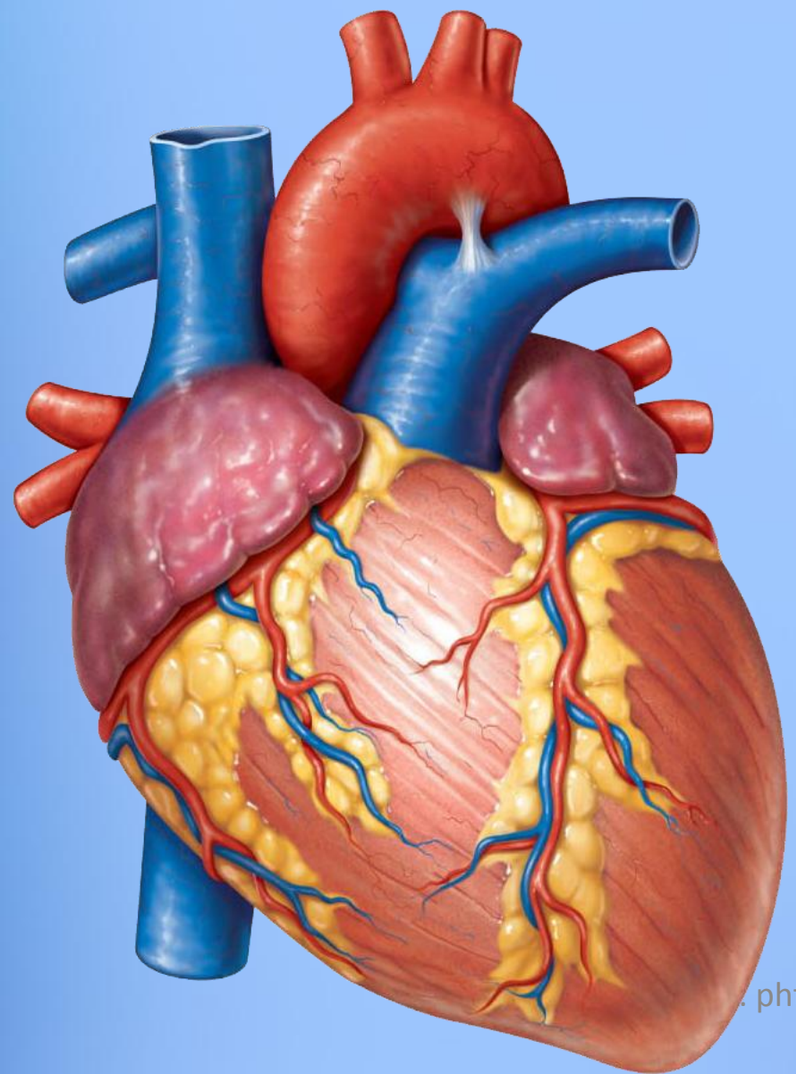
11

REGULATION OF BLOOD PRESSURE



Cardiovascular Block

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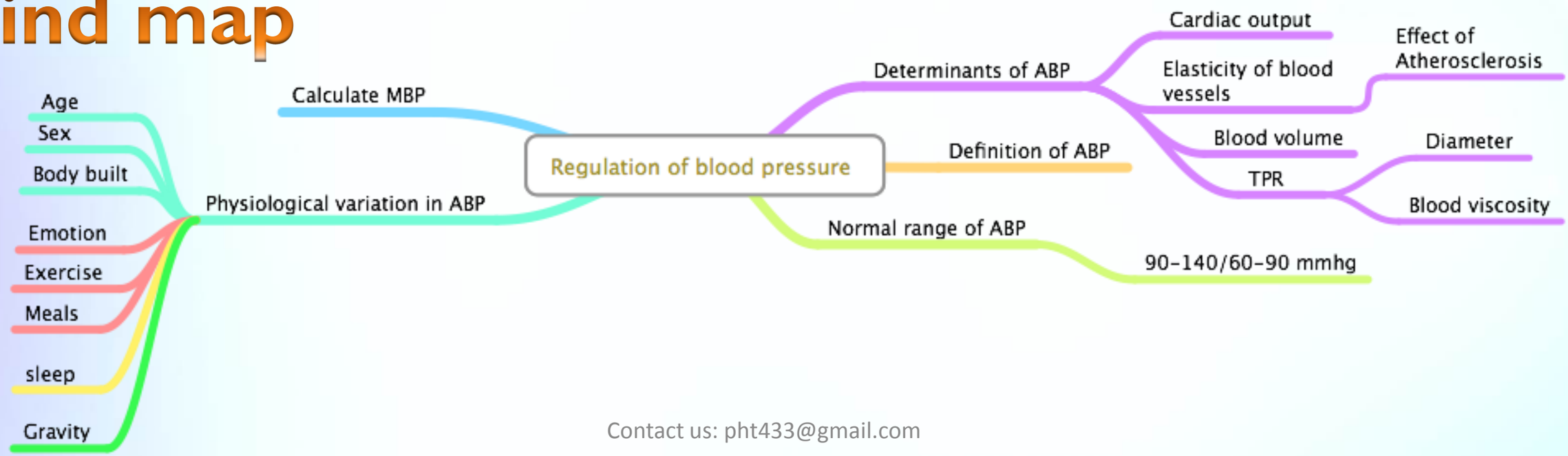
Objectives

- Understand the concept of mean blood pressure, systolic, diastolic, and pulse pressure.
- Calculate mean BP
- Understand normal variations in ABP.
- Understand the relationship between CO, BP and total peripheral resistance.
- Describe and understand factors determining blood pressure
- Regulation of arterial blood pressure.

Mind map



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Arterial Blood Pressure

The passes through the blood vessels it created a pressure on the lateral walls of blood vessels

BP range: 90-140/60-90 mmHg.

Systolic > diastolic

Systolic
diastolic

Physiological variation in arterial blood pressure:

Age: At birth: 50/30
Adult : 120/80
Old age 170/90

Sex: males have higher BP than F (F has estrogen hormone) before meanopause.

Body built : increase in obese.

Emotions
Exercise
Meals
↑ BP

Sleep ↓ BP

Gravity: The pressure in any vessel .
This difference due to effect of Gravity. Gravitational effect = 0.77 mmHg/cm at the density of normal blood.

- below heart level ↑
- above heart level ↓

In adult human in upright position, if mean BP at heart level = 100 mmHg, the mean pressure in an artery at the head (50 cm above heart) = 100-[0.77X 50] = 62 mmHg,

- Above the heart we Subtract
- Below the heart we sum

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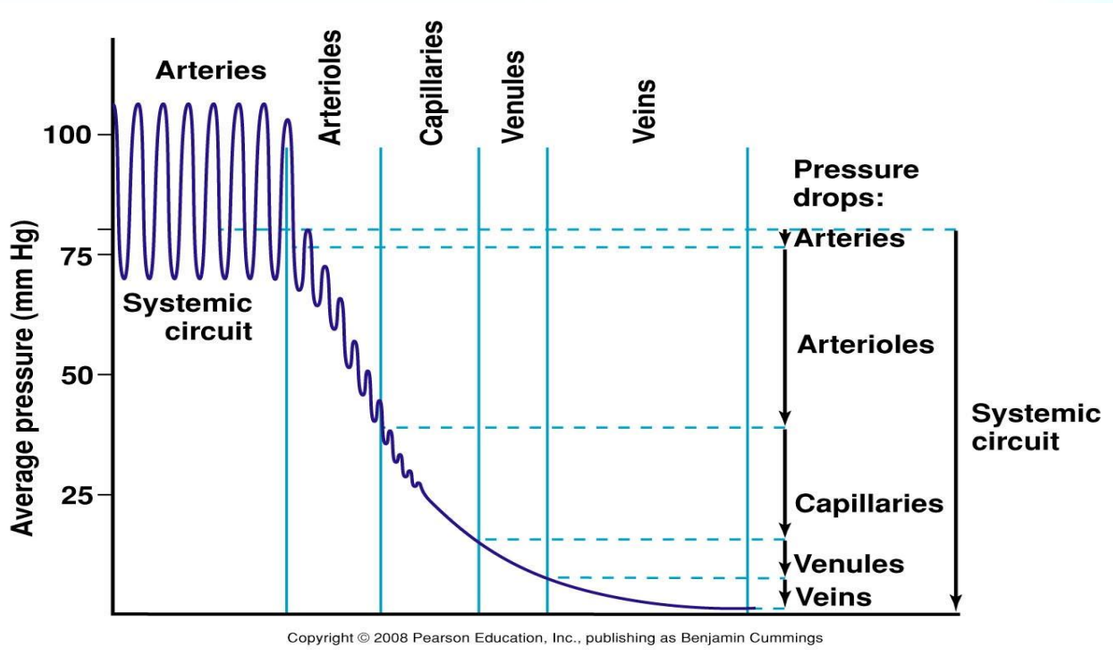
Blood pressure

- PP = SP – DP
- MABP = Diastolic + PP/3
- CO = $\frac{ABP}{TPR}$
- ABP = CO X TPR



PP : Pulse Pressure it is the difference between systolic pressure an diastolic pressure

SP (Systolic pressure) : Highest BP recorded in the circulation during systole maximum ejection phase (120 mmHg)

DP (Diastolic pressure) : Lowest BP recorded in the circulation in diastole (8 mmHg)

MABP : Mean arterial blood pressure.
ABP : Arterial blood pressure

ABP : Total peripheral resistance

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Determinants of arterial blood pressure:

- Cardiac output (CO) :
- Elasticity of blood vessels:
- Blood volume:
- Total peripheral resistance (TPR):

Determinants of ABP

CO

ABP = CO X TPR

CO = HR X SV

ABP = HR X SV X TPR

- Heart Rate
- Stroke Volume
- Total Peripheral Resistance

} affect MABP

Elasticity of blood vessels:

Changes in great vessels elasticity affects BP. Atherosclerosis makes blood vessel like a tube, so during systole as blood is ejected into the arteries, they don't distend and pressure increases significantly.

- Extend so the BP dose not increase
- Recoil so the BP dose not decrease

Blood volume:

- Increase VR
  - Increase CO
  - Increase ABP
- Decrease VR
  - Decrease CO
  - Decrease ABP

- Blood loss
- Plasma loss
- Fluid loss

} Blood Volume

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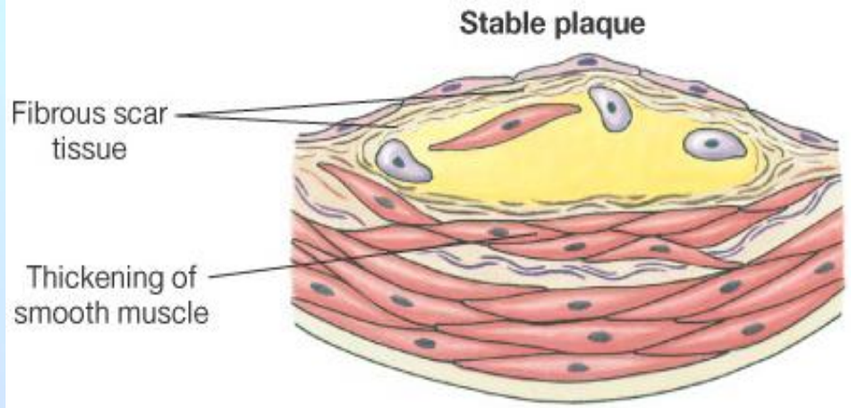
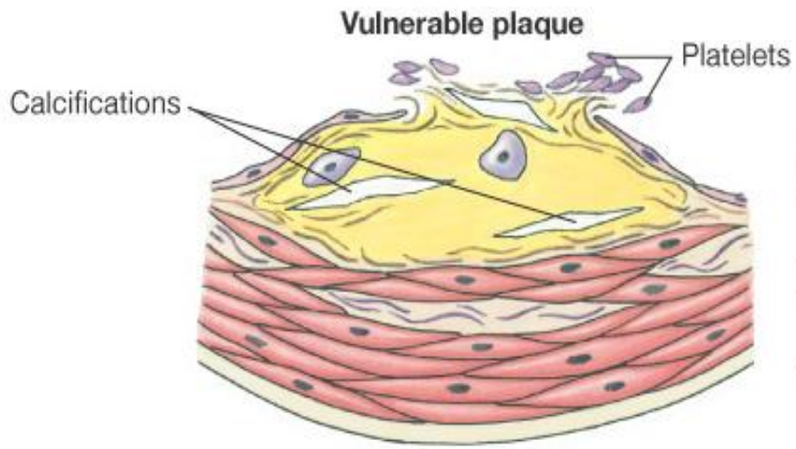
Atherosclerosis: decreases elasticity



(c) As cholesterol accumulates, fibrous scar tissue forms around it. Migrating smooth muscle cells divide, thickening the arterial wall and narrowing the lumen of the artery. This stage is known as a fibrous plaque.

During systole : ⬆ BP
(Systolic Hypertension)



(d) In the advanced stages of atherosclerosis, calcified scar tissue will form. If the endothelium is damaged and collagen is exposed, platelets stick to the damaged area and a blood clot (thrombus) forms. If blood flow in the coronary blood vessel is stopped, a heart attack is the result.

During diastole : ⬇ BP because there is no recoil

Total peripheral resistance (TPR):

TPR is determined by:

1. • diameter of blood vessel (r).

2. • Blood viscosity:

   a. Red cells: Polycythemia increases viscosity.

   b. Plasma proteins: Hypoprotenimia decreases viscosity.

Total peripheral resistance (TPR):

1. • **ABP is directly proportional to TPR**
2. • **Change in blood vessels' diameter by increase or decrease will affect blood pressure.**
3. • **TPR Is inversely proportional to blood vessel diameter (r) :**

a. • **$R \alpha 1/r^4$** → **R means TPR and r diameter of the blood vessel**

b. • **If r is doubled, TPR is reduced by 16, and so on……..**

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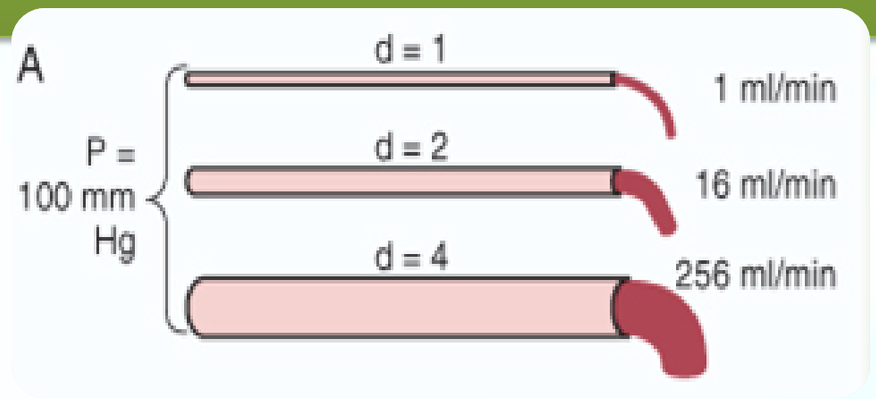
TPR and vessel diameter

Slight changes in the diameter of a vessel cause **tremendous changes** in the vessel's ability to conduct blood when the blood flow is streamlined .

Although the diameters of these vessels **increase only four fold**, the respective flows are 1, 16, and 256 ml/mm, which is a 256-fold increase in flow. Thus, the conductance of the vessel increases in proportion to the *fourth power of the diameter* c



Factors affecting vessel diameter

Vasodilator agents

- Nitric oxide.
- Histamine.
- Atrial natriuretic peptide (ANP).
- Prostacyclin

Vasoconstrictor agents

- Norepinephrine.
- Angiotensin II.
- Vasopressin.
- Endothelin-1
- Thromboxane A.

Summary

The concept of mean blood pressure & Calculate mean BP :

the average arterial pressure during a single cardiac cycle = Diastolic + PP/3

Understand the relationship between CO, BP and TPR

ABP = CO X TPR → ABP = HR X SV X TPR

Describe and understand factors determining blood pressure

CO

Elasticity of blood vessel

Blood volume:

TPR

Understand normal variations in ABP:

Age(as we get older ABP ⇡)

Sex(males have ⇡ BP)

ABP ⇡ in obese.

Gravity(below heart level ⇡& above heart level ⇣)

Regulation of arterial blood pressure.

	CO → Affect MABP	Elasticity of blood vessels:	Blood volume
	Heart Rate Stroke Volume TPR	**Changes in great vessels elasticity affects BP**	**↑CO→↑ABP ↓CO→↓ABP**
TPR	• **ABP is directly proportional to TPR** • **TPR Is inversely proportional to blood vessel diameter (r) → R α $1/r^4$**		

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Q1 An 30 years old man came to the ER and when measuring his BP it was 140/80, is he..

a. Hypertensive
b. Normal
c. Hypotensive

Q2 In measuring total peripheral resistance (TPR) If r is doubled, TPR is increased by 16

a. True
b. False

Q3 In standing position if mean BP at heart level = 120mmHg, what will be the mean pressure in an artery at the head (40 cm above heart)?

a. 120-(0.77+40)
b. 120+(0.77X40)
c. 120-(0.77x40)

Q4 ABP is inversely proportional to TPR

a. True
b. False

....MCQS....

Q5 During Systole what happens to TPR:

a. ⬆?
b. ⬇?
c. Nothing changes

Q6 Polycythemia increases viscosity:

a. True
b. False

Q7 Plasma loss can happen because of (commonly) :

a. Vomiting
b. Burns
c. Surgery

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ANSWERS Q1:b Q2:b Q3:C Q4:b Q5: a Q6:a Q7:b

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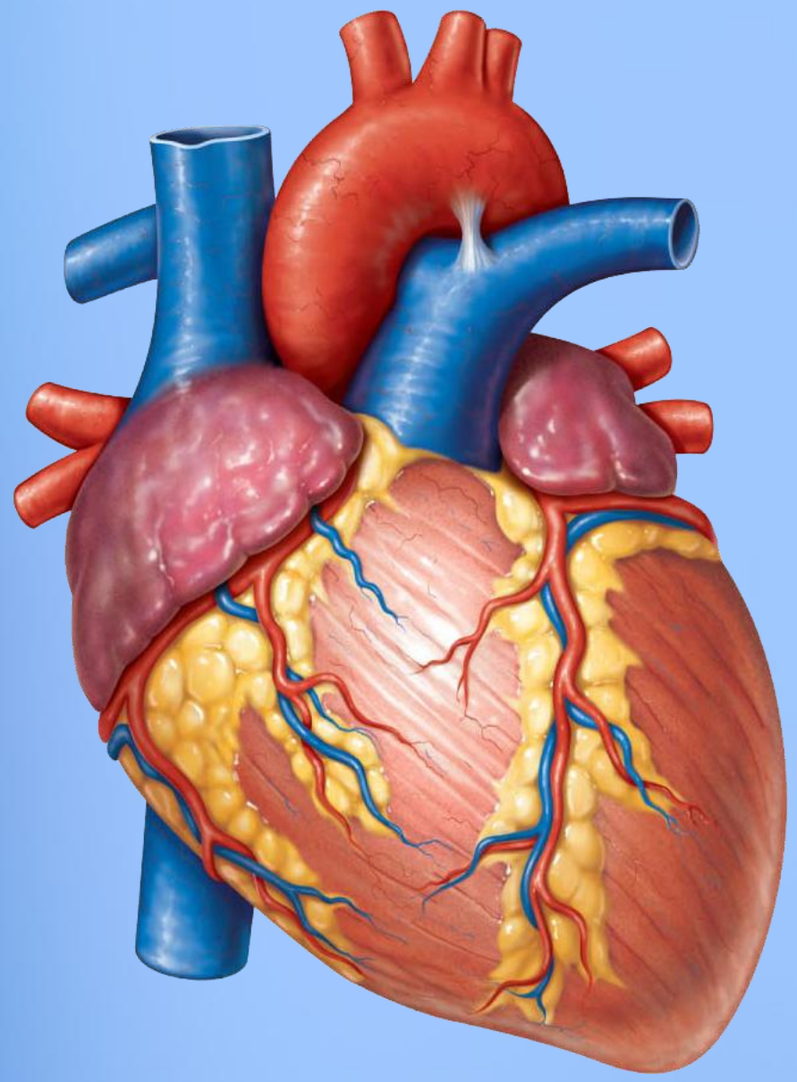
12

BLOOD PRESSURE



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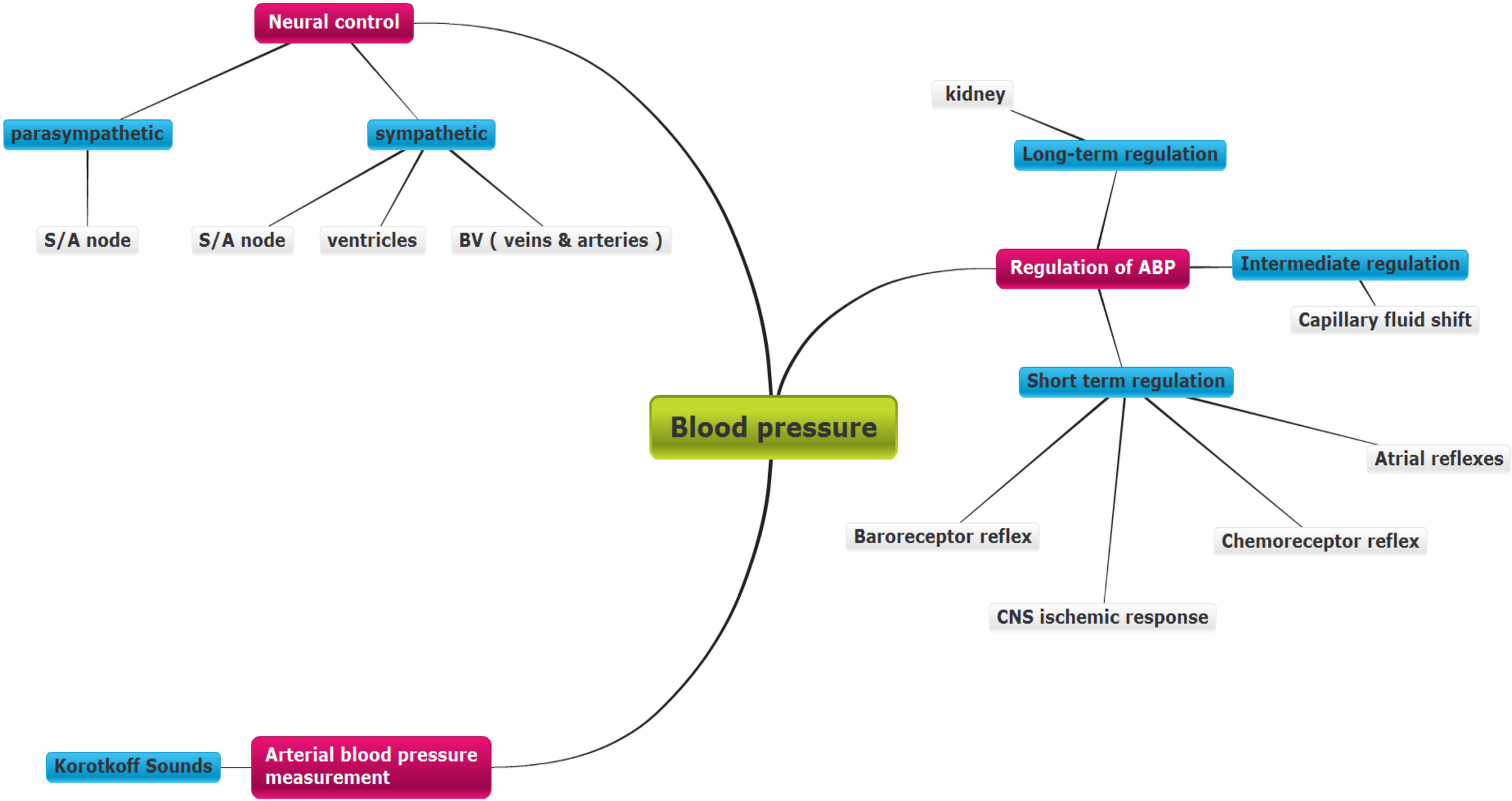
Mind map



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❖ The important to control Blood pressure

Blood pressure is a key factor for **providing blood** (thus oxygen and energy) to organs especially heart, kidney and brain.

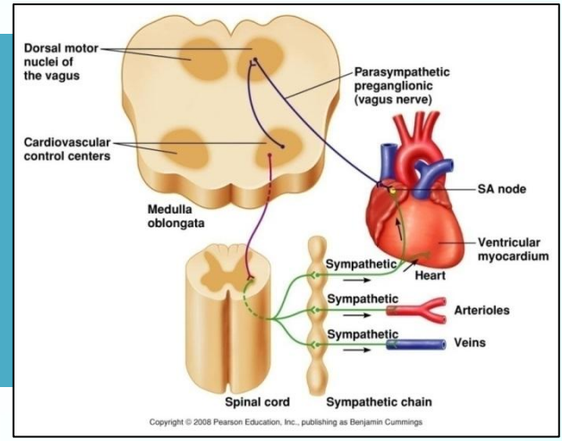
❖ Neural control ; medullary CVCs

The **vasomotor center** integrates all these information
The **vasomotor sends** decision to the **ANS center**:

-Both **parasympathetic and sympathetic** innervate the **S/A node** → can accelerate or slow down the heart rate

-The **sympathetic** NS innervates **the myocardium and the smooth muscle of the arteries and veins** → promotes vasoconstriction

CVs centers in **medulla**
control the → heart & Blood vascular (veins & arteries)
There is tow types of center : Vasoconstrictor center , Vasodilatation center
The **sympathetic** supply the **S/A node , ventricles**
and BV (veins & **arteries**)



Control VR | **Control TPR** | **↑contractility**

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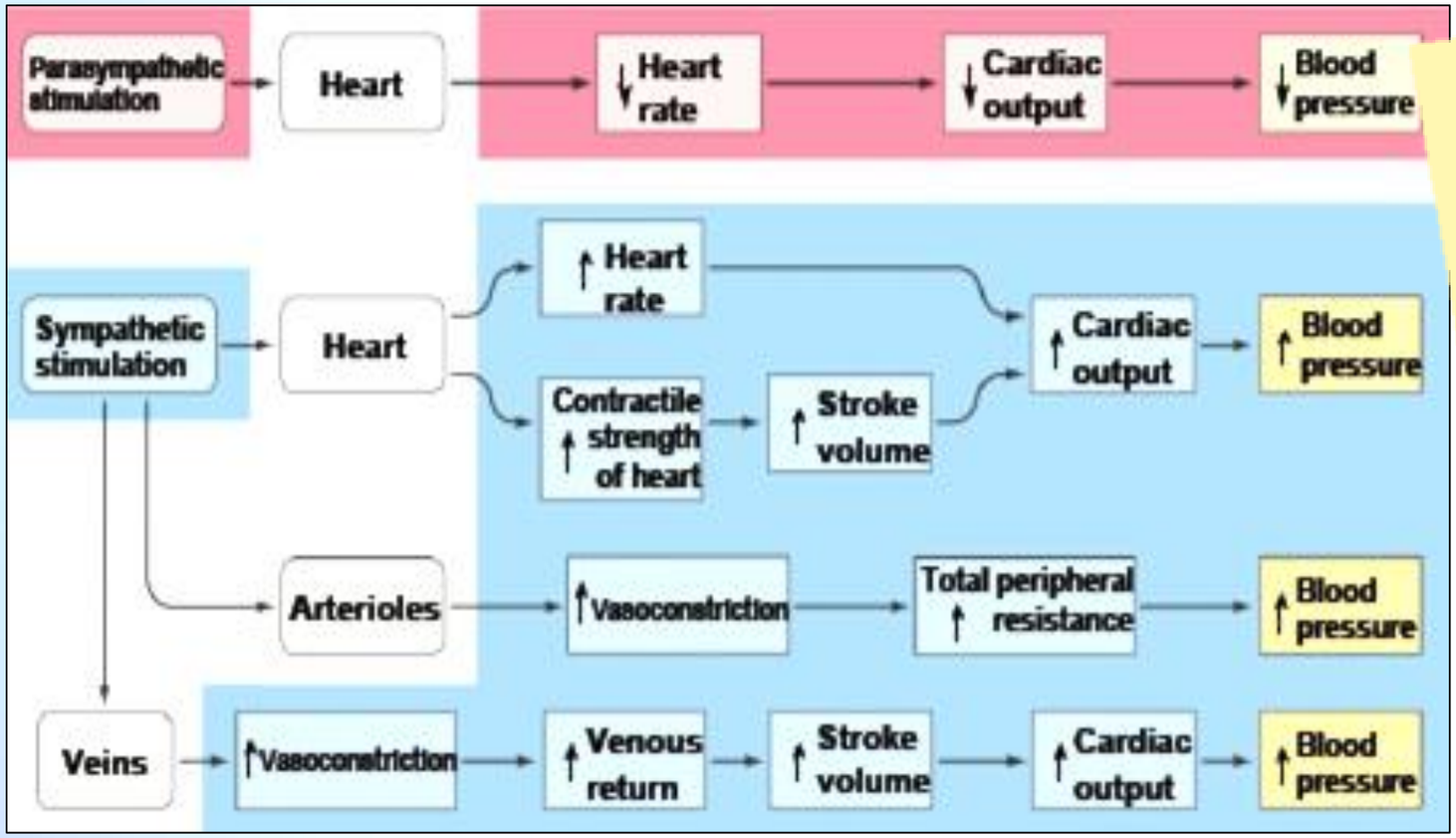
❖ Neural control ; Regulation of blood pressure



1. the parasympathetic doesn't innervate the veins , arteries & myocardium
2. ↑ CO → ↑ BP
3. ↑ Parasympathetic activity → ↓BP
4. ↑ sympathetic activity → ↑ BP

Regulation of ABP

- ***Short term regulation (nervous)***
  - **Baroreceptor reflex.**
  - **Chemoreceptor reflex.**
  - **CNS ischemic response.**
  - **Atrial reflexes**
- ***Intermediate regulation***
- ***Long-term regulation.***

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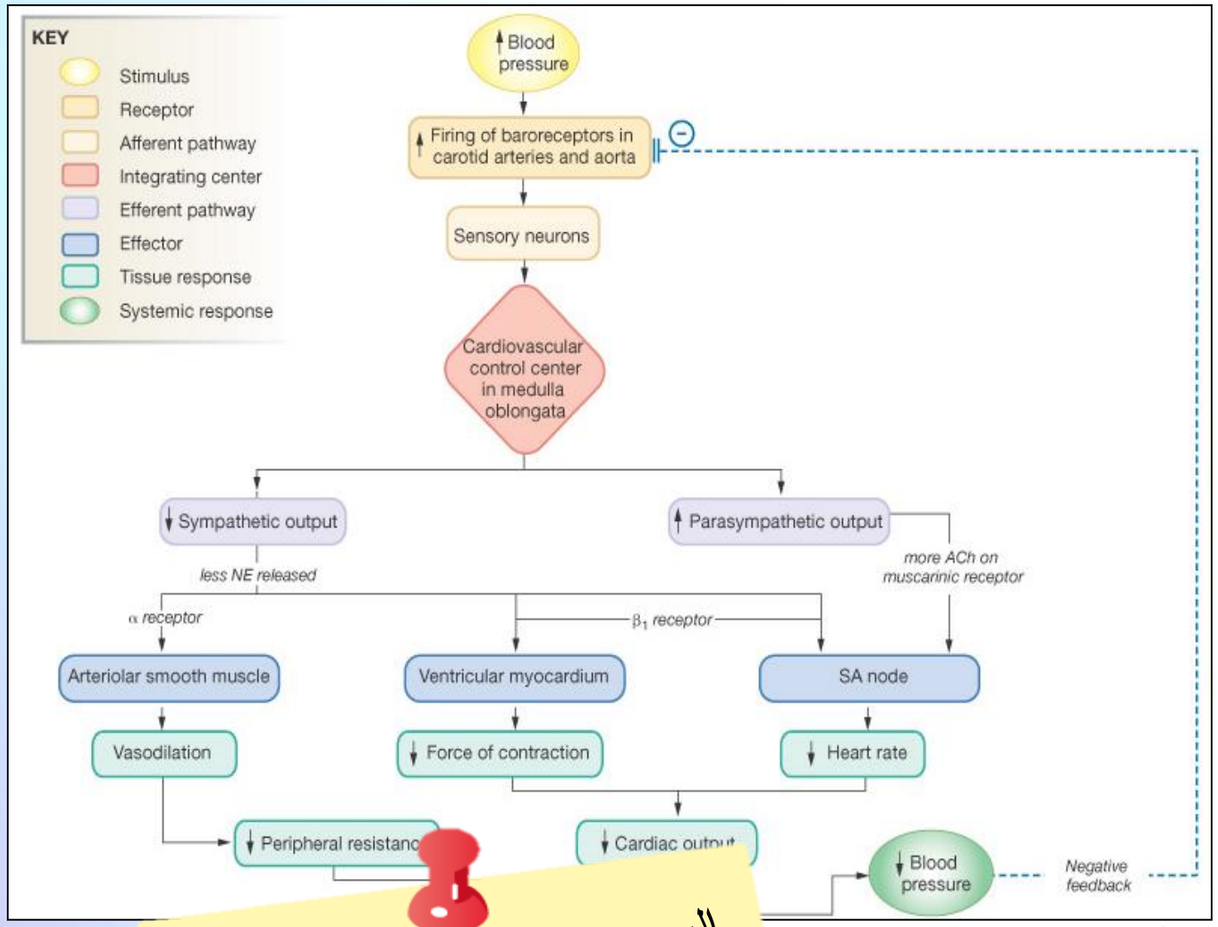
Short term regulation (nervous)

	1-Baroreceptor reflexes:	2. Chemoreceptors	3- CNS ischemic response:	4- Atrial Reflexes
receptors	Stretch receptors.			Low pressure receptors especially in the RA
Located in	Carotid sinus and aortic arch	Carotid bodies and aortic body		
respond to	• rapidly changing BP. **In the range 60-180 mmHg.** • No response in Constancy pressure	• when ABP **becomes less than 60** mmHg • they are not involved in ABP control at normal range (doesn't work in resting)	When BP < 20 mmHg	Respond to changes in blood volume.
Comments	They sense the blood pressure in the aortic arch and internal carotid → send signal to the vasomotor center in the medulla oblongata along vagus and glossopharyngeal Ns.	• Chemosensitive cells, stimulated in response to: O2 lack, CO2 excess, H+ excess	It is one of **the most powerful activators** of the sympathetic vasoconstrictor system.	

Regulation of Blood Pressure by baroreceptors



ال Baroreceptor تعمل في حدود من ١٨٠-٦٠ فعندما يرتفع الضغط فأنها تزيد تأثير ال parasympathetic لينخفض الضغط

و إذا قل الضغط فأنها تقلل من تأثير parasympathetic و تزيد من sympathetic ليرتفع الضغط

Reflexes initiated by baroreceptors:

↓ **ABP** → inhibitory impulse discharge from baroreceptors → vasomotor center is released from inhibition resulting in:

a. (+) heart: HR & contractility.
b. (+) sympathetic VC tone: vasoconstriction.

↑ **ABP** → Stretch of receptors → ↑ rate of firing and impulses travel along vagus & glossopharyngeal to the medullary CVCs:
The responses will be

a. (+) vagal center : decrease HR.
b. (-) vasoconstrictor center: Vasodilatation.

Remember :

1. vagal center = **parasympathetic**
2. Baroreceptor not work when the BP more than 180 or less then 60

Regulation of blood pressure with baroreceptors

https://www.youtube.com/watch?v=ajLgwCygHsc

Important

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Baroreceptors are important in maintaining ABP constant during changes in body posture:

When you change your posture from supine to erect, a drop in ABP in the head and upper part of the body will occur.

As baroreceptor reflex becomes activated, strong sympathetic impulses lead to VC and minimize the decrease in BP.

Resetting of baroreceptors:

- This property makes baroreceptors NOT suitable for long term regulation of ABP, as they are rapidly reset to the new pressure.
- Adaptation of a receptor means decrease in impulse discharge from the receptor despite persistence of the stimulus.

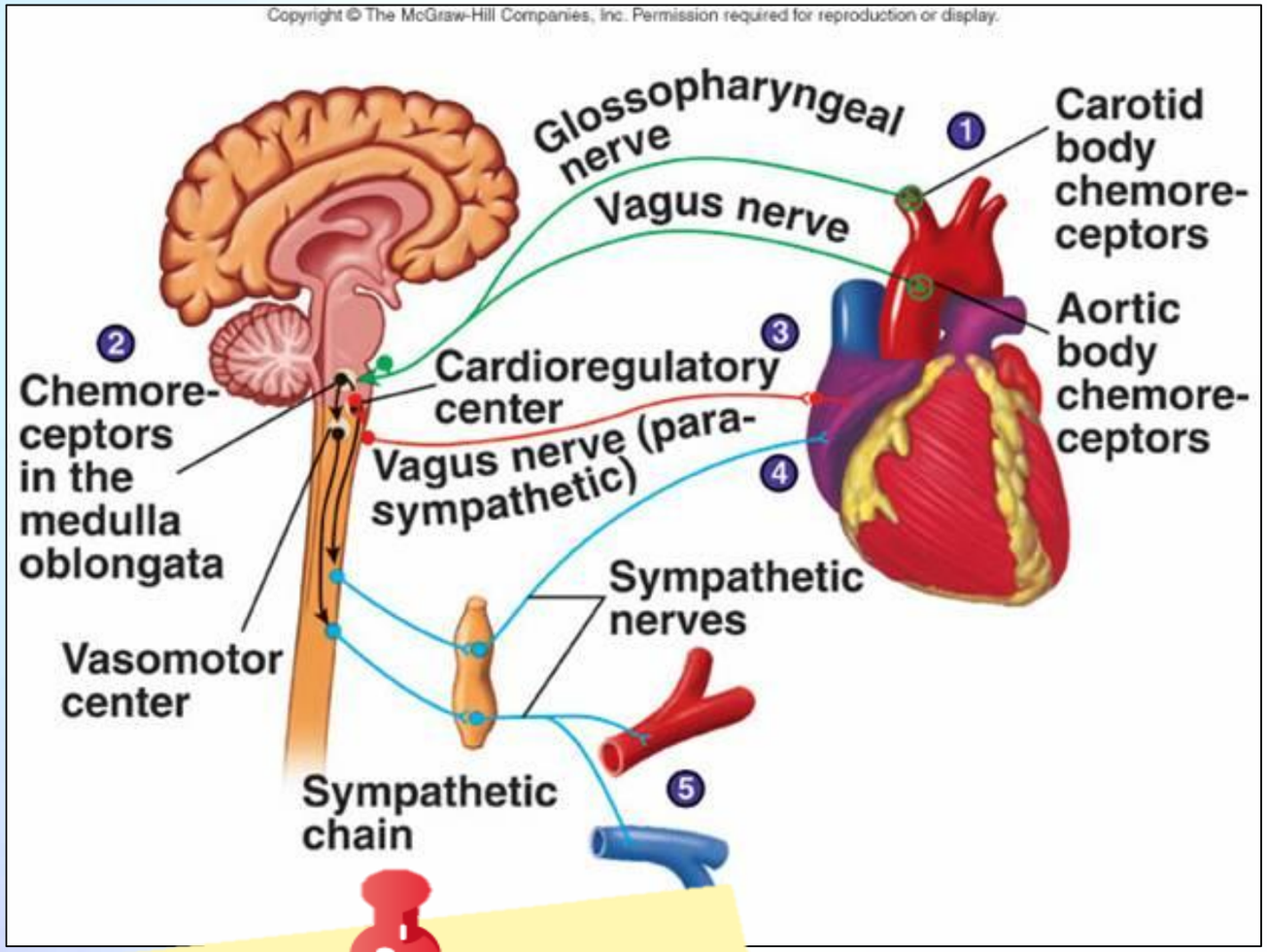
When a patient take antihypertensive he will get tachycardia at the first days then nothing , all this due to Resetting of baroreceptors

What is the effect of denervation of baroreceptors?

for example what happen in heart transplantation? , we cut the nerves but the receptors are still there .

any change in BP can't be detect by those receptor (the connection between the receptors and the central not found(cut))

Chemoreceptor reflex



Chemoreceptor is response when ABP becomes less than 60

so, they should increasing the blood pressure by :
↑ **sympathetic response** and ↓ **parasympathetic response** → vasoconstriction → ↑BP

- Chemosensitive cells, stimulated in response to: O2 lack, CO2 excess, H+ excess
- when ABP **<u>becomes less than 60</u>** mmHg
- they are not involved in ABP control at normal range
  (doesn't work in resting)

When blood flow to chemoreceptors decreases it leads to → ↓O2, ↑CO2, ↑H+ → stimulat chemoreceptors. Lead to Signals (+) CVS → ***<u>vasoconstriction</u>***

- Chemoreceptor have a very high blood flow (1200 ml/min/g tissue). This makes it easy for these cells to detect changes in O2, CO2, and H+

Chemoreceptor Reflex Control of Blood Pressure

https://www.youtube.com/watch?v=1IKHv5j49Kg

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3- Atrial Reflexes :

- Respond to changes in blood volume

What happen if blood volume is increased? e.g infusing 500 ml into a person:

↑ blood volume → stretch of the atria leading to:

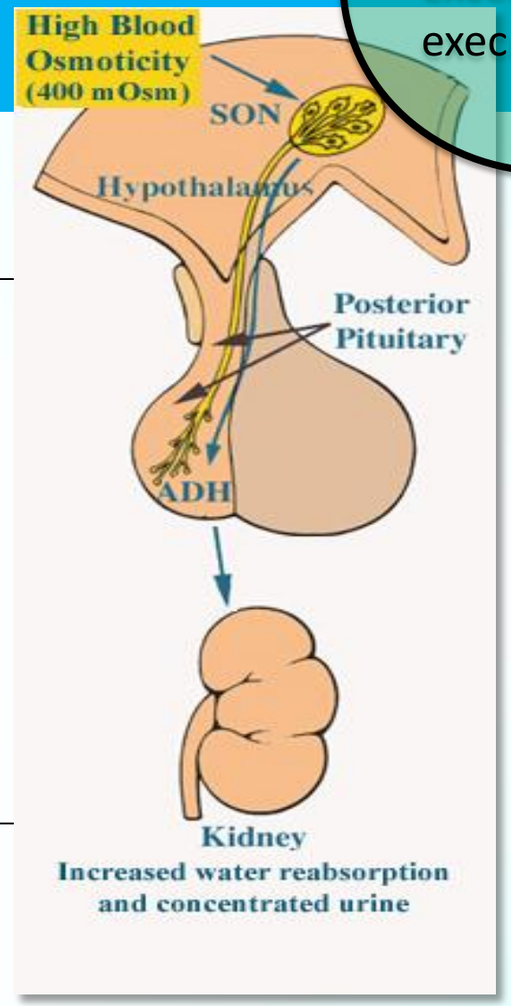
a. (+) ANP (Atrial natriuretic peptide) release VD of renal vessels, diuresis, natriuresis.

b. Hypothalamus:

1. (-) ADH (Anti-diuretic hormone) → water diuresis.
2. (-) sympathetic discharge → VD of renal vessels

c. stretch SAN and increase HR

Natriuresis = excess salt execration



Control of blood volume

Anti-diuretic hormone = ADH

- Secreted by the posterior pituitary in response to ↑blood osmolarity (often due to dehydration).

- Action:

Promote water reabsorption by the kidney tubules → H2O moves back into the blood → less urine formed

What happens if there is sudden loss of blood volume by 800 ml?

↓ blood volume → leading to:

a. (-) ANP (Atrial natriuretic peptide) release VC of renal vessels, less blood go to kidney

b. Hypothalamus:

1. (+) ADH (Anti-diuretic hormone) → prevent any water loss .
2. (+) sympathetic discharge → VC of renal vessels

c. decrease HR

Opposite of ↑ blood volume

4- CNS ischemic response:

- It operates as an emergency arterial pressure control system that acts rapidly and powerfully to prevent further decrease in ABP whenever blood flow to the brain decreases to lethal level.

- When BP < 20 mmHg → cerebral ischemia of vasomotor center → strong excitation of vasomotor center (due to accumulation of CO2, lactic acid,….) → strong VC of blood vessels including the kidney.

Intermediate regulation of BP

Capillary fluid shift

Capillary shift mechanism

Fluid shift from the interstitial spaces into blood capillaries → ↑ Blood volume → causes diarrhea and dehydration , Takes 12 hours.

HYPOVOLEMIA

Fluid shift from blood capillaries into the interstitial spaces → ↓ Blood volume → causes edema .

HYPERVOLEMIA

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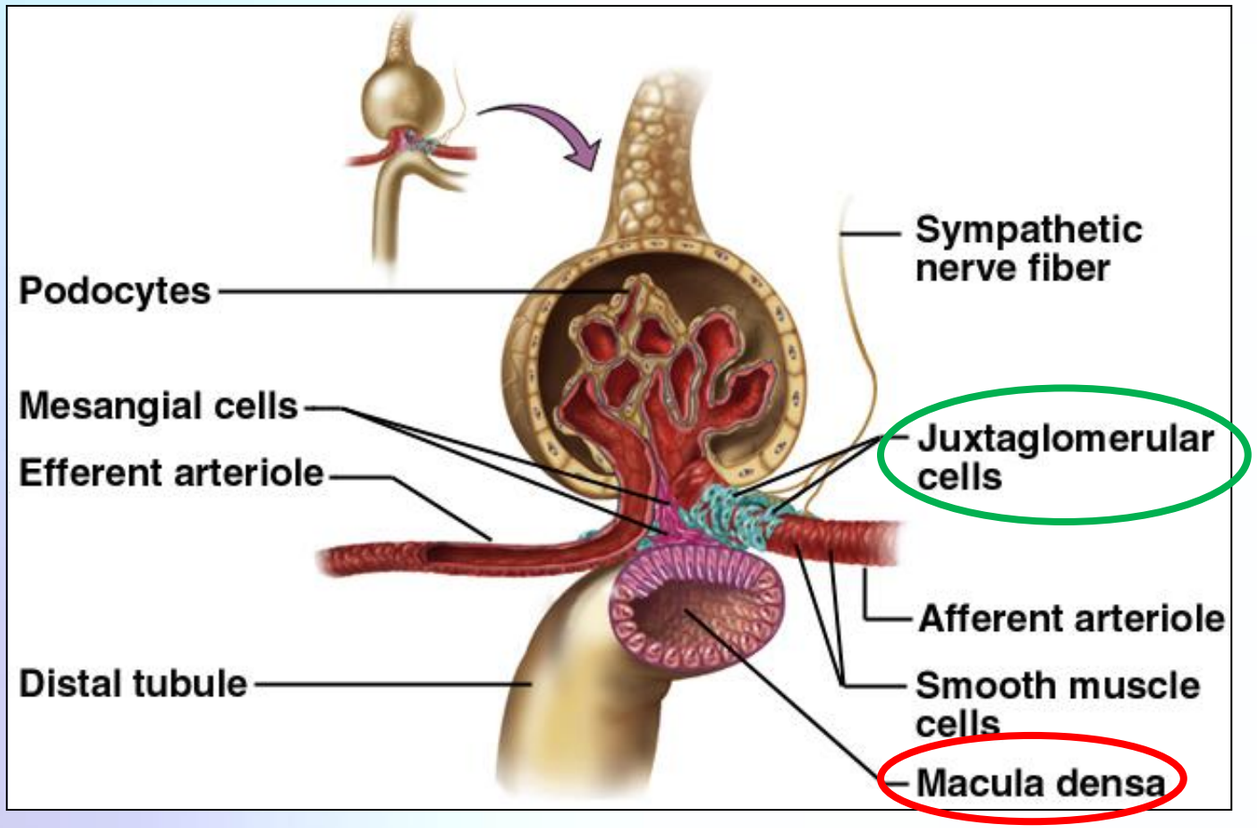
Long Term Regulation of BP

Role of the kidney:

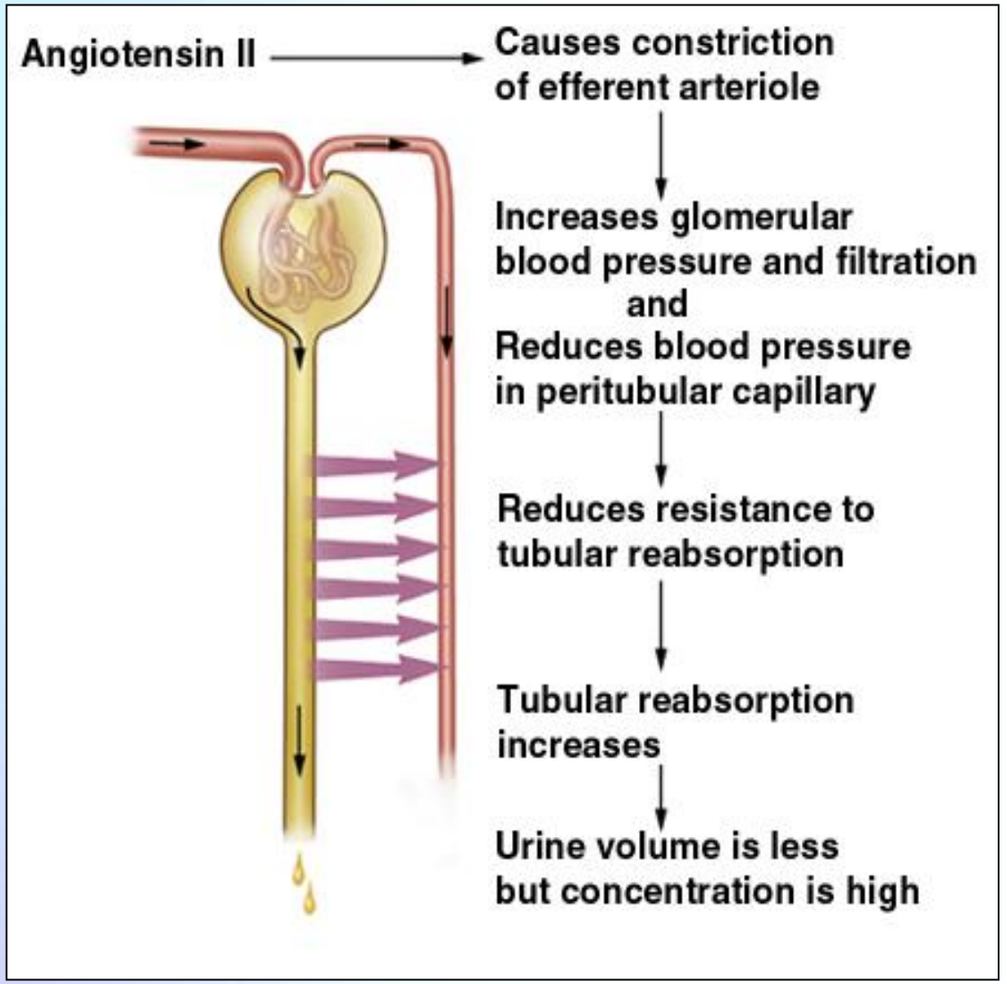
The kidney excretes excess salt and water (natriuresis and diuresis).

Juxtaglomerular Apparatus

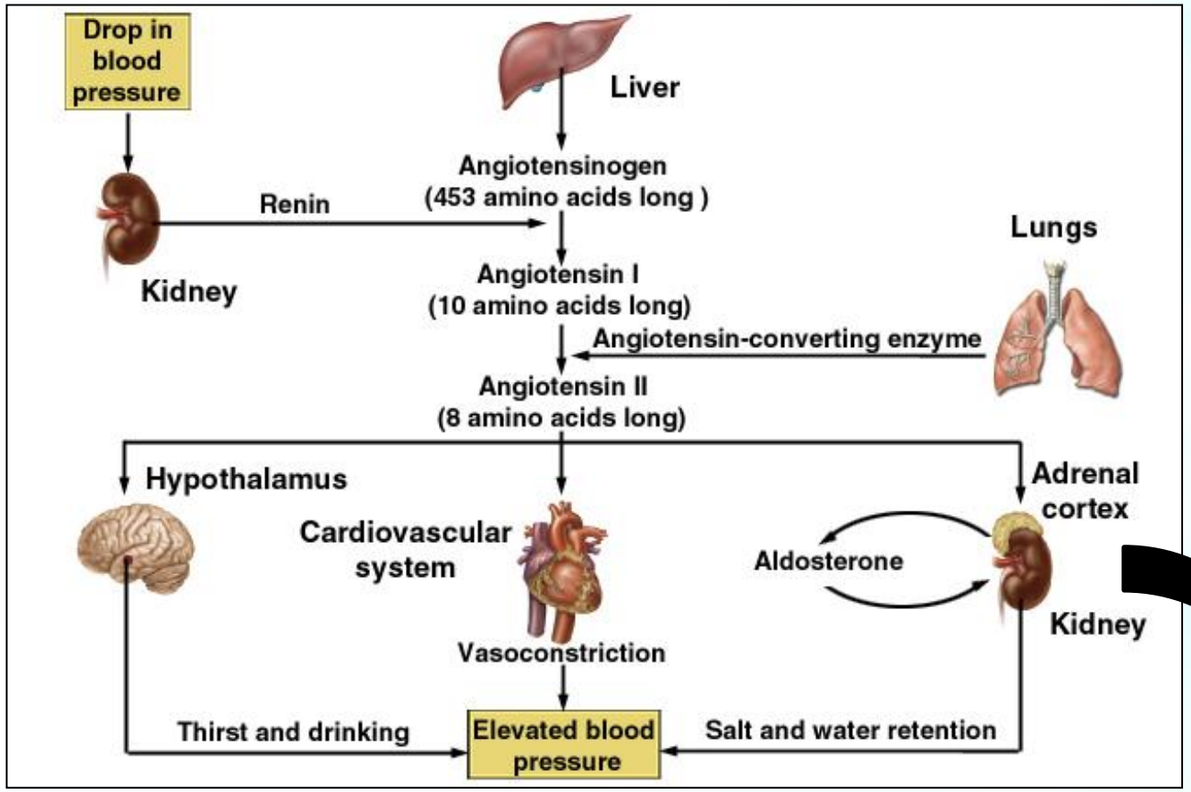


- **<u>Macula densa : Sensitive to the level of salt</u>**
- **decrease in Na concentration** → the **macula densa** send signal to the **juxtaglomerular cells** → release **renin** directly into circulation → **renin** conversion the **angiotensinogen** released by the liver to **angiotensin I** → **Angiotensin I** is subsequently converted to **angiotensin II** by the enzyme angiotensin-converting enzyme found in the lungs → **Angiotensin II** is causes blood vessels to constrict → **increased blood pressure**

Effects of Angiotensin II



Role of the kidney in ABP regulation



Angiotensin II effect the :

1. **Brain (hypothalamus) :** ↑ feeling thirsty and drinking → ↑ blood volume → ↑BP
2. **CVS :** ↑ vasoconstriction → ↑BP
3. **Kidney : In the adrenal cortex**, it acts to cause the release of aldosterone → Aldosterone acts on the tubules in the kidneys → causing them to reabsorb more sodium and water from the urine → This increases blood volume → increases BP.

Renin Angiotensin Aldosterone System

https://www.youtube.com/watch?v=bY6IWVgFCrQ

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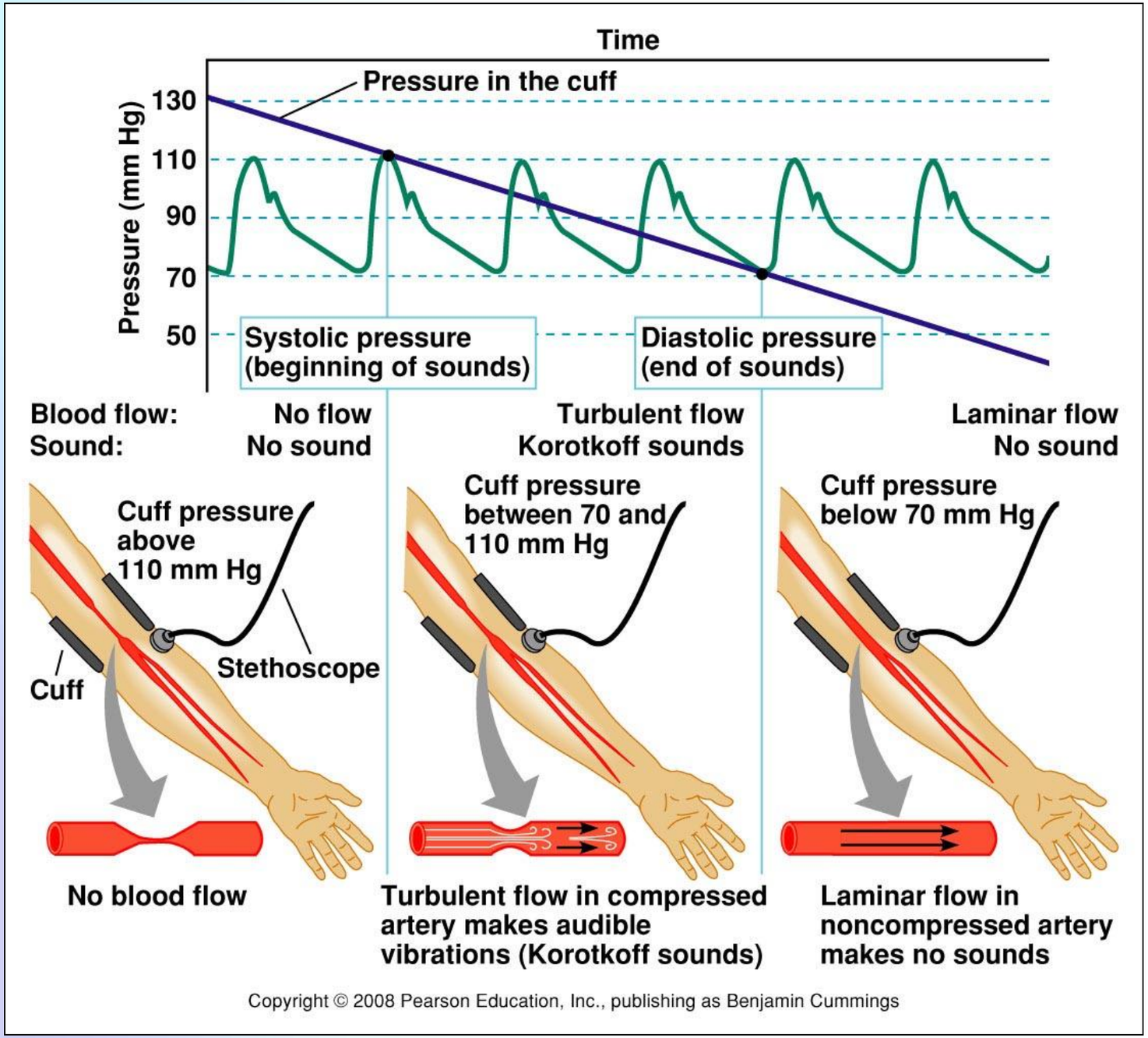
Arterial blood pressure measurement



Korotkoff Sounds:

arterial sounds heard through a stethoscope applied to the brachial artery distal to the cuff of a sphygmomanometer that change with varying cuff pressure and that are used to determine systolic and diastolic blood pressure

For more information :

http://en.wikipedia.org/wiki/Korotkoff_sounds

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SUMMARY

Regulation of ABP

Short term regulation (nervous)

Baroreceptor reflex

Located in: Carotid sinus and aortic arch

They respond to a rapidly changing BP. In the range 60-180 mmHg.

CNS ischemic response

It is one of the most powerful activators of the sympathetic vasoconstrictor system.

When BP < 20 mmHg

Chemoreceptor reflex

Chemosensitive cells, stimulated in response to: O2 lack, CO2 excess, H+ excess

activated when ABP becomes less than 60 mmHg.

Atrial reflexes

Receptors: Low pressure receptors especially in the RA.

Respond to changes in blood volume

Intermediate regulation

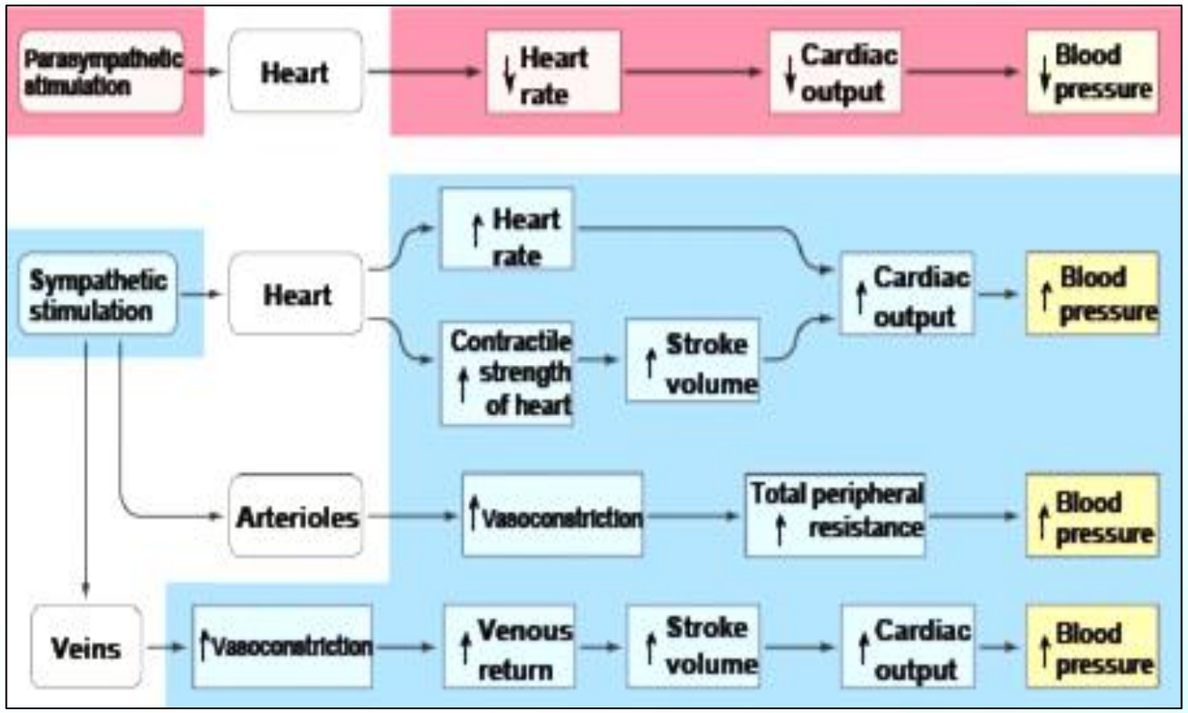
Capillary shift mechanism:

Fluid shift from the interstitial spaces into blood capillaries → ↑ Blood volume → causes diarrhea and dehydration , Takes 12 hours

Long-term regulation.

Role of the kidney by :

release **renin from juxtaglomerular cells** → conversion the **angiotensinogen** to **angiotensin I** → **Angiotensin I** converted to **angiotensin II** → causes blood vessels to constrict → **increased blood pressure**



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MCQs

1. Capillary fluid shift from interstitial space to blood capillary causes :
a. ↓ Blood volume b. ↑ Blood volume
c. Constant Blood volume

2. Anti-diuretic hormone response to :
a. ↑blood osmolarity b. due to dehydration
c. ↓ blood osmolarity d. a&b

3. Adaptation of a receptor means _____ in impulse discharge from the receptor despite persistence of the stimulus :
a. Increase b. decrease c. constant
b. Non of them

4. in ABP at normal range, they are not involved in ABP control:
a. Atrial reflexes b. Chemoreceptors
c. CNS ischemic response d. none of them

5. important in maintaining ABP constant during changes in body posture :
a-Baroreceptor reflexes b. Chemoreceptors
c- CNS ischemic response d. Atrial Reflexes

6. It is one of the most powerful activators of the sympathetic vasoconstrictor system:
a. Baroreceptor reflexes b. Chemoreceptors
c. CNS ischemic response d. Atrial Reflexes

7. Juxtaglomerular Cells Release The :
a. Renin b. angiotensin II
c. Angiotensinogen d. Aldosterone

8. The Blood pressure increase to 170 the Short term regulation of ABP is :
a. Baroreceptor reflexes b. Chemoreceptors
c. CNS ischemic response d. Atrial Reflexes

Ans. : 1. b 2. d 3. b 4. b 5. a 6.c 7. a 8. a

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MCQs

9. Angiotensin I is converted to angiotensin II by :
a. angiotensinogen -converting enzyme
b. angiotensin-converting enzyme
c. Aldosterone -converting enzyme
d. Angiotensin enzyme

10. parasympathetic and sympathetic innervate the S/A node :
a. T b. F

11. always Chemoreceptor response is vasoconstriction for Increase BP, Unlike the Baroreceptor response is vasoconstriction or Vasodilatation which depend of ABP :
a. T b. F

12. Chemoreceptor have a very low blood flow , makes it easy for these cells to detect changes in O2, CO2, and H+ :
a. T b. F

Ans. : 9. b 10. a 11. a 12. b

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