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

N. P. Mitagvariya and J. I. Bicher*

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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.

*Present address: Daniel Freeman Memorial Hospital, Inglewood, California 90301.

Laboratory of Regulatory Mechanisms of the Metabolic Basis of Brain Function, I. S. Beritashvili Institute of Physiology, Academy of Sciences of the Georgian SSR, Tbilisi. Department of Therapeutic Radiology and Physics, Henry Ford Hospital, Detroit, Michigan. (Presented by Academician of the Academy of Medical Sciences of the USSR A. A. Ado.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 98, No. 7, pp. 37-39, July, 1984. Original article submitted May 4, 1983.

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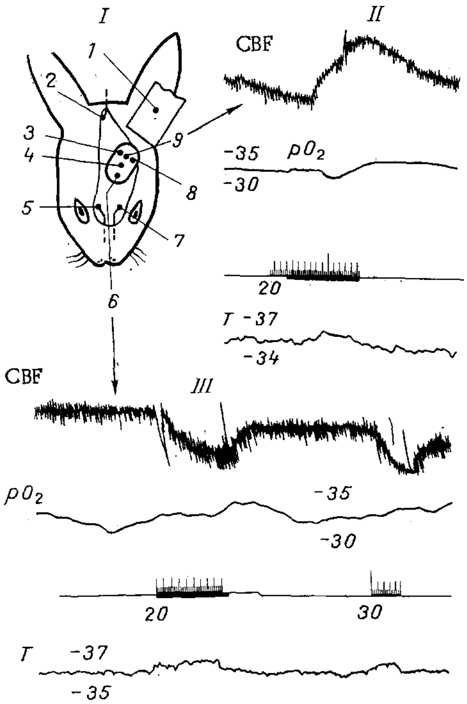

Fig. 1

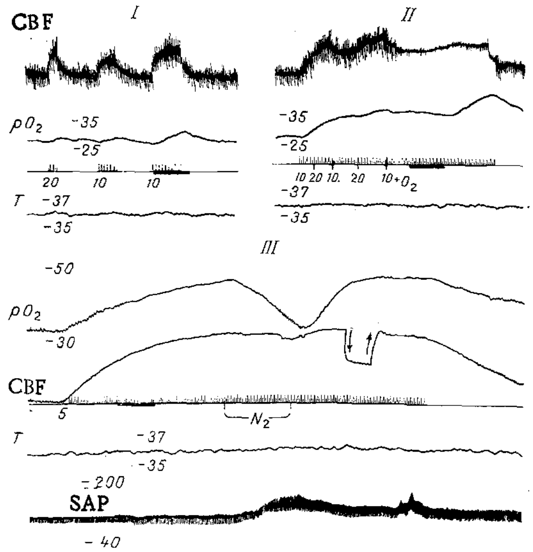

Fig. 2

Fig. 1. Scheme of arrangement of electrodes and MW generator on rabbit's head (I) and effects of local MW radiation of exposed cerebral cortex (II, III). 1) MW generator; 2, 5, 7) comparison electrodes; 3) zone of temperature measurement; 8) zone of pO_2 measurement; 4, 6, 9) zones of CBF measurement (scale in mm Hg); T) temperature (scale in °C). Time marker shows duration of irradiation. Numbers below time marker indicate power of irradiation (in W); bold line — 1 min.

Fig. 2. Effects of MW radiation of zone of medulla (I) combined with inhalation of pure oxygen (II) and inhalation of pure nitrogen (III). SAP — scale in mm Hg. Arrows indicate mechanical displacements of recording pen. Remainder of legend as in Fig. 1.

EXPERIMENTAL METHOD

Experiments were carried out on 53 adult rabbits anesthetized with a combination of chlorpromazine (50 mg/kg) and ketamine (40 mg/kg), immobilized with flaxedil, and artificially ventilated.

The systemic arterial pressure (SAP) was measured by means of standard transducers (the catheter was introduced into the femoral artery). CBF was recorded in various parts of the cortex qualitatively, by the method of electrochemical hydrogen generation directly in brain tissue [9], and also quantitatively, by the hydrogen clearance method [2]. The value of pO_2 in the cerebral cortex was measured polarographically with platinum—iridium electrodes, calibrated in glucose—glucose oxidase solution and physiological saline. The temperature of the brain tissue was measured with copper—constantan microthermoelectrodes (tip diameter 30-100 μ). All parameters were recorded on a polygraph (Grass Medical Instruments).

Microwaves with a frequency of 2450 MHz were generated by a Raytheon magnetron and applied to the animal's head by means of waveguides. The MV radiator was square in cross section (20 × 20 mm) [9]. It was placed at a distance of up to 1 cm from the zone of irradiation and was oriented so that the lines of force of the field were perpendicular to the electrodes used. In this way interference in the course of irradiation, the power of which varied from 5 to 40 W, could be avoided.

EXPERIMENTAL RESULTS

The scheme of the experiments of series I (28 rabbits) is illustrated in Fig. 1, I. CBF was recorded successively in three zones (points 4, 6, and 9) of the exposed cortex. The zones were located at different distances from the MW generator. An area of cortex including the region on which the electrodes were mounted was irradiated.

As Fig. 1, II shows, MW radiation caused an initial fall of CBF followed by a sharp rise in the first zone (point 9). In the second zone (point 4) there was a greater fall of CBF followed by a rise. In the third zone (point 6) only a fall of CBF was observed (Fig. 1, III). After switching off the MW generator CBF returned to its initial level in all zones. As a rule, in every case oxygenation of the brain tissue was increased and its temperature raised in the zone of irradiation.

Analysis of the data with local irradiation of the cortex shows that changes observed in both CBF and pO_2 must be due to the thermal effect of MW radiation. Since this effect was local in character, heat-induced hyperthermia in the zone of heating of the tissue led to a decrease in blood flow in the surrounding tissue, and as the heat penetrated further, the initial decline was gradually replaced by an increase in CBF, displacing the zone of reduced blood flow even further. In this case there was evidently local redistribution of the tissue blood flow, a phenomenon analogous to the well-known "Robin Hood syndrome" [1].

In the experiments of series II (25 rabbits) MW radiation was applied to a zone of the medulla, whereas CBF, pO_2, and temperature were measured, just as previously, in the parietal cortex. Irradiation even of relatively low power (under 5 W) was found to cause an increase in CBF and pO_2 (Fig. 2) in any zone of the cortex, and without any appreciable rise in temperature. Relatively long irradiation led to a maximum increase in CBF under these circumstances. It is clear from Fig. 2, III that inhalation of pure oxygen combined with irradiation did not lead to an increase in CBF, despite the fall in pO_2 and rise in SAP.

Quantitative analysis of the results of measurement of CBF and pO_2 showed that even with short-term irradiation (not more than a few seconds) of a zone in the medulla, CBF increased on average up to 250% of its initial level and pO_2 up to 130%.

This series of experiments showed that MW radiation can have a powerful action on CBF even without intervention of the hyperthermia factor. It can be tentatively suggested that a center regulating the cerebral circulation exists in the medulla, although its location and its actual existence have not yet been proved. If this is so, MW radiation evidently disturbs its normal functioning, with a consequent sharp fall in tone of the entire vascular system of the brain and, correspondingly, a marked increase (possibly maximal) in the circulation.

Another interesting fact is that prolonged irradiation of a zone in the medulla (or increasing the power of the microwaves above 20 W) leads to disturbances of the normal SAP level.

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