EFFECT OF SURGICAL ABLATION OF THE BRUNNER'S GLAND REGION OF THE DUODENUM ON ASSIMILATION OF NUTRIENTS IN RATS

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It is generally agreed that the secretion of the duodenal glands is involved in protection of the intestinal mucosa against the action of hydrochloric acid and pepsin, which enter the duodenum with the chyme from the stomach [9]. However, the results of comparative morphological investigations [5, 6] and also some experimental data [10] contradict this point of view.

The aim of this investigation was to study assimilation of the basic nutrients after exclusion of the Brunner's gland region of the duodenum from the digestive process as a result of resection of the corresponding segment.

EXPERIMENTAL METHOD

Experiments were carried out on male Wistar rats weighing 200-250 g. The operations performed are shown diagramatically in Fig. 1. In the animals of group 1 part of the duodenum was removed together with part of the pyloric division of the stomach, and the stomach was anastomosed end-to-end with the duodenum. The region of the duodenum resected in this case was about 1.5 cm long, and corresponded to the zone of distribution of the duodenal glands in rats [5]. Rats of group 2, used as the control, underwent ligation of the pyloric part of the stomach, followed by end-to-end gastro-duodenostomy at a distance of 2-2.5 cm from the beginning of the duodenum. Thus the Brunner's gland region was excluded from the passage of chyme, but secretion of the duodenal glands could still pass into the distal part of the duodenum. Rats of group 3, also a control group, underwent a mock operation. All operations were performed under ketamine anesthesia (1-2 mg/kg, intraperitoneally).

Assimilation of nutrients was studied 1.5 months after the operations. The rats were put on a diet artificially balanced for all nutrients, and containing 17.4% protein, 60.2% carbohydrates, 19% fat, and 3.4% minerals After adaptation for 1 week to the new conditions of feeding, the weight of food consumed and of feces excreted, in which the content of the principal nutrients was subsequently determined by the usual methods [3], was estimated in animals kept in individual metabolism cages for 5 days, in accordance with existing recommendations [2]. Assimilability of protein, carbohydrates, fat, and minerals was estimated on the basis of the relative amount of them retained in the body during the metabolic experiment The number of animals studied in each group is given in Table 1 After the end of the experiment, the completeness of removal of the glandular area of the duodenum was verified histologically. Morphological and functional evaluation of the duodenal glands was carried out by cytophotometric analysis of the concentration of PAS-positive secretion in the cytoplasm and of RNA in the nucleoli of the glandulocytes, stained with gallocyanin. The concentration was judged from the transmittance, measured by the plug method at a wavelength of 550 nm for PAS-positive material and 570 nm for RNA In all groups no fewer than 150 cells from each of the five chosen animals were analyzed. The results were subjected to statistical analysis with estimation of individual and group dispersion [4].

TABLE 1. Assimilability of Principal Nutrients in Animals of Experimental Groups (M ± m)

Group of animals	Number of animals	Assimilability, %			
		Protein	carbo-hydrates	fats	Minerals
1 — Rats with resection of Brunner's gland region	16	86,7±1,1	91,8±1,6	97,0±0,3	85,0±1,7
2 — Rats with gastroduodenoanastomy	18	91,7±1,6*	94,8±0,8	98,1±0,3	88,3±2,7
3 — Rats undergoing mock operation	15	93,1±1,0**	94,2±0,6	98,2±0,6	90,8±1,3

Legend. Asterisks indicate significant difference compared with group 1: $*p < 0.05$, $**p < 0.01$.
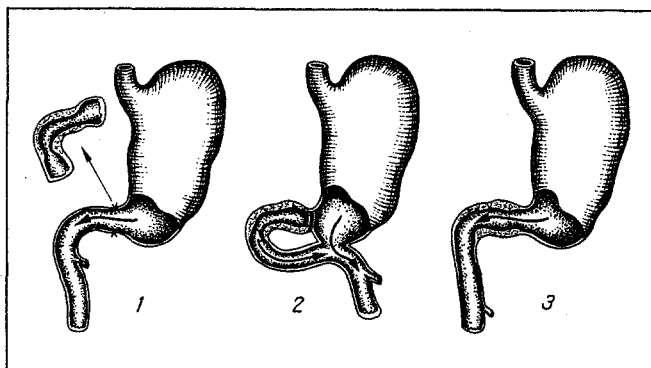

Fig. 1. Diagram showing operations: 1) resection of Brunner's gland region of duodenum, 2) ligation of pylorus and gastroduodenostomy, 3) mock operation.

EXPERIMENTAL RESULTS

In the region of the anastomosis formed after resection of the Brunner's gland region of the duodenum, complete healing of the walls of the resected organs took place with restoration of the integrity of the epithelial cover of the mucosa. There were no glands in the submucosa of the duodenum (Fig. 2). Meanwhile, in none of the animals of this group were erosions found in the intestinal mucosa, as would have been expected after removal of the glands, considering their supposed protective function. Our results confirm data obtained by other workers [10] who studied the duodenum 1 week after resection of its Brunner's gland portion. The protective mucous barrier formed in the absence of secretion of the duodenal glands is evidently sufficiently resistant to the action of factors of the enteral medium.

In the control animals undergoing gastroduodenostomy the structure of the main part of the glandular lobules and also the content of secretion in them did not differ from those in rats undergoing the mock operation (Fig. 3), and the mean level of transmittance for PAS-positive material in the cytoplasm of the granulocytes was 19.3 ± 2.9 and 17.4 ± 2.3 conventional units respectively. No statistically significant differences likewise were found in the concentration of nucleolar RNA in the glandulocytes of rats of the two control groups: 24.6 ± 1.1 and 21.8 ± 1.5 conventional units respectively. Consequently, exclusion of the Brunner's gland region of the duodenum from the passage of chyme did not induce any morphologically recordable changes in functional activity of the duodenal glands.

Mean values of dry weight of food consumed showed no statistically significant differences, and amounted to 65.2 ± 8.2 g in group 1, 76.3 ± 3.7 g in group 2, and 82.2 ± 6.5 g per animal in group 3. There was likewise no difference in the quantity of feces excreted during the period of the experiment, and its dry weight calculated per rat was 5.3 ± 0.5 g in group 1, 4.1 ± 0.8 g in group 2, and 4.5 ± 0.8 g in group 3. The relative content of fat and minerals in the feces did not differ in animals of the groups studied. The content of carbohydrates in the feces of rats of groups 1 and 2 was a little less than in animals undergoing the mock operations, but this was not reflected in the values of assimilability of carbohydrates (Table 1). Meanwhile a marked increase was observed in the relative protein content in the feces of rats of the experimental group, especially when compared with values in animals undergoing the mock operations ($p < 0.05$). The protein fraction in the samples, calculated per animal, was 28.3 ± 1.6% in group 1, 26.8 ± 2.0% in group 2, and 22.7 ± 0.7% in group 3.
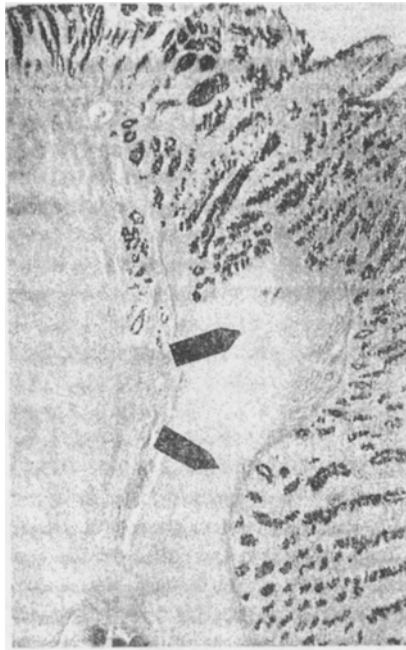
Fig 2. Zone of gastro-duodenal anastomosis 1.5 months after resection of Brunner's gland region of duodenum in a rat. No glands are present in the duodenal submucosa (arrows). PAS reaction. 30×.
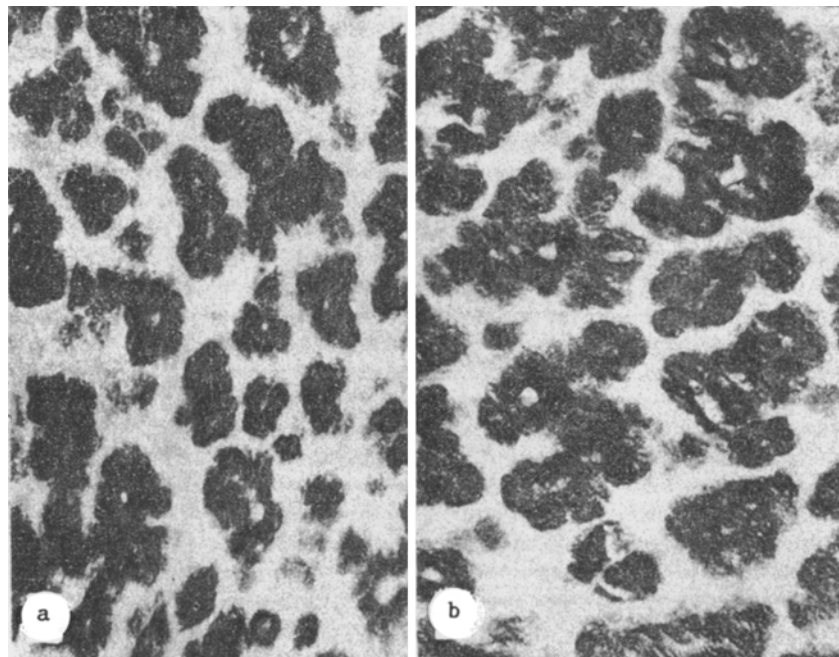

Fig 3. Terminal parts of duodenal glands in rats of control groups. As regards their content of secretion, glands of animals after gastroduodenostomy (a) do not differ from those of rats undergoing mock operations (b). PAS reaction. 270×.

There is no doubt that this was the result of the lower assimilability of protein discovered in rats after ablation of the Brunner's gland region of the duodenum, compared with animals of the other two groups, serving as controls (Table 1).

It can be concluded from these results that in the absence of secretion of the duodenal glands, definite disturbances of digestion took place in the lumen of the duodenum of these animals, manifested in particular as reduction of the level of protein assimilation. This may be linked with insufficient digestive activity of the intestinal juice, the formation of which is influenced by secretion of the duodenal glands [6]. It has been shown [7] that the duodenal juice collected through a fistula of the Brunner's gland region of the duodenum contains a pepsinlike factor, whose concentration increases in response to feeding. The presence of pepsinogen II actually in the secretory granules of the glandulocytes of the duodenal glands has been demonstrated immunocytochemically [8]. Another possibility is that removal of the Brunner's gland region of the duodenum leads to disturbance of the adsorptive properties of the floccular structures of the chyme, the formation of which under normal circumstances is accompanied by the formation of an enteral medium with high surface activity [1] Involvement of the glycoprotein-rich secretion of the duodenal glands in this process seems very probable, for it constitutes the greater part of the intestinal juice when in the proximal portion of the duodenum [6, 9]. Weakening of the adsorptive properties of the chyme, when the secretion of the glands is not present in its composition, changes the character of enzyme—substrate interactions, and this ultimately must lead to a disturbance of the assimilability of nutrients. If such changes in adsorption took place under the present experimental conditions, it must be presumed that they are selective in character only in relation to proteinhydrolyzing enzymes, for no abnormalities of assimilability of other nutrients were found.

Thus after resection of the Brunner's gland part of the duodenum, the assimilability of protein in the animals was reduced. Views put forward to explain the possible causes of development of these changes require additional experimental verification. The results indicate that the function of the duodenal glands may be connected with direct or indirect involvement in hydrolysis of nutrients.

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