Ashur University
College of Medicine

Grade 1

Cardiovascular Module
Cardiovascular Physiology
Lec.10

Coronary circulation



Ass. Professor Internal Medicine

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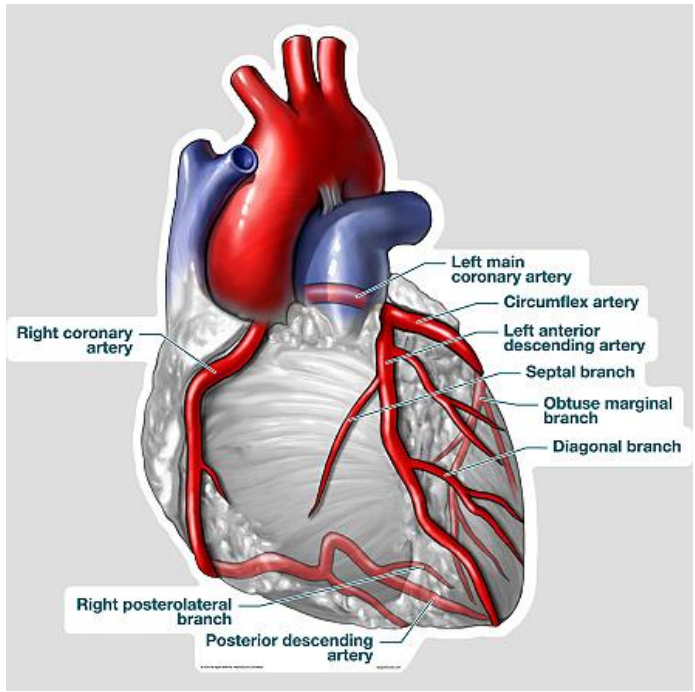


Objectives :

1- Review the physiologic anatomy of coronary circulation (identify the coronary blood vessels, their major branches and anastomosis).



2- Explain changes in coronary blood flow in relation to the metabolic needs, changes in heart rate and during cardiac cycle.



Characteristics of coronary circulation

- **It is a very short, very rapid circulation**.
- **It is a very rich circulation**. The heart weighs about 320 gm (0.5% of the body weight), and receives 200 mL blood/min

(4% of the cardiac output).

There is one capillary for each myocardial fiber.

- **It is the only circulation where blood flow occurs mainly during diastole**.
- It is regulated mainly by the amount of metabolites released from the cardiac muscle cells **(metabolic autoregulation)**, not by autonomic nerve supply.
- Any increase in the metabolic activity of the heart should be accompanied by a parallel increase in coronary blood flow.

Coronary arterial supply

- After the aorta leaves left ventricle, it gives;

  Right and Left coronary arteries.

Left coronary artery two branches:

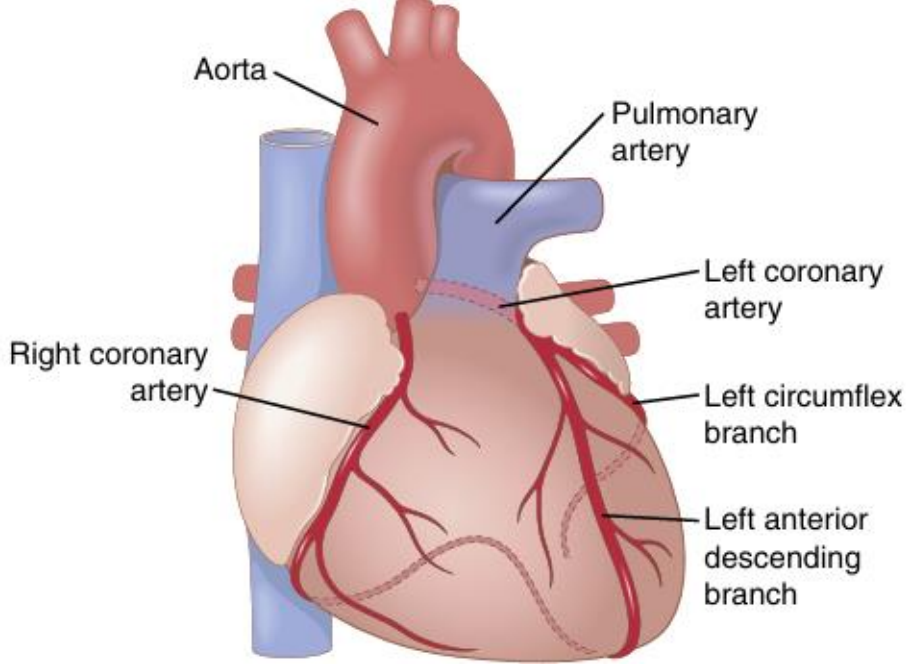
1) Anterior interventricular artery (left anterior descending (LAD)); travels down the anterior interventricular sulcus toward the apex. It gives smaller branches to the interventricular septum and anterior walls of both ventricles.

2) Circumflex artery; It supplies blood to the left atrium and posterior wall of the left ventricle.

Right coronary artery two branches:

1) The marginal artery supplies the lateral aspect of the right atrium and ventricle.

2) The posterior interventricular artery travels down and supplies the posterior walls of both ventricles.



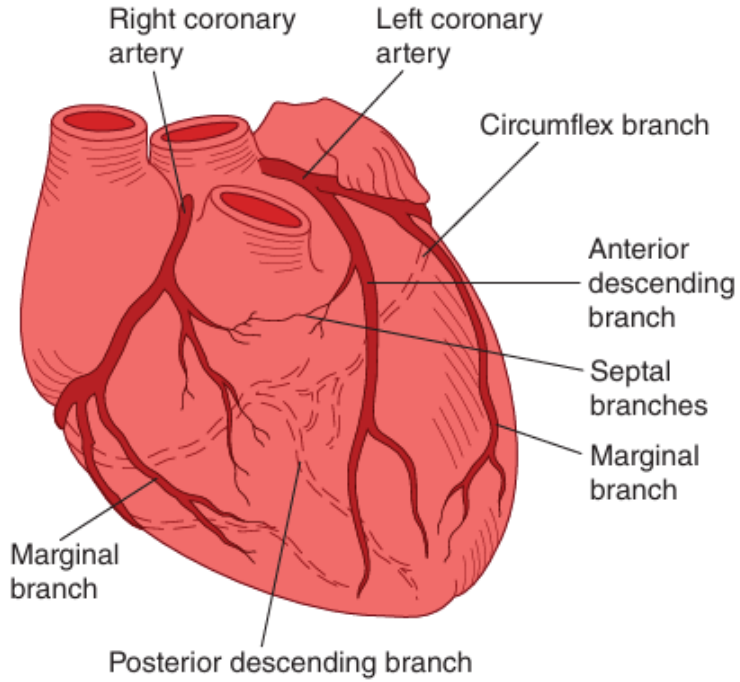


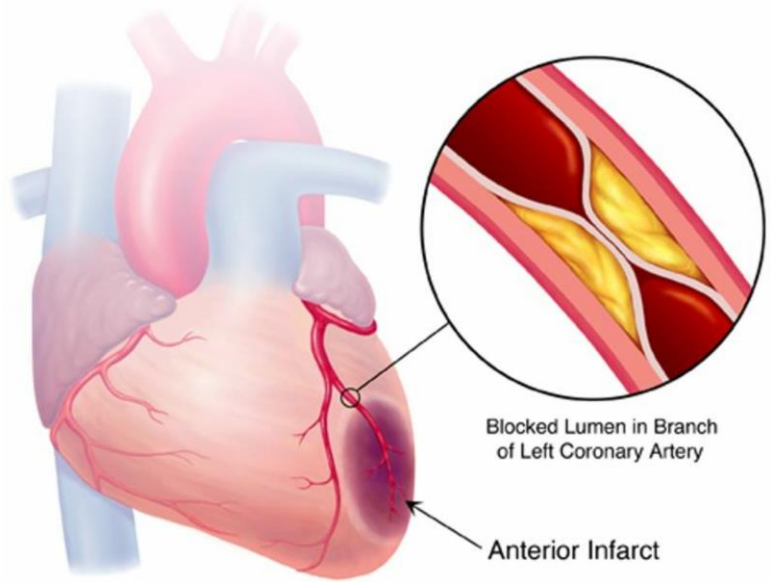
Figure Coronary arteries → →

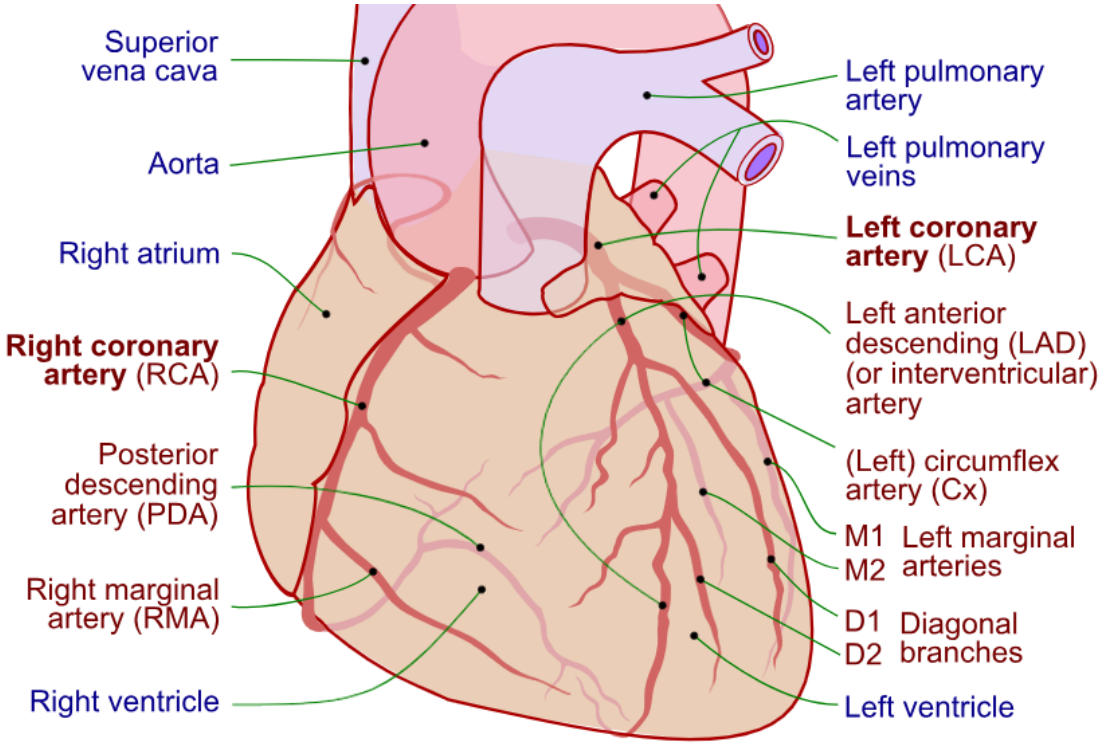
Coronary anastomosis

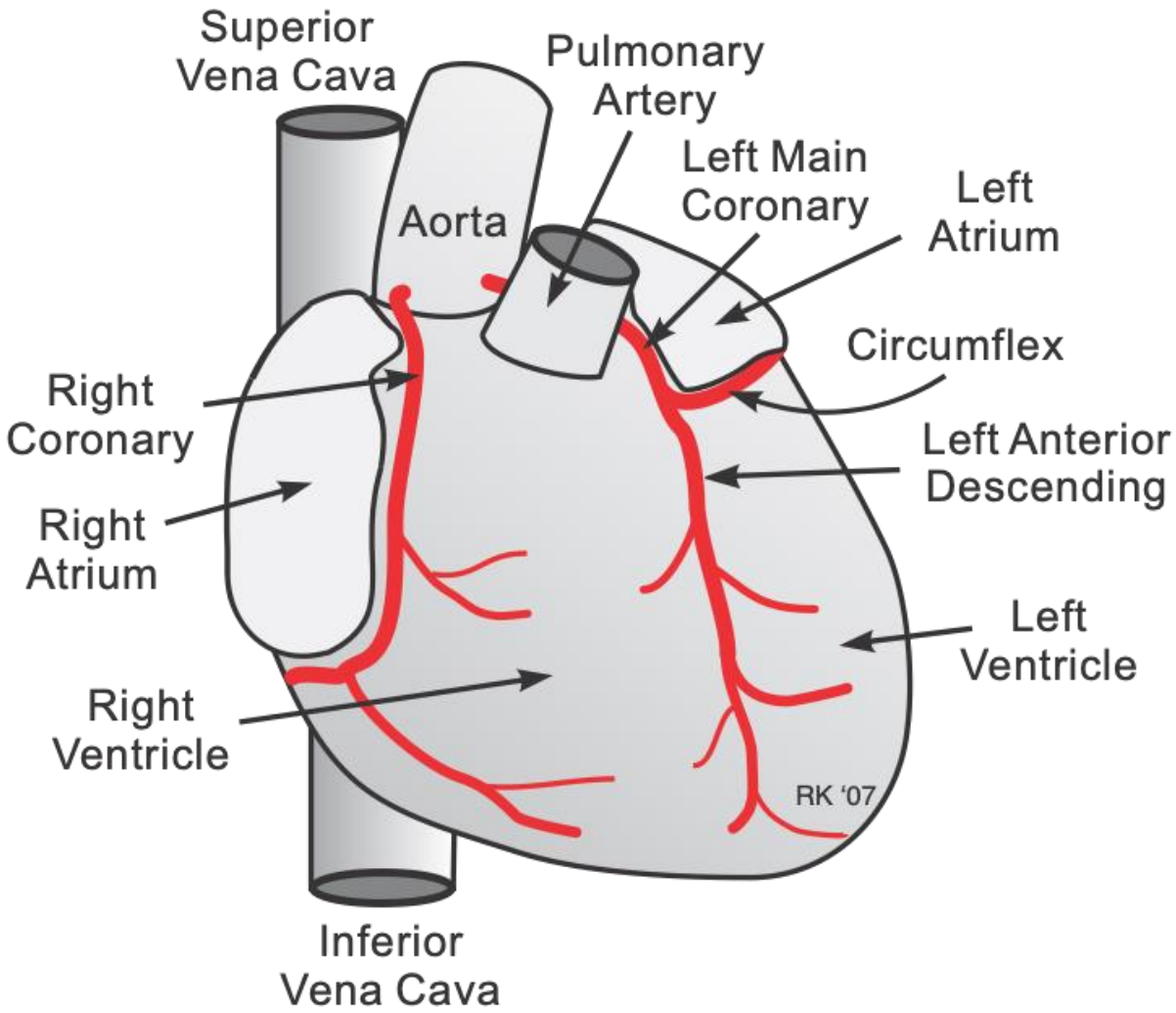
- An interruption of blood supply to any part of the myocardium can cause necrosis within minutes **(myocardial infarction).** If one artery becomes obstructed, blood continues to reach myocardial tissue through the other artery.

- The most important **anastomoses is the point at which the circumflex artery and right coronary artery meet on the posterior side of the heart**; they combine their blood flow into the posterior interventricular artery.

- Another is the meeting of the **anterior and posterior interventricular arteries at the apex of the heart.**







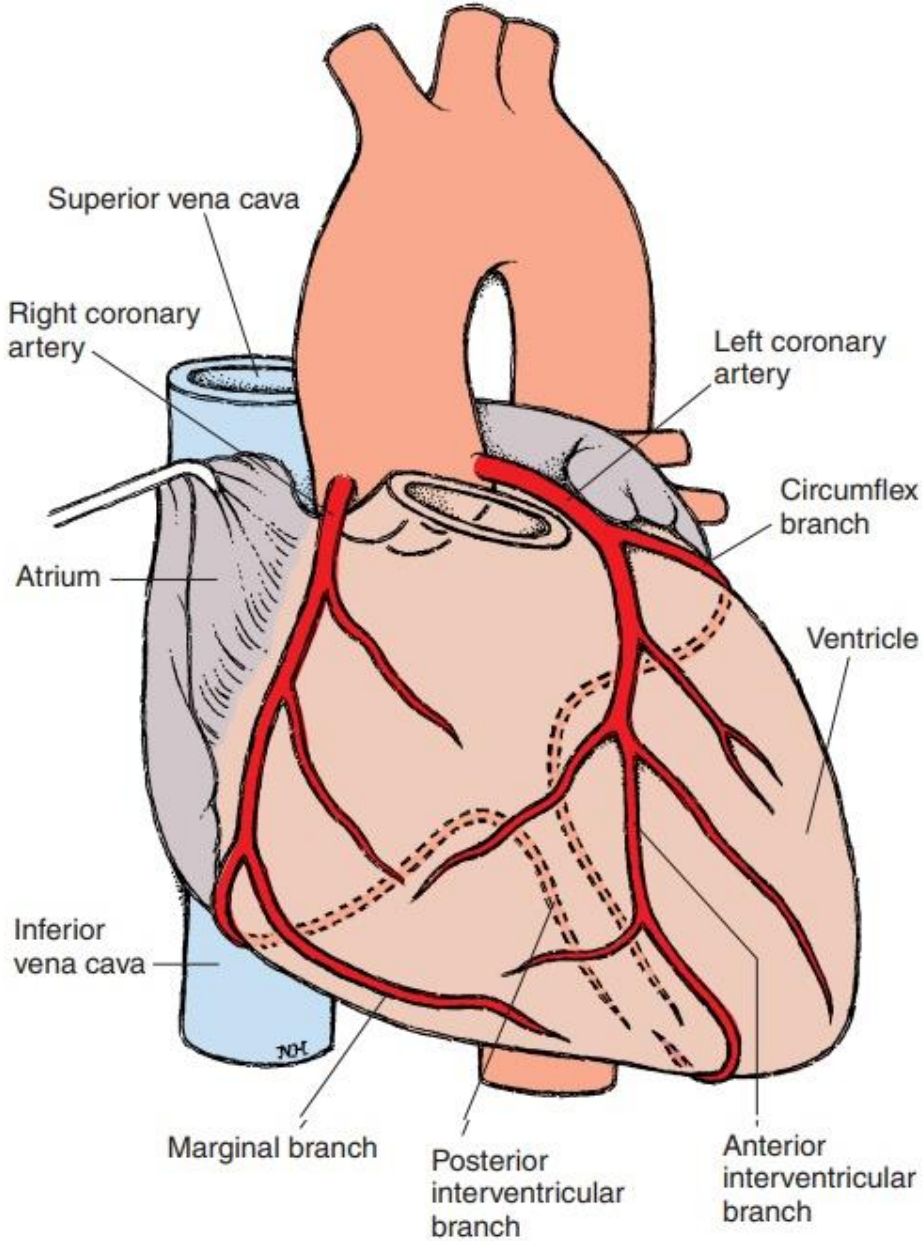
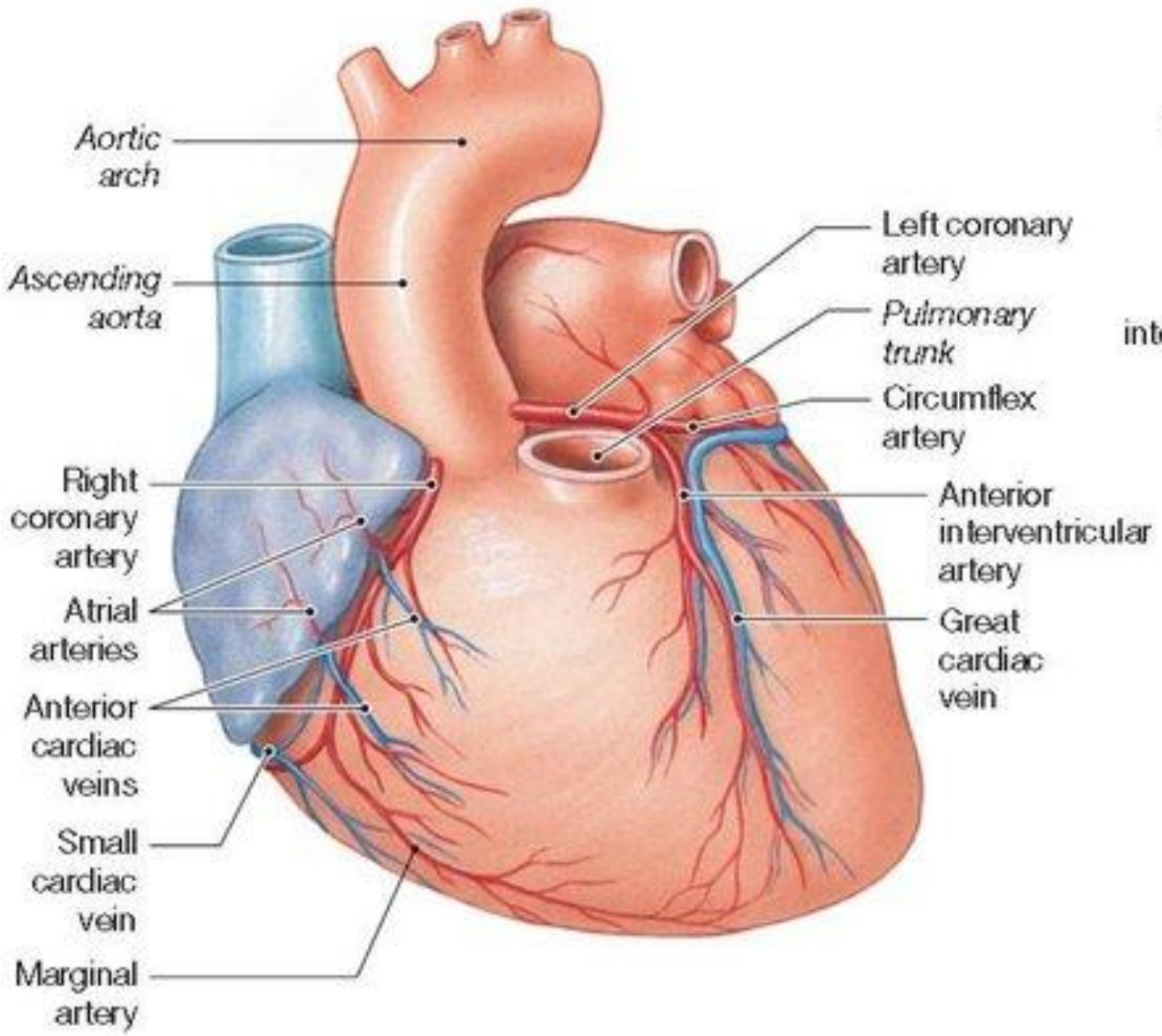
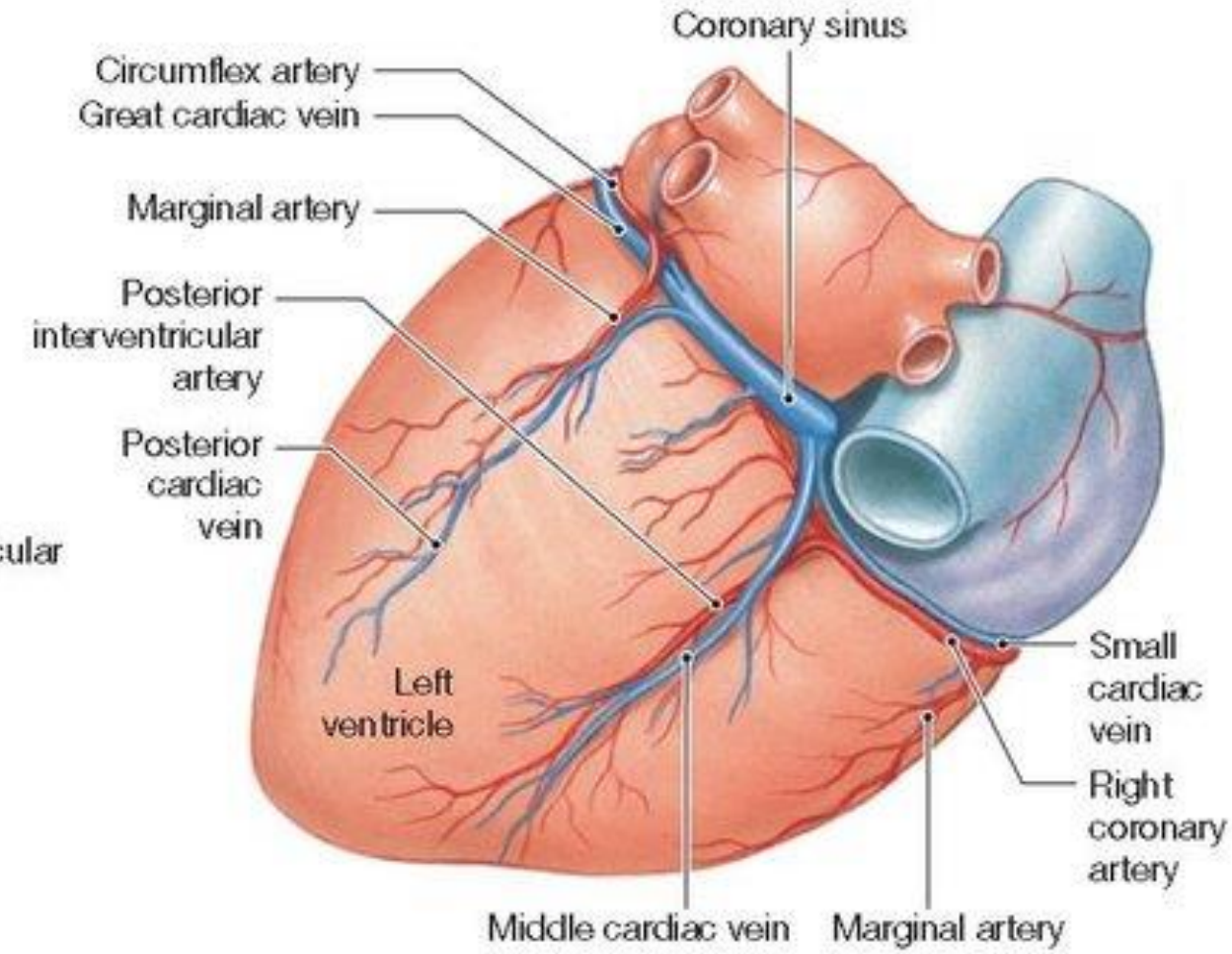


FIGURE Coronary Circulation. Anterior view of coronary arteries

Coronary circulation





Factors affecting the coronary blood flow

- **Metabolic factors:**
- **Mechanical factors:**
- **Nervous factors:**
- **Hormonal factors:**

1- Metabolic factors

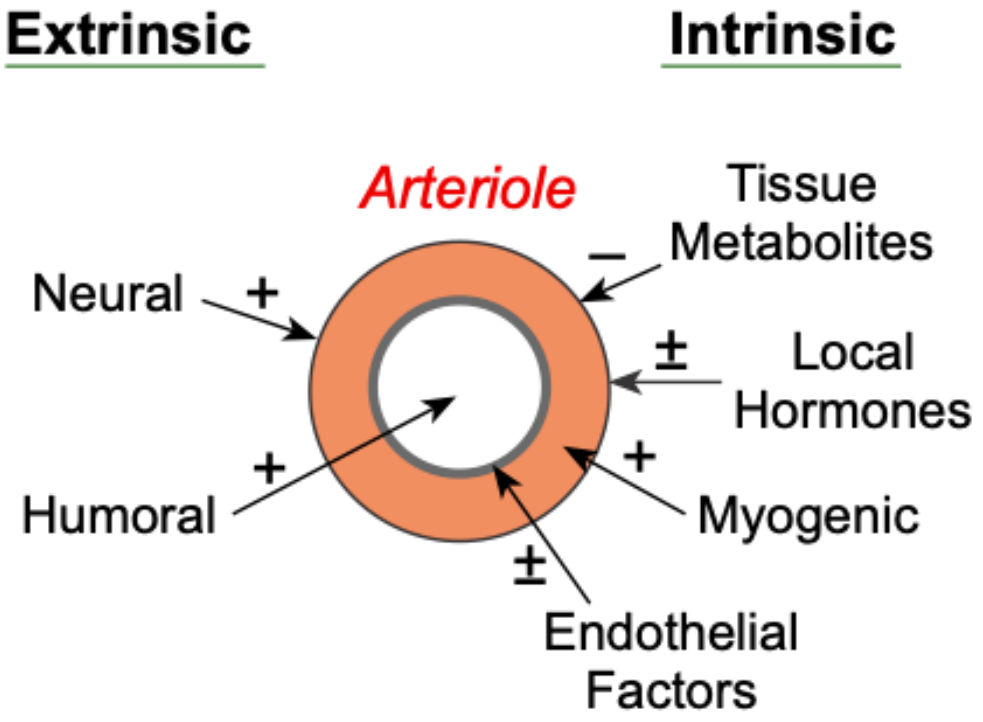
The coronary blood flow is regulated mainly by the metabolic needs of the heart **(Metabolic Autoregulation)** . **Coronary vasodilation** during high metabolic activity is caused by:

1- Local hypoxia, hypoxia is a strong coronary vasodilator.

2- Vasodilator metabolites : Adenosine: strong coronary vasodilator released by cardiac cells. Hypercapnia (elevated carbon dioxide CO_2) + ↑ H+ , Lactic acid , ↑ K+

3- Endothelium-vasodilators: Nitric oxide (NO) ,Bradykinin and Prostacyclin

All these factors are released during metabolic reactions of the myocardial cells causing some degree of coronary vasodilation. With increased metabolic activity they are released in higher amounts leading to more coronary dilation.



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.

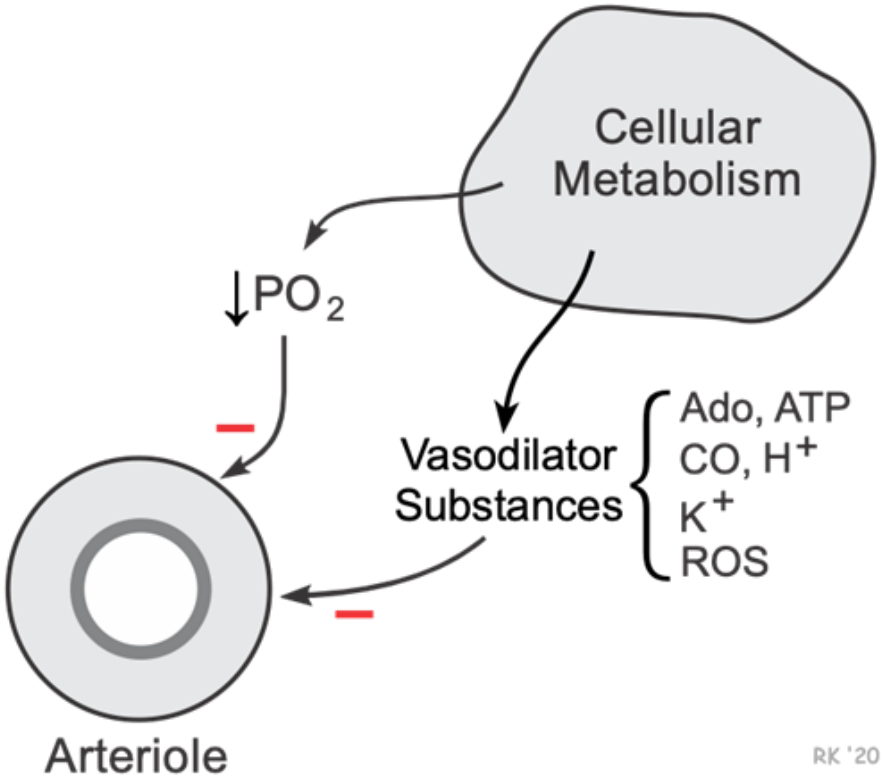
Metabolic autoregulation

Autoregulation :

Intrinsic ability of an organ to maintain a constant blood flow despite changes in perfusion pressure , independent of any neural or humoral influences.

Increased metabolic activity of the heart dilates the coronary blood vessels which is induced by:

- **Hypoxia.**
- **Vasodilator metabolites** :
  1. Adenosine
  2. CO2 and H+
  3. Lactic acid
  4. K+
- **Endothelium-vasodilators:**
  1. Nitric oxide (NO)
  2. Bradykinin.
  3. Prostacyclin.

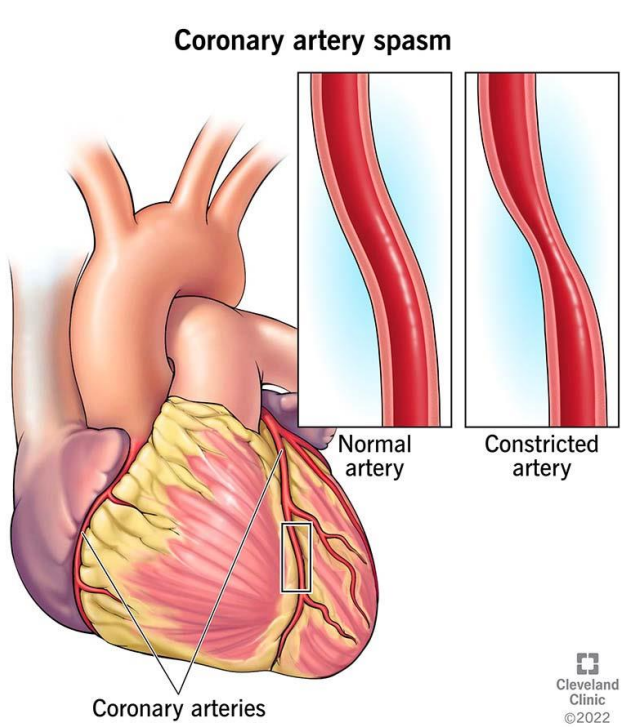


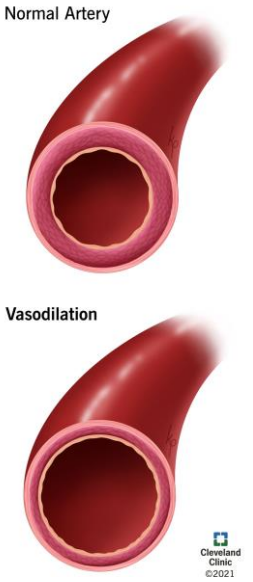
Myogenic autoregulation

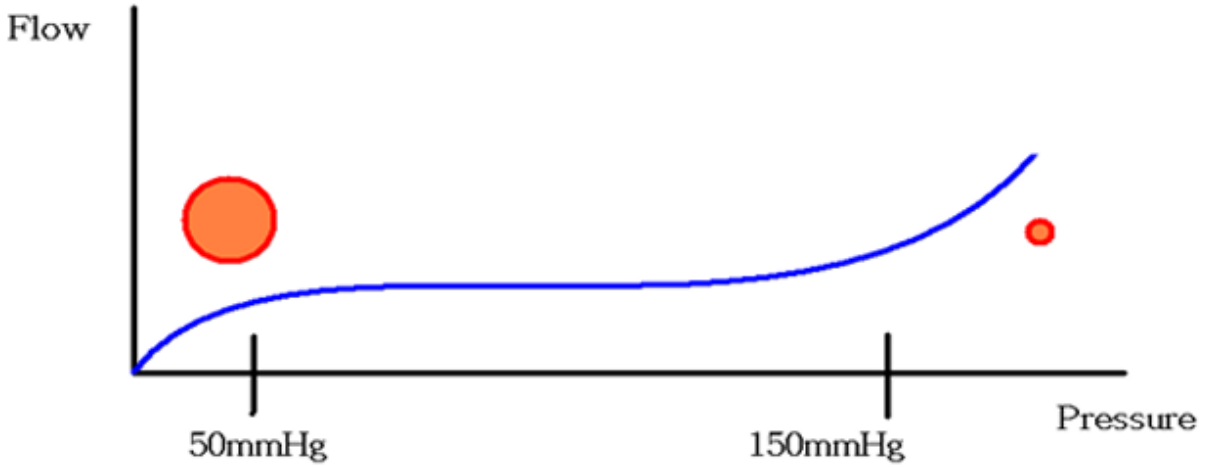
Myogenic autoregulation of the coronary blood flow is done by coronary constriction when pressure increases and dilation when pressure decreases to maintain adequate coronary flow regardless of the pressure level. The mechanism :

Blood pressure increases → distention of the arteriole and stretch of its wall →intrinsic myogenic contraction response → vasoconstriction.

The opposite reaction occurs when the blood pressure falls → vasodilation.



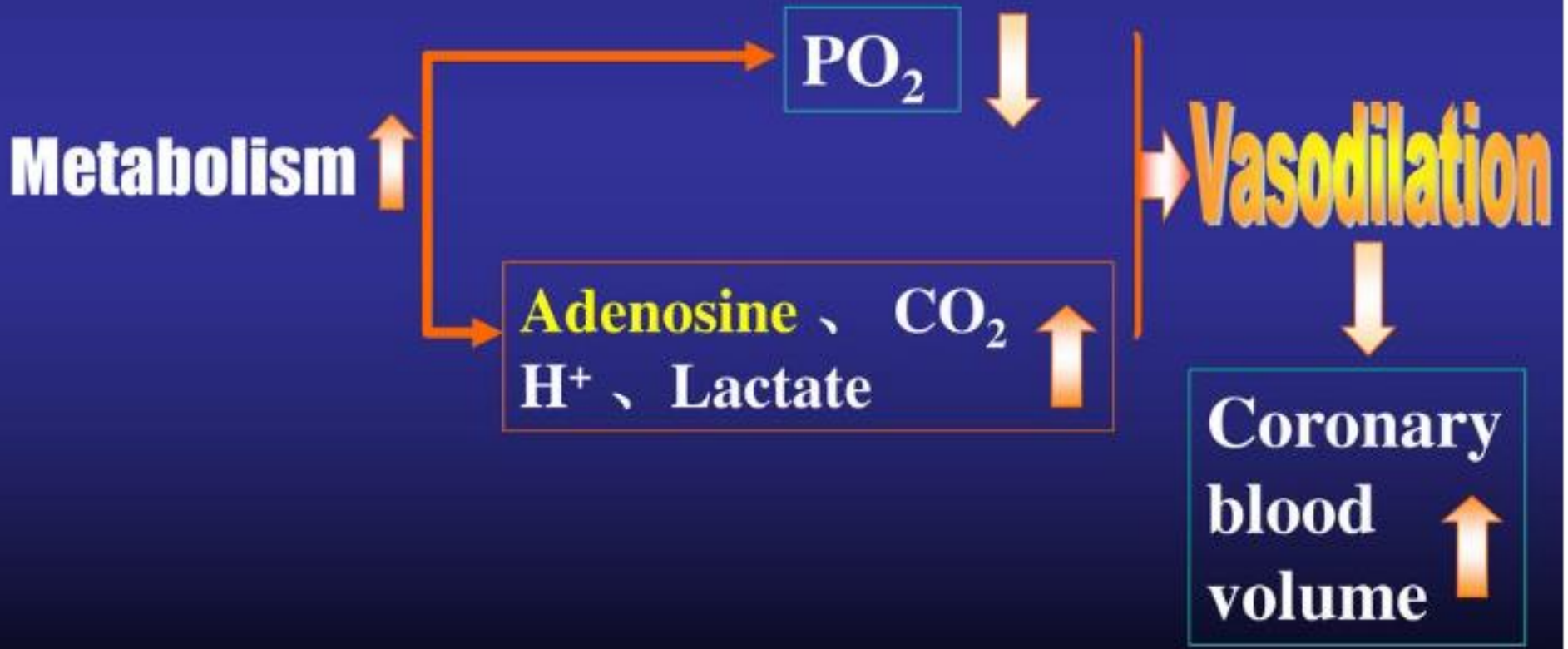




Regulation of Coronary Circulation

1.Metabolic autoregulation

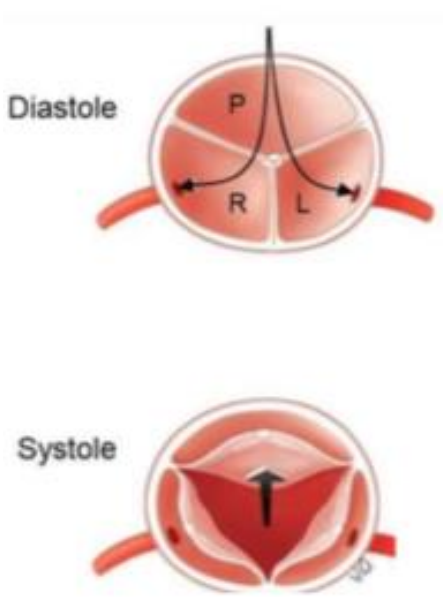
Chemical Factors

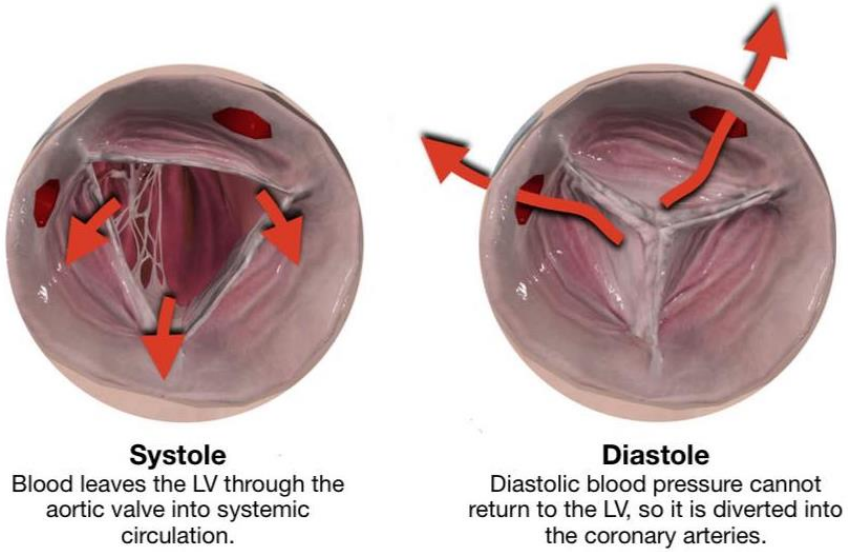


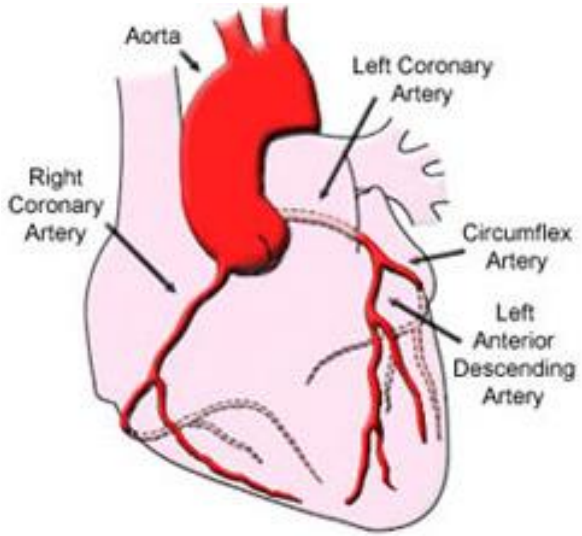
2- Mechanical factors

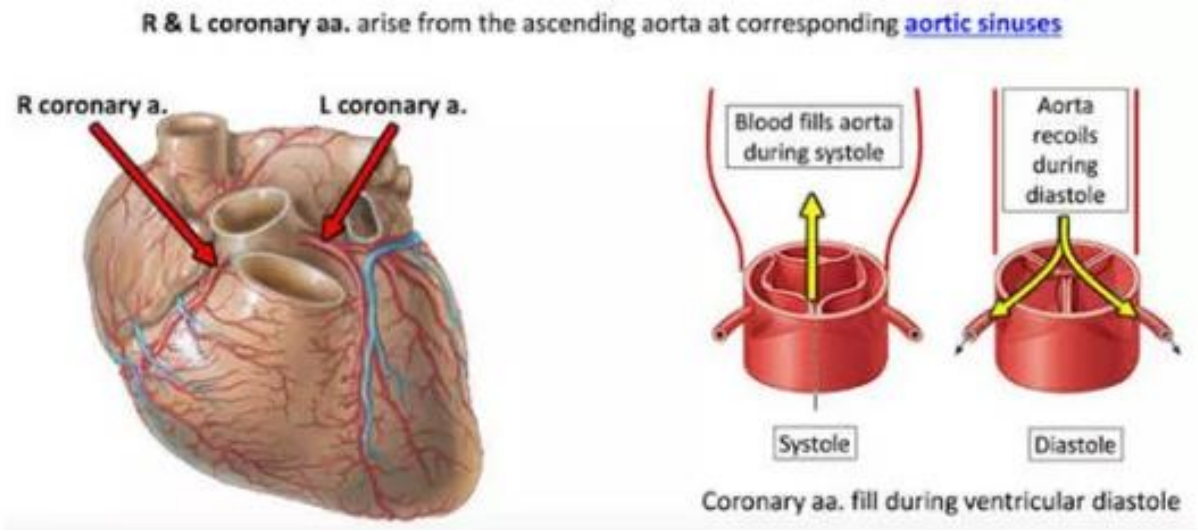
- The phase of the cardiac cycle:

The left ventricle gets its blood supply mainly during diastole. The highest flow occurs during the isometric relaxation phase. During the isometric contraction phase, the left ventricular myocardial fibers squeeze the coronary vessels between them, stopping the blood flow in them.





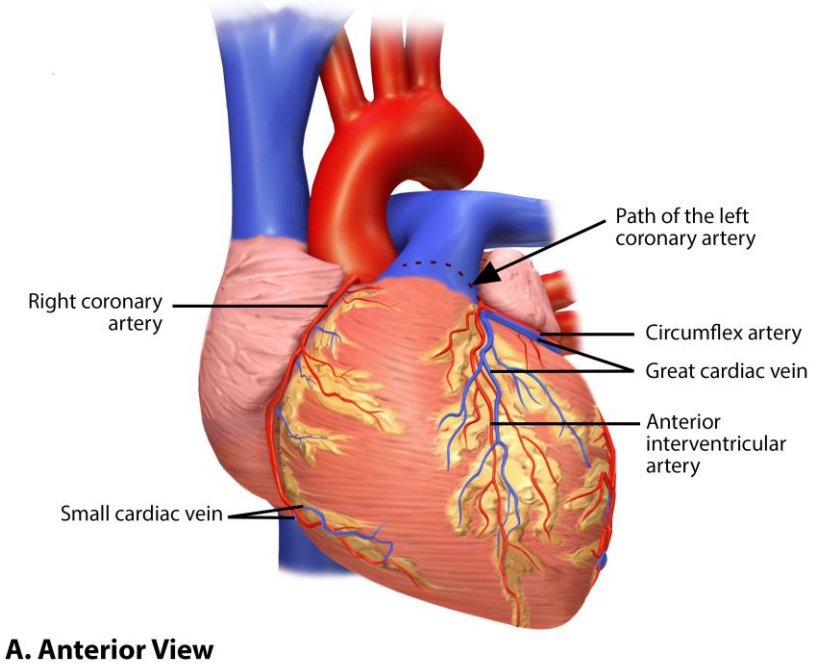


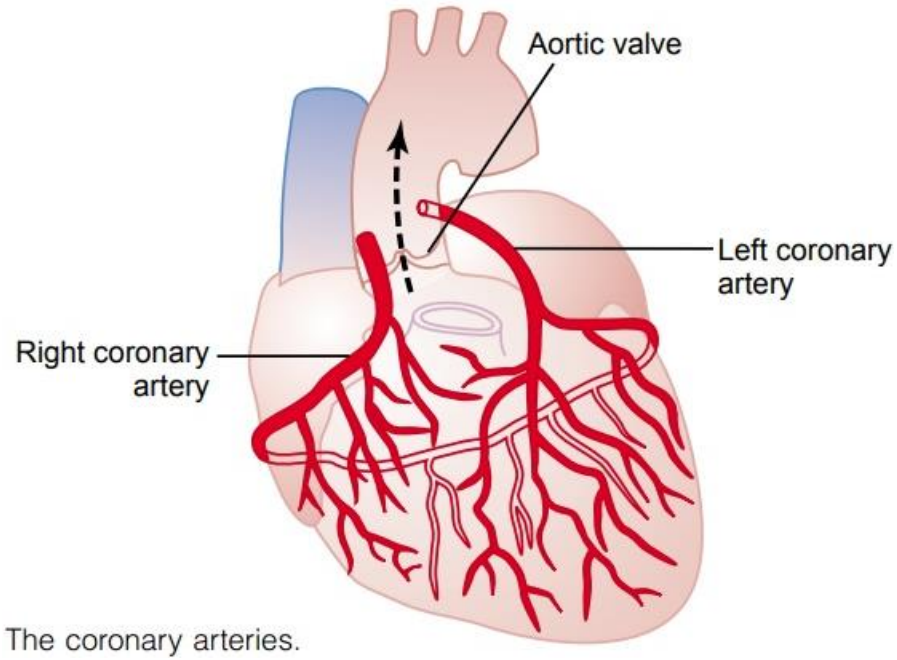


Mechanical factors …cont.

The aortic pressure: As the aortic pressure is the perfusion pressure for the coronary blood flow, **acute changes in aortic blood pressure are accompanied with parallel changes in the coronary blood flow.**

However, if the change is long lasting, the tone of the coronary vessels is readjusted to maintain adequate coronary flow regardless of the pressure level **(Autoregulation of the coronary blood flow).**





The coronary arteries.

Mechanical factors …cont.

The heart rate:

An **increase in the heart** rate influences the coronary blood flow in two opposite ways:

① It decreases the diastolic period, so decreasing the coronary blood flow.

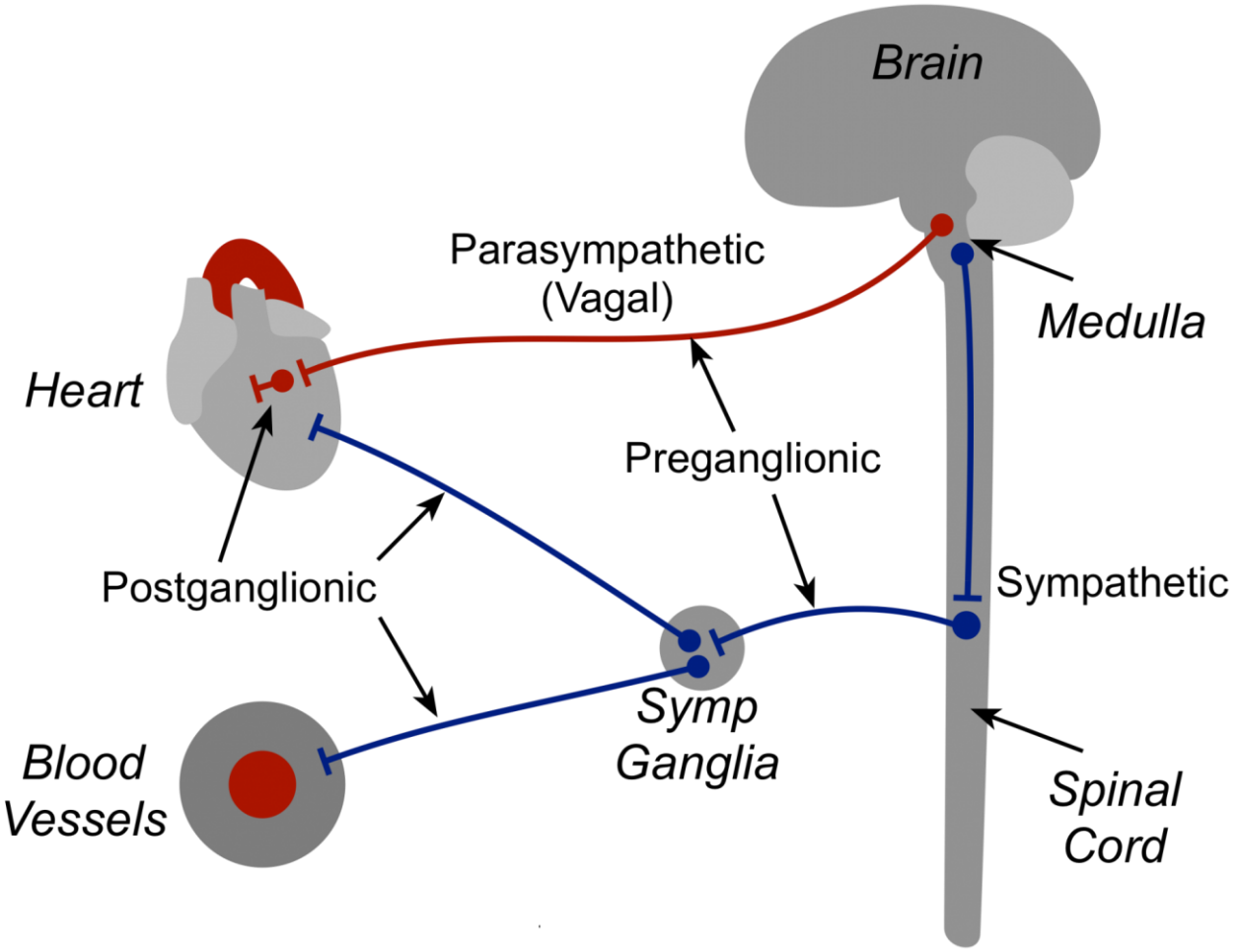
② It increases the metabolic activity, so increasing the coronary blood flow.

A **decrease in heart rate** decreases the metabolic activity and decreases the amount of vasodilator metabolites.

3- Nervous factors

Sympathetic stimulation increases the metabolic activity of the heart which has a strong vasodilator effect on the coronaries through the release of vasodilator metabolites.

Parasympathetic vagal stimulation decreases the heart rate and metabolic activity thus it decreases coronary blood flow



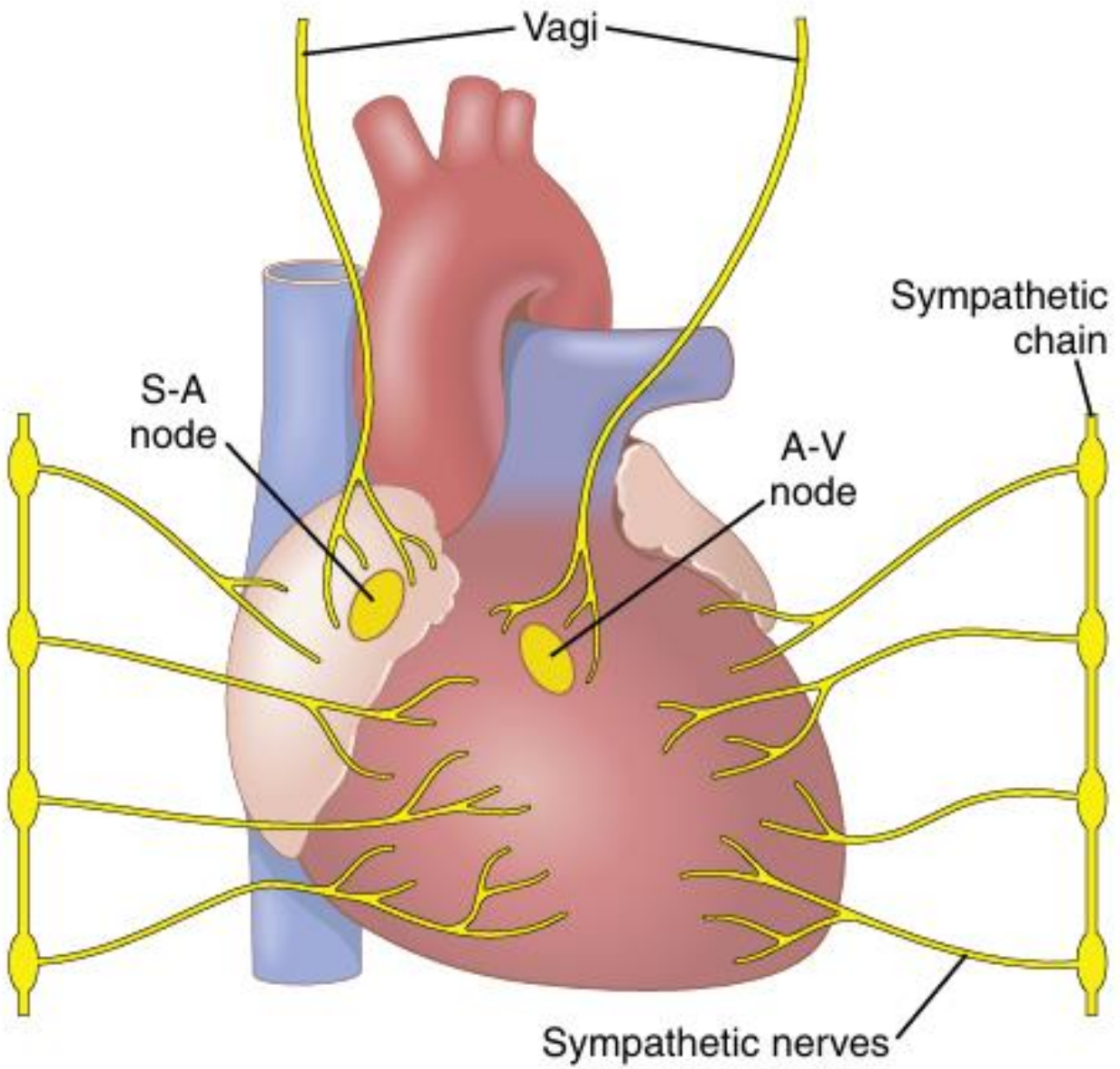
Nervous factors …cont.

Figure:

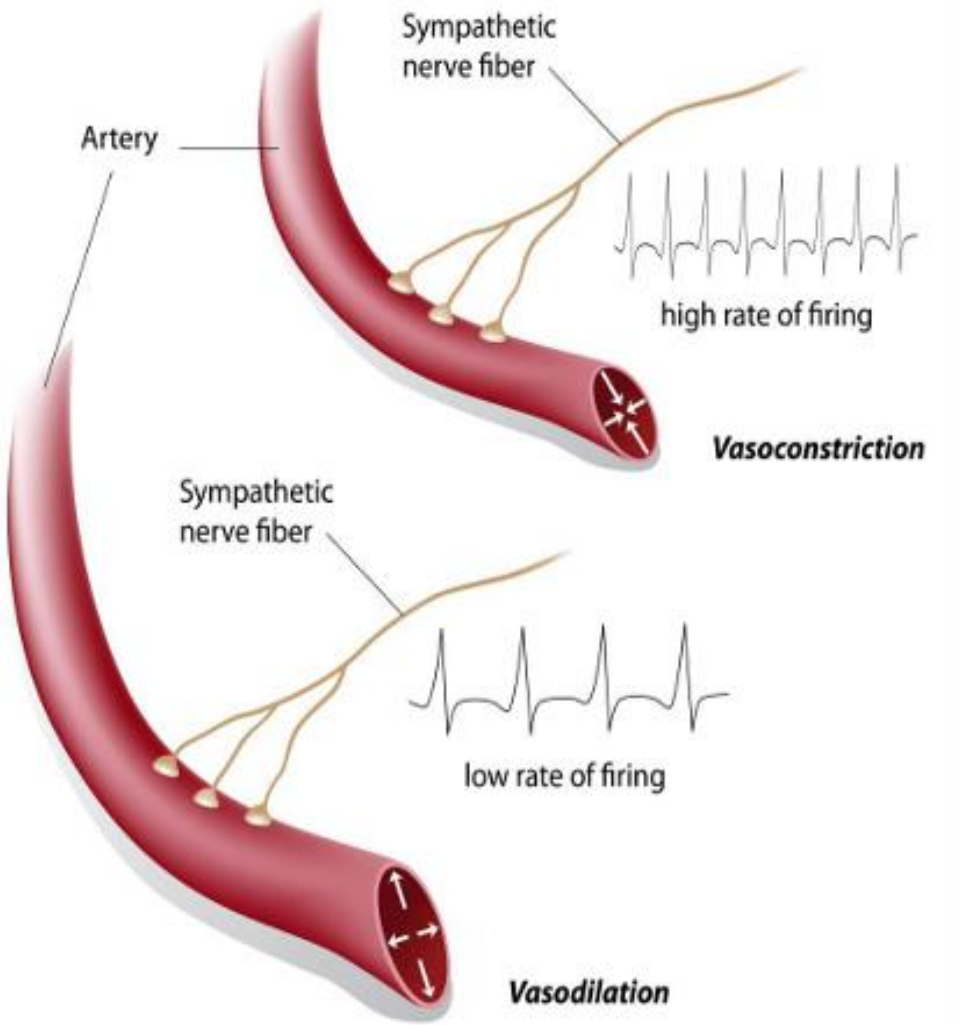
Cardiac sympathetic and parasympathetic nerves.(The vagus nerves to the heart are parasympathetic nerves.)

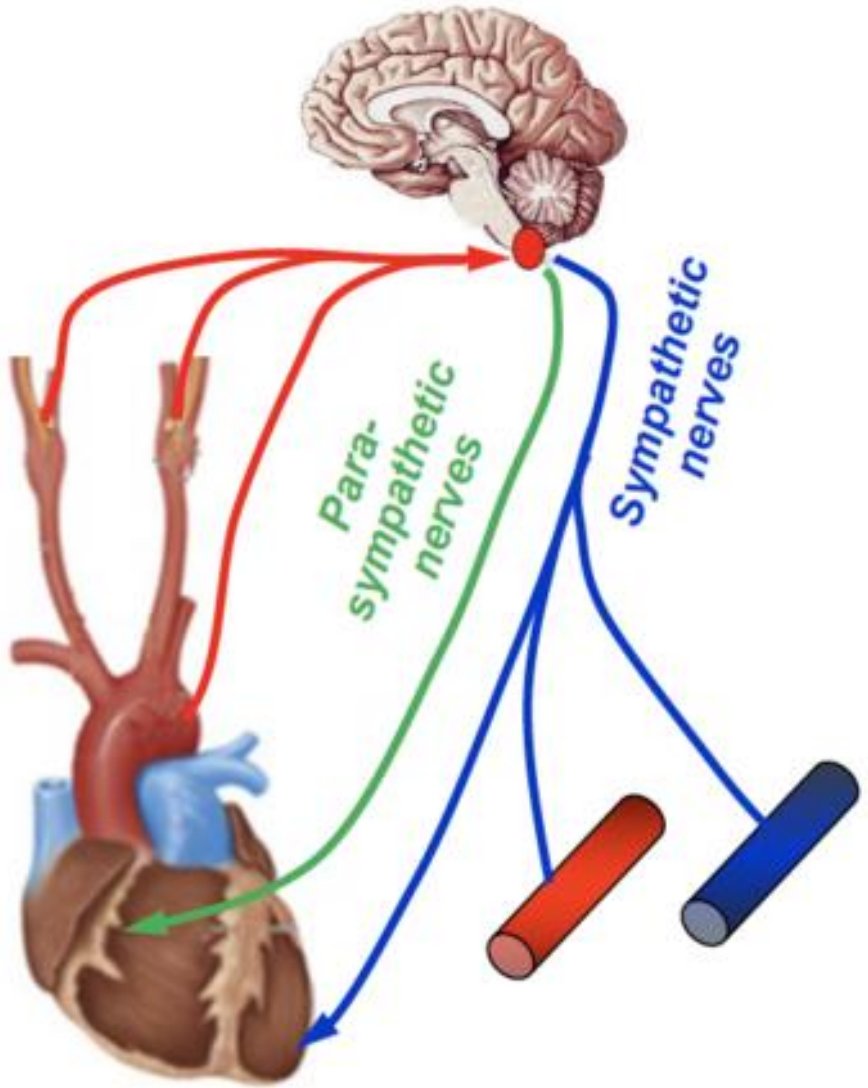
A-V, Atrioven tricular node ;

S-A, sinoatrial node



Nervous factors …cont.



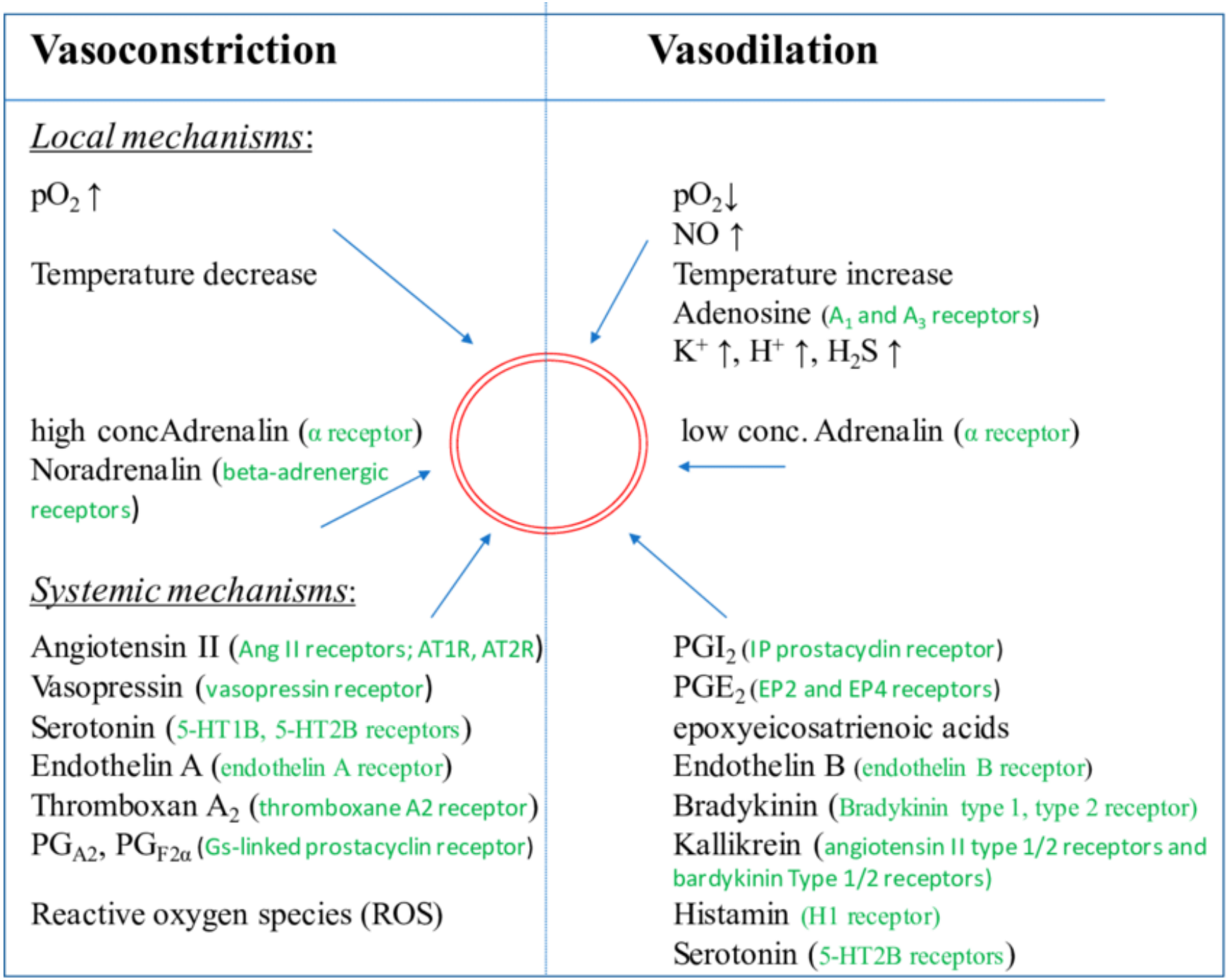


4- Hormonal factors

- **Noradrenaline** is secreted by the sympathetic nerves and the adrenal medulla. It is a strong vasoconstrictor of the coronaries by stimulating the α-adrenergic receptors.
- **Adrenaline** is secreted by the adrenal medulla. It stimulates the metabolic activity of the heart leading to coronary vasodilation.
- **Vasopressin (also called antidiuretic hormone - ADH**). It is a hormone secreted by the posterior pituitary gland in response to hypovolemia or plasma hypertonicity. It is a strong vasoconstrictor of all vessels including the coronaries.
- **Angiotensin II** is formed during hypotension, hypovolemia, hyponatremia or renal ischemia. It is a powerful constrictor of vessels including the coronaries.

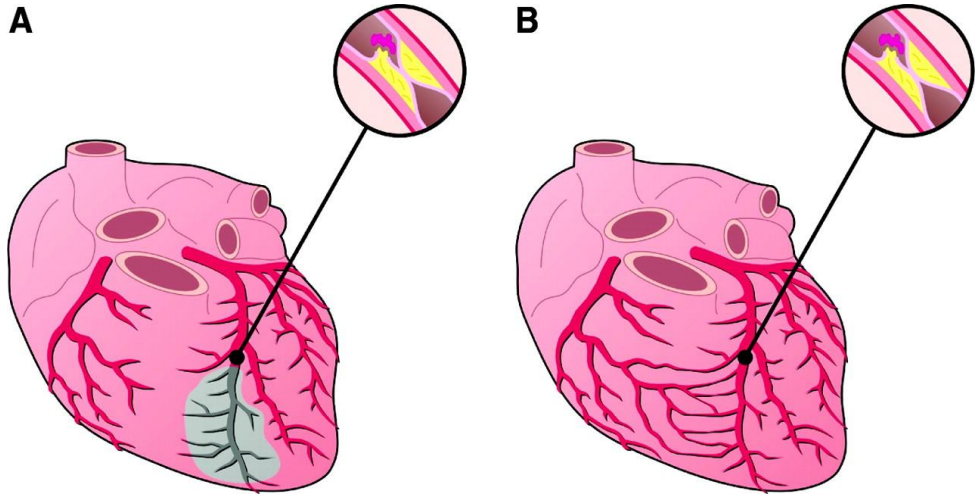
- Vasoconstrictors tighten the blood vessels to raise blood pressure.
- Vasodilators dilate or widen the blood vessels to improve blood flow and lower blood pressure.

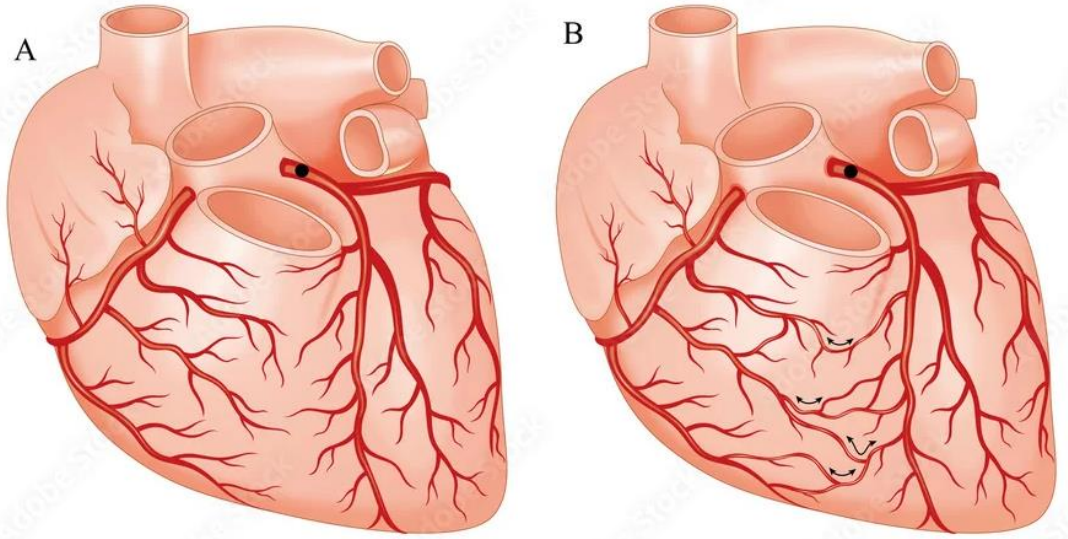



Vasoconstriction
Vasodilation
Local mechanisms:
pO2 ↑
Temperature decrease
high concAdrenalin (α receptor)
Noradrenalin (beta-adrenergic receptors)
Systemic mechanisms:
Angiotensin II (Ang II receptors; AT1R, AT2R)
Vasopressin (vasopressin receptor)
Serotonin (5-HT1B, 5-HT2B receptors)
Endothelin A (endothelin A receptor)
Thromboxan A2 (thromboxane A2 receptor)
PGA2, PGF2α (Gs-linked prostacyclin receptor)
Reactive oxygen species (ROS)
pO2↓
NO ↑
Temperature increase
Adenosine (A1 and A3 receptors)
K+ ↑, H+ ↑, H2S ↑
low conc. Adrenalin (α receptor)
PGI2 (IP prostacydin receptor)
PGE2 (EP2 and EP4 receptors)
epoxyeicosatrienoic acids
Endothelin B (endothelin B receptor)
Bradykinin (Bradykinin type 1, type 2 receptor)
Kallikrein (angiotensin II type 1/2 receptors and bardykinin Type 1/2 receptors)
Histamin (H1 receptor)
Serotonin (5-HT2B receptors)

Coronary anastomoses and angiogenesis

- With sudden occlusion of a coronary artery, the small anastomoses dilate within few seconds **(metabolic autoregulation).**
- **Angiogenesis is stimulated by the severe local hypoxia**; New vessels appear and start to allow blood flow after 8-24 hours.
- **Angiogenesis continues at a lower rate afterwards to take the flow back to the normal basal level in about one month.**

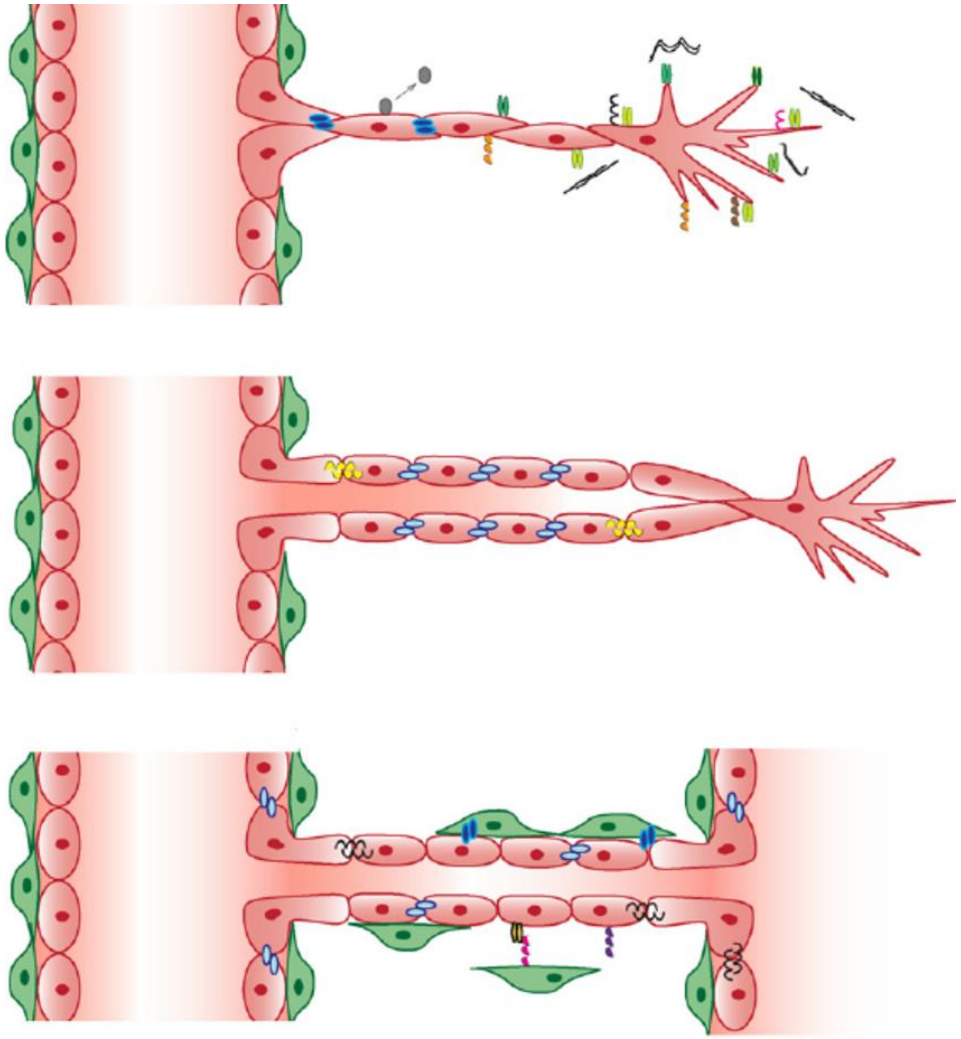




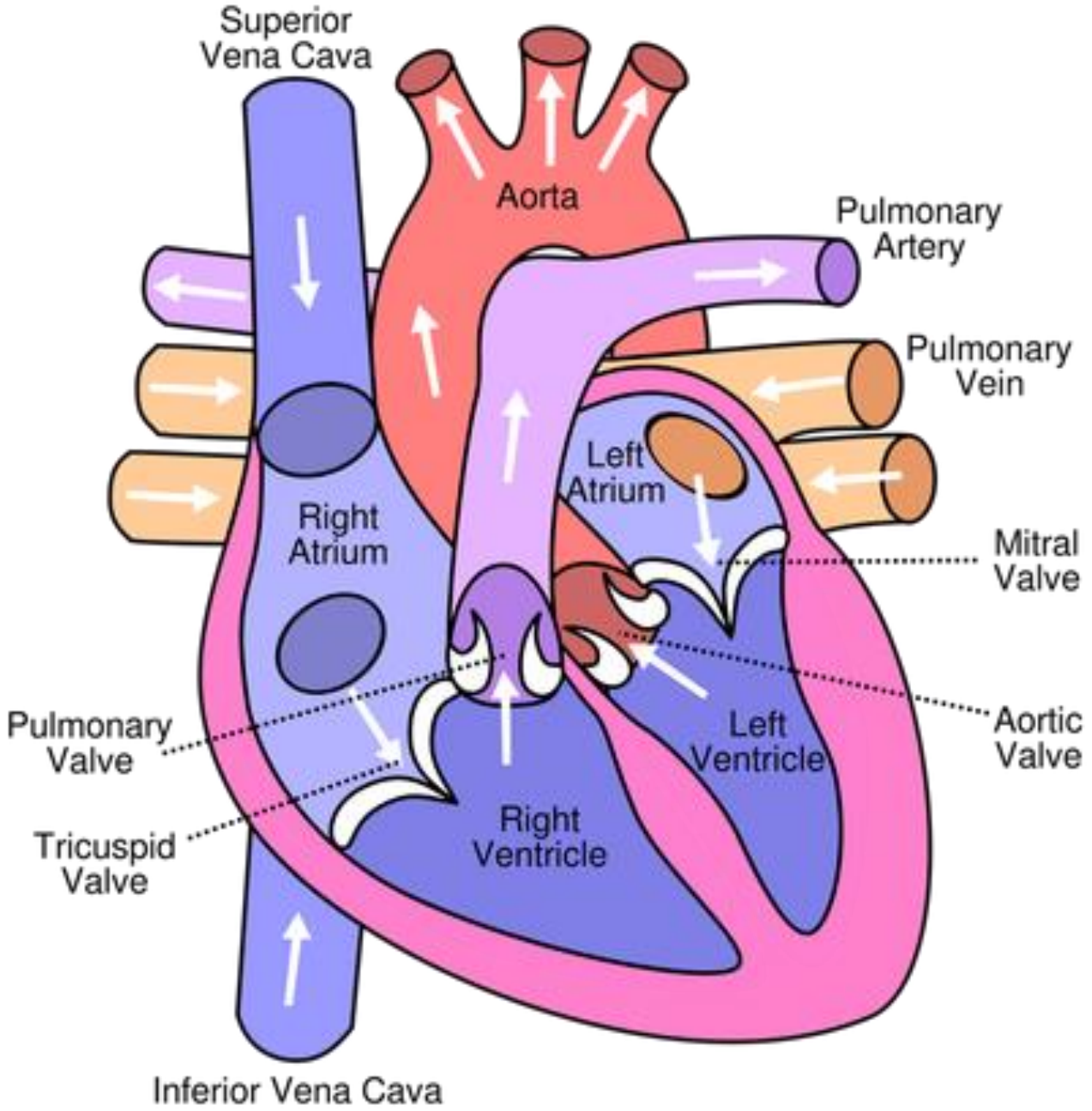
Collateral circulation protection in acute left main artery occlusion

Figure : Schematic drawing of the coronary artery circulation without (A) and with interarterial anastomoses (B) between the right coronary artery and the occluded left anterior descending artery (occluded downstream of the third diagonal branch). → →

Angiogenesis



The Heart


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava



THANK YOU