Practical 2: Action potentials in the heart. The law of periodic inexcitability of the heart. The influence of ions and mediators on heart activity. Effect of vagal stimulation on heart activity. Vagal escape

Objectives:

1. **Excitability** and **resting potential**
2. The **action potential** in the myocardium
3. The **law of periodic inexcitability** of the heart - computer simulation (PhysioEx 8.0)
4. Effect of **ions** and **mediators** on the heart
5. Discuss the effect of **vagal stimulation** on the heart rate and **vagal escape** - computer simulation (PhysioEx 8.0)

Excitability and resting potential

Define the resting potential and the mechanisms that maintain it.

The action potential in the myocardium

Define the threshold value and initiation of the action potential.

a. Slow response fibers

b. Fast response fibers

Define the refractory period: the absolute and relative refractory period.

Law of periodic inexcitability of the heart

This law states that while depolarized, the heart doesn't react to any other stimulus, being in the absolute refractory period. There is a short period of time, at the end of the action potential, when the cardiac cell can respond to additional stimuli, generating a premature depolarization and a premature contraction, called extra-systole or premature beat, which is usually followed by a compensatory pause.

In the lab, the cardiac mechanical activity and its response to different electric stimuli can be recorded on the frog heart as a *direct cardiogram*, using the Marey cardiograph (called direct because the cardiograph is connected directly to the heart). Marey cardiograph is composed of two paddles, one fixed and one mobile connected to a pen; you will place the beating heart between these two paddles, in order to observe the changes in volume and shape of the heart, by means of a kymograph that rotates to record the movements of the mobile paddle. Single or multiple electric stimuli of different frequencies can be applied during systole and diastole (during different phases of the action potential) and the recording is then observed. The heart will not respond during the absolute refractory period. Extra-systoles and the

compensatory pauses that follow can be observed when the stimulus is applied during the relative refractory period. The experiment can be simulated on a computer using the PhysioEx 8.0 software.

Effect of ions on the heart

Hyperpotasemia: decline in heart rate and contractility; for high K+ levels, the heart stops in diastole.

Hypercalcemia: rise in heart rate and contractility; at very high Ca concentration, the heart stops in systole (rigor calcis).

Acidosis (lactic acid): decline in heart rate and contractility; high acidity can irreversible damage the heart.

Ions effects on the frog heart can be simulated on a computer using the PhysioEx 8.0 software.

Effect of autonomic nervous system mediators on the heart activity. Vagal stimulation.

Both the parasympathetic and sympathetic nervous systems innervate the heart. Sympathetic fibers are distributed both to atriums and ventricles, while parasympathetic fibers are supplying the atriums, SA node and AV node.
Stimulation of the sympathetic nervous system (adrenaline, noradrenaline release) increases the rate and force of contraction of the heart. Stimulation of the parasympathetic nervous system (vagal nerves, through acetylcholine) decreases the depolarization rhythm of the sinoatrial node and slows transmission of excitation through the atrio-ventricular node.
If vagal stimulation is excessive, the heart stops beating. After a short time (few seconds), the ventricles begin to beat again, at a lower frequency. This phenomenon is called **vagal escape** and may be the result of an idioventricular rhythm, acetylcholine depletion or sympathetic stimulation.

Vagal stimulation effect on the frog heart and vagal escape can be observed on a Marey cardiograph, by stimulating the nerve with a DC current using an electrode.
The experiment can be simulated on a computer using the PhysioEx 8.0 software.

In clinics, parasympathetic stimulation is obtained through the different vagal maneuvers: Valsalva maneuver; Dagnini –Aschner (oculo –depressor reflex); carotic sinus massage; viscero–vagal reflex.