ANALYSIS OF FUNCTIONAL HETEROGENEITY OF THE SMALL INTESTINE ON THE BASIS OF GLUCOSE TRANSPORT PARAMETERS

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Functional heterogeneity of the small intestine is discussed on the basis of heterogeneity of enterocyte populations with respect to their accumulating and self-regulating properties and to the systems of the initial and final stages of assimilation (in particular, with respect to the parameters of their temporal organization).

KEY WORDS: small intestine; accumulating and mucoso-serosal glucose transport; functional heterogeneity.

The general concept of functional heterogeneity of the small intestine (FHSI) rests on a solid basis [1], but no detailed characteristics are available of its individual parameters. In this paper some features of FHSI are examined in relation to indices such as the mucoso-serosal transport of glucose and its storage in accumulating preparations of the mucosa. The experimental techniques used were described previously [5, 9].

The level of mucoso-serosal transport is the resultant of interaction between the entire diffusion-based system of pumps and transport mechanisms and is an integrative parameter of the function of a given enterocyte population. In relation to this parameter, in adult fasting Wistar rats the activity of the jejunum is higher than that of the ileum, a feature which correlates in particular with the pool of phloridzin-sensitive receptors and the energy supply for transport mechanisms [2,3]. Heterogeneity of these divisions of the small intestine has been demonstrated by successive incubation. Ugolev and Loginov [7,10] observed a phenomenon of activation and inactivation of transport activities with different dynamics in adjacent segments both of the jejunum and of the ileum. According to this phenomenon, FHSI is well defined during short incubations [6] and is reduced during longer incubations, in the course of which it can reappear in the presence of phloridzin [4].

In order to discover the distinguishing features of FHSI due predominantly to the function of pumps of the apical membrane, the level of glucose accumulation was compared during consecutive incubations of preparations obtained from all parts of the small intestine. It will be clear from Fig. 1 that only the level of accumulation and saturation in the regions of the intestine compared was similar when the concentration gradient was low (0-30 min of incubation). With a higher concentration gradient similarity was found in the proximal and middle portions of the intestine (30-120 min). The dynamics of the second accumulation was uniform only in the distal portion: The increase in absorption was only +15% during incubation periods from 30 to 45 and 45 to 60 min (as against +25 and +50% in the proximal portion and against +65% and +25% in the middle portion).

The facts described above, confirming the unequal distribution of absorbing cells [1] and the nonidentity of self-regulation of individual cell populations along the intestine [6], point to a possible difference between enterocytes with respect to the value of the gradient against which they can accumulate glucose.

The data for the distal portion of the intestine are specially interesting. In intact adult rats preparations from this part accumulate glucose against the gradient (Fig. 1), but do not transport it against the gradient to the serous surface [11,12]. This fact can be understood in the light of information on heterogeneity of the pumps of apical and basal membranes of the absorbing cells [8]. In that case the distal segment of the ileum may be a convenient model with which to study the characteristics of the basal pumps.

The dynamics of the final glucose concentration in the "serosal" fluid from intact rats, rats after laparotomy, or rats with ligation of the bile and pancreactic ducts, on incubation of preparations from the distal

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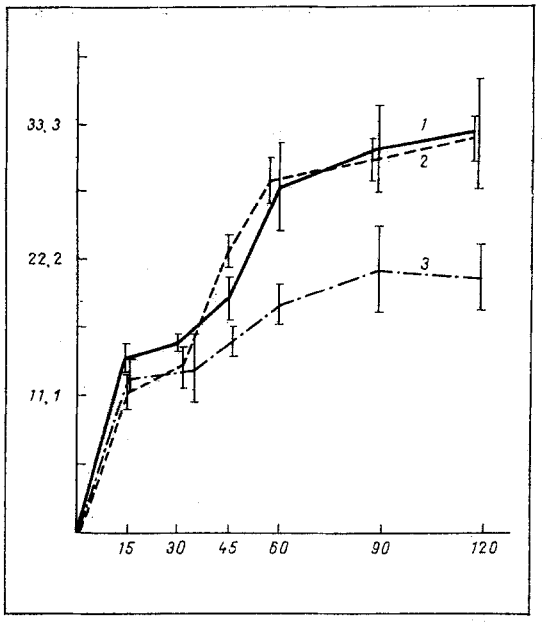

Fig. 1. Glucose accumulation in accumulating preparations of mucosa from different parts of rat small intestine. Incubation in 11.1 mM glucose solution. Mean values (M ± m; n = 6): 1) proximal, 2) middle, 3) distal part of intestine. Abscissa, duration of incubation (in min); ordinate, concentration of accumulated glucose (in mM).

TABLE 1. Mucoso-serosal Glucose Transport Against the Concentration Gradient (increase in mg %) in Distal Part of Rat Ileum (initial glucose concentration in "mucosal" and "serosal" fluid 200 mg %; incubation for 30 min)

Rat No.	Time of experiment, h	Animals					
		intact	4th day after laparotomy	after ligation of bile and pancreatic ducts			
				4th	7th	14th	28th
				day			
1	8—9	—6	+52	0	—6	+34	+58
2	9—10	—24	+23	+62	+36	+30	+57
3	10—11	+140	—38	+80	+21	+22	+57
4	11—12	—10	—82	+19	+47	+47	+155
5	12—13	—10	—21	+33	+84	+61	—

portion of the ileum, was studied. As Table 1 shows, in the intact rats glucose characteristically disappeared from the "serosal" fluid; the degree of decrease in the glucose concentration varied in different animals, and in one case there was actually a tendency for glucose to accumulate. On the 4th day after laparotomy the dynamics was different: The degree of both the decrease and the increase in glucose concentration itself increased. Finally, 1 month after ligation of the bile and pancreatic ducts transfer of glucose to the serous surface against the gradient was typical, although its dynamics varied appreciably when observed in the course of the experiment.

Comparison of the data given in Fig. 1 and Table 1 and also published in [8] shows that the heterogeneity of the transport systems at the input and output of the enterocyte appears possible, at least in the region of the ileum studied. Changes in the level and dynamics of mucoso-serosal transport in the course of adaptation (Table 1) confirms the possibility of control over the properties of these systems [11]. Meanwhile simple phenomenologic analysis of the dynamics of the process in all six groups of rats (Table 1) indicates indirectly that in systems with temporal organization [6] a phase shift may be the cause of functional heterogeneity under both normal and pathological conditions.

FHSI for the parameters of glucose transport is thus due to interaction between many factors and it can be characterized most completely only on the basis of data from all levels of organization of the small intestine.

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THYROID FUNCTION AND MOTOR ACTIVITY IN DOGS DURING DEVELOPMENT

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The intensity of motor activity and the serum level of protein-bound iodine (PBI) were investigated in 62 puppies aged from 1 to 12 months. During the first 4 months of life a parallel increase in motor activity and PBI of the puppies was observed. The increase in motor activity of puppies between the ages of 7 and 9 months was not accompanied by any increase in PBI. In hypothyroidism caused by methimazole in puppies aged 1 and 3 months increased motor activity was observed, whereas in animals aged 7 months it was reduced. A higher intensity of motor activity than in the control animals also was observed 1 month after the operation in puppies thyroidectomized at the ages of 1 and 3.5 months. The activity of puppies thyroidectomized at the age of 1 month was sharply reduced 2-4 months after the operation. In dogs thyroidectomized at the ages of 7.5 and 11.5 months, reduced activity was observed as early as 1 month after the operation. The data showing opposite effects of thyroid hormones on the behavior of puppies at different ages point to a complex relationship between motor activity and thyroid function.

KEY WORDS: thyroid gland; motor activity; ontogeny.

In the postnatal development of man and animals periods of maturation of thyroid function can be distinguished [1,3,4,7-9,11,12]. These periods may perhaps determine age differences in the formation of certain

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