Role of Stomach Regions and Duodenum in the Formation of Electrical Activity of Gastroduodenal Complex

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Functional activity of components of the gastroduodenal complex (gastric cardia, gastric corpus, pylorus, and duodenal bulb) was studied in 4 series of acute experiments. One of these regions was subjected to electrical stimulation in each series. Our results suggest that the cardia possesses rhythm-forming properties, the corpus plays a system-organizing role, the pylorus plays a trigger role, and the duodenal bulb produce synchronizing effects.

Key Words: *gastroduodenal complex; electrical activity*

The gastroduodenal complex (GDC) plays a major role in the functional relationship between gastrointestinal organs [5]. GDC acts as a source and object of regulatory influences realized via the central nervous system, autonomic ganglia, humoral, and hormonal mechanisms [3,8,9].

It should be emphasized that each component of GDC is a relatively autonomous region with specific functional characteristics. Previous studies revealed principles of hierarchy, specific features of afferent systems, and mechanism underlying reconstruction of systemic "cooperation" between various components of GDC during digestive activity and at the initial stages of damage [1,2,5].

Here we evaluated the role of individual components of GDC in the formation of electrical activity.

MATERIALS AND METHODS

Four series of acute experiments were performed on adult outbred cats weighing 2.5-3 kg. Individual components of GDC were subjected to electrical stimulation. We recorded baseline electrical activity of the gastric cardia (CD), gastric corpus (GC), pylorus (PL), and duodenal bulb (DB). Threshold electrical stimulation (12.5 Hz) was applied to one component of GDC for 3 min, and electrical activity of stomach regions and DB was recorded. We performed comparative and correlation analysis of amplitude-frequency characteristics of myoelectric activity. Our study illustrates the role of various components of GDC in the formation of coordinated electrical activity.

RESULTS

Directed permanent changes in myoelectric activity of various components in GDC were observed 15-30 min after treatment. They manifested in changes in the mean number of electrical oscillations per time unit, their amplitude, and relationship between frequency and amplitude characteristics of myoelectric activity for various components of GDC.

Myoelectric activity of CD and DB (input and output of the system) increased by 59.5 and 46.1%, respectively, in the early period after stimulation of CD. The mean amplitude of myoelectric activity decreased in GC, PL, and DB. Electrostimulation was followed by a significant increase in the amplitude of electrical impulses from smooth muscles per 1 min (power, mV/min). The power of impulses from smooth muscle structures in other components of GDC markedly decreased. During electrical stimulation of CD

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myoelectric activity of PL decreased most significantly. CD and DB (input and output of the system) played a major functional role and determined the power of generated impulses during electrostimulation of CD. Our results are consistent with changes in frequency characteristics of myoelectric activity observed during electrostimulation of CD. The data indicate that CD plays a special role in the formation and modulation of frequency characteristics of myoelectric activity in various regions of the stomach and first portion of the duodenum.

In the next series we evaluated the role of activation of GC in the electrical response of GDC. Electrostimulation of GC moderately increased the frequency of myoelectric activity in various regions of the stomach. The increase in this characteristic varied from 14.6 (PL) to 17.2% (CD). We revealed a significant increase in the number of generated impulses in DB (24.12%). Stimulation of GC was followed by a 22.9% decrease in the mean amplitude of myoelectric activity in DB. The mean power of myoelectric activity increased in PL (by 17.25%) and surpassed that in other GDC components. The power of impulses increased by 29.5% in CD.

Electrostimulation of PL did not affect frequency characteristics of myoelectric activity in various components of GDC. The mean amplitude of myoelectric activity increased by 19.4% only in GC ($p<0.01$).

The mean amplitude of myoelectric activity increased by 14.2, 16.9, and 24.0% in CD, PL, and DB, respectively. The mean power of generated impulses increased only in PL (by 20.7%). This phenomenon illustrates changes accompanying activation of PL.

Correlation analysis of myoelectric characteristics was performed to evaluate the role of each component of GDC in coordinated activity.

Correlation analysis of frequency characteristics of myoelectric activity in stomach regions and DB revealed pronounced changes in their relationships after electrical stimulation of CD.

Under control conditions significant correlations (r) were found between activity in CD and GC, CD and PL, and GC and PL. It characterizes the relationship between frequency characteristics in stomach regions as moderate positive correlations. The complex of CD, GC, and PL plays a special role in the systemic organization of GDC. These results reflect stable relationships between frequency characteristics of myoelectric activity in stomach regions and relative autonomy of DB. Electrical stimulation of CD had no effect on frequency relationships. Correlation coefficients for pairwise relationships were statistically significant. Values of r increased more than by 3 times for the relationships between CD and DB, GC and DB, and PL and DB.

Changes in frequency characteristics of myoelectric activity indicate that electrical stimulation enhanced the relationships between DB and stomach regions. Before stimulation of CD the rank series of multivariate correlation coefficients (E_r) for the studied structures appeared as GC (36.2%)>CD (34.6%)> PL (29.2%)>DB (0.0%). The coefficient of multivariate correlation (E_r) for various components of GDC changed after electrical stimulation of CD: CD (28.3%)> GC (25.9%)>DB (23.1%)>PL (22.7%).

Correlation analysis of frequency characteristics of myoelectric activity revealed an increase in the degree of "cooperation" between stomach regions after stimulation of GC. Therefore, after treatment the relationships between CD, GC, and PL became more significant compared to those observed in the initial state.

After stimulation of GC the overall coefficient of multivariate correlation for components of GDC increased by 66%, while the rank series remained unchanged (GC>CD>PL>DB). Under these conditions a system-organizing role of GC was enhanced. The contribution of GC in the overall correlation coefficient increased from 36.2 to 39.7%. The relationships between frequency characteristics of myoelectric activity for the CD-GC-PL complex became more significant after stimulation of PL. Electrical stimulation of PL was followed by an increase in the overall coefficient of multivariate correlation for frequency characteristics, while the rank series remained practically unchanged (Fig. 1, *a*).

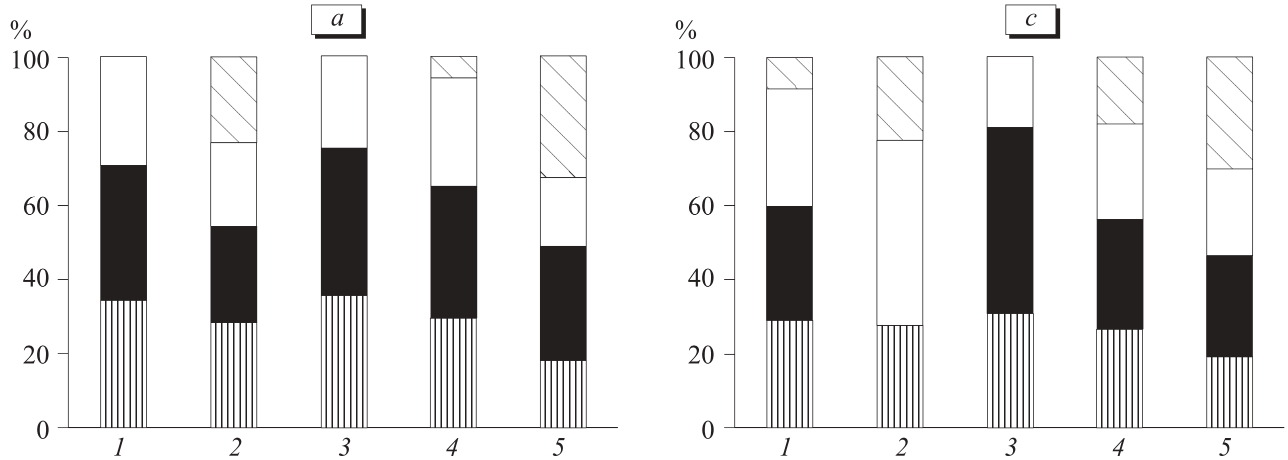
The coefficients of correlation between CD and DB, GC and DB, and PL and DB significantly increased after stimulation of DB. These results indicate that DB played the major role in the systemic organization of frequency characteristics of myoelectric activity in GDC (Fig. 1, *a*). The rank series of multivariate correlation coefficients was DB>GC>PL=CD.

Correlation analysis was performed with amplitude characteristics of myoelectric activity.

The contribution of GC into the overall coefficient of multivariate correlation was 32.8%. The rank series of correlation coefficients appeared as follow: GC> CD>DB>PL (Fig. 1, *b*).

Stimulation of CD enhanced a system-organizing role of DB for amplitude characteristics of myoelectric activity (Fig. 1, *b*) and changed the rank series of multivariate correlation coefficients: DB (33.6%)>CD (31.6%)>GC (18.2%)>PL (16.5%).

Correlation analysis revealed significant changes in amplitude characteristics of myoelectric activity after stimulation of GC. However, the treatment affected multivariate correlation coefficients. The contribution of various components of GDC into the overall correlation coefficient was nearly similar (Fig. 1, *b*).



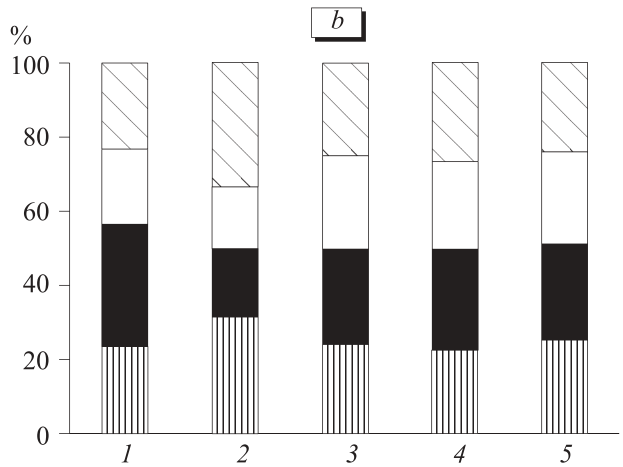


Fig. 1. System-organizing role of components of the gastroduodenal complex by frequency (*a*) and amplitude characteristics (*b*) and power of myoelectric activity (*c*) in the initial state (*1*) and after electrical stimulation of the gastric cardia (*2*), corpus (*3*), pylorus (*4*), and duodenal bulb (*5*). Light bars: pylorus. Dark bars: gastric corpus. Shading: gastric cardia. Slant shading: duodenal bulb.

Electrical stimulation of PL affected systemic "cooperation" between various components of GDC. It manifested in a significant increase in *r* for CD-PL and GC-DB (Fig. 1, *b*). Multivariate relationships between amplitude characteristics became more pronounced, which was accompanied by an increase in the contribution of DB into the overall correlation coefficient. The series of multivariate correlation coefficients for amplitude characteristics of myoelectric activity in GDC underwent changes.

Under control conditions the rank series of multivariate correlations between amplitude characteristics of myoelectric activity was the following: GC>CD>DB>PL. After electrical stimulation it appeared as GC>DB>PL>CD.

Strong positive correlations between amplitude characteristics of myoelectric activity in various components of GDC were revealed after electrical stimulation of DB. The multivariate correlation coefficient (E_r) increased. GC retained a system-organizing role (Fig. 1, *b*). The rank series appeared as follow: GC>CD>PL>DB.

Power characteristics for various components of GDC were also subjected to correlation analysis. We revealed weak, but statistically significant positive correlations between power characteristics of CD and GC, CD and PL, and GC and PL. A weak negative correlation was found between PL and DB.

Stimulation of CD impaired this weak correlation. The relationships were revealed between CD and PL (weak positive correlation) and PL and DB (weak negative correlation).

The initial rank series of statistically significant E_r for power characteristics appeared as PL (0.440)>GC (0.430)>CD (0.407)>DB (0.119). In percents of the overall correlation coefficient it was the following: PL (31.5)>GC (30.8)>CD (29.2)>DB (8.5).

Electrical stimulation of CD produced the following quantitative changes: PL (0.317)>CD (0.176)>DB (0.141)>GC (no correlation). In percents it appeared as PL (50.0)>CD (27.8)>DB (22.2)>GC (no correlation).

After electrical stimulation of GC the coefficient of correlation between CD and GC increased by 84.9%. This treatment was followed by change in the sign and 270.9% increase in the coefficient of correlation between GC and PL. The power of myoelectric activity played a greater system-organizing role in the rank series of E*r* after stimulation of GC. E*r* for the power of GC was 50% of the overall correlation coefficient.

Correlation analysis revealed considerable changes in the degree of "cooperation" between the powers of myoelectric activity after stimulation of PL. The correlation coefficients markedly increased for various pairwise relationships. The degree of overall multivariate correlation increased by 2.76 times (Fig. 1, *c*).

Electrical stimulation of DB increased the correlation coefficients for DB-stomach regions and GC-PL. A considerable increase in the degree of multivariate correlation was accompanied by changes in the rank series: DB>GC>PL>CD.

The study of multivariate correlation and electrical stimulation of gastric CD showed that this region plays a role in the increase of functional "cooperation" between frequency characteristics in GDC. These results suggest that gastric CD possesses rhythm-forming properties in GDC. Correlation analysis revealed that stimulation of CD is accompanied by an increase in the degree of relative "cooperation" with PL (power of myoelectric activity) and DB (frequency and amplitude of myoelectric activity). The observed changes reflect a rise in functional importance of the pyloroduodenal zone in GDC after stimulation of CD.

GC plays a system-organizing role in systemic "cooperation" between components of GDC. Electrical stimulation of PL is followed by differential activation of various components in GDC and improves their relationships.

Stimulation of DB affected amplitude and frequency characteristics of myoelectric activity and functional "cooperation" between various components of GDC. It manifested in an increase in the mean amplitude and power of myoelectric activity. These data suggest that DB plays a special role in the formation of amplitude characteristics and synchronization of electrical responses of smooth muscle structures in GDC.

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