MECHANISMS OF COMPENSATION OF THE EVACUATORY FUNCTION OF THE STOMACH AFTER EXCLUSION OF THE PYLORIC SPHINCTER

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UDC 616.33-009.1-003.96

The rate of evacuation of solid food from the stomach was investigated in chronic experiments on dogs with fistulas of the stomach and proximal part of the duodenum. After exclusion of the pyloric sphincter (by the operations of pyloroplasty or gastroduodenostomy) the evacuatory function of the stomach remained basically compensated although, judging from the free passage of edible rubber balls 3 mm in diameter from the stomach into the duodenum, no structures replacing the pyloric sphincter could be found. Compensation of the evacuatory function of the stomach under these conditions is achieved through a marked increase in the role of the enterogastric reflex.

KEY WORDS: pyloric sphincter, evacuation from the stomach; drainage operations.

The writers showed previously [4] that after Heineke–Mikulicz pyloroplasty more rapid emptying of the stomach was observed in some of the dogs. This paper gives the results of an investigation of the mechanisms responsible for compensation of the evacuatory function of the stomach.

EXPERIMENTAL METHOD

Experiments were carried out on five dogs with fistulas of the stomach and proximal part of the duodenum (located 4 or 7 cm away from the pyloric sphincter).

After control investigations a Heineke–Mikulicz pyloroplasty was performed on two dogs and gastroduodenostomy was performed by Jaboulay's method on three dogs. In one of these dogs, simultaneously with the gastroduodenostomy, the pyloric sphincter was ligated. The dogs used for Jaboulay's operation were those in which the distance between the pyloric sphincter and the duodenal fistula was 7 cm. Tests were resumed 2-3 weeks after the operation. The rate of evacuation of 150 g of bread from the stomach was determined by the method of multiple drainage of the retropyloric fistula [1]. The bread was mixed with 600 edible rubber balls 1-1.5 mm in diameter, which left the stomach unhindered together with the chyme. Every 25 min the duodenal fistula was opened for 5 min. The presence of the rubber balls was determined in the evacuated portion of chyme, so that the moment of emptying of the stomach could be established with an accuracy of 15-20 min, by noting the time of disappearance of rubber balls and fragments of bread from the evacuated contents. The rate of evacuation from the stomach was determined by the time required for complete emptying of the stomach, measured in six or seven experiments on each dog.

EXPERIMENTAL RESULTS

Comparison of the rates of evacuation of solid food from the stomach before and after exclusion of the pyloric sphincter showed that after Heineke–Mikulicz pyloroplasty the rate of evacuation from the stomach was increased by 6.4% in one dog and reduced by 0.7% in the other dog. After Jaboulay's gastroduodenostomy the rate of evacuation was reduced by 6-8% in two dogs; in the dog with ligation of the pyloric sphincter it was

Department of Pharmacology and Experimental Pathology of the Digestive Tract, Research Institute of Physiology, Kiev University. (Presented by Academician of the Academy of Medical Sciences of the USSR V. S. Savel'ev.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 83, No. 6, pp. 666-669, June, 1977. Original article submitted October 1, 1976.

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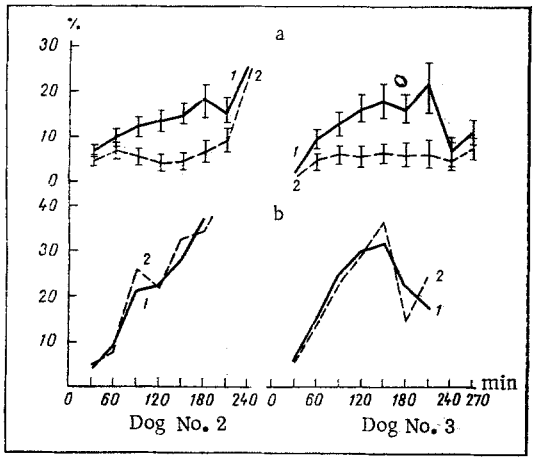

Fig. 1. Dynamics of evacuation of balls of different sizes from stomach before (a) and after (b) operations of Heineke–Mikulicz pyloroplasty (dog No. 2) and Jaboulay's gastroduodenostomy (dog No. 3). 1) Balls 1 mm in diameter; 2) balls 3 mm in diameter. Abscissa, time after test meal (in min); ordinate, ratio (in %) between number of balls of each size leaving stomach in 30-min time intervals and number of balls remaining in stomach.

TABLE 1. Effect of Heineke–Mikulicz Pyloroplasty and of Jaboulay's Gastroduodenostomy on Duration of Evacuation from the Stomach (M ± m)

Type of operation	Dog	Time of evacuation from the stomach, min		Quickening or slowing of evacuation, %	P
		before operation	after operation		
Heineke – Mikulicz pyloroplasty	1	347,1±5,2	325,0±10,7	+6,4	>0,05
	2	367,5±9,6	370,0±5,0	—0,7	>0,05
Jaboulay's gastroduodenostomy	3	315,0±13,4	336,0±9,0	—6,3	>0,05
	4	309,0±5,9	261,4±17,3	+15,4	<0,05
	5	352,5±7,5	381,7±5,8	—7,6	<0,05

TABLE 2. Effect of Exclusion of Enterogastric Reflex on Time of Evacuation of 150 g of Bread from Stomach before and after Operations of Pylorplasty and Gastroduodenostomy (M ± m)

Type of operation	Dog	Gastric emptying time, min		Quickening of evacuation, %	
		normally	after exclusion of enterogastric reflex		
Heineke – Mikulicz pyloroplasty:					
before operation	1	347,1±5,2	312,0±12,9	10,1	<0,05
	2	367,5±9,6	273,0±13,0	25,7	<0,05
after operation	1	325,0±10,7	231,9±13,1	28,6	<0,05
	2	370,0±5,0	215,0±5,0	41,9	<0,05
Jaboulay's gastroduodenostomy:					
before operation	3	315,0±13,4	267,0±7,3	15,2	<0,05
	4	309,0±5,9	228,0±11,0	26,2	<0,05
after operation	3	336,0±9,0	230,0±10,5	31,5	<0,05
	4	261,4±17,3	130,0±10,0	50,3	<0,05

increased by 15%. A significant change in the rate of evacuation from the stomach was thus observed in only one dog (Table 1).

Ignoring certain differences in the consequences of the operation and accepting a high degree of compensation of the evacuatory function of the stomach, the four following causes of this effect can be postulated: 1) In the region where the stomach was joined to the duodenum, morphological reconstruction took place enabling

the rate of emptying of the stomach to be compensated, i.e., something resembling a sphincter had formed; 2) the sphincter determining the rate of emptying the stomach was inefficient; 3) compensation took place through the ability of the stomach itself to regulate the rate of its own emptying; 4) compensation took place on account of mechanisms involving the duodenum, i.e., the enterogastric inhibitory reflex.

To test the first hypothesis the ability of the pyloric sphincter to discriminate evacuation of rubber balls of large diameter was studied. For this purpose, before and after exclusion of the pyloric sphincter, the dynamics of evacuation of balls 1 and 3 mm in diameter together with bread from the stomach was investigated. As the graphs in Fig. 1 show, before the operation the small balls left the stomach much faster than the larger balls; after the operation both sizes of balls passed from the stomach at equal speeds, i.e., at the time of resumption of the tests after the operation the pyloric sphincter was inactive.

To test the role of the enterogastric reflex in compensation of the evacuatory function of the stomach experiments were carried out as follows. The gastric contents escaping from the duodenal fistula were collected not during intervals of 5 min, but continuously throughout the period of investigation. Under these circumstances the chyme did not enter the small intestine and the enterogastric reflex was largely excluded, for the passage of the chyme along 4 or 5 cm of the initial part of the duodenum could not play any decisive role. Whereas before exclusion of the pyloric sphincter the enterogastric reflex caused a delay of evacuation from the stomach by 10-25%, after the operation the delay was increased from 30-50% (Table 2).

Two conclusions can thus be drawn. First, as some workers [2, 3, 5, 6] consider, the pyloric sphincter plays an important role in the regulation of emptying of the stomach and does not simply discriminate against the expulsion of large pieces of food from the stomach and reduce the duodenogastric reflex [7, 8]. Second, the increase in the rate of evacuation from the stomach in a dog with a nonfunctioning pyloric sphincter is compensated by an increase in the role of the enterogastric reflex. Undoubtedly the stomach itself plays an important part in this effect, for its peristaltic waves "bite off" a fixed portion of the gastric contents, not more than 30-50% more than the mean volume of chyme that must leave the stomach, at the moment of complete occlusion in the distal half of the antral portion. It must be assumed that it is because of the regulatory function of the pyloric sphincter that about one third of the chyme is propelled backward into the antral portion during the passage of each peristaltic wave.

Although the difference between the rate of emptying of the gastric contents in dogs with an intact pyloric sphincter and with a destroyed or "by-passed" pyloric sphincter is comparatively small, the range of spread of the data among dogs undergoing the operations of pyloroplasty and gastroduodenostomy amounts to 10-15%. Destruction of the sphincter by pyloroplasty, abolishing the obstacle along the natural passage of the chyme, can be assumed only to accelerate evacuation from the stomach, and this is substantially moderated by the enterogastric reflex. After gastroduodenostomy the natural passage of the chyme is distorted. Perhaps some of the chyme, leaving the stomach through the pyloric sphincter, returns into it through the gastrostomy and delays evacuation of the gastric contents through it. This hypothesis is confirmed by the fact that in a dog with a ligature applied to the pyloric sphincter after the operation of gastroduodenostomy, the rate of evacuation from the stomach after the operation was not reduced by 6-7%, as in the other dogs, but increased by 15%.

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