



PHYSIOLOGY

FACULTY OF PHARMACEUTICAL SCIENCES

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LECTURE 9-PARTS (1) & (2) : STRUCTURE AND FUNCTION OF BLOOD VESSELS AS WELL AS FACTORS AFFECTING BLOOD FLOW AND BLOOD PRESSURE

Objectives

1. Discuss **structure and function of blood vessels.**
2. Describe **capillary exchange.**
3. Explore **hemodynamics: factors affecting blood flow.**

(Pages 730- 743 of the reference)

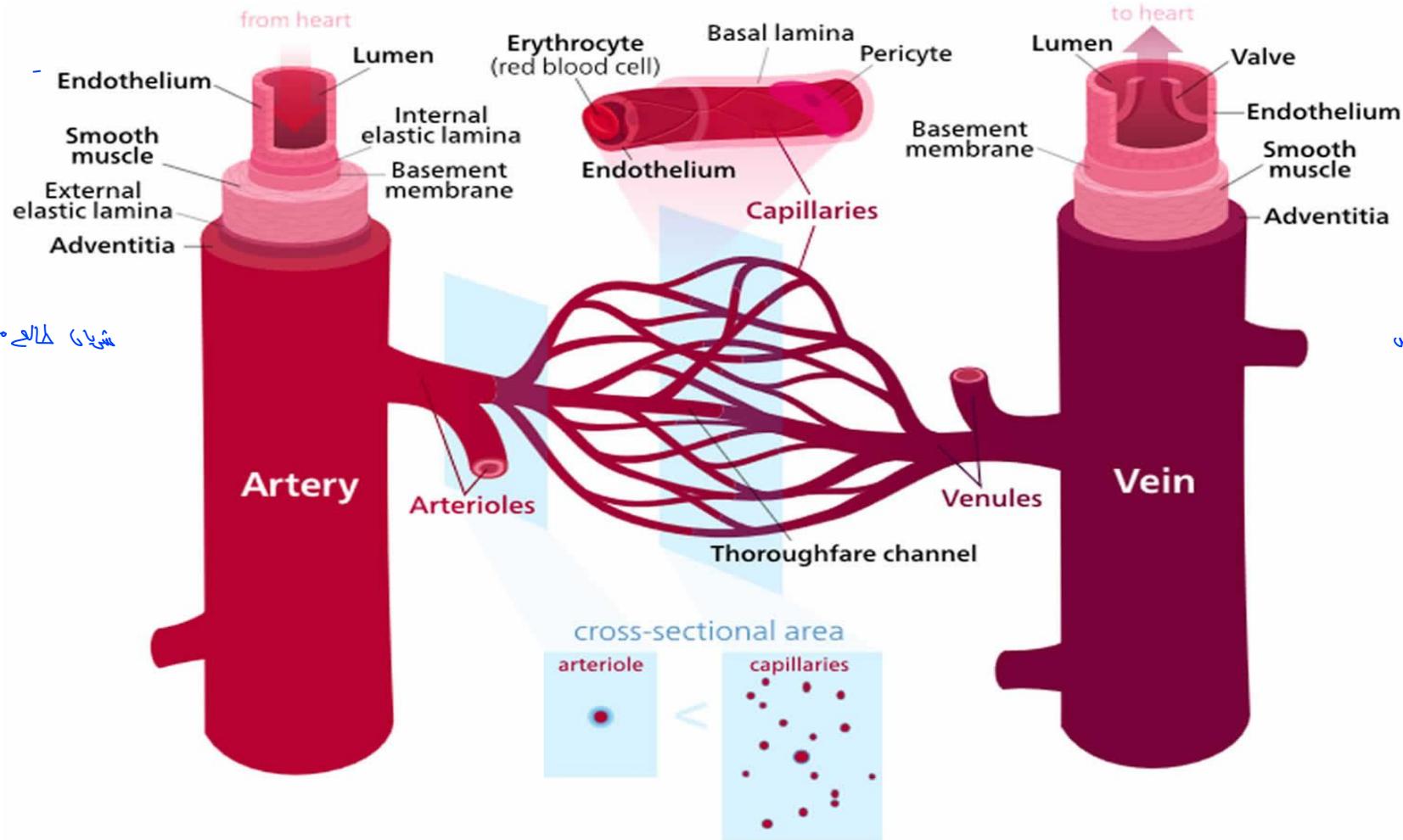
Objectives

4. Discuss **control of blood pressure and blood flow.**

5. Describe **checking circulation.**

6. Explore **shock and homeostasis.**

(Pages 744- 753 of the reference)



شرايين تخرج من القلب

وريد يدخل إلى القلب

STRUCTURE AND FUNCTION OF BLOOD VESSELS

- The five main types of blood vessels are ^{الشرايين} **arteries**, ^{الشُرينات} **arterioles**, ^{الشُعيرات الدموية} **capillaries**, ^{الأوردة الصغيرة} **venules**, and ^{الأوردة الكبيرة} **veins**.
- **Arteries** carry blood away from the heart to other organs. Large, elastic arteries leave the heart and divide into medium-sized, muscular arteries that branch out into the various regions of the body. Medium-sized arteries then divide into small arteries, which in turn divide into still smaller arteries called **arterioles**.
- As the **arterioles enter a tissue**, they **branch into numerous tiny vessels called capillaries**. The thin walls of capillaries allow the exchange of substances between the blood and body tissues. Groups of capillaries within a tissue reunite to form small veins called venules. These in turn merge to form progressively larger blood vessels called veins. Veins are the blood vessels that convey blood from the tissues back to the heart.

* Blood vessels :-

arteries → convey the blood away from heart to other organs in the body.

muscular arteries → medium-sized that branch out into the various region of the body.

arterioles → smaller arteries

capillaries → arterioles enters tissue they branch into tiny vessels called capillaries → thin wall of capillaries allow to exchange the substance between the blood and body tissues.

venules → capillaries within a tissue reunite and form small veins called venules.

veins → merge the venules → convey the blood from organs to the heart.

BASIC STRUCTURE OF A BLOOD VESSEL

The three structural layers of a generalized blood vessel **from innermost to outermost** are the tunica interna (intima), tunica media, and tunica externa (adventitia).

و كَيْفَتُهَا تَحْتَ الدَّمِ لِوَسْطِ بِلَدَتِ وَصَاحِبِ
الْمَكَارِ

TUNICA INTERNA (INTIMA)

3 طبقات
وهي أقل سماكتها بين الطبقات ال 3

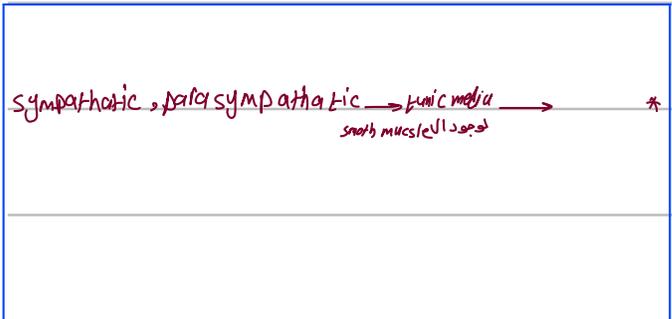
❖ **The tunica interna (intima)** forms the **inner lining of a blood vessel** and is in **direct contact with the blood** as it flows through the **lumen, or interior opening**, of the vessel. Although this layer has multiple parts, these tissue components contribute **minimally to the thickness of the vessel wall.**

رشد

❖ Its **innermost layer is called endothelium**, is a **thin layer of flattened cells** that **lines the inner surface of the entire cardiovascular system** (heart and blood vessels). The **endothelial cells are active participants in a variety of vessel-related activities**, including **physical influences on blood flow, secretion of locally acting chemical mediators** that influence the contractile state of the vessel's **overlying smooth muscle, and assistance with capillary permeability**. In addition, their smooth luminal surface **facilitates efficient blood flow by reducing surface friction.**

تلف الكفة

وظائف ال endothelium :-



1- Frection smooth blood flow, وبالتالي تقلل من الإحكاك

2- تحافظ على ضغط الدم في الأوعية الدموية (Vascular tone) بين بقا ضغط على توازن ال vasoconstriction, vasodilation

3- تفرز ال Vasodilator و ال Vasconstrictor

4- جزيئات ال tunica media

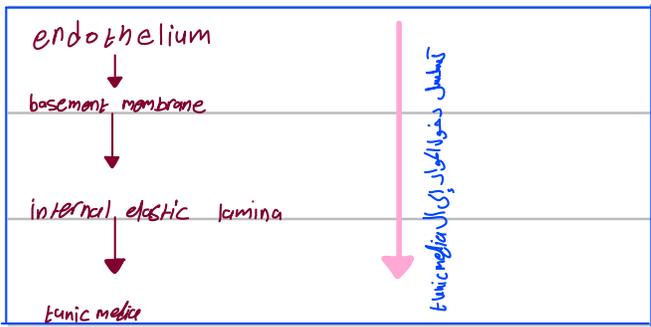
5- تقلل من حدوث ال inflammation (proinflammatory, antiinflammatory)

6- تقلل من حدوث ال coagulation ← التخثر

* يتقل balance او توازن بين الأشياء المتبطة والمضادة ال inflammation

* تقلل على زيادة الصفائح الدموية التي تقاوم توازن بين ال procoagulatory factor و ال anticoagulatory

* ال basement و ال internal elastic lamina ← ال membrane



1- كاسر للجدار إلى ال tunica media

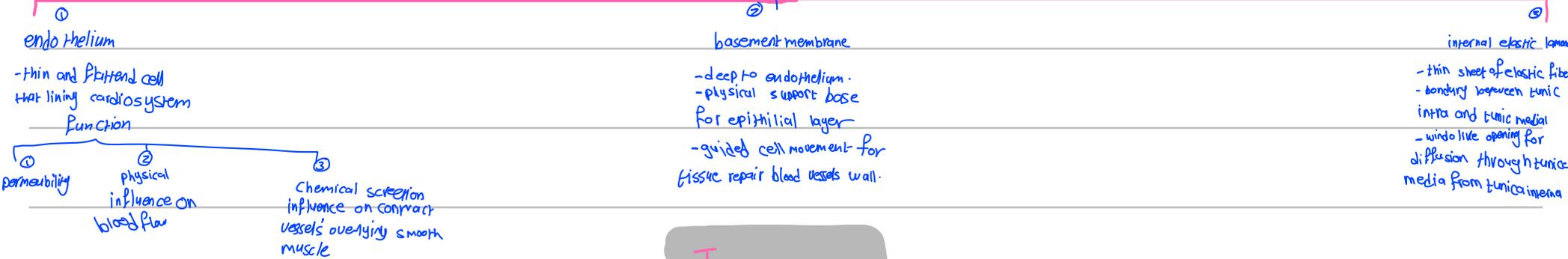
2- support

TUNICA INTERNA (INTIMA)

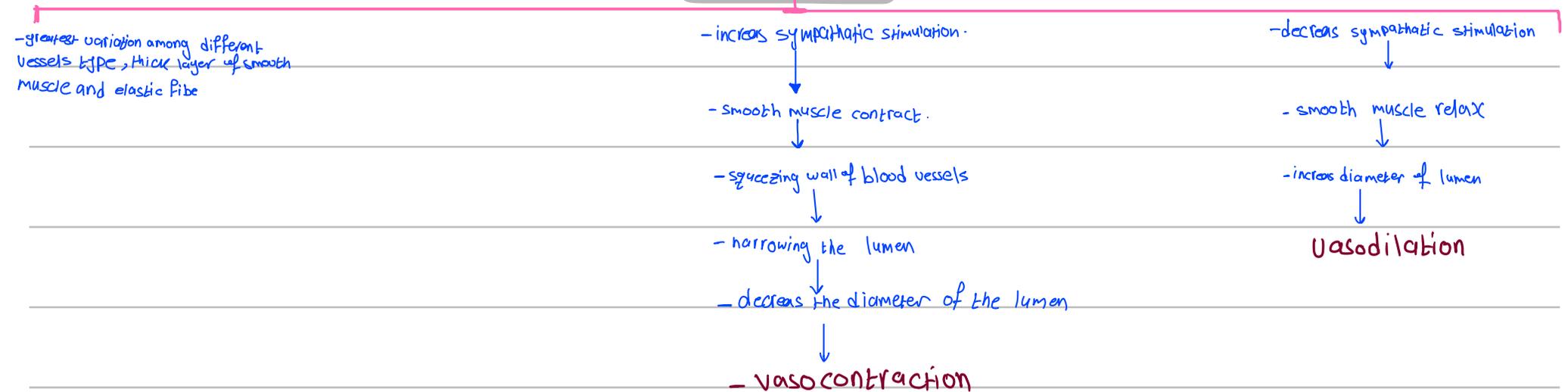
- ❖ The **second component** of the tunica interna is a **basement membrane** deep to the endothelium. It provides a **physical support** base for the **epithelial layer**. It appears to play an important role in **guiding cell movements during tissue repair of blood vessel walls**.
Physical support
repair tissue
- ❖ The **outermost part of the tunica interna**, which **forms the boundary** between the **tunica interna** and **tunica media**, is the **internal elastic lamina**, is a **thin sheet of elastic fibers** with a **variable number of windowlike openings** that facilitate diffusion of materials through the **tunica interna** to the **thicker tunica media**.
الطبقة بين ال Tunica interna و Tunica media حال
Physical support

Tunica interna → intima, inner lining of blood vessels, direct contact with blood that flows through lumen (inner opening of blood vessels), contribute minimally of thickness of wall.

Tunica interna



Tunica media



Tunica externa

- outer surface
of blood vessels

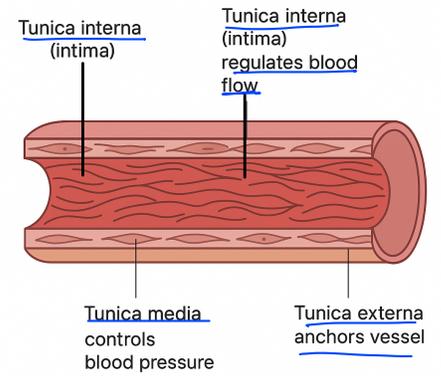
- consists elastic, collagen fibers

- supply the vessels with

with nerves and self-vessel

- help anchor vessels

to surrounding the tissue





← بتغير شكلها حسب نوع الوعاء الدموي

- ✓ Is the tissue layer that displays the **greatest variation among the different vessel types**. In most vessels, it is a relatively **thick layer** comprising **mainly smooth muscle** cells and **substantial amounts of elastic fibers**.
- ✓ An **increase in sympathetic stimulation** typically stimulates the **smooth muscle to contract**, squeezing the vessel wall and narrowing the lumen. Such a **decrease in the diameter of the lumen of a blood vessel** is called **vasoconstriction**.
- ✓ In **contrast**, when **sympathetic stimulation decreases**, **smooth muscle fibers relax**. The resulting **increase in lumen diameter** is called **vasodilation**.

fibers ← TUNICA EXTERNA → external elastic lamina
حاجة درسم

The outer covering of a blood vessel, the tunica externa, consists of elastic and collagen fibers.

In addition to the important role of supplying the vessel wall with nerves and self-vessels, the tunica externa helps anchor the vessels to surrounding tissues.

Lunica interna,

* وحيث ان thickness لهاي الطبقات يختلف حسب نوع ال blood vessels لكن ingeneral يتكلم

Al capillaries :- عندها فقط الطبقة الأخرى ما عندها ال smooth muscle الطبقة الثانية

① الطبقة الأخرى thinnest من الثانية .

② الثانية والثالثة حسب نوع ال blood vessels .

* حجم نوافذ هاي الطبقات كلما بدت عن القلب ال thickness ببعدها رجع -تختلف .

ARTERIES

تھرت
Their walls stretch easily or expand without tearing in response to a small increase in pressure (due to their plentiful elastic fibers).

کا حوازی

The wall of an artery has the **three layers of a typical blood vessel**.



الشرايين المرنة ELASTIC ARTERIES

- **The largest arteries in the body.**
- **TUNICA INTERNA**: Well-defined internal elastic lamina. تحتوي على غشاء مرني داخلي واضح
- **TUNICA MEDIA**: Thick and dominated by **elastic fibers**; well-defined external elastic lamina.
- **TUNICA EXTERNA**: **Thinner** than tunica media.
- **Function**: **Conduct blood from heart to muscular arteries.**

بال elastic arteries ال Tunica externa ال Tunica media ال

MUSCULAR ARTERIES

- **The Medium-sized arteries.**
- **TUNICA INTERNA:** Well-defined internal elastic lamina.
- **TUNICA MEDIA:** Thick and dominated by smooth muscle; thin external elastic lamina.
- **TUNICA EXTERNA:** Thicker than tunica media.
- **Function: Distribute blood to arterioles.**

ARTERIOLES

- **Microscopic (15–300 micrometer in diameter).**
- **TUNICA INTERNA:** Thin with a fenestrated internal elastic lamina that disappears distally.
- **TUNICA MEDIA:** One or two layers of circularly oriented smooth muscle; distalmost smooth muscle cell forms a precapillary sphincter.
- **TUNICA EXTERNA:** Loose collagenous connective tissue and sympathetic nerves.
- **Function:** Deliver blood to capillaries and help regulate blood flow from arteries to capillaries.

True or False — Ultra-Precise Version

1. The tunica interna contributes minimally to the overall thickness of the vessel wall.
2. Endothelial cells help regulate the contractile state of smooth muscle in the tunica media.
3. The smooth luminal surface of the tunica externa reduces friction for blood flow.
4. Arteries can stretch easily without tearing because their tunica interna contains abundant elastic fibers.
5. Elastic arteries have a well-defined internal elastic lamina and a tunica media dominated by elastic fibers.
6. In elastic arteries, the tunica externa is thicker than the tunica media.
7. Muscular arteries have a tunica media dominated by smooth muscle rather than elastic fibers.
8. The external elastic lamina of muscular arteries is thin compared to that of elastic arteries.
9. The tunica externa of muscular arteries is thicker than their tunica media.
10. Arterioles contain a fenestrated internal elastic lamina that becomes more prominent distally.
11. Most arterioles have only one or two layers of circularly arranged smooth muscle in the tunica media.

12. The precapillary sphincter is formed by the last smooth muscle cell of an arteriole.
13. Arterioles deliver blood to capillaries and help regulate blood flow from veins to capillaries.
14. The tunica externa of arterioles consists mainly of loose collagenous connective tissue and sympathetic nerves.
15. Elastic arteries function primarily to distribute blood to arterioles.
16. Muscular arteries are responsible for distributing blood to arterioles.
17. Arterioles have a diameter ranging between 15 and 300 micrometers.
18. The internal elastic lamina is well-defined in both elastic and muscular arteries.
19. Capillaries are formed directly from the branching of elastic arteries.
20. Venules are formed by the reunion of capillary networks within tissues.

*الأجوبة

1. True
2. True
3. False - tunica interna (endothelium)
4. False - elastic fibers are in tunica media
5. True
6. True - tunica externa is thicker
7. True
8. True
9. True
10. False - fenestrated lamina is in tunica interna
11. True
12. True
13. True - precapillary sphincter is at the junction of the last smooth muscle cell of an arteriole
14. True
15. True - elastic arteries are primarily for distribution
16. True - muscular arteries are for distribution
17. True - diameter is 15-300 micrometers
18. True - internal elastic lamina is well-defined in both
19. True - capillaries are formed from the branching of elastic arteries
20. True - venules are formed by the reunion of capillary networks

5-10 micrometer

CAPILLARIES

- **Microscopic, smallest blood vessels (5–10 micrometer in diameter).**
- **TUNICA INTERNA:** Endothelium and basement membrane.
- **TUNICA MEDIA:** None.
- **TUNICA EXTERNA:** None.
- **Function: Permit exchange of nutrients and wastes between blood and interstitial fluid; distribute blood to postcapillary venules.**

10-50 micrometer

POSTCAPILLARY VENULES

→ white blood cell emigration

- **Microscopic (10–50 micrometer in diameter).**
- **TUNICA INTERNA:** Endothelium and basement membrane.
- **TUNICA MEDIA:** None.
- **TUNICA EXTERNA:** Sparse.
- **Function:** **Pass blood into muscular venules; permit exchange of nutrients and wastes between blood and interstitial fluid and function in white blood cell emigration.**

تمرير الدم إلى الأوردة العضلية (muscular venules)، والسماح بتبادل المغذيات والفضلات بين الدم والسائل خارج الخلوي، والمساهمة في هجرة خلايا الدم البيضاء.

MUSCULAR VENULES

- **Microscopic (50–200 micrometer in diameter).**
- **TUNICA INTERNA:** Endothelium and basement membrane.
- **TUNICA MEDIA:** One or two layers of circularly oriented smooth muscle.
- **TUNICA EXTERNA:** Sparse.
- **Function:** Pass blood into vein; act as reservoirs for accumulating large volumes of blood (along with postcapillary venules).

VEINS

- **Range from 0.5 mm to 3 cm in diameter.**
- **TUNICA INTERNA:** Endothelium and basement membrane; no internal elastic lamina; contain valves; lumen much larger than in accompanying artery.
- **TUNICA MEDIA:** Much thinner than in arteries; no external elastic lamina.
- **TUNICA EXTERNA:** Thickest of the three layers.
- **Function: Return blood to heart,** facilitated by valves in limb veins.

CAPILLARY EXCHANGE

- Is the movement of substances between blood and interstitial fluid.
- Substances enter and leave capillaries by **three basic mechanisms: diffusion, transcytosis, and bulk flow.**

DIFFUSION

- The most important method of capillary exchange is simple diffusion.
- Because O_2 and nutrients normally are present in higher concentrations in blood, they diffuse down their concentration gradients into interstitial fluid and then into body cells. CO_2 and other wastes released by body cells are present in higher concentrations in interstitial fluid, so they diffuse into blood.

TRANSCYTOSIS

- A **small quantity** of material crosses capillary walls by **transcytosis**.
- In this process, substances in blood plasma become **enclosed within tiny pinocytic vesicles** that first enter endothelial cells by endocytosis, then move across the cell and exit on the other side by exocytosis.

* يعني لما الجزيء A بدو يتنقل يتم حارطته بحويصلات دقيقة ← Endocytosis
بدها يتنقل إلى الجهة الأخرى ويتم إطلاقه عن طريق الـ Exocytosis

BULK FLOW: FILTRATION AND REABSORPTION

- Bulk flow is a passive process in which large numbers of ions, molecules, or particles in a fluid move together in the same direction.
- Bulk flow occurs from an area of higher pressure to an area of lower pressure, and it continues as long as a pressure difference exists.
- ^{دھیر} Diffusion is more important for solute exchange between blood and interstitial fluid, but bulk flow is more important for regulation of the relative volumes of blood and interstitial fluid.
- Pressure-driven movement of fluid and solutes from blood capillaries into interstitial fluid is called **filtration**. Pressure-driven movement from interstitial fluid into blood capillaries is called **reabsorption**.

فیلٹریشن اور ری ابلورپشن

HEMODYNAMICS: FACTORS AFFECTING BLOOD FLOW

- **Blood flow** is the volume of blood that flows through any tissue in a given time period (in mL/min). **Total blood flow is cardiac output (CO)**, the volume of blood that circulates through systemic (or pulmonary) blood vessels each minute.
- How the cardiac output becomes distributed into circulatory routes that serve various body tissues depends on **two more factors**:
- **(1) the pressure difference that drives the blood flow through a tissue.**
- **(2) the resistance to blood flow in specific blood vessels.**
- Blood flows from regions of **higher pressure** to regions of **lower pressure**; **the greater the pressure difference, the greater the blood flow.** **But the higher the resistance, the smaller the blood flow.**

$\uparrow \Delta P \rightarrow \uparrow \text{B. flow}$

$\uparrow R \rightarrow \downarrow \text{B. flow}$

①

Blood flow: - volume of blood that flow through in any tissue in a given

time period. ml/min

- Blood flows from high pressure to small pressure.
- greater pressure difference \longrightarrow greater blood flow.
- greater resistances \longrightarrow smaller blood flow

②

Total blood flow is cardiac output (CO)

③

Cardiac output: - volume of blood that circulates in systemic or (pulmonary) vessels each minute

تنتقل الدم: القوة المتولدة على جدران الأوعية الدموية بشكل عمودي على جدران الأوعية الدموية

BLOOD PRESSURE



Contraction of the ventricles generates blood pressure (BP), the hydrostatic pressure exerted by blood on the walls of a blood vessel.

← يمارس الدم على جدران الأوعية الدموية

BP is determined by cardiac output, blood volume, and vascular resistance.

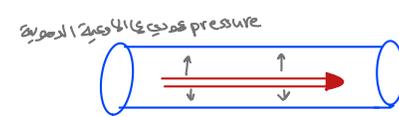
BP is highest in the aorta and large systemic arteries; in a resting, young adult, BP rises to about 110 mmHg during systole (ventricular contraction) and drops to about 70 mmHg during diastole (ventricular relaxation).

Mean arterial pressure (MAP), the average blood pressure in arteries, is roughly one-third of the way between the diastolic and systolic pressures. It can be estimated as follows:

الوسيلة الحسابي للدم المتحرك بالأوعية

MAP = diastolic BP + $\frac{1}{3}$ (systolic BP - diastolic BP)

puls. B.P
↑
puls. pressure } HR



pressure exerted by the blood on the vessel wall

BLOOD PRESSURE

عدد ضربات القلب * حجم الضربة

- We have already seen that **cardiac output equals heart rate multiplied by stroke volume**. Another way to calculate cardiac output is to **divide** mean arterial pressure (MAP) by **resistance (R): $CO = MAP/R$** . By rearranging the terms of this equation, you can see that **$MAP = CO * R$** .
- Blood pressure also depends on the **total volume of blood** in the cardiovascular system. **The normal volume of blood in an adult is about 5 liters**. Any decrease in this volume, as from **hemorrhage**, **decreases the amount of blood that is circulated through the arteries each minute**.
- A **modest decrease** can be **compensated** for by **homeostatic mechanisms** that help maintain blood pressure, but if the **decrease in blood volume is greater than 10%** of the total, blood pressure **drops**. **Conversely, anything that increases blood volume, such as water retention in the body, tends to increase blood pressure.**

$$CO = \frac{MAP}{R}$$

cardiac output

الذئبة

توضيح

* Cardiac output: → احتساب اللد
* حجم الدم الذي يبطلو في الأوعية الدموية

كل ما زاد حجم الدم زاد ضغط الدم

* كلما زادت ال resistance قل ال blood flow

VASCULAR RESISTANCE

Resistance

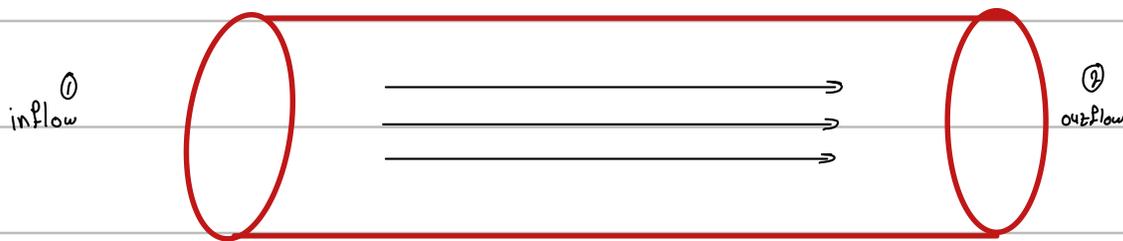
- Vascular resistance is the opposition to blood flow due to friction between blood and the walls of blood vessels.
- Vascular resistance depends on (1) ^{radius} size of the blood vessel lumen, (2) ^{عكسية} blood viscosity, and (3) total blood vessel length.

لزوجة الدم
جهازلات لزوجة الدم زادت
الكفاءة

الوعاء الدموي الاطول مقاومته اكث
كلما زاد طول الوعاء الدموي كلما زادت المقاومة لتدفق الدم

قلبي الوعاء الدموي كلما كان القطر الصغير زادت المقاومة

$$\text{Bloodflow} = \Delta P$$



الدم كيف يتحرك من المنطقة الأكثر ضغطاً إلى الأقل ضغطاً

Flow, pressure, Resistance

* كلما زاد ال radius زادت ال Resistance ، $R \propto \frac{1}{r}$ ، $\text{Flow} \propto r$

$$\boxed{\text{Flow} = \frac{\Delta P}{R}}$$

* كلما زاد طول الوعاء الدموي زادت ال Resistance ، $R \propto L$ ، $\text{Flow} \propto \frac{1}{L}$

* كلما زادت لزوجة الدم زادت ال Resistance ، $R \propto \nu$ ، $\text{Flow} \propto \frac{1}{\nu}$

الأمعية الدموية تصف وتوسع إحدى تملك خاصية ال *elasticity* ← وهذا الطبيعي بالنسبة للأوعية الدموية وبني الطبيعي أن الأوعية الدموية تكون ملتصقة نتيجة تآكل الدهون على جدرانها، كما يوجد عندهم نوع تسمى الترابي

SIZE OF THE LUMEN

- The smaller the lumen of a blood vessel, the greater its resistance to blood flow.
- Resistance is inversely proportional to the fourth power of the diameter (d) of the blood vessel's lumen.

$$R \propto \frac{1}{r^4}$$

BLOOD VISCOSITY

- The viscosity of blood depends mostly on the ratio of red blood cells to plasma (fluid) volume, and to a smaller extent on the concentration of proteins in plasma.
- The higher the blood's viscosity, the higher the resistance.
- Any condition that increases the viscosity of blood, such as dehydration or polycythemia (an unusually high number of red blood cells), thus increases blood pressure.
- A depletion of plasma proteins or red blood cells, due to anemia or hemorrhage, decreases viscosity and thus decreases blood pressure.

نقصان

نقص في

نقص في

SYSTEMIC VASCULAR RESISTANCE (SVR)

- **Resistance** to blood flow through a vessel is directly **proportional** to the **length** of the **blood vessel**.
- The longer a blood vessel, the greater the resistance.
- **Systemic vascular resistance (SVR)**, also known as **total peripheral resistance (TPR)**, refers to all of the vascular resistances offered by systemic blood vessels.
- The diameters of arteries and veins are large, so their resistance is very small because most of the blood does not come into physical contact with the walls of the blood vessel. The smallest vessels—**(arterioles) capillaries, and venules**—contribute the most resistance.

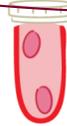
المقاومة الكلية الموجودة بالأوعية

أصغر الأوعية التي يتصل بها
هذه عندي ال (TPR)

Determinants of Resistance:

*

Blood Viscosity (η) \propto Resistance

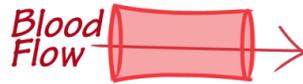


↓ Resistance



↑ Resistance

Vessel Length (l) \propto Resistance



↓ Resistance



↑ Resistance

Vessel Radius (r) \propto Resistance



↓ Resistance



↑ Resistance

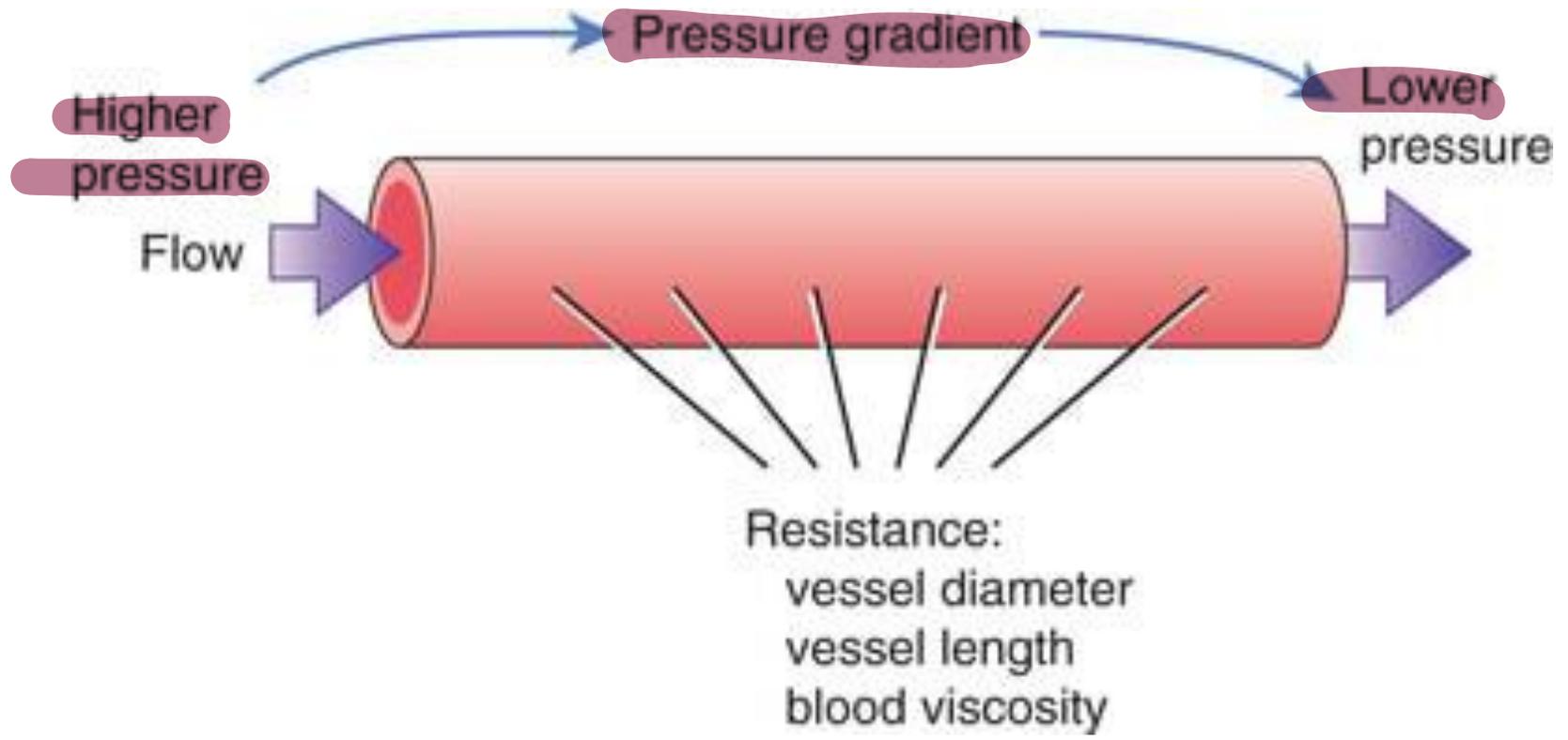
* كلما كان فوق المنطق اجبي ده يكون ال cardiac output
بتجأ أعلى .

Factors Affecting Blood Flow

Pressure and resistance both affect blood flow to tissues, but they have opposing effects.

Blood flow and pressure are directly related: when pressure increases, flow increases.

Blood flow and resistance are inversely related: when resistance increases, flow decreases.



← سرعة

VELOCITY OF BLOOD FLOW

* سرعة الدم (blood velocity) يكون أقل إذا كانت cross sectional area أكبر ← علاقة عكسية

- Earlier we saw that blood flow is the volume of blood that flows through any tissue in a given time period (in mL/min).
- The **speed or velocity of blood flow** (in **cm/sec**) is **inversely related to the cross-sectional area**.
- **Velocity is slowest where the total cross-sectional area is greatest.**
- Each time an **artery branches**, the **total cross-sectional area of all of its branches is greater than the cross-sectional area of the original vessel**, **so blood flow becomes slower and slower as blood moves further away from the heart, and is slowest in the capillaries.**

2) ليش السرعة لها علاقة
بالمساحة المقطعية؟

العلاقة عكسية تماماً:

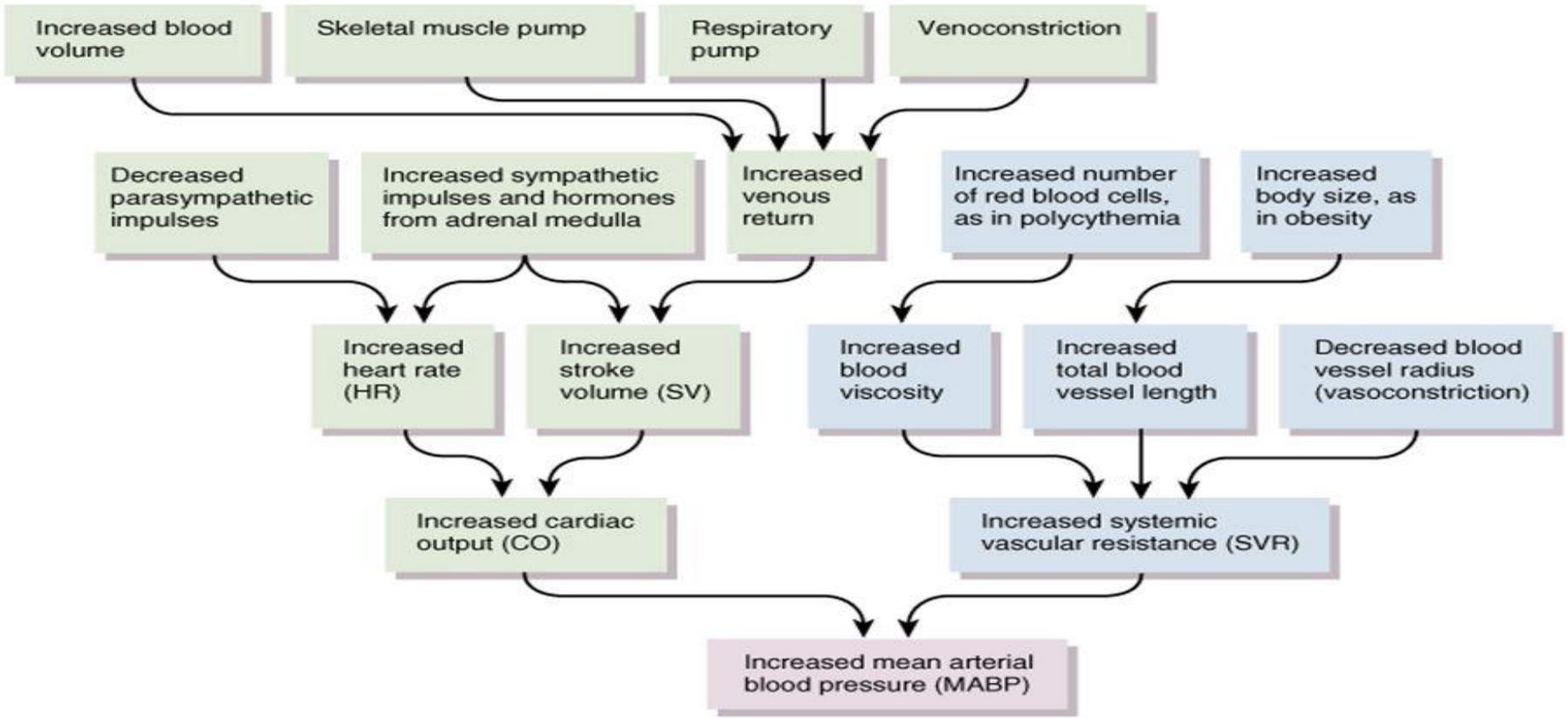
• مساحة مقطعية كبيرة → سرعة أقل

• مساحة مقطعية صغيرة → سرعة أعلى

كلما تفرع الشريان، تكون المساحة
المقطعية المجمعة لفرعه أكبر من
مساحة الشريان الأصلي، وبالتالي سرعة
الدم تصبح أبطأ وأبطأ كلما ابتعد عن
القلب، وتكون الأبطأ في الشعيرات الدموية

Savelk

Factors that Increase Blood Pressure



Physiological factors affecting blood pressure

Factor	Effect on blood pressure
The pumping action of the heart	The greater the cardiac output, the higher the arterial pressure
The blood volume	The greater the blood volume, the higher the arterial pressure
The viscosity of the blood	The more viscous the blood, the higher the arterial pressure
The condition of the blood vessels (resistance)	The greater the resistance, the higher the arterial pressure

CONTROL OF BLOOD PRESSURE AND BLOOD FLOW

- Several interconnected negative feedback systems control blood pressure by adjusting heart rate, stroke volume, systemic vascular resistance, and blood volume.
- Some systems allow rapid adjustments to cope with sudden changes, such as the drop in blood pressure in the brain that occurs when you get out of bed; others act more slowly to provide long-term regulation of blood pressure.



تنظيم معدل الدم لضغط الدم

CONTROL OF BLOOD PRESSURE AND BLOOD FLOW

❑ Role of the Cardiovascular Center in the (medulla oblongata):

- ❖ 1- helps regulate heart rate and stroke volume.
- ❖ 2- controls neural, hormonal, and local negative feedback systems that regulate blood pressure and blood flow to specific tissues.

مركز التحكم بالجهاز الدوري

❖ Groups of neurons scattered within the CV center:

- ❖ Some neurons stimulate the heart (cardiostimulatory center); others inhibit the heart (cardioinhibitory center).
- ❖ Still others control blood vessel diameter by causing constriction (vasoconstrictor center) or dilation (vasodilator center).

cardiovascular

cardiovascular

↪ ↑ BP

↪ ↓ BP

1. ROLE OF THE CARDIOVASCULAR CENTER

- ❖ The **cardiovascular center** receives **input** both **from higher brain regions and from sensory receptors**. Nerve impulses descend from **the cerebral cortex, limbic system, and hypothalamus** to affect the cardiovascular center.
- ❖ The **three main types** of sensory receptors that provide input to the cardiovascular center are **proprioceptors, baroreceptors, and chemoreceptors**.
- ❖ **Proprioceptors** monitor movements of **joints** and **muscles** and provide input to the cardiovascular center during physical activity. ** تعطي معلومات عن الحركة العضلية الهيكلية*
- ❖ **Baroreceptors** monitor changes in pressure and stretch in the walls of blood vessels.
- ❖ **Chemoreceptors** monitor the concentration of various chemicals in the blood.

CV Center

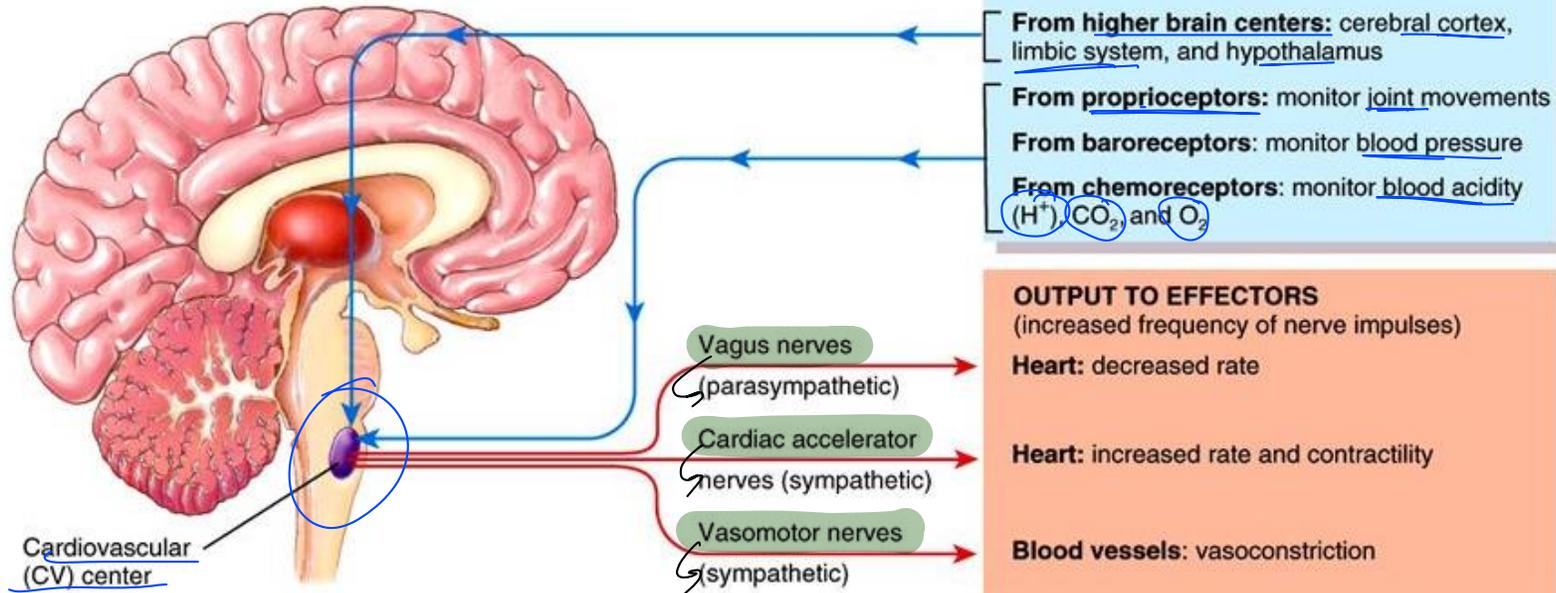


Figure 21.12 Tortora - PAP 12/e
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ROLE OF THE CARDIOVASCULAR CENTER

- ❖ **Output** from the cardiovascular center flows along **sympathetic and parasympathetic neurons of the ANS.**
- ✓ **Sympathetic impulses reach the heart via the cardiac accelerator nerves. An increase in sympathetic stimulation increases heart rate and contractility.**
- ✓ **Parasympathetic stimulation, conveyed along the (vagus (X) nerves), decreases heart rate.**

الخاصة	Sympathetic (الودي)	Parasympathetic (اللاودي)
العصب/الأعصاب المستخدمة	Cardiac accelerator nerves	Vagus nerve (X)
الأثر على معدل ضربات القلب (HR)	يزيد (HR ↑)	يقلل (HR ↓)
الأثر على قوة الانقباض (Contractility)	يزيد القوة (↑ Contractility)	لا يؤثر
يشغل في أي حالات؟	النشاط، الخوف، التوتر، انخفاض الضغط، التعاريف	الراحة، النوم، الهضم، الهدوء
الناقل العصبي	Norepinephrine	Acetylcholine
النتيجة العامة	تجفير القلب وتسريعه	تهديئة القلب وإبطائه

ROLE OF THE CARDIOVASCULAR CENTER

- ❖ The cardiovascular center also continually sends impulses to smooth muscle in blood vessel walls via vasomotor nerves.
- ✓ Impulses propagate along sympathetic neurons that innervate blood vessels in viscera and peripheral areas.
- ✓ The result is a (moderate state) of tonic contraction or vasoconstriction, called vasomotor tone, that sets the resting level of systemic vascular resistance. Sympathetic stimulation of most veins causes constriction that moves blood out of venous blood reservoirs and increases blood pressure.

تحتوي

في الأوعية الدموية والناتجة من الجهاز الهضمي

التقلص المستمر

مخازن الدم الوريدية

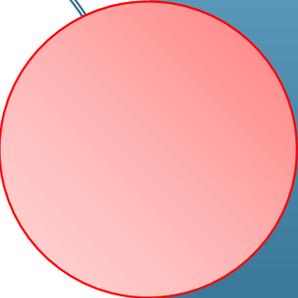
2. NEURAL REGULATION OF BLOOD PRESSURE

The nervous system regulates blood pressure via negative feedback loops that occur as two types of reflexes: baroreceptor reflexes and chemoreceptor reflexes.

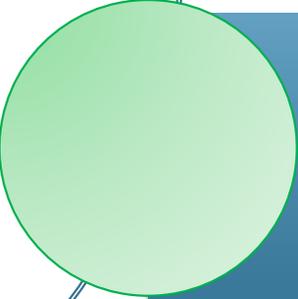
→ monitor change in pressure and stretch of blood vessels wall.

→ monitor change in concentration of various chemical in a blood

BARORECEPTOR REFLEXES

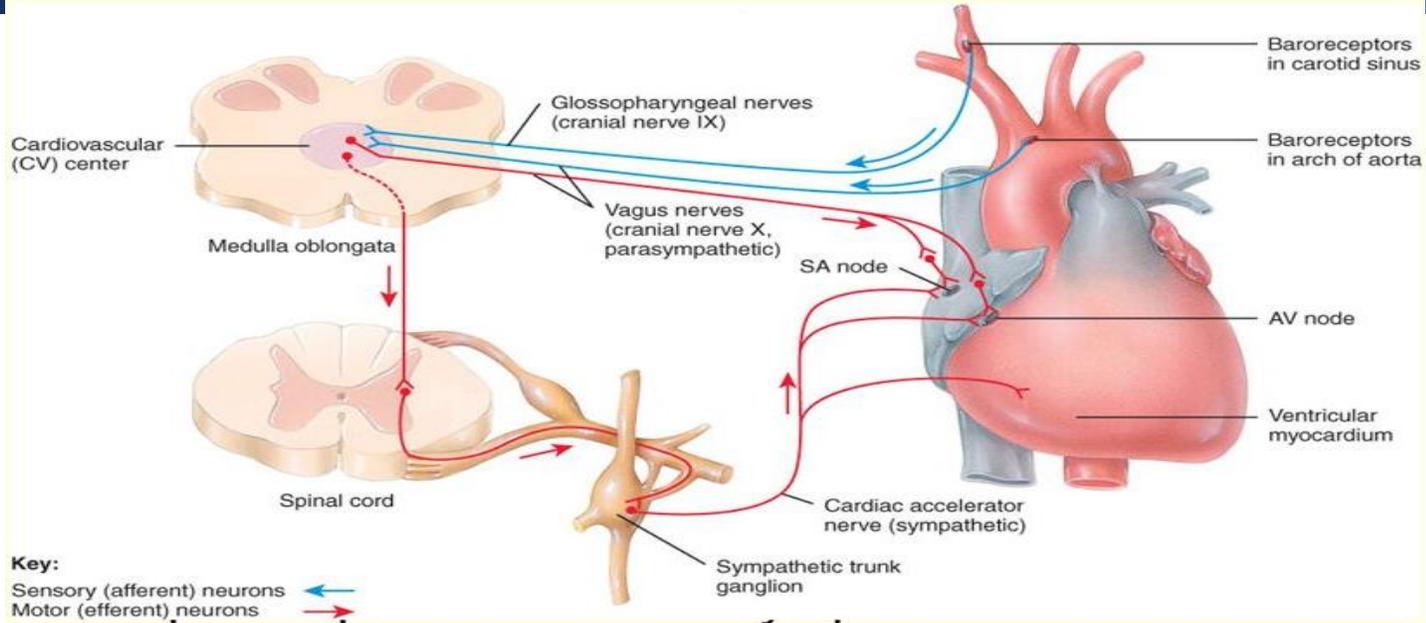


Baroreceptors are **pressure-sensitive sensory receptors**. They are located in the **aorta, internal carotid arteries** (arteries in the **neck** that **supply blood to the brain**), and other large arteries in the neck and chest.

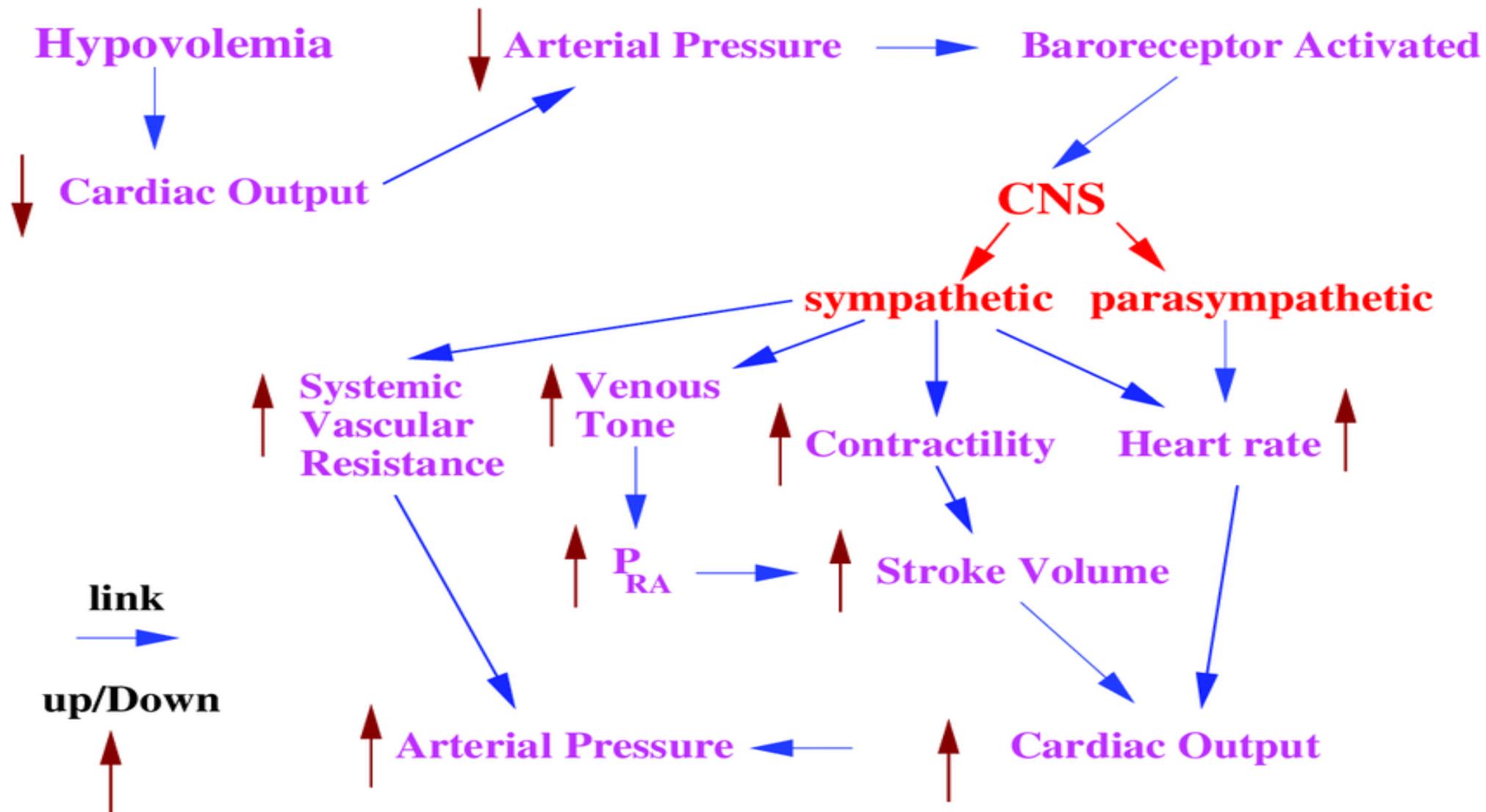


They send impulses to the **cardiovascular center** to help **regulate blood pressure**.

Innervation of the Heart



- Slow it down with parasympathetic stimulation (X)¹⁰
- Sensory information from baroreceptors (IX)⁹

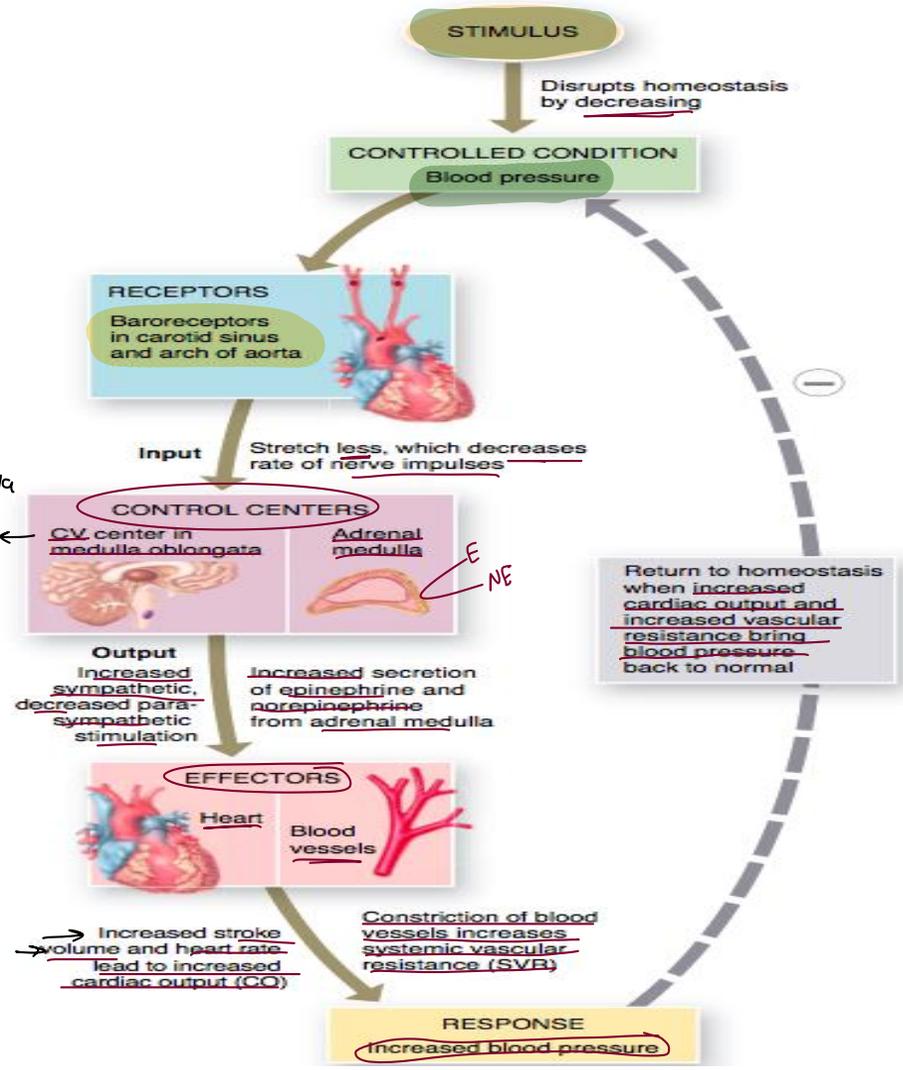


BARORECEPTOR REFLEXES

- Baroreceptors are pressure-sensitive neurons that monitor stretching.
- When blood pressure falls, the baroreceptors are stretched less, and they send nerve impulses at a slower rate to the cardiovascular center. In response, the CV center decreases parasympathetic stimulation of the heart by way of motor axons of the vagus nerves and increases sympathetic stimulation of the heart via cardiac accelerator nerves.
- Moving from a prone (lying down) to an erect position decreases blood pressure and blood flow in the head and upper part of the body. The baroreceptor reflexes, however, quickly counteract the drop in pressure. Sometimes these reflexes operate more slowly than normal, especially in the elderly.

CU center
↑ sympathetic
↓ para sympathetic

Adrenal medulla
↑ E, NE



Return to homeostasis when increased cardiac output and increased vascular resistance bring blood pressure back to normal

RESPONSE Increased blood pressure

2. إفراز الكاتيكولامينات (Catecholamine Release)

- المصدر: لب الغدة الكظرية (Adrenal Medulla) والنهايات العصبية الودية.
- الهرمونات: أدرينالين (Epinephrine) ونورأدرينالين (Norepinephrine).
- التأثيرات:
 - تحفيز القلب (Cardiac Stimulation) ← زيادة معدل وقوة ضربات القلب.
 - تضييق الأوعية الدموية (Vasoconstriction) في الجلد والأعضاء.
 - زيادة النتاج القلبي والمقاومة الوعائية لرفع الضغط.

3. إفراز الألدوستيرون (Aldosterone Release)

- المصدر: لبخا الغدة الكظرية.
- التأثيرات:
 - زيادة احتباس الماء في الكلى ← تقليل الخلية ← زيادة حجم الدم.
 - تضييق الأوعية الدموية (Vasoconstriction) ← زيادة مقاومة الأوعية الدموية.

4. تضيق الأوعية الدموية (Vasoconstriction)

- المحرك: الأنجوتنسين II الكاتيكولامين والألدوستيرون.
- التأثير: زيادة المقاومة الوعائية العنبرية (SVR) لرفع ضغط الدم.

5. زيادة حجم الدم (Increased Volume)

- من احتباس الماء والصوديوم بواسطة الألدوستيرون والأنجوتنسين II.

6. تحفيز القلب (Cardiac Stimulation)

- يرتبط تحفيز القلب بزيادة معدل الضربات وبقوة الضربات.

ICD ©

1. تفعيل نظام الرينين-أنجوتنسين-الدوستيرون (RAAS Activation)

الخطوات:

- انخفاض ضغط الدم → تقل التربة الكلية.
- تفرز الكلى الرينين (Renin).
- الرينين يحول أنجوتنسينوجين إلى أنجوتنسين I.
- إنزيم محول لأنجوتنسين (ACE) يحوله إلى أنجوتنسين II.
- تأثيراته:
 - تضييق الأوعية الدموية (Vasoconstriction).
 - تحفيز إفراز الألدوستيرون (Aldosterone) من الغدة الكظرية ← يحتفظ بالصوديوم والماء في الكلى ← زيادة حجم الدم.

إفراز الكاتيكولامينات → Catecholamine Release

- الكاتيكولامينات هي هرمونات تفرزها الغدة الكظرية (Adrenal Medulla) أو الأعصاب الودية (Sympathetic nerves).
- أهمها: أدرينالين (Epinephrine) ونورأدرينالين (Norepinephrine) ودوبامين (Dopamine).

شرح مبسط لكيفية عملها:

- عند تغير الكاتيكولامينات؟
 - تزيد انخفاض ضغط الدم أو نقص الدم في الجسم.
 - تزيد التوتر العضلي أو النشاط البدني المتكثف.
 - يشكل توتر عند الحاجة لزيادة قوة الجسم على المقاومة أو الحركة (Fight or flight response).
- كيف تعمل؟
 - الكاتيكولامينات تتركز على القلب والأوعية الدموية لتأثير:
 - زيادة معدل ضربات القلب (↑ Heart Rate) → يزيد حجم الدم.
 - زيادة قوة انقباض القلب (↑ Contractility) → يزيد حجم النخ.
 - انقباض الأوعية الدموية في بعض المناطق → يرفع ضغط الدم.
 - توسع الأوعية الدموية في العضلات الهيكلية → يحسن تدفق الدم للعضلات.
 - تحفيز تحرير الجلوكوز من الكبد → يعطي طاقة سريعة.

Blood Loss

1 RAAS Activation

2 Catecholamine Release

3 Vasopressin Release

Vasoconstriction Increased Volume Cardiac Stimulation

مخطط RAAS Activation (بسيط)

- انخفاض ضغط الدم أو حجم الدم
- الكلى تفرز الرينين
- تحويل أنجوتنسينوجين (من الكبد) → أنجوتنسين I (بواسطة ACE في الرينين)
- تحويل أنجوتنسين I → أنجوتنسين II

- انقباض الأوعية الدموية → ↑ ضغط الدم مباشرة
- تحفيز إفراز الألدوستيرون من الغدة الكظرية
- احتباس الصوديوم والماء في الكلى → ↑ حجم الدم → ↑ ضغط الدم

نقطة مهمة للحفظ:

- أداة الجسم لرفع ضغط الدم وحجم الدم عند الحاجة = RAAS
- زيادة نشاطه المستمر → ارتفاع ضغط الدم → إجهاد القلب

CHEMORECEPTOR REFLEXES

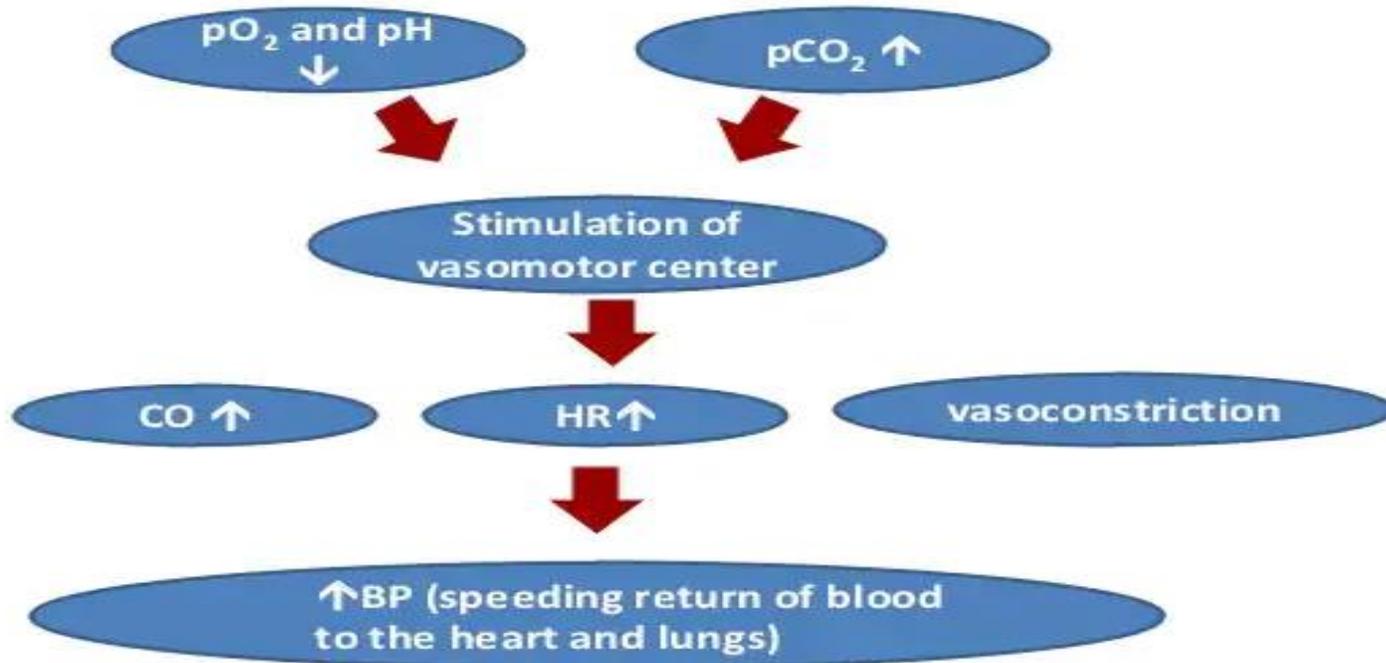
- **Chemoreceptors**, sensory receptors that **monitor the chemical composition of blood**, are **located close to the baroreceptors** of the **carotid sinus** and **arch of the aorta** in **small structures called carotid bodies and aortic bodies**, respectively.

- These chemoreceptors **detect changes in blood level of O₂, CO₂, and H⁺**. **Hypoxia** (lowered O₂ ^{توافرها} availability), **acidosis** (an increase in H⁺ concentration), or **hypercapnia** (excess CO₂) stimulates the chemoreceptors to send impulses to the cardiovascular center. In response, the CV center **increases sympathetic stimulation to arterioles and veins**, producing **vasoconstriction** and an **increase in blood pressure**. These chemoreceptors also **provide input to the respiratory center in the brain stem to adjust the rate of breathing**.

كما توفر هذه المستقبلات الكيميائية معلومات أيضًا إلى مركز التنفس في جذع الدماغ لضبط معدل التنفس.

Chemoreceptor

- Chemosensitive cells that respond to changes in $p\text{CO}_2$ and $p\text{O}_2$ and pH levels (Hydrogen ion).



3- HORMONAL REGULATION OF BLOOD PRESSURE

1- Renin-angiotensin-aldosterone (RAA) system:

- When blood volume falls or blood flow to the kidneys decreases, **juxtaglomerular cells in the kidneys secrete renin into the bloodstream.** جسمي الدم →
- In sequence, renin and angiotensin-converting enzyme (ACE) act on their ^{المواد الأولية} substrates to produce the active hormone angiotensin II, which **raises blood pressure in two ways.**
- **First**, angiotensin II is a potent vasoconstrictor; it **raises** blood pressure by **increasing** systemic vascular resistance.
- **Second**, it stimulates secretion of **aldosterone**, which increases reabsorption of sodium ions and water by the kidneys. The water reabsorption increases total blood volume, which increases blood pressure.

3- HORMONAL REGULATION OF BLOOD PRESSURE

E, NE

2- Epinephrine and norepinephrine:

- In response to sympathetic stimulation, the adrenal medulla releases epinephrine and norepinephrine.
- These hormones increase cardiac output by increasing the rate and force of heart contractions.

3- Antidiuretic hormone (ADH):

- It is produced by the hypothalamus and released from the posterior pituitary in response to dehydration or decreased blood volume.
- It causes in an increase in blood volume and a decrease in urine output.

الغدة الخلفية للغدة النخامية

posterior pituitary

خبرنا ان الاربعة

في جميع الحالات
طما ان الاربعة

3- HORMONAL REGULATION OF BLOOD PRESSURE

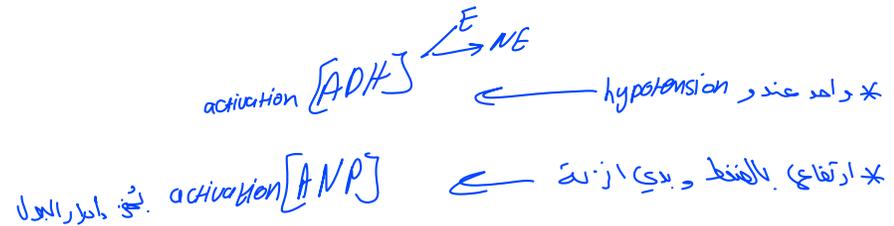
عكس كلهم

4- Atrial natriuretic peptide (ANP): بدي انزل الضغط

- Released by cells in the atria of the heart, atrial natriuretic peptide (ANP) **lowers blood pressure by causing vasodilation and by promoting the loss of salt and water in the urine, which reduces blood volume.**

ملخص سوپر سريع قبل الامتحان

- RAAS: Vasoconstriction + \uparrow BV
- Epinephrine/Norepinephrine: \uparrow CO
- ADH: \uparrow BV + vasoconstriction
- ANP: \uparrow Na⁺ loss + vasodilation \rightarrow \downarrow BP



4- AUTOREGULATION OF BLOOD FLOW

- In each capillary bed, local changes can regulate vasomotion.
- When vasodilators produce local dilation of arterioles and relaxation of precapillary sphincters, blood flow into capillary networks is increased, which increases O₂ level.
- Vasoconstrictors have the opposite effect.
- The ability of a tissue to automatically adjust its blood flow to match its metabolic demands is called autoregulation.

توسيع و تضيق الأوعية

تنظيم تدفق الدم تلقائيًا

قدرة النسيج على ضبط تدفق الدم تلقائيًا ليطابق احتياجاته الأيضية تسمى Autoregulation.

الدم يدخل الأوعية
و الخارج منها
قوات من الدم تسمى

4- AUTOREGULATION OF BLOOD FLOW

- **Autoregulation** also controls regional blood flow in the brain; blood distribution to various parts of the brain changes dramatically for different mental and physical activities.
- During a conversation, for example, blood flow increases to your motor speech areas when you are talking and increases to the auditory areas when you are listening.

Autoregulation also controls regional blood flow in the brain...”

يعني مش بس العضلات والقلب والكلى عندهم ...autoregulation

الدماغ عنده نظام Autoregulation قوي جداً لأنه لازم يحافظ على إمداد ثابت بالدم مهما تغيّر الضغط.

بس كمان في إشي مهم:

جوا الدماغ نفسه، كل منطقة تاخذ كمية دم حسب شغلها اللحظي.

يعني الدماغ بوزع الدم على أقسامه بطريقة ذكية ودقيقة حسب الحاجة اللحظية.

4- AUTOREGULATION OF BLOOD FLOW

- Two general types of stimuli cause autoregulatory changes in blood flow: بالمغزى وبهناك بغير اعني لانك مهميتى وتوسعت للأوعية الدموية وبالتالي زاد تدفق الدم

1. **Physical changes.** Warming promotes vasodilation, and cooling causes vasoconstriction. In addition, smooth muscle in arteriole walls exhibits a myogenic response— it contracts more forcefully when it is stretched and relaxes when stretching lessens. تمنع

2. **Vasodilating and vasoconstricting chemicals.** Several types of cells—including white blood cells, platelets, smooth muscle fibers, macrophages, and endothelial cells—release a wide variety of chemicals that alter blood-vessel diameter.

4- AUTOREGULATION OF BLOOD FLOW

→ local control

- An important difference between the pulmonary and systemic circulations is their autoregulatory response to changes in O_2 level.
- The walls of blood vessels in the systemic circulation dilate in response to low O_2 . With vasodilation, O_2 delivery increases, which restores the normal O_2 level.
- By contrast, the walls of blood vessels in the pulmonary circulation constrict in response to low levels of O_2 . This response ensures that blood mostly bypasses those alveoli (air sacs) in the lungs that are poorly ventilated by fresh air. Thus, most blood flows to better-ventilated areas of the lung.

CHECKING CIRCULATION

1. Pulse:

- systolic BP - diastolic BP
- relaxation contraction
- The alternate (expansion) and (recoil) of elastic arteries after each systole of the left ventricle creates a traveling pressure wave that is called the pulse.
 - The pulse is strongest in the arteries closest to the heart, becomes weaker in the arterioles, and disappears altogether in the capillaries.
 - The pulse rate normally is the same as the heart rate, about 70 to 80 beats per minute at rest. **Tachycardia** is a rapid resting heart or pulse rate over 100 beats/min. **Bradycardia** is a slow resting heart or pulse rate under 50 beats/min.

CHECKING CIRCULATION

2. Measuring Blood Pressure:

❑ The term **blood pressure** usually refers to the pressure in arteries generated by the **left ventricle during systole** and the pressure remaining in the arteries when the ventricle is in **diastole**. Blood pressure is usually measured in the **brachial artery** in the left arm.

❑ The device used to measure blood pressure is a **sphygmomanometer**.

جهاز قياس ضغط الدم

❑ The normal blood pressure of an adult male is **less than 120 mmHg systolic** and **less than 80 mmHg diastolic**. For example, **"110 over 70"** (written as 110/70) is a normal blood pressure. **ideal 120/80** بس ال **140/90** الكبير بالعمر

CHECKING CIRCULATION

2. Measuring Blood Pressure:

$$\text{Pulse pressure} = \text{systolic BP} - \text{diastolic BP}$$

- The difference between systolic and diastolic pressure is called **pulse pressure**. This pressure, normally about 40 mmHg, provides information about the condition of the cardiovascular system. For example, conditions such as **atherosclerosis** greatly increase pulse pressure. The normal ratio of systolic pressure to diastolic pressure to pulse pressure is about 3:2:1.

→ تصك الشرايين

$$\begin{array}{l} \text{systolic : diastolic : pulse pressure} \\ 3 : 2 : 1 \end{array}$$

SHOCK AND HOMEOSTASIS

❑ **Shock** is a failure of the cardiovascular system to deliver enough O_2 and nutrients to meet cellular metabolic needs.

❑ The causes of shock are many and varied, but all are characterized by inadequate blood flow to body tissues. With inadequate oxygen delivery, cells switch from aerobic to anaerobic production of ATP, and lactic acid accumulates in body fluids. If shock persists, cells and organs become damaged, and cells may die unless proper treatment begins quickly.

إذا استمرت الصدمة، تتعرض الخلايا والأعضاء للتلف، وقد تموت الخلايا ما لم يبدأ العلاج المناسب بسرعة

TYPES OF SHOCK

➤ Shock can be of four different types:

☐ (1) **Hypovolemic shock** due to decreased blood volume

← انخفاض حجم الدم

☐ (2) **Cardiogenic shock** due to poor heart function.

← ضعف وظيفة الدم

→ myocardial infarction (heart attack)

☐ (3) **Vascular shock** due to inappropriate vasodilation.

← تضيق الأوعية المناسبة للأوعية الوعائية

☐ (4) **Obstructive shock** due to obstruction of blood flow.

← انسداد تدفق الدم

TYPES OF SHOCK

مش حفظ

Cause	Pathophysiology*	Patterns of abnormalities		
		Filling status	Cardiac function	Systemic resistance
Hypovolemic	Loss of volume	low	low	high
Vasogenic	Vasodilation	low	high	low
Cardiogenic	Pump failure	high	low	high
Obstructive	Obstruction to flow	Variable**	low	high

*primary problem mentioned in BOLD ; **depending on site of obstruction

HYPOVOLEMIC SHOCK

- ✓ It is due to decreased blood volume (i.e. **blood loss** as **acute (sudden)** hemorrhage and **loss of body fluids** i.e. through **excessive sweating**).

تَوَرَّك زَائِد

- ✓ Whatever the cause, **when the volume of body fluids falls**, **venous return to the heart declines**, **filling of the heart lessens**, **stroke volume decreases**, and **cardiac output decreases**. **Replacing fluid volume as quickly as possible is essential in managing hypovolemic shock.**

أهم النقاط للحفظ		
نوع الصدمة	السبب	النتيجة
Hypovolemic	نقص حجم الدم	انخفاض تدفق الدم
Cardiogenic	ضعف القلب	انخفاض ضخ الدم
Vascular	توسع وعائي غير مناسب	انخفاض ضغط الدم
Obstructive	انسداد الدم	انخفاض تدفق الدم

CARDIOGENIC SHOCK

↳ myocardial infarction (heart attack)

✓ The heart fails to pump adequately, most often because of a myocardial infarction (heart attack).

يشكل كافي

عندما القلب

احتماء

له نوبة قلبية

✓ Other causes of cardiogenic shock include poor perfusion of the heart (ischemia), heart valve problems, excessive preload or afterload, impaired contractility of heart muscle fibers, and arrhythmias.

نقص التروية

بعد الإنقباض

بعد الانقباض

ضعف تروية العضلات

اضطراب نظم القلب

عدم انتظام ضغط الدم

مشاكل بعد القلب

VASCULAR SHOCK

بكون وجهه محمر

- ✓ A variety of conditions can cause inappropriate dilation of arterioles or venules.
- ✓ In anaphylactic shock, a severe allergic reaction—for example, to a bee sting—releases histamine and other mediators that cause vasodilation.
- ✓ In neurogenic shock, vasodilation may occur following trauma to the head that causes malfunction of the cardiovascular center in the medulla.
في الصدمة العصبية (Neurogenic Shock)، قد يحدث توسع في الأوعية بعد إصابة في الرأس تؤدي إلى خلل في مركز القلب والأوعية في النخاع المستطيل (medulla).
- ✓ Shock stemming from certain bacterial toxins that produce vasodilation is termed septic shock. في عنا بكتيريا الصدمة الناتجة عن سموم بكتيرية تسبب توسع الأوعية تُسمى الصدمة الإنتانية

OBSTRUCTIVE SHOCK

- ✓ It occurs when blood flow through a portion of the circulation is blocked.
- ✓ The most common cause is **pulmonary embolism**, a blood clot lodged in a blood vessel of the lungs.

لما يكون في انسداد فعلي يمنع تدفق الدم بشكل طبيعي.

أشهر سبب هو الانصمام الرئوي، اللي بيسكّر شريان في الرئة ويمنع الدم يوصل للقلب بشكل صحيح، فبينخفض الخرج القلبي وبيصير Shock

HOMEOSTATIC RESPONSES TO SHOCK

- ❖ **Activation of the sympathetic division of the ANS:** aortic and carotid baroreceptors initiate powerful sympathetic responses throughout the body. One result is marked vasoconstriction of arterioles and veins of the skin, kidneys, and other abdominal viscera. (Vasoconstriction does not occur in the brain or heart.) Constriction of arterioles increases systemic vascular resistance, and constriction of veins increases venous return.
- ❖ **Release of local vasodilators:** In response to hypoxia, cells liberate vasodilators—including potassium ions, hydrogen ions, lactic acid, adenosine, and nitric oxide—that dilate arterioles and relax precapillary sphincters. Such vasodilation increases local blood flow and may restore O₂ level to normal in part of the body.

SIGNS AND SYMPTOMS OF SHOCK

- **Systolic blood pressure is lower** than 90 mmHg.
- **Resting heart rate is rapid** due to sympathetic stimulation and increased blood levels of epinephrine and norepinephrine.
- **Pulse is weak and rapid** due to reduced cardiac output and fast heart rate.
- **Skin is cool, pale, and clammy** due to sympathetic constriction of skin blood vessels and sympathetic stimulation of sweating.
- **Mental state is altered** due to reduced oxygen supply to the brain.
- **Urine formation is reduced** due to increased levels of aldosterone and antidiuretic hormone (ADH).
- **The person is thirsty** due to loss of extracellular fluid.
- **The pH of blood is low** (acidosis) due to buildup of lactic acid.
- **The person may have nausea** because of impaired blood flow to the digestive organs from sympathetic vasoconstriction.



THANK YOU

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