ECG from an Isolated Frog Heart

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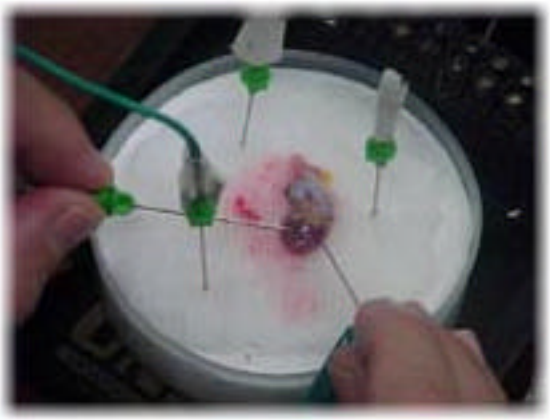


The simple experiments with isolated frog (or toad) heart are usually rather interesting for any young experimentalist even if only the visual observation of different effects (potassium ions, adrenaline etc.) is used. With PowerLab system such experiments appear to be much more impressive as well as serious. Demonstration experiments described below can be included in courses of general physiology and pharmacology (before classic experiments with Langendorff heart), as well as biophysics or medical physics.

PowerLab system should provide measurements of ECG (BioAmplifier), electrostimulation of the heart (Stimulus Isolator) and standard analog output (for model experiments). We have used combination of PowerLab 410 with MacLab/2e. The modern models PowerLab/4ST or PowerLab4/20T are ideal for experiments described below.

The standard Petri dish can be used as a simple **"organ chamber"** for experiments with isolated frog heart *in vitro*. A round disk (around 5 mm thickness, made from an appropriate piece of plastic foam) should be placed on the bottom of the dish and covered with two or three layers of medical gauze or other appropriate material soaked with physiological saline (PS), e.g. Ringer solution. It is useful to combine such an "organ chamber" with a reservoir on a stand, to provide an opportunity to wash the heart by falling drops of PS from the reservoir, and also to provide easy connections and positions of cables from/to your PowerLab.

Pin electrodes for measuring ECG *in situ* and *in vitro* can be made from syringe needles of appropriate size. To provide an easy connection to the standard PowerLab ECG cable with snap lead wires (R, L and Earth) they can be connected by the thin isolated wires to the metal parts of

disposable ECG electrodes. For measurement of ECG pin electrodes can be attached to or pricked into any places around the heart. Another pair of the same needle electrodes for electrostimulation of the heart should be connected appropriatly to the PowerLab output or to an Isolated Stimulator.

It is very attractive for the students to construct a "human phantom" for experiments with the isolated frog heart. A special chamber - the **"human phantom"** can be made from an appropriate piece of plastic foam. It is very easy to "draw" on the surface of this material (using a knife, or chloroform, or hot solder) a silhouette of a man, and to fill it with PS. When a beating isolated heart is placed in the appropriate area and positioned in the "chest" of phantom, all planar ECG leads are available for measurement using pin electrodes.

Exercises:

1. ECG in situ

2. ECG in vitro

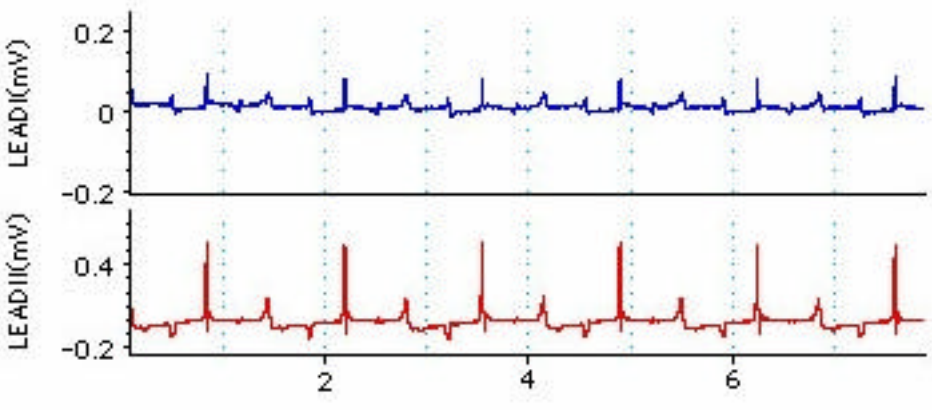
3. If heart "stops"

4. Frog heart with cardiostimulator

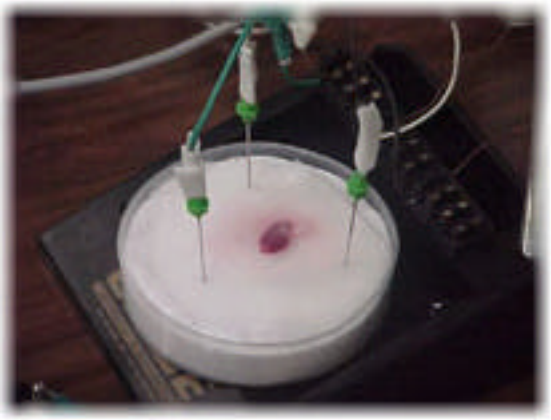
5. Miocardial "Infarction"

Exercise 1: ECG in situ

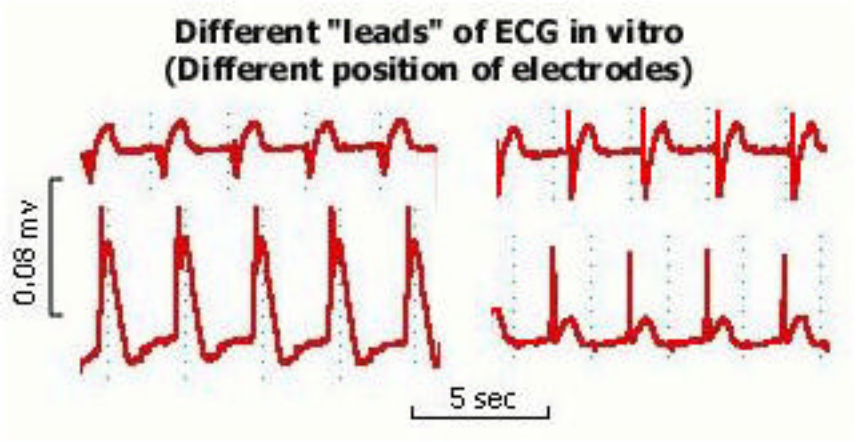
It is very easy and worthwhile to measure ECG signal (e.g. I and II standard leads for human) with a whole frog, before opening the chest, but after decapitation and destruction of the spinal cord (medulla).Later Chart extension Vector ECG can be used very effectively.



Exercise 2: ECG in vitro



The procedure of preparation of the heart (the dissection of the chest and accurate extirpation of the heart, washing it in PS) lasts around 2 min. When the heart is placed in Petri dish it usually continues beating. If not, a mechanical stimulation or treatment with adrenaline can help to "reanimate" it. In the course of experiments the heart should be washed periodically with dropping PS. Visual observation of the heart beatings *in vitro* leads to the conclusion that contraction (excitation) starts in the area of atria and then the wave of excitation moves to the ventriculus.



The quite "normal" ECG signal is observed when three electrodes are placed in three points corresponding to the position of electrodes around the heart where human ECG is measured (two hands and one leg). It is easy to try to identify also R peak as the moment of contraction of ventricle using visual observation, or force transducer (with Bridge Amplifier front-end), or even with the simple standard finger pulse piezo-transducer.

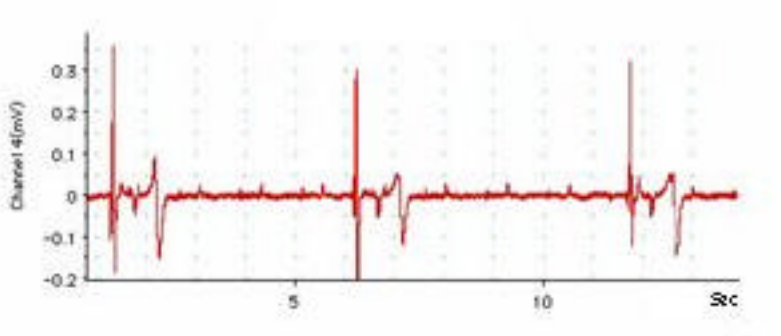
Experiments on the effect of the position and recombination of electrodes on the shape, amplitude and noise are very demonstrative, as well as the effect of changing the position of the heart.

Discussion in the course of experiment:

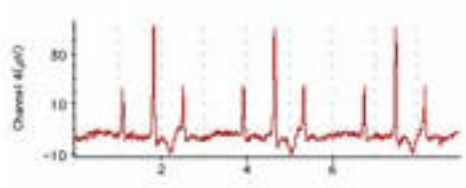
1. *What is a mechanism of the excitation and how it propagates in the heart muscle?*
2. *What is a mechanism of contraction?*
3. *What is the mechanism of pacemaker activity?*
4. *What is a mechanism of generation of electric field outside the heart?*
5. *What are we measuring from physical point of view: current or voltage?*
6. *What is the electrical axis of the heart and how it manifests itself in this experiments?*
7. *Amplitudes of the peaks. Triangle of Einthoven. Can we see it in this experiment?*
8. *Why we can discriminate using ECG astenic and hyperstenic people as well as hypertrophy of left or right ventricles?*
9. *Why different methods of measurements of ECG (number/position of electrodes) are used in medical practice?*

Exerciese 3: If heart "stops"

If heart "stops" occasionally (no contractions of ventricle) it is not a problem, but a chance to demonstrate an "intensive therapy": slight direct massage (e.g. with fingers, or with a drop of PS), or addition of adrenaline, or electrostimulation with pulses from Isolated Stimulator (electrodes applied directly to the heart). The last treatment is usually most effective if appropriate (not to high) stimulus is applied



The heart stop induced by application on miocard of a drop of isotonic solution of potassium ions with following attempts to "heal" the heart with washing, adrenaline administration and/or electric stimulation is another impressive demonstration.



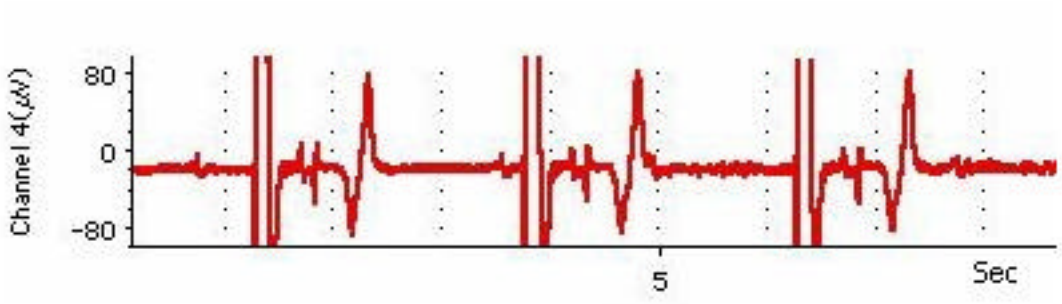
It is interesting that usually in this experiments the contraction of atrium is not stopped and always can be seen visually. It is possible to detect corresponding P peaks and thus identify it in ECG.

Discussion in the course of experiment*:*

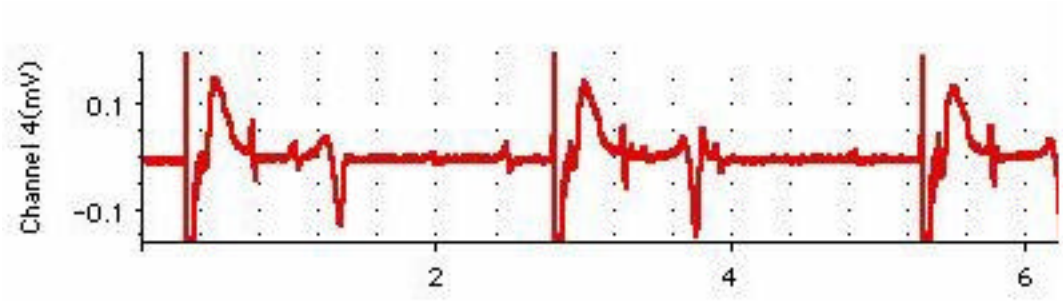
1. *What is happened with the heart when beating stops?*
2. *How different types of treatments recover autonomic contractions?*
3. *What is a mechanism of effect of potassium ions?*
4. *What is a nature of peaks in ECG?*

Exercise 4: Frog heart with cardiostimulator

If it is impossible to recover automatic contractions of ventricles it is always possible to observe contractions of heart stimulated by continuos pulses from Stimulator or Isolated stimulator.



Stimuli can be applied directly to the heart or to the conductive support near of the heart. It is interesting to investigate the range of stimulation rate when the heart works without visible arrhythmia, and also the range of appropriate amplitudes of stimulation signals. Sometimes it is possible to observe the activity of natural pacemaker producing regular contractions of atriums independently on external electrostimulation.



Discussion in the course of experiment:

1. *Basic principles of cardiostimulation of patients.*
2. *Heart rate variability in health and desease*

Exercise 5: Miocardial "infarction"

Miocardial "infarction" can develop spontaneously (surely as a result of previous exercises) or caused specially by local application of crystals of salt (e.g.K+) on the surface of miocard. Appearence of the white spot (for students: "zone of infarct") is accompanied by "pathological" changes of ECG. Very soon the heart irreversibly stops.

Discussion in the course of experiment:

1. *Why the change of ECG is observe at miocardial infarction?*
2. *What is a mechanism of the death of patients with miocardial infarction?*