Systemic Arterial Blood Pressure and its Regulation

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DEFINITIONS AND NORMAL VALUES

- ¶Arterial blood pressure is defined as the **lateral pressure** exerted by the column of blood on wall of arteries.
- The pressure is exerted when blood flows through the arteries.
- Generally, the term ‘blood pressure’ refers to **arterial blood pressure.**
- Arterial blood pressure is expressed in four different terms:
- 1. Systolic blood pressure
- 2. Diastolic blood pressure
- 3. Pulse pressure
- 4. Mean arterial blood pressure.

SYSTOLIC BLOOD PRESSURE

- Systolic blood pressure (systolic pressure) is defined as the **maximum pressure** exerted in the arteries **during systole** of heart.
- ***Normal Systolic pressure:*** 120 mm Hg (110 mm Hg to 140 mm Hg).

DIASTOLIC BLOOD PRESSURE

- Diastolic blood pressure (diastolic pressure) is defined as the **minimum pressure** exerted in the arteries **during diastole** of heart.
- ***Normal diastolic pressure****:* 80 mm Hg (60 mm Hg to 80 mm Hg).

PULSE PRESSURE

- Pulse pressure is the difference between the systolic pressure and diastolic pressure.
- ***Normal pulse pressure:*** 40 mm Hg (120 – 80 = 40).

MEAN ARTERIAL BLOOD PRESSURE

- Mean arterial blood pressure is the average pressure existing in the arteries.

Mean arterial blood pressure = Diastolic pressure + 1/3 of

pulse pressure

VARIATIONS

PHYSIOLOGICAL VARIATIONS

1. *Age*

Arterial blood pressure increases as age advances.

Systolic pressure in different age

- Newborn : 70 mm Hg
- After 1 month : 85 mm Hg
- After 6 month : 90 mm Hg
- After 1 year : 95 mm Hg
- At puberty : 120 mm Hg
- At 50 years : 140 mm Hg
- At 70 years : 160 mm Hg
- At 80 years : 180 mm Hg

Diastolic pressure in different age

- Newborn : 40 mm Hg
- After 1 month : 45 mm Hg
- After 6 month : 50 mm Hg
- After 1 year : 55 mm Hg
- At puberty : 80 mm Hg
- At 50 years : 85 mm Hg
- At 70 years : 90 mm Hg
- At 80 years : 95 mm Hg

2. *Sex*

- In females, up to the period of menopause, arterial pressure is 5 mm Hg less than in males of same age.
- After menopause, the pressure in females becomes equal to that in males of same age.

3. *Body Built*

- Pressure is more in obese persons than in lean persons.

5. *After Meals*

- Arterial blood pressure is increased for few hours after meals due to increase in cardiac output.

6. *During Sleep*

- Usually, the pressure is reduced up to 15 to 20 mm Hg during deep sleep. However, it increases slightly during sleep associated with dreams.

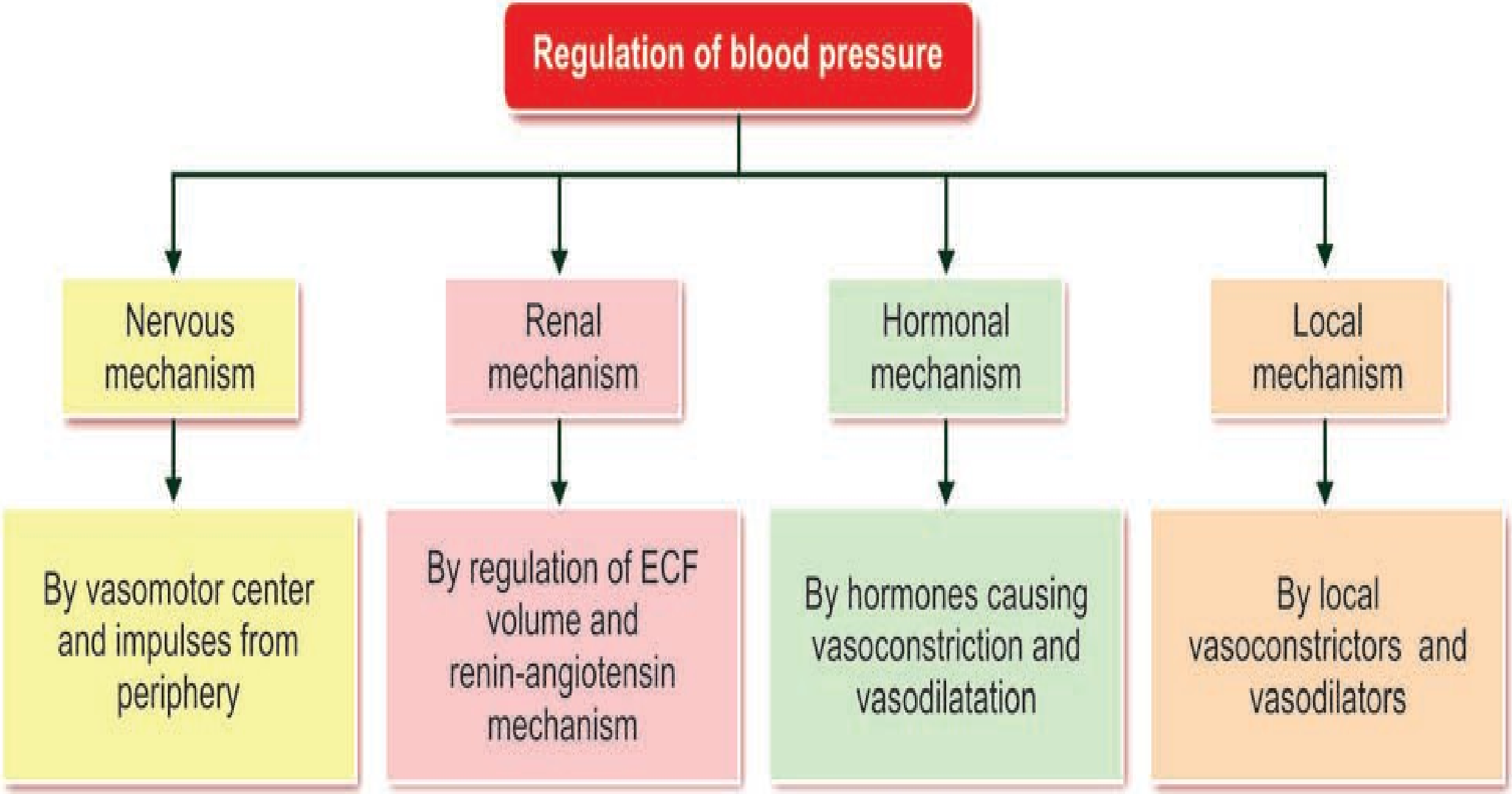
7. *Emotional Conditions*

- During excitement or anxiety, the blood pressure is increased due to release of adrenaline.

REGULATION OF ARTERIAL BLOOD PRESSURE

- Body has **four** such regulatory mechanisms to maintain the blood pressure within normal limits :

- A. Nervous mechanism or **short term** regulatory mechanism
- B. Renal mechanism or **long term** regulatory mechanism
- C. Hormonal mechanism
- D. Local mechanism.


Regulation of blood pressure
Nervous mechanism
Renal mechanism
Hormonal mechanism
Local mechanism
By vasomotor center and impulses from periphery
By regulation of ECF volume and renin-angiotensin mechanism
By hormones causing vasoconstriction and vasodilatation
By local vasoconstrictors and vasodilators

NERVOUS MECHANISM FOR REGULATION OF BLOOD PRESSURE – SHORT-TERM REGULATION

- Nervous regulation is **rapid among** all the mechanisms involved in the regulation of arterial blood pressure.
- When the pressure is altered, nervous system brings the pressure back to normal within **few minutes**.
- Although nervous mechanism is **quick in action,** it operates only for a short period and then it adapts to the new pressure.
- Hence, it is called short term regulation.

- The nervous mechanism regulating the arterial blood pressure operates through the vasomotor system.

Vasomotor System

- Vasomotor system includes three components:
- 1. Vasomotor center
- 2. Vasoconstrictor fibers
- 3. Vasodilator fibers.

1. VASOMOTOR CENTER

- Vasomotor center is bilaterally situated in the **reticular formation of medulla oblongata** and the **lower part of the pons**.
- Vasomotor center consists of three areas:
    - i. Vasoconstrictor area
    - ii. Vasodilator area
    - iii. Sensory area.

i. *Vasoconstrictor Area*

- Vasoconstrictor area is also called the **pressor area.** It forms the **lateral portion** of vasomotor center.
- Vasoconstrictor area **sends impulses** to blood vessels through **sympathetic vasoconstrictor fibers.**
- So, the stimulation of this area causes **vasoconstriction** and **rise in arterial blood pressure**. This area is also concerned with acceleration of heart rate.

ii. *Vasodilator Area*

- Vasodilator area is otherwise called **depressor area.**
- It forms the **medial portion** of vasomotor center.
- This area **suppresses** the vasoconstrictor area and causes vasodilatation.
- It is also concerned with cardio inhibition.

iii. *Sensory Area*

- Sensory area is in the **nucleus of tractus solitarius**, which is situated in **posterolateral part of medulla and pons**.
- This area **receives sensory** impulses via **glossopharyngeal and vagal nerves** from the periphery, particularly from the **baroreceptors.**
- Sensory area in turn, controls the vasoconstrictor and vasodilator areas.

2. VASOCONSTRICTOR FIBERS

- Vasoconstrictor fibers belong to the **sympathetic division of autonomic nervous system**. These fibers cause vasoconstriction by the release of neurotransmitter substance, **noradrenaline.**
- Noradrenaline acts through **alpha receptors of smooth muscle fibers** in blood vessels.
- Vasoconstrictor fibers play major role than the vasodilator fibers in the regulation of blood pressure.

3. VASODILATOR FIBERS

Vasodilator fibers are of three types:

i. Parasympathetic vasodilator fibers

ii. Sympathetic vasodilator fibers

iii. Antidromic vasodilator fibers

i. *Parasympathetic Vasodilator Fibers*

- Parasympathetic vasodilator fibers cause dilatation of blood vessels by releasing **acetylcholine.**

ii. *Sympathetic Vasodilator Fibers*

- Some of the sympathetic fibers cause vasodilatation in certain areas, by secreting **acetylcholine.**
- Such fibers are called **sympathetic vasodilator** or **sympathetic cholinergic fibers.**

iii. *Antidromic Vasodilator Fibers*

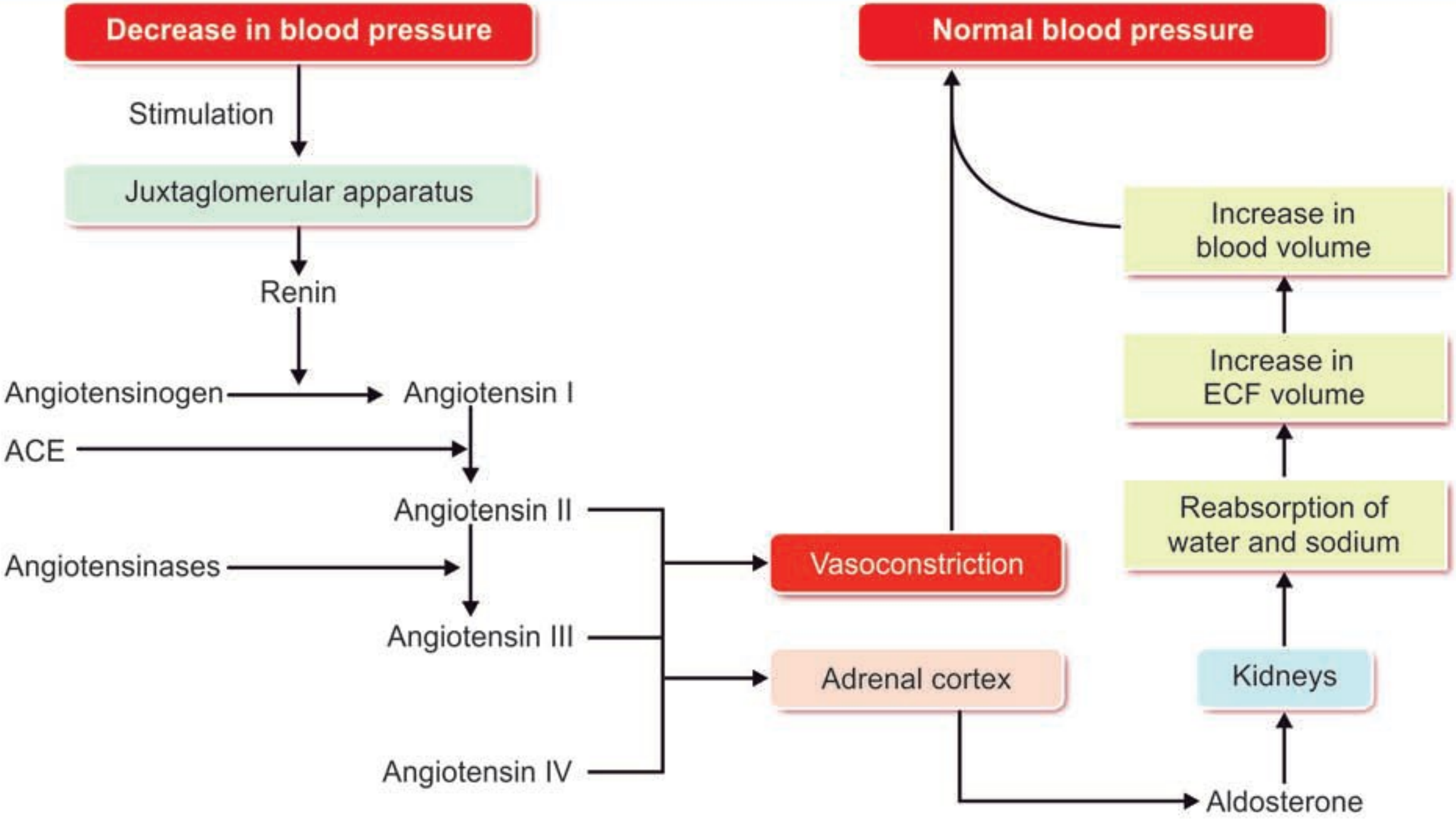
- Normally, the impulses produced by a cutaneous receptor (like pain receptor) pass through sensory nerve fibers.
- But, some of these impulses pass through the other branches of the axon in the opposite direction and reach the blood vessels supplied by these branches.
- These impulses now dilate the blood vessels.
- It is called the **antidromic** or **axon reflex** and the nerve fibers are called antidromic vasodilator fibers.

¶ RENAL MECHANISM FOR REGULATION OF BLOOD PRESSURE – LONG-TERM REGULATION

- Kidneys play an important role in the long term regulation of arterial blood pressure.
- When blood pressure alters slowly in several days/ months/ years, the nervous mechanism adapts to the altered pressure and looses the sensitivity for the changes.
- It cannot regulate the pressure any more.
- In such conditions, the renal mechanism operates efficiently to regulate the blood pressure.
- Therefore, it is called **long term regulation**.

Kidneys regulate arterial blood pressure by two ways:

1. By regulation of ECF volume
2. Through renin angiotensin mechanism.


Decrease in blood pressure
Stimulation
Juxtaglomerular apparatus
Renin
Angiotensinogen
Angiotensin I
ACE
Angiotensin II
Angiotensinases
Angiotensin III
Angiotensin IV
Vasoconstriction
Adrenal cortex
Aldosterone
Kidneys
Reabsorption of water and sodium
Increase in ECF volume
Increase in blood volume
Normal blood pressure

HORMONAL MECHANISM FOR REGULATION OF BLOOD PRESSURE

- Many hormones are involved in the regulation of blood pressure.

Hormone which increases arterial blood pressure	Hormone which decreases arterial blood pressure
1. Adrenaline 2. Noradrenaline 3. Thyroxine 4. Aldosterone 5. Vasopressin 6. Angiotensin 7. Serotonin	1. Vasoactive intestinal polypeptide (VIP) 2. Bradykinin 3. Prostaglandin 4. Histamine 5. Acetylcholine 6. Atrial natriuretic peptide 7. Brain natriuretic peptide 8. C type natriuretic peptide

LOCAL MECHANISM FOR REGULATION OF BLOOD PRESSURE

- some local substances also regulate the blood pressure.
- The local substances regulate the blood pressure by vasoconstriction or vasodilatation.

LOCAL VASOCONSTRICTORS

- Local vasoconstrictor substances are derived from vascular endothelium. These substances are called **endothelium-derived constricting factors** (EDCF).
- Common EDCF are endothelins (ET), which are peptides with 21 amino acids. Three types of endothelins ET1, ET2 and ET3 are identified so far.

LOCAL VASODILATORS

Local vasodilators are of two types:

- 1. Vasodilators of metabolic origin
- 2. Vasodilators of endothelial origin

Vasodilators of Metabolic Origin

- Vasodilators of metabolic origin are carbon dioxide, lactate, hydrogen ions.

Vasodilators of Endothelial Origin

- Nitric oxide (NO)

THANK YOU