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MORPHOLOGICAL INVESTIGATION OF THE INTRAVASCULAR RED CELL DISTRIBUTION IN THE AORTIC ARCH

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KEY WORDS: young and old red blood cells; carotid and femoral arteries.

Qualitative and quantitative correlation is known to exist between the blood supply and function of various organs [4]. A high intensity of its metabolism and negligible reserves of energy substrates and oxygen are the reasons why the brain is particularly sensitive to hemocirculatory disturbances and render strict control of its blood supply essential. However, exposure to hypoxia does not simultaneously block the various functions of parts of the CNS. The high safety factor of the blood supply is due to unique mechanisms of compensation and unique features of the circulation in the brain [1]. At the same time, the possible presence of additional mechanisms, ensuring that mainly the brain is supplied with oxygen, cannot be ruled out. These mechanisms may be associated with qualitative differences in the composition of the blood responsible for nutrition of the cells of the brain and peripheral organs. We know that the profile of average velocities of blood flow in different parts of the aorta is virtually flat, but the symmetry of the profile diminishes as the blood flow travels along the ascending aorta into its arch, and division of the blood flow is observed where the vessels branch [6, 7]. It can be postulated that after division of the flow, blood entering the side branches and blood continuing to flow along the main trunk of the aorta differ qualitatively.

In the investigation described below the distribution of red blood cells by degree of maturity was determined in the bloodstream.

EXPERIMENTAL METHOD

Experiments were carried out on 18 mongrel dogs of both sexes weighing 4.5-5 kg. Blood (2 ml) was taken for investigation from the carotid and femoral arteries of the dogs under pentobarbital (40 mg/kg, intravenously) anesthesia. These arteries were chosen because skeletal muscle at rest has a lower oxygen consumption than brain. The following parameters of age of the cells were chosen: volume, surface area [11], and diameter of the red cell [2], and its hemoglobin content [12]. The hemoglobin content was determined relative to dry weight of red cells, because under normal conditions hemoglobin accounts for 95% of their dry weight [8]. Dry weight was measured by interferometry on a Biolar-PI microscope (Poland). The interferometric investigations were carried out in a chamber, in which the diameter of the cells and the difference in optical path for 50 arbitrarily chosen red cells were measured [3]. Dry weight was calculated by the equation:

$$m = \frac{\psi \cdot S}{100 \cdot \alpha},$$

where ψ denotes the difference in optical path, S the area of the cell, and α is the specific increment of the refractive index, which for hemoglobin is 0.00193.

To determine the red cell count and hematocrit index traditional methods of hematology were used. The volume and average thickness of the cells were calculated by Todorov's method [9]. The results were subjected to statistical analysis by Student's and Kolmogorov–Smirnov tests.

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TABLE 1. Parameters of Arterial Blood Taken from Carotid and Femoral Arteries

Hematologic parameter	Red cells from carotid artery	Red cells from femoral artery	P
Number or red cells in 1 mm^3 of blood	6 026 766	5 939 444	>0,05
Diameter of red cells, μ	6,825±0,03	6,544±0,02	<0,05
Dry weight of red cells, pg	23,879±0,2	24,184±0,2	>0,05
Hematocrit index	39,73±2,29	46,00±1,90	<0,05
Mean red cell volume, μ^3	66,025±3,1	76,937±2,89	<0,05
Mean thickness of cells, μ	1,815±0,09	2,15±0,09	<0,05

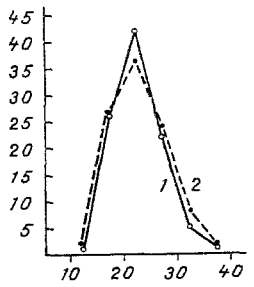

Fig. 1

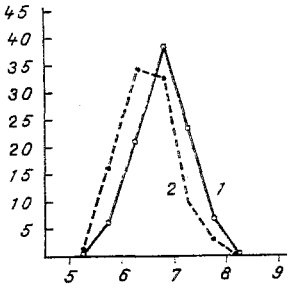

Fig. 2

Fig. 1. Red cell distribution by dry weight in blood taken from carotid (1) and femoral (2) arteries. Abscissa, dry weight (in pg); ordinate, number of cells (in %).

Fig. 2. Red cell distribution by diameter in blood taken from carotid (1) and femoral (2) arteries. Abscissa, red cell diameter (in μ); ordinate, number of cells (in %).

EXPERIMENTAL RESULTS

According to data in the literature [10], the enzyme activity of red blood cells falls with aging, whereas the mean hemoglobin concentration per cell and the density increase. As a result of the present investigation differences were found in the hemoglobin content in blood taken from the carotid and femoral arteries. In the carotid artery, for instance, the quantity of solid matter in one red cell was 23.879 ± 0.22 pg, whereas in the femoral artery it was 24.184 ± 0.25 pg. Despite normal values of average dry weight of the red cells obtained from the two vessels, a relative increase in both "light" and "heavy," more saturated with hemoglobin, cells was observed compared with these parameters in red cells obtained from the carotid artery. Cells with a dry weight of 15-25 pg accounted for 42.25% of the total from the carotid artery and 36.25% of the total from the femoral artery (Fig. 1). These results are evidence that there were more young red cells in the carotid than in the femoral artery.

Red cells of different ages also differed in their geometric parameters: volume, surface area, and diameter. For instance, the younger cells have a larger diameter [2] and volume and surface area decrease with aging [11]. Measurement of the diameter of red cells in arterial blood showed that cells with a greater diameter predominate in blood taken from the carotid artery (39%) compared with red cells from the femoral artery (33.5%). Consequently, the mean diameter of cells from the carotid artery was greater: the Prince-Jones curve under these circumstances was shifted to the right (FIg. 2). The results of determinations of the hematocrit index, the red cell count in 1 mm^3 of blood, and their mean diameter, and the calculated values of average volume and sruface area of the cells are given in Table i. The hematocrit index of blood from the femoral artery was significantly higher than that of blood the carotid artery. This may be due to the fact that during aging, red blood cells become spherical in shape [9].

Thus the relative content of young forms of red cells in the arterial blood supplied to the brain is greater than in blood supplied to the periphery. This is shown by the lower hemo-

globin content in cells from the carotid artery, and their greater diameter. This separation is evidently of great physiological importance: young forms of red cells can exchange their oxygen for carbon dioxide more efficiently, for affinity of red cells for oxygen increases with age [5].

However, the cause of this effect is not clear. It may be that a definite role is played in this situation by hemodynamic differences at the point of branching of the vessels from the aortic arch.

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EFFECT OF HEPARIN ON ACTIVATION OF THE ANTICLOTTING SYSTEM BY α-THROMBIN

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α-Thrombin is a bioregulator of hemostasis and of the liquid state of the blood and is responsible both for blood clotting and for activating the anticlotting potential of the body [2]. The bioregulatory functions of α-thrombin are effected through a special site of its molecule — the recognition center for high-molecular-weight compounds, located outside the active center proper [2, 5]. For certain functions of α-thrombin to be realized, contact between the recognition center and the complementary site on the cell receptor is sufficient [2, 10]. For instance, the hormone-like activity of thrombin is manifested as excitation of the anticlotting system [2], and also as stimulation of chemotaxis of monocytes, activation of neutrophils, and aggregation of lymphocytes [9, 10]. The recognition center also makes an important contribution to stimulation of synthesis and release of prostacycline, to induction of aggregation of platelets and enhancement of their reactivity, to activation of the blood clotting inhibitor protein C, and other functions, by maintaining the unique specificity of α-thrombin for protein substrates and cell receptors [2, 3, 10]. The recognition site for high-molecular-weight compounds consists of a number of subcenters: the chemotaxic domain, the fibrinogen recognition site, and the cationic subcenter [10]. The latter is responsible for interaction of thrombin with heparin [10]. It has been postulated that the

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