Microcirculation Bed of the Rabbit Ear after Blood Substitution

L. A. Mikhailichenko and M. I. Reutov

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The indexes of the microcirculation are stable under conditions of hemorrhage and blood substitution and do not reflect the degree of circulatory system anemization [2, 5, 13.]

It has been established that the microvascular hematocrit does not follow the systemic hematocrit [7, 8], and heterogeneity of the reactions of the microcirculatory bed (Mb) is observed. While blood flow in the minute arteriolae is increased, in the arteriolae with a diameter of 43-54 μ it is decreased, and the average reaction of the Mb indicates a diminishment of blood flow [9]. The diameter of the arteriolae can thereby decrease, but the venulae are not affected. Clinicians point to the uselessness of hemodilution in patients with satisfactory perfusion or with an absence of collateral blood flow [6]. The aim of the present investigation was to study the features of Mb reaction to moderate hemodilution in paired organs such as rabbit ears.

MATERIALS AND METHODS

Experiments were carried out on new microvessels of rabbit ears 3-4 months after implantation of a chamber, as described previously [1]. Six rabbits weighing 2.5±0.1kg were used. Twelve chambers were implanted and 72 fragments of Mb were observed. Local anesthesia (1 ml of 0.5% Novacain solution injected subcutaneously) was performed only in the case of isovolume hemodilution.

For this purpose blood (10 ml/kg body weight) was taken from the femoral vein and replaced with an equal volume of rheopolyglucin. The hemodilution was moderate in order to permit repeated use of animals with imlanted chambers. Blood samples were taken from the internal vein of the ear. Photography was performed to obtain an image of the microvessels. The set of measured Mb indexes is presented in Table 1; the methods of data registration and processing were described earlier [1]. All the measurements were performed at room temperature 30 min before and after blood substitution. The reliability of index differences was assessed by Student 's *t* test for conjugated pairs.

RESULTS

As it shown in Table 1, the left Mb decreases in area after blood substitution, mainly due to a drop in the number of microvessels (the length of the bed decreases by 38%, and the diameter by 5.9%), and the L/D ratio is 35% lower than the initial one. The changes in the right Mb morphometric characteristics are not pronounced: the Mb area increases by 7.3%, the mean diameter by 7.9%, and the L/D ratio is 19 % lower than the initial one. It may be considered that the after-effect of hemodilution on Mb resistance is doubled for the left bed. But, according to Poiseuille's law, the resistance to the flow is in direct proportion to the viscosity of the flowing liquid and to the length of the bed, and is in inverse propor-

Institute of General Pathology and Pathological Physiology, Russian Academy of Medical Sciences. (Presented by V. V. Kupriyanov, Member of the Russian Academy of Medical Sciences)

TABLE 1. Microcirculatory Bed Indexes of Rabbit Ears after Blood Substitution ($M \pm m$)

Bed indexes	Conventional symbols	Left bed (24 fragments)		Right bed (24 fragments)	
		initial values	after hemodilution	initial values	after hemodilution
Microvessel projection area mm²	A	0.296±0.096	0.176±0.032	0.247±0.064	0.265±0.085
Microvessel projection length, mm	L	7.372±2.132	4.568±0.988	7.240±1.376	7.212±1.256
Mean microvessel diameter, m	D	55.0±10.9	51.7±12.9	47.5±5.9	51.2±10.7
Length/diameter ratio	L/D	149.4±47.2	97.33±39.6	176.4±56.2	145.3±30.6
Viscosity in cP with tension of displacement 3.65 d/cm²	m	3.15±0.41	2.65±0.56	3.65±0.81	3.43±0.78
Number of erythrocytes per unit of volume, з10⁴	N	650±128	661±79*	588±215	647±260
Mean erythrocyte volume, c.u.	V	40.39±9.17	39.87±11.38	42.06±7.38	45.26±7.21
Erythrocyte weight, c.u.	W	26,712±8,871	26,320±.2,833*	23,797±6,771	27,302±8,581
Electrophoretic mobility, cm/sec/V/cm	EPM	1.225±0.146	1.654±0.202	1.192±0.209	1.258±0.115

Note. An asterisk means that the deviation of an index from the initial level is not significant $p>0.05$.

TABLE 2. Relative Contribution of Individual Factors to Bed Resistance (R) Variation after Poiseuille

Object	Bed indexes				
	μ/μ_o	L/L_o	D_o/D	$(D_o/D)^4$	$R/R_o=q=\mu/\mu_o \times L/L_o \times (D_o/D)^4$
Left ear	0.842	0.619	0.941	1.275	0.647
Right ear	0.940	0.996*	1.078	0.740	0.693

Note. For conventional symbols see Table 1. Symbol o is for the initial level.

tion to the tube diameter to the fourth power. In this case, the change of the resistance may be assessed by the q coefficient, as is shown in Table 2. For the left and right Mb the q value was similar , but the left q decreases mainly due to the reduced number of perfused vessels, whereas the right q decrease relates to vessel dilatation. The microvessel constriction observed in the left Mb may be considered, on the other hand, as a factor preventing the fall of the resistance. It may be pointed ou that the change of the mean diameter of the left microvessels is the same as that of the arterial chain under moderate hemodilution [9], and the right is the same as that of the venous chain. Table 1 demonstrates that the erythrocyte concentration per unit volume of the blood draining from the inspected region was not affected by the moderate hemodilution (left) or even increased (right). The same result has been observed in the microvessels of the skeletal muscles [7, 8] and of the mesentery [9], where the decrease of the capillary hematocrit was less than of the systemic one. These deviations were attributed to a redistribution of the blood flow in the bed-bordering regions. The observed asymmetrical reactions in symmetrical microcirculatory beds may be a reflection of normal physiological asymmetries, as has been noted by investigators of symmetrical regions of the brain [3, 4, 10-12].

Thus, reaction to hemodilution depends on the morphofunctional features of organization of the left and right ear MB, which is in agreement with previous data on postischemic alterations [1].

REFERENCES

1. L. A. Mikhailichenko and M. I. Reutov, *Byull. Eksp. Biol.*, **108**, № 8, 162-163 (1989).
2. V. T. Morozov, *Lab. Delo*, № 12 , 947-949 (1987).
3. S. P. Nogina, N. V. Sanotskaya, D. D. Matsievskii, *et al.*, in: *Physiology, Pathophysiology, and Pharmacology of the Brain Circulation* [in Russian], Tbilisi (1988), p.133.
4. N. N. Petrishchev, L. N. Dorokhova, and D. Yu. Semenov , in: *Mechanisms of Platelet Hemostasis Disturbance* [in Russian], Leningrad (1988), pp.17-25.
5. G. M. Solov'ev and G. G. Radzivil, *Hemorrhage and Regulation of Blood Supply in Surgery* [in Russian], Moscow (1973).
6. J. C. Grotta, *Stroke*, **18**, 264-267 (1987).
7. B. Klitzman, *Microvasc. Res.*, **29**, 231(1985).
8. L. Lindbom, S. Mirhashemi, M. Intaglietta, *et al.*, *Acta Physiol. Scand.*, **134**, 503-512 (1988).
9. H. H. Lipowsky and J. C. Firrell, *Amer. J. Physiol.*, **250**, H908-H922 (1986).
10. M. S. Magnoni, S. Govoni, H. Kobayashi, et al., *Stroke*, **19**, 38-41 (1988).
11. J. S. Perlmutter, W. J. Poweres, P. Hersovitsh, *et al.*, *J. Cerebral Blood Flow Metab.*, **7**, 64-67 (1987).
12. G. Rodrigaes, S. Warkentin, J. Resber, *et al.*, *Ibid.*, **8**, 783-789 (1988).
13. E. Vicaut, *Cah. Cecec.*, **9**, 11-13 (1986).