CAUSE OF DISPARITY BETWEEN BLOOD PLASMA OSMOLALITY AND ITS SODIUM CONCENTRATION AFTER COLD STRESS IN RATS

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Regulation of the osmotic concentration of the internal milieu of the organism or of water activity (in the thermodynamic sense) is closely linked with regulation of blood levels of electrolytes, glucose, and nonprotein nitrogen. The effect of other organic substances present in blood plasma on osmolality is considered to be small. We now know that mobilization of fatty acids and elevation of their blood levels take place [3] in higher animals in response to psychological and physiological stress.

The aim of this investigation was to study whether organic substances released into the blood stream during stress affect the parameters of water—electrolyte homeostasis.

EXPERIMENTAL METHOD

Wistar rats weighing 160-180 g were used. Animals of one group were subjected to temperature stress in a refrigerator at —12°C for 20 min, and animals of the other group were given an intraperitoneal injection of adrenalin (from "Tonogen") in a dose of 0.3 mg/100 g body weight. Before the experiments began the animals were anesthetized with pentobarbital (5 mg/100 g body weight). Blood samples were collected through a catheter introduced into the femoral artery. In the course of the experiment four samples were collected, and the total blood loss did not exceed 2.5-3.0% of the circulating blood volume. The blood withdrawn was immediately centrifuged. Plasma for further study was sedimented on a K-24 ultracentrifuge for 1.5 h at 22,300g and 0°C, after which the middle fraction of liquid — the internatant —was analyzed. Other objects tested were human milk and river lamprey *(Lampetra fluviatilis)* blood plasma.

Osmolality of the blood plasma and internatant was determined with a differential milliosmometer [1] and the Na^+ and K^+ concentrations on a "Flapho-4" flame photometer. The water content in the plasma was determined as the difference between the weight of the sample before and after drying at constant temperature of 105°C for 36 h.

EXPERIMENTAL RESULTS

As the body temperature of rats exposed to cold stress fell, the osmolality of their blood plasma rose and the Na^+ concentration fell (Fig. 1a). Stress is accompanied by release of catecholamines [3]. In a parallel series of experiments, adrenalin was therefore injected into rats whose body temperature was maintained at about 35°C. Similar changes were observed in these experiments (Fig. 1b). On the basis of the results it was postulated that during stress the ratio between the concentrations of organic substances dissolved in the blood plasma may change, and this will affect the osmotic parameters of the blood. To test this hypothesis, plasma of the same samples was sedimented. The osmolality of the internatant and its Na^+ concentration during cold stress in the control period were found virtually not to differ from those in native plasma. As the body temperature fell, the difference between the osmolality and Na^+ concentration in the plasma and its internatant increased. These differences were maximal when the body temperature was minimal, and they showed opposite trends: Osmolality of the internatant decreased whereas its Na^+ concentration increased (Fig. 1a). After injection of adrenalin, analysis of these same parameters revealed no differences in the first 10 min between internatant and native plasma. Only in the last samples were sharp differences similar to those found during cold stress observed (Fig. 1b). The decline of osmolality of the

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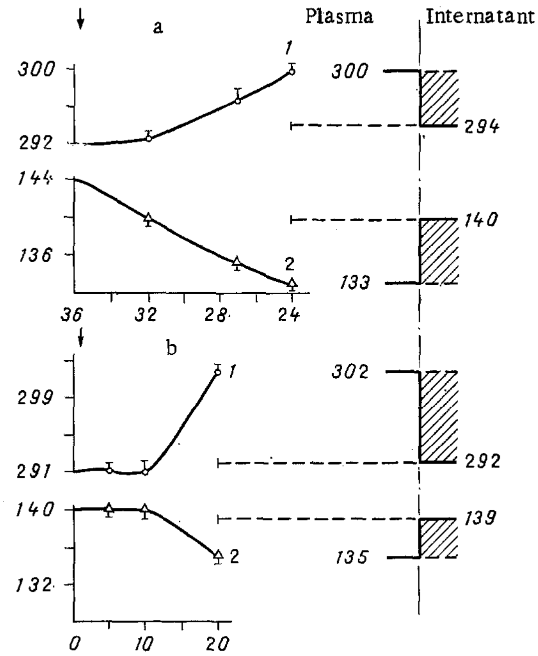

Fig. 1. Osmolality (1) and Na^+ concentration (2) in blood plasma and internatant of plasma from rats during stress. Abscissa: a) temperature (in °C); b) time (in min). Rats in (a) exposed to temperature of −12°C for 20 min; rats in (b) given adrenalin 0.3 mg/100 g body weight and kept at 35°C. 1) Osmolality of plasma (in milliosmoles/kg H_2O); 2) plasma Na^+ concentration (in mM). Levels of osmolality and Na^+ concentration in plasma and its internatant in last samples shown on right. Arrows indicate beginning of procedure.

internatant can be explained by an increase in its content of free solvent water, whereas the increase in the Na^+ concentration can be explained by a decrease in the volume of plasma in the internatant on account of sedimentation of insoluble plasma lipids. These could be nonesterified fatty acids (NEFA), the concentration of which in the same plasma rises in such cases [3].

It was decided to verify whether the same disparity exists between osmolality and Na^+ concentration in cold-blood animals, with a high blood lipid level under natural conditions. Comparison of the composition of native plasma of lampreys, whose blood NEFA concentration is higher than in mammals [4], and of the plasma internatant showed that osmolality of the plasma was 261.9 ± 7.58 milliosmoles/kg H_2O ($X \pm S$, $n = 8$), whereas that of the internatant fell to 257.7 ± 7.46 milliosmoles/kg H_2O ($X \pm S$, $n = 8$); the content of water in the internatant was 95.2 ± 0.46% compared with 93.4 ± 0.84% in the plasma. The Na^+ concentration in the plasma was 117.1 ± 3.36 mM and K^+ 3.65 ± 0.73 mM; the values of the same parameters in the internatant were 121.8 ± 3.58 and 3.86 ± 0.74 mM, respectively. Since the changes found were identical in character for the various parameters the method of tied pairs was used to assess the significance of differences ($P < 0.001$ was obtained). In this case organic substances dissolved in the plasma evidently affect the activity of the solvent water (depress it), and thereby bring about an increase in osmolality of the plasma. The decrease in the Na^+ and K^+ concentrations could be the result of an increase in volume of the plasma. Considering the blood level of NEFA in lampreys, transported in the blood in the form of a complex with albumin, and with high density [3], it must be postulated that the increase in water content in the internatant is linked with release of solvent water from under the influence of lipoproteins, differing in density from plasma and separated from it as a result of sedimentation. It was previously held that disparity between osmolality of the plasma and its components (Na^+ with accompanying anions, glucose, urea) is associated with the presence of osmotically active substances of unknown nature [2]. The results of the present experiments suggest that in certain physiological states, plasma osmolality may be influenced by organic complexes, whose concentration is increased in this situation.

Since during sedimentation of the plasma lipoproteins were separated with respect to density, and since the plasma internatant which also was analyzed lay between them, an attempt was made to discover which lipoproteins play the principal role in the observed effect. For comparison, human milk was chosen: This is known to be in osmotic equilibrium with blood and to have a low content of high-density lipids [5]. The osmolality of whole human milk was 296 milliosmoles/kg H_2O, and of the internatant 297 milliosmoles/kg H_2O ($n = 5$); the water content in milk was 88.7% and in the internatant 89.1%. The two liquids likewise did not differ significantly in Na^+ and K^+ concentration. Consequently, the different effects of organic complexes on the osmotic parameters of blood and milk could be due both to their density and to different proportions of their individual components.

Stress induced by lowering of body temperature or injection of adrenalin thus causes an increase in osmolality of the blood plasma and a fall in its Na^+ concentration. This is evidently due to the release of organic complexes of high density which, on entering the blood stream, reduce the activity of the solvent water.

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EFFECT OF MICROWAVE RADIATION ON LOCAL BLOOD FLOW AND TISSUE OXYGENATION IN THE BRAIN

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The biologically active region of the radiofrequency spectrum of electromagnetic radiation, namely microwaves, is widely used nowadays in clinical practice to produce localized hyperthermia [6-8]. This accounts for the theoretical and practical interest in the study of other possible effects of microwave (MW) radiation (especially on the CNS) within the ranges of power, frequency, and exposure that are utilized clinically.

It has been shown [4, 5] that during MW irradiation of brain tissue, the rise in temperature is accompanied by an increase in oxygen partial pressure (pO_2) in the tissue. At the same time the character of responses of brain tissue pO_2 to inhalation of pure oxygen undergoes a dramatic change, evidently because of disturbance in the function of the pO_2 self-regulating mechanism [3].

In the investigation described below the dynamics of the local cerebral cortical blood flow (CBF) during local MW irradiation under different conditions was studied concurrently with that of pO_2.

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