The phenomenon of pulsus alternans was first described by Traube [14] in 1872. Many theories have been put forward to explain the mechanism of the alternation, and according to the most popular of these it is due to partial asystole of the myocardium [1, 2, 7, 11]. Synchronized investigations of the hemodynamic, mechanical, acoustic, and electrical manifestations of the cardiac activity have enabled closer studies to be made of the dynamics of the ventricular contractions in this form of cardiac pathology. In experiments on animals with pulsus alternans, changes have been described in the phonocardiogram [9], the intraventricular pressure and the duration of the periods of contraction and ejection [2, 4, 10, 13]. One or two clinical papers have also been published [6, 12] on the subject of the changes in the phonocardiogram and in the phases of the cardiac cycle in pulsus alternans.

The present communication describes the results of the study of the dynamics of the cardiac contraction in experimental pulsus alternans of different degrees of severity.

**METHOD**

The investigation was conducted on 22 adult dogs weighing 9-18 kg, anesthetized with morphine and urethane. In the experiments synchronized recordings were made of the electrocardiogram, the phonocardiogram, and the

![Fig. 1. Changes in duration of phases of systole in different degrees of pulsus alternans. Ratio of ventricular contractions 1:3 (A), 1:2 (B), 2:3 (C). ab) Phase of asynchronous contraction; bc) isometric; cd) ejection. Significance of curves (from top to bottom): pressure in left ventricle, in aorta; ECG standard lead II. The dots denote the times of stimulation of the sino-auricular node.](image-url)
intraventricular pressure. A type EMZ-01 electromanograph with a jet recording system was used for this purpose.

To produce alternation of the ventricular contractions the method of electrical stimulation of the sino-auricular node was used [2]. The electrical stimuli were applied by means of a bipolar intracardial electrode and a type SIF-4 stimulator designed at the Institute of Normal and Pathological Physiology. The impulse was rectangular in shape, its voltage 1.5-3 V, and its duration 2 msec. The impulses followed one another at the rate of 300 per min.

To prevent the onset of respiratory atrioventricular block during electrical stimulation of the sino-auricular node [2], bilateral vagotomy was performed on the animals.

For the analysis of the phases of cardiac contraction [3-5, 8] on the tracing of the pressure in the left ventricle and aorta (Fig. 1), determinations were made of the duration of: 1) the phase of asynchronous contraction (of the electromechanical period, or the period of spreading of the wave of contraction), given by the interval ab from the beginning of the Q wave of the electrocardiogram (ECG) to the beginning of the rise of intraventricular pressure; 2) the phase of isometric contraction, given by the interval bc from the beginning of the rise of intraventricular pressure to the beginning of the rise of pressure in the aorta; 3) the phase of contraction, consisting of the phase of asynchronous contraction and the phase of isometric contraction; 4) the phase of ejection of blood, given by the interval cd from the beginning of the rise of intra-aortic pressure to the incisura on the curve of intra-aortic pressure; 5) mechanical systole, consisting of the phase of isometric contraction and the phase of ejection; and 6) electromechanical systole, consisting of the mechanical systole and the phase of asynchronous contraction.

Determinations of the mean rate of increase of intraventricular pressure, the intrasystolic index (the ratio between the duration of the phase of ejection and the duration of the mechanical systole, in %), and the index of contraction of the myocardium (the ratio between the duration of the phase of contraction and the duration of the electromechanical systole, in %) were also made.

These calculations were made before the beginning of electrical stimulation when the original rhythm was present, during stimulation when pulsus alternans had developed, and when the cardiac contractions reproduced fully the rhythm of stimulation.

RESULTS

The investigations showed that alternation of the cardiac contractions is accompanied by alternation of the tones of the phonocardiogram. Alternation of both sounds I and II was observed. If the alternation was of a very marked degree, sound II was often absent (Fig. 2A).