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ROLE OF THE LIGAMENT OF TREITZ IN REGULATING SOLID FOOD EVACUATION FROM THE DUODENUM

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Since the discovery by Treitz of a supporting muscle of the duodenum, most attention has been paid to the study of its morphology and anatomy [4, 10, 15, 16], whereas its functional role remains unclear. It has been suggested that the ligament of Treitz (LT), as a component of the duodenojejunal junction, is an active regulator of the propulsive ability of the duodenum [2, 10]. However, there have been no direct investigations whose results could characterize, quantitatively and qualitatively, the functional role of LT as a regulator of the evacuatory function of the duodenum. Besides its theoretical interest, this problem also is of great practical importance because of the widespread use of the operation of division of LT in modern surgery for the treatment of duodenostasis [4].

The aim of this investigation was to study the effect of division of LT on the duration and time course of evacuation of solid food from the duodenum.

EXPERIMENTAL METHOD

Chronic experiments were conducted on three dogs with two fistulas: duodenal (5 cm distally to the pyloric sphincter) and intestinal (3 cm distally to LT). The animals were investigated before and during 6 months after division of LT. The experiments were carried out over a period of 6 h after the dogs had been fed a diet (100 g bread + 25 g milk) to which 600 black spheres 1 mm in diameter, made of edible rubber, were added as a comparison substance. To assess evacuation from the duodenum, 30 min after feeding and during excretion of the spheres from the intestinal fistula, 50 red spheres were injected into the duodenum by means of a special plunger. The number of black spheres reflected the general dynamics of evacuation

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TABLE 1. Duration of Evacuation of Red Spheres from Duodenum throughout the Digestive Process, before and after Division of LS (pooled data for 3 dogs)

Group of animals	Time taken by red spheres to move along duodenum, min								
Intact	33,7±5,3	28±7	23,2±6	21,7±4	24,4±6	30±11,3	40,9±3	47±6	55±8
After division	48,3±6,5	40±3	36,4±4	31,5±9	26±6,7	56,7±3	70±4,5		
p	<0,05	<0,05	<0,05	<0,05	>0,05	<0,05	<0,05		

from the stomach and duodenum, the number of red spheres reflected the dynamics of evacuation of the contents from the duodenum. In separate experiments the evacuatory function of the stomach was assessed by the method of periodic drainage of the retropyloric fistula [3].

EXPERIMENTAL RESULTS

The first stage of these investigations was to study evacuation from the duodenum of intact dogs. Whereas in the literature most attention has been paid to the duration of the transit of food along the duodenum [5, 12], the question of the dynamics of this process throughout the digestive cycle has not been considered. Analysis of normal evacuation revealed the following features. It will be clear from Table 1, which gives the results of determination of the time taken by 50 red spheres to move along the duodenum throughout the process of digestion, cycle by cycle (the term cycle is taken to mean the time in which all the spheres introduced into the intestine emerge from the intestinal fistula) during the first 90 min after feeding a gradual decrease was observed in the time spent by the spheres in the duodenum. Later, until the 210th minute, minimal values of this parameter were determined. At the end of the evacuation process the length of stay of the spheres in the duodenum was maximal. Data on the time course of evacuation from the stomach and duodenum are given in Fig. 1a. The graph shows that there is a general rule for the evacuatory activity of the stomach and duodenum. The absolute weight, having reached a maximum at the 90th minute, began to fall steadily until the 210th minute. During this period the steady fall of the absolute velocity indicates the exponential character of evacuation of the stomach and duodenum. Thus under normal conditions the rate of movement of solid food along the duodenum obeys an exponential law and it depends on the absolute quantity of food evacuated from the stomach, i.e., the basic principle for organization of the evacuatory function of the proximal part of the gastrointestinal tract is absolute coordination of the evacuatory activity of the stomach and duodenum.

To discover the role of LT in the evacuatory process similar experiments were carried out on the same dogs after its division. Division did not affect emptying of the stomach: the duration of evacuation showed a very small but not significant increase and emptying obeyed an exponential law. A different picture was observed in the study of the evacuatory function of the duodenum. As Table 1 shows, division of LT increased the time spent by each portion of spheres in the duodenum ($p < 0.05$). It must also be pointed out that before the operation the highest velocity of the movement of the spheres along the duodenum was observed 90-120 min after feeding, and 150 min after the operation; the period of rapid evacuation, moreover, was much shorter. Thus after division of LT the rate of passage of the food along the duodenum was slowed, and the period of intensive evacuation was shifted to the right by 60 min. The dynamics of evacuation underwent a significant change after the operation (Fig. 2). In dogs undergoing the operation, during the first 150 min after feeding emptying was sometimes intensified, sometimes weakened, periodically, evidence of the nonexponential character of evacuation. Later, having reached its maximum, the absolute rate of evacuation fell until the 270th minute, with a transient rise at the end of this process. The fact will be noted that while the normal weight of gastric emptying was preserved, the rate of evacuation from the duodenum after division of LT was lower than that in dogs with an intact LT throughout the digestive process and it never reached the peak values mentioned above. The question arises, how can dissociation of the rates of emptying of the stomach and duodenum be explained, having regard to the relatively small cubic capacity of the duodenum compared with that of the stomach. We know [11] that intensive absorption of water, carbohydrates, and protein decomposition products (up to 80%) takes place in the duodenum. When passage along the duodenum is delayed, the relative quantity of absorbed nutrients may be increased even more. It must also be recalled that the dogs were fed with a small volume of the stimulus (100 g of bread).

A particularly interesting problem was to discover whether coordinates of the evacuatory processes in the stomach and duodenum, which we discovered in experiments on dogs with an intact LT, still remains after its division. The results are presented in the form of a linear graph (Fig. 1b). After division of LT the precise coordination of the time of movement of food along the intestine with the time of its evacuation from the stomach was disturbed. Whereas in the case of evacuation from the stomach the absolute velocity reached a peak at the 90th minute and then decreased steadily until the 210th minute,

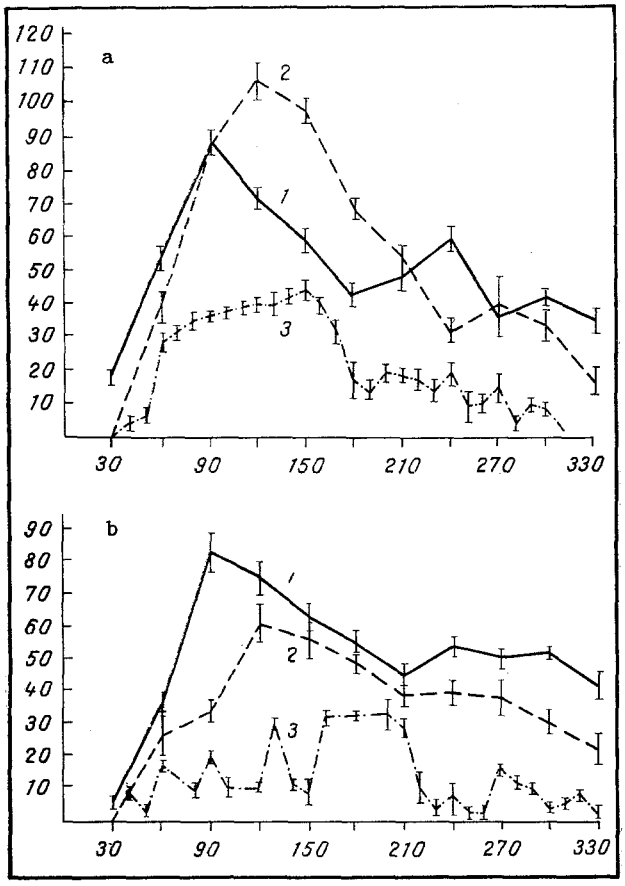

Fig. 1

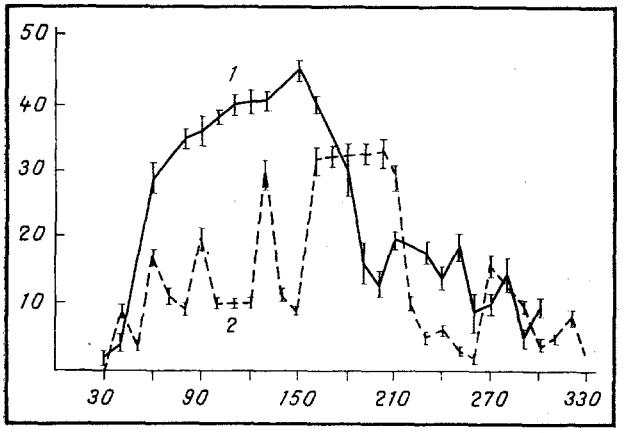

Fig. 2

Fig. 1. Dynamics of evacuation of rubber spheres from stomach and duodenum before (a) and after (b) division of LT following a carbohydrate meal: 1) Evacuation from stomach; 2) evacuation from stomach and duodenum; 3) evacuation from duodenum. Abscissa, time after feeding (in min); ordinate, number of spheres evacuated from stomach (duodenum).

Fig. 2. Dynamics of evacuation of rubber spheres from the duodenum before and after division of LT, on a carbohydrate diet: 1) Before, 2) after operation. Abscissa, time after feeding (in min); ordinate, number of spheres evacuated from duodenum.

in the duodenum the velocity of passage of food reached a maximum after 150 min, after which the stimulation of evacuation was replaced by its inhibition. Thus the strength of the evacuatory activity of the duodenum is independent of the intensity of gastric emptying within the given time interval. As was pointed out above, in this case the passage of chyme after division of LT was weaker than normally throughout the experiment. It can be concluded from all the facts described above that division of LT disturbs coordination of the evacuatory function of the stomach and duodenum and also has an inhibitory action on the evacuatory activity of the intestine. This conclusion is in agreement with views expressed by some workers who consider that LT plays an important role in determination of the rate of emptying of food from the duodenum [10, 15, 17]. Further confirmation of the "useful role" of LT was reported as long ago as in the 1930s [1]. It has been suggested [16] that due to contraction of the muscle of the ligament kinking of the intestine is straightened out and, as a result, the passage of chyme in this region is improved. A similar point of view is held by other workers [7, 10]. Some workers [15] have suggested that because of the presence of nerve ganglia in LT, coordination ought to exist between the contractile activity of the pyloric sphincter and LT, and the opening of the duodenum at the duodenojejunal junction ought to follow opening of the pylorus after a short interval. This hypothesis was confirmed by the present experiments. The experimental results indicate functional unity of the gastroduodenal complex, which includes LT. The latter corrects the character and intensity of evacuation from the duodenum and coordinates it with the process of evacuation from the stomach. Indirect proof of the importance of LT in the regulation of evacuation from the duodenum is given by information in the literature on the higher incidence of recurrence

after division of LT when used for the surgical correction of duodenostasis. Recently many workers have noted that this operation does not improve, but sometimes worsens, passage along the duodenum [6], although the opposite point of view has been expressed [2, 3]. Our own data suggest that disturbance of coordination of gastric and duodenal activity after division of LT is one cause of the dyskinesia of the duodenum which develops. Some workers consider that a disturbance of this mechanism is the principal etiologic factor of duodenostasis [14]. According to the author cited in [13], coordination of motor activity in the gastroduodenal zone is the most important factor for integration of the different digestive functions of the duodenum. Disturbance of coordination of the work of the stomach and duodenum is recognized to be a frequent and important clinical sign [9].

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