CIRCULATING BLOOD VOLUME AND ITS RESPIRATORY SURFACE DURING CRANIOCEREBRAL HYPOTHERMIA

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The effect of local brain cooling on the circulating blood volume and its respiratory surface was studied in dogs. With a fall in the body temperature from 36 to 30°C the circulating blood volume and circulating erythrocyte volume increased. If cooling continued, these indices decreased. Plasma begins to leave the blood stream simultaneously with the beginning of exposure to cold. The respiratory surface of the blood increases with a fall in body temperature to 30°C, but decreases in response to further cooling.

KEY WORDS: *hypothermia*; *circulating blood volume*; *respiratory surface of the blood*; *spleen*.

The circulating blood volume and respiratory surface of the blood were investigated in dogs during craniocerebral hypothermia.

EXPERIMENTAL METHOD

Experiments were carried out on 35 mongrel dogs weighing 8-14 kg. After trimeperidine premedication and induction with hexobarbital, anesthesia was maintained with ether and air. The experimental animal's head was contained in the factory-built "Termokholod-2f" hypothermic apparatus. Blood was taken from the femoral vein before exposure to cold and as the body temperature fell to 34, 30, 28, and 24°C. The circulating blood (CBV), plasma (CPV), and erythrocyte (CEV) volumes were determined by the Evans' Blue (T-1824) dilution method [2]. The diameter and mean surface area of the erythrocytes, the number of erythrocytes in 1 ml blood and in the total circulation, the hematocrit index, and the respiratory surface of the blood were recorded simultaneously [6]. The area of the spleen was measured planimetrically.

EXPERIMENTAL RESULTS AND DISCUSSION

Local cooling of the brain caused a considerable change in the CBV (Table 1). With a fall in body temperature from 36 to 24°C, CBV fell on the average by 46% and CPV by 60% below normal. The CEV showed phasic changes. With a moderate or average degree of craniocerebral hypothermia CEV rose by 9%, but at the end of cooling (at 24°C) it became 13% below the initial level.

The data showing the decrease in CBV during local brain cooling agree with results obtained during general hypothermia [1, 3, 4, 9]. However, the dynamics of these changes evidently depended on the method of cooling. In general hypothermia the CBV was directly proportional to body temperature from the very beginning of exposure to cold. During local brain hypothermia, this linear function appeared only at the level of deep hypothermia (when the body temperature was below 28°C). The trigger mechanism for the changes in CBV in general hypothermia is considered to be a sharp increase in blood catecholamine concentration: With a fall in temperature from 36 to 30°C the concentration of sympathomimetic substances is doubled [3]. Craniocerebral hypothermia causes a very moderate reaction of the sympathico-adrenal system. During local brain cooling, within the same temperature range (36-30°C) the catecholamine concentration increases by not more than 25% [8]. It is probably because of these differences that during superficial and moderate craniocerebral hypothermia CBV remains close to normal, whereas in general hypothermia it falls by one-third.

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TABLE 1. Changes in CBV, CPV, and CEV during Local Brain Cooling (M ± m)

Body temperature, °C	CBV	CPV	CEV
36	62,4±2,18	34,7±1,07	27,3±1,43
34	58,4±1,54	29,8±0,74	28,2±1,14
30	65,2±6,95	31,0±3,34	33,8±3,78
28	52,5±3,07	24,4±1,56	25,1±1,89
24	40,7±3,12	16,7±1,19	24,2±2,14
Reheating 32	83,9±2,77	42,9±1,18	40,0±1,77

TABLE 2. Changes in Number of Circulating Erythrocytes, Their Mean Surface Area, and Respiratory Surface of Blood during Craniocerebral Hypothermia (M ± m)

Body temperature, °C	Total number of erythrocytes in circulation, millions/kg	Mean surface area of erythrocytes, μ^2	Respiratory surface of blood, cm^2/kg
36	319,9±7,37	105,1±0,62	331,9±17,18
34	350,4±4,71	102,0±0,47	357,1±3,65
30	365,1±20,52	104,0±2,21	361,7±8,61
28	327,6±19,89	101,7±0,88	314,5±6,04
24	304,8±9,76	100,9±0,42	298,6±5,0
Reheating 32	359,2±10,29	102,4±1,77	365,5±5,53

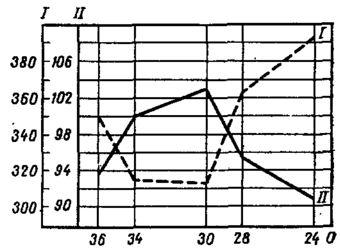

Fig. 1. Changes in number of circulating erythrocytes (I) and area of spleen (II) in craniocerebral hypothermia. Ordinate: I) number of erythrocytes in circulation (in millions/kg); II) area of spleen (in %); abscissa, body temperature (in °C).

The decrease in CBV during local brain hypothermia takes place on account of hemoconcentration. The hematocrit index rose from 42.6 ± 2.4% at 38°C to 59.9 ± 2.9% at 24°C. The main cause of these changes is evidently the disturbance of the microcirculation. In the early stages of craniocerebral hypothermia the permeability of the capillary walls is increased and plasma escapes into the interstitial space. On cooling to below 28°C capillaries whose contents are shut off from the circulation by constriction of their walls begin to appear [7]. The total CEV undergoes minimal changes under these circumstances. However, CEV alone does not enable the oxygen transport capacity of the erythrocytes to be evaluated completely, for the volume of gas diffusing through a membrane is proportional to the surface area of the cell. The total respiratory surface of the blood cells increases a little with a fall in body temperature to 30°C, but decreases during further cooling (Table 2). The area of the respiratory surface corresponds to the number of circulating erythrocytes. Their increase and decrease in the circulation, observed in the present experiments, were evidently not connected with the activity of the blood-forming or blood-destroying organs, for in the early stages of craniocerebral hypothermia both erythropoiesis and erythrodiaeresis are completely inhibited [5].

In the writer's view, the change in the number of circulating erythrocytes was connected with the activity of the spleen. Cooling the body to 30°C in these experiments was accompanied by erythrocytosis and contraction of the spleen; subsequent lowering of the temperature was accompanied by a decrease in the number of erythrocytes in the circulation and by swelling of the spleen (Fig. 1). The simultaneous development of these processes suggests that the increase in the number of cells was the result of the discharge of blood from the spleen into the blood stream, whereas their decrease was the result of storage in the pulp of the spleen.

The blood volume and the number of circulating erythrocytes are closely linked with the oxygen requirements of the body. The increase in the respiratory surface of the blood with a fall in body temperature to 30°C on account of the discharge of erythrocytes from the spleen can be considered to be an adequate response to extremal stimulation, for within this range of body temperatures cooling throws some strain on the physiological functions. Depression of the protective response to cold at 28-24°C considerably lowers the oxygen demand of the tissues. Under these circumstances there is a compensatory decrease in the number of cells supplying oxygen on account of their retention in the blood depot.

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