AUTOMATISM OF THE SPECIFIC VENTRICULAR MUSCLE OF THE ISOLATED DOG'S HEART DURING PROLONGED COOLING TO 0-4°

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Experiments on isolated dogs' hearts, kept in the cold (0-4°) and periodically reheated for 2-3 h, showed that different parts of the specific muscle differ in their functional resistance. Electrical and mechanical activity of the region of the functional synapse between the specific muscle and myocardium disappears first of all.

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It can now be taken as proven that the specific muscle tissue responds by contraction to excitation generated in one of the pacemakers or in the branches of the bundle of His [1, 5, 8, 11-15]. The transmission of excitation into the myocardium of the ventricles takes place through contraction of the Purkinje's fibers [6, 8, 14]. It has been shown in the writers' laboratory that the heart of warm-blooded animals is a heterogeneously excitable muscular system [1-4, 9].

The object of this investigation was to study the dynamics of different forms of automatic activity of the specific musculature of the isolated dog's heart during prolonged cooling.

EXPERIMENTAL METHOD

The hearts of 40 intact dogs (aged 3-5 years, weight 10-12 kg) were investigated. The hearts was removed under morphine – urethane anesthesia and controlled respiration. After isolation, the heart was placed in Ringer's solution. A cannula, introduced into the aorta, was connected to a coronary perfusion system, filled with Ringer – Locke solution, saturated with oxygen, at a temperature of 37-38°. The wall of the left ventricle was incised above the ventricular septum, and the heart was laid on a cork slab so that the left branch of the bundle of His with its ramifications beneath the endocardium could be closely examined. Observations were made on the whole network of branches of the left bundle which could be seen with a binocular microscope (magnification 10-12×) in reflected light.

The heart was reheated every day (for 7-10 days) from 0-4 to 37-38° for 2-3 h by immersing it in Ringer's solution of the appropriate temperature, and coronary perfusion was carried out periodically for intervals of 5-10 min. Besides visual observations on the specific musculature, the electrical and mechanical activity of individual portions of the left branch of the bundle of His was recorded (with the myocardium at rest) on a type MPO-2 loop oscillograph [4]. The EKG also was recorded (on the ÉKT-02 apparatus).

EXPERIMENTAL RESULTS

The investigations showed that on the 2nd-5th day of cooling of the heart to a temperature of 0-4°, interrupted by reheating daily to 37-38°, restoration of the electrical and mechanical manifestations of automatism of the left branch of the bundle of His and its ramifications followed a regular pattern. Elevation of the temperature of the heart to 34-35°, for instance, led initially to the appearance of fibrillation of the bundle (the ventricular myocardium did not fibrillate and did not contract). With elevation of the

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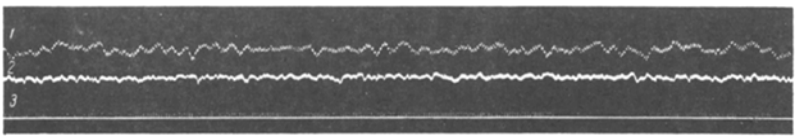

Fig. 1. Mechanical contractions and electrical activity of left branch of bundle of His (3rd day of keeping isolated dog's heart at 0-4°). Fibrillation of specific muscle. From top to bottom: mechanical contractions, electrical activity, time marker (50 m/sec). Read from right to left.

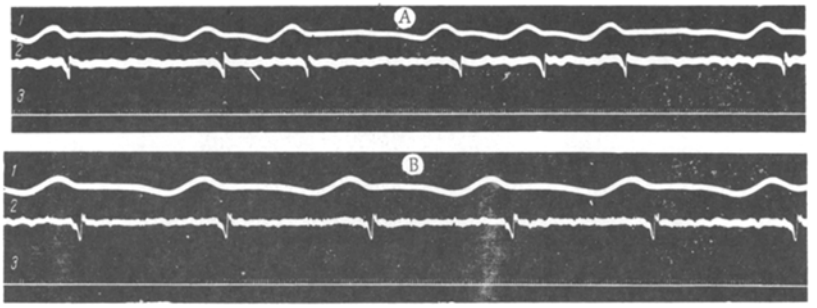

Fig. 2. Mechanical contraction and electrical activity in left branch of bundle of His (4th day of keeping isolated dog's heart at 0-4°). Transformation of arrhythmic contractions of specific muscle (A) into rhythmic (B). Legend as in Fig. 1. Read from right to left.

temperature to 37-38°, active fibrillation of the bundle and of all its branches running under the endocardium as far as the apex of the heart was observed (Fig. 1). If, against the background of active fibrillation of the specific muscle, 0.1% adrenalin solution (1:500), 10% caffeine solution (1:500), 40% glucose solution (12.5:500), and oxygen were added to the contact solution until saturation, as a rule the fibrillation changed into rhythmic contraction. During the first 2-3 days on "survival" of the heart, contractions of the left branch of the bundle of His and of all its observable ramifications were restored (Fig. 2).

After brief coronary perfusion (5-10 min) with Ringer–Locke solution (temperature 37-38°), saturated with oxygen, and after the addition of 1 ml of 0.1% adrenalin solution, in 32 of 40 cases the EKG could be recorded from the isolated heart on the 2nd-5th day of "survival," and in some cases the appearance of myocardial contractions through restoration of the synaptic connection between the specific muscle and the myocardium of the left ventricle could be observed visually. At these same times of "survival" of the heart, rhythmic contractions of the ramifications of the left branch of the bundle of His in the region of the apex of the heart could not be restored in 8 cases. In these areas, irreversible fibrillation was observed, whereas the higher branches and the main branch of the bundle of His contracted rhythmically at 60-80 min. In these cases coronary perfusion did not restore the automatic activity of the myocardium of the left ventricle.

On the 5th-7th day of keeping the heart in the cold, with daily reheating, a regular combination was observed of irreversible fibrillation of the terminal ramification of the left branch, arrhythmic contractions of the proximal branches, and rhythmic contractions of the main branch. Extinction of automatism of the specific muscle began in the very small ramifications near the apex of the heart, and gradually moved proximally to the base. The last manifestation of automatism was irreversible fibrillation of the main left branch of the bundle of His (on the 7th-10th day of "survival" of the heart). Hence, while possessing the function of automatism, the specific muscle possesses all forms of muscular activity: rhythmic contractions, arrhythmia, and fibrillation. It can be concluded from these results that different parts of the specific muscle differ in their degree of functional resistance, i.e., that the muscle is heterogeneous.

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