A study of the parameters of excitability of the cytoplasmic membrane of DM fibers (Table 1) showed that after denervation of the corresponding belly typical denervation changes developed in it, for the existence of the intermediate tendon between the bellies prevents any possibility of crossed innervation. These changes were manifested as a fall in the levels of RMP, AP, and CDL (in both bellies), the rheobase values of the stimulating current (in the anterior belly), and the amplitude of the negative afterpotential (in the posterior belly), and as an increase in LP (in the posterior belly) and duration of the negative after-potential (in both bellies). It can be concluded from analysis of the character of these changes that they were virtually indistinguishable from disturbances of the electrogenic properties of fibers of other muscles which have both sensory and motor innervation [5, 10, 11].

These results as a whole are evidence that neurotrophic influences on muscle fibers in muscles opening the mouth are affected mainly by terminals of efferent nerves.

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ERYTHROCYTE RESPONSE AND METABOLIC CHANGES IN LONG-TERM EXPERIMENTAL HYPERCATECHOLAMINEMIA

L. A. Apollonova

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Recent investigations are evidence of increased interest in the study of the mechanisms of involvement of the blood system in adaptation to stress and to extremal factors [1, 3, 13]. Changes in erythrocyte metabolism and the role and participation of enzymes in its disturbances have received careful study [14]. The view is now held that mechanisms of individual resistance to stress must be investigated at molecular and cellular levels, and that blood cells must be an informative object for study in this connection [12].

Considering the leading role of the sympathicoadrenal system in adaptation processes, it was decided to study the response of the erythron and metabolic shifts on a model of hypercatecholaminemia developed in the writer's laboratory [11].

EXPERIMENTAL METHOD

Experiments were carried out on 17 mongrel dogs of both sexes weighing 15-20 kg. Under thiopental sodium anesthesia chronic catheterization of the aorta and superior vena cava was

Central Research Laboratory, Central Postgraduate Medical Institute, Moscow.

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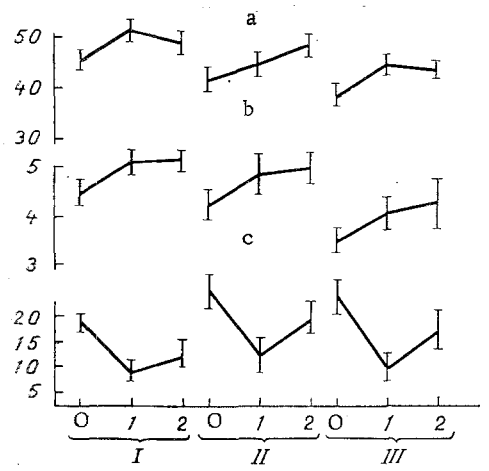

Fig. 1

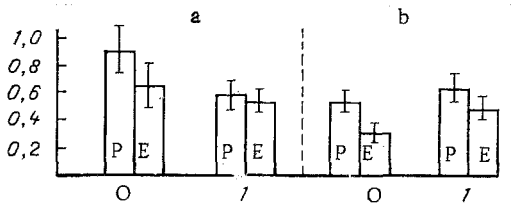

Fig. 2

Fig. 1. Changes in hematologic parameters in dogs during infusion of NA. a) Hematocrit; b) erythrocytes (millions); c) ESR (mm in 1 h). Here and in Fig. 3: I) 1st day, II) 3rd day, III) 6th day of NA infusion; 0) initial values.

Fig. 2. Changes in CBV of dogs on 1st (a) and 6th (b) days of NA infusion. P) Plasma volume; E) erythrocyte volume; 0) initial values.

carried out for the function test and for taking blood samples. The initial data obtained for these dogs 3-4 days after the operation (the time necessary for restoration of the normal state of the hematologic and biochemical parameters), were used as the control for the subsequent tests. The experiments were carried out in the fall and winter, and they all began at the same time of day, namely 10-11 a.m. Even-tempered animals, adapted beforehand to the experimental situation, were selected for the experiments.

Parameters of the acid-base balance (ABB) and gas concentrations in arterial and venous blood were investigated by the Siggaard-Andersen method on an AME-I apparatus (Radiometer, Denmark), the circulating blood volume (CBV) and its components [2], the hemoglobin concentration (by the hemoglobin cyanide method), and the ESR, erythrocyte and reticulocyte counts, hematocrit, and mean volume of one erythrocyte (by the usual method) were investigated.

Experimental hypercatecholaminemia, causing stress-induced damage to the cardiovascular system [9], was produced by intravenous drip infusion of noradrenalin (NA) in a dose of 2.3 μg/kg/min for 2 h daily for 6 days. Intravenous injection of the NA solution was given fixation of the animal, in a comfortable position, preventing the possibility of development of immobilization stress. Blood samples were tested on the 1st, 3rd, and 6th days of infusion. To study the time course of the parameters during NA infusion, blood samples were taken before and 60 and 120 min after its beginning. The numerical results were subjected to statistical analysis by "Elektronika BZ-21" computer, with calculation of significance of Student's test. The level of significance adopted was $P \leq 0.05$.

EXPERIMENTAL RESULTS

Analysis of the data showed that each infusion of NA was accompanied by a significant rise of the hematocrit and erythrocyte count 1 h after its beginning, followed by a fall (Fig. 1). The hemoglobin concentration rose but not significantly. The mean erythrocyte volume fell during infusion on average by 10%. The suspension stability of the erythrocytes increased, as shown by a significant decrease in the ESR (Fig. 1). Each successive determination of the original values of hemoglobin concentration, hematocrit, and erythrocyte count before the beginning of the next NA infusion, however, showed a decrease compared with the previous value. By the 6th day the hematocrit index and erythrocyte count per unit volume of blood were significantly lower than at the beginning of the experiment. On the 1st day the peripheral blood reticulocyte count was significantly raised after infusion of NA. By the 6th day, however, the reticulocyte count did not differ significantly from its initial value and showed no appreciable change after administration of NA.

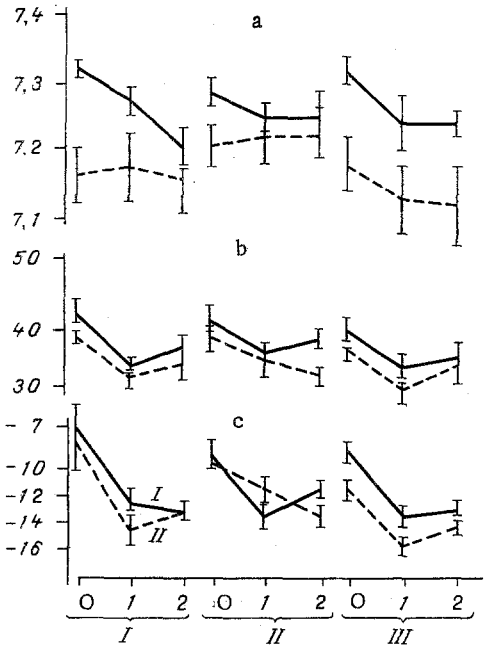

Fig. 3. Changes in parameters of ABB of arterial (continuous line) and venous (broken line) blood during infusion of NA in dogs. a) pH; b) BB (in mmoles/liter); c) BE (in mmoles/liter).

During the first infusion of NA, 1 h after its beginning CBV was reduced by 28%, chiefly due to a decrease in the circulating plasma volume. After the 6th day of daily NA infusion, CBV was 46% less than initially; a statistically significant decrease in the mass of circulating erythrocytes was observed under these circumstances. Infusion of NA against this background was accompanied by an increase in CBV with a significant increase in the mass of circulating erythrocytes (Fig. 2).

During a single infusion of NA the ABB parameters of the arterial blood shifted toward metabolic acidosis, and the shift was particularly marked at the height of infusion, and showed a tendency toward normalization by the 2nd hour of infusion. At the end of the complete course signs of moderate compensated metabolic acidosis appeared: pH 7.28 ± 0.02; BE −12.0 ± 0.65 mmole•liter^{-1}; BB 38.2 ± 1.89 mmole•liter^{-1}; pCO_2 36.8 ± 4.2 mm Hg (Fig. 3). Each NA infusion was accompanied by moderate hypocapnia and pCO_2 of the arterial blood fell on average by 14%. The partial pressure of oxygen in the blood did not change significantly during NA infusions.

Comparison of the parameters of ABB of the arterial blood during NA infusion on the 1st, 3rd, and 6th days revealed a decline in the significance of the differences between arterial and venous blood with respect to the values of pH, base excess (BE), and concentration of buffer bases (BB, AB) on the 1st and 3rd days of the infusions, followed by restoration of the difference by the 6th day (Fig. 3). This suggests some kind of arterialization of the venous blood during long-term drip infusion of NA on the first days of the procedure, possibly as a result of activation of the blood flow along arteriolo-venular shunts and which partly explain the decrease in CBV.

Opening of the arteriolo-venular shunts during a single exposure to stress or intravenous drip infusion of NA is confirmed by the results of biomicroscopy of the mesenteric blood vessels [5, 10]. Another mechanism explaining the predominant reduction of the circulating plasma volume at the height of NA infusion on the 1st day is an increase in permeability of the microvessels and an increase in the number of plasmatic capillaries, observed in such situations [5, 8, 10]. It is probably in this way that physiological storage of plasma in depots takes place. The reduction in plasma volume combined with an increase in the arterial hematocrit index during infusion of NA were described previously [15].

A 6-day course of NA infusions caused an increase in all the structural parameters of the capillary bed of the splanchnic basin [9], and together with the considerable decrease in

CBV and the significant reduction in the mass of circulating erythrocytes and the hematocrit, this may be evidence of pathological storage of blood in depots as a result of stress-indueed injury to the cardiovascular system. Intravenous drip infusion of NA against this background led to an increase in CBV, the mass of circulating erythrocytes, and hematocrit, probably due to expulsion of blood from the depots.

Each infusion of NA was thus accompanied by a temporary rise of the red blood parameters, the mechanisms of which differed on the 1st and 6th days: moderate hemoconcentration during the first NA infusions and expulsion of blood from the depots during prolonged exogenous hypercatecholaminemia.

The physiological significance of the responses described above, in the writer's opinion, is that they increase the mass of circulating erythrocytes and of hemoglobin, which increases the oxygen capacity of the blood. The increase in suspension stability of the erythrocytes improves the conditions for oxygen utilization. A moderate shift of pH toward acidosis has the same effect. The increase or decrease in CBV due to mobilization or storage of blood present in the vascular bed is an adaptive response by means of which an adequate blood supply to the heart is maintained. Under these circumstances the shortest path of the blood flow from arterioles to venules is the most economical from the point of view of energy expenditures [4].

Meanwhile prolonged hypercatecholaminemia, as these investigations showed, leads to an excessive increase in adaptive effects. For instance, the redistribution of blood, advantageous from the point of view of an adequate blood supply to vitally important organs, leads to pathological storage of a considerable part of the blood volume. The decrease in CBV, including the mass of circulating erythrocytes, which lowers the venous return of blood, is also accompanied by a decrease in oxygen capacity. The developing metabolic acidosis, the compensatory hyperventilation and, as a result, the hypocapnic alkalosis, may be the cause of the attacks of angina which may arise [6]. The conditions are thus created for the development of stress-induced injury in the organs, and stress itself is converted from an adaptation factor into an injury factor.

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