THE INFLUENCE OF SYMPATHETIC DENERVATION ON THE CONTENT OF GLYCOGEN AND HIGH-ENERGY PHOSPHORUS COMPOUNDS IN THE MYOCARDIUM

V. A. Govyrin

I. M. Sechenov Institute of Evolutionary Physiology (Director – Academician L. A. Orbell*) of the Academy of Sciences of the USSR, Leningrad

(Presented by Active Member AMN SSSR S. V. Anichkov)

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According to Schumann, the energy resources of the heart, consisting mainly of glycogen, adenosinetriphosphoric acid, and creatinephosphate, are goverened by a complex neurohumoral mechanism (M. E. Raiskina [8], Raab [17]), and influences from the extracardiac sympathetic nerves play an important part in determining the functional condition of this mechanism.

Chang [12], E. S. Rozovskaya [10], Schumann [18], M. E. Raiskina [7], and Raab [17] showed that stimulation of the sympathetic nerves of the heart, as well as imitation of this effect by injection of adrenalin and noradrenalin, are accompanied by an increase in the work of the the heart and, at the same time, increased expenditure of energy, as a result of which there is a fall in the content of glycogen, ATP, and creatinephosphate in the myocardium.

According to Raab [17], stimulation of the sympathetic nerves and injection of adrenalin lead to a considerable increase in the catecholamines in the heart.

Slightly more complex, and, therefore, more difficult to explain, is the change in the content of high-energy compounds observed during stimulation of the augmenting nerve of Pavlov alone [2]. M. E. Raiskina [9] showed that stimulation of the augmenting nerve accelerates the renewal of the phosphorus compounds of the heart and that this effect evidently underlies its action on the heart.

Of great interest to the study of the mechanisms of the trophic influence of the sympathetic nervous system is the use of the method of sympathetic denervation in experiments of long duration. Information on this subject in the literature is scanty and often contradictory. The existing papers by B. B. Brandsbrug [4], F. M. Lampert [5], Jonnesco and Ionescu [14], N. A. Podkopaev [6], E. S. Shakhbazyan [11] and Long et al. [16], are devoted almost exclusively to the effect of sympathetic denervation, usually incomplete, on the structure of the heart and certain of its functional aspects.

Little work has been done on the biochemical changes in the heart muscle after sympathetic denervation. The work of Raab [17] and of Goodall and Kirshner [13] showed a sharp fall in the content of adrenalin and noradrenalin in the heart of cats and sheep after sympathetic denervation. Meanwhile, the elucidation of the relationship between the presence or absence of sympathetic influences on the heart and the content of energy-producing compounds therein may help towards the understanding of the mechanism of the tropic influences of the sympathetic nervous system on the heart. The present research is devoted to the study of this problem.

METHOD

For the experiments we used 10 cats in which the sympathetic nerve supply of the heart was completely removed (one-stage extirpation of both sympathetic trunks from the superior cervical ganglion to the 8th-9th segment of the thoracic chain), and 14 control animals. Investigations were carried out at various times from 20 to 110 days after sympathetic denervation. For the biochemical estimations, the apex of the heart was taken from cats, anesthetized with nembutal, and under artificial respiration, and the tissue rapidly frozen in liquid nitrogen. Glycogen was estimated by the method of Kemp and Kits van Hijningen [15], adenosine polyphosphates as readily hydrolyzed phosphorus, and creatinephosphate by M. A. Alekseeva's method [3]. In the course of the experiments, recordings of the electrocardiogram were made, and histological examinations were carried out on the hearts of operated and control animals.

RESULTS

Sympathetic denervation led to an obvious increase in the content of glycogen, adenosine polyphosphates and creatinephosphate in the heart. In spite of

*Deceased.

TABLE Content of Glycogen, Adenosine Polyphosphate, and Creatinephosphate in the Myocardium (in mg % of Crude Substance)

Serial No.	Time after operation (in days)	Glycogen	Adenosine polyphosphate as P	Creatinephosphate
	Normally			
1	—	548	Not determined	70,0
2	—	381	32,8	74,9
3	—	Not determined	19,6	85,2
4	—	456	26,6	78,5
5	—	Not determined	26,7	136,2
6	—	809	31,8	101,5
7	—	450	33,3	132,0
8	—	651	36,3	103,6
9	—	539	31,3	145,6
10	—	837	22,6	146,5
11	—	428	16,3	Not determined
12	—	653	27,2	151,9
13	—	716	24,8	194,4
14	—	—	27,2	176,8
	M±m	588±47,1	27,4±1,6	122,8±11,2
	After sympathetic denervation			
1	20	777	35,2	100,3
2	23	1 106	22,1	149,0
3	53	911	35,1	150,8
4	56	935	34,8	172,8
5	60	744	33,4	147,6
6	90	1 069	35,6	81,4
7	90	540	31,2	157,3
8	96	892	33,0	176,6
9	101	1 032	50,1	160,0
10	110	930	43,4	136,1
	M±m	893±55,0	35,4±2,3	143,2±9,1

individual variations in the content of these compounds, the average glycogen content of the myocardium for the group of operated animals was increased by 50%, that of adenosine polyphosphates by 30%, and that of creatinephosphate slightly. The results obtained were thus directly opposite to the effect of stimulation of the sympathetic nerves of the heart.

The raised level of glycogen and high-energy phosphorus compounds indicates changes in the energy metabolism of the heart, and evidently demonstrates a reduction in its intensity. It is still difficult to judge whether any connection exists between this phenomenon and the sharp fall in the content of adrenalin and noradrenalin in the heart after sympathetic denervation, which was observed by Goodall and Kirshner [13].

The increased content of glycogen and high-energy phosphorus compounds may still be detected in myocardium 3-3½ months after sympathetic denervation, i.e., at times when the level of adrenalin and noradrenalin, according to Goodall and Kirshner, had returned to their initial values once more.

It seems very unlikely to us that there is any connection between the increased content of these compounds and the slight decrease in the heart rate after sympathetic denervation.

This hypothesis is based on the experiments of M. E. Raiskina [9], who showed that the increase in the content of glycogen and high-energy phosphorus compounds was connected with a slowing in their renewal in the heart muscle after sympathetic denervation. We regard these phenomena as disturbances of the energy metabolism of the heart resulting from the abolition of the trophic influences of the sympathetic nerves of the heart.

SUMMARY

Complete desympathization of the heart provokes changes in the macroergasic metabolism of myocardium. In operated animals a rise is noted in the content of glycogen, adenosinepolyphosphates, and creatinephosphates. This phenomenon may be regarded as one of disturbances of the macroergasic metabolism of the

heart provoked by the exclusion of the trophic effects of the cardiac sympathetic nerves.

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