Arterial Blood Pressure & Its Regulation

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- Important
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- Only in boys'
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Only in Boys' Slides

Only in Girls' Slides

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Arterial Blood Pressure

Blood pressure define as the force exerted by the blood against a vessel wall.

- Blood pressure is an important characteristic of our body since it is the force that drives blood along blood vessels after it has left the heart.

- Without blood pressure, nutrients, oxygen, and proteins could not travel from the arterial side of the body to the venous side.

Arterial Blood Pressure cont.

- **Systolic blood pressure:** Is the maximum level of arterial blood pressure. It is reached during the rapid ejection phase of ventricular systole. For a normal adult, it is about 120 mmHg (range of normal: 90-140).

- **Diastolic blood pressure:** Is the minimum level of arterial blood pressure. It is reached during the isometric contraction phase of ventricular systole. For a normal adult, it is about 80 mmHg (range of normal: 60-90).

Just keep in mind

ABP = CO x TPR

Pulse Pressure

Is the difference between the systolic and diastolic blood pressure values.

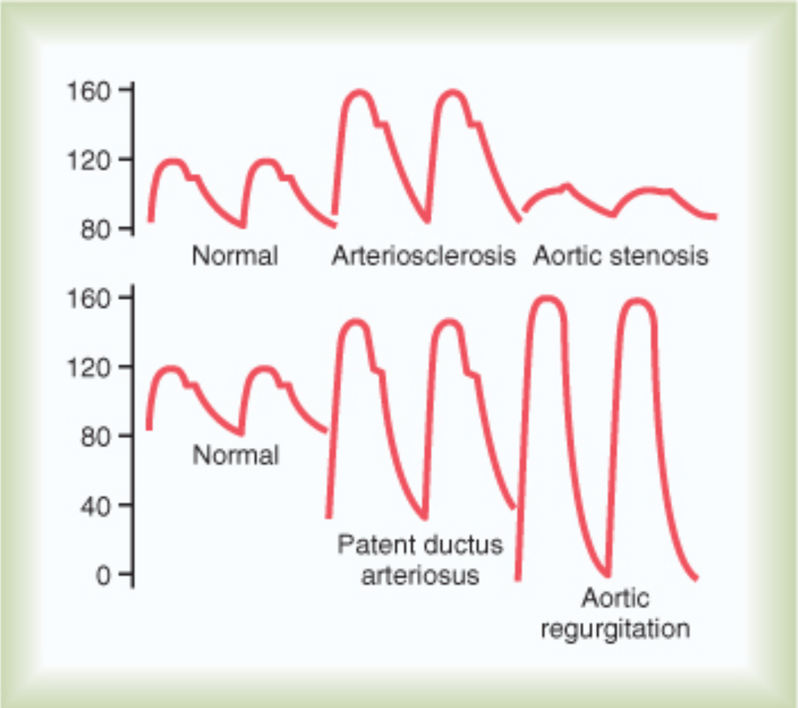
- For a normal adult the pulse pressure = 120 – 80 = 40 mmHg.

Pulse pressure= Systolic pressure – Diastolic pressure

Pulse pressure is determined by <u>two parameters</u>:

1. Change in volume (ΔV): could be approximated as SV
2. Compliance

Abnormalities in Pulse Pressure



- ✓ **Atherosclerosis:** Pulse pressure tends to increase with ageing because of a decrease in arterial compliance ("hardening of the arteries").

- ✓ **Aortic regurgitation:** in early diastole, blood leaks back into the ventricles. As a results, diastolic pressure falls to very low levels.

Mean Arterial Pressure (MAP)

Is the average pressure responsible for driving blood into the tissues throughout the cardiac cycle.

- MAP is not halfway between systolic and diastolic pressures because arterial pressure remains closer to diastolic than to systolic pressure for a longer period of each cardiac cycle.

MAP = Diastolic pressure + 1/3 pulse pressure

- Mean arterial pressure tends to increase with age because of an age-dependent increase in total peripheral resistance which is controlled primarily by arterioles.

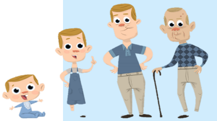
✧ Normal blood pressure Range for a healthy human usually near to

90-140 / 60-90 mmHg

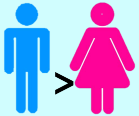
↑ SYSTOLIC ↑ DIASTOLIC

Physiological Variation In Arterial Blood Pressure

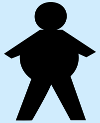
Age
At birth: 50/30
Adult : 120/80
Old age 170/90



Sex
males have higher BP than female before menopause.



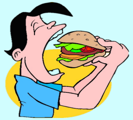
Body Built
increase in obese.



Emotions
Increase Blood pressure

Exercise
Increase Blood pressure

Meals
Increase Blood pressure



Sleep
Decrease Blood pressure

Gravity
Decrease Blood pressure

The pressure in any vessel below the heart is increased while the pressure in any vessel above decreased due to gravity effect

Determinants of Arterial Blood Pressure:

Cardiac Output

ABP = CO x TPR

↓

CO = HR x SV

↓

ABP = HR x SV x TPR

Thus any factor affect SV,HR or TPR will affect the ABP

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.

✧ **Atherosclerosis: decreases elasticity elasticity**
= increases ABP

Blood Volume

+ if increased:

Increase in CO
Increase in ABP

- if decreased:

decrease in VR
decrease in CO
decrease in ABP

E.g.:
Hemorrhage & dehydration

Total Peripheral Resistance

is determined by:
1. diameter of blood vessel (r).
2. Blood viscosity.*

*RBC and plasma proteins increase blood viscosity

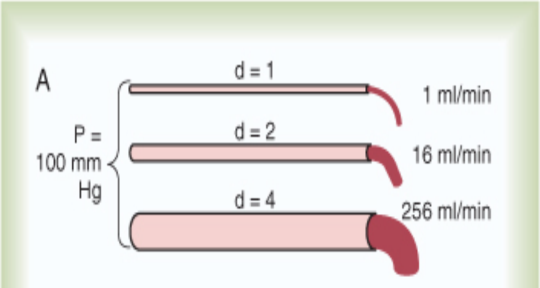
E.g.:
-Polycythemia increases viscosity
= increases BP
-Hypoprotienemia decreases viscosity
= decreases BP

Total Peripheral Resistance

- ✧ ABP is directly proportional to TPR
- ✧ Change in blood vessels' diameter by increase or decrease will affect blood pressure.
- ✧ TPR Is inversely proportional to blood vessel diameter (r) : $R \alpha 1/r^4$
- ✧ If r is doubled, TPR is reduced by 16, and so on……..

TPR & Vessel Diameter

✓ Bare in mind that the pressure is constant, meaning its the same proportion in all 3 vessels. Thus, its basically ruled out, leaving only the diameter and TPR.



- ✧ 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 fourfold, 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.

Factors Affecting Vessels Diameter

'Chemical mediators'

Vasoconstrictor Agents

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

Vasodilator Agents

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

Systemic and Pulmonary Vascular Resistances

As blood flows through the systemic and pulmonary circulations friction develops between the moving fluid and the stationary walls of the blood vessels. Thus, the vessels tend to resist fluid movement through them. Such resistance is known as vascular resistance.

The resistance to the flow of the blood through the systemic circulation is known as systemic vascular resistance and the resistance to the flow of the blood through the pulmonary circulation is known as pulmonary vascular resistance.

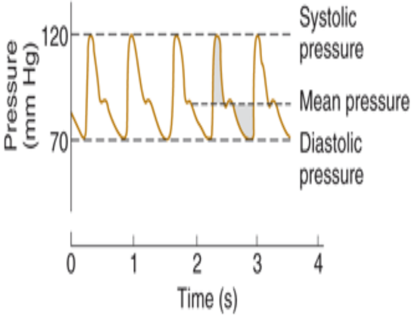
The ratio of pulmonary to systemic vascular resistance is approximately 1:6.

It is because the vascular resistance to flow that we need the heart in the cardiovascular system.

Measurement of Blood Pressure in Systemic Circulation

Direct

Arterial catheter

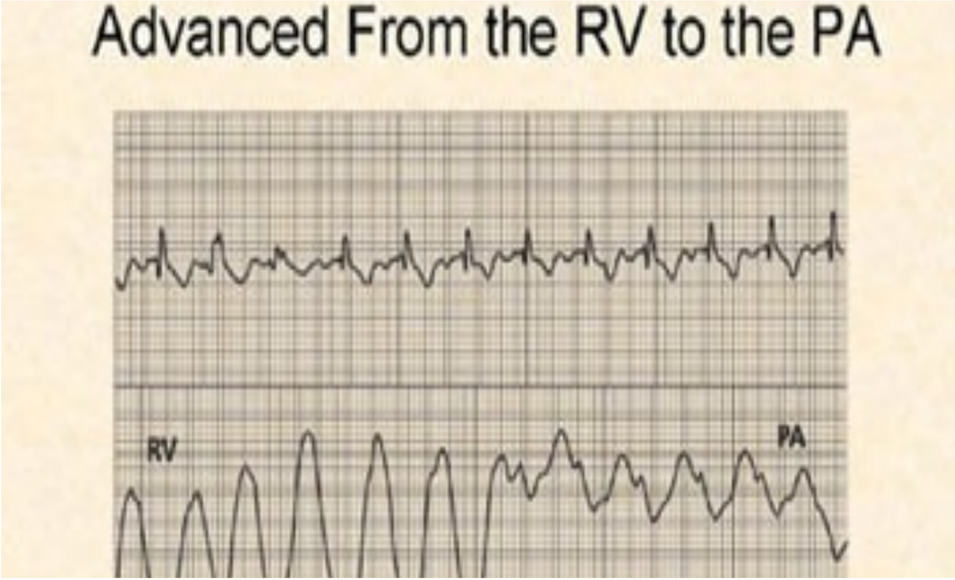


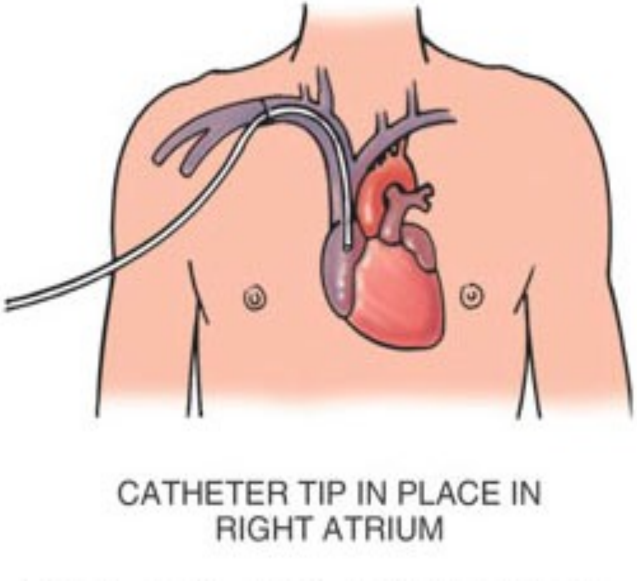
Indirect

Stethoscope and blood pressure cuff

Measurement of Arterial Blood Pressure in The Pulmonary Circulation

Right Heart Pressures
Swan-Ganz / PA Catheter





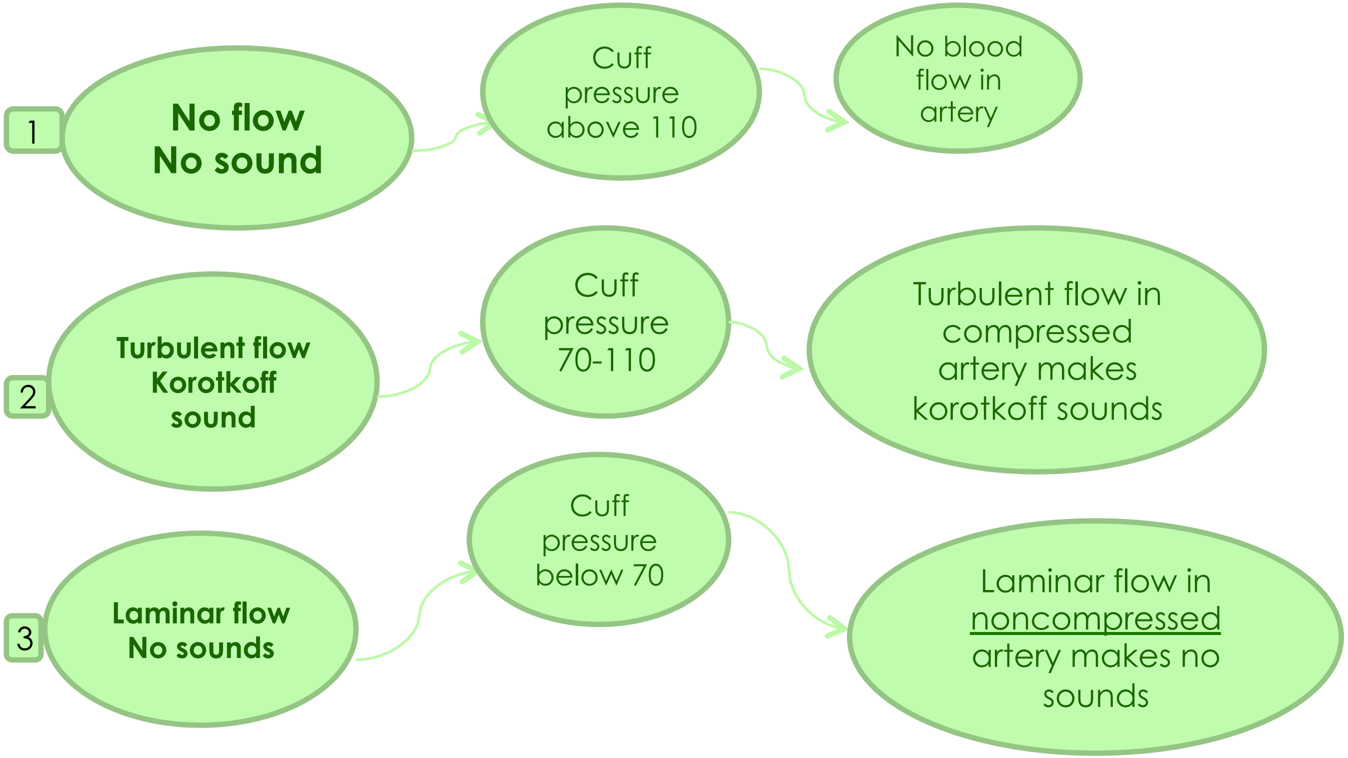
Pressures in The Systemic and Pulmonary Circulations

Pressures in the pulmonary circulation		Pressures in the systemic circulation	
Right ventricle	25/0 mm Hg	Left ventricle	120/0 mm Hg
Pulmonary artery	25/10 mm Hg	Aorta	120/80 mm Hg
Mean pulmonary artery	15 mm Hg	Mean arterial BP	93 mm Hg
Capillary	7-9 mm Hg	Capillary: skeletal renal glomerular	30 mm Hg 45-50 mm Hg
Pulmonary veins	5 mm Hg	Peripheral veins	7-15 mm Hg
Left atrium	5-10 mm Hg	Right atrium (CVP)	0 mm Hg
Pressure gradient	15-5 = 10 mm Hg	Pressure gradient	93-0 = 93 mm Hg

Arterial Blood Pressure Measurement

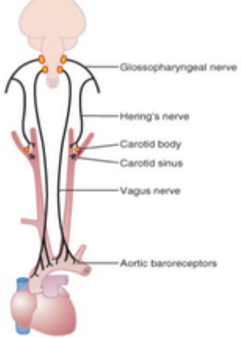
- Listen to Korotkoff sounds.

Korotkoff sounds are blood flow sounds that healthcare providers observe while taking blood pressure.



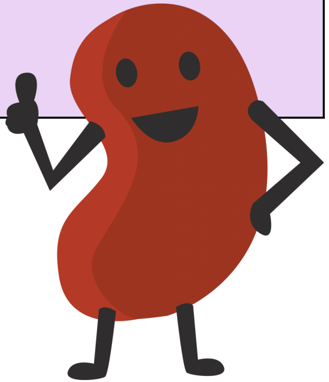
Regulation of Blood Pressure

Short Term Regulation (nervous)	Intermediate Regulation	Long-term Regulation
They regulate cardiac function and arteriolar diameter.	Capillaries (capillary fluid shift)	They regulate blood volume.
A. Baroreceptor reflex. B. Chemoreceptor reflex. C. CNS ischemic response. D. Atrial reflexes		Hormonal (kidney)



Why is it 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.

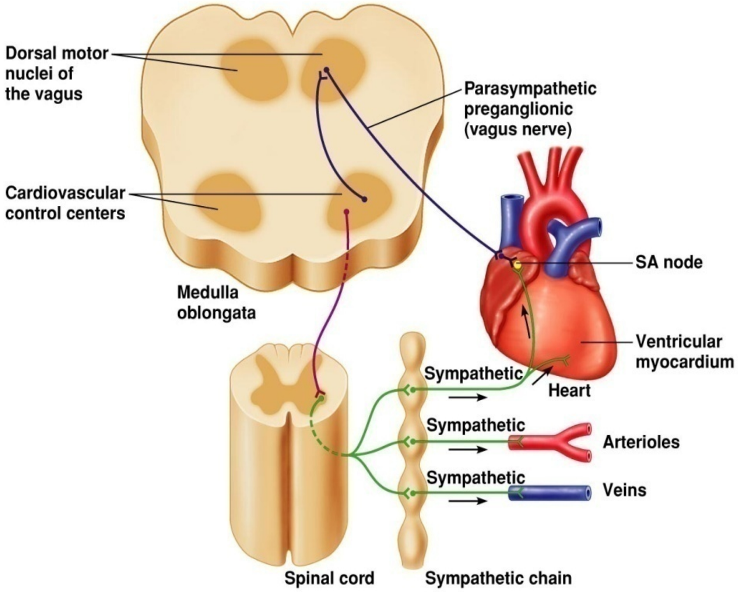


Neural Control (Medullary CVCs*)

✧ **The vasomotor center integrates all these information**

The vasomotor sends decision to the Autonomic System center:

-Both parasympathetic and sympathetic innervate the S/A node → can accelerate or slow down the heart rate
-The sympathetic Nerves System innervates the myocardium and the smooth muscle of the arteries and veins → promotes vasoconstriction



*: CardioVascular Center System

A. Baroreceptors Reflexes

✧ **Definition:**

It's a **stretch receptors** located in some of the major arteries through out of the body to maintains the ABP when these stretch receptors are stretches more than normal or not becomes activated.

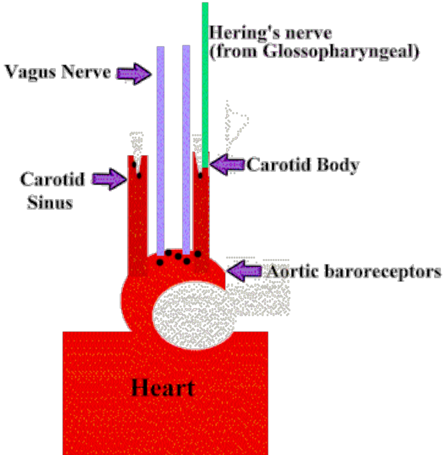
✧ **Location:**

It Located in: **Carotid sinus**(a dilatation in the carotid artery) and **aortic arch** .

✧ **Function:**

-The Baroreceptors 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** Nerves.

-They respond to a rapidly changing BP. In the range 60-180 mmHg (and that respond is what we called it **Baroreceptor Reflex**



✧ **Explanation**

Baroreceptors are important in maintaining ABP constant during changes in body position: When you change your body position from setting for long time into standing up normally the ABP in the head and any organ above the Heart level will be decreased this will activate the baroreceptors to make a reflex.

As barorecptor reflex becomes activated, strong sympathetic impulses lead to Vasoconstrictor and minimize the decrease in BP

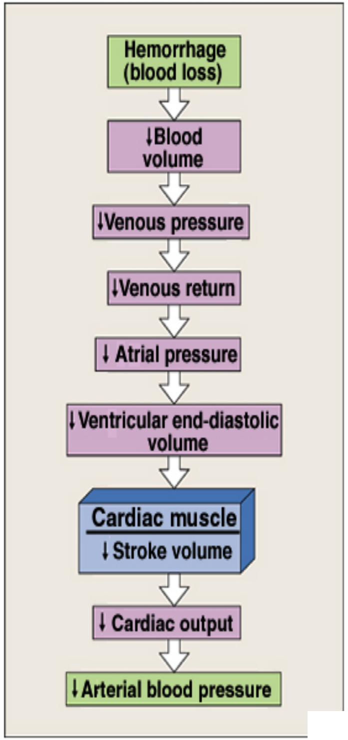
Baroreceptors Reflexes

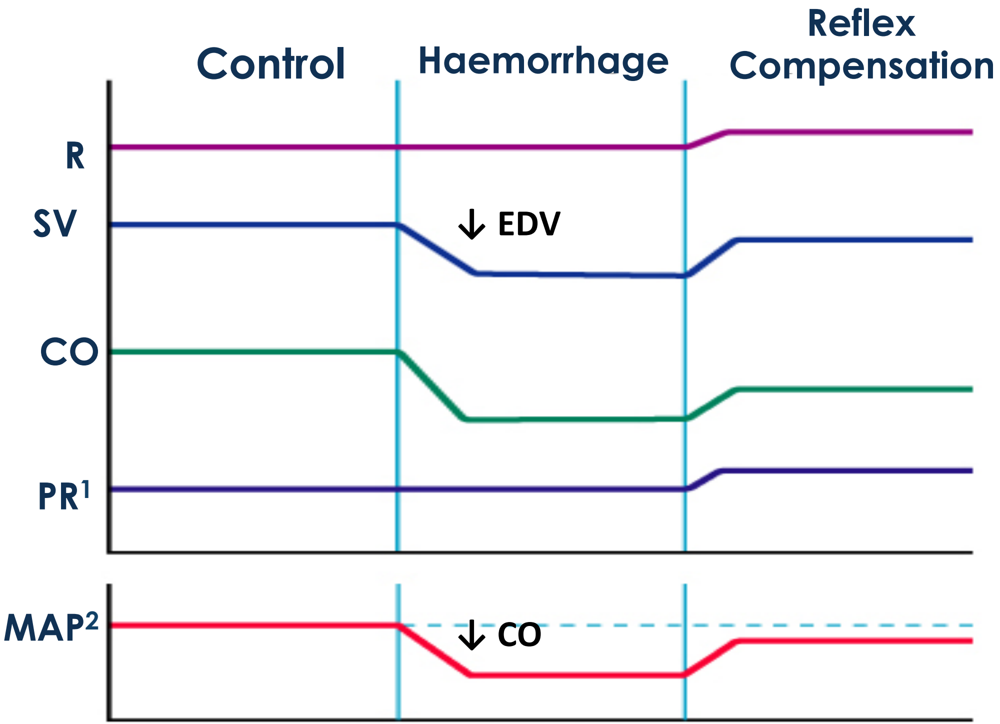
Reflexes Initiated By Baroreceptors	
↓ **ABP**	↑ **ABP**
Inhibitory impulse discharge from **baroreceptors** ↓ Because the **vasomotor center** is now released from inhibitory impulses it becomes **activated** ↓ ✓ (+) stimulate the heart: **increase HR & contractility**. ✓ (+) stimulate sympathetic vacoconstriction tone: **Vasoconstrictor**	Stretch of receptors ↓ Increase in rate of firing and impulses travel along the Glossopharyngeal & vagus. ↓ These impulses will go to the medullary CVCs (Cardiovascular centers) ↓ (+) stimulate the **vagal center**[1] **: decrease HR.** (-)inhibits vasoconstrictor center: **Vasodilatation**

1: Parasympathetic

Cardiovascular Changes Initiated By The Baroreflex in Hemorrhage (Decrease In Blood Volume)

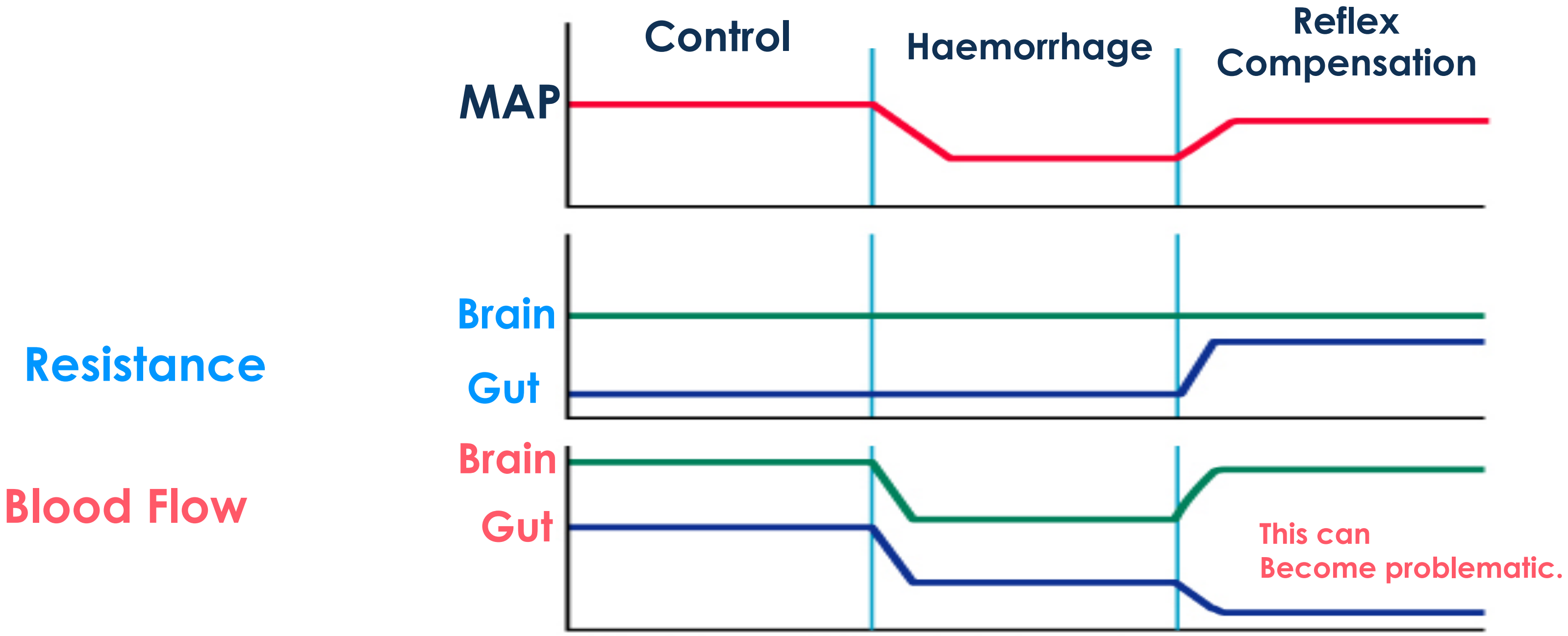
Decrease in blood volume





1: Peripheral Resistance
2: Mean Arterial Pressure

Cont.



✧ **Explanation :**
Why it's problematic because when there is a decrease in blood volume (Haemorrhage) the body wants the flow of the blood to the important organs (Heart & Brain) is enough to avoid STROKE and DEATH and this property need to close some arteries supply other organs such as (Gastrointestinal organs) of course you will not have stroke but because poor blood supply to these organs will makes some problems less dangerous. **(this explain the elevation of resistance of gut because the body has all ready close there supplying vessels which lead to increase resistance**

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.

Explanation
This property means the baroreceptors is resetting from time to time because if not happened the baroreceptors will adapt to the new BP.

Any change in this new BP means it's not normal

Example:
Let's suppose we have an athlete guy who is exercising daily his BP probably is always increasing the baroreceptors among time will adapt to this increasing in BP and consider it as normal ABP

Unimportance of Baroreceptors in Long-term Pressure Control

As we mention in the last female slide about the adaptation of baroreceptors and how the adapt fast:

- if ABP deviates from its normal operating point for more than a few days, the arterial baroreceptors adapt to this new pressure.

- This adaptation of the baroreceptors obviously prevents the baroreflex from functioning as a long-term blood pressure control system.

B. Chemoreceptors Reflexes

✧ **Definition:**

It's a Chemosensitive cells, stimulated in response to: O2 lack, CO2 excess, H+ excess in the tissues

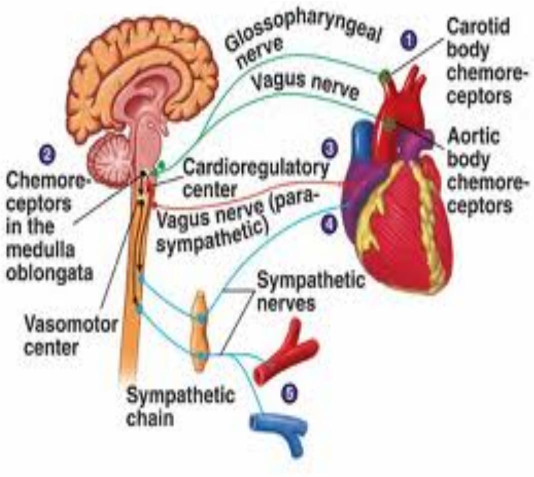
✧ **Location:**

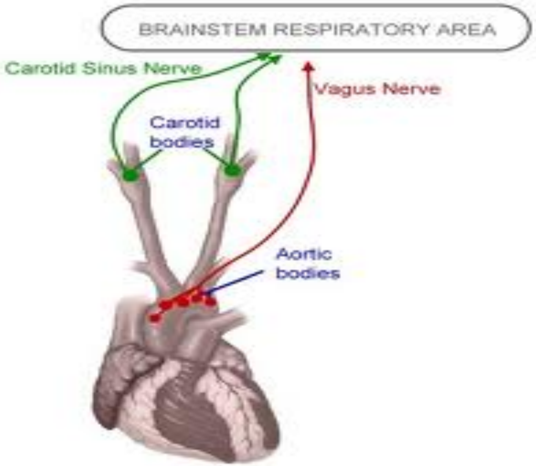
Mostly all the tissue including the vessels.

✧ **They 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+.**

✧ **Function:**

Become activated when ABP becomes less than 60 mmHg. So, they are not involved in ABP control at normal range. When blood flow to chemoreceptors decreases it leads to ↓O2, ↑CO2, ↑H+ this will stimulate the chemo signals which well activates the CVS resulting in **Vasoconstriction**





C. CNS Ischemic Response

- It acts rapidly and powerfully as an emergency when there is further decrease in ABP, whenever blood flow to **the brain** decrease to lethal level.

- When BP < 20 ➡ Cerebral ischemia of vasomotor center ➡ strong excitation of vasomotor center (due to accumulation of CO_2,lactic acid….) ➡ strong **vasoconstriction** of all the blood vessels to keep the patient alive by maintaining the blood flow to the brain and the heart.

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

D. Atrial Reflexes

Low pressure receptors especially in the right atrium respond to changes in blood volume.

HOW?

- ✧ If blood volume is increased (E.g.: infusing 500 ml into person)
- ✧ ↑Blood volume → Stretch of atria → inhibiting of cardiovascular center.
- ✧ **This will leads to:**
  - **↑Atrial Natriuretic Peptide (ANP) →** ↓blood volume (towards normal)

    -Due to Vasodilation of renal vessels, diuresis, natriuresis.
  - **↓ADH secretion→** ↓blood volume.
  - **↓Sympathetic drive to kidney:**

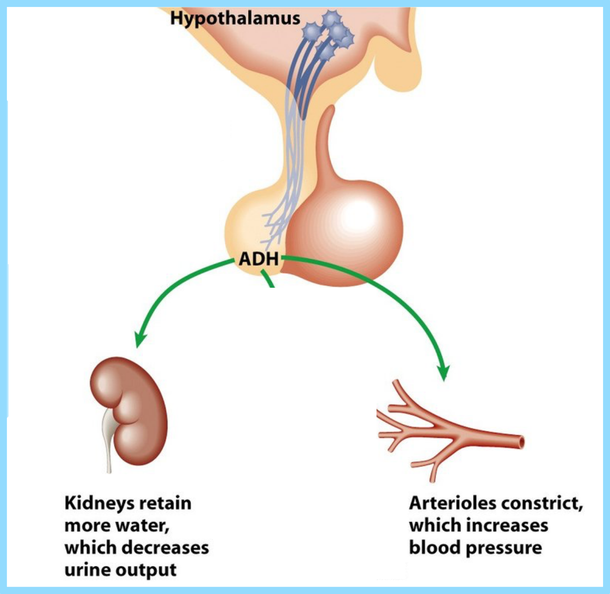
    -↓**renin secretion** → ↓aldosterone → ↓RAAS → ↓blood volume.

    -**Dilate of afferent arterioles** → ↑glomerular capillary hydrostatic pressure → ↓GFR → ↓Blood volume.

Control of Blood Volume

Anti-diuretic hormone(ADH) '**vasopressin**':
Secreted by the posterior pituitary in response to ↑blood osmolality (often due to dehydration).

- It will Promote water reabsorption by the kidney tubules → H2O moves back into the blood → less urine formed.
- It will cause vasoconstriction→ ↑TPR→ ↑BP



↑Increase Blood Volume	↓ Decrease Blood Volume
1-(+) ANP release causing Vasodilation of renal vessels **2- Hypothalamus:** a.(-) ADH leads to water diuresis B.(-) Sympathetic discharge – VD **3- Stretch SAN and increase HR**	**1-(-) ANP** causing vasoconstriction **2- Hypothalamus:** a. (+) ADH leads to water retention. b. (+) Sympathetic discharge leads to VC

Catecholamines (Adrenaline and Noradrenaline)

✧ **Adrenaline** released from the adrenal medulla circulates in the blood and can bind to both α and β adrenoceptors(BUT more β)

✧ **Noradrenaline** released from the sympathetic nerves binds primarily to α adrenoceptors.

α-adrenoceptor stimulation promotes vasoconstriction.

β -adrenoceptor stimulation promotes vasodilation.

Low adrenaline → binding to β-adrenoceptors → *vasodilation.*

High adrenaline → binding to both α and β → *vasodilation or/and vasoconstriction.*

*β-Receptors → in cardiac and skeletal muscles → so adrenaline will increase *vasodilation.*

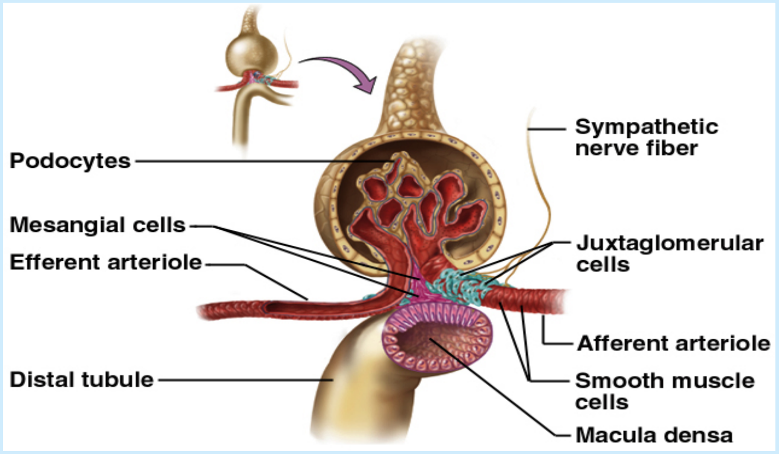
*α-receptors → In most other tissues → so adrenaline will increase *vasoconstriction*

Long Term Regulation

- ✧ Kidney has a major role of regulation of the ABP.
- ✧ The kidney excretes excess salt and water (natriuresis and diuresis)

✧ Juxtaglomerular apparatus

It will release renin when the blood pressure in arterioles decreased to Elevate the blood pressure to normal.



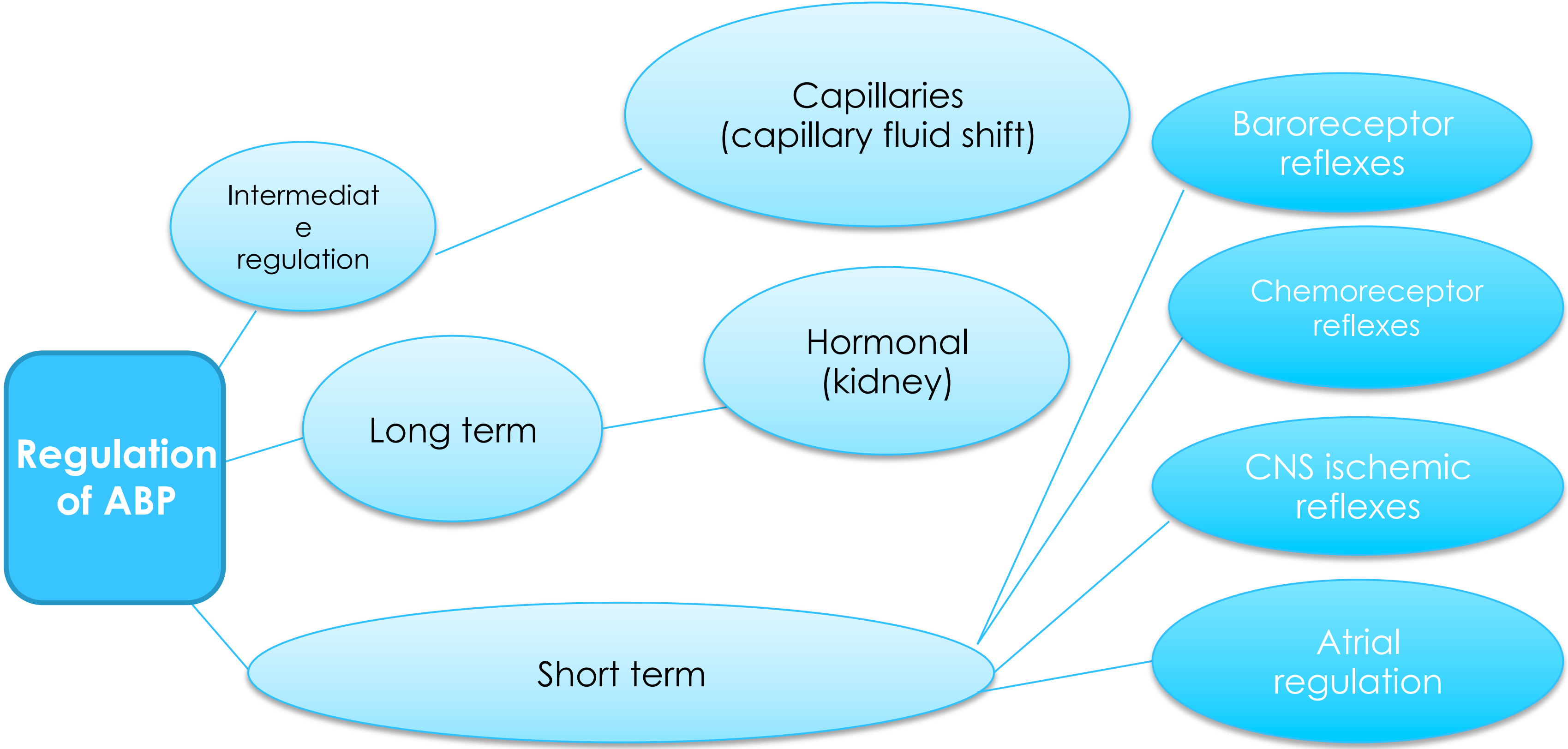
When BP↓ ➡ JGA releases renin ➡ it will convert angiotensinogen to Ang I ➡ Ang I to Ang II By angiotensin converting enzyme(ACE)

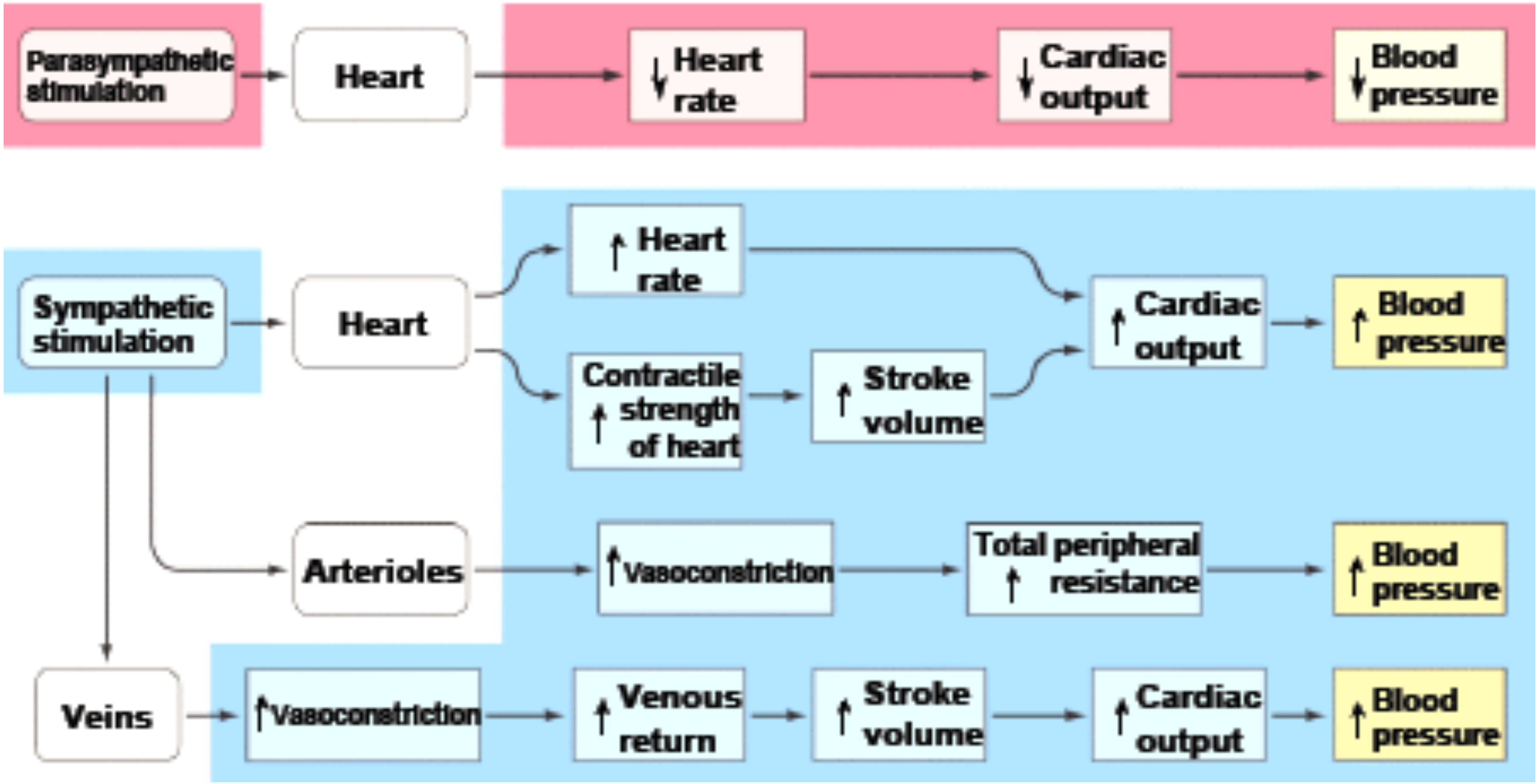
Ang II will work on:

*Cardiovascular system: **Vasoconstriction of efferent arteriole**
*Hypothalamus: **thirst and drinking**
*Adrenal cortex: **aldosterone ➔ salt-water retention**

ALL these mechanisms lead to elevating the blood pressure to normal.

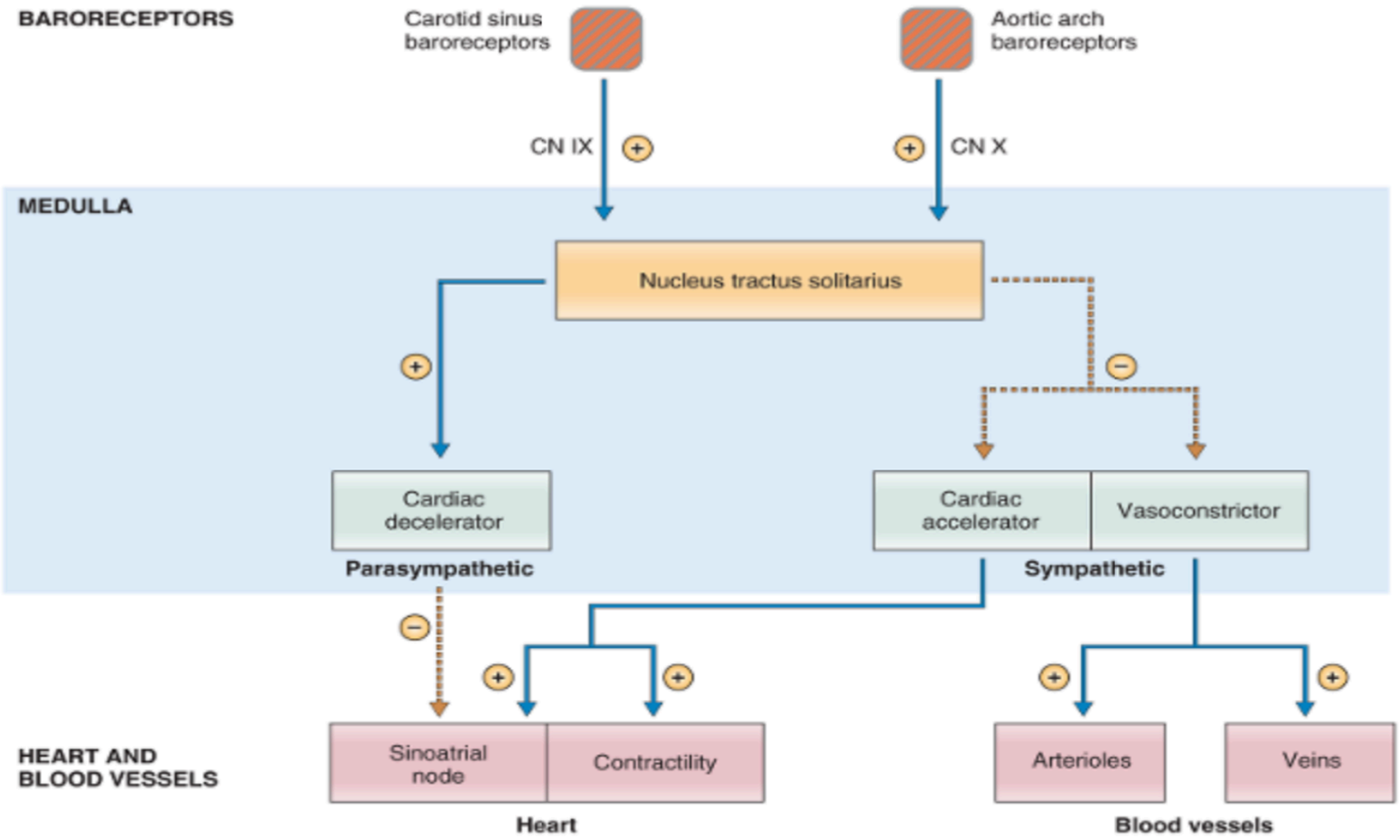
Mind Map

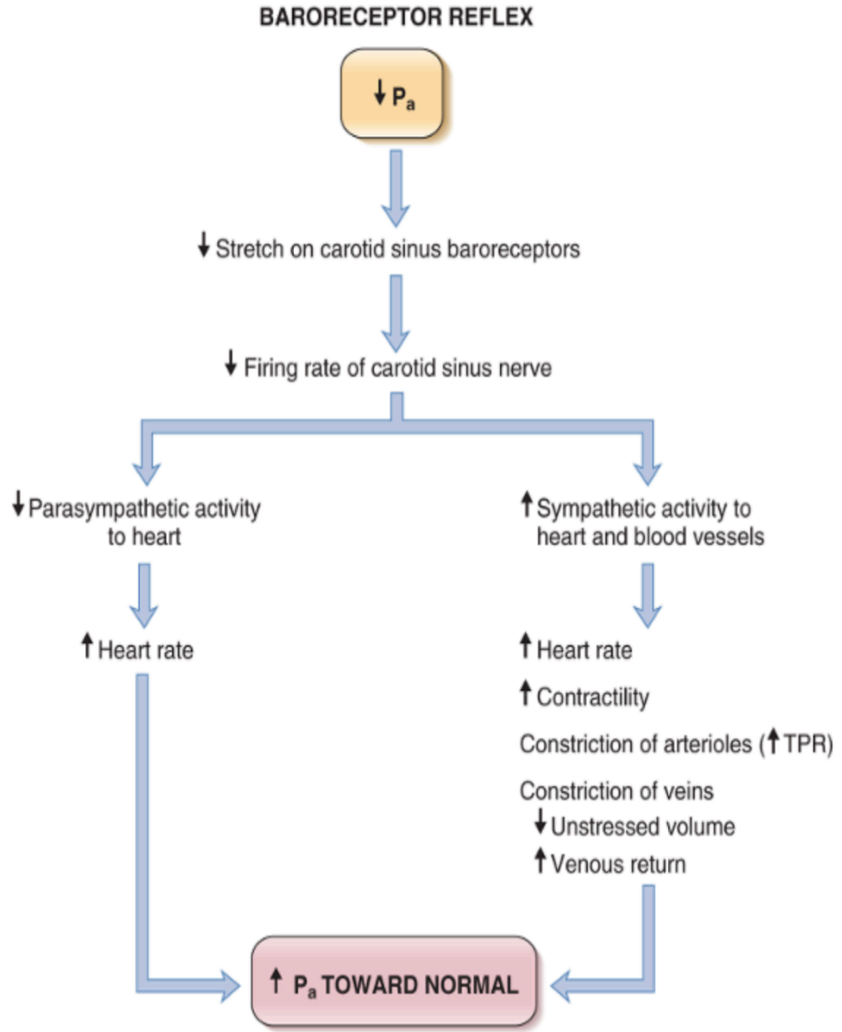

Regulation of ABP
Intermediate regulation
Capillaries (capillary fluid shift)
Long term
Hormonal (kidney)
Short term
Baroreceptor reflexes
Chemoreceptor reflexes
CNS ischemic reflexes
Atrial regulation


Parasympathetic stimulation
Heart
↓ Heart rate
↓ Cardiac output
↓ Blood pressure
Sympathetic stimulation
Heart
↑ Heart rate
Contractile ↑ strength of heart
↑ Stroke volume
↑ Cardiac output
↑ Blood pressure
Arterioles
↑ Vasoconstriction
Total peripheral ↑ resistance
↑ Blood pressure
Veins
↑ Vasoconstriction
↑ Venous return
↑ Stroke volume
↑ Cardiac output
↑ Blood pressure

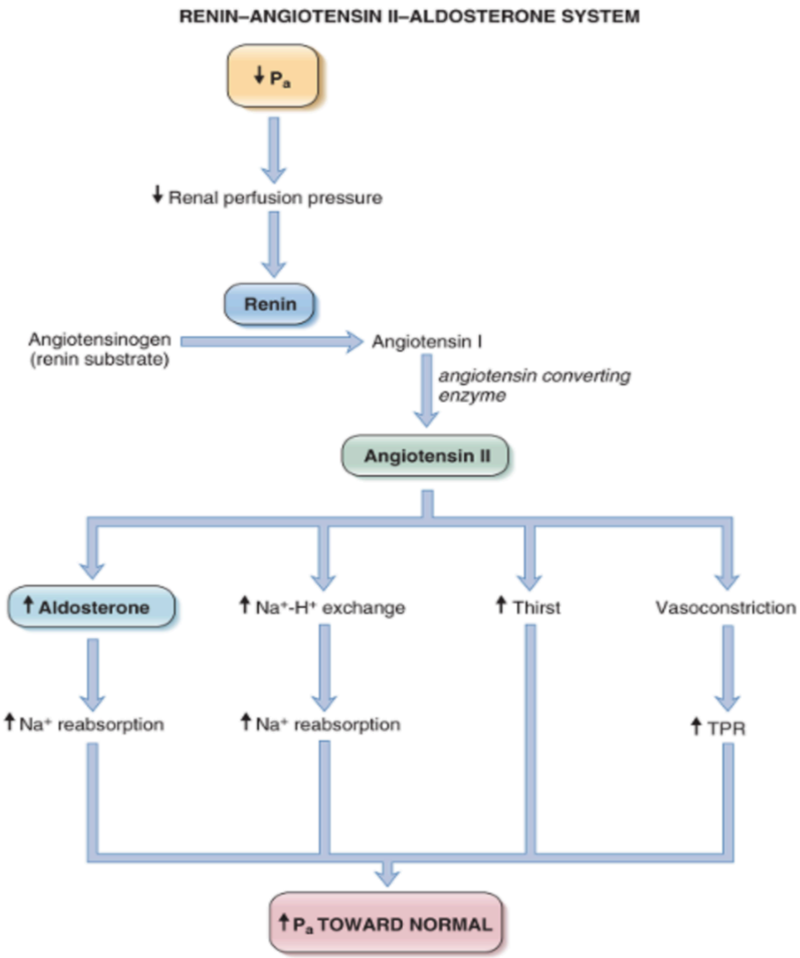
Summaries

Summaries


BARORECEPTORS
Carotid sinus baroreceptors
Aortic arch baroreceptors
CN IX
CN X
MEDULLA
Nucleus tractus solitarius
Cardiac decelerator
Parasympathetic
Cardiac accelerator
Vasoconstrictor
Sympathetic
HEART AND BLOOD VESSELS
Sinoatrial node
Contractility
Heart
Arterioles
Veins
Blood vessels



BARORECEPTOR REFLEX
↓ P_a
↓ Stretch on carotid sinus baroreceptors
↓ Firing rate of carotid sinus nerve
↓ Parasympathetic activity to heart
↑ Sympathetic activity to heart and blood vessels
↑ Heart rate
↑ Heart rate
↑ Contractility
Constriction of arterioles (↑ TPR)
Constriction of veins
↓ Unstressed volume
↑ Venous return
↑ P_a TOWARD NORMAL



RENIN–ANGIOTENSIN II–ALDOSTERONE SYSTEM
↓ P_a
↓ Renal perfusion pressure
Renin
Angiotensinogen (renin substrate)
Angiotensin I
angiotensin converting enzyme
Angiotensin II
↑ Aldosterone
↑ Na^+-H^+ exchange
↑ Thirst
Vasoconstriction
↑ Na^+ reabsorption
↑ Na^+ reabsorption
↑ TPR
↑ P_a TOWARD NORMAL

Summaries

MCQs

A 26 years old man came to the ER in King Khalid university Hospital with an ambulance after a car accident , the CBC of the patient is decrease because of losing a lot of blood in the accident , vital signs show decrease in BP hypotension and an increase in pulse rate.

1-In this case the reflex Compensation of the blood flow to the Heart is:

A. Increase blood flow to the Heart but not normal
B. Decrease blood flow to the Heart but not normal
C. Blood flow will remain the same
D. Nothing will change in blood flow

2-In this case the baroreceptors will not send the inhibitory impulses to the :

A.Vasomotor center
B. Vagal center
C. Vasoconstrictor center
D. Saud's center ☺

3-In this case the resistance of the vessels in the colon will :

A. Increase
B. Decrease
C. Remain the same
D. Highly decreased

Q4) what factor makes it easy for chemoreceptors cells to detect changes in O2, CO2, and H+?

A. The blood volume
B. The pulse rate
C. The speed of the blood flow
D. The venous return effectivness

MCQs cont.

5-Which one of these is the effect of angiotensin II ?
A. Vasoconstriction of afferent artery.
B. Vasodilation of efferent artery.
C. Vasoconstriction of efferent artery.
D. Vasoconstriction of both efferent and afferent.

6-Which mechanisms of these acts when blood flow to brain decreased?
A. Chemoreceptor reflexes.
B. Baroreceptor reflexes.
C. CNS ischemic response.
D. Atrial regulation.

7-Anti diuretic hormone(ADH) acts as vasodilator agents?
A. true
B. false

1.A
2.A
3.A
4.C
5.C
6.C
7.B

Done by:

- Bandar Alsarani
- Saud Mohammed
- Faisal Aljebrein
- Nawaf Alfozan
- Nouf Almasoud

BEST OF LUCK