MICROCIRCULATION OF THE SMALL INTESTINE IN VARIOUS PHASES OF ITS MOTOR ACTIVITY

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Experiments on guinea pigs, rabbits, and rats with simultaneous recording of motor activity of the small intestine and the state of its microcirculation showed that the diameter of the intramural vessels of the intestine depends on its contractile activity. On the basis of their data the authors suggest an explanation for the mechanism of disturbance of the secretory and absorptive function of the small intestine after blocking of its nervous reflexes and transplantation.
KEY WORDS: *small intestine; microcirculation; motor activity.*

After autografting of the small intestine, changes are observed in its motor, secretory, and absorptive functions [2, 3, 5-12, 14, 15, 18]. Processes of absorption and secretion are associated with the character of the microcirculation in the villi of the small intestine [13].

It was therefore decided to investigate the state of the microcirculation of the small intestine in relation to the phases of its motor activity.

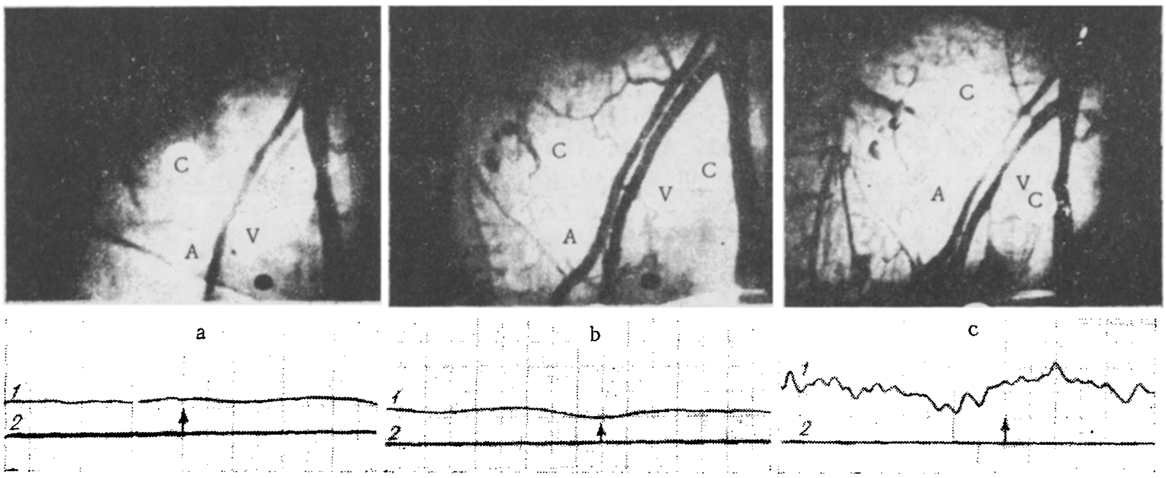

Fig. 1. State of intramural blood vessels of guinea pig small intestine in various phases of contraction: a) contraction; b) relaxation; c) tetanic contraction after application of adrenalin. Photomicrographs (16×): A) arteriole; V) venule; C) capillaries. Movements recorded by balloon-graphic method: 1) intestinal movements; 2) initial pressure. Arrow shows time of photography. Tape-winding speed 1.25 mm/sec. Calibration: 1 mm = 0.2 mm Hg.

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TABLE 1. Diameter of Intramural Blood Vessels of Small Intestine in Various Phases of Its Motor Activity (guinea pig)

Parameter studied	Spontaneous activity				Evoked activity	
	contraction		relaxation		tetanus	
	n	$M \pm \sigma$	n	$M \pm \sigma$	n	$M \pm \sigma$
Intraluminal pressure (mm Hg)	13	18,91±1,05	13	18,19±0,6	8	19,47±0,92
Arteriole diameter (μ)	10	89,0±12,42	11	93,18±11,67	7	95,0±17,3
	25	84,2±13,3	24	86,66±19,65	16	65,93±17,9
	16	75,0±13,16	21	71,19±14,82	7	71,43±17,25
Venule diameter (μ)	10	110,5±42,38	11	184,09±34,16	7	164,28±13,36
	24	84,79±20,9	24	121,87±15,3	15	92,66±28,3
	14	84,28±16,27	20	128,75±33,27	6	103,33±16,63

Note. Same vessels were investigated during each experiment. Vessels in other fields of observation with different initial diameters responded similarly.

EXPERIMENTAL METHOD

Under thiopental anesthesia laparotomy was performed and a small rubber balloon (volume 1 ml for rabbits, 0.4 ml for guinea pigs, and 0.25 ml for rats) was introduced into the lumen of the small intestine of the three species of animals to record its contractions. The balloon was connected to a source of light for transillumination (a quartz light guide). The abdominal wound was closed, leaving only the segment of intestine for study exposed and covered with transparent polyethylene film to maintain its temperature and moistness. The animals were artificially ventilated (DP-2 apparatus) after relaxation by tubocurarine. Movements of the small intestine were recorded through the balloon on an RM-150 polygraph. The microcirculation was investigated in transmitted light with the MBS-1 magnifying glass. The intramural blood vessels of the intestine were photographed synchronously with the phases of its motor activity and the diameters of the vessels were then measured on the photographs. Vascular responses of the microcirculation of the small intestine were studied during spontaneous and evoked activity (application of 0.01% adrenalin solution to the mesentery).

EXPERIMENTAL RESULTS AND DISCUSSION

Contractions of the small intestine in all the animals studied evoked similar changes in the microcirculation. In the guinea pigs, in particular (Table 1), during spontaneous intestinal contraction the diameter of the arterioles and of the accompanying venules was virtually identical (Fig. 1a). During relaxation of the intestinal muscle, the diameter of the arterioles was unchanged whereas the venules were dilated by about 1.5 times ($P < 0.001$). The capillaries also were slightly dilated (Fig. 1b). Changes in the diameter of the intramural vessels depended less on the absolute values of intraluminal pressure than on the pressure difference between the phases of contraction and relaxation.

Under the influence of adrenalin contractions of the small intestine were more prolonged and had a marked tonic component, or they assumed the character of tetanic contraction. The intraluminal pressure rose considerably. During these contractions the diameter of the arterioles and venules increased slightly. Meanwhile the capillary network was distended, the venules were irregularly dilated, especially where postcapillaries entered them (Fig. 1c), and previously invisible small venules and capillaries appeared. All these changes in the microcirculation are evidence of slowing of the blood flow.

During spontaneous intestinal activity synchronous changes thus took place in the phases of contraction and relaxation of the intramural arterioles and venules. This evidently reflects normal interaction between the contractile and transport function of the intestine, thus ensuring adequacy of metabolic and trophic processes in its wall.

During tonic and, in particular, tetanic contraction primary constriction of the venules was due to distension of the capillary network which, in turn, produced secondary dilatation of the venules. This is shown by the changes in their diameter and the uneveness of outline of the postcapillaries. The more prolonged the intestinal contraction, the more marked the disturbances of its hemodynamics. Irregularity of the diameter of the venules, dilatation of the capillary network, and the appearance of previously invisible small vessels point to changes in the capacity and resistance of the microcirculatory system [1, 4, 17], as manifested by an increase in the venous pressure. This increase in venous pressure leads to an increase in capillary permeability, an increase in pressure in the surrounding tissues, and dilatation of the intercellular spaces and lymphatic capillaries. Such events in the intestinal wall are bound to influence its secretory and absorptive functions.

The results of these experiments suggest that the hypersecretion of the liquid part of the intestinal juice and insufficiency of absorption [2, 5, 7] arising after autografting of the intestine are based on disturbances of the microcirculation caused by the hypertonic type of intestinal motor activity resulting from the interruption of nervous influences. The fact that after deliberate reinnervation, restoring normal contractile activity of the transplanted intestine, its normal function and morphology are restored [5, 7], also becomes understandable.

Special investigations by the writers and by other workers [16] have shown that the dynamics of the microcirculation is similar in the uterus also: During contraction of the myometrium the arterioles and venules constrict or their lumen may actually be closed completely.

The influence of contractile activity on the microcirculation is evidently a common feature to the hollow smooth-muscle organs.

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