MICROCIRCULATORY SYSTEM IN THE WALL OF THE RAT SMALL INTESTINE AFTER NEUROREFLEX ISOLATION

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The precapillary vessels constitute the main component of the resistive vessels, and relations between the precapillary and postcapillary pressure determine the hydrostatic pressure in the capillaries themselves and the exchange of liquid phase between the blood and interstitial fluid [8, 10, 12].

Studies of changes in the microcirculatory system of the small intestine under neuroreflex isolation conditions have recently been published [3, 5, 9]. However, microcirculatory disturbances develop before disorders of the macrohemodynamics and also before disturbances of function of the small intestine [2, 4, 6].

This paper describes a study of the dynamics of relations between the mean diameter of the arterioles and venules in the wall of the small intestine of Wistar albino laboratory rats under neuroreflex isolation conditions.

EXPERIMENTAL METHOD

Male rats weighing 180-240 g were used. Under general open ether anesthesia with neuroleptanalgesia (0.1 ml droperidol, 0.1 ml fentanyl, and 0.025 ml of 0.1% atropine solution/100 g body weight) after midline laparotomy the cranial mesenteric vessels were mobilized and freed from adventitia, the root of the mesentery was divided for a short distance, and the small intestine itself also was divided in its proximal and distal portions, just as in the model of neuroreflex isolation used on dogs [4, 6]. The operation ended with restoration of continuity and of the normal anatomical connections of the intestine. The abdominal wall was closed in layers. During the first 3 days after the operation all animals were given 0.1 ml of a 1% solution of trimeperidine intramuscularly twice a day to prevent shock due to pain.

The spontaneous response of the blood vessels of the microcirculatory system of the small intestine was studied on the 1st, 3rd, 5th, 10th, and 20th days after neuroreflex isolation by the transillumination method. The mean diameter of the blood vessels in the wall of the small intestine was determined in five control and 29 experimental albino rats. The microcirculatory system of the intestine was photographed under a binocular microscope. Next, the diameter of the arterioles and venules of the 1st, 2nd, 3rd, and 4th orders, branching from the intestinal vasa recta, was measured, using the calibrated scale of the microscope ocular. The numerical results were subjected to statistical analysis with determination of coefficients of correlation.

EXPERIMENTAL RESULTS

On the 1st day after neuroreflex isolation the mean diameter of the 1st order arterioles was increased by 40.1% above normal ($P < 0.01$), and that of the 2nd order arterioles by 15.2% ($P < 0.001$), and this was accompanied by a decrease in diameter of the 3rd order arterioles by 27.8% ($P < 0.001$) and of the 4th order arterioles by 19.3% ($P < 0.01$) (Table 1). Venules of the 1st, 2nd, and 3rd orders were constricted by 43.6, 31.3, and 23.7% respectively ($P < 0.001$). These changes evidently reflect the response of the microcirculatory system to anesthesia, operative trauma, interruption of lymphatic pathways, and neuroreflex isolation. On the 3rd day after neuroreflex isolation the diameter of the arterioles of the 1st, 2nd, and 4th orders showed a tendency to return to normal, but not that of the 3rd order arterioles, the diameter of which was 47.3% below

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TABLE 1. Changes in Mean Diameter of Arterioles and Venules in Wall of Small Intestine after Neuroreflex Isolation (M ± m)

Time of observation, days	Order of branching of vessels	Mean diameter of arterioles, μ	P	Mean diameter of venules, μ	P	Ratio between diameters of arterioles and venules
Normal	1-st	76,4±4,3		192,1±2,8		1:2,53
	2-nd	66,5±5,4		117,3±3,5		1:1,77
	3-rd	59,8±4,3		88,1±2,5		1:1,28
	4-th	26,7±1,3		30,8±1,8		1:1,15
1	1-st	107,4±5,3	<0,001	108,3±3,1	<0,001	1:1,09
	2-nd	76,7±2,7	<0,01	80,9±3,1	<0,001	1:1,05
	3-rd	50,2±2,2	<0,01	67,4±1,8	<0,001	1:1,34
	4-th	21,5±1,3	<0,001	41,7±1,6	<0,001	1:1,95
3	1-st	80,4±3,1	<0,2	102,5±3,8	<0,001	1:1,27
	2-nd	56,8±2,2	<0,01	94,7±5,0	<0,001	1:1,68
	3-rd	36,7±4,3	<0,001	71,3±3,3	<0,001	1:1,97
	4-th	23,1±1,7	<0,01	30,6±1,5	>0,5	1:1,30
5	1-st	83,2±2,1	<0,02	141,1±3,8	<0,001	1:1,69
	2-nd	67,8±2,1	>0,5	112,8±3,5	<0,1	1:1,69
	3-rd	50,5±2,1	<0,01	39,3±2,0	<0,001	1:0,78
	4-th	38,6±1,3	<0,001	32,4±0,8	<0,2	1:0,84
10	1-st	91,2±5,5	<0,001	251,3±3,8	<0,001	1:2,76
	2-nd	83,4±2,9	<0,001	177,9±7,1	<0,001	1:2,01
	3-rd	63,0±3,5	<0,5	64,8±2,9	<0,001	1:1,02
	4-th	25,2±1,3	<0,1	28,4±1,2	<0,05	1:1,12
20	1-st	116,3±4,8	<0,001	103,8±7,3	<0,001	1:0,90
	2-nd	70,2±3,9	<0,5	74,9±3,1	<0,001	1:1,06
	3-rd	32,6±3,3	<0,001	59,2±2,6	<0,001	1:1,53
	4-th	17,9±1,4	<0,001	39,4±1,6	<0,001	1:2,28

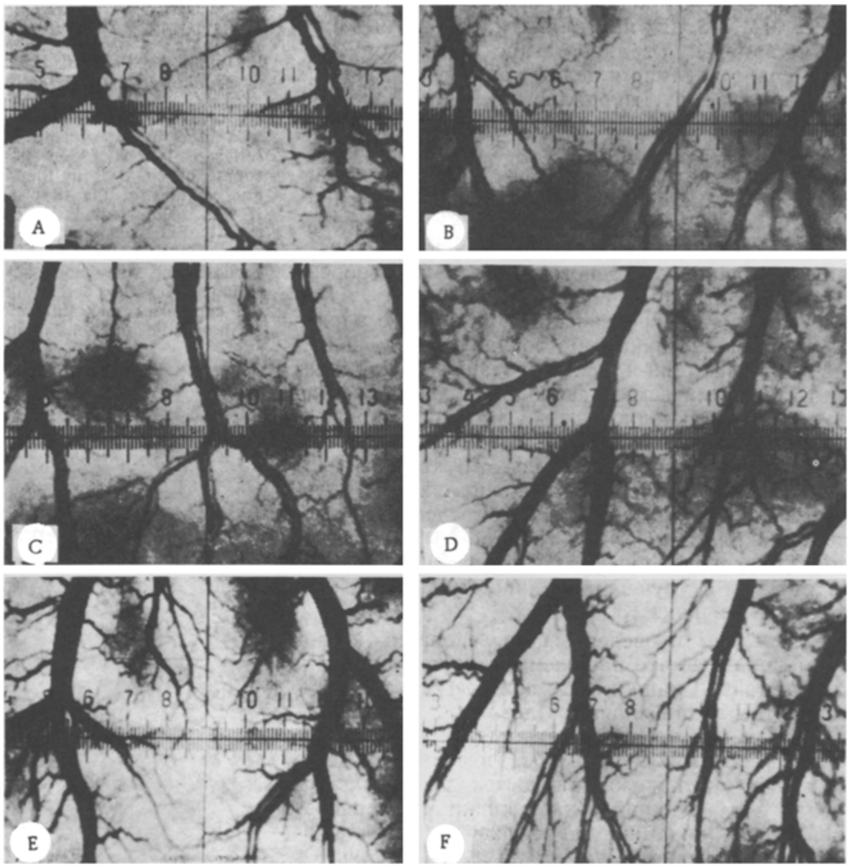

Fig. 1. Dynamics of changes in mean diameter of arterioles and venules in wall of small intestine or rats after neuroreflex isolation: a) control, b) 1st day, c) 3rd day, d) 5th day, e) 10th day, f) 20th day after neuroreflex isolation. Scale division equivalent to 10 μ.

normal ($P < 0.001$). Meanwhile the mean diameter of the venules decreased (Fig. 1): 1st order by 46.8%, 2nd by 20%, and 3rd by 18.1% ($P < 0.001$). On the 5th day after the operation hyperemia of the whole precapillary network was present, but at the same time the venules were constricted. Approximately the same picture was observed on the 10th day after neuroreflex isolation also. Later the diameter of the 1st and 2nd order arterioles increased a little whereas the 3rd and 4th order arterioles narrowed ($P < 0.001$). Meanwhile the diameter of the 1st, 2nd, and 3rd order venules was characterized by its lowest values on the 20th day after neuroreflex isolation. The only exceptions were the 4th order venules (Fig. 1), whose diameter was increased by 30.9% to $39.4 \pm 1.6\mu$ ($P < 0.001$).

Changes in the diameter of the 1st order arterioles and venules showed negative correlation: on the 1st day after operation the coefficient of correlation (σ) was -0.77 ± 0.37 ($P < 0.01$) on the 10th day -0.86 ± 0.30 ($P < 0.01$), and on the 20th day -0.73 ± 0.39 ($P < 0.001$). The mean diameter of the 2nd order arterioles and venules showed negative correlation only on the 1st day after neuroreflex isolation. Later and until the end of the period of observation changes in the mean diameter of the arterioles and venules showed positive correlation (Table 1; $P < 0.01$). The diameter of the 3rd order arterioles also showed negative correlation: on the 3rd day the value of σ was $+0.76 \pm 0.37$ ($P < 0.01$) and on the 20th day $+0.61 \pm 0.46$ ($P < 0.01$). The dynamics of changes in the mean diameter of the 4th order arterioles did not correlate significantly with that of the corresponding venules. Only on the 20th day was constriction of the arterioles accompanied by dilatation of the venules ($\sigma = -0.76 \pm 0.37$; $P < 0.01$), and in the writers' opinion this reflected profound changes in the gradient of pre- and postcapillary resistance and a whole range of functional and morphological disorders in the small intestine described in the literature [1, 3, 10, 11, 13].

The profound morphological changes found in the mucous membrane and in other layers of the wall of the small intestine reflect trophic disturbances arising in response to disturbances of coordination of the microcirculatory system following neurogenic isolation [7, 12]. Changes in the diameter of the 1st order blood vessels in the intestinal wall are evidently responsible for the hemodynamic changes observed following isolation and transplantation of the small intestine [5, 9]. Not only disturbances of the normal structure and enzymic organization of neurons of the intramural nervous plexuses and their compensatory hyperfunction [5-7], but also the excessive motor activity and, in particular, enhancement of the tonic reactions of the intestinal musculature, and also improvement in the macrocirculation in the intestinal wall play an important role in the pathogenesis of the microcirculatory disturbances in the wall of the small intestine after neuroreflex isolation [3-5, 11, 13].

The results of the experiments described above suggest that disturbances of the microcirculation in the wall of the rat small intestine after neuroreflex isolation are relatively early and essential changes, and they explain disturbances of the function of the tissue–blood barriers, in exchange between the blood and interstitial fluid, and also in various functions of the small intestine that upset coordination between the processes responsible for digestion.

LITERATURE CITED

1. E. A. Vorob'eva, M. A. Gudkova, and G. S. Semenova, in: Vascular and Nervous Connections in the Body [in Russian], Kursk (1970), p. 23.
2. V. I. Kozlov, Arkh. Anat., No. 10, 102 (1970).
3. V. P. Kulik, A. N. Maksimenkova, and L. S. Finikova, Byull. Éksp. Biol. Med., No. 3, 261 (1976).
4. V. P. Kulik and A. N. Maksimenkova, Fiziol. Zh. SSSR, No. 9, 1249 (1970).
5. V. P. Kulik and A. N. Maksimenkova, Éksp. Khir. No. 2, 24 (1975).
6. V. P. Kulik and A. N. Maksimenkova, Functions and Morphology of the Transplanted Intestine [in Russian], Moscow (1974).
7. V. A. Titkova, Arkh. Patol., No. 8, 42 (1964).
8. A. M. Chernukh, The Microcirculation in Health and Disease [in Russian], Moscow (1974).
9. W. Ballinger, M. Christy, and W. Ashby, Surgery, 52, 151 (1962).
10. B. Folkow and E. Neil, Circulation, New York (1971), p. 462.
11. J. Gero and M. Gekova, Blood Vessels, 15, 277 (1978).
12. H. N. Mayrovitz, Microvasc. Res., 10, 322 (1975).
13. U. G. Stanffer, Z. Kinderchir., 22, 241 (1977).