conditions the conductance of the activated channels for the fast outward current is much greater than the conductance of the inward channels. For that reason, despite activation of the channels of the fast inward current, the resultant current is outward in direction during depolarization of the membrane. In the presence of TEA, when the channels of the fast outward current were partially blocked, a component of inward current appeared in the resultant current, the current-voltage characteristic curve of which included a region with negative resistance. Under these conditions the muscle cells acquired the ability to generate gradual action potentials [3, 6].

The dependence of the fast outward current on the membrane potential level in the smooth-muscle cells of the pulmonary artery was similar in character to that in other types of smooth muscles (ureter [5], uterus [7]), and it indicates that under normal conditions the overwhelming majority of channels of the fast outward current are in an inactivated state. During hyperpolarization, inactivation of the channels is abolished and the fast outward current increased. Depolarization, on the other hand, leads to even greater activation of these channels. This mechanism evidently plays a part in the regulation of excitability of muscle cells during a change in membrane potential under the influence of physiologically active substances.

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HIGH ERYTHROCYTE CONCENTRATION IN BLOOD CIRCULATING IN THE BRAIN

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KEY WORDS: cerebral circulation; distribution of erythrocytes in blood vessels; local hematocrit; microcirculation.

An uneven distribution of erythrocytes in blood flowing through the vascular system was noted a long time ago. For instance, it is now 100 years since Kostyurin [1] found that the erythrocyte concentration in human blood flowing from the region of the clavicle is higher than in blood from the little toe. It was shown later [8] that blood circulating in the region of the renal tubules contains more erythrocytes than blood circulating in the renal cortex. On the basis of such investigations of phenomena of the microcirculation the following principle of redistribution of erythrocytes in the vascular system of organisms was formulated: Blood with a relatively higher concentration of erythrocytes is found in microvessels in parts of the body where the local circulation is intensified, and vice versa [2-4].

It might be supposed that blood in the brain, where the circulation is particularly intensive [6], would contain more erythrocytes than in peripheral parts of the circulatory system. The experiments described below were carried out to test this hypothesis.

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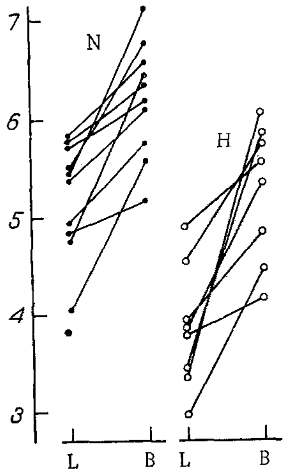

Fig. 1

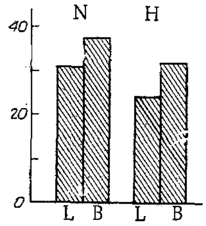

Fig. 2

Fig. 1. Differences in concentration of erythrocytes in blood circulating in hind limb and brain uner conditions of arterial normotension and hypotension in different experiments. L) Hind limb; B) brain; N) normotension; H) hypotension. Ordinate, erythrocyte count (in millions/μl blood).

Fig. 2. Local hematocrit index in blood from hind limb and brain in arterial normo- and hypotension. Ordinate, hematocrit index (in % of blood volume). Remainder of legend as to Fig. 1.

EXPERIMENTAL METHOD

Experiments were carried out on adult rabbits of both sexes weighing 2.5-3.5 kg (14 animals), anesthetized with hexobarbital (40-50 mg/kg, intravenously). A polyethylene cannula of the greatest possible diameter, connected by a three-way tube either to a mercury manometer or to a pressurized reservoir to lower the general arterial blood pressure (BP) by bleeding from the arteries, was introduced extraperitoneally into the right iliac artery. To take samples of venous blood from the left hind limb an incision was made in the skin and taken down to the femur. To take samples of venous blood from the brain, a burr-hole was drilled in the parietal region of the skull and the dura was removed.

To determine the erythrocyte concentration blood samples were taken into appropriate mixing chambers: from a muscular (sometimes also a cutaneous) branch of the femoral vein (by an incision in its wall) and from a large pial vein draining blood from the cerebral cortex (by injuring the wall of the vein with a needle under a binocular microscope); in six experiments blood also was taken from the aorta (by withdrawing it through the cannula inserted into the iliac artery). This procedure was undertaken very carefully, paying special attention to ensure that no liquids (lymph, tissue fluid, or CSF) were mixed with the whole blood. Meanwhile the pipet of the hematocrit was filled with blood.

Erythrocytes were counted in a Goryaev's hemocytometer; only those data when the dilution of blood in the mixing chambers was relatively uniform and the standard deviations in separate squares of the hemocytometer were not significant (mean ± 6.9), are given below.

The results were subjected to statistical analysis by Student's t-test.

EXPERIMENTAL RESULTS

Under normotensive conditions (mean BP 90-110 mm Hg) the number of erythrocytes in blood taken from veins of the hind limb varied in different experiments from 4,050,000 to 5,820,000/μl (mean 5,218,000 ± 569,000 cells/μl). No significant differences were found in blood taken from cutaneous and muscular branches of the femoral vein: Erythrocytes were rather more numerous sometimes in one, sometimes in the other. In the presence of arterial hypotension, when the general BP fell to 60-70 mm Hg (blood samples were taken approximately 10 min after the fall of pressure) the erythrocyte count in blood from the branches of the femoral vein was always reduced (by 20-35%) to a mean value of 3,970,000 ± 618,000/μl.

In blood taken from the cerebral veins the erythrocyte concentration was always higher than in blood from the hind limb of the same animal (the interval between taking blood samples did not exceed a few minutes). These differences occurred in both normotension and hypotension (Fig. 1). In normotension the erythrocyte count in blood from the cerebral vein varied from 5,170,000 to 7,140,000/μl (mean 6,207,000 ± 590,000/μl). If the erythrocyte count in blood from the hind limb is taken as 100%, in the brain it was 20.0 ± 11.5% greater; the differences were statistically significant ($P < 0.001$). Corresponding differences affected the hematocrit index: In blood from the hind limb its mean value was 31.5 ± 3.7%, but in blood circulating in the brain it was 37.5 ± 4.2% (Fig. 2). In hypotension the erythrocyte count in blood taken from the cerebral vein varied from 4,110,000 to 6,090,000/μl (mean 5,260,000 ± 690,000/μl), i.e., it was 34.0 ± 20.7% greater than in blood taken from the branches of the femoral vein in the same experiment; the differences are statistically significant ($P < 0.001$). In arterial hypotension the hematocrit index in blood from the brain averaged 31.7 ± 3.6%, but in blood from the hind limb it was 23.9 ± 3.4% (Fig. 2).

Blood from the aorta contained about the same number of erythrocytes as blood from the brain vessels (5,412,500 ± 630,000 and 5,515,000 ± 860,000/μl, respectively; $P > 0.5$).

Although in the present experiments venous blood flowing from the organs was investigated, differences in the erythrocyte concentration also undoubtedly must have affected the arterial blood flowing into them. This is shown, in particular, by the following fact: An increase in the erythrocyte concentration in venous blood because of the switching of some water from the blood system into the lymphatic system could have taken place only in the limb and not in the brain (where there is no lymphatic system); in the brain, secretion of CSF takes place chiefly in the choroid plexuses, and this cannot be reflected in the erythrocyte concentration in blood flowing along microvessels of the cerebral cortex.

The experiments showed that blood circulating in the brain vessels is richer in erythrocytes than in the peripheral parts of the vascular system. The differences are increased in arterial hypotension, when the blood flow in the brain is better maintained by regulation than in other organs [5]. Consequently, new evidence has been obtained of the preferential distribution of erythrocytes in blood flowing into those parts of the body where the circulation is particularly intensive because of the high metabolic demands of their structural elements [2, 3]. This is undoubtedly a matter of great importance for the oxygen supply to structural elements of tissues, which utilize oxygen in the brain in particularly large quantities [6]. Meanwhile the results of the present experiments also shed light on the previously unexplained phenomenon of a higher hematocrit index in blood from the aorta than in blood from certain peripheral organs — muscles, intestines, kidneys, skin, etc. [7]: Erythrocytes of blood from the aorta are evidently distributed mainly to the brain and to those organs in which the intensity of the circulation is higher at that moment.

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