ROLE OF THE FUNCTIONAL STATE OF THE ALIMENTARY CENTER IN THE MOTOR-EVACUATORY ACTIVITY OF THE STOMACH OF DOGS

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In our previous communications we described alterations in the motor-evacuatory activity of the stomach of dogs during the formation and healing of experimental gastric ulcers. The need for the investigation of the mechanisms whereby this function is regulated emerged from a consideration of our findings, since the published literature of this subject is very scanty, and the data are quite contradictory.

It was first shown in I. P. Pavlov's laboratory (Serdyukov) that the acidity of the stomach contents plays a very important part in the mechanism regulating this evacuatory activity. This finding was later confirmed by observations on human subjects, reported by a number of workers [1, 4, 7, and others]. Nevertheless, certain authors [2, 5, 6], especially foreign ones [8], deny the existence of any connection between the acidity of the stomach contents and the speed of their evacuation from the stomach, and consider that the determining factors in the process of evacuation are the mechanical conditions prevailing in the stomach itself; the degree of filling, its peristaltic activity, and the pressure developed in the pyloric antrum.

Very little attention has been paid to the role of the central nervous system in the mechanism of the evacuatory activity of the stomach, and the published data are quite contradictory.

Thus, for example, S. I. Galperin [3] arrives at the conclusion that sham feeding reflexly elicits full or partial closure of the prepyloric sphincter, which would be expected to lead to retardation of evacuation.

On the other hand, Cohnheim and Best [9] found, in experiments on esophagotomized dogs, that sham feeding has the opposite effect, and accelerates evacuation from the stomach of water introduced through a fistula.

In the present research we made a roentgenological study of the role of the functional state of the alimentary center in the mechanism of the evacuatory activity of the stomach.

EXPERIMENTAL METHODS

The experiments were performed on dogs which had been fasted for 18-20 hours. The stomach was washed out before each experiment, until the mucosa gave a neutral reaction. Barium sulfate suspension was introduced, without the knowledge of the dogs, through a gastric fistula, in the same dosage to all the animals (8 g of barium sulfate in 24 ml of water per kg body weight), at the same speed and at constant temperature, applying a small positive pressure. The dog was examined in a horizontal position (lying down), using a tracheoscope, or in a vertical position (standing behind the screen), with the x-rays directed laterally. Care was taken to exclude from the x-ray room any factors which might affect gastric excitability.

X-raying of the stomach was begun while the barium suspension was still being introduced. In order to be able to follow the dynamics of the evacuatory activity of the stomach we took radiograms during the first 3-4 minutes after beginning to introduce the suspension, and at 15 minute, or even shorter, intervals thereafter.

In our experiments we determined: a) the time at which barium began to leave the stomach and enter the duodenum, and b) the way in which evacuation of the stomach contents took place, and the time at which the process was completed.

We performed a series of experiments on each dog, with the object of ascertaining the evacuatory activity of the stomach under ordinary experimental conditions, without the application of outside stimuli (sham feeding, natural conditioned reflex stimuli, etc.).

The experiments were performed on 7 dogs; since the results were the same for all of them, we present those obtained for three of them only, for the purposes of illustration (see Table).

TABLE

Role of the Functional State of the Alimentary Center on the Motor-Evacuatory Activity of the Stomach, in Dogs

Conditions of experiment	Evacuation of stomach contents*										
	Start of passage of Ba into the duodenum (in min)	Amount of barium evacuated during minutes									Time taken for complete emptying of the stomach (in min.)
		5	15	20	30	45	60	82	90	120	180	
Dog Lisa											
Background	0,5	2/3		Traces of Ba left in stomach							25—30
Two minutes of sham feeding	1,5—2		1/2			2/3	4/5	Insignificant residue of Ba in stomach			100—110
Natural conditioned reflex stimulus	1,5—2		2/3		4/5	Traces of Ba left in stomach					48—50
Introduction of histamine	0,5		2/3		4/5		Traces of Ba left in stomach				60—65
Dog Polkan											
Background	0,5	2/3			3/4	Traces of Ba left in stomach					50
Two minutes of sham feeding	1,5—2	1/3			1/2				4/5	Traces of Ba left in stomach	185
Natural conditioned reflex stimulus	1,5—2		1/2		2/3	4/5		Traces of Ba left in stomach			95—100
Introduction of histamine	1,5—2		1/2		2/3	4/5		Traces of Ba left in stomach			90—95

* 8 g of barium sulfate in 24 ml of water were introduced through a gastric fistula, per kg body weight of dog.

TABLE (continued)

Conditions of experiment	Evacuation of stomach contents: Start of passage of Ba into the duodenum (in min.)	Amount of barium evacuated during minutes: 5	15	20	30	45	60	82	90	120	180	Time taken for complete emptying of the stomach (in min.)
Dog Ryzhik												
Background	0,5		3/4		4/5	Insignificant residue of Ba in stomach						55
Two minutes of sham feeding	1,5—2		1/3		1/2		3/4		4/5	Insignificant residue of Ba in stomach		130
Natural conditioned reflex stimulus	1,5—2		1/2		2/3	4/5		Traces of Ba left in stomach				80
Introduction of histamine	1,5—2		2/3		5/6		Insignificant residue of Ba in stomach					65

EXPERIMENTAL RESULTS

Under ordinary conditions, passage of barium suspension into the duodenum begins while it is still being introduced, and the evacuation of the stomach contents proceeds swiftly, especially during the first 15 minutes, during which time over $^2/_3$ of the stomach contents are evacuated. Only insignificant amounts remain in the stomach after 30-50 minutes, and in some animals the stomach has been completely emptied by then.

The following experiments were performed on each of the seven dogs, with the object of elucidating the effect of the functional state of the alimentary center on the motor-evacuatory activity of the stomach. After washing out the stomach, and checking that the mucosa gave a neutral reaction, sham feeding was instituted for 2 minutes, and in most cases radiographic examination of the motor-evacuatory activity of the stomach was commenced as soon as an acid reaction of the gastric mucosa was perceived.

The results (see Table) showed that under these conditions evacuation of the stomach contents is considerably retarded, lasting for 120-180 minutes (i.e., 2-3 times slower than usual). The nature of the process also changes: it proceeds more uniformly, not being faster to begin with. Passage of barium into the duodenum does not take place immediately on its introduction, but only $1^1/_2$-2 minutes later.

In the next series of experiments we attempted to ascertain to what extent this alteration in the motor-evacuatory activity of the stomach due to sham feeding was dependent on stimulation of the cortical alimentary center.

With this object, we stimulated the alimentary center of all seven dogs, applying a natural conditioned stimulus.

After washing out the stomach to a neutral reaction of its mucosa, we cut a lump of meat up into pieces for 4-5 minutes, in sight of the dog, as if in preparation for feeding it. The reaction of the gastric mucosa usually became acid after 5-7 minutes, and secretion of gastric juice began; at this moment we proceeded to the radiographic observation of the motor-evacuatory activity of the stomach.

We found from these experiments that the evacuation of the stomach contents was considerably retarded, and proceeded more uniformly than when the barium suspension was introduced through the fistula without preliminary stimulation of the alimentary center.

Passage of barium from the stomach into the duodenum does not begin at once, but $1\frac{1}{2}$-2 minutes after introduction of the suspension into the stomach was commenced. The alterations in the motor-evacuatory activity of the stomach were basically the same as after sham feeding, although they were less pronounced (see Table).

The differences in evacuation times after sham feeding and after stimulation with a natural conditioned stimulus are ascribable to the summation of exteroceptive impulses and impulses originating in the buccal cavity in the former case, leading to a more intense stimulation of the alimentary center.

It should also be remembered that the secretory responses of the gastric glands to natural conditioned stimuli is much weaker than that due to sham feeding. It lasts for only 45-50 minutes, the amount of gastric juice secreted varies from 5-17 ml (whereas with sham feeding a mean secretion of 45-50 ml is found during the first hour alone, and secretion persists for 2-3 hours), and the acidity is very low. Free acid is either absent, or amounts to no more than 0.12, as compared with 0.4-0.5 with sham feeding.

The differences between the evacuation times for sham feeding and natural conditioned stimulation may hence also be ascribed, to a certain extent, to the differences in the amount of secretion in the former case, and in its acidity in the latter.

We have referred above to the work of Serdyukov, of I. P. Pavlov's laboratory, who first showed that hydrochloric acid plays an important part in the motor-evacuatory activity of the stomach of dogs. We therefore proceeded to investigate the extent of the effect of gastric secretion in sham feeding and in response to a natural conditioned stimulus, on the motor-evacuatory acitivy of the stomach.

With this object, we performed a series of experiments in which subcutaneous histamine injections were given to the dogs.

We first determined the amount and the acidity of gastric secretion produced by the dogs in response to sham feeding for 2 minutes. We then injected a dose of histamine, such that it caused about the same secretory effect in a given dog as did the sham feeding.

After washing out the stomach until the mucosa gave a neutral reaction, we injected the appropriate dose of histamine subcutaneously, and 3-5 minutes after gastric secretion had begun we filled the stomach with barium suspension, and proceeded immediately to the radiographic recording of gastric motor-evacuatory activity.

An examination of the results shows that passage of stomach contents into the duodenum commenced during the first $1-1\frac{1}{2}$ minutes (rarely towards the end of the second minute) after beginning to introduce barium suspension. Evacuation of stomach contents was retarded, although to a much smaller extent than with sham feeding, although the amount of gastric juice secreted was about the same as in sham feeding, and in some cases even larger.

Our findings permit of the following conclusions. The motor-evacuatory activity of the stomach is a complex and coordinated process, in the regulation of which a quite important part is played by the functional state of the alimentary center, reflex and conditioned reflex stimulation of which causes considerable retardation of evacuation.

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EFFECT OF STIMULATION OF THE HYPOTHALAMUS ON THE MOTOR-SECRETORY ACTIVITY OF THE EMPTY STOMACH, IN EXTENSIVE EXPERIMENTS ON DOGS

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The effect of stimulation of the hypothalamus on the periodic activity of the fasting stomach has been relatively little studied. Most of the work done was in conditions of short experiments, and the results obtained were contradictory. We have been unable to find any references in the literature to the effect of hypothalamic stimulation on gastric secretion in extensive experiments.

Some of the published work has been on animals in which the hypothalamus had been destroyed. N. N. Burdenko and B. N. Mogilnitzki [7] found that destruction of the hypothalamus in dogs was followed by an increase in the amount and the acidity of the gastric juice. Beattie [8] found that stimulation of the lateral wall of the hypophyseal infundibulum of cats under light barbiturate narcosis was followed by increased peristalsis and gastric secretion.

I. I. Burachevsky [1] studied the periodic activity of the empty stomach after damaging the tuber cinereum. He found no significant difference following this operation, as compared with normal animals.

G. M. Davydov [2] found that lesions of the region of the tuber cinereum caused increased gastric secretion in dogs.

G. Bodechtel and O. Kaufmann [9] observed increased peristalsis after stimulating the anterior part of the hypothalamus, whereas E. Gelgorn [3] found the opposite effect.

Rusishvili (1949) found that lesions of the hypothalamic region of dogs caused disturbances in the periodic activity of the stomach and in the spontaneous secretion of gastric juice. I. A. Chereshnev [5] showed that stimulation of the hypothalamus of dogs delayed evacuation of gastric contents into the duodenum.

G. and B. Uvnas [10] found that stimulation of the frontal lobes, basal nuclei, and hypothalamus of cats (acute experiments) was followed after 30-40 seconds by contraction of the stomach.

From all these data it might be concluded that stimulation of the anterior parts of the hypothalamus causes motor and secretory activity of the stomach, which are inhibited by stimulation of the posterior parts. We have attempted, using improved methods and in extensive experiments, to investigate the effect of hypothalamic stimulation in dogs on the motor-secretory activity of the empty stomach.

* In Russian.