EFFECT OF HYPERTHERMIA ON LYMPH FLOW AND TONE OF THE LUMPHATIC VESSELS

L. E. Bulekbaeva and R. S. Vasil'chenko

UDC 612.42.014.43+612.591:612.42

The action of a high temperature on man and animals has constantly attracted the attention of investigators [1, 2, 5-7, 9].

The effect of general hyperthermia on the lymph flow is mentioned only occasionally in the literature, and the reports are contradictory. For instance, in animals overheated in a chamber, an increase [13] or a decrease [10] of the lymph flow was described. No observations on changes in the tone of the lymphatics in these conditions could be found.

In the present investigation the effect of hyperthermia on the lymph flow and the tone of the lymphatics was examined.

EXPERIMENTAL METHOD

Experiments were carried out on adult dogs anesthetized with morphine and hexobarbital. The animals were placed in a chamber with electric lamps fitted on its walls.

The air temperature in the chamber was kept between 45 and 50°. The fee end of the tracheal cannula was brought outside the chamber, while a side branch of the tube remained inside the chamber, so that the animal inhaled air at a temperature of 28-32°. The animal's rectal temperature was measured by means of an electrothermometer. Hyperthermia (to 42-44°) lasted for between 1.5 and 3 h, after which the animal died. The blood pressure in the common carotid artery was recorded on a kymograph by a mercury manometer, respiration by an intratracheal method, and the lymph flow from the thoracic duct was recorded by means of an automatic electromagnetic counter.

Altogether 29 experiments were carried out, in 9 of which the thoracic duct was perfused with warm Tyrode solution (37-38°) under a pressure of 6-12 cm water.

EXPERIMENTAL RESULTS

Elevation of the animal's body temperature by 0.5-1° was usually accompanied by an increase in the lymph flow (Figs. 1 and 3). With a further increase in the body temperature, the lymph flow continued to

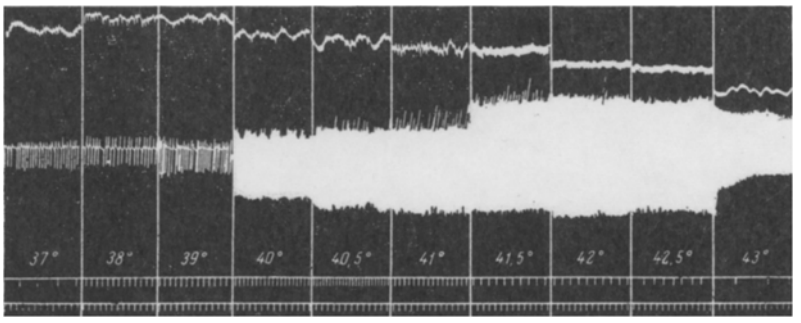

Fig. 1. Changes in arterial pressure, respiration, and lymph flow during hyperthermia. From top to bottom: arterial pressure, respiration, zero line of arterial pressure, lymph flow, time marker in 5 sec intervals.

Laboratory of Lumphatic Circulation, Institute of Physiology, Academy of Sciences of the Kazakh SSR, Alma-Ata (Presented by Academician V. V. Parin). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 64, No. 8, pp. 17-20, August, 1967. Original article submitted February 18, 1966.

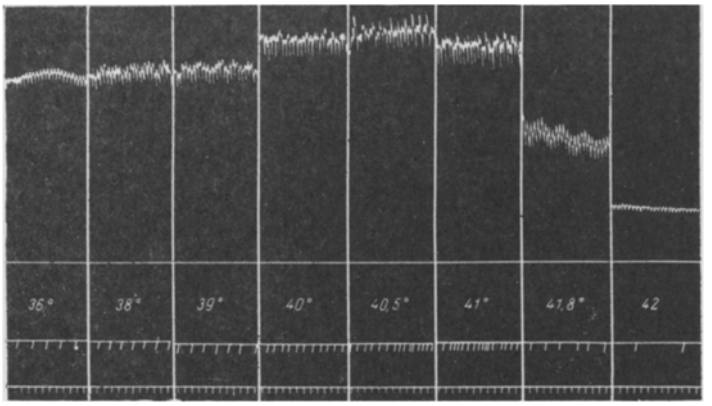

Fig. 2. Changes in arterial pressure and flow or perfusion fluid from thoracic duct during hyperthermia. From top to bottom: arterial pressure, zero line of arterial pressure, flow of perfusion fluid, time marker in 5 sec intervals.

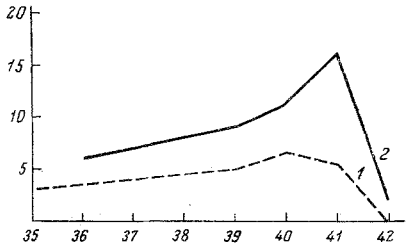

Fig. 3. Graph showing changes in flow of lymph (1) and perfusion fluid (2) from the thoracic duct during hyperthermia. Abscissa—body temperature, ordinate—number of drops of fluid per min.

rise to reach a maximum at 40.0-40.5°, when its average level was 4.1 times higher than initially. Hyperthermia was accompanied by a diminished lymph flow in only one experiment. At a body temperature of 40.6-41° the lymph flow began to decrase and stopped altogether just before the animal died from hyperthermia.

The changes in arterial pressure and respiration during hyperthermia (Figs. 1 and 2) were in agreement with those reported in the literature [1, 2, 5-7, 12].

Hyperthermia accompanied by perfusion of the thoracic duct led to an increase in the flow of perfusion fluid. This reached its maximum when the body temperature was 41° (Figs. 2 and 3), when its level was 3.3 times higher than initially. At a body temperature above 41.5° the flow of perfusion fluid gradually diminished. Hence, during hyperthermia biphasic changes were observed in the tone of the thoracic duct: an initial decrease followed by an increase.

Several authors [3, 4, 7] have reported dilution of the blood in initial stages of hyperthermia. In animals in hyperthermia an increase in the content of extracellular water has been discovered as a result of tissue dehydration and redistribution of the body fluid [8]. It may be supposed that tissue dehydration, an increase in the volume of extracellular water, and an increase in the permeability of the capillaries must bring about increased lymph formation. The lymph thus formed, when entering the blood stream, maintains the volume of the blood plasma at a certain level and thus prevents loss of fluid, which is usually observed in acute hyperthermia.

The increase in lymph flow may perhaps also be associated with the severe dyspnea of the animal, for an increase in the excursions of the thorax is one of the factors promoting the movement of lymph. However, no strict relationship could be found between the rate of lymph flow and the changes in respiration during hyperthermia. Sometimes at the height of the dyspnea the lymph flow was diminished.

In the last stages of hyperthermia a decrease in the lymph flow and narrowing of the lumen of the thoracic duct were observed. The reason for this may be that inactivation of enzymes, coagulation of proteins, changes in metabolic processes [11], tissue hypoxia [12], and disturbances of the hemodynamics and excitability of the autonomic nervous system [6] develop during hyperthermia.

The biphasic changes in the rate of lymph flow and in the tone of the lymphatics during hyperthermia are thus intimately connected with the general changes developing in the organism during hyperthermia.

LITERATURE CITED

1. A. M. Blinova, O. F. Zavalishina, and Kh. S. Koshtoyants, in the book: The Effect of High Temperature on the Animal Organism and on Man [in Russian], No. 1, 69 Moscow–Leningrad (1934).
2. N. V. Danilov, Fiziol. Zh. SSSR, 30, No. 1, 87 (1941).
3. G. V. Derviz et al., in the book: Effect of High Temperature on the Animal Organism and on Man [in Russian], No. 1, 151 Moscow–Leningrad (1934).
4. A. I. Israel', in the book: Proceedings of the 1st and 2nd Uzbekistan Conferences of Physiologists, Biochemist, and Pharmacologists [in Russian], 226, Tashkent (1939).
5. M. E. Marshak, Gigiena Truda, No. 7-8, 3 (1926).
6. B. A. Saakov, Mechanisms of General Complications of Thermal Injuries [in Russian], Kiev (1963).
7. A. Yu. Tilis, Hemodynamics and Biochemical Changes in Solar Hyperthermia [in Russian], Tashkent (1964).
8. M. A. Khvoinitskaya, R. V. Chagovets, and F. N. Cherevko, Byull. éksp. Biol., No. 12, 9 (1951).
9. A. Yu. Yunusov, Physiology of the Blood of Man and Animals in a Hot Climate [in Russian], Tashkent (1961).
10. Chao Shiotso, Wang Ti-hsin, Acta physiol. sinica, 22, 9 (1958).
11. Duck Whan Cho, Bull. Yamaguchi med. Sch., 8, 121 (1961).
12. H. M. Frankel, J. P. Ellis, Jr., and S. M. Cain, Am. J. Physiol., 205 733 (1963).
13. J. D. McCarrell, Ibid., 130, 34 (1940).