

EFFECT OF DESTRUCTION OF THE PYLORIC SPHINCTER ON EVACUATION FROM THE STOMACH

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Evacuation from the stomach was investigated by a method of multiple drainage of an infrapyloric fistula, using edible rubber balls as material for comparison. The duration of evacuation from the stomach after pyloroplasty by the Heineke-Mikulicz method was reduced in all the dogs but the effect was statistically significant in only 2 of the 5 dogs. Pyloroplasty did not abolish the exponential character of evacuation from the stomach and was not reflected in the pH of the duodenal chyme. The addition of fat to the diet lengthened the evacuation time from the stomach equally before and after pyloroplasty.

KEY WORDS: pyloric sphincter; evacuation from the stomach.

The role of the pyloric sphincter in the regulation of evacuation from the stomach is the subject of much lively discussion [2-6, 8, 10, 18-20].

In the investigation described below evacuation of food of solid consistency (bread) from the stomach was studied after the function of the pyloric sphincter had been blocked by the Heineke-Mikulicz operation for pyloroplasty extensively used in clinical surgery.

EXPERIMENTAL METHOD

Five dogs (weight 10-18 kg) with fistulas of the gastric fundus and proximal parts of the duodenum (8-10 cm below the pyloric sphincter) were used. Evacuation from the stomach was studied by the method of multiple drainage of the infrapyloric fistula [1]. Balls 1-2 mm in diameter, made of special edible rubber were used as the material for comparison. By this method it is possible to determine both the total duration of evacuation from the stomach and the dynamics of evacuation throughout the period of digestion in the stomach. Graphs of the evacuatory activity of the stomach were plotted between semilogarithmic coordinates. The hydrogen ion concentration in each 5-minute sample of chyme was determined with a type pH-340 pH-meter.

TABLE 1. Effect of Heineke-Mikulicz Pyloroplasty on Duration of Evacuation from Stomach

Dog No.	Time of evacuation from stomach (in min)		Acceleration of evacuation (%)	P
	before operation	after operation		
1	300±6,7	289±6,6	4	>0,05
2	352±7,8	332±14,0	6	>0,05
3	360±6,1	322±7,1	11	>0,05
4	355±7,4	299±10,0	18	<0,05
5	396±8,2	217±7,2	82	<0,05

After the initial investigations on the dogs, pyloroplasty was carried out by the Heineke-Mikulicz method. During the operation the pylorus was divided by a longitudinal incision extending 3 cm into the stomach and 3 cm into the duodenum. The wound was sutured transversely by means of a Lembert-Albert continuous inverting suture. Tests were carried out on all five dogs on alternate days starting 8 days after the operation.

At the end of the experiment, two dogs were killed and the state of the region connecting the stomach with the duodenum was studied. The external appearance was normal, but a finger passed through the incision in the pyloric portion into the duodenum did not encounter the resistance usually exerted by the pyloric sphincter.

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TABLE 2. Effect of Fat Loading (25 g Margarine) on Evacuation Time of 100 g Bread from Stomach before and after Heineke-Mikulicz Pyloroplasty

Dog No.	Intact stomach			Operated stomach		
	time of emptying stomach (min)		delay of evacuation after fat loading (%)	time of emptying stomach (min)		delay of evacuation after fat loading (%)
	normally	during fat loading		after operation	during fat loading	
1	300,0±6,7	352,9±12,6	117,6	289,0±6,6	405,0±13,4	140,1
3	360,0±6,1	489,3±12,8	135,9	322,0±7,1	388,0±11,0	120,5
4	355,0±7,4	454,6±16,5	128,1	299,0±10,0	375,0±6,7	125,4
<i>M±m</i>	338,0±6,7	432,3±14,0	127,9	303,3±7,9	389,3±10,4	128,4

TABLE 3. Effect of Heineke-Mikulicz Pyloroplasty on Acidity in the Duodenum

Dog No.	Acidity of chyme in duodenum, pH		<i>P</i>
	before operation	after operation	
3	5,1±0,1	5,25±0,08	>0,05
4	5,0±0,06	5,08±0,08	>0,05

EXPERIMENTAL RESULTS AND DISCUSSION

The duration of evacuation of 100 g bread from the stomach before and after pyloroplasty by the Heineke-Mikulicz method is given in Table 1.

It will be clear from Table 1 that, although after pyloroplasty the evacuation time from the stomach was shortened in all five dogs, the difference was statistically significant in only two animals.

In all the dogs emptying of the stomach took place in three phases: a phase of increase in the rate of evacuation, a phase of exponential evacuation, and a phase of rapid emptying of the stomach; i.e., it followed the same course as in dogs with an intact pyloric sphincter (Fig. 1).

In view of evidence of the stimulant effect of fat on the pyloric sphincter [10] it was interesting to examine changes in the evacuation from the stomach after pyloroplasty in response to fat loading. For this purpose, the rate of evacuation of a mixture consisting of 100 g bread and 25 g margarine from the stomach was investigated before and after pyloroplasty. As the results in Table 2 show, the addition of fat to the diet led to equal delay in evacuation from the stomach in dogs with an intact or a divided pyloric sphincter.

The results in Table 3 show that destruction of the pyloric sphincter was not accompanied by significant changes of pH in the chyme in the middle part of the duodenum. Characteristically the reaction of the chyme remained relatively stable even in dog No. 4, in which the pyloroplasty induced a statistically significant acceleration of evacuation from the stomach.

All theoretically possible variants of the effect of blocking the pyloric sphincter on evacuation from the stomach have been mentioned in the literature: acceleration [15,16], no effect [12, 17], and delay [3, 7, 20]. The disagreement between the results may depend both on the method used to block the pyloric sphincter (insertion of a rigid tube into the sphincter, various types of pyloroplasty or pylorotomy) and on the species of animal or the type of food stimulus. For example, pyloroplasty by Finney's method does not affect the rate of evacuation of solutions of carbohydrates from the stomach and it delays emptying of fatty foods [14]. The present experiments were carried out under conditions as close as possible to natural. Bread is a normal constituent of the animals' diet; the sphincter was destroyed by an operation that does not deform the stomach or lead to an excessive increase in size of the stoma connecting the stomach with the duodenum. The fact that pyloroplasty in all the animals was accompanied by accelerated evacuation from the stomach points to a regulatory role of the pylorus in evacuation from the stomach. However, the wide scatter of the results and, in particular, the absence of a statistically significant change in the rate of evacuation in 3 of the 5 dogs point to the presence of highly effective compensatory mechanisms that can take over the function of the pyloric sphincter. Even under the specific conditions of food loading these mechanisms can delay evacuation from the stomach. This calls into question the importance of the role of the pyloric sphincter in the delay of gastric evacuation after the intake of fat. The high effectiveness of

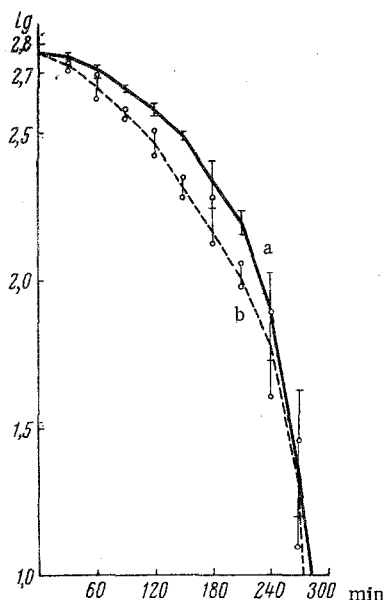


Fig. 1. Dynamics of evacuation of 100 g bread from dog's stomach before and after Heineke-Mikulicz pyloroplasty. Abscissa, time of evacuation (in min); ordinate, logarithm of quantity of food in stomach (in g) after every 30 min; a) before, b) after operation. Values of $M \pm m$ given.

compensation is also demonstrated by maintenance of the normal pH of the duodenal chyme in the pylorotomized dogs. In dogs with a divided pyloric sphincter the pH within the stomach also remains within normal limits [14]. The preservation of the normal hydrogen ion concentration in the stomach and duodenum of pylorotomized dogs is indirect proof that the regurgitation of the intestinal contents into the stomach was on a much greater scale than normally in these animals. Some workers have ascribed the basic role in the prevention of the regurgitation of the duodenal contents into the stomach to the pyloric sphincter [11, 13, 16].

There are indications in the literature that the evacuatory function of the stomach is controlled by an inhibitory entero-gastric reflex and by changes in the transport activity of the duodenum [3, 9, 19]. Presumably these mechanisms are responsible for the complete or partial compensation taking place after destruction of the pyloric sphincter. The relative importance of these factors is not known.

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