

PECULIARITIES ATTENDING THE RESISTANCE
OF THE HEART TO LOCAL ISCHEMIC ALTERATION
IN DOGS OF DIFFERENT AGES

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In investigations carried out on the isolated heart of rabbits of different ages it was established that its resistance to the effect of various alternating effects (chloral hydrate, diphtheria, dysentery, staphylococcal, and tetanus toxins) increases with age [4-7].

The purpose of the present study was to characterize the peculiarities of the resistance of the heart to local in ischemic alteration in dogs of different age.

EXPERIMENTAL METHOD

In the experiment we used 80 dogs ranging in age from 1 day old to maturity. The experiments were carried out under anesthesia (ether for puppies aged up to 1 month and morphine-ether for dogs older than 1-1½ months). The chest was opened under artificial respiration conditions. Local ischemic alteration was created by ligating one of the branches of the left coronary artery at the level of the bifurcation. The degree of the resistance of the heart under the described conditions was estimated by the duration and character of the changes of its activity after ligating the coronary artery. To judge the activity of the heart we recorded the EKG in II standard lead.

EXPERIMENTAL RESULTS

The data obtained made it possible to distribute the investigated dogs into 3 age groups. The 1st group included puppies up to 16-18 days old (28 animals), the 2nd group included puppies from 16-18 days to 2-2½ months of age (18 dogs), and the 3rd group contained puppies older than 2½ months and mature dogs (34 animals).

For puppies older than 2½-3 months and for mature dogs, i.e., during the period when they already have a well-expressed vagus tone, the work of the heart continued for 14-18 h (the longest duration of our observations) after ligation of one of the branches of the coronary artery. In most experiments deformed ventricular complexes (a decrease in amplitude or the disappearance of the R wave, the appearance of a deep Q wave or QS complex) periodically occurred on the EKG. In other experiments deformation of the ventricular complex was expressed by a typical shift of the ST segment which approached the characteristic of a monophasic potential. In a number of experiments the electrocardiographic characteristic of the heart after ligation of the coronary artery hardly changed. The absence of changes or a greater or lesser frequency of the manifestation of deformed ventricular complexes depended on whether or not the heart after ligation of the coronary artery continued to maintain connection with the centers of vagal innervation.

Under conditions of a preserved connection of the heart with the centers of vagal innervation together with an infrequent development of deformed ventricular complexes (Fig. 1, 1,2) or even with their complete absence in certain experiments, the activity of the heart can continue for 14-18 h without noticeable signs of its decreasing. With ligated vagi with a more frequent occurrence of deformed ventricular complexes (Fig. 1, 3,4), the work of the heart can stop 8-14 h after ligation of the coronary artery.



Fig. 1. EKG of mature dogs before and after ligating coronary artery. 1) Initial recording; 2) 45 min after ligating coronary artery; 3) 10 min after ligating vagi which was done 4 h after ligating coronary artery; 4) 40 min after ligation of vagi; 5) stimulation of vagus (restoration of normal sinoatrial rhythm).

It is necessary to note that during the time of observations, the body temperature of the mature dog either did not change or dropped by 1-2°.

Young puppies (up to 16-18 days old) during the period of sympathetic regulation of heart activity respond by a progressive slowing down of the heart rhythm for a certain time after ligation of the coronary artery. In this case deformation of the ventricular complex was not observed in all experiments. When there was a gradual drop of body temperature the heart stopped after 30 min-1½ h (Fig. 2). In a series of experiments with special warming of the animals, the body temperature was maintained within 35-36.5°. In these cases, the work of the heart stopped after 2-3 h; of 28 puppies only in 2 was the duration of the work of the heart after ligation of the coronary artery 4 h and in 1 puppy, 6 h. This duration was established in puppies aged 14-16 days. Unlike the dogs of the 3rd group, the heart rhythm of the puppies of the first group after ligation of the coronary artery did not quicken; on the contrary, a gradual and ever progressing slowing down of the rhythm was noted. Thus, based on this sign which indicates the absence of the ability to maintain the initial heart rhythm, the myocardium of young puppies is characterized by a much lesser resistance to the formation of a local ischemic focus as compared with the resistance of the heart of mature dogs.

This fact was, it would seem, all the more unexpected, since, as is known, the blood supply of the myocardium calculated per unit mass or area decreases with age. For example, according to the data of M. S. Tolgskaya [9], in children aged 2 years 25-30 vessels identical in diameter are found on appropriate sections of the myocardium in the field of view; in children aged from 2-6 years, 15-20; and in children older than 6 years, 8-12 vessels are in the field of view. It would seem the more abundant vascularization of the heart in early age should promote its higher resistance to local ischemic alteration.

The resistance to local ischemic alteration in puppies of the 2nd group increased, however, it was still minor. The heart of the puppies of this group can work from 8-10 h after ligation of the coronary artery.

It has been established [1, 2] that for dogs with the occurrence of a vagal tone, especially from the 2½-3 months of life, the degree of polarization of the myocardium increases. Polarization was estimated by the characteristics of the ohmic and capacitive components of impedance at low (10 kc) and high (200 kc) frequencies. This made it possible to estimate the coefficient of polarization. Thus, the experiments carried out by O. T. Vakhidova showed that the coefficient of polarization of puppies aged 16-18 days is equal to 1.8-2, whereas it reaches 6 for mature dogs owing to the occurrence and further increase in the degree of vagal tone. The magnitude of the injury potential, which also characterizes the degree of polarization, was 6-10 mV for 16-18 day old puppies and was 40 mV by 3 months of age.

The results of the investigation carried out in our laboratory permitted I. A. Arshavskii to conclude that the increase in the degree of polarization of the myocardium caused by the occurrence of the vagal tone compensates its deteriorating vascularization. The action potentials and the work of the heart in this case begin to be accomplished not by the energy of chemical transformations as in early age, but primarily by a structural-polarization factor [2].

It was established that the myocardium of young puppies is appreciably more sensitive and less resistant to ischemic alteration than the myocardium of mature dogs, and the increase in resistance coincides with the occurrence

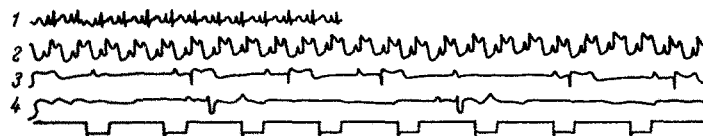


Fig. 2. EKG of 5 day old puppy before and after ligation of coronary artery. 1) Initial recording (heart beat 200 per min); 2) after ligation of coronary artery; 3) 25 min after ligation of coronary artery (heart beat 40 per min); 4) 1 h 25 min after ligation of coronary artery (heart beat 22 per min).

of the vagal tone. We undertook to estimate the effect of stimulation of the vagus nerve on the heart altered by ligation of the coronary artery. The peripheral segment of the vagus was stimulated by an induction current or by the current of an electron stimulator. The experiments were set up on puppies older than 3 months and on mature dogs.

Upon stimulation of the peripheral segment of the vagus the deformed ventricular complexes which arose before this disappeared completely or partially depending on their initial frequency. After stimulation of the vagus, especially if it lasted several minutes, the heart changed to a normal rhythm or an almost normal sinoatrial rhythm (Fig. 1, 5).

In 1884 N. E. Wedensky was the first to reveal a very important fact: the occurrence of electropositivity in the frog heart upon stimulation of the vagus nerve [7]. The electropositivity is evidence of an increase in polarization which is higher in comparison with the current degree of polarization in the so-called initial resting state. This discovery was then confirmed by W. Gaskell [10]. The facts obtained in our laboratory give us grounds to recognize the value of the vagus as a trophic nerve with a quite substantial favorable effect on plastic metabolism and the rate of repolarization processes. In the investigations of A. I. Smirnov et al. [8] the positive trophic value of the vagus with respect to the myocardium was also emphasized in connection with a different form of analysis.

In the same way that the tonic excitation which arises during postnatal development in the center of the vagal innervation increases the degree of polarization of the myocardium, under conditions of our experiments stimulation of the vagus in precisely the same way permitted repolarization of the heart which was depolarized by ischemic teration. Thus, repolarization, compensating alteration caused by local ischemia, facilitated the restoration of normal heart work.

SUMMARY

Following ligation of the coronary artery in puppies, aged from 16-18 days, the duration of the work of the heart in conditions of open chest and extracorporeal circulation proved to be 2-3 h. There is a rise of myocardial resistance to local ischemia in puppies aged from 16 days to 2.5 months. This rise is particularly marked in animals over 2.5-3 months of age and in adult dogs.

A rise of the cardiac resistance to local ischemia coincided with the appearance of the vagus tone and increased myocardial polarization.

A decrease of myocardial resistance to local ischemia follows vagus section. Stimulation of the peripheral portion of the vagus causes a disappearance of deformed ventricular complexes and normalizes the work of the heart.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
