INTERMITTENT ENERGIZATION AS A FACTOR IN THE FUNCTIONAL ORGANIZATION OF THE SMALL INTESTINE

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KEY WORDS: small intestine; spatiotemporal organization; intermittent energization.

Intermittent energization is known to be responsible for informational interaction between the elements of a biosystem and oscillatory phenomena [1, 2, 8-10]. The writer has evaluated the role of this factor in the spatiotemporal organization of the small intestine (SI), taking account of its modular structure and the existence of several periodic components [4].

EXPERIMENTAL METHOD

Experiments were carried out on intact rats and rats with cholepancreaticostasis after ligation of the biliary-pancreatic duct.

Hungry rats were killed every 1.5 h between 9 a.m. and 1 p.m. Six segments were isolated (0-10-20-30-40-50-60 cm from the ligament of Treitz) from SI and incubated for 30 min in glucose solution (11.1 mM, pH 7.4; 37°C, oxygenation). Muco-serous hexose transport, by mechanisms of active transport (AT) and facilitated diffusion (FD), was determined as described previously [3].

EXPERIMENTAL RESULTS

Assessment of the energization level from the ratio AT/FD revealed the existence of a definite dynamics of this index with time (Fig. 1) and functional heterogeneity of the segments of SI studied (Fig. 2). Analysis of its spatial organization showed (Table 1) that

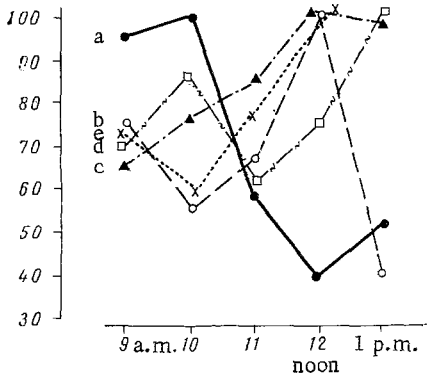

Fig. 1. Dynamics of changes in AT/FD ratio for glucose in SI of hungry rats under normal and pathological conditions. Abscissa, time of experiment; ordinate, ratio (in % of maximum). a) Control; b, c, d, e) 4th, 7th, 14th, and 28th days of cholepancreaticostasis, respectively (mean values, n = 5).

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TABLE 1. Correlation between Levels of Glucose AT (numerator) and FD (denominator) in Segments of SI of Hungry Rats under Normal and Pathological Conditions (n = 5)

Day of cholepancreaticostasis	Segments of SI compared														
	1—2	1—3	1—4	1—5	1—6	2—3	2—4	2—5	2—6	3—4	3—5	3—6	4—5	4—6	5—6
Control	0,81 / 0,72	0,88 / 0,92	0,91 / 0,31	0,63 / 0,25	0,87 / —0,35	0,82 / 0,45	0,93 / 0,49	0,93 / 0,16	0,82 / —0,81	0,79 / 0,18	0,78 / 0,21	0,89 / —0,15	0,74 / 0,89	0,89 / —0,07	0,65 / 0,36
4-th	0,02 / 0,10	0,84 / —0,22	0,85 / 0,14	0,78 / —0,88	—0,18 / —0,55	—0,07 / 0,93	0,06 / 0,90	0,20 / 0,02	0,02 / 0,16	0,45 / 0,84	0,95 / 0,31	—0,53 / 0,37	0,41 / 0,17	0,30 / 0,46	—0,47 / 0,87
7-th	0,34 / 0,78	0,69 / 0,66	0,27 / 0,41	0,65 / —0,64	—0,08 / —0,45	0,64 / 0,91	0,72 / 0,85	0,91 / —0,12	0,79 / —0,35	0,52 / 0,83	0,68 / —0,03	0,54 / —0,52	0,70 / 0,19	0,79 / —0,27	0,54 / —0,07

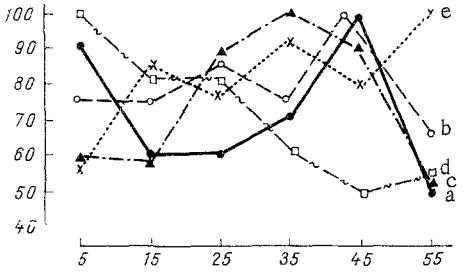

Fig. 2

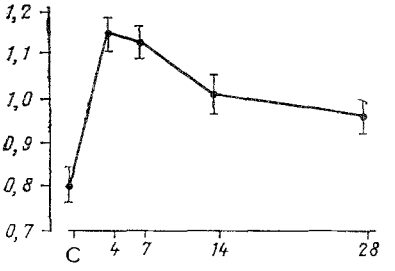

Fig. 3

Fig. 2. Topography of AT/FD for glucose along SI of hungry rats under normal and pathological conditions. Abscissa, length of intestine (in cm from ligament of Treitz). Remainder of legend as to Fig. 1.

Fig. 3. Changes in AT/FD ratio for glucose in SI of hungry rats after ligation of biliary-pancreatic duct. Abscissa, days after operation; ordinate, value of ratio AT/FD (M ± m; n = 8). C) Control.

correlation in the control between all segments was high and positive only with respect to the AT level. The zone of high positive correlation for the FD level was much lower, and between some segments there was actually a tendency toward negative correlation, which was high between segments 2-6. Pathological changes were accompanied by increased energization of SI (Fig. 3), by readjustment of its temporal dynamics (Fig. 1), and by phasic changes both in the topography of functionally heterogeneous segments (Fig. 2) and in the character of correlation between them (Table 1). This correlation changed similarly for both AT and FD levels. Weakening (or disappearance) of correlation between some segments, strengthening (or appearance) of correlation between others, and also replacement of positive by negative correlation or vice versa, were typical. In the presence of pathological changes differences between systems with low and high energization were preserved; some reactions, moreover, exhibited phasic relationships between them (Table 1). It is important to note that by the end of the first month of cholepancreaticostasis the pattern of spatial organization of SI that was so clearly marked in the control animals was not yet restored.

Some features of the functional organization of SI thus definitely depend on energization of its elements. The temporal dynamics of transport activity in an experiment lasting several hours, the topography of heterogeneous SI modules and correlation between them, and the character and dynamics of the pathological reorganizations — with respect to all these features there was a clear difference between the behavior of systems with low and high energization. It can be postulated that the control of these systems differs. We know, in particular, that central regulation is faster than autonomic, and for that reason, against the background of diurnal rhythms it leads to particularly wide variation of parameters [10]. The higher variability of AT than of the other main parameters of muco-serous glucose transport was discussed previously [6]. The results of correlation analysis of the spatial organization of SI discussed above also point to different mechanisms and channels of communication of the AT and FD systems. Data in the literature [9, 10] suggest that AT systems

have strong central control, whereas FD systems are largely dependent on autonomic mechanisms of homeostasis. The dynamics of the functional topography of SI (Fig. 2) confirms observations [4, 7] showing that the phase shift in SI, as in a system with temporal organization, may determine heterogeneity of its modules. However, the fact must be taken into account that intermittent energization of the elements of a biosystem is an important condition for informational interaction between them [2, 9].

Finally, the facts observed under pathological conditions show that they may be accompanied not only by desynchronization of the food transport systems [5], but also by disintegration of the spatial organization of SI, a phenomenon which lasts a long time.

Intermittent energization thus determines some of the particular features of the spatiotemporal organization of SI under normal and pathological conditions.

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