Regulation of arteriolar diameter

by

Dr. Nourelhuda A. Mohammed

Associate Professor Of Medical Physiology

Faculty Of Medicine , Mutah University

2025-2026

What are arterioles ?????

- Arterioles are the terminal branches of the arterial system.
- **Characters of arterioles**

1) ⇩ Elastic elements & ⇧ **smooth muscle layer**.

2) Have **great resistance** to blood flow.

3) Have sympathetic **VC** fibers with **continuous tone.**

4) Sensitive to chemicals of blood.

5) Endothelium can synthesize **chemical mediators**.

6) The only site at which arterioles can be seen is the **retina**.

Functions of arterioles:

1. Determination of the peripheral resistance:

Control the peripheral resistance so, Control the arterial blood pressure Especially (***DBP***)

2. They control blood flow to the tissues:

By changing their diameter through producing VD or VC, as they have a smooth muscle layer.

- **VC ⇨ ⇩ Blood flow.** **VD ⇨ ⇧ Blood flow.**

Factors regulating arteriolar diameter

I- Local regulation :

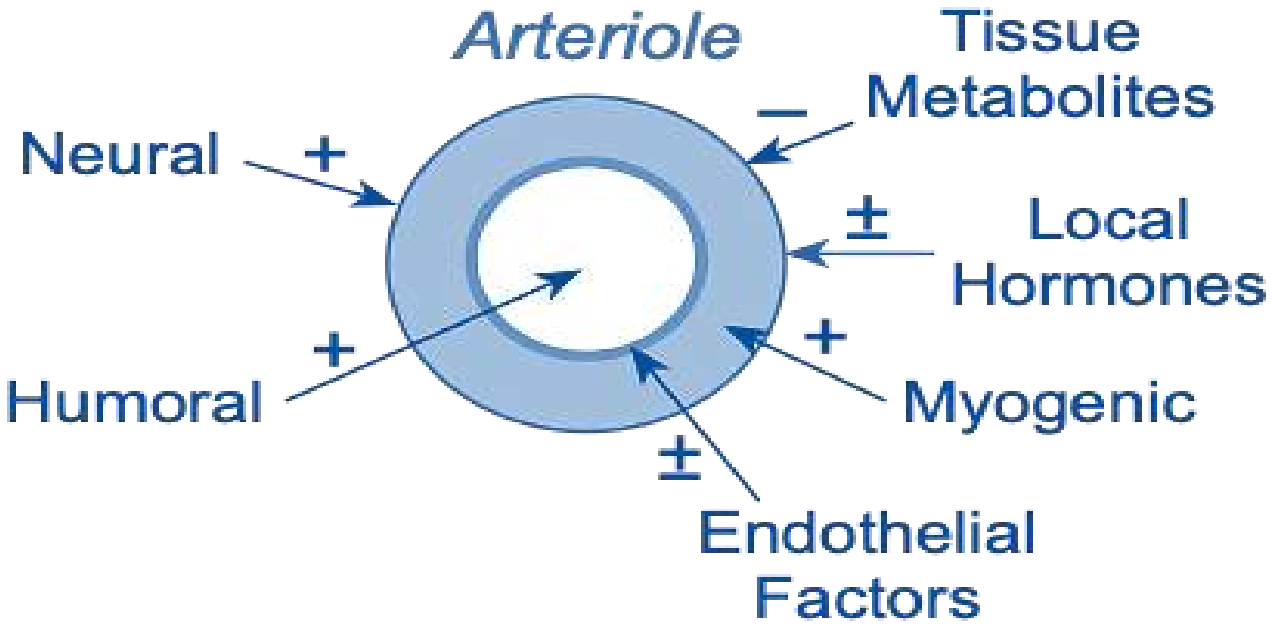
- All tissues are able to regulate their blood supply through local control of **resistance vessels**.
- Flow is linked to tissue need.

II-Systemic (central) regulation : All resistance vessels are **innervated by the sympathetic nervous system (SNS).**

III- Hormonal: Many circulating hormones modulate resistance vessels.

IV- Endothelial: The **endothelial lining of resistance** vessels acts as a **source for a number of vasoactive compounds.**

Extrinsic **Intrinsic**



Vasoconstrictor (+) and vasodilator (–) influences acting upon arterioles determine vascular tone. Extrinsic factors are from outside of the tissue, whereas intrinsic factors are from within the tissue or vessel. Tone is determine by the balance of all the factors.

I- Local regulation

1. *O2 tension (PO2)*

- Decreased PO_2 leads to a direct vasodilator effect on the arteriolar smooth muscles (except for the pulmonary vessels which constrict due to O_2 lack.
- When the metabolic activity of a tissue decreases, PO_2 is increased leading to VC.
- ⇩PO_2 is the most potent VD in the heart.
- ⇧PCO_2 is the most potent VD in the CNS.
- The normal (PO_2) ⇨ **partial VC** and this is maintained by VC tone.

I- Local regulation

2. *Metabolites*

- ⇧Metabolic activity of tissue ⇨ metabolic changes as:

a) ⇩ PO2

b) ⇧ PCO2 & ⇧ H+ (acidosis)

- These metabolic changes (⇧ Metabolites) ⇨ **VD**.

Hyperemia

- It is increase in blood flow to organ due to **VD** due to accumulation of metabolites.
- It is of 2 types:

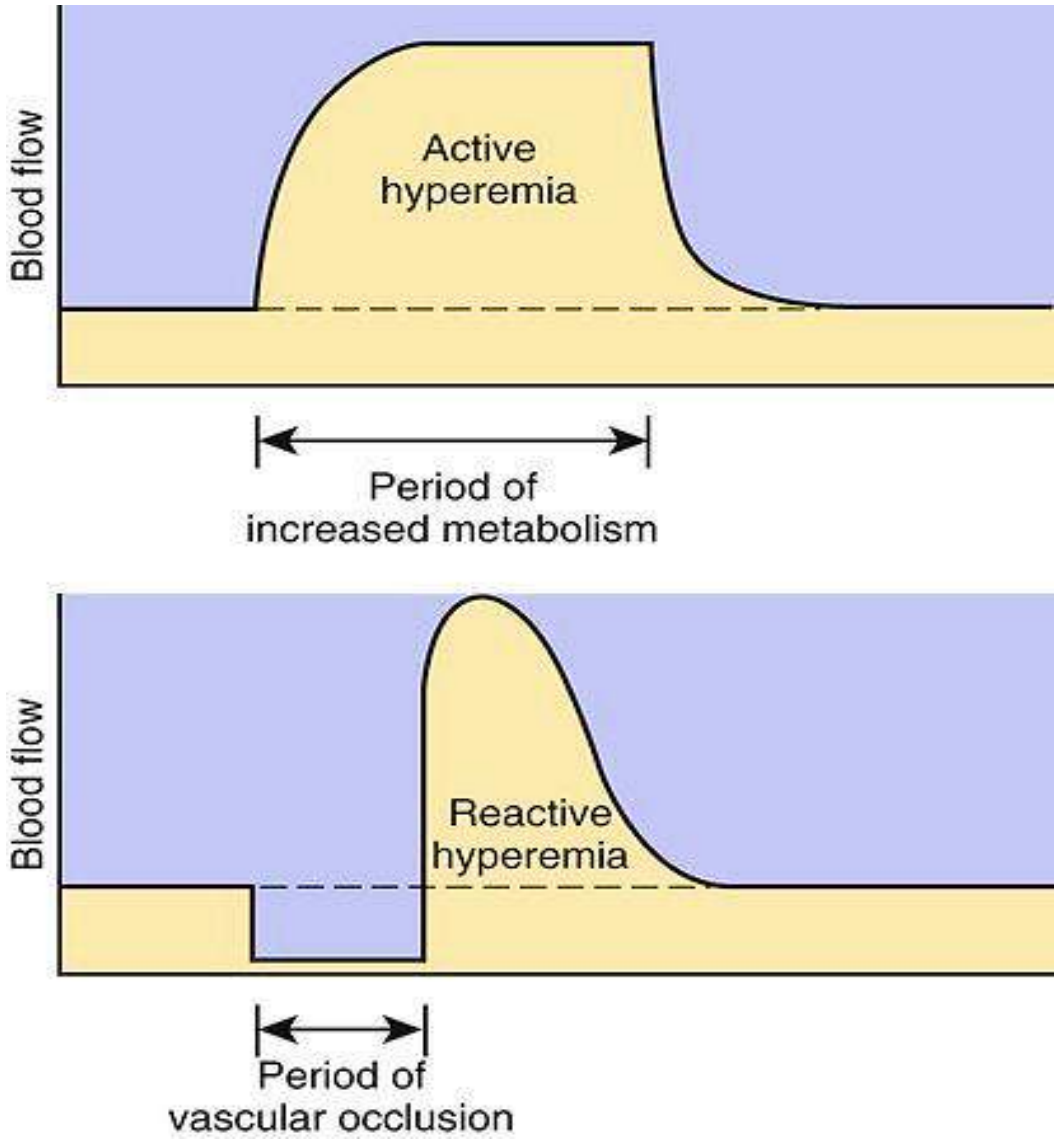
a) Active hyperemia

⇧ Blood flow at the **active tissues** by **VD** produced by accumulation of **metabolites** due to increased activity**.**

b) Reactive hyperemia

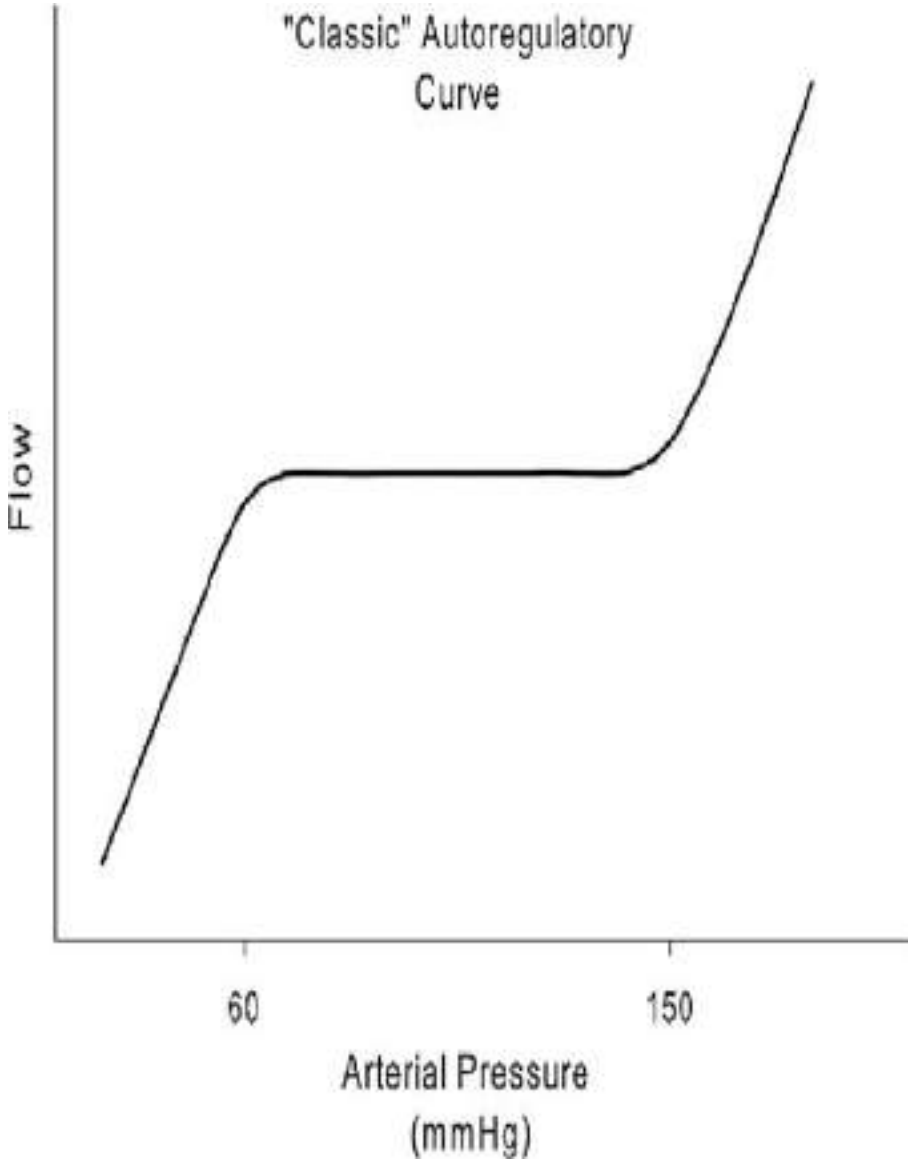
⇧ Blood flow of a tissue produced by accumulation of metabolites due to **temporary occlusion of its blood supply**.

Active hyperemia and reactive hyperemia



I- Local regulation

- ***3. Intrinsic mechanism (autoregulation)***
- It is the ability of a tissue to regulate its blood flow according to its need.
- ***Site***
- Most of vascular beds have this capacity.
- It is well developed in kidneys, liver, myocardium and brain.



- ***Mechanism of autoregulation***

a. ***Myogenic theory*****:** When the blood flow increases to a tissue, it causes stretching the vascular smooth muscles resulting in their depolarization and vascular smooth muscle contraction that decreased the blood flow to normal i.e. **to keep the wall tension.**

b. ***Metabolic theory*****:** If the blood flow to an organ is decreased, vasodilator metabolites accumulate producing vasodilatation which will increase the blood flow to wash the metabolites and remove their effect.

II-Systemic (central) regulation

Neuronal regulatory mechanisms (rapid & short acting)

A. Vasoconstrictor fibers (VC)

1. Sympathetic VC:

-The sympathetic fibers arise from the **LHCs** of the thoraco-lumbar segments of the spinal cord .

- They **discharge continuously**, due to descending **tonic excitation** from the **vasomotor center (VMC)** in medulla oblongata, leading to generalized **partial VC** which is called **sympathetic VC tone.**

- Vasoconstriction is produced by increasing the sympathetic activity.

- Vasodilatation is produced by decreasing the sympathetic activity.

- Stimulation of **VMC** ⇨ ⇧ VC tone ⇨ ⇧ peripheral resistance and arterial blood pressure and vice versa.

2. Parasympathetic VC:

- No vasoconstrictor parasympathetic fibers are known.

- Parasympathetic stimulation to the **heart** causes **coronary VC** (***indirect***) by decreasing the metabolic activity and elevation of O2 tension ⇨ **VC**

B. Vasodilator fibers (VD)

1. Sympathetic VD:

- All sympathetic innervations to blood vessels cause VC **except** in:

a) Coronary vessels:

- This occurs **indirectly** by increasing heart rate and the metabolic activity of the heart ⇨ ⇩ O2 tension and accumulation of metabolites ⇨ VD
- This is called (**metabolic theory of autoregulation**)

b) Skeletal muscles vessels:

- The sympathetic (**VD**) fibers that originates in the **cerebral cortex**.
- Then, relays in the **hypothalamus**.
- Then, it passes through the **medulla oblongata** to the **LHCs** of the thoraco-lumbar segments of the spinal cord and activate the **sympathetic VD** fibers to skeletal muscle blood vessels.
- These fibers are **not under the control of the VMC**
- They start to operate and dilate the skeletal muscle blood vessels **Even before** the start of the exercise and so help to increase the skeletal muscle blood flow during exercise.

C. The splanchnic areas

- As the blood vessels of these areas are rich in **beta adrenergic** receptors that **produce VD**.

D. Sweat glands

- They are **sympathetic cholinergic VD fibers** that supply blood vessels of the sweat glands.
- Their activity is controlled by the **heat loss center** in the anterior hypothalamus, independent from the **VMC**

2. Parasympathetic vasodilator fibers

- The only parasympathetic fibers which are direct vasodilator are those which supply the **genital organs** (sacral outflow).
- The parasympathetic fibers in **the facial** and **glossopharyngeal** nerves which supply the salivary glands **produce VD** indirectly by increasing metabolic activity of these glands during **active secretion**.

Antidromic vasodilator impulses

- When **pain** receptors are stimulated by a painful stimulus→ dilatation of the adjacent blood vessels occurs.

- **Mechanism**

- It is a local axon reflex **i.e.** stimulation of pain receptors initiates impulses travel along sensory nerve fibers toward central nervous system (CNS) until they reach a branch, they travel a long it (**antidromically**) When they reach the arterioles, they cause a release of substance P which has a VD effect on the arterioles thus, the area of inflammation become red (flare).

III- Hormonal

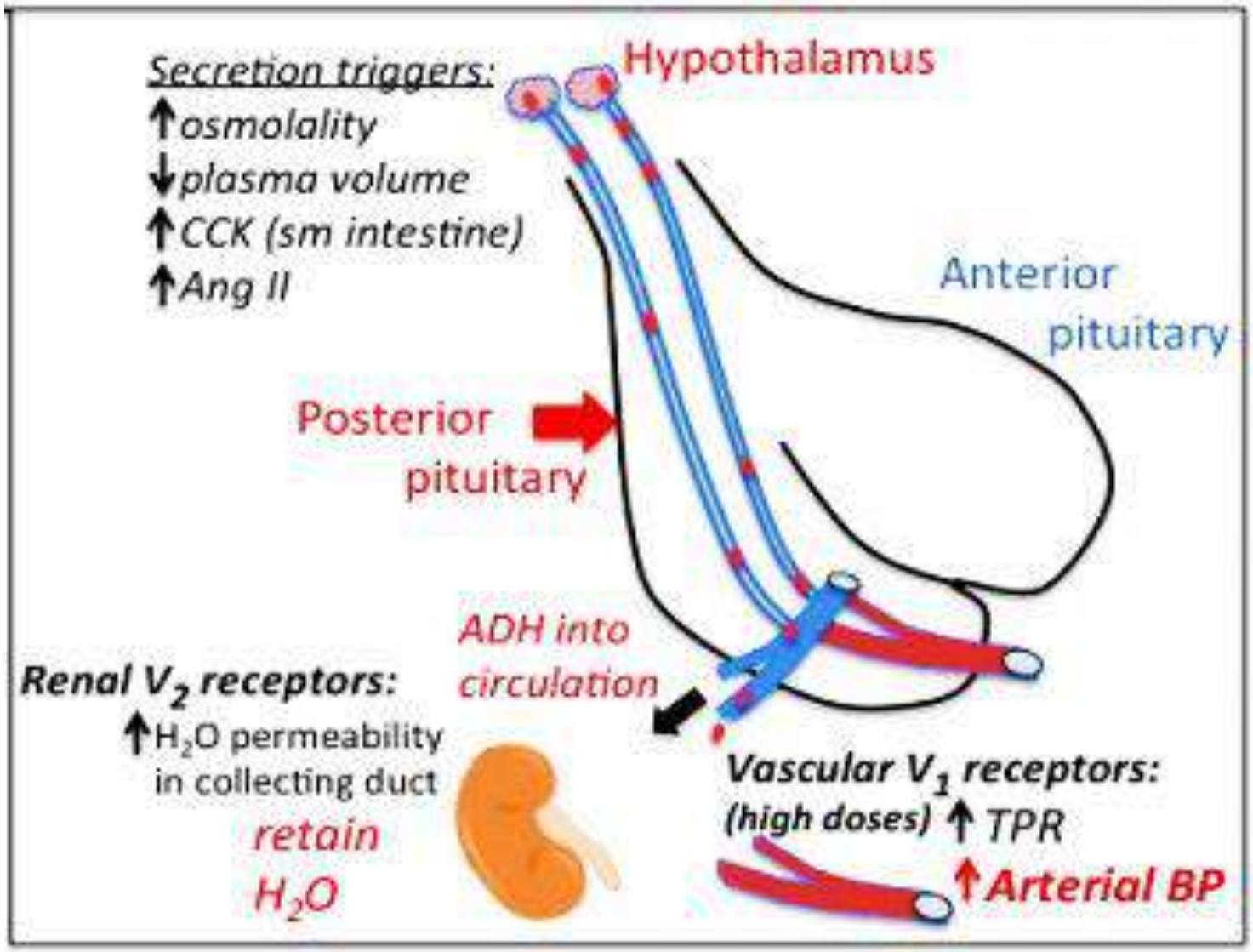
1. Antidiuretic hormone (ADH)

- Also known as **vasopressin.**
- The normal amount in blood doesn't affect the arterial pressure, but if its level increases, it will cause **marked VC** and increases the blood pressure. Thus, it plays important role in **acute hemorrhage**.
- It secreted by the **posterior pituitary gland**.

Mechanism of action

- It acts on **V1 receptors** (in vascular smooth muscle) to increase Ca+2 concentration in smooth muscle fibers **causing VC** and increased blood pressure.
- It acts on **V2 receptors** (in the nephrons) **increasing cAMP** which increases the permeability of the cells to **water**, Thus, it increases the extracellular fluid volume and arterial blood pressure.

Antidiuretic hormone Secretion & Effects



III- Hormonal

2. Angiotensin II

- Decreased blood pressure (e.g. dehydration, salt restriction, hemorrhage) causes reduction in renal blood flow which results in **renal ischemia** that stimulates the juxtaglomerular apparatus to **secrete renin** which acts on **alpha globulin** in the plasma called angiotensinogen producing **angiotensin I** which is converted to **angiotensin II** (Ang-II) by the angiotensin convertase enzyme in the lung.

- Ang-II affects Vascular smooth muscles directly via **AT1A** receptors.

Effects of angiotensin II:

a) Has a strong direct arteriolar **VC** (50 times as noradrenaline) leading to increased peripheral resistance and blood pressure.

b) Stimulates noradrenaline release from postganglionic sympathetic fibers which causes **VC** increasing peripheral resistance and blood pressure.

c) Stimulates antidiuretic hormone (**ADH, vasopressin**) secretion from the posterior pituitary causes water retention ,VC and increase blood pressure.

d) Stimulates **aldosterone** release from the suprarenal cortex which causes salt and water retention that results in an increase in blood volume, cardiac output and blood pressure.

e) Stimulates **thirst sensation** which increases water intake resulting in an increase in blood volume and blood pressure.

III- Hormonal

3. Catecholamines

- Sympathetic stimulation causes release of adrenaline and nor-adrenaline which circulate in the blood and cause the same effects of the sympathetic nervous system on

the arterioles i.e.

- Noradrenaline: has **a potent VC** effect on the blood vessels by stimulating alpha (**α**) adrenergic receptors.
- Adrenaline: in small doses causes VD of blood vessels in skeletal muscles and liver by acting on **b_2** adrenergic receptors.

4. Circulating vasodilator substances

1) Kinins:

Actions of kinins

1. **VD** by release of endothelium derived relaxing factor (NO) causing marked decrease in blood pressure.
2. Act as mediators for **VD** in active salivary glands.
3. Increase capillary permeability.
4. Contraction of smooth muscles as in respiratory system.
5. Positive chemotaxis effect (attract WBCs).
6. Stimulation of **pain** receptors.

2) Atrial natriuretic peptide (ANP)

- It is secreted mainly from the atria .

It is secreted when:

1. right atrial pressure is increased.

2. NaCl intake is increased. 3. blood volume is increased.

4. venous return is increased

- **It decreased** in rising from supine to erect position due to decreased venous return).

Actions of ANP: are opposite to action of angiotensin II **i.e.**

1. It has **VD** effect as it decreases the response of the blood vessels to vasoconstrictor substances. Thus, it decreases blood pressure.

2. It causes natriuresis **i.e. Increases loss of Na+ in urine**.

3. It **decreases aldosterone** secretion.

4. It **decreases vasopressin** hormone secretion.

5. It **decreases renin** release causes decrease angiotensin II formation.

IV- Endothelial

1-Nitric oxide

- NO is a potent vasodilator. It is known as **endothelium-derived relaxing factor** (**EDRF**).
- it is synthesized from **arginine amino acid** by action of endothelial *NO synthase*.
- It increases **cGMP** causing **VD**.
- It is released by endothelium under the effect of *bradykinin*, *substance P, vasoactive intestinal peptide (VIP)* as a mediator for their vasodilator effects.
- Its deficiency as in cases of endothelium injury causes loss of its vasodilator effect

IV- Endothelial

2- Prostacyclin and thromboxane A2

- Both are formed from **arachidonic acid** by cyclooxygenase enzyme.
- Both are in balance with each other in control of vascular diameter and platelet plug formation.
- ***Prostacyclin***: is released from endothelium, causes VD and inhibition of platelets aggregation.
- ***Thromboxane A2***: *is* released from platelets and causes VC and increase platelet aggregation.

- **Aspirin (acetylsalicylic acid)**

- causes **irreversible inhibition of cyclo-oxygenase** enzyme and re-synthesis of this enzyme by platelets needs long time while the life span of platelets is few days (from 8 to 12 day).
- So, there is **decrease** in formation of **thromboxane A2** causing VD and inhibition of platelets aggregation. That is why **aspirin** is used to prevent clot formation.

IV- Endothelial

3. Endothelium-derived hyperpolarizing factor

- EDHF opens K^+ channels in the plasma membranes of VSMCs. The membrane hyperpolarizes
- Hyperpolarization reduces membrane Ca^{+2} permeability, causing intracellular Ca^{+2} levels to fall and vasodilation.

IV- Endothelial

4. Endothelins (ETs)

- ETs are 3 types each is a polypeptide (21amino acid)(**3iso-forms**)
- They synthesized and released by endothelial cells in response to many factors, including Ang-II, mechanical trauma, and hypoxia.
- They have two types of receptors ET A (VC)& ET B (VD)in the vascular walls.

- ET-1 is a potent vasoconstrictor that binds to ETA receptors on VSMC membranes
- ET-1 triggers intracellular Ca^{+2} release causing vasoconstriction.

Thank you