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A SIMPLE METHOD FOR THE RECORDING OF THE CONTRACTIONS OF THE ISOLATED RAT'S HEART, IF NECESSARY, TOGETHER WITH THE ELECTROCARDIOGRAM

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(3 figures)

Introduction

A large part of our knowledge of the physiology of the heart is based on experiments carried out on the isolated frogs' heart. It is obvious however, that the isolated mammalian heart is a more analogous substrate than the frogs' heart for the study of the physiology of the human heart in health and disease.

The rat presents many advantages as an experimental animal, but the frequency with which the rats' heart contracts (200 to 400 per minute), requires an apparatus specially designed for the recording of this very quick rhythm, particularly if it is necessary to record the mechanical and electrical phenomena simultaneously.

A method is described which enables the recording of the contractions of the isolated rats' heart by electrical transmission. It is possible to register the electrocardiogram simultaneously. The isolated heart is perfused in the usual way according to LANGENDORFF (1895).

Method

Rats weighing about 250 grams were used for the experiments. After fixing a canula (C, fig. 1) in the aorta, the heart is taken out of the anaesthetized and heparinized animal and connected

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with a Langendorff perfusion apparatus. A small and strong magnet, weighing 1.5 grams (M, fig. 1) is attached to the apex of the heart by means of a thread and a small hook. The magnet induces an induction current in the coil (S, fig. 1), in which the magnet is moving up and down; the resulting potential is registered by an electrocardiograph. We used the direct recording two-channel «CARDIOPAN-2» (a). The coil is connected to the second channel of the electrocardiograph and the electrocardiogram is recorded simultaneously, undisturbed by the recording of the mechanical phenomena of the heart, by the first channel, by means of the wires designated for the first

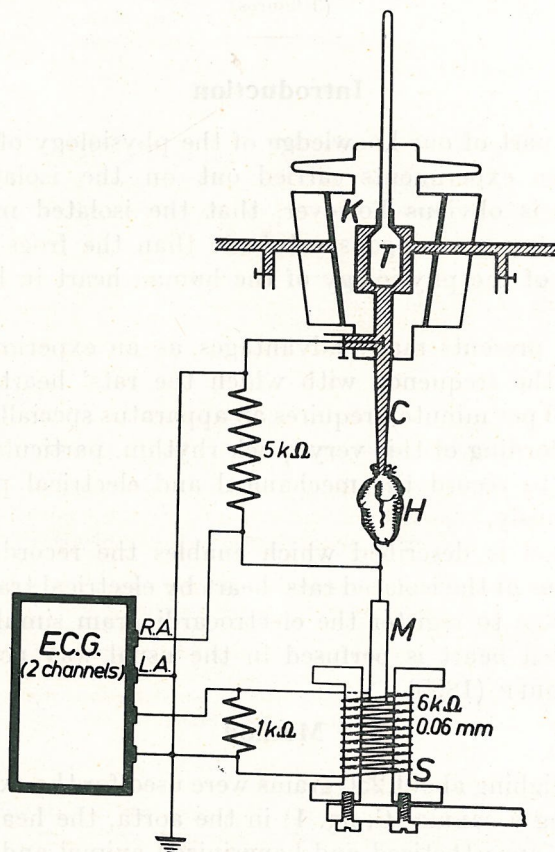


FIG. 1. — Arrangement for simultaneous recording of Inductocardiogram and Electrocardiogram of the isolated rat's heart, perfused according to LANGENDORFF. The aorta is tied to the tip of a canula (C) which is connected to the tap (K), with inbuilt thermometer (T), through which the perfusion fluid is administered.

lead. Figure 1 illustrates the connections, necessary to get a unipolar electrocardiogram. The electrocardiograph is designed for different paper speeds; recording with high speed (50 mm. per sec.) makes the interpretation of the curves easier. The coil has to be carefully protected against the perfusion fluid, which flows out of the heart, e. g. by covering it with solid paraffin.

The method does not record the actual contraction and relaxation of the heart muscle, but the velocity with which these take place. The movements of the magnet induce a current in the coil; the faster the movement, the stronger the current and the larger the registered excursions. If the speed of the movements decreases, the strength of the current diminishes.

The technique is especially suitable for the registration of movements of organs contracting with a high frequency, like the isolated heart of the rat. The method has also been tried to record the mechanical action of the isolated frog's heart, which contracted with a frequency of 30 to 40 per minute. But as a consequence of this slow action, the magnet began to swing, which influenced the curve. If one wishes to determine frequencies only, the technique is suitable for the registration of low frequencies as well. We suggest to call the curve obtained by this technique : « *Inductocardiogram* ».

Results

Figure 2 demonstrates the curve of an inductocardiogram recorded together with the electrocardiogram. The frequency of the heart amounts to 240 per minute. The paper speed is 50 mm. per second. A diagram of an inductocardiogram is presented in figure 3. The following peaks can easily be distinguished :

- a* = contraction phase of ventricular systole ;
- b* = systolic pause ;
- c* = ventricular diastole ;
- d* = diastolic pause.

It seems very probable that the peak « *a* » is analogous to the Maximum-Ejection phase, whereas « *b* », which we suggest to call : « systolic pause », represents the Reduced-Ejection phase.

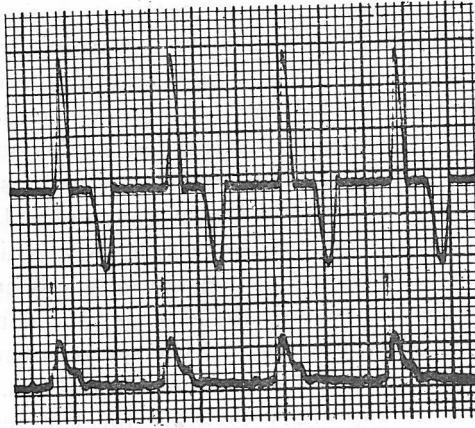


FIG. 2. — Simultaneously recorded inductocardiogram (upper line) and electrocardiogram (lower line) of the isolated rats' heart.

If the contraction height of the heart diminishes at a constant frequency, the magnet covers a shorter distance in the same unit of time so that less current is induced in the coil and the registered excursions decrease. A change in frequency at a constant contraction amplitude, would also result in a change of the height

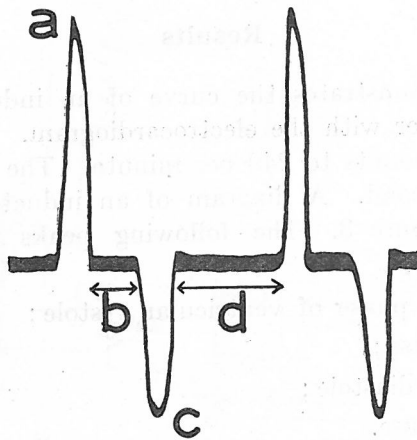


FIG. 3. — Diagram illustrating different components of an inductocardiographic curve.

For details, see text.

of the registered excursions but in reality this never happens, because a decrease of frequency is for the greatest part due to an increase of the diastolic pause and not to an increase of the time necessary for the contraction phase of the ventricular systole.

In our experiments with this technique it was noticed that the survival time of the rats' heart perfused according to LANGENDORFF (1895), increased considerably, in comparison to experiments in which a direct recording of the contractions was used. With the direct recording technique the survival time of the hearts varied from 4 to 6 hours, whereas with the present technique this time has been found as high as 9 hours. This is probably due to the fact that the heart does not need to supply energy for this frictionless registration.

Discussion

The method has the following advantages :

- (1) The apparatus can follow the high frequency of the contractions of the rats' heart easily so that it makes the isolated rats' heart available for physiological, pharmacological and pathophysiological studies.
- (2) It is possible by means of a two- or multi-channel electrocardiograph to record the mechanical and the electrical phenomena of the heart simultaneously.
- (3) As a result of the smaller mechanical burden the survival time of the heart increases.
- (4) It is possible to study the systole and the diastole of the isolated heart separately, especially when the registration paper is used at a high speed.

Summary

A simple method is described by which it is possible to record the mechanical phenomena of the isolated rats' heart by electrical transmission. If necessary the electrocardiogram can be recorded simultaneously.

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- (c) The rats were generously supplied by *Organon Laboratories Inc.*, Oss, Holland.

REFERENCE

LANGENDORFF, O. (1895). — *Pflüger's Arch.*, **61**, 291.