IMPROVEMENT OF THE BLOOD FLOW IN ORGANS AND PREVENTION OF THROMBOSIS BY COLD

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Heat and cold are used to control the hemodynamics of organs and tissues. Warming parts of the body is widely used to improve the blood flow, and cooling to arrest bleeding [1, 3]. It is considered in such cases that warmth induces arterial hyperemia whereas cold induces vascular spasm. However, the writers' previous experiments to study the effect of temperature on tone of the heart vessels proved the opposite: Cold has a spasmolytic action, whereas warmth produces marked spasm of smooth muscle [4, 5]. On the basis of these data it was postulated that cooling various tissues must induce a spasmolytic effect, i.e., must lower the high tone of the smooth-muscle cells whereever they are situated. In particular, this must improve the blood flow in the cooled area.

In the present investigation the effect of cooling from 37 to 20°C on smooth muscle tone was investigated in the intestine and blood vessels of the internal organs.

EXPERIMENTAL METHOD

Experiments were carried out on two or three segments of the small intestine of six dogs, on segments of the isolated small intestine of seven rats, on isolated circular segments of arteries of the human uterus, and on vessels of the distal phalanx of the human finger. The diameter of the intramural vessels of the dog's small intestine was studied in transmitted light while the loop of intestine to be studied was kept in a special constant-temperature chamber after midline laparotomy under hexobarbital anesthesia. Smooth muscle tone in circular segments of uterine arteries 1 mm in diameter and segments of the rat small intestine 5 mm long was investigated by a strain-gauge method under isometric conditions [7]. The response of the peripheral vessels was studied by photosphygmography on vessels of the distal phalanx of the fingers of six subjects by the usual method [2]. The effect of temperature on the blood clotting system was studied by means of the GKGM4-02 hemocoagulograph on blood samples from 11 patients.

EXPERIMENTAL RESULTS

The experiments showed that lowering the temperature from 37 to 20°C increases the tone of vascular smooth muscle, but the effect is of short duration, it arises during the first minute of cooling and lasts for 3-8 min of hypothermia. After 3-8 min of continued hypothermia the spasm disappears and persistent relaxation of the vascular smooth muscle arises in the internal and peripheral organs and intestine. Maximal relaxation of smooth muscle was found after 15-20 min of hypothermia and it lasted throughout the period of cooling. The spasmolytic action of cold was exhibited both in isolated organs and in the body as a whole.

An increase in smooth muscle tone was produced experimentally by placing the test regions in solution with high potassium concentration (120 mM KCl). Placing isolated segments of rat small intestine and of human uterine arteries in the same solution at 37°C induced persistent hyperpotassium contracture. Cooling this same solution to 20°C led to a very small and brief

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TABLE 1. Thromboelastogram of Human Blood Plasma Incubated at Different Temperatures (M ± m)

Parameter	Temperature	
	37 °C	20 °C
R, min	4,6±0,44	7,0±0,2*
K, min	2,23±0,28	7,92±1,3*
ma, mm	55,8±1,79	44,3±0,35*
E, relative units	130±0,2	88±13*
C_i , mm/min	18,34±1,37	3,79±0,88*

Legend. R) Reaction time, K) time of clot formation, ma) maximal amplitude, E) maximal elasticity of clot, C_i) coagulation index.
*P = 0.05.

increase in their tone, followed by a persistent fall of tension in the vessel wall and intestine by 31 ± 1.2 and 79 ± 1.6%, respectively. Placing the loop of dog small intestine in the solution with high potassium concentration at 37°C also led to the formation of persistent hyperpotassium contracture, accompanied by a reduction of the width of the intestine by 53 ± 1.3% and by abrupt constriction of visible vessels. Cooling this same solution to 20°C had a spasmolytic effect: The width of the intestine and the diameter of its vessels returned to their original size.

All the results described above point to a spasmolytic action of cold against a background of increased vascular smooth muscle tone in the internal organs. The response of the peripheral vessels to cooling was similar. Vascular tone in the distal phalanx of the human finger fell considerably on cooling the finger to 10°C. This was shown by an increase in amplitude of the photosphygmogram by 95 ± 6%.

During the first 1-8 min of cooling transient spasm develops, but subsequent cooling invariably lowers vascular tone. The maximal spasmolytic effect develops in this case after 12-20 min of cooling. Relaxation of the peripheral vessels thus produced continued throughout the period of cooling. Further proof of the action of cold as described above was given by visually observed changes in color of the cooled finger. During the first 1-8 min it was pale, whereas from the 5th to the 10th minute of cooling the finger became red. At this time, simultaneously with hyperemia of the finger, the patient ceased to feel any unpleasant sensations arising at the beginning of cooling in the region of the finger.

The mechanism of the spasmolytic action of cold is as follows. The writers showed previously that hypothermia induces sudden inhibition of respiration and of oxidative phosphorylation in the mitochondria, which is aimed at inhibiting various energy-dependent processes [8]. When the level of energy production is depressed, high tension cannot be developed by the myocytes: Tone of the vessel wall is reduced. Proof that vascular smooth muscle tone depends on the intensity of oxidative phosphorylation in the mitochondria is given by the results of the writers' experiments with malonate (a specific inhibitor of succinate dehydrogenase), which also abolished spasm of the vessels [5].

Experiments to study the hemostasis system showed strong dependence of its activity on temperature (Table 1). Cooling to 20°C had a marked hypocoagulation effect, aimed at preventing thrombosis. A characteristic feature of the hypocoagulation effect of cold is that it affects predominantly phases I and II of clotting: Cooling leads to lengthening of those phases by 71 and 225%, respectively. The hypocoagulation action of cold is due, in all probability, to a decrease in the intensity of biochemical reactions.

To improve the hemodynamics of the internal organs and limbs in pathology connected with hypertension of the intramural and peripheral vessels, their cooling is thus indicated: This leads to relaxation of the vessels and prevents thrombosis. Cooling the organs also protects them from ischemic damage: Hypothermia is a widely accepted and indisputable method of protecting tissues from injury during ischemia and anoxia. For cold to exhibit its spasmolytic action, prolonged cooling is necessary — at least 15-20 min. The ensuing spasmolytic effect is maintained throughout the period of cooling.

LITERATURE CITED

1. B. V. Petrovskii (ed.), Great Medical Encyclopedia [in Russian], Vol. 6, Moscow (1977), p. 506.
2. N. N.Savitskii, Biophysical Principles of the Circulation and Clinical Methods of Studying Hemodynamics [in Russian], Leningrad (1974).
3. D. F. Skripnichenko, Emergency Abdominal Surgery [in Russian], Kiev (1970).
4. S. P. Sutyagin, A. L. Urakov, and A. G. Baranov, in: Pathochemistry of Metabolism and Mechanisms of its Regulation [in Russian], Tyumen' (1982), pp. 77-78.
5. S. P. Sutyagin, A. L. Urakov, and A. G. Baranov, Krovoobrashchenie, No. 6, 52 (1982).
6. A. L. Urakov, S. P. Sutyagin, S. A. Ushnurtsev, et al., in: Adaptation to Extremal Conditions [in Russian], Vol. 4, Syktyvkar (1982), p. 96.
7. A. L. Urakov, S. P. Sutyagin, A. G. Baranov, et al., in: Abstracts of Proceedings of the 3rd All-Union Conference on Problems in Biomechanics [in Russian], Vol. 1, Riga (1983), pp. 333-334.
8. A. L. Urakov, S. A. Ushnurtsev, and G. B. Zamost'yanova, Farmakol. i Toksikol., No. 1, 51 (1983).

TURNOVER OF ERYTHROCYTE AND PLATELET GLYCOPROTEIN AMINO SUGARS IN CARBOHYDRATE-FED RATS

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Previous investigations have shown that the chemical composition of diets has a significant effect on the half-renewal time of proteins and lipids of subcellular fractions of the rat liver [3, 5-9]. These investigations not only have extended our knowledge on the plastic function of food, but have also provided new opportunities for the quest for adequate methods of assessing foodstuffs at the intracellular strucutral level. However, isolation of subcellular structures and obtaining isolated membranes from tissues, such as the liver, require the use of complex and time-consuming physicochemical methods. As the model, we therefore chose erythrocyte ghosts and platelets, which can be isolated without any such difficulty. In addition, tests of renewal of blood components can be used in clinical practice.

The content of glycoproteins in erythrocyte membranes and in platelets is relatively small compared with the important role which they perform in the functions of these cells. The qualitative contribution of the carbohydrate component in biomembranes is not determined by their quantitative composition. For instance, if sialic acid is removed by the use of enzymes from a number of serum glycoproteins, the half-life of these asialoglycoproteins is shortened from several tens of hours to a few minutes, i.e., the presence of sialic acids determines the circulation time of glycoproteins in the blood stream. Sialic acid determines the lifetime not only of glycoproteins, but also of certain cells, and in particular, of erythrocytes. Other monosaccharides of carbohydrate chains, fucose for example [2], also plays the same role.

The aim of this investigation was to study the rate of degradation of amino sugars of platelets and erythrocyte membranes of rats kept on carbohydrate diets, using starch and sucrose.

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