Effect of Hemodilution and Hemoconcentration on Postischemic Alterations of Microvessels in Rabbit Paired Auricles

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Morphometric parameters of microvessels in paired rabbit ears and blood sampled from the internal vein were studied after ischemia reproduced under conditions of prior hemodilution and hemoconcentration. In hemodilution the postischemic alterations were found to be more pronounced in microvessels of the left ear, while for the right the same was true for rheological characteristics of the outflowing blood. Under conditions of hemoconcentration after ischemia the changes in rheological indexes were more marked on the left and in vasomotor indexes on the right.

Key Words: *microvessels; hemodilution; hemoconcentration; ischemia; asymmetry*

Mechanisms of adaptive reactions of the microcirculation to hemodilution and hemoconcentration are being studied on different organs and tissues both in clinical settings [1,5,7,8,13] and in experiment [9-12]. Not only has organ-specificity of these mechanisms been shown, but also the invariability of some organs in the face of such action [6]. However, in studies of the microcirculation of paired organs, as a rule only one of the pair has been examined. Meanwhile, previous studies performed on fragments of the microcirculatory bed (MCB) of rabbit paired auricles showed differences in the reaction of the microvessels of symmetrical beds in response to both hemodilution [3] and hemoconcentration [4]. Differences in postischemic alterations of microvessels from symmetrical sides were found as well [2]. Continuing the studies reported earlier [3,4], we explore here the dynamics of postischemic alterations in the rabbit auricle MCB under conditions of preliminary hemodilution and hemoconcentration.

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MATERIALS AND METHODS

Experiments were carried out on newly formed rabbit auricle microvessels. The experimental object was prepared as described previously [2]. Six rabbits weighing 2.5±0.1 kg were used. The number of implanted chambers was 12, allowing for observations of 72 MBC fragments. Blood substitution was performed as described previously [3]. Hemoconcentration was achieved by the administration of a diuretic [4]. Ischemia was produced by compression of the auricle with a soft clamp [2]. Blood was sampled from the internal vein before and after hemodilution and hemoconcentration and then after 30-min ischemia and 1 h after occlusion. Photography of microvessels was performed simultaneously. The indexes estimated were as follows: the area of MCB fragments, the specific length of microvessels (L), and their mean diameter (D), as well as rheological parameters of blood flowing from the ischemic region: the apparent viscosity (μ), erythrocyte concentration per unit of blood volume, mean volume of an erythrocyte, and its electrophoretic mobility. The methods of data recording and processing were described ear-

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TABLE 1. Effect of Hemodilution on Postocclusion Alterations in the Parameters of the Microcirculatory Bed in Rabbit Paired Ears in Relation to the Level Just Prior to Occlusion ($M \pm m$)

Parameter	Left bed				Right bed			
	initially	after hemodilution	after occlusion	recovery	initially	after hemodilution	after occlusion	recovery
μ/μ_0	1.188±0.155	1	1.020±0.251*	0.952±0.208*	1.063±0.234	1	0.901±0.287	0.782±0.065
L/L_0	1.658±0.466	1	1.207±0.330	1.349±0.440	1.003±0.190*	1	1.108±0.313	1.012±0.296*
D/D_0	1.062±0.210	1	1.050±0.225	0.997±0.193*	0.926±0.115	1	1.015±0.273*	0.974±0.156*
$(D_0/D)^4$	0.792	1	0.822	1.012	1.360	1	0.942	1.111
q	1.560	1	1.012	1.300	1.445	1	0.940	0.879

Note. The erythrocytic mass in the blood flowing from the regions after blood substitution was not only not decreased but was even increased for the right side [3]. Here and in Tables 2 and 3: *insignificance of deviation.

lier [2]. The reliability of deviations of the parameters in relation to the level prior to occlusion was assessed by Student's test for conjugated pairs.

RESULTS

Parameters whose changes can determine the resistance of MCB according to the well-known Poiseuille law are listed in Tables 1 and 2. The change of resistance in such a case is specified by a coefficient:

$$q=\mu/\mu_0 \times L/L_0 \times (D_0/D)^4$$

where μ_0, L_0, and D_0 are the values of the parameters just prior to occlusion. A value of $q>1$ points to a possible rise of MCB resistance, while $q<1$ points to its decrease. For ease of comparison of the postischemic dynamics of parameters under conditions of hemodilution and hemoconcentration with the dynamics without preliminary influence on the MCB, the relationships of parameters for the same phases of observation calculated as described earlier [2] are presented in Table 3.

It is clear from Table 1 that the postocclusion change of parameter q for the left bed is insignificant, while the alterations of bed length and of the diameter of its microvessels prove to be counter, namely, the changes of extent promote a q rise, whereas, dilatation of microvessels serves to lower it. On the right a postocclusion decrease of q is promoted by a drop of viscosity and slight dilatation of microvessels, whereas an increase of the number of perfused vessels is a counter.

The data presented in Table 2 suggest that under conditions of elevated hemoconcentration after occlusion parameter q exceeds that at the preocclusion phase regardless of which side is examined. But on the left its increase results from a rise of viscosity and microvessel constriction, while a decrease of the number of perfused vessels impedes the rise of q. Constriction of microvessels that is more pronounced on the right than on the left favors q elevation, while a reduction of blood viscosity and a decrease of bed length are counterfactors.

It follows from a comparison of the data in Tables 1 and 3 that while hemodilution abolishes the postischemic q rise for the left bed, for the right bed it prevents its sharp drop. Here we find a shift of the dominating factors of q change. Whereas on the left without preliminary hemodilution its rise could have been due to the increase of both viscosity and the number of perfused vessels, the postischemic outcome under conditions of hemodilution was due to vasodilatation. Evidently, under conditions of hemodilution, when the number of open vessels remains below the level prior to hemodilution, the vasomotor mechanisms "kick in" during the process of regulation of homeostasis on

TABLE 2. Effect of Hemoconcentration on Postocclusion Alterations in the Parameters of the Microcirculatory Bed in the Rabbit Paired Ears in Relation to the Level Just Prior to Occlusion ($M \pm m$)

Parameter	Left bed				Right bed			
	initially	hemoconcentration	after occlusion	1 h after occlusion	initially	hemoconcentration	after occlusion	1 h after occlusion
μ/μ_0	1.082±0.119	1	1.100±0.237	0.964±0.175	0.873±0.083	1	0.985±0.051*	0.866±0.067
L/L_0	1.131±0.275	1	0.905±0.212	0.814±0.202	1.080±0.249	1	0.933±0.181	0.980±0.203*
D/D_0	1.046±0.156	1	0.981±0.203*	0.912±0.192	1.013±0.249*	1	0.965±0.123	0.977±0.177*
$(D_0/D)^4$	0.835	1	1.079	1.445	0.949	1	1.153	1.098
q	1.022	1	1.074	1.134	0.895	1	1.060	0.931

Note. Hemoconcentration after administration of diuretic was increased by 30.5% on the left and by 22.1% on the right [4].

TABLE 3. Postocclusion Alterations in the Parameters of the Microcirculatory Bed in Rabbit Paired Ears in Relation to the Level Just Prior to Occlusion ($M \pm m$)

Parameter	Left bed				Right bed			
	initially	prior to occlusion	after occlusion	1 h after occlusion	initially	prior to occlusion	after occlusion	1 h after occlusion
μ/μ_0	1	1	1.136±0.086	0.888±0.161	1	1	0.926±0.119	0.946±0.110
L/L_0	1	1	1.132±0.119	0.988±0.142*	1	1	1.031±0.030*	0.919±0.063
D/D_0	1	1	1.033±0.014	0.964±0.033	1	1	1.097±0.086	1.074±0.058
$(D_0/D)^4$	1	1	0.914	1.158	1	1	0.691	0.752
q	1	1	1.175	1.016	1	1	0.660	0.654

Note. The table is constructed from previous data [2].

the left side. In contrast, on the right the vasomotor mechanisms under conditions of hemodilution are less significant, and therefore the prevention of the sharp fall of parameter q is realized via an increase of the number of perfused vessels during the postischemic period.

From a comparison of the data listed in Tables 2 and 3 it follows that hemoconcentration does not result in a change of the direction of the postocclusion deviation in parameter q for the left bed, but abolishes its postocclusion drop on the right. In this case, similarly as with hemodilution, there is a shift of the dominant factors responsible for a rise or fall of q. Whereas on the left without any previous change in hemoconcentration the postocclusion rise of q is dictated by an increase of viscosity and of the number of functional vessels, while their diameter manifests itself as a counterfactor, under conditions of hemoconcentration the increase of left bed resistance is determined by the increase of viscosity and vasoconstriction (albeit slight) and the direction of influence of the bed length is opposite. On the right, constriction of vessels causes resistance to rise under conditions of hemoconcentration, while the alterations in viscosity and length hinder this increase. As follows from Table 3, changes in diameter, on the contrary, promote a drop of resistance, while alterations of length promote its rise when preliminary treatment of the bed is omitted.

When we compare the data from Tables 1 and 2, we find that the state of hemodilution "decommissions" the rheological factor from the reaction to occlusion for the left bed and the vasomotor factor for the right. Hemoconcentration, conversely, decommissions the rheological factor for the right bed and the vasomotor factor for the left.

Thus, the findings do not provide a direct answer as to whether hemodilution is useful or hemoconcentration harmful for the postischemic outcome in the MCB of paired organs. However, it is clear that the compensatory-adaptive mechanisms which determine the postischemic outcome manifest themselves in different ways for microvessels from symmetrical organs.

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