Arterial Blood Pressure-1

Dr. Eman El Eter

Objectives

- By the end of this lecture the students are expected to:
- Understand the concept of mean blood pressure, systolic, diastolic, and pulse pressure.
- Calculate mean BP
- Understand normal variations in ABP.
- Understand the relationship between CO, BP and total peripheral resistance.
- Describe and understand factors determining blood pressure
- Regulation of arterial blood pressure.

Physiological variation in arterial blood pressure:

BP range: 90-140/60-90 mmHg.

- Age:
  At birth: 50/30
  Adult : 120/80
  Old age 170/90
- Sex: males have higher BP than F before meanopause.
- Body built : increase in obese.
- Emotions (↑ BP)
- Exercise. (↑ BP)
- Meals. (↑BP)
- Sleep (↓BP)

- Gravity:
- The pressure in any vessel below heart level is increased while decreases in a vessel above heart level due to effect of Gravity. Gravitational effect = 0.77 mmHg/cm at the density of normal blood.
- In adult human in upright position, if mean BP at heart level = 100 mmHg, the mean pressure in an artery at the head (50 cm above heart) = 100-[0.77X 50] = 62 mmHg,

Blood pressure

- Definitions:
- Pulse pressure:
  PP = SP-DP

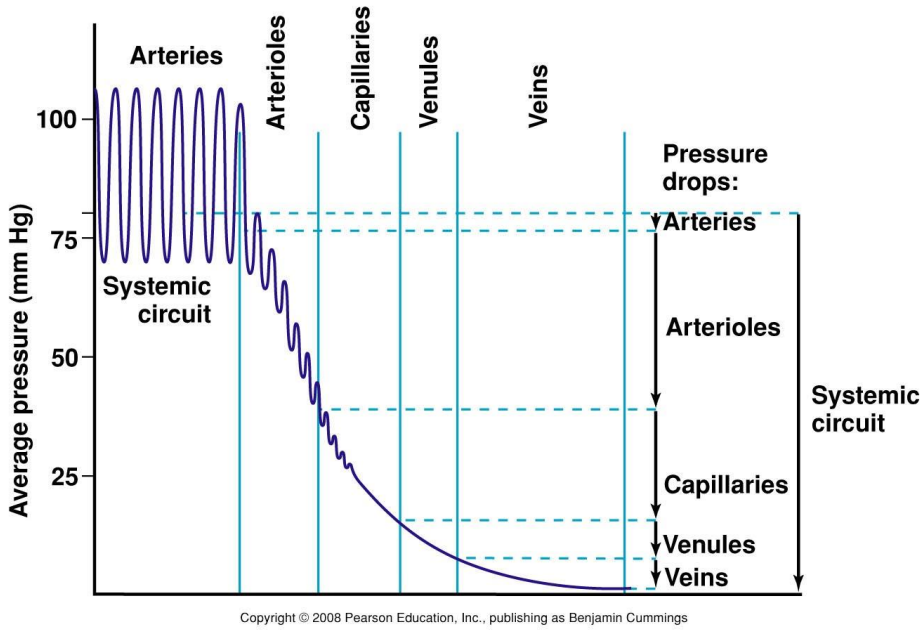
- Mean arterial blood pressure (MABP)

MABP = Diastolic + PP/3

CO = ABP

TPR

ABP = CO X TPR



Determinants of arterial blood pressure:

1-Cardiac output:

- CO= HR X SV

ABP = CO X TPR

ABP= HRxSVxTPR
heart rate, stroke volume and peripheral resistance affect MABP

Determinants of ABP, continued,..

2- 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.

3- Blood volume:

An increase in blood volume → ↑CO increase ABP.

A decrease in blood volume as in Hege, dehydration- → decrease VR- → decrease CO → decrease VR.

Atherosclerosis: decreases elasticity

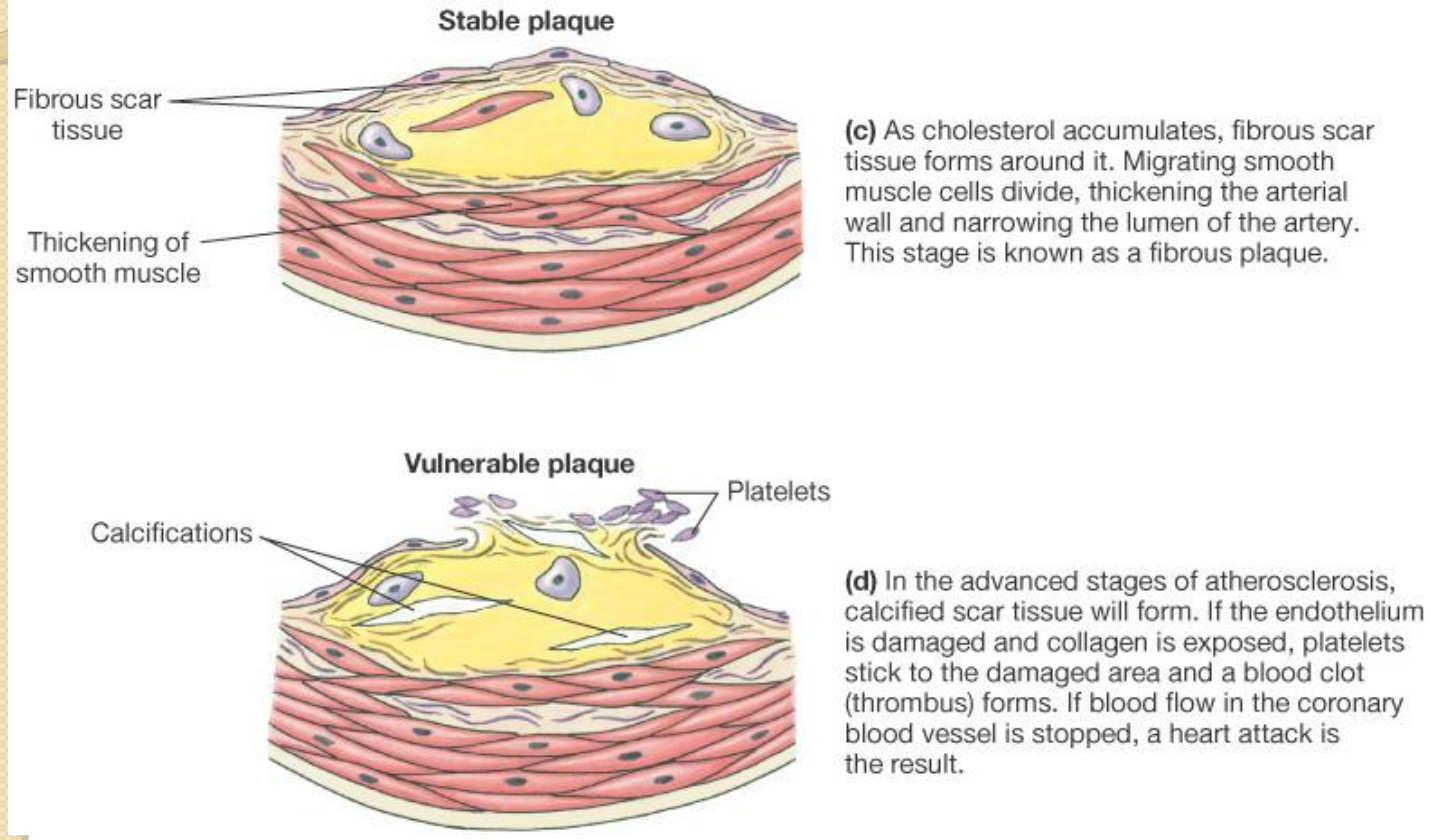


Figure 15-24: The development of atherosclerotic plaques

Determinants of ABP, continued,..

4-Total peripheral resistance:

APB is directly proportional to TPR

TPR is determined by:

1. diameter of blood vessel (r).

2. Blood viscosity:

a. Red cells

Polycythemia increases viscosity.

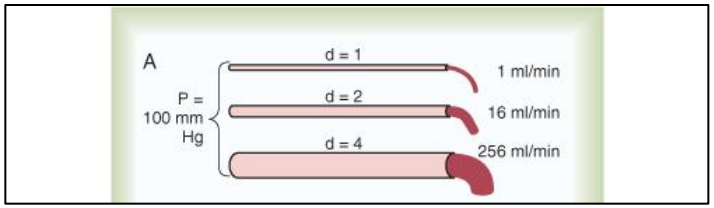
b. Plasma proteins:

Hypoprotenimia decreases viscosity.

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) :
- $R \alpha 1/r4$
- If r is doubled, TPR is reduced by 16, and so on……..

TPR and vessel diameter



- 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 vessel diameter:

- Vasodilator agents:
  - Nitric oxide.
  - Histamine.
  - Atrial natriuretic peptide (ANP).
  - Prostacyclin
- Vasoconstrictor agents:
  - Norepinephrine.
  - Angiotensin II.
  - Vasopressin.
  - Endothelin-1
  - Thromboxane A.

Why is it important to control blood pressure?

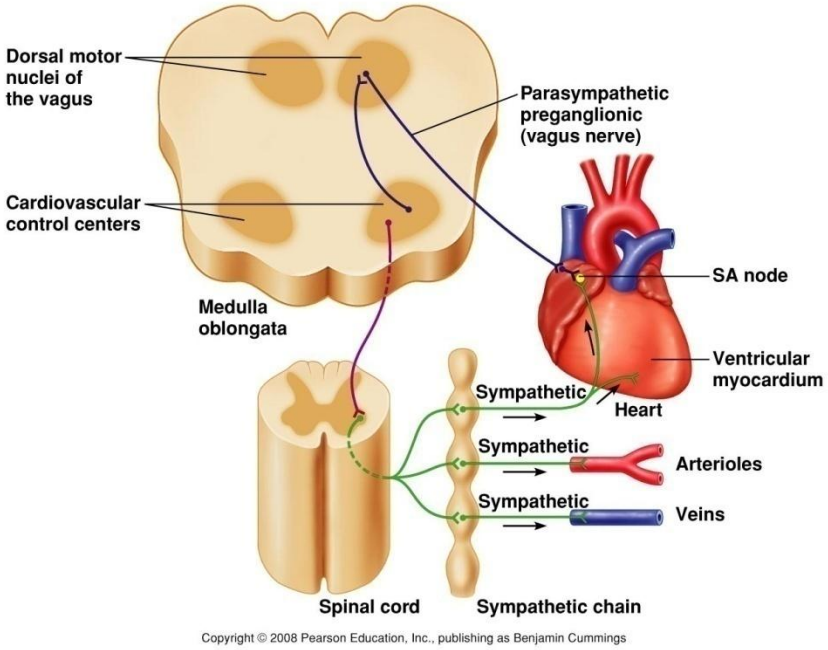
- Importance:

  Blood pressure is a key factor for providing blood (thus oxygen and energy) to organs especially heart, kidney and brain.

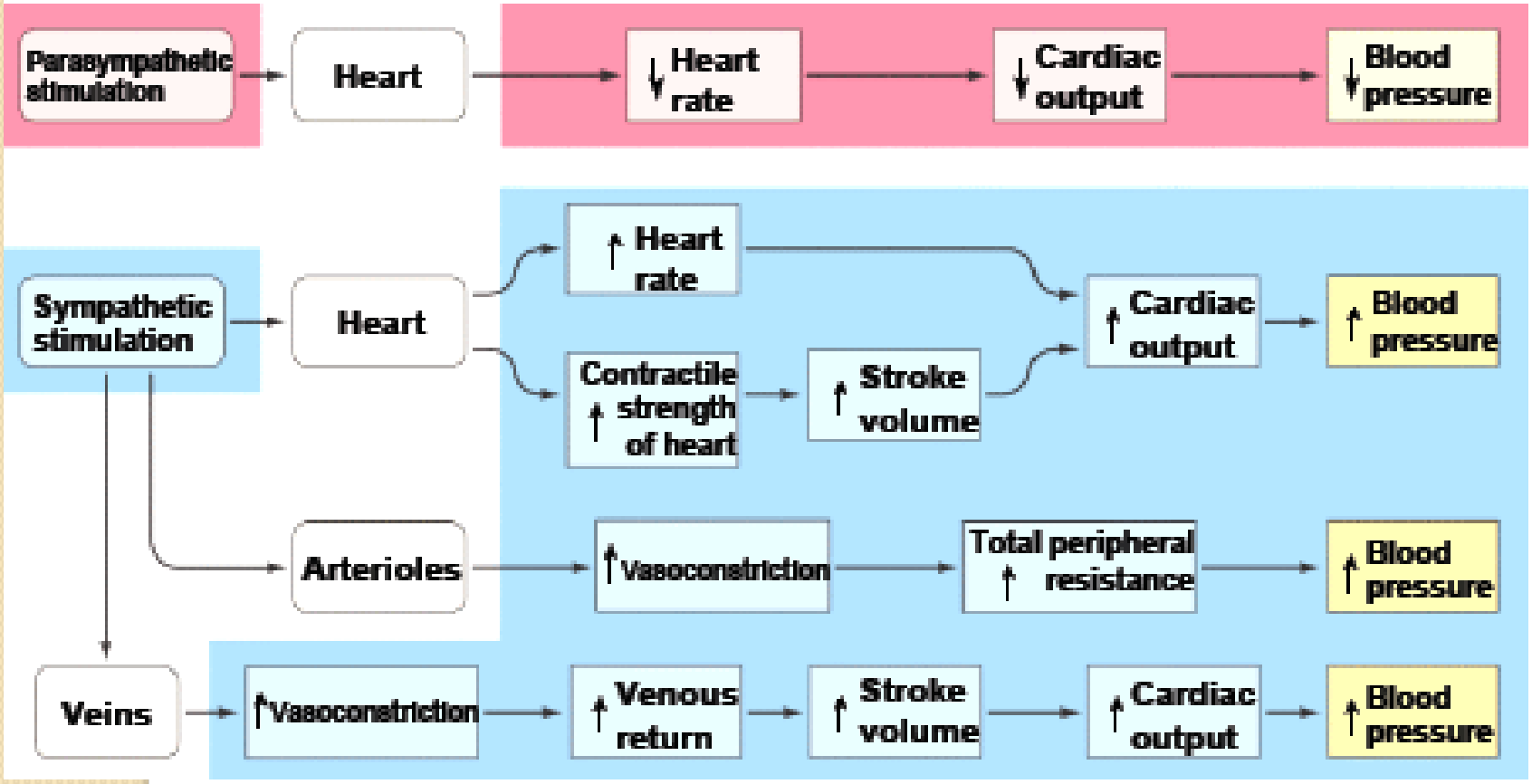
Neural control ; medullary CVCs

The vasomotor center integrates all these information

The vasomotor sends decision to the ANS center:
-Both parasympathetic and sympathetic innervate the S/A node → can accelerate or slow down the heart rate
-The sympathetic NS innervates the myocardium and the smooth muscle of the arteries and veins → promotes vasoconstriction



Regulation of blood pressure

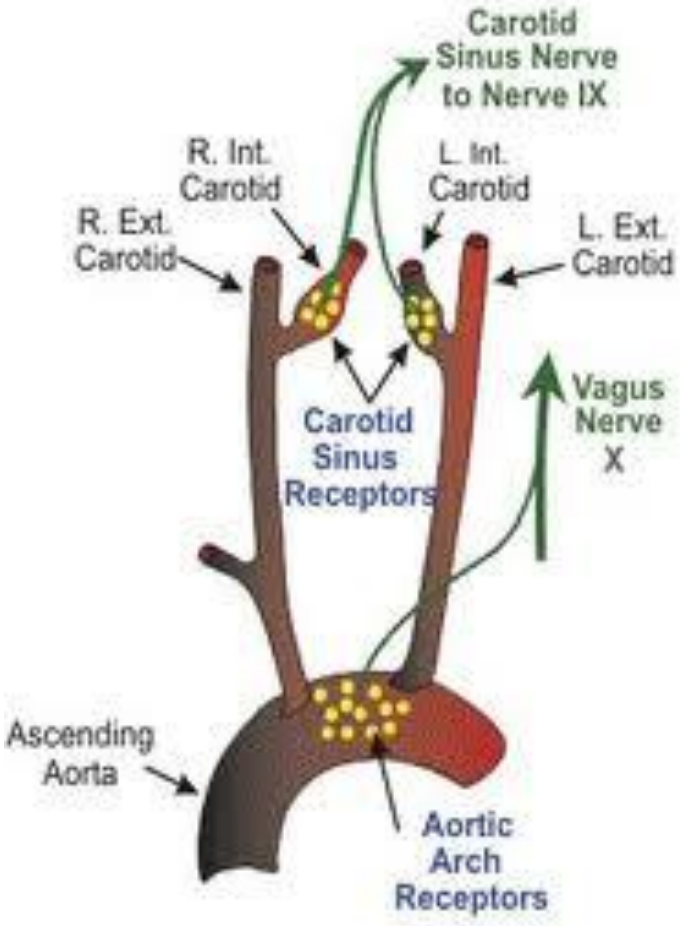


Regulation of ABP

- 1. Short term regulation (nervous):
- a. Baroreceptor reflex.
- b. Chemoreceptor reflex.
- c. CNS ischemic response.
- d. Atrial reflexes.
- 2. Intermediate regulation.
- 3. Long-term regulation.

1-Baroreceptor reflexes:

- Baroreceptors: Stretch receptors. Located in: Carotid sinus and aortic arch .
- They 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 Ns.
- They respond to a rapidly changing BP. In the range 60-180 mmHg.



Baroreceptor reflexes:

- Reflexes initiated by baroreceptors:
- ↑ **ABP** ⟶ Stretch of receptors ⟶ ↑ rate of firing and impulses travel along vagus & glossopharyngeal to the medullary CVCs: The responses will be
    a. (+) vagal center : decrease HR.
    b. (-) vasoconstrictor center: VD
- ↓ **ABP** ⟶ ↓ inhibitory impulse discharge from baroreceptors ⟶ vasomotor center is released from inhibition resulting in:
    a. (+) heart: HR & contractility.
    b. (+) sympathetic VC tone: VC.

Regulation of Blood Pressure

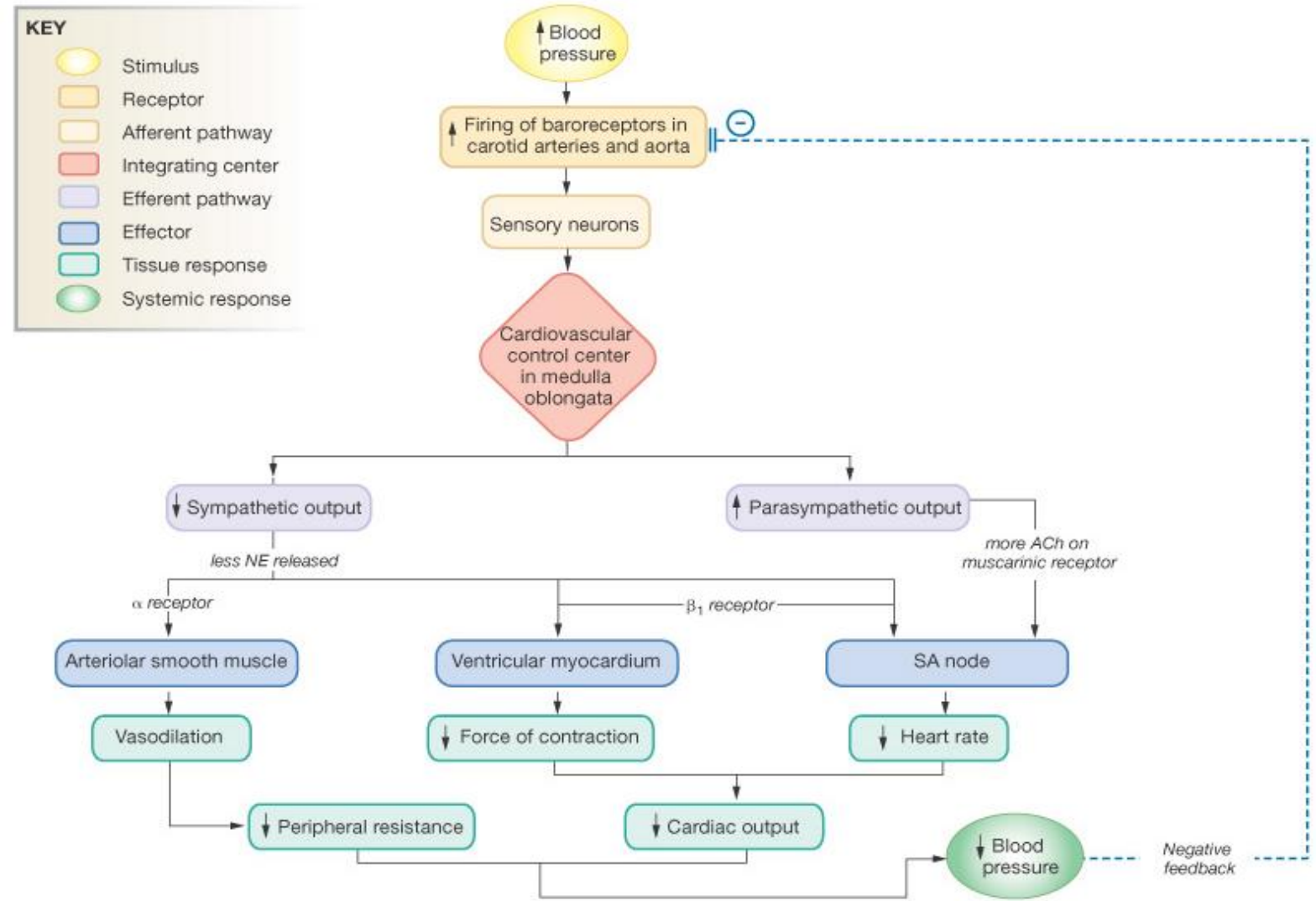


Figure 15-22: The baroreceptor reflex: the response to increased blood pressure

Baroreceptors, continued:

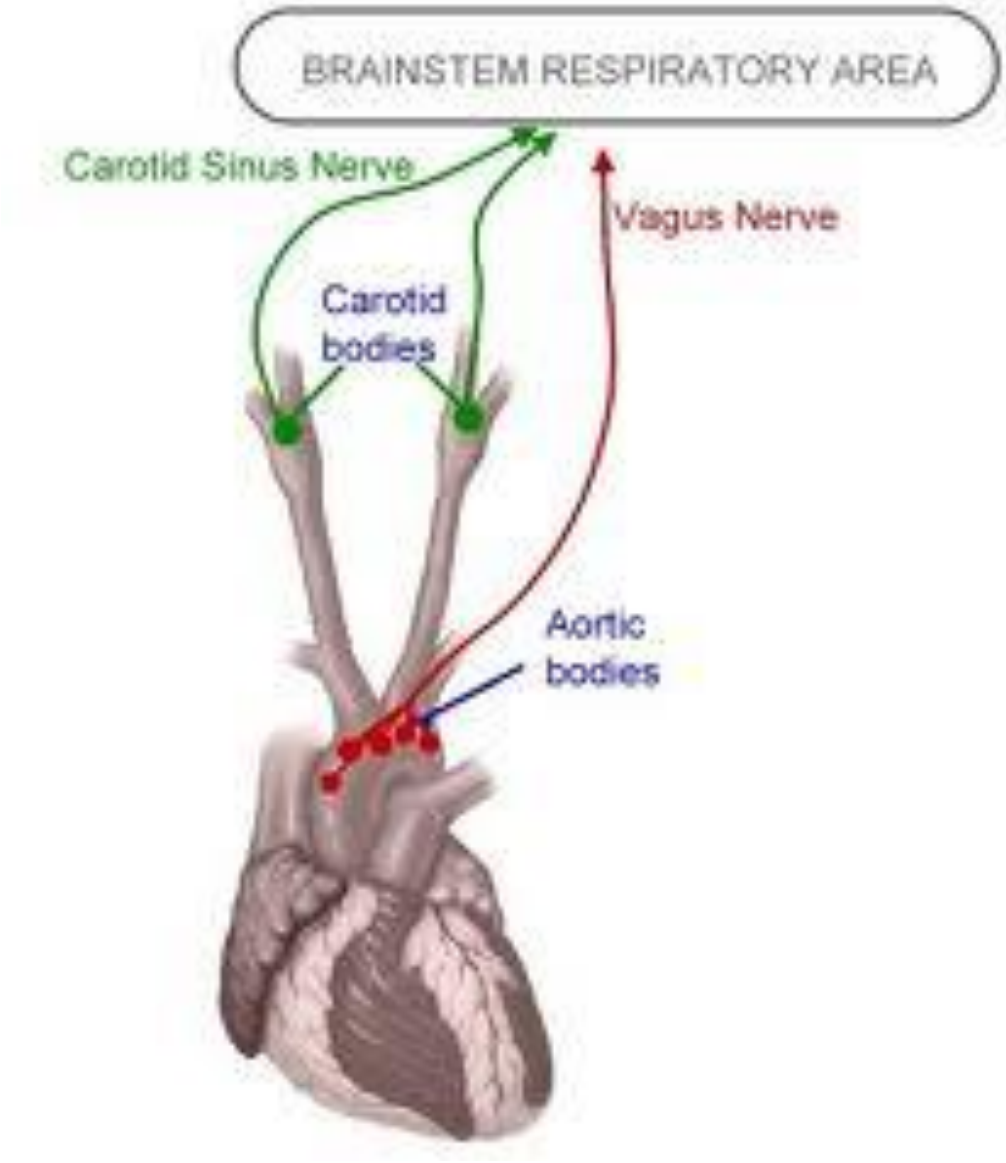
- Baroreceptors are important in maintaining ABP constant during changes in body posture:
- When you change your posture from superior to erect, a drop in ABP in the head and upper part of the body will occur.
- As barorecptor reflex becomes activated, strong sympathetic impulses lead to VC and minimize the decrease in BP.

Baroreceptors, continued

- ***Resetting of baroreceptors:***
- This property makes baroreceptors not suitable for long term regulation of ABP, as they are rapidly reset to the new pressure. They adapt rapidly to the new pressure level.
- Adaptation of a receptor means decrease in impulse discharge from the receptor despite persistence of the stimulus.

- ***What is the effect of denervation of baroreceptors?***

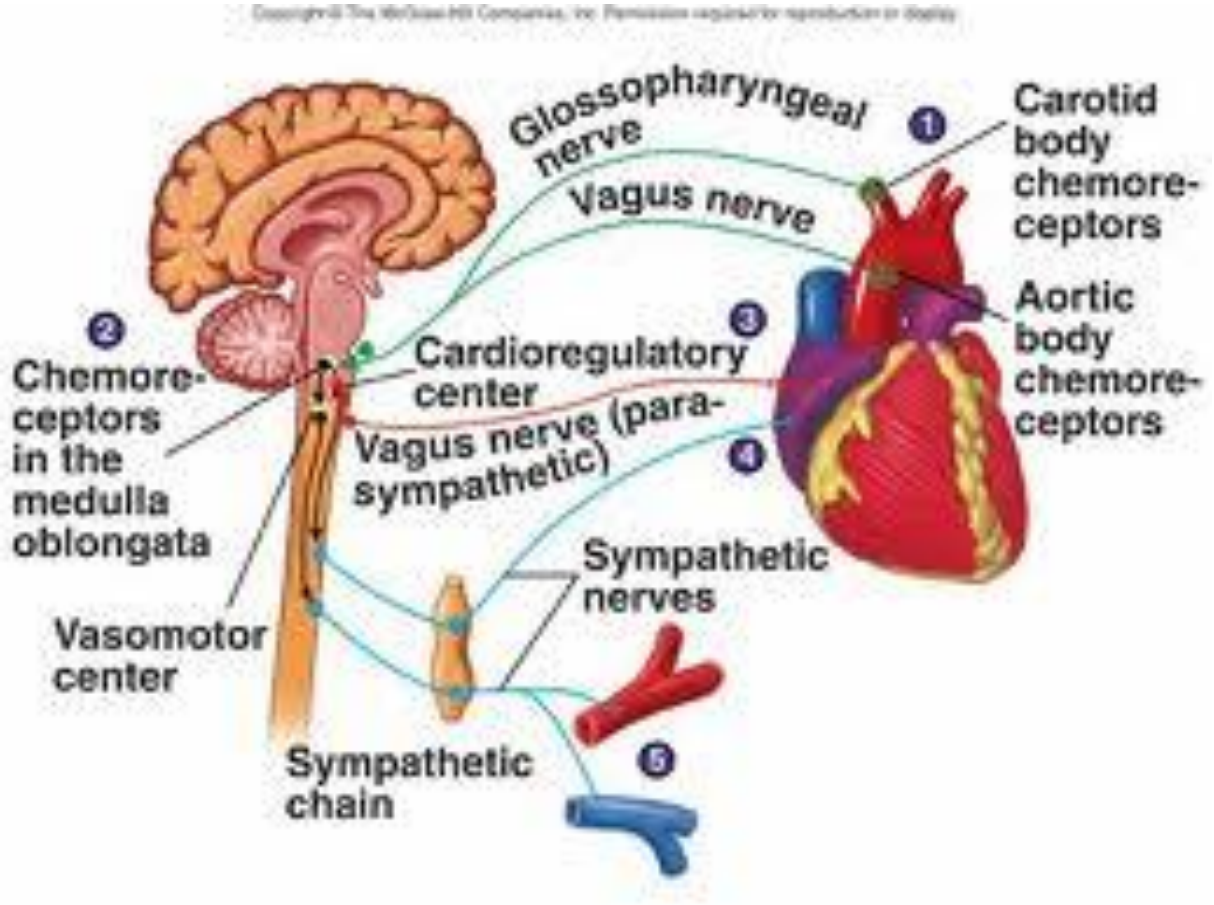
Chemoreceptors:



2-Chemoreceptor reflex:

- Chemosensitive cells, stimulated in response to: O2 lack, CO2 excess, H+ excess.
- 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+.
- 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+ → (+) chemo. Signals (+) CVS → VC

Chemoreceptor reflex



3-CNS ischemic response:

- It operates as an emergency arterial pressure control system that acts rapidly and powerfully to prevent further decrease in ABP whenever blood flow to the brain decreases to lethal level.
- It is one of the most powerful activators of the sympathetic vasoconstrictor system.
- When BP < 20 mmHg ⟶ cerebral ischemia of vasomotor center ⟶ strong excitation of vasomotor center (due to accumulation of CO2, lactic acid,….) ⟶ strong VC of blood vessels including the kidney.

4- Atrial Reflexes

- Receptors: Low pressure receptors especially in the RA.

  Respond to changes in blood volume.
- What happen if blood volume is increased? e.g infusing 500 ml into a person:
- ↑ blood volume ⟶ stretch of the atria leading to:

a. (+) ANP release ⟶ VD of renal vessels, diuresis, natriuresis.

b. Hypothalamus:

   1. (-) ADH ⟶ water diuresis.

   2. (-) sympathetic discharge ⟶ VD of renal vessels

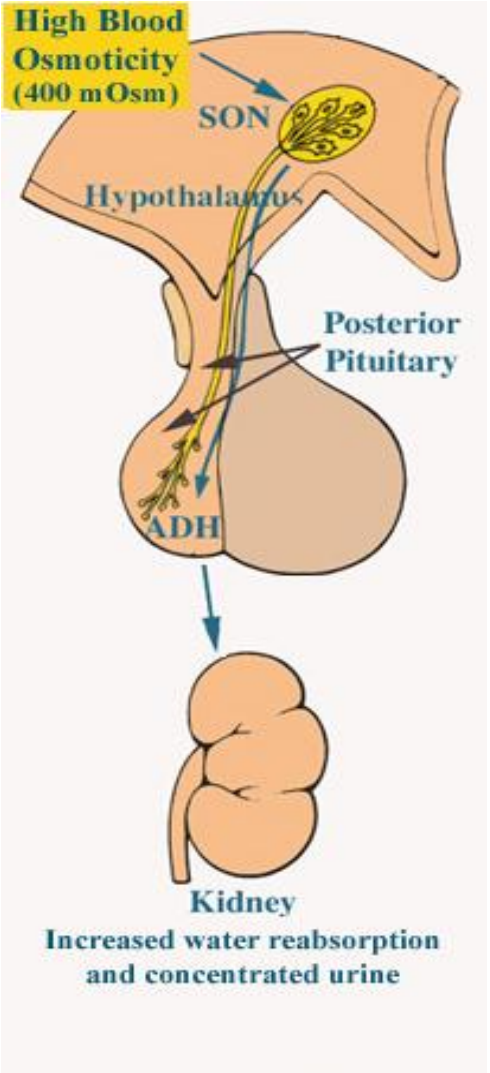
c. stretch SAN and increase HR

Control of blood volume

Anti-diuretic hormone = ADH

-Secreted by the posterior pituitary in response to ↑blood osmolarity (often due to dehydration).

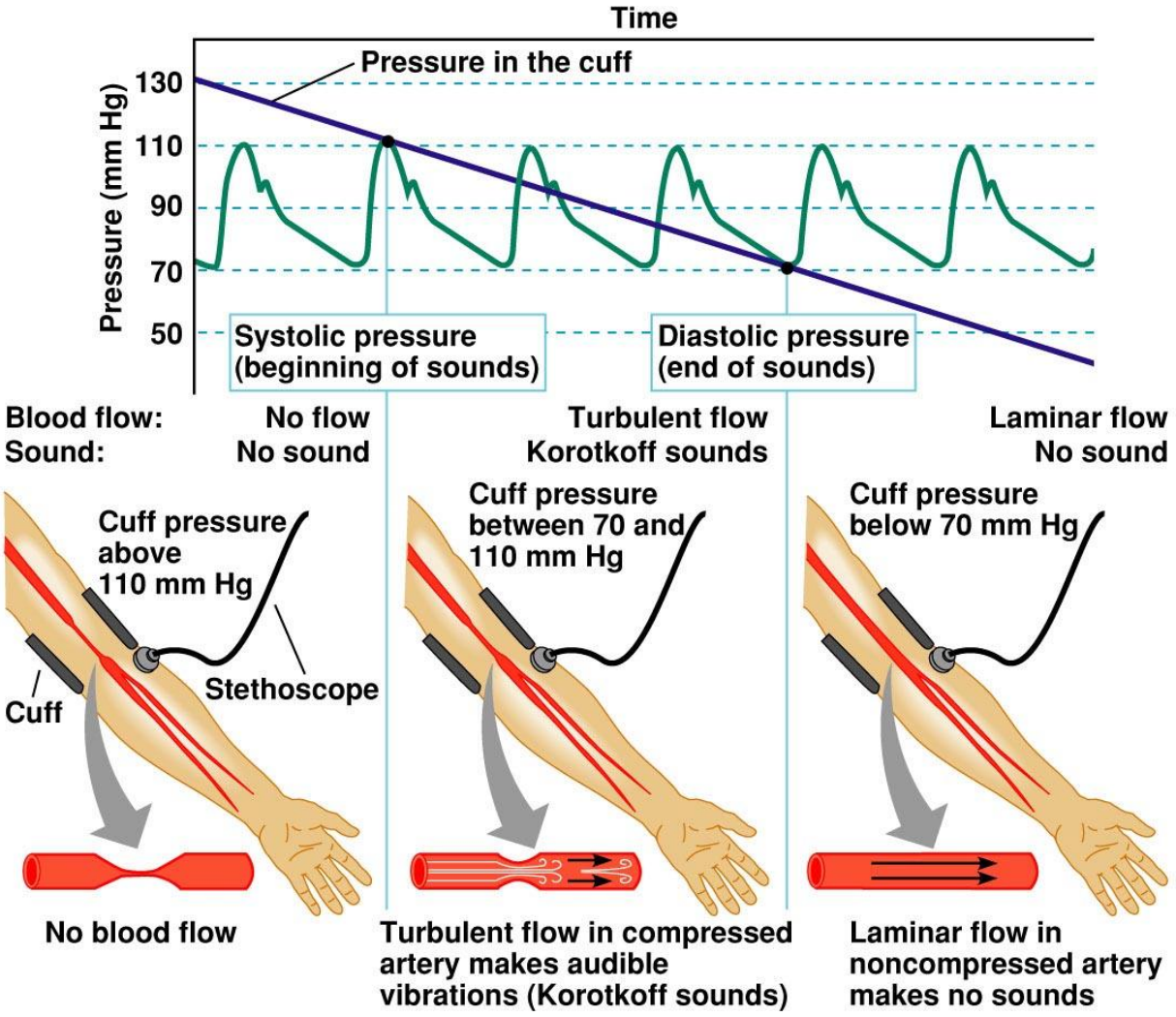
- Action:
Promote water reabsorption by the kidney tubules → H2O moves back into the blood → less urine formed



Atrial reflexes, continued,…

- What happens if there is sudden loss of blood volume by 800 ml?

Arterial blood pressure measurement



Korotkoff Sounds