Role of Serotoninergic Structures in Coordination of Electric Activity in the Gastroduodenal Complex

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Myoelectric activity in various portions of the stomach and duodenum in normal and after vagotomy and intravenous injection of serotonin adipinate was studied in acute experiments on cats. Vagotomy disturbed coordination of myoelectric activity in the stomach and duodenum. Intravenous injection of serotonin adipinate restored coordination and increased myoelectric activity in the stomach, particularly, in the pylorus. Under these conditions the pacemaker of myoelectric activity in the gastric corpus and autonomic regulation of the duodenum were preserved. Intravenous injection of serotonin adipinate most significantly changed myoelectric activity in the pylorus. Myoelectric activity in the cardia increased after vagotomy against the background of serotonin adipinate. Our findings suggest that serotoninergic structures maintain functional heterogeneity of digestive organs and coordinate their interrelationships.

Key Words: *electric activity; gastroduodenal complex; serotoninergic structures*

Modern concepts of digestive physiology and pathophysiology suggest that motor activity of the gastrointestinal tract is regulated by neurotransmitters and hormones and depends on rhythmic activity of smooth muscle cells integrated in functional units [5,7].

It should be emphasized that serotonin plays an important role in motor activity of the gastrointestinal tract at all levels of regulation from raphe nuclei with primary serotoninergic neurons [9,11] to neurons of the metasympathetic nervous system [6,8]. Serotonin is synthesized and accumulated in enterochromaffin cells of the gastrointestinal tract and acts as the paracrine or endocrine hormone [1,8].

There are data that the vagus nerves modulate serotonin content in enterochromaffin cells of the gastrointestinal tract [12,13].

The afferent-efferent structure of the vagus nerves, their role in the regulation of afferent impulses from the stomach and duodenum [2], the presence of serotonin-sensitive afferent fibers, and relationships with the metasympathetic nervous system [3] suggest that vagal modulation of coordinated activity in the gastroduodenal complex (GDC) is realized via serotoninergic structures.

Previous studies showed that intravenous injection of serotonin adipinate normalizes myoelectric activity (MEA) of the gastrointestinal tract disturbed by vagotomy [4].

Here we studied changes and coordination of MEA in various portions of GDC after systemic administration of serotonin adipinate and vagotomy.

MATERIALS AND METHODS

Experiments were performed on 30 adult cats weighing 2-3 kg 12-14 h after food intake. The animals were anesthetized with 0.9% α-chloralose (50-70 mg/kg, intraperitoneally). After median laparotomy recording electrodes were fixed on the anterior surface of the gastric cardia (CD), gastric corpus (GC), pylorus (PL), and duodenal bulb (DB).

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MEA was recorded unipolarly by routine electrogastrographic techniques [10].

A Bioskript-1 eight-channel electroencephalograph equipped with low-frequency filters was used for recording.

The amplitude parameters of MEA were estimated. We analyzed changes in the mean amplitude of MEA and functional cooperation in various portions of GDC. The pairwise correlation coefficient (r) for maximum amplitudes of MEA over 1 min reflected the degree of functional cooperation. To this end, 20-min fragments were analyzed.

MEA was recorded before (baseline level) and after administration of serotonin adipinate and bilateral truncal vagotomy. Serotonin adipinate (0.1%, 0.4-0.5 mg/kg) was injected into the small subcutaneous vein of cat hindlimbs.

The results were statistically analyzed on a computer.

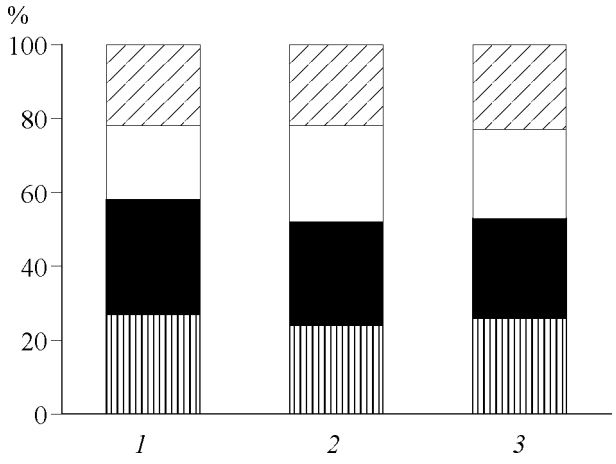

Fig. 1. System-forming role of various portions of the gastroduodenal complex in the initial state (*1*), after intravenous injection of serotonin adipinate (*2*), and after vagotomy and intravenous injection of serotonin adipinate (*3*). Vertical shading: cardia. Dark area: gastric corpus. Light area: pylorus. Slant shading: duodenal bulb.

RESULTS

The amplitude of baseline MEA was maximum in PL (Table 1), which is consistent with our previous experiments [4] and published data that this gastric portion plays an important role in evacuation function.

We studied functional cooperation between various portions of GDC. By the amplitude of MEA, r was highest for the relationships between GC and other portions of GDC (especially between CD and GC). Functional relationships of CD with PL and DB were characterized by the lowest r (Table 2).

The total correlation coefficient was highest for GC, which indicates that this portion of the stomach plays a system-forming role in GDC. By the gradient of functional cooperation, GDC portions were arranged in the following order: GC — CD — DB — PL (Fig. 1, *1*).

Intravenous injection of serotonin adipinate to cats with intact innervation markedly increased the amplitude of MEA in various portions of GDC, particularly, in CD and GC (Table 1). An increase in the amplitude of MEA was minor in DB, which is probably associated with the role of endogenous serotonin in the regulatory mechanisms in this GDC portion.

After intravenous injection of serotonin adipinate to animals with intact innervation the correlation coefficient for linear relationships between CD and PL, GC and PL, and PL and DB increased by 195, 88, and 90.2%, respectively.

Studies of curvilinear relationships showed that when the degree of cooperation for CD—PL and GC—PL increased, the amplitude of MEA in these portions of GDC more significantly depended on PL MEA (Table 2). However, the increase in the correlation coefficient for DB—PL was associated with a stronger dependence of PL MEA on DB MEA. The correlation coefficient for PL—DB increased more significantly than that for DB—PL (Table 2).

TABLE 1. Amplitude of MEA in Various Portions of GDC after Intravenous Injection of Serotonin Adipinate and Vagotomy (mV, $M \pm m$)

MEA amplitude	CD	GC	PL	DB
Baseline	3.025±0.110	1.628±0.050	4.032±0.120	3.21±0.11
After serotonin administration	4.528±0.150***	2.339±0.080***	5.617±0.170***	4.107±0.130***
changes, %	49.7	43.7	39.3	27.9
After vagotomy	4.999±0.190***	2.12±0.08***	4.975±0.150***+	3.453±0.120+
changes, %	10.4	-9.36	-11.4	-15.9
changes in relation to the baseline level, %	65.26	30.2	23.4	7.6

Note. Here and in Table 2: *p<0.05, **p<0.01, and ***p<0.001 compared to the baseline level; +p<0.01 compared to MEA after serotonin administration.

TABLE 2. Correlation between MEA Amplitudes in Various Portions of GDC after Intravenous Injection of Serotonin Adipinate and Vagotomy (*M*±*m*)

Conditions	CD—GC	CD—PL	CD—DB	GC—PL	GC—DB	PL—DB
Baseline	0.579±0.060	0.16±0.07	0.162±0.070	0.284±0.070	0.33±0.06	0.254±0.070
After serotonin administration	0.663±0.060	0.472±0.070**	0.129±0.070	0.534±0.060*	0.361±0.070	0.483±0.070*
changes, %	14.5	195	-20.4	88	9.4	90.2
After vagotomy	0.651±0.050	0.507±0.060***	0.478±0.060**+	0.611±0.060**	0.49±0.06	0.342±0.070
changes, %	-1.8	7.42	270	14.4	35.7	-29.2
changes in relation to the baseline level, %	12.4	216.9	195.1	115.1	48.5	34.7

By the gradient of functional cooperation, GDC portions were arranged in the following order: GC — PL — CD — DB (Fig. 1, *2*).

These data indicate that intravenous injection of sodium adipinate enhanced the role of the gastropyloroduodenal region in coordinated activity of GDC.

The amplitude of MEA in PL and DB markedly decreased after vagotomy. However, under these conditions the mean amplitude of MEA in GDC portions surpassed or did not differ from the baseline level (Table 1).

Vagotomy changed the relationships between various portions of GDC. After parasympathetic denervation the correlation coefficient for linear relationships between CD and DB markedly increased (Table 2). Studies of curvilinear relationships showed that these changes were accompanied by a more strict dependence of DB MEA on CD MEA.

The coefficient for curvilinear dependence of MEA amplitude markedly increased for GC—PL, GC—DB, and DB—GC relationships. The correlation coefficients for PL—DB and DB—PL significantly decreased (Table 2).

By the gradient of functional cooperation, portions of GDC were arranged in the following order: GC — CD — PL — DB (Fig. 1, *3*).

On the whole, after vagotomy against the background of serotonin adipinate pretreatment the degree of coordination between MEA amplitudes was comparable with the baseline or surpassed it (CD—PL, CD—DB, and GC—PL).

It should be emphasized that both the system-forming role of GC and relative autonomy of DB were preserved under various experimental conditions (Fig. 1).

The fact that intravenous injection of serotonin adipinate produced the most significant changes in the relationships between MEA in PL and other potions of GDC suggest that serotoninergic structures play a role in coordinated activity of the pyloroantral zone.

Vagotomy performed after intravenous injection of serotonin adipinate increased functional role of CD. Our findings suggest that serotoninergic structures are involved in both the maintenance of the baseline functional heterogeneity of GDC and formation of adaptive reactions in the early stage of functional disturbances.

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