PHYSIOLOGY

MECHANISM OF THE INFLUENCE OF SYMPATHETIC INNERVATION ON THE MOTOR-PERIODIC ACTIVITY OF THE STOMACH OF THE DOG

R. Z. Bogdanov and I. V. Senkevich

From the Department of Physiology (Chairman-Corresponding Member of the Acad. Med. Sci. USSR Prof. A. V. Kibyakov) Kazan State Medical Institute (Director-Docent R. A. Vyaselev)

(Received August 27, 1955. Presented by Academician L. A. Orbeli)

The periodic activity of the digestive apparatus was first discovered in the I. P. Pavlov laboratory. As was established by Boldyrev [3], in almost all the sections of the gastrointestinal tract, outside the period of digestion, one sees a regular alternation of the states of activity and rest both of the motor and secretory functions. The periodic motor function of the dog stomach consists of periods of work lasting 15-20 minutes and periods of rest, lasting for $1^1/_2$-$2^1/_2$ hours.

The periodic activity of the digestive apparatus has been investigated by many authors, who have confirmed the I. P. Pavlov laboratory findings. However, up to quite recently the mechanism ensuring the alternation of periods of rest and work was not clear.

A. J. Carlson [10] considered the prime cause of the periodic contractions to be the automatism of the neuromuscular apparatus. In his view, the external nerves and humoral agents only modify the primary automatic mechanism, but by themselves, are not capable of ensuring periodic activity.

The initial work conducted in the I. P. Pavlov laboratory, had already indicated the participation of the central nervous system in the periodic activity of the gastrointestinal tract. Thus, Cheshkov [8] discovered suppression of periodic motor activity of the stomach of dogs after a transverse cut of the vagus nerves. Later, certain investigators also observed the suppressive influence of vagotomy on the hunger contractions of the gastrointestinal tract [7]. On the other hand, others denied this influence.

A transverse incision of the sympathetic nerves, innervating the gastrointestinal tract, according to Raeva and Pupko [6], leads to longer periods of work and shortening of rest periods.

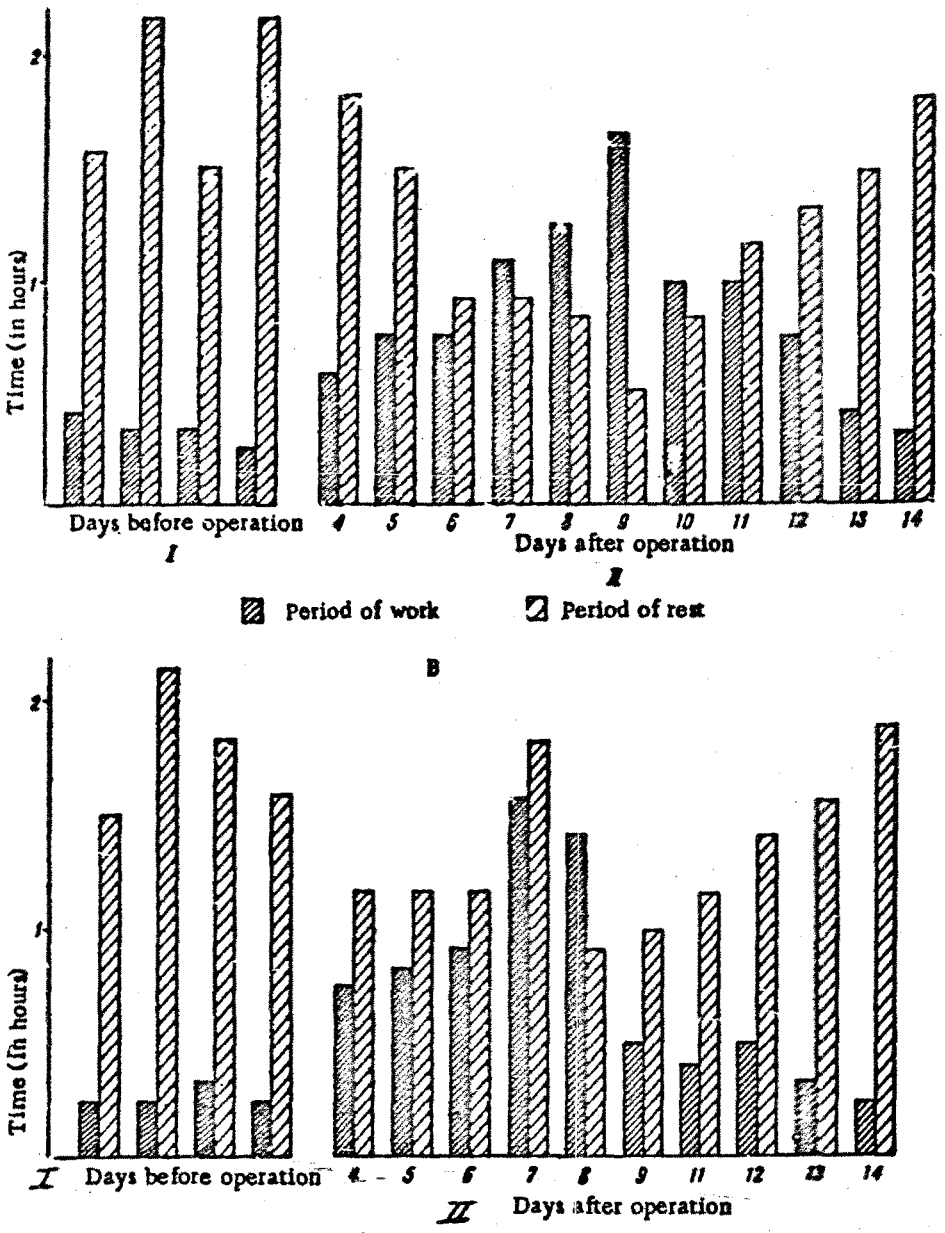
The work conducted at the Bykov and Usievich laboratories, showed the dependence of the character of the hunger peristalsis on the functional state of the cerebral cortex.

Investigators have also intereeted themselves in the influence of humoral factors, released on stimulation of nerve conductors, on the periodic activity of the gastrointestinal tract. It was found that introduction of choline in the blood of the animal, produces prolongation of the rest periods, and introduction of adrenalin, curtails such periods [1]. The blood taken from the animal during the work period, contains an acetylcholine -like substance [5] and displays properties of vascular dilation, while the blood during the period of rest has a vascular constriction effect [9]. During the period of work, the blood cholinesterase activity [2] increases.

In the present work, we sought to clarify to what degree sympathetic innervation influences the periodic activity of the stomach of the dog, digestion being excluded, and the role in this process of the humoral chain.

EXPERIMENTAL METHODS

The experiments were conducted on dogs with fistulas of the stomach according to Basov. Recording of



Duration of periods of work and rest in dog Akbai (A) and Sarbai (B).

I) before operation, II) after operation.

the contractions of the stomach was conducted by the balloon method. Before the experiment, the dogs were starved for 18-20 hours. After establishing the character of the periodic activity (duration of periods of work and rest), the chromaffin tissue of the suprarenals was removed in the dogs by extirpating one of the suprarenals and cauterizing the medullary layer of the other. Starting from the 4th day after the operation, the investigations were resumed and continued up to the 15th postoperative day.

EXPERIMENTAL RESULTS

The experiments were conducted on two dogs named Akbai and Sarbai. In the dog, Akbai, the duration of the period of work of the stomach before the operation was 15-25 minutes, the rest period lasted 1 hour 30 minutes – 2 hours and 10 minutes. On the 4th day after the operation, it was possible to detect some changes in the duration of the periods of work and rest, the former becoming longer and the latter shorter. These changes with each passing day became more and more pronounced. Thus, on the 6th day, the duration of the period of work had already risen to 45 minutes and the period of rest decreased to 55 minutes. On the 9th post-

operative day, when these changes reached the maximum, the period of work lasted 1 hour 40 minutes, and the period of rest, only 30 minutes. From the 10th day, the work periods started to diminish, while the rest period increased, reaching preoperative values towards the 13 and 14th day after the operation. The changes described are depicted in the Figure, A.

In the dog, Sarbai, the duration of the periods of work before the operation varied 15-20 minutes, and the duration of the periods of rest from 1 hour 30 minutes to 2 hours. From the 4th postoperative day, a considerable extension of the period of work and reduction of the period of rest was seen, which on that day were respectively 45 minutes and 1 hour 10 minutes. The maximum changes were observed on the 8th postoperative day, when the period of work reached 1 hour 25 minutes, and the period of rest, 55 minutes. On the 13-14th day after operation, the normal duration of the periods of work and rest started to return. Thus, on the 13th day, the duration of the period of work was 20 minutes and on the 14th day, 15 minutes. The period of rest on the 13th postoperative day lasted 1 hour and 35 minutes, and on the 14th day, 1 hour and 55 minutes. The findings are illustrated in the Figure, B.

Extirpation of a considerable part of the chromaffin tissue was accompanied by a sharp fall in the adrenalin content in the blood of the animal. In this respect, as was shown by the investigations of the A. V. Kibyakov laboratory [4], the sympathin-forming function of sympathetic innervation is disturbed, leading to the disappearance of the trophic influence of this innervation on the innervated tissues. In particular, the influence on the tonic state of the musculature of the intestinal wall is absent. The disturbance of the sympathin-forming function of the sympathetic innervation is of a temporary character; toward the 12-13th day after the operation, it is restored, apparently in connection with the vicarious hyperfunction of the remaining chromaffin tissue.

We observed changes in the character of the periodic activity of the dog stomach from the 4th day to the 12th day after extirpation of the medullary layer of the suprarenals, that is, at those times, that the disturbance of sympathin synethesis in the animal organism was particularly marked. Consequently, we consider that the cause of the distortion of the character of the motor periodic activity of the dog stomach in those times was a disturbance of the sympathin-forming function of the sympathetic innervation.

Our findings justify the conclusion that the sympathetic innervation participated in the formation of the periodic activity of the dog stomach, ensuring a definite duration of the periods of work and rest. This sympathetic innervation influence is effected with the participation of its humoral link—sympathin.

LITERATURE CITED

[1] Anichkov, C. V., Russ. Fiziol. Zhur. Vol. 6, No. 4-6, pp. 84-86 (1924).

[2] Baranova, N. F., Works of the I. P. Pavlov Institute of Physiology* (Moscow-Leningrad, 1954), Vol. 3, pp. 480-489.

[3] Boldyrev, V. N., Periodic Work of the Digestive Apparatus on an Empty Stomach, dissertation* (St. Petersburg, 1904).

[4] Kibyakov, A. V., Nature of the Regulatory Influence of the Sympathetic Nervous System* (Kazan, 1950).

[5] Prokopenko, V. G., Byull. Exptl. Biol. i Med. Vol. 13, No. 3-4, pp. 91-92 (1942).

[6] Raeva, N.V., and Pupko, L. K., Arkh. Biol. Nauk. Vol. 38, No. 3, pp. 741-747 (1935).

[7] Tetyaeva, M. B., Fiziol. Zhur. SSSR. Vol. 33, No. 5, pp. 611-626 (1947).

[8] Cheshkov, A. M., A year and 7 months of Life of the Dog after Simultaneous Excision of Both Vagi in the Neck, dissertation* (St. Petersburg, 1902).

[9] Shcherbakov, S.A., Problems of Modern Physiologists, Biochemists and Pharmacologists* (Moscow, 1949), Vol. 1, pp. 565-566.

[10] Carlson, A. J., The Control of Hunger in Health and Disease (Chicago, 1916).

* In Russian.