CHANGES IN THE RESORPTIVE CAPACITY OF THE SMALL INTESTINE DURING A STABLE INCREASE OF PORTAL PRESSURE

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The functional and morphological state of the wall of the small intestine was studied in dogs with stable portal hypertension. Disturbance of the portal circulation was shown to lead to morphological changes in the wall of the small intestine and to a decrease in its resorptive capacity for lipids, carbohydrates, and proteins.

KEY WORDS: small intestine; portal pressure; absorption in the intestine.

The disturbances of digestion and absorption in portal hypertension have not yet been fully investigated [3, 4].

It was therefore decided to study the resorptive capacity of the small intestine for proteins, lipids, and carbohydrates and also morphological changes in its wall during stable portal hypertension.

EXPERIMENTAL METHOD

In each of a series of chronic experiments on 16 dogs absorption in the basal state was first investigated; portal hypertension was then produced surgically and absorption again investigated. At the end of the experiments laparotomy was performed, the portal pressure was measured, and a piece of the small intestine was taken for histological analysis. The extrahepatic form of portal hypertension was produced by one-stage partial occlusion of the trunk of the portal vein with the aid of a Lavsan graft. The venous pressure was thereby increased from 40-100 to 280-380 mm water. To study the resorptive capacity of the small intestine tests with oleic acid, glyceryl trioleate, and I^{131}-labeled albumin, and also with glucose and D-xylose were used. Absorption of the labeled compounds was judged from the level of radioactivity of samples of venous blood taken from a vein of the hind limb 1, 3, 4, 5, 6, and 9 h after injection of the preparation; the radioactivity of the 24-h sample of urine and of the stools collected for 72 h also was measured. The rate of absorption of carbohydrates was estimated from the increase in the blood sugar 15 min after glucose loading [1]. The blood sugar was measured by the orthotoluidine method. By the test with D-xylose the quantity of monosaccharide absorbed could be estimated from the level of its excretion with the urine during the 5 h after injection of 25 g pentose in 250 ml water. The concentration of D-xylose in the urine was determined by the orcine method [2].

EXPERIMENTAL RESULTS

During the first 48 h after the operation the dogs were lethargic, their gait was unsteady, and they refused to eat. All the dogs periodically produced liquid stools. The body weight of the animals gradually decreased. The wall of the small intestine was edematous and cyanotic, and the blood vessels were dilated and tortuous.

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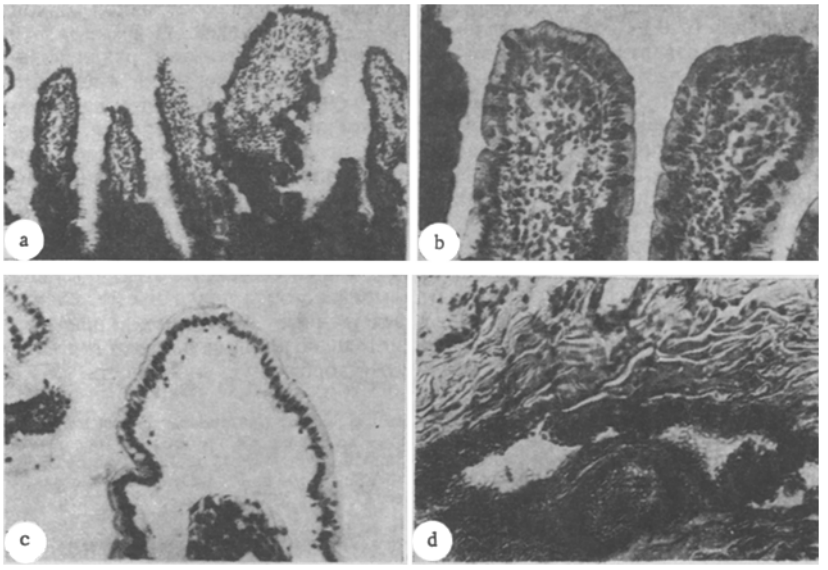

Fig. 1. Morphological changes in the wall of the small intestine in dogs with disturbance of the portal circulation by extrahepatic occlusion of the portal vein: a) shortening and thickening of villi, thinning and loss of definition of the brush border (hematoxylin–eosin, 80×); b) increase in number of goblet cells (mucicarmine; 140×); c) edema of subepithelial layer, covering epithelium detached (hematoxylin–eosin; 200×); d) marked venous stasis in submucosa (hematoxylin–eosin; 120×).

Changes in the mucosa and submucosa consisted of shortening and thickening of the villi, thinning of the brush border, and a loss of clarity of the intercellular boundaries (Fig. 1a), together with an increase in the number of goblet cells (Fig. 1b). The subepithelial layer of the villi was edematous and the covering epithelium easily detached (Fig. 1c). Features of sclerosis and venous stasis appeared in the submucosa (Fig. 1d).

The absorption of lipids was severely disturbed. After loading with I^{131}-glyceryl trioleate the radioactivity of the blood in all tests was much lower than initially. Whereas in healthy dogs the radioactivity of the blood reached a maximum after 5 h (8.49 ± 0.32% of the injected dose), in the same dogs after the creation of portal hypertension the maximum of radioactivity was observed later (after 6 h) and it was lower (4.73 ± 0.38%; $P < 0.05$). The radioactivity of the 24-h sample of urine from the dogs before the operation was 48.00 ± 0.82% of the injected dose, but after the operation it fell to 34.40 ± 0.46% ($P < 0.05$). The radioactivity of the stools rose after the operation from 3.0 ± 0.25 (in the healthy animals) to 10.20 ± 0.53% of the injected dose.

The radioactivity of the blood of the animals with portal hypertension after loading with I^{131}-oleic acid also was lower than initially. Whereas in the healthy dogs a maximum of 8.77 ± 0.39 % was reached after 4 h, after the development of portal hypertension it reached 5.69 ± 0.39% after 5 h ($P < 0.05$). In this case the radioactivity of the 24-h sample of urine fell from 54.2 ± 2.17 to 40.4 ± 1.92% of the injected dose ($P < 0.05$). The radioactivity of the stools, however, rose once more from 2.05 ± 0.30 to 8.19 ± 0.97% of the injected dose.

These observations show that a disturbance of the blood flow in the portal vein not only causes morphological changes in the wall of the small intestine, but also disturbs the absorption of fatty acids and of the hydrolysis products of neutral fat.

The rate of absorption of glucose in the dogs with portal hypertension also was considerably reduced. In healthy dogs 15 min after loading the increase in the blood sugar was 35.0 ± 6.4 mg%; after the creation of portal hypertension it was only 13.5 ± 3.4 mg% ($P < 0.05$).

The excretion of D-xylose with the urine collected during the 5 h before the operation was 3.79 ± 0.20, but after the operation it fell to 2.12 ± 0.44 g ($P < 0.05$).

The absorption of carbohydrates thus also was reduced in the dogs with portal hypertension.

In the healthy dogs 1 h after administration of I^{131}-albumin maximal radioactivity of the blood was observed: 9.44 ± 0.35% of the injected dose. By 9 h after the beginning of the investigation the radioactivity of the blood was only 2.65 ± 0.21%. The elimination of radioactivity with the 24-h sample of urine was 62.0 ± 1.51%, and its elimination with the stools was 1.04 ± 0.11% of the injected dose.

After the development of portal hypertension maximal radioactivity of the blood was observed only 4 h after the injection of the preparation, when its level was 7.10 ± 0.52% of the injected dose ($P < 0.05$). Later the character of the changes in radioactivity of the blood was the same as before the operation. The elimination of radioactivity with the 24-h sample of urine after the operation fell to 49.4 ± 1.57% ($P < 0.05$). The elimination of radioactivity with the stools of the dogs after the operation was higher than in the preoperative period: 3.43 ± 0.20%.

Disturbance of the portal circulation thus had a significant effect on the morphological state of the wall of the small intestine, causing venous stasis in the mucosa and submucosa. These changes and, perhaps, the direct disturbances of the blood flow in the system of the portal vein have a marked effect on the biological properties of the intestine and, in particular, on its resorptive capacity.

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