Functional Heterogeneity of Damaged Gastroduodenal Complex

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Peculiarities of myoelectric activity in the gastric corpus, pylorus, and duodenum during acute damage to the stomach and simulated partial intestinal obstruction were studied on cats. During adaptation, the functional systems of digestion organs are characterized by disruption of the relationships between their elements. Disturbances of adaptive processes were accompanied by strengthening of these relationships, which made the whole system more vulnerable.

Key Words: *gastroduodenal complex; functional heterogeneity; alteration*

The level of functional heterogeneity of a system significantly varies during pathology, which reflects peculiarities of the adaptive and compensatory reactions. Specifically, the existence of flexible relationships determines wide adaptive potencies of the system, while strengthening of the relationships between the elements of a system makes it more vulnerable [5]. We previously showed that typical immediate adaptation reactions in visceral systems are characterized by activation and consolidation of inhibitory processes primarily developing at the level of intraorganic nervous system and manifesting in potentiation of the autonomic control of the damaged organ and elevation of its functional heterogeneity [6].

For evaluation of the role of functional uncoupling in gastroduodenal complex (GDC), we examined all stages of the pathological process. Changes in correlation relationships between GDC subdivisions were examined in chronic experiments under conditions of simulated partial duodenal obstruction and compared with the data obtained in experiments with acute damage to the pylorus.

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MATERIALS AND METHODS

In experiments on mature male cats, chronic disturbance of duodenal patency (CDDP) was simulated by standardized narrowing of the duodenal lumen. The state of experimental animals was scored by specially developed criteria. The terms of observation were 30-45 days.

Myoelectric activity (MEA) of GDC (the gastric corpus, pylorus, and proximal duodenum) was recorded using a Bioscript-1 8-channel electroencephalograph equipped with additional low-pass filters [1,2]. The recording electrodes were implanted directly on the examined regions and sutured with atraumatic needles to the visceral peritoneum. All experiments were performed on fasting animals. The functional state and peculiarities of interrelations between the examined parts of the gastrointestinal tract were assessed on the basis of amplitude-frequency parameters and correlation analysis of MEA. The results of chronic experiments were compared with the data obtained in experiments with acute damage to the pylorus wall.

RESULTS

In intact subdivisions of GDC, MEA amplitude was high in the pylorus, but decreased in the gastric

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corpus and duodenum. During the first 20 min after acute damage to the pylorus, the mean amplitude of pyloric MEA increased by 29.8%, while duodenal MEA amplitude decreased by 28.3%. Changes in MEA amplitude in the stomach were insignificant. On minutes 25-50 after alteration of the pyloric region, its MEA amplitude returned to near initial level. The mean value of duodenal MEA amplitude remained low and did not change significantly. The parameters of gastric corpus MEA remained stable throughout the entire experiment (Fig. 1). The positive significant medium-strength correlations were found between changes in MEA amplitude in gastric corpus and pyloric region as well as between these changes in the gastric corpus and duodenum. The correlation between changes in MEA amplitude in the pyloric region and duodenum were weak but significant. To minutes 25-50 after damage to the pyloric region, the lost correlation between MEA changes in the gastric corpus and duodenum partially recovered, but similar correlation between the gastric corpus and pylorus did not restore for 2 h and longer (Table 2).

These chronic experiments showed that signs of decompensation appeared on day 30 after damage and aggravated to day 45, when the symptoms of intestinal obstruction developed. During the compensation period, MEA amplitude decreased by 38% and 27% in the proximal segment of the duodenum and pylorus, respectively, but increased by 33% in the gastric corpus (compared to control values). On day 45 after damage, MEA amplitude in duodenum and pylorus decreased by 43% and 67%, respectively. To this time, MEA amplitude of the gastric corpus increased by 15% in comparison with the control group (Table 1).

On day 30, paired correlation coefficients of MEA amplitudes were significant only in the gastric corpus and duodenum. However, this feature changed to posttraumatic day 45. All correlation coefficients significantly increased in comparison with the initial values. These correlations became significant, which attested to strengthening of the relationships between various GDC subdivisions, in particular, between the pyloric region and duodenum, as well as between the pylorus and gastric corpus (Table 2).

These data suggest that during acute traumatic period, the immediate adaptation processes are characterized by significant elevation of functional heterogeneity in GDC, which remains enhanced during the compensatory period of CDDP. During the development of decompensatory signs characterizing CDDP on posttraumatic day 45, the relationships

TABLE 1. Changes of Amplitude of Myoelectric Activity (mV) in Various GDC Regions during Early Period of Acute Damage and during CDDP Modeling ($M \pm m$)

GDC region	Initial (control) data	Acute damage to pyloric region on posttraumatic minute 20	CDDP	
			day 30	day 45
Gastric corpus	2.12±0.08	1.91±0.09	2.75±0.05	2.44±0.07
Pylorus	3.21±0.13	3.39±0.15*	2.34±0.10*	1.06±0.12*
Duodenum	2.48±0.10	1.90±0.09*	1.54±0.12*	1.41±0.60*

Note. *$p<0.05$ compared to initial values.

TABLE 2. Changes in Paired Correlation Coefficients between MEA Amplitude in Various GDC Regions during Early Period of Acute Damage and during CDDP Modeling ($M \pm m$)

GDC region	Initial (control) data	Acute damage to pyloric region on posttraumatic minute 30	CDDP	
			day 30	day 45
Gastric corpus—pyloric region	0.338±0.002*	0.133±0.07	0.036±0.049	0.467±0.049*
	0.384±0.002*	0.275±0.07*	0.206±0.038*	0.670±0.094*
Pyloric region—duodenum	0.226±0.002*	0.130±0.07	0.087±0.026	0.659±0.034*
Σ	0.948	0.275	0.206	1.796

Note. Σ: sum of significant correlation coefficients. *Significant correlation coefficients.

between the elements of GDC significantly strengthened, which indicated moderation of functional heterogeneity in the system of damaged GDC. The changes in the sum of significant correlation coefficients obtained at the various stages of the experiments provide an indirect assessment of the degree of relationships between GDC elements (Table 2).

During CDDP decompensation, the sum of significant correlation coefficients increased almost 2-fold in comparison with the initial values.

Our data agree with the reports that the amplitude of electric activity in GDC smooth muscles is the most sensitive parameter characterizing functional activity of the digestive organs and reflecting the degree of synchronization of their subdivisions [3,4,8]. The data obtained demonstrated that the elements of undamaged GDC are characterized by medium-strength correlations, which weaken significantly during adaptation to extreme influences (acute and chronic experiments). During decompensation these correlations strengthen, which reflects moderation of GDC functional heterogeneity, limitation of GDC adaptive potency, and elevation of GDC vulnerability. During acute period, the damage-induced disturbances in the interaction between GDC subdivisions, which result from consolidation of inhibitory processes [7], reflect the basic reaction of immediate adaptation capable to prevent generalization of the pathologic process, thereby improving the adaptive capacity of the integral system.

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