TROPHIC CHANGES IN THE MYOCARDIUM FOLLOWING SPINAL AND VAGUS DEAFFERENTATION OF THE HEART

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The great importance of afferent systems of the heart in ensuring an adequate trophic basis for cardiac activity is demonstrated. Division of the sensory roots of the vagus nerve and spinal deafferentation of the heart lead to changes in the ECG, and disturbances of the structure and protein metabolism of the heart muscle.

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Numerous morphological investigations [4, 7-15, 17] have shown that the afferent innervation of the heart is effected through the vagus nerves and the dorsal roots of the upper 5 thoracic segments of the spinel cord (D_1-D_5).

Because of the importance of the afferent section of the reflex arc as the initial link in mechanisms of regulation of body functions, we investigated the effect of spinal and vagus deafferentation of the heart on cardiac function and on myocardial metabolism.

EXPERIMENTAL METHOD

Experiments were carried out on male cats. The spinal ganglia were extirpated in the animals of one group (20 cats) at the level D_1-D_5 bilaterally in one stage, while in animals of another group (15 cats) the sensory roots of the vagus nerves were divided intracranially on both sides in two stages with an interval of one month between operations. The ECG of the animals was recorded in three standard and one chest lead before the operation and at various times after it. The spectra of mitogenetic radiation of the experimental and control animals was studied [1, 2]; the protein fraction of the myocardium were investigated by Ivanov's method [6]; ATPase was determined by Zubenko's method [5], phosphorus being subsequently determined by Lowry's method [16].

EXPERIMENTAL RESULTS

After partial deafferentation of the heart (spinal and vagus), the heart rate increased during the first days after operation (by 20-40 beats/min), returning to normal in the following weeks. However, three weeks after division of the roots of the left vagus nerve (stage 1 of the operation), the heart rate rose again, so that by the time of stage 2 of the operation (division of roots of the right vagus nerve) the heart rate of these animals was higher than initially (by 30-50 beats/min). The heart rate increased also during the first days after bilateral division of the vagus nerve roots (by 50-60 beats/min). On the following days the heart rate slowed, and one month after the operation it was normal or below the initial level.

The increase in heart rate soon after partial deafferentation may be regarded as due to changes in tone of the extracardial nerves. The slowing of the heart in the later stages was possibly due to degenerative changes in the heart muscle and in its intramural nervous apparatus arising on account of disturbances of the afferent innervation of the heart.

Changes in the ventricular complex of the ECG which were found in the experimental animals, in the form of reduplication and widening of the QRS complex, displacement of the S-T interval above or below the isoelectric line, and distortion of the T wave also indicate the presence of degenerative changes in the heart muscles (Figs. 1 and 2).

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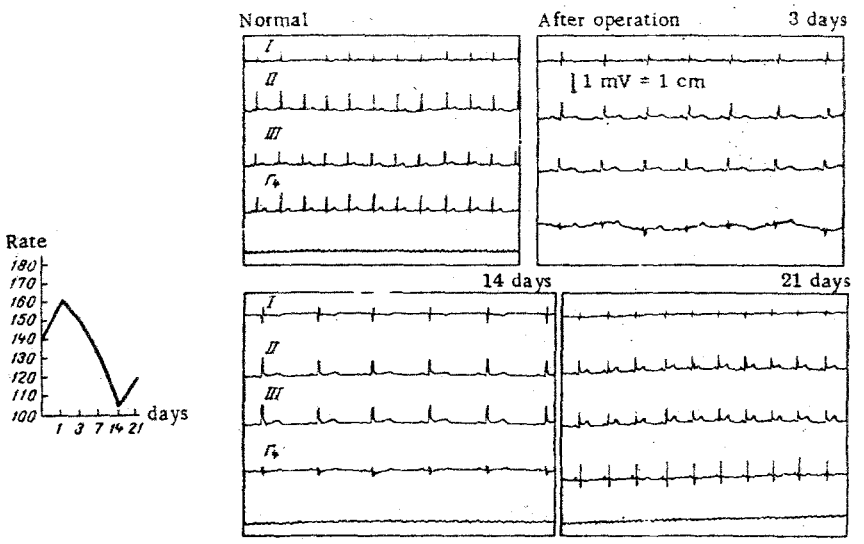

Fig. 1. Changes in heart rate (on the left) and ECG (on the right) of cat No. 10 at various times after removal of the spinal ganglia.

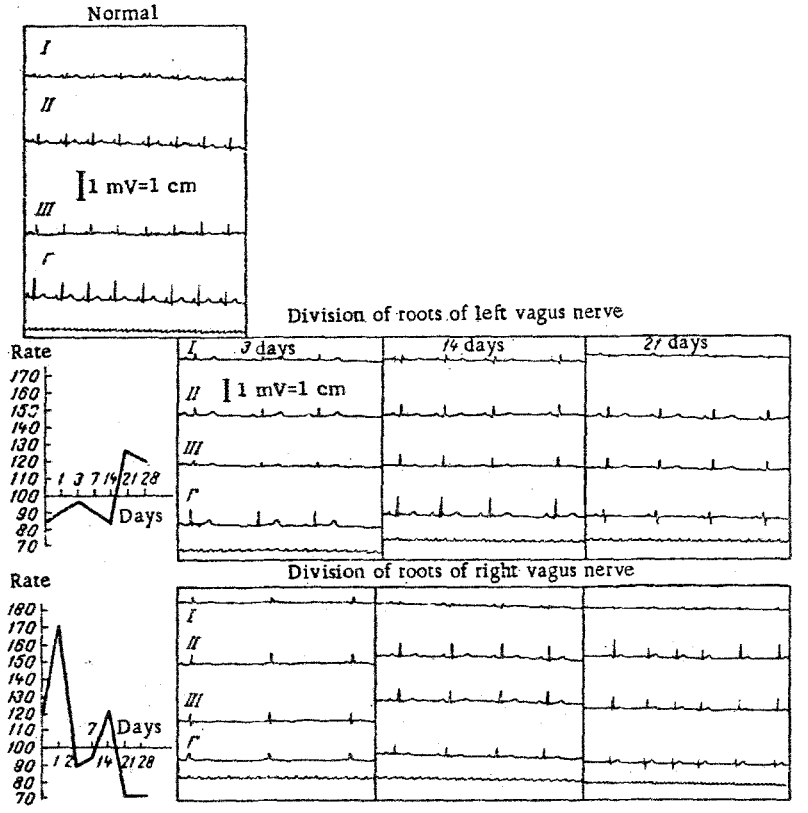

Fig. 2. Changes in heart rate (on the left) and ECG (on the right) of cat No. 8 at various times after division of afferent roots of vagus nerves.

Biochemical analysis of the protein fractions of the myocardium revealed a decrease in the content of sarcoplasmic proteins by 12% below the normal level and also a decrease in the content of actomyosin and in its ATPase activity during the first two weeks after spinal deafferentation of the heart. The normal level of sarcoplasmic proteins was observed 1-2 months and also 1 year after this operation. The content of myofibrillary proteins was above normal on account of an increase in content of the principal contactile protein, actomyosin. The ATPase activity of this protein was also considerably increased.

TABLE 1. Protein Composition and ATPase Activity of Heart Tissue (M ± m)

Index		Normal	Removal of spinal ganglia at level D_1-D_5			Division of roots of vagus nerve
			Time after operation			
			2 weeks	2 months	1 year	2 months
Sarcoplasmic proteins	In mg nitrogen/g wet tissue	8.46 ± 13 P	7.46 ± 0.23 <0.01	8.5 ± 0.21	8.5 ± 0.33	7.73 ± 0.16 <0.01
Myofibrillary proteins		8.88 ± 0.14 P	8.88 ± 0.36	9.76 ± 0.22 <0.001	10.12 ± 0.3 <0.01	7.65 ± 0.2 =0.1
Actomyosin		5.7 ± 0.07 P	5.38 ± 0.2	6.49 ± 0.12 <0.001	6.5 ± 0.13 <0.001	5.22 ± 0.23
Fraction T		3.16 ± 0.06 P	3.32	3.33	3.6	2.45 ± 0.11 <0.001
Solid residue in %		20.2	20.2	20.6	21.1	19.6
ATPase activity of actomyosin (in μg phosphorus/mg nitrogen)		61.6 ± 3.1 P	50.1 ± 2.6 =0.05	98.8 ± 5.2 <0.001	74.0 ± 4.3 =0.05	82.2 ± 3.5 =0.02

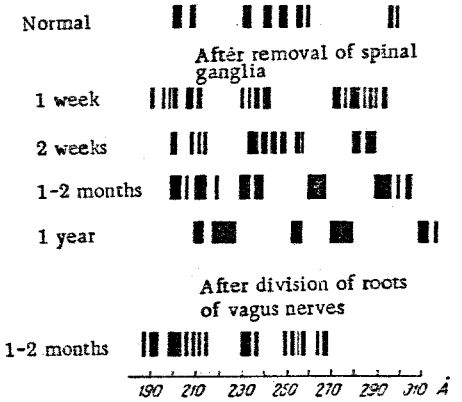

Fig. 3. Spectra of mitogenetic radiation of heart muscle after removal of spinal ganglia and division of afferent roots of the vagus nerves in vivo. Numbers below show wavelengths in Angstrom units.

The content of sarcoplasmic and myofibrillary proteins of the myocardium was below normal 1-2 months after vagus deafferentation. An increase of 32% in ATPase activity of actomyosin was found (Table 1).

The decrease in content of myocardial proteins may be regarded as the result of degenerative changes arising after partial deafferentation of the heart. At the same time, differences must be noted in the effects of vagus and spinal deafferentation on myocardial protein metabolism. For example, 1-2 months after spinal deafferentation, restoration of the normal content of sarcoplasmic and myofibrillary proteins was observed, whereas at the same time after vagus deafferentation the protein content was still below normal.

The spectra of mitogenetic radiation of the cat's heart obtained by the method of biodetection at various times after spinal and vagus deafferentation are illustrated in Fig. 3. It can be seen that the spectrum of radiation of the cat's heart taken one week after spinal deafferentation consists of a large number of narrow bands. Two months after the operation the radiation spectrum of the heart contains fewer bands and they are wider. One year after the operation the number of spectral bands is smaller still and the bands are even wider.

The radiation spectrum of the cat's heart 1-2 months after division of the afferent roots of the vagus nerves consists of a large number of narrow bands.

As a previous investigation showed [3], the radiation spectrum of the heart of normal animals (cat, rabbit) consists mainly of wide bands. This indicates the regularity of the molecular substratum of the heart muscles. For this reason, the appearance of wider bands in the radiation spectrum of the heart 2 months and 1 year after spinal deafferentation can be taken as evidence of the development of compensatory processes in the myocardium, resulting in gradual restoration of the molecular regularity of the myocardial substratum and in a return to a normal radiation spectrum. The narrow bands of the heart's radiation spectrum 1-2 months after vagus deafferentation may thus indicate more profound disturbances of the molecular regularity of the myocardial substratum than after spinal deafferentation, when, as already mentioned, partial recovery has already taken place.

The study of functional and biochemical disturbances and changes in the spectra of mitogenetic radiation of the heart muscle thus shows that partial deafferentation of the heart leads to definite trophic disturbances in the heart muscle, more severe after vagus deafferentation than after spinal deafferentation. Besides these quantitative relationships, it was also found that the different type of deafferentation of the heart also exhibit certain qualitative differences.

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