathetic nervous system is important in control of circulation (it is predominant in the control of contractility).
  All vessels are supplied only by sympathetic nervous system (except capillaries and precapillary sphincters and some metarterioles), its stimulation results in vasoconstriction, and vasodilation is the result of inhibiting it.
  Capillaries aren't supplied by sympathetic or parasympathetic nervous systems.
  Parasympathetic nervous system is important in regulating the heart function (it is predominant in the control of heart rate).



- Any control system should have: stimulus, control and response. Here the stimulus is the <u>change in the blood pressure (not the pressure)</u>, the control system is found in the brain, the response is either by increasing or decreasing the pressure.



- How the control system knows that there is a change in the pressure?
  There must be receptors that sense that change. These receptors are called ***Baroreceptors***. The best place for the baroreceptors is be as close as possible to the most sensitive and important areas (Heart and brain); closest to the heart in the aortic arch ***"Aortic baroreceptors"***, the brain is supplied by the carotid artery so there are ***"Carotid sinus baroreceptors"*** (slightly above the bifurcation of each carotid artery). These baroreceptors sense any change in the blood pressure that is going to the brain. These are called ***High pressure baroreceptors.***
  These baroreptors sense the changes and send them to the **Cardiovascular center** in the medulla oblongata (part of the brain stem).



- Signals from the "carotid baroreceptor" are transmitted to the medulla oblongata through (*Herings Nerve*) to the *Glossopharyngeal (IX) nerve* .Signals from the "aortic baroreceptors" are transmitted through the *vagus nerves* to medulla oblongata.
- If there is increase in pressure (more stretch) the receptors increase their discharge /AP /firing/ impulse rate in the afferent nerves

  ⇨ cardiovascular center → inhibits the cardioaccelatorty and stimulates the cardioinhibitory → send less sympathetic and more parasympathetic to the heart → decrease in the contractility and heart rate → decrease in the SV and CO

  ⇨suppress the vasoconstrictor area → send less sympathetic to the vessels → vasodilation → decrease TPR

By decreasing the CO and TPR, the MAP is decreased towards its normal value.

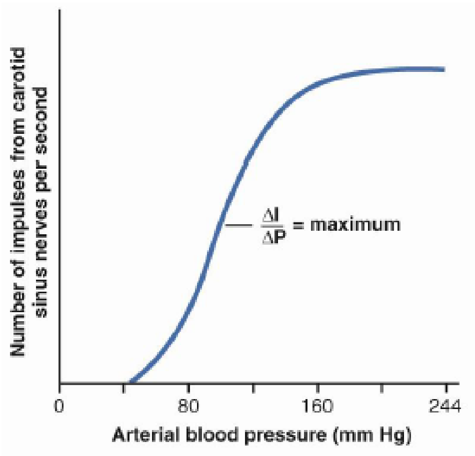
- If there is decrease in pressure (less stretch) the receptor decrease their discharge /AP /firing/ impulse rate in the afferent nerves

  ⇨ cardiovascular center → stimulates the cardioaccelatorty and inhibits the cardioinhibitory → send more sympathetic and less parasympathetic to the heart → increase in the contractility and heart rate → increase in the SV and CO

⇨less inhibitory effect on the vasomotor center → send more sympathetic to the vessels → vasoconstriction → increase TPR

By increasing the CO and TPR, the MAP is increased towards its normal value.

- The baroreceptors have a basal rate of firing, which is important for positive and negative control (can be increased or decreased).
- They work on a Negative feedback mechanism, responds to pressure between 60 and 180 mmHg.
- Baroreceptor reflex functions most effectively/ it is most sensitive around the normal MAP *100mmHg.* So it is called "*pressure buffer system*"; any small change in the pressure around 100mmHg causes very change in the impulses rate.



- As we mentioned before, when you change your position from supine to standing position, the MAP is decreased, and through the short term regulation within seconds the MAP is increased toward its normal value.