SPLENIC FUNCTION IN CRANICEREBRAL HYPOTHERMIA

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Experiments on dogs showed that if the body temperature is lowered from 36 to 24°C the volume blood flow of the spleen falls from 53.9 ± 1.94 to 17.9 ± 0.84 ml/100 g/min and the arteriovenous difference for oxyhemoglobin falls from 19.5 ± 0.58 to 3.3 ± 0.23%. Deep hypothermia completely inhibited the ability of the spleen to extract erythrocytes with low resistance from the blood stream. Lowering the body temperature from 36 to 30°C was accompanied by a decrease in area of the spleen to 92.6 ± 2.6%, and subsequent cooling led to the accumulation of blood in the pulp, so that the area of the organ increased to 108.7 ± 4.82%.

KEY WORDS: hypothermia; activity of the spleen.

Splenic function as reflected in its ability to fragment erythrocytes and its depot function were studied during craniocerebral hypothermia.

EXPERIMENTAL METHOD

Experiments were carried out on 38 dogs of both sexes weighing 8-16 kg. The animals were premedicated with trimeperidine and anesthesia was induced with thiopental sodium and maintained with endotracheal ether and air. Local cooling of the brain was carried out in the commercially produced "Termokholod-2F" hypothermia apparatus.

During cooling from 36 to 24°C at intervals of 2°C blood was taken from the splenic artery and vein and from the pulp of the spleen and the chemical stability of the erythrocytes was studied by the oxygen erythrogram method [4] and the arteriovenus difference for oxyhemoglobin was determined. The volume velocity of the blood flow in the spleen was measured polarographically [9] and the area of the organ planimetrically [11]. The degree of filling of the spleen with blood and the tone of its vessels were judged from the corresponding rheographic indices [10]. The results were subjected to biometric analysis on the Minsk-32 computer.

EXPERIMENTAL RESULTS AND DISCUSSION

The experiments showed that craniocerebral hypothermia appreciably reduces the local blood flow through the spleen and that the greatest changes take place after cooling to 34-32°C (Table 1).

The arteriovenous difference for oxyhemoglobin in blood flowing into and out of the spleen decreased with a fall in temperature from 36 to 24°C from 19.5-0.58 to 3.3-0.23%, chiefly on account of arterialization of the venous blood.

The results indicate depression of the activity of the spleen during local cerebral hypothermia. These changes are in full agreement with the response of other functional systems of the body to cold. However, the vital activity of the spleen was depressed more rapidly. Even under normothermic conditions the spleen has a lower metabolic rate than other organs [11], and for that reason in the early stages of hypothermia metabolism in the spleen is inhibited.

The lowering of the general level of activity in the spleen was reflected in its ability to remove red cells destined for hemolysis and fragmentation from the blood stream. Under normothermic conditions the blood

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TABLE 1. Changes in Local Blood Flow through Spleen during Craniocerebral Hypothermia (M ± m)

Body temperature (in °C)	Local splenic blood flow (in ml/100 g/min)
Initial	53,9± 1,94
34	42,7± 4,7
32	31,1± 1,34
30	27,2± 1,49
28	22,7± 0,96
26	20,2± 0,90
24	17,9± 0,84

$P \leqslant 0{,}01$

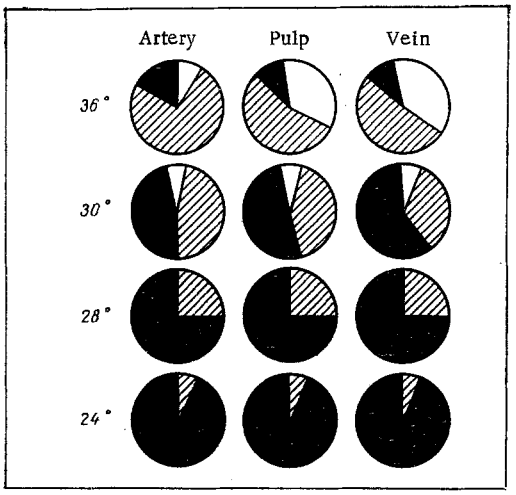

Fig. 1. Changes in chemical resistance of red cells in blood from the splenic artery, pulp, and vein during craniocerebral hypothermia. Unshaded segments) red cells with increased resistance, black segments) with reduced resistance, shaded) with average resistance (in %).

flowing from the spleen contains more resistant red cells compared with blood entering the organ. During cooling to 30-32°C the ability of the red cells to resist hemolytic treatment was reduced after passage of the blood through the spleen. Between 28 and 24°C any effect of the spleen on the qualitative composition of the red blood cells ceased, and their chemical resistance became identical in the splenic artery and vein and in the pulp (Fig. 1). At this temperature most of the circulating red cells belonged to the group with reduced resistance, the total number of which in 1 ml blood was 1.5 times greater than normally [8, 9]. Under normothermic conditions such changes in the state of the erythron take place after splenectomy [5]. Deep local cerebral hypothermia completely suppressed the selective power of the organ, while leaving its morphological integrity intact, thus simulating a "functional splenectomy," which disappeared as soon as the action of the cold ceased with restoration of the initial temperature.

The level of the depot function of the spleen during local brain cooling did not correspond to the state of its other functional properties. During moderately severe and average hypothermia depression of the general activity of the spleen took place simultaneously with the decrease in its storage capacity. However, cooling from 30 to 24°C led to the accumulation of blood in the sinuses of the spleen (Fig. 2), so that in the whole series of experiments the area of the organ became 30% greater than initially. This disagrees with data in the literature [1-3, 7, 8], according to which the body of the spleen responds to a fall of body temperature by the discharge of blood. However, in all the investigations cited the activity of the spleen was studied either during isolated cooling of the organ [7, 8] or in nonpharmacological hypothermia [1, 2] or during general cooling of the body [3].

It has now been established that there are differences in principle between the mechanisms of development of craniocerebral and general hypothermia. In general hypothermia cold retains its role as a stress stimulus for a long time, and as such it causes emptying of the spleen. In local cerebral hypothermia, some strain on the functions is found only on cooling to a temperature of 34-32°C, and it is only within this range of temperatures that the spleen contracts in the organism undergoing craniocerebral hypothermia.

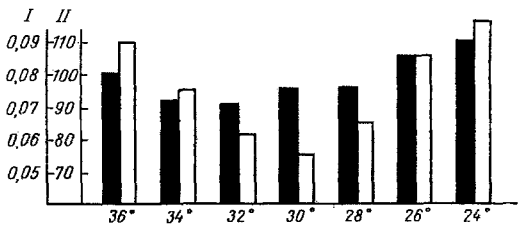

Fig. 2. Changes in area of spleen and its blood volume in craniocerebral hypothermia. Abscissa: body temperature (in °C); ordinate: I) rheographic index (in Ω), characterizing degree of filling with blood, II) area of spleen (in %). Black columns represent area of spleen; unshaded columns show rheographic index.

The increase in the depot capacity of the spleen during deep hypothermia is accompanied by the appearance of a blood pressure gradient in the portal system of the circulation. With lowering of the body temperature from 36 to 32°C, constriction of the splenic vessels is observed. The rheographic index, reflecting their tone, rises from 35.9 ± 0.91 to 39.6 ± 1.52%, i.e., by 10% over normal. The rheogram of the liver shows changes in the same direction. The index reflecting the state of the hepatic vessels varies from 27.3 ± 2.2 to 28.9 ± 2.7%. Starting from 30°C, the tone of the muscle walls in the spleen relaxes, the anacrotic phase of the pulse wave is shortened, the rheographic index falls, so that at 24°C it is 50% of its initial level, whereas in the liver vasoconstriction is intensified and the index of tone of the vessels becomes 27% above normal. Construction of the hepatic vessels, arising simultaneously with dilatation in the spleen, leads to a passive inflow of blood into the pulp and enables the depot capacity of the organ to be preserved despite complete inhibition of certain other functions of the spleen.

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