Uncoupling of Afferent and Myoelectric Reactions in Portions of Gastroduodenal Complex in Acute Damage Period

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In two series of experiments on cats, afferent reactions of organs of the gastroduodenal complex (gastric corpus, pylorus, and duodenal bulb) were studied and myoelectric activity of these portions of the gastroduodenal complex was examined. In each series, only one portion of the gastroduodenal complex was stimulated with electrical pulses. It was found that processes underlying changes in functional heterogeneity and enhancement or moderation of their interrelations in the acute damage period can affect the development of early regional adaptation.

Key Words: *electrical activity; gastroduodenal complex; system heterogeneity*

Functional heterogeneity of a system (organ), a basic property forming hierarchy between subdivisions, determines the development of pathological processes, which was shown in altered heart [2]. Increase in functional heterogeneity caused by predominance of excitation processes disturbs interaction between the portions of the system and can severely impair its work. During the formation of early adaptation reactions, the inhibitory processes are consolidated. They are determined by specific character of the early stress-limiting response, whose development is controlled by opiate, GABAergic, and other related systems [1]. In addition, hyperinhibition promotes uncoupling of regulation between system parts, although it also implies the possibility of achieving beneficial adaptive results such as limitation of catecholamine response and spastic processes, improvement of hypoxia tolerance *etc*.). Here we studied the peculiarities of functional heterogeneity in gastroduodenal complex (GDC) by changes in the evoked afferent activity and myoelectric reactions in stomach subdivisions and duodenal bulb (DB).

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MATERIALS AND METHODS

Two series of acute experiments were carried out on cats weighing 2-3 kg. The cats were narcotized with intraperitoneal α-glucochloralose, injected with myorelaxin, and artificially ventilated. In the first series, afferent reactions of GDC organs were examined by recording evoked potentials in the cerebral cortex (CC) and medial center of the thalamus (MCT) during individual electrical stimulation of the wall of gastric corpus, pylorus, and DB.

In the second series, myoelectric activity of GDC portions was assessed by conventional electrogastrography.

Myoelectric activity was recorded in the smooth muscle wall of the same GDC portions.

The functional state and interrelations between subdivisions of gastrointestinal tract were assessed by amplitude-frequency parameters and correlation analysis of their myoelectric activity.

Acute damage to GDC portions was modeled by subserous injection of neutral formalin. In the first part of the study gastric corpus, pylorus, and DB were damaged, while in the second part only pylorus was damaged.

RESULTS

In the first series, the evoked potentials were recorded during electrical stimulation of intact organs, thereafter gastric corpus was acutely damaged. In 5-7 min, the total amplitude of the initial phases of the potentials evoked by stimulation of the altered region of the stomach decreased in CC from 184.0±19.8 to 43.0±5.6 μV and in MCT from 139.0±11.4 to 58.0±4.3 μV (p<0.01). In this period, the amplitude of the potentials evoked by stimulation of the pylorus also decreased. By contrast, the total amplitude of the initial phases of the potentials evoked by stimulation of DB slightly increased in CC from 150.0±14.6 to 158.0±15.2 μV and in MCT from 123.0±11.8 to 139.0±9.6 μV.

In 20-25 min after the damage to the gastric corpus, the total amplitude of the initial phases of the potentials evoked in CC and MCT returned almost to the initial values. The potentials evoked by stimulation of DB were little changed from 158.0±15.9 to 143.0±12.3 μV. Depression of potentials evoked by stimulation of the pylorus was observed during no less than 1.5 h. On minute 25 after damage, the amplitudes of evoked potentials were 18.0±3.1 μV and 48.0± 5.1 μV in CC and MCT, respectively (p<0.01).

In the second series, the pylorus was acutely damaged, which in 5 min induced deep depression of potentials evoked in CC and MCT by stimulation of any portion of GDC. In CC, the potentials evoked by stimulation of the gastric corpus, pylorus, and DB decreased to 38.0±4.6 μV, 18.0±3.4 μV, and 24.0±2.1 μV, respectively (p<0.01). In MCT, the corresponding values were 26.0±2.9 μV, 42.0±8.9 μV, and 39.0±5.6 μV (p<0.01). In 20-25 min after the damage to the pylorus, the total amplitude of potentials evoked in CC and MCT by stimulation of the gastric corpus and DB virtually coincided with the initial values. The potentials evoked in CC and MCT by stimulation of the gastric corpus were 193.0±18.4 μV and 144.0±11.5 μV, respectively. The potentials evoked in CC and MCT by stimulation of DB were 136.0±12.8 μV and 115.0±10.2 μV, respectively. By contrast, inhibition of afferent activity of the pylorus lasted at least 1.5 h, and in 25 min after the damage, the amplitudes of evoked potentials were 28.0±6.2 μV and 50.0±7.4 μV in CC and MCT, respectively (p<0.01).

Acute damage to DB inhibited afferent reactions in the pylorus (CC: 19.0±3.1 μV; MCT: 12.0±4.5 μV) and DB (CC: 9.0±1.8 μV; MCT: 24.0±3.8 μV). The amplitude of evoked potentials recorded during stimulation of the gastric corpus tended to increase (this increase was significant for MCT). In CC it was 201.0±17.4 μV, while in MCT it was 193.0±18.1 μV (p<0.01). On min 25 after damage to DB, the potentials evoked by stimulation of the gastric corpus retained the rising trend, which was more pronounced in MCT (165.0±16.9 μV) than in CC (189.0±17.6 μV). The potentials evoked by stimulation of DB did not significantly differ from the initial ones (CC: 118.0±12.2 μV; MCT: 128.0±12.6 μV), retaining the decreasing trend in CC.

Thus, acute damage to any of the examined portions of GDC induced deep and long-term depression of afferent reactions of the pylorus and significant inhibition of afferent response in the affected portion (Fig. 1). Damage to the gastric corpus or DB slightly increased the amplitude of the afferent response in the undamaged portion. Inhibition of the afferent reactions evoked by electrical stimulation was reversible in all subdivisions of GDC. During the acute period of the damage, heterogeneity of centripetal activity in GDC markedly increased. The effect of damage to the pylorus was the most radical: it resulted in a short period of afferent depression, which was evidently stabilized by activation of intraorganic departments in the stress-limiting systems, most of all, in GABA- and opioidergic systems.

In the second part of this study, the peculiarities of interrelations between the portions of GDC were examined by correlation analysis of myoelectric activity in the gastric corpus, cardia of the stomach, pylorus, and DB under the conditions of damaged pylorus, because this portion of GDC produced the most stable changes in afferent activity. The predominance of high-amplitude parameters of myoelectric activity attests to synchronization of activity in the working system. Therefore, we examined the peculiarities of changes in the mean amplitudes of myoelectric activity at the same periods after acute damage to the stomach,

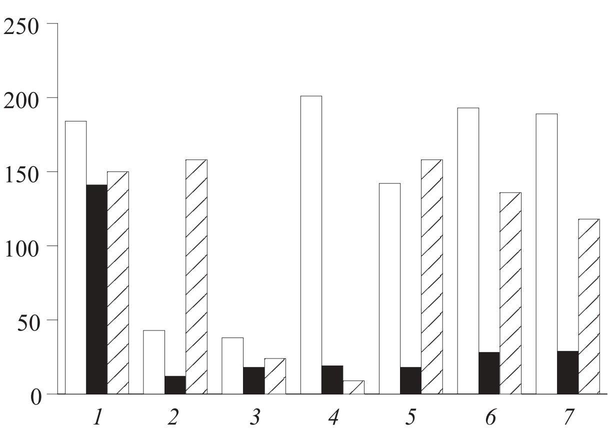

Fig. 1. Changes in total amplitude (μV) of initial phases of evoked potentials in cerebral cortex during stimulation of different portions of gastroduodenal complex. *1*) initial data; *2*) 5-25 min after damage to gastric corpus (GC); *3*) 5-25 min after damage to pylorus (P); *4*) 5-25 min after damage to duodenal bulb (DB); *5*) 25-50 min after damage to GC; *6*) 25-50 min after damage to P; *7*) 25-50 min after damage to DB. The open, filled, and dashed bars correspond to stimulation of GC, pylorus, and DB.

TABLE 1. Changes of Mean Amplitude of Myoelectric Activity (mV) of GDC Portions during Early Period after Acute Damage (*M*±*m*)

GDC portion	Initial data	Acute damage to pylorus	
		5-25 min	25-50 min
Cardia	1.92±0.07	2.71±0.11*	1.44±0.07*
Gastric corpus	2.12±0.08	1.92±0.09	1.91±0.09
Pylorus	3.21±0.13	4.17±0.16*	3.39±0.15*
DB	2.48±0.10	1.78±0.07*	1.90±0.09*

Note. Here and in Tables 2: *$p<0.05$ compared to initial data.

which were used to analyze changes in afferent reactions of GDC portions (Table 1).

The initial period after acute damage to the pylorus was characterized by an increase in the mean amplitude of myoelectric activity in the cardia (by 44.1%) and pylorus (by 29.8%) contrary to the decrease of this activity in DB (by 28.3%). However, the amplitude characteristics were little changed: 25-50 min after alteration of the pylorus the mean amplitude of myoelectric activity in the cardia decreased by 46.9%. At the same period, the amplitude of myoelectric activity in the pylorus returned to normal. The mean amplitude of myoelectric activity in DB practically did not change, while that of gastric corpus remained stable throughout the experiment.

To evaluate functional interrelationships between the portions of the stomach and duodenum, we carried out a correlation analysis of the amplitudes of myoelectric activity (Table 2). Paired coefficients of linear correlation calculated for initial amplitudes of myoelectric activity made it possible to characterize these interrelationships as positive and significant correlations of medium strength (cardia—gastric corpus, gastric corpus—pylorus, gastric corpus—DB). The correlations cardia—DB and pylorus—DB were weak, but significant. The correlation cardia—pylorus did not change significantly.

In the early period after acute damage, the revealed interrelations were broken, and the corresponding correlations became insignificant. The correlation coefficients for gastric corpus—DB and pylorus—DB not only decreased, but even became inverse. In the following 25 min, the significance of cardia—gastric corpus correlation partially recovered, but remained weak. The correlation cardia—DB returned to the initial value, and the correlation gastric corpus—DB increased significantly, but remained below the value measured before damage to the pylorus. The correlation cardia—pylorus returned to the initial value, while that of gastric corpus—pylorus and pylorus—DB remained decreased. These data attest to partial recovery of functional interrelationships between cardia, gastric corpus, and DB (Fig. 2). By contrast, the interrelationships between the pylorus and other portions of GDC did not restore during the entire experiment.

The comparison of peculiarities in afferent responses and manifestations of myoelectric activity in GDC portions showed that the normal level of system heterogeneity significantly increases during the acute damage period, which was most expressed after alteration of the pylorus.

There are data that the processes of predominantly intraorganic origin contribute to the development of afferent depression during the acute period of damage

TABLE 2. Changes in Correlation of Amplitudes of Myoelectric Activity (mV) in GDC Portions after Formalin Necrosis of the Pylorus (*M*±*m*)

GDC portion	Initial data	Acute damage to pylorus	
		5-25 min	25-50 min
Cardia—corpus	0.455±0.002*	0.10±0.07	0.172±0.070*
Cardia—pylorus	0.166±0.002*	0.026±0.070	0.104±0.070
Cardia—DB	0.223±0.002*	0.028±0.070	0.234±0.070*
Gastric corpus—pylorus	0.338±0.002*	0.016±0.070	0.133±0.070
Gastric corpus—DB	0.384±0.002*	-0.029±0.070	0.275±0.070*
Pylorus—DB	0.226±0.002*	-0.055±0.070	0.130±0.070

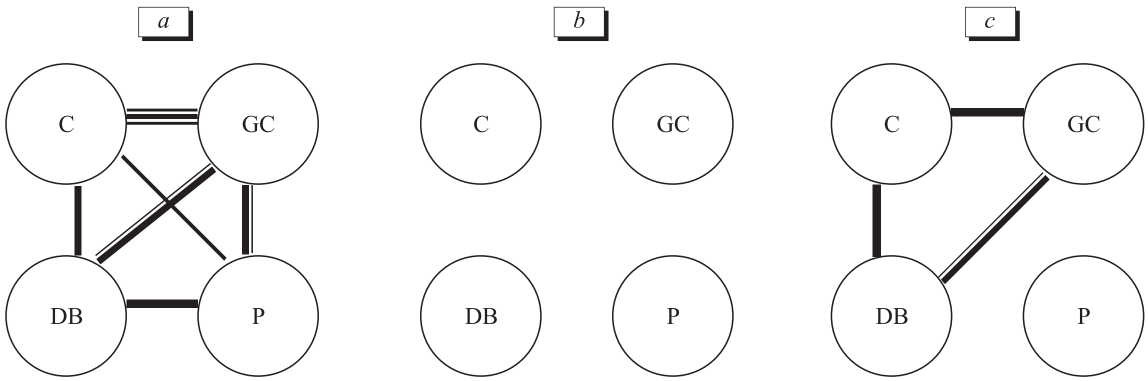

Fig. 2. Changes in correlation between amplitudes of myoelectric activity in various portions of gastroduodenal complex. *a*) before damage; *b*) in 5-25 min after damage to pylorus (P); *c*) in 25-50 min after damage to the pylorus.

to visceral organs. Drastic disturbances in the interrelations between GDC portions attests to enhancement of inhibitory processes in the system and suggests that the development of uncoupling within afferent and/or myoelectric responses of the organ systems reflects a typical character of the development of early adaptation of the organ or system to the extraordinary stimulus.

Depression of afferent reactions in the damaged organ or its subdivisions results from elevation of the interoceptive thresholds and probably attests to consolidation of inhibitory processes at the level of intraorganic nervous system. These processes enhance functional heterogeneity in the damaged organs, which is typical of regulatory disturbances during pathology [2]. The increase in functional heterogeneity suggests the possibility of achieving benefitial adaptive results, since it can prevent not only central, but also intraorganic generalization of excitatory processes. GDC is a highly organized system of closely related portions significantly differing by structure, function, and regulatory properties, so the processes underlying the changes in functional heterogeneity, which are activated during acute damage period, can principally influence the development of early adaptation in affected organs.

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