Blood Pressure and its Regulation

Blood Pressure (BP):

① Blood pressure is the hydrostatic pressure exerted by the blood on the blood vessel wall or it can also be defined as the lateral pressure exerted by a column of blood against the arterial wall.

② Blood pressure is measured in mm Hg and expressed in terms of systolic pressure over diastolic pressure. [SBP/DBP; normal = 120/70 mm Hg average]

③ Systolic blood pressure (SBP) is the maximum pressure within the large arteries during systole. Average value is 120 mm Hg. It indicates the extent of work done by heart.

④ Diastolic blood pressure (DBP) is the minimum pressure within the large arteries during diastole. Average value is 70 mm Hg. It measures the total peripheral vascular resistance

⑤ Pulse Pressure (PP) is the difference between Systolic blood pressure and diastolic blood pressure. PP = SBP − DBP. It indicates the force the heart generates when it contracts. It determines the pulse volume.

The average value of PP is 50 mmHg.

(6) Mean Blood Pressure (MBP): It is the average blood pressure in the arteries throughout the cardiac cycle. It is also denoted as Mean Arterial Pressure (MAP).

$$MBP/MAP = DBP + \frac{1}{3}(SBP - DBP)$$

It measures the pressure necessary for proper perfusion of all organs. Its range is 95-100 mmHg.

(7) The arterial blood pressure in humans is recorded routinely with the instrument called Sphygmomanometer, and usually by the auscultatory method (Korotkoff, 1905) An inflatable cuff attached to mercury manometer is wrapped around the arm and a stethoscope is placed on the brachial artery. Cuff is rapidly inflated, artery is occluded, and no sound heard by stethoscope. Now pressure in cuff is slowly lowered and the cuff pressure at which sounds are first heard is the Systolic pressure. As cuff pressure is further lowered, sounds become louder, then dull and muffled and then dissapear. The diastolic pressure is the cuff pressure when sound dissapears. These sounds are called "Sounds of Korotkoff".

Regulation of Blood Pressure.

① Blood pressure is determined by cardiac output, blood volume and vascular peripheral resistance. Several interconnected negative feedback systems regulate blood pressure by adjusting stroke volume, heart rate, peripheral resistance and blood volume.

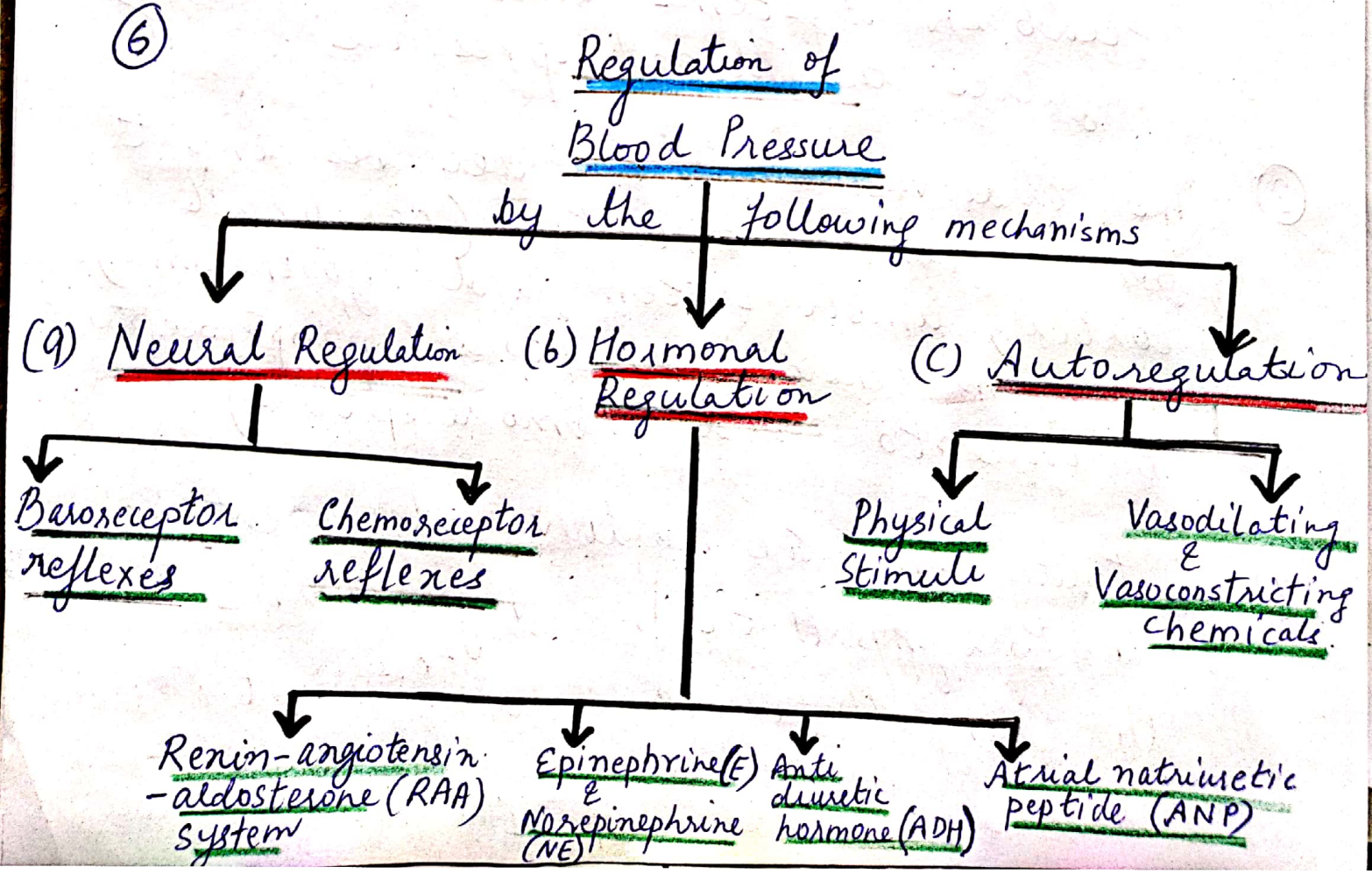
② The Cardiovascular ~~Center~~ (CV) Center in the medulla oblongata also controls Neural, hormonal and local negative feedback systems that ultimately regulate the blood pressure.

③ The cardiovascular center receives input from higher brain centers (cerebral cortex, limbic system, and hypothalamus) and from sensory receptors (proprioceptors, baroreceptors and chemoreceptors)

④ Output from the cardiovascular center
(i) Parasympathetic via Vagus nerves
(ii) Sympathetic via cardiac accelerator nerve

(5) The Cardiovascular center also sends impulses to smooth muscles in blood vessel walls via Vasomotor nerves (sympathetic). The nerves exit the spinal cord and then pass into the Sympathetic trunk ganglia; then innervate blood vessels in viscera and peripheral areas. Thus setting a moderate state of tonic contraction or vasoconstriction called "Vasomotor tone" which sets the peripheral vascular resistance.

(6)



(a) Neural Regulation of blood pressure

(i) Baroreceptor Reflexes.

Pressure sensitive receptors called baroreceptors are present in the aorta, internal carotid arteries and other large arteries in the neck & chest. Two most important baroreceptor reflexes are

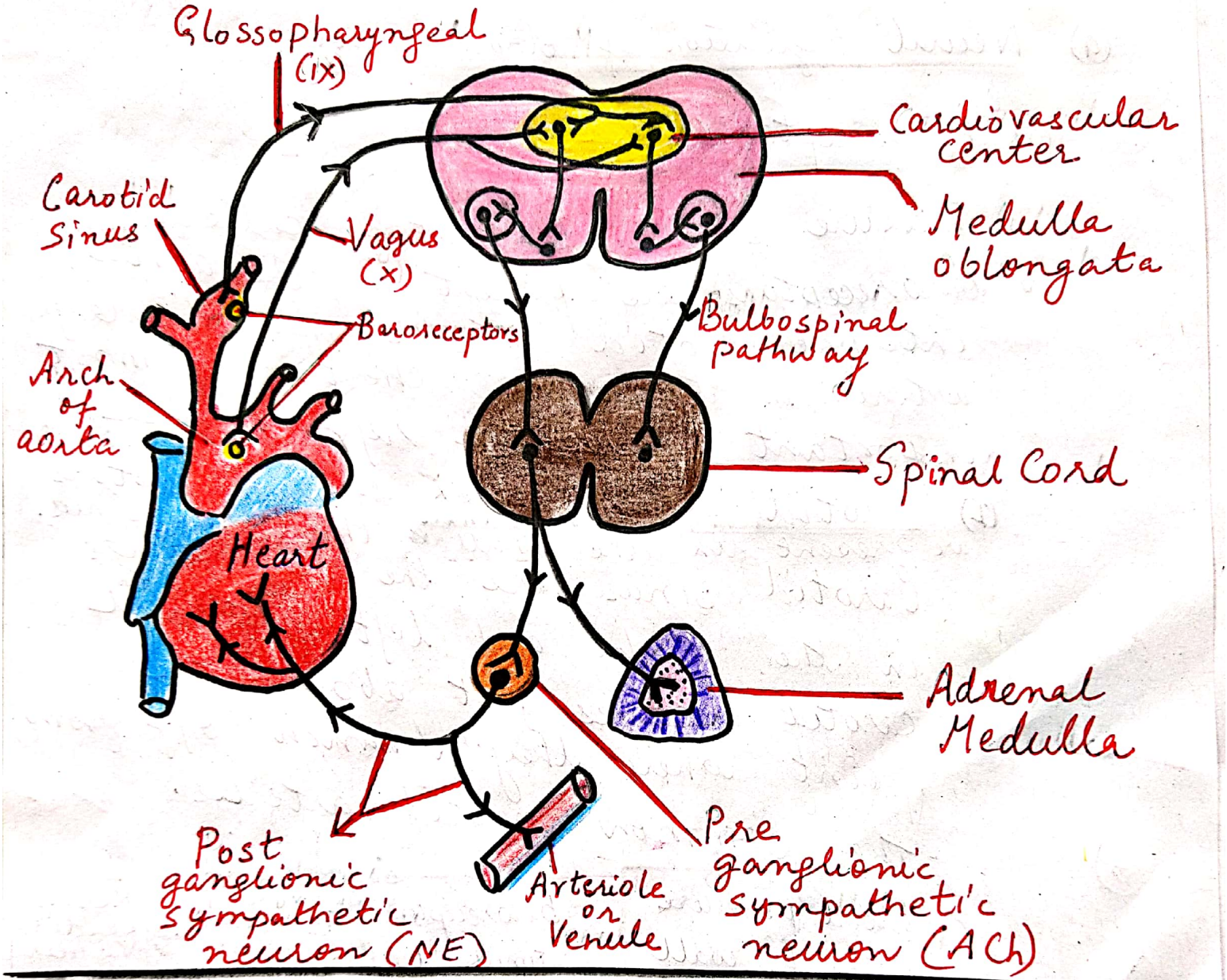
(I) **Carotid sinus reflex** :- Baro receptors are present in the wall of the carotid sinus.. Carotid sinus are the widenings in the right and left internal carotid arteries just above the point where they branch off from the common carotid arteries.

Blood pressure stretches wall of carotid sinus → Baroreceptors Stimulated → Via IX nerve (Glosso-pharyngeal) → Reach Cardio-Vascular Center in Medulla

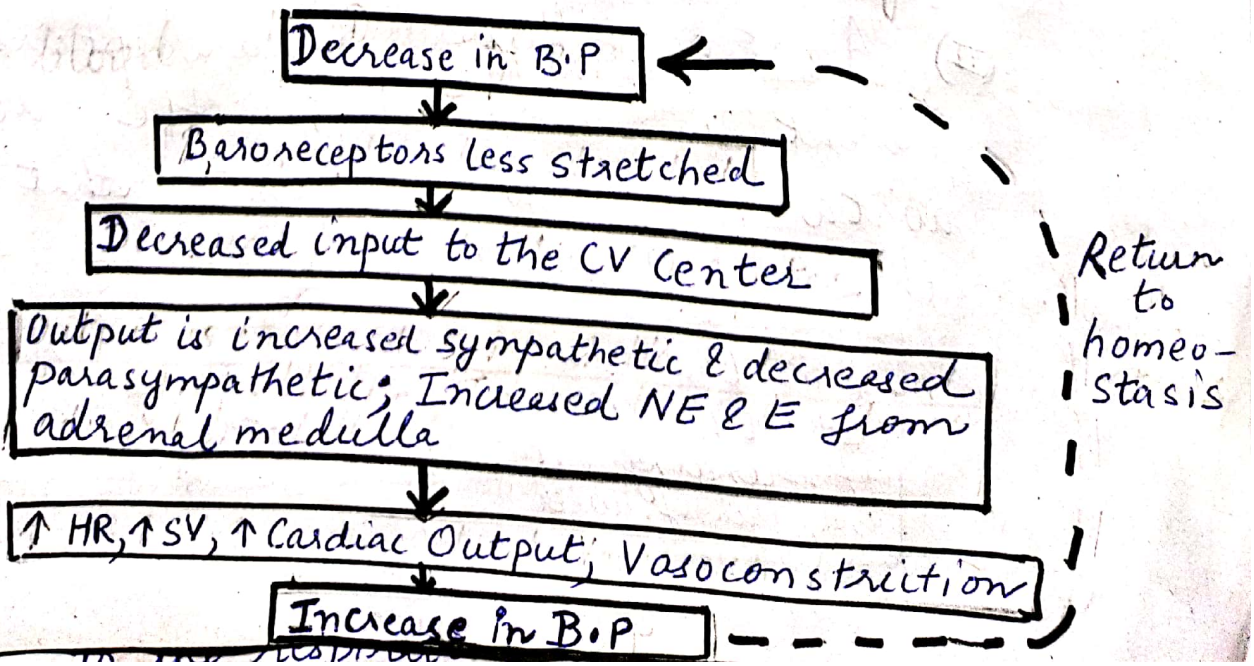
(II) **Aortic reflex** :- Baroreceptors are present in the wall of the ascending aorta and arch of aorta that begin the aortic reflex.

Blood pressure stretches wall of ascending aorta and arch of aorta → Baroreceptors Stimulated → Via X nerve (Vagus) → Reach Cardio-Vascular Center in Medulla

Baroreceptor reflexes & medullary control of blood pressure

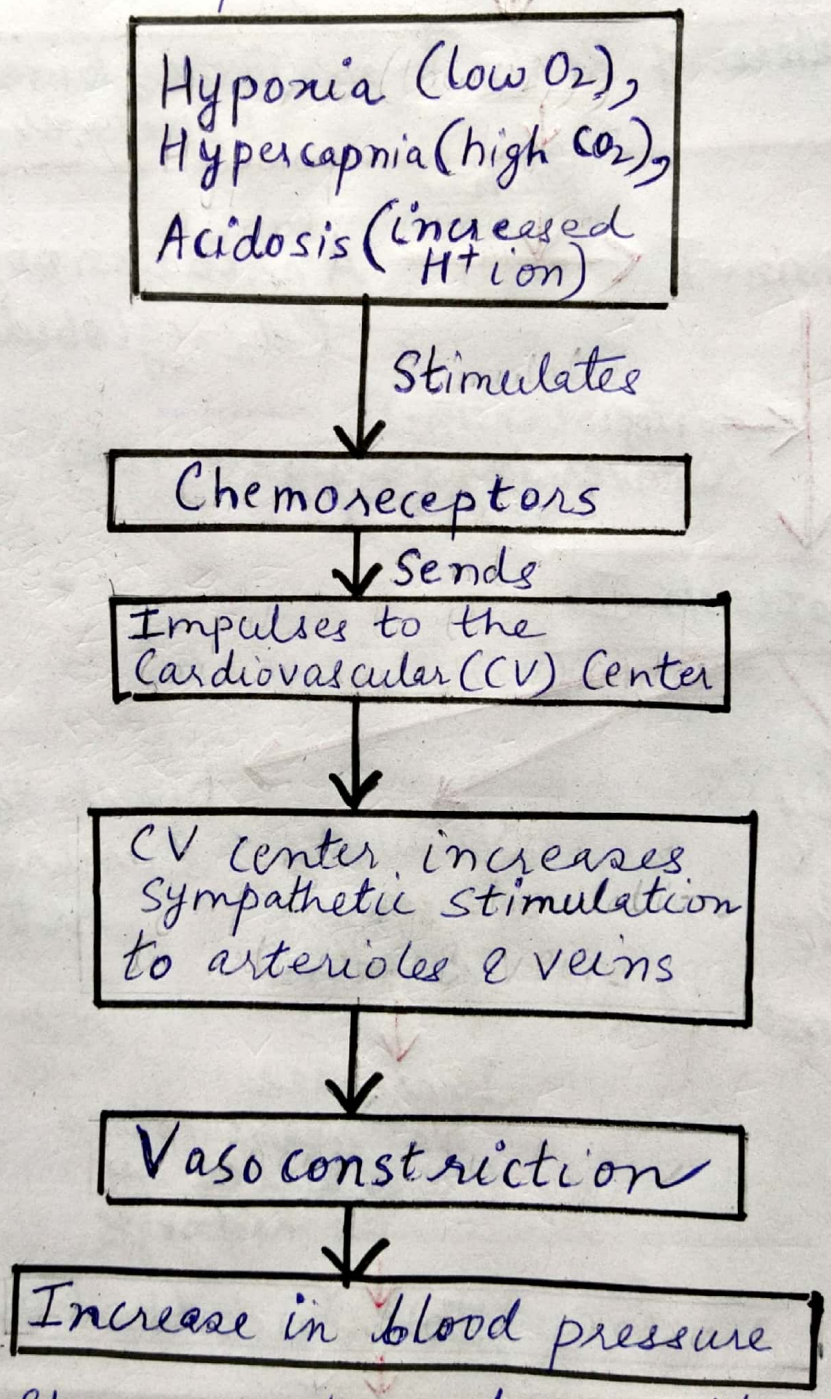


Negative Feedback regulation of blood pressure (B.P) by baroreceptor reflexes



(ii) Chemoreceptor Reflexes

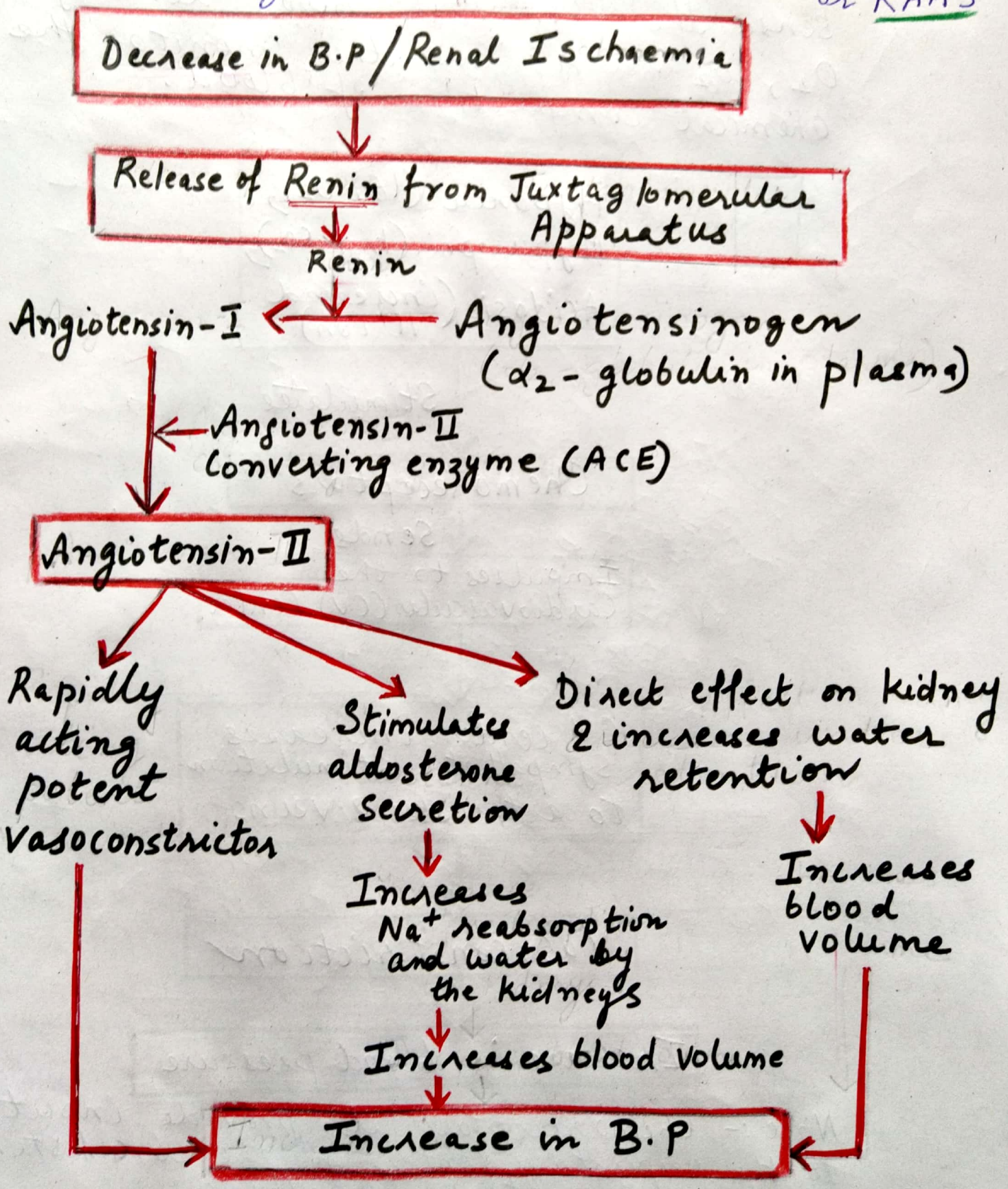
Chemoreceptors are located in the carotid bodies and aortic bodies. They sense the changes in blood level of O_2, CO_2 and H^+ and thus monitor the chemical composition of blood.



Note :- Chemoreceptors also provide input to the respiratory center in the brain stem to adjust the rate of breathing.

(6) Hormonal Regulation of Blood Pressure.

(i) Renin-angiotensin-aldosterone (RAA) system or RAAS



(ii) Epinephrine and norepinephrine.

On sympathetic stimulation, the adrenal medulla liberates epinephrine and norepinephrine which increase cardiac output by increasing the rate and force of contraction. They also cause vasoconstriction. Thus cause increase in blood pressure

(iii) Antidiuretic hormone (ADH)

ADH is released from the posterior pituitary in response to dehydration or a decrease in blood volume. It causes vasoconstriction and also enhances movement of water from kidneys to blood thus causing an increase in blood volume and ultimately increase in blood pressure. That is why ADH is also called Vasopressin.

(iv) Atrial natriuretic peptide (ANP)

ANP decreases blood pressure by causing vasodilation and by enhancing the loss of salt and water which reduces blood volume.

[Note :- ANP is released from cells in the atria of the heart]

(c) Autoregulation of Blood pressure

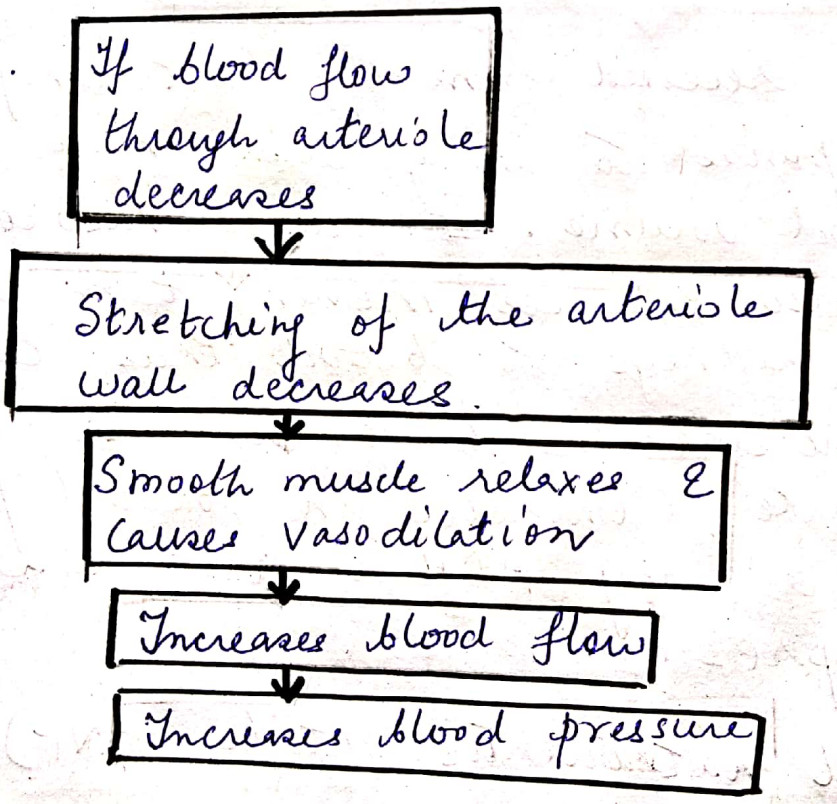
(i) Physical stimuli

Warming ⟶ causes vasodilation

Cooling ⟶ causes vasoconstriction

Stretching
- → More stretching → Smooth muscle in arteriole wall contracts more forcefully
- → Less streching → Smooth muscle in arteriole wall relaxes.

eg.



(ii) Vasodilating and Vasoconstricting chemicals

Vasodilating Chemicals	Vasoconstricting Chemicals
K^+, H^+, lactic acid, adenosine (from ATP), Nitric oxide (NO), Kinins etc	Thromboxane A_2, Superoxide radicals, Serotonin (from platelets), Endothelins (from endothelial cells)

(7) Clinical Significance.

(i) Blood pressure regulation is important to maintain enough pressure to peffuse all organs of the body, however B.P should not be too high as it can cause harm to the body.

(ii) If acute hypotension occurs the baroreflex function attempts to return it to normal pressure

(iii) If chronic hypertension occurs treatment is essential as it can result in cerebral, cardiac and renal complications.

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