INVESTIGATION OF THE PHASE STRUCTURE OF THE CARDIAC CYCLE IN RABBITS BY POLYCARDIOGRAPHY

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The following durations for the cardiac cycle and its components in rabbits were obtained by polycardiography: cardiac cycle 0.18-0.35 sec, phase of asychronous contraction 0.029±0.001 sec, phase of isometric contraction 0.013±0.001 sec, phase of contraction 0.042±0.001 sec, period of expulsion 0.083 sec, mechanical systole 0.096 sec, total systole 0.125 sec, protodiastole 0.10 sec, and diastole 0.096 sec. The duration of the expulsion period and the durations of mechanical and total systole and also of diastole were found to be significantly dependent (r = 0.86) on the duration of the cardiac cycle.

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Phase analysis of cardiac activity has been widely applied in physiology and clinical medicine as a result of the fundamental investigations by Wiggers [6], who first determined the structure of the cardiac cycle with a high degree of accuracy and gave a full description of it on the basis of curves of the intraventricular and intravascular pressure. Blumberger [5] has given a simple method of calculating the contraction time and expulsion time on the basis of synchronized recordings of the electrocardiogram (ECG), phonocardiogram (PCG), and sphygmogram of the carotid artery. The polycardiographic method of phase analysis is simple, logical, and well-grounded [1-4]. It can be used not only in clinical practice, but also experimentally.

This paper describes the results of a polycardiographic study of the phase structure of left ventricular systole in healthy rabbits.

EXPERIMENTAL METHOD

Experiments were carried out on 34 healthy rabbits weighing 2-3.5 kg. The polycardiogram was recorded with the animals in recumbency 15-20 min after fixation to the bench on a type M-072 "Krasnogvardeets" 3-channel electrocardiograph with phonocardiographic unit and a sphygmographic attachment.

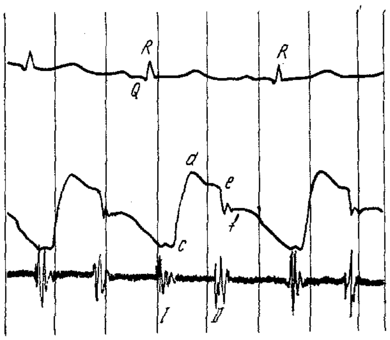

Fig. 1. Polycardiograms of rabbit No. 23. I) 1st sound; II) 2nd sound. Explanation in text.

The ECG was recorded in lead II by means of subcutaneous electrodes [3]. The PCG was recorded at the apex of the heart for a nominal frequency of 140/sec. The sphygmogram of the carotid artery was recorded by means of a pick-up fixed to the angle of the mandible of the animals at the point of maximal pulsation of the vessel.

The phase structure of the cardiac cycle was analyzed by Blumberger's method [5] as modified by V. L. Karpman [1]. In this method the phase of asynchronous contraction corresponds to the interval from the beginning of the Q(R) wave of the ECG to the beginning of the high-frequency oscillations of the 1st sound on the PCG (Fig. 1). The phase of isometric contraction is determined by subtracting segment c-f of the sphygmogram of the carotid artery from the interval between the 1st and 2nd sounds on the PCG. The period of contraction is composed of the phase of isometric and the phase of asynchronous contraction. The duration of the expulsion period corresponds to the segment c-e of the carotid pulse curve, and interval e-f is equal to protodiastole.

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TABLE 1. Phase Structure of Left Ventricular Cycle in Rabbits

Phase	Duration of phase (in sec)		
	minimal	maximal	mean
Period of contraction	0.035	0.060	0.042±0.001
Asynchronous contraction	0.020	0.030	0.029±0.001
Isometric contraction	0.005	0.020	0.013±0.001
Period of expulsion	0.070	0.130	0.083 (0.085)
Mechanical systole	0.080	0.150	0.083 (0.097)
Total systole	0.110	0.180	0.125 (0.125)
Protodiastole	0.005	0.010	0.010
Diastole	0.065	0.170	0.096 (0.096)

The position of the point e was determined by N. N. Savitskii's method [2]. In addition, mechanical systole (the sum of the period of expulsion and the phase of isometric contraction), the total systole (sum of mechanical systole and the phase of asynchronous contraction), and diastole (the difference between the total duration of the cardiac cycle and the total systole) were determined.

EXPERIMENTAL RESULTS

The duration of the cardiac cycle in the rabbits examined varied from 0.18 to 0.35 sec. Results for the phase structure are given in Table 1.

No significant correlation could be found between the duration of the cardiac cycle and the period of contraction. However, a definite relationship (coefficient of correlation 0.86) was observed between the duration of the expulsion period, of mechanical and total systole, and of diastole, on the one hand, and the heart rate on the other. This relationship can be described with a high level of probability by the equation of a linear function $y = kC + a$, which Karpman [1] used in the phase analysis of the cardiac cycle in healthy human subjects.

By graphic analysis we obtained the following equations for calculating the theoretical values of the expulsion period (E), the periods of mechanical (S_m), and total systole (S_0), and diastole (D) for a cardiac cycle (C) of given duration in rabbits:

$$E=0{,}349\cdot C+0{,}008$$
$$S_m=0{,}406\cdot C+0{,}008$$
$$S_0=0{,}426\cdot C+0{,}031$$
$$D=0{,}571\cdot C-0{,}030$$

Deviation of actual individual values from those calculated from these equations did not exceed ±0.01 sec.

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