CONNECTION BETWEEN PREMEABILITY OF THE TISSUE-BLOOD BARRIERS AND CONTENT OF TRACE ELEMENTS IN THE ORGANS AFTER EXTENSIVE RESECTION OF THE SMALL INTESTINE

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Investigations of the permeability of the tissue-blood barriers (TBB) and of trace element metabolism after extensive resection of the small intestine in dogs and rats showed a connection between changes in the content of trace elements and disturbance of the permeability of the TBB. Changes in the permeability of the TBB can be regarded as reflecting disturbances of metabolism, especially phosphorus metabolism, in the corresponding organs and tissues.

Experimental and clinical investigations have shown that extensive resection of the small intestine is followed by the development of a symptom-complex of disturbances of the function of the digestive system, together with the development of functional and structural changes in some other organs and of profound metabolic disturbances [1, 5, 7, 12, 14, 15]. The function of organs and their metabolism are known to be closely connected with the state of tissue-blood barriers (TBB) [8, 11, 13]. To discover the mechanism of these pathological changes, it was decided to make a parallel study of TBB function and of certain components of metabolism.

The content of trace elements (iron, copper, zinc, and cobalt) and the permeability of the TBB were investigated after experimental extensive resection of the small intestine.

TABLE 1. Dynamics of Content of Iron, Copper, Zinc, and Cobalt, and Activity of Some Metalloenzymes (ceruloplasmin and transferrin) in Blood of Dogs after Extensive Resection of Small Intestine

Time after operation (in days)	Statistical index	Iron (in mg%)	Iron saturation of transferrin (in conventional units)	Copper (in mg%)	Ceruloplasmin activity (in conventional units)	Zinc (in mg%)	Cobalt (in μg%)
Control	M±m	61,5±5,4	0,19±0,01	0,18±0,01	25,7±1,6	0,51±0,03	7,1±0,4
3	M ± m	49,2±,59	0,16±0,02	0,21±0,03	20,3±2,7	0,62±0,07	8,1±0,
	P	<0,5	<0,5	<0,2	<0,2	<0,2	<0,5
8	M ± m	42,2±5,7	0,10±0,01	0,17±0,02	11,8±1,4	0,53±0,05	7,8±0,9
	P	<0,05	<0,001	>0,5	<0,001	>0,5	>0,05
20	M ± m	36,4±4,6	0,09±0,01	0,12±0,01	9,3±1,2	0,67±0,09	13,2±2,1
	F	<0,01	<0,001	<0,01	<0,001	<0,2	<0,05
30	M ± m	38,7±3,0	0,09±0,01	0,19±0,02	7,7±0,8	0,46±0,07	1,4±0,2
	P	<0,01	<0,001	>0,5	<0,001	<0,5	<0,01

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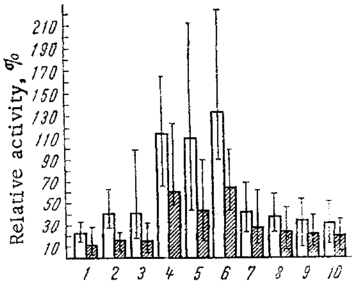

Fig. 1

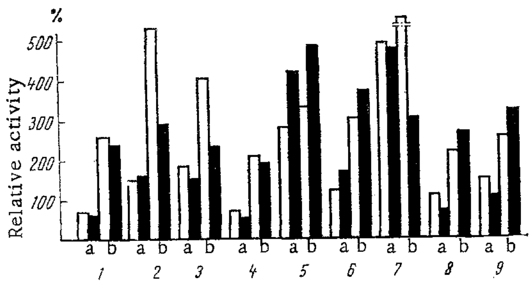

Fig. 2

Fig. 1. Penetration of P^{32} into various internal organs 30 days after extensive resection of the small intestine in dogs (exposure 30 min): 1) stomach; 2) small intestine; 3) large intestine; 4) liver; 5) spleen; 6) kidneys; 7) left ventricle; 8) right ventricle; 9) left atrium; 10) right atrium. Here and in Fig. 2, unshaded columns – control, shaded columns – experiment.

Fig. 2. Penetration of P^{32} into internal organs 10 days after extensive resection of small intestine in rats: a) exposure 30 min; b) exposure 60 min; 1) stomach; 2) small intestine; 3) large intestine; 4) pancreas; 5) liver; 6) spleen; 7) kidneys; 8) lungs; 9) ventricle.

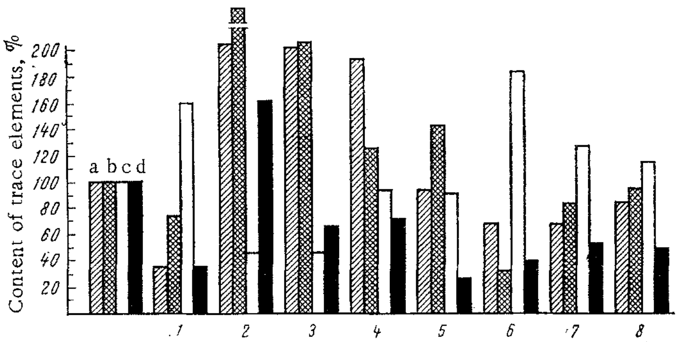

Fig. 3. Changes in content of iron (a), copper (b), zinc (c), and cobalt (d) in various organs of dogs 30 days after extensive resection of small intestine and jejuno-transverse colostomy. 1) Liver; 2) heart muscle; 3) spleen; 4) pancreas; 5) kidneys; 6) lungs; 7) small intestine; 8) large intestine.

EXPERIMENTAL METHOD

Ten dogs and 22 rats were used, and seven-eighths of the length of the small intestine was resected in five dogs and 11 rats. The remaining animals did not undergo operation and acted as controls. After resection, continuity of the intestine was restored by jejuno-transverse colostomy in the dogs and by entero-enterostomy in the rats. The length of the segment of small intestine resected was 230-390 cm in the dogs and 40-45 cm in the rats. Observations on the dogs continued for one month and on the rats for 10 days. The content of trace elements in the blood and organs was determined colorimetrically [3, 4].

Permeability of the TBB was studied by an isotope method, using radioactive phosphorus as indicator. The indicator was injected intravenously as $Na_2HP^{32}O_4$ in a dose of 50 μCi/kg body weight. The dogs were killed by air embolism 30 min after injection of the indicator, and the rats were decapitated 30 and 60 min after its injection. The radioactivity of the organs was determined on a B-3 instrument. The results were expressed as percentages of activity of the blood (relative activity).

EXPERIMENTAL RESULTS

In the experiments on dogs, 30 days after extensive resection of the small intestine the intensity of incorporation of radioactive phosphorus into the tissues of the wall of the small and large intestines, spleen, and kidney was reduced (Fig. 1). The incorporation of radioactive phosphorus into the tissues of the liver, stomach, lungs, pancreas, and different parts of the heart muscle showed a tendency to decrease.

Ten days after resection of the small intestine, changes in the penetration of radioactive phosphorus into the tissues of most organs of the rats were the same as in the dogs. There was a particularly marked decrease in the relative activity of the tissues of the small and large intestine, and also of the kidney, measured 60 min after injection of the isotope. In the liver and spleen, on the other hand, the content of radioactive phosphorus was higher than in the control animals (Fig. 2).

Besides changes in the permeability of the TBB of the individual organs to radioactive phosphorus, the content of essential trace elements such as iron, copper, zinc, and cobalt in these organs also showed considerable changes (Fig. 3). The content of these trace elements in the blood, as Table 1 shows, fell progressively. The activity of the metalloenzymes ceruloplasmin and transferrin, coupled with copper and iron ions, in the blood serum also changed.

Since the blood is the internal medium of the body, changes in the content of trace elements in the blood are evidently the result of changes taking place in the organs and tissues. The specificity of disturbance of the metabolism of each trace element is known to depend on its biological role and the intensity of other biochemical changes during the period concerned [2, 6].

The results described show that extensive resection of the small intestine leads not only to the pathological changes already familiar [3, 4], but also to disturbance of the permeability of the TBB of individual organs to radioactive phosphorus and to changes in their content of iron, copper, zinc, and cobalt ions.

There is reason to suppose that functions of the TBB are closely interconnected with the content of trace elements. One reason for the changes in the content of trace elements could be a disturbance of the property of the TBB to keep the content of metals in the tissues and fluids at the optimal level. At the same time, changes in the content of trace elements which activate important enzymic reactions, and thus influence various aspects of metabolism, must in turn affect function of the TBB.

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