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Chapter I

Properties of the myocardium

The heart pumps the blood along the vascular networks, providing the oxygen and nutrients needed by the organs and tissues and removes toxic substances. Thus, the cardiovascular system has three components with a functional role:

1. ***HEART*****,** muscular organ, with a double pump function, the left heart having a role in maintaining the large circulation (of high pressure, systemic) and the right pump having a role in maintaining the pulmonary circulation;
2. ***BLOOD***
3. vascular system:***systemic and pulmonary circulation*****,** connected in series. It constitutes of:

- ***arteries*** which are blood vessels that distribute oxygenated blood**:**
  - *elastic type arteries* (large arteries: aorta, subclavian, carotid, iliac), with a conduction role; these transform the pulsatile blood flow (generated by the rhythmic activity of the heart) into a continuous flow;
  - *muscular type arteries* (medium arteries) involved in vasoconstriction and vasodilatation, constituting the resistance territory;
  - *arterioles and metaarterioles.*
- ***capillaries and postcapillary venules*** which play a role in carrying out the exchange between blood and tissues;

- ***veins*** – collect blood, ensuring its return to the heart and have the function of a blood reservoir, containing approximately 65% of the total blood volume**.**

From the inside out, the heart is made up of:

- ***endocardium****:* lines the cardiac chambers on the inside, having a protective role; it consists of cells similar to endothelial cells and, through direct contact with intracavitary blood, prevents the formation of thrombi through its smooth surface; it has the least vascularization among the three layers, being the first to be affected during ischemic processes;
- ***myocardium*** (heart muscle): ensures the pump function of the heart, being formed of modified muscle fibers, cardiomyocytes; it is more present at the level of the ventricular structures, especially at the level of the interventricular septum and the left ventricle;
- ***pericardium:*** it has the 2 layers, the serous (visceral), also known as the epicardium, and the fibrous (parietal) layer; these leaflets delimit the pericardial space which contains a small amount of pericardial fluid. The pericardium has a protective, fixing and mechanical role, reducing the friction of the cardiac walls.

The accumulation of **more than 50 ml** of liquid in the pericardial space is called **liquid pericarditis**, being frequently of neoplastic, tuberculous or autoimmune etiology. Clinically, it is manifested by precordial pain, pericardial friction, and diffuse changes appear on the ECG, such as: ST elevation with PR depression and global decrease in path amplitude (low voltage complexes).

PROPERTIES OF THE MYOCARDIUM

- EXCITABILITY/ bathmotropic function;
- AUTOMATISM / chronotropic function;
- CONDUCTIVITY/ dromotropic function;
- CONTRACTILITY/ inotropic function;
- RELAXATION/ lusitropic function.

Excitability (bathmotropic function)

It is the property of the myocardial cell to respond to stimuli by producing a propagated action potential. The myocardial cell has a special property: it is excitable only in diastole to ensure the role of a rhythmic pump (in systole it is in the absolute refractory phase) - ***the law of periodic inexcitability of the heart.***

The membrane of the myocardial cell is polarized, because there is an unequal distribution of electrical charges on either side of the membrane, through the permanent activity of ***membrane transport systems*** at rest.

When a stimulus with threshold intensity acts on a myocardiocyte, structural changes occur in the canalicular proteins, causing them to open. The passage of ions through specific membrane channels generates ionic currents of two types:

- ***Depolarizing current,***which causes the intracellular penetration of positive charges (Na, Ca), decreasing the electronegativity;
- ***Repolarizing current***, which causes positive charges (K) to leave the cell, increasing the electronegativity inside the cell.

Transmembrane transport systems are represented by:

1. Ion channels

K channels

a. ***Inwardly rectifying potassium channels (Kir)*** - active in the resting phase; these are of several types:

- **Kir (K1)** role in maintaining the resting potential around -90 mV;
- **K_{ATP}** (ATP-dependent potassium channels), metabolically regulated: are stimulated (opened) by reduction of intracellular ATP (normal ATP levels block activation), producing membrane hyperpolarization (via K efflux):
  - in conditions of ischemia (ischemia is accompanied by ATP depletion), hyperpolarization causes a decrease in myocardial contractility,thus protecting it;
- **mediator-dependent potassium channels** (Ex: adenosine, acetylcholine, etc.) are activated through specific receptors.

b. ***Voltage-gated potassium channels*** are slowly activated after depolarization, playing a role in repolarization and determining the action potential duration:

- **outward transient potassium current** (Ito): responsible for phase 1 of the AP;
- **the slow potassium channel, K_s** (slow);
- **fast potassium channel, K_r** (fast)**;**
- **ultrafast potassium channel, K_{ur}** (ultrarapid current), determines the shorter duration of AP, being present at the level of the atria**.**

Voltage dependent Na channels are active in phase 0 of rapid depolarization

Voltage dependent Ca channels are of 2 types:

a. ***Type L*** (long lasting)

- have an activation threshold of -40 mV;
- it activates slowly;
- are found in:
  - working myocardial fibers => phase 2 of AP;
  - node cells => phase 0 of AP;
  - skeletal muscles => excitation-contraction coupling**.**

b. ***Type T*** (transient)

- have an activation threshold at more electronegative values of the membrane potential (< -40 mV);
- it activates quickly;
- are found at the level of the NSA => repetitive BP discharges (diastolic depolarization).

Non-selective ion channels:

a. channels that mediate the ***pacemaker current, If*** (the funny current) and take part in the spontaneous diastolic depolarization of cells with automatism; this means that:

- are activated by hyperpolarization;
- cause the entry of intracellular Na+ (occasionally also the transfer of K+);

– ivabradine and acetylcholine inhibit these channels.

b. channels that are ***stretch activated***, permeable especially for Ca, are responsible for mechano-electrical feedback and have arrhythmogenic potential.

2. Ion pumps –primary active transport systems

a. ***ATP-ase dependent of Na and K***

- it is electrogenic: it actively introduces 2 K+ ions into the cell and removes 3 Na+ ions;
- is inhibited by digitalis.

b. ***ATP-ase dependent of Ca***

- forces cytoplasmic Ca out.

3. Ion exchangers

a. ***the Na+/Ca++ exchanger***

– located especially at the level of the T-tubes;

– is a voltage-sensitive system:

- negative potentials (< -40 mV) expel Ca;
- more positive potentials (> -40mV) introduce Ca into the cell.

b. ***the Na+/H+ exchanger***

– intervenes in conditions of myocardial ischemia, protecting the heart from intracellular acidosis

Action potentials in the myocardium

Depending on the speed of depolarization, two types of myocardial fibers are differentiated:

a. with ***fast answer***– atrial myocytes, Purkinje fibers and ventricular myocytes; AP has 5 distinct phases;

b. with ***slow answer***– in ASN, AVN; AP is conducted in only 3 phases.