Changes in Contractile Activity of the Duodenum, Jejunum, and Ileum under Conditions of Psychogenic Stress in Rabbits

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Psychogenic stress in rabbits caused by fixation of the animal to a frame was accompanied by an increase in duodenal contractile activity. In the jejunum, initial inhibition of motor activity gave way to activation more pronounced in the proximal part. In both parts of the ileum, inhibition of contractile activity was noted. A proximodistal gradient of the excitatory and inhibitory effects on the motility of the small intestine was demonstrated.

Key Words: *psychogenic stress; contractile activity of the small intestine*

Stress inhibits the evacuation of the stomach and accelerates the colonic transit [10]. The data on the nature of stress-induced changes in the small intestine transit of chyme are ambiguous: some authors noted its acceleration [5], while others deceleration [8]. There is evidence on increased contractile activity (CA) of the duodenum and jejunum during stress [7], but some authors [6] reported a decrease in motor activity of the duodum and jejunum under these conditions. This contradiction in the pattern of stress-induced changes in CA can be due to differences in the studied objects and employed methods. In this regard, it seems interesting to study stress-induced changes of CA in various parts of the small intestine in animals of the same species using standardized techniques.

MATERIALS AND METHODS

Chronic experiments were carried out on male rabbits weighing 2.5-3 kg. Bipolar electrodes were implanted to 17 animals with strict adherence to the principles of abdominal surgery. The following sites of the intestine were selected for the subserous implantation of electrodes: the proximal part and the distal third of post-pyloric duodenum and two sites from each proximal and distal third of both jejunum and ileum. The animals were included in the experiment 10-12 days after surgery without food and water deprivation. Intestinal myoelectrical activity (MEA) was recorded on ERG-16s encephalograph (0.1 time constant, 7.5 mm/sec recording rate, and sensitivity of 250 μV per 1 cm pen deviation). After 30-min recording of baseline MEA, psychogenic stress was modeled in rabbits by catching and rigid fixation to a frame in the supine position. This induces a pronounced stress reaction manifesting in a sharp increase in HR [3] and plasma levels of ACTH, corticosteroids, epinephrine, and norepinephrine [4,9]. All experiments were performed with due regard to ethical principles for animal experiments.

For the quantitative analysis of MEA, two 30-min periods after the start of the stress exposure were chosen (first and second stages of the response) in each experiment. CA was assessed by the index of contractile activity (ICA, a product of the number of spikes over 40-sec period and mean spike amplitude in mm over the same period of time) and expressed in arbitrary units. Statistical processing of the data was performed using Origin 6.1. The arithmetic mean and standard error of the mean were calculated. Statistical significance of between-groups differences in independent samples was evaluated by ANOVA.

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RESULTS

Stress increased CA in the proximal and distal parts of the duodenum (Fig. 1). The mean values of ICA in both portions of the duodenum during the first and second stages of the stress response significantly surpassed the baseline values (Table 1): by 40 and 75% in the proximal portion and by 51 and 75% in the distal portion, respectively.

In the proximal and distal portions of the jejunum, marked inhibition of CA was observed during the first phase of the stress response (Fig. 1). ICA decreased by 30 and 38%, respectively, compared to baseline ($p>0.05$; Table 1). It should be noted that despite statistical insignificance of this decrease in the whole, in 4 of 6 experiments ICA reduction in the proximal and distal parts of the jejunum was statistically significant: 41% ($p<0.01$) and 59% ($p<0.01$), 63% ($p<0.001$) and 68% ($p<0.01$), 55% and 65% ($p<0.05$), and 58% ($p<0.01$) and 55% ($p<0.05$), respectively. This demonstrates functional significance of CA inhibition in the proximal and distal jejunum in the first phase of the stress response.

In the second phase of the stress reaction, we observed an increase in CA in the jejunum, more pro-

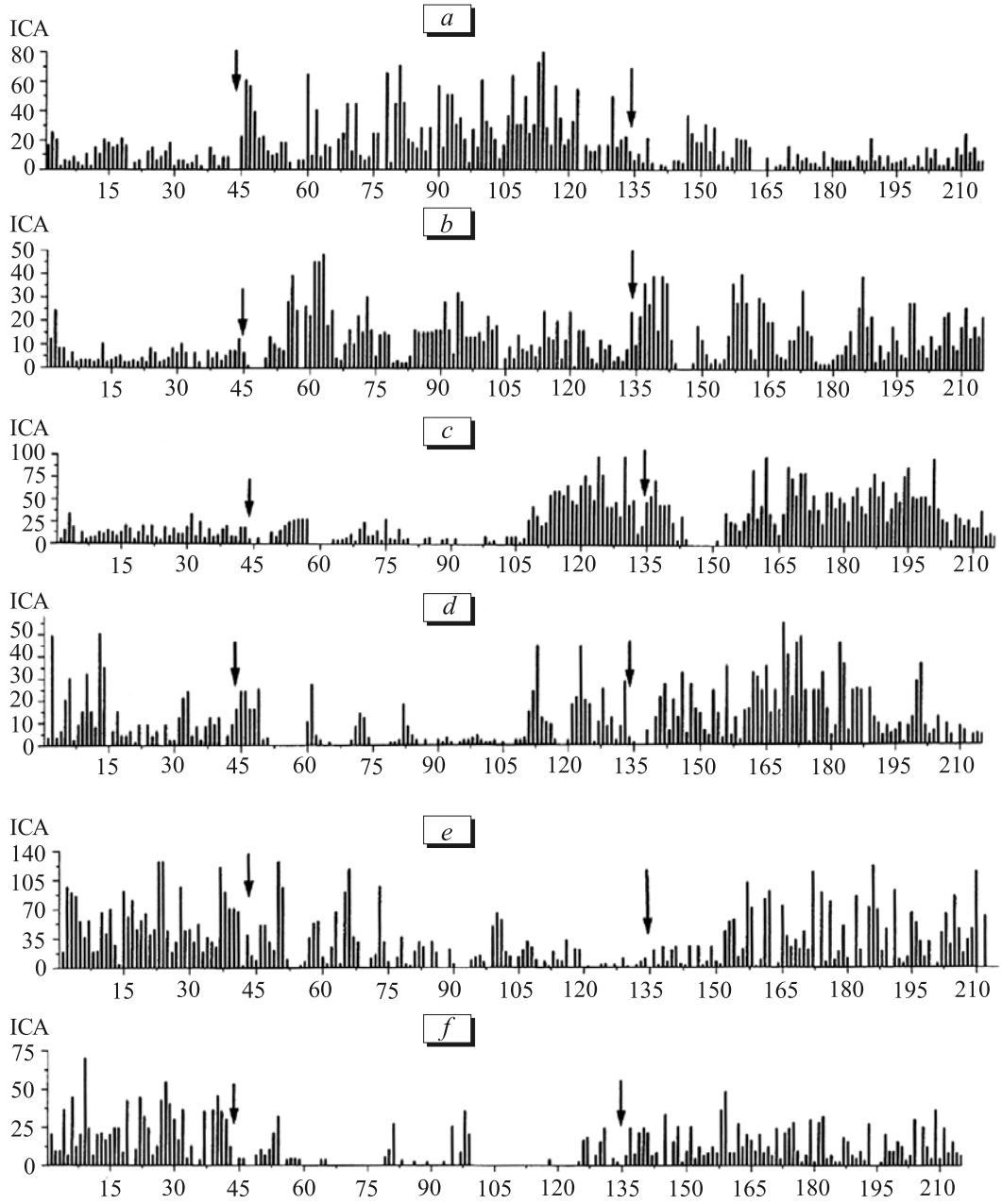

Fig. 1. Changes in ICA in the proximal and distal parts of the duodenum, jejunum, and ileum during psychogenic stress. *a*, *c*, *e*: proximal part; *b*, *d*, *f*: distal part. Arrows indicate the start and end of the stress exposure. Abscissa: serial number of 40-second periods of MEA recording.

TABLE 1. Changes in Duodenal, Jejunal, and Ileal ICA in Rabbits during Stress (*M*±*m*)

Portion of the intestine		Baseline	Fixation			
			stage 1		stage 2	
			abs.	Δ, %	abs.	Δ, %
Duodenum	proximal part (*n*=5)	14.7±1.2	20.6±2.2*	+40	25.8±2.3**	+75
	distal part (*n*=6)	10.7±1.1	16.2±2.1*	+51	18.7±2.0**	+75
Jejunum	proximal part (*n*=6)	22.8±3.6	15.9±3.2	-30	35.6±4.4*	+62
	distal part (*n*=6)	17.1±3.3	10.5±2.7	-38	19.7±3.2	+15
Ileum	proximal part (*n*=6)	33.9±4.7	9.1±2.2***	-73	16.6±2.7**	-51
	distal part (*n*=5)	23.5±2.9	6.9±1.6**	-70	6.9±1.8**	-70

Note. *p<0.05, **p<0.01, ***p<0.001 compared to background values.

nounced in the proximal part (Fig. 1): ICA in this portion significantly increased compared to the baseline value by 62% (Table 1), while in the distal portion it exceeded the baseline levels by only 15% (p>0.05).

In the proximal part of the ileum, stress caused suppression of CA (Fig. 1); ICA significantly decreased compared to the baseline level during the first and second phases of the reaction by 73 and 51%, respectively (Table 1). In the distal ileum CA was also inhibited (Fig. 1); ICA decreased by 70% in both phases of the reaction.

Thus, psychogenic stress in rabbits induced a short-term inhibition of duodenal CA followed by its increase. In the jejunum, the initial inhibition of motility was followed by its activation, more pronounced in its proximal part; in both parts of the ileum, inhibition of CA was detected.

In experiments on dogs [7], psychogenic immobilization stress increased the frequency of spike bursts in the duodenum and proximal jejunum. In experiments on rats [11], immobilization stress caused increased the frequency of spike bursts in the jejunum. These experiments demonstrating CA enhancement in the duodenum and jejunum during stress are consistent with the results of our study. At the same time, other authors [6] reported complete suppression of duodenojejunal migrating motor complex phase-2 spike activity in fasting humans. This is not consistent with our data on CA enhancement in the duodenum and jejunum (in the second phase of the reaction) during stress. The difference in the results can be attributed to the mismatch of the experimental conditions and functional status of the research object. In our experiments, the rabbits had unlimited access to food. The same explanation is valid for the data inconsistent with ours and obtained in experiments on fasting rats in which psychogenic stress increased the number of spike bursts in the ileum [11]. We had previously reported that duodenal and ileal motor response to stress (acute blood loss) depended on the initial level of CA [2]. These data confirm the important role of the initial functional state of the experimental animal characterized, in particular, by unequal activation of one of the two regulatory circuits (excitatory and inhibitory) of the enteric nervous system. Changes in the duodenal response to repeated emotional stress reported by us [1] also confirm the importance of the initial functional state for manifestations of the motor reactions of the small intestine to stress.

The above reported changes in ICA during the first and second phases of the stress reaction (in % of

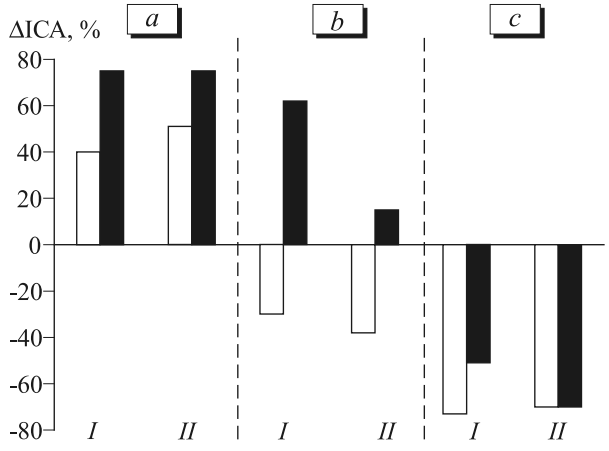

Fig. 2. Proximodistal gradient of excitatory and inhibitory effects of the psychogenic stress on CA in the proximal (*I*) and distal (*II*) parts of the duodenum (*a*), jejunum (*b*), and ileum (*c*). Ordinate: changes in ICA in the studied portions of the small intestine (% of baseline activity). Light and dark bars correspond to stages 1 and 2 of the stress response, respectively.

baseline) for all studied portions of the small intestine attests to weakening of the stimulating effect of stress and potentiation of the inhibitory effect from the duodenum to the ileum (Fig. 2).

The peristaltic reflex, the basic mechanism for the transit of chyme in the digestive tract, consists in intestinal contraction above the site of stimulation and relaxation below it. Chyme passage in the gastrointestinal tract requires strictly coordinated changes in motility of its different parts, including the motor reaction to stress. As was mentioned above, the data on changes in chyme passage in the small intestine during stress are ambiguous: some authors noted its acceleration [5], while others deceleration [8]. Our experiments demonstrated the existence of a proximodistal gradient of the excitatory and inhibitory effects on small intestinal motility under conditions of psychogenic stress in rabbits. Functionally, this manifests in the prevalence of enhanced CA in the duodenum and proximal jejunum and CA inhibition in the distal jejunum and both parts of the ileum. Such distribution of sites of CA stimulation and inhibition along the intestine under conditions of stress should obviously facilitate chyme passage towards the distal direction and accelerate its passage in the small intestine.

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