

EFFECT OF THE ULTRAHIGH-FREQUENCY ELECTROMAGNETIC FIELD ON THE CARBOHYDRATE METABOLISM OF THE RAT BRAIN

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UDC 612.82.015.32.014.426

During the action of a uhf electromagnetic field with a frequency of 48 MHz and of nonthermogenic intensity, the concentration of lactic and pyruvic acids in the rat brain tissue rises while the glycogen content falls. These effects are dependent on the intensity of the field and the duration of its action. In the case of prolonged exposure to a field of intensity 800 W/m, the lactic acid concentration in the brain remains elevated one month after the end of exposure.

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Electromagnetic fields of ultrahigh frequency are widely used in radio, television, medicine, and industry.

Disturbances of function of the nervous system have been discovered in workers in charge of uhf equipment [2, 9]. Abnormalities of the conditioned-reflex and bioelectrical activity of the brain have been discovered experimentally in animals [3, 7], together with morphological changes in nerve tissue [1].

The object of the present investigation was to study the carbohydrate metabolism of nerve tissue during exposure to a uhf electromagnetic field. Because the use of protective measures has resulted in exposure to only low intensities under industrial conditions [4], the effect of electromagnetic fields not causing a rise of body temperature of animals was studied.

EXPERIMENTAL METHOD

Experiments were carried out on 80 female rats weighing 150-170 g. The source of the uhf electromagnetic field was a UVCh-4 generator operating on a frequency of 48 MHz. The experimental animals were placed between the plates of a condenser in cages made of organic glass.

Three series of experiments were carried out. In series I the experimental rats were exposed to a uhf electromagnetic field of intensity 400 W/m (15 sessions each lasting 1 h), in series II the intensity was 800 W/m for the same duration, and in series III the intensity was 800 W/m and 75 sessions were given. Investigations were carried out 24 h after the end of exposure. Some animals of series II and III were sacrificed one month after the end of exposure to the uhf field. Simultaneously with the experimental animals, rats of the control groups of corresponding sex and age were sacrificed. The glucose concentration in the brain was investigated by Nelson's method, glycogen by Kerr's method, lactic acid by the method of Barker and Summerson, pyruvic acid by the method of Friedeman and Haugen as modified by Prokhorova and Tupikova [6]. The concentration of lactic and pyruvic acids in the rats' blood was also investigated by the same methods.

EXPERIMENTAL RESULTS

The results of these experiments are given in Table 1. After repeated exposure to a uhf electromagnetic field of intensity 400 W/m the concentrations of lactic and pyruvic acids in the brain of the experimental animals were identical with those in the controls. However, the blood lactic acid level of these animals was considerably increased. This suggests that changes had taken place in the carbohydrate metabolism of other organs (liver and muscles).

Biochemical Laboratory, Khar'kov Research Institute of Work Hygiene and Occupational Diseases (Presented by Academician S. E. Severin, Academy of Medical Sciences of the USSR.) Translated from *Byulleten' Éksperimental'noi Biologii i Meditsiny*, Vol. 68, No. 7, pp. 56-58, July, 1969. Original article submitted June 7, 1968.

TABLE 1. Concentration of Lactic and Pyruvic Acids in Blood and Brain of Rats following Exposure to uhf Fields of Different Intensities or Different Durations

Intensity of uhf field and duration of exposure	Test object	Lactic acid (in mg%)		Pyruvic acid (in mg%)	
		Control	Expt.	Control	Expt.
400 W/m 15 Sessions	Blood	22,2±4,1 (4)	33,0±2,3 (7) $P<0,05$	3,2±0,4 (7)	3,5±0,4 (7)
	Brain	32,2±2,1 (8)	31±2,9 (13)	2,1±0,2 (7)	2,2±0,1 (15)
800 W/m 15 Sessions	Blood	15,1±3,2 (8)	26,7±1,8 (12) $P<0,01$	2,4±0,2 (8)	3,2±0,1 (22) $P<0,01$
	Brain	22,8±1,9 (7)	30,4±2,1 (8) $P=0,02$	1,7±0,1 (8)	2,0±0,1 (19) $P=0,01$
800 W/m 75 Sessions	Brain	47,7±3,7 (17)	69,5±1,9 (11) $P<0,01$	—	—

Note. Here and in Table 2 the number of observations is given in parentheses.

TABLE 2. Lactic Acid Concentration in Blood and Brain of Rats One Month after End of Exposure to uhf Field of Intensity 800 W/m in Relation to Duration of Exposure

Duration of exposure	Test object	Lactic acid concentration (in mg%)	
		Control	Expt.
15 Sessions	Blood	15,1±3,2 (8)	19,9±2,7 (5) $P>0,1$
15 Sessions	Brain	23,3±1,4 (3)	22,5±1,3 (5)
75 Sessions	»	47,7±3,7 (17)	75,2±0,81 (5) $P<0,01$

Repeated exposure to a uhf electromagnetic field of intensity 800 W/m caused marked changes in the concentration of lactic and pyruvic acids in both the brain tissue and blood of the animals. Accumulation of these products of carbohydrate metabolism in nerve tissue may reflect a disturbance of their oxidation and also, possibly, an increase in glycolysis.

Changes of a similar character in the lactic acid concentration in the nerve tissue of the rats were observed after a longer exposure (75 sessions) to a uhf field of intensity 800 W/m. Its accumulation under these circumstances was still more marked. The glycogen concentration in the brain of rats of this group was significantly below that of the control animals in the absence of any definite changes in the glucose concentration.

Fluctuations in the lactic acid concentration in the control rats were evidently due to differences in the conditions of the various series of experiments or to seasonal factors. Considerable differences are found in the figures for the lactic acid concentration in the brain of intact rats given in the literature: 22 mg% [5], 28-54 mg% [8], 36 mg% [10], and so on.

The lactic acid concentration in the brain and blood of the rats in the experiments of series II one month after exposure to the uhf field was indistinguishable from that in the control animals (Table 2). The lactic acid concentration in the brain of rats exposed for longer periods to a uhf field of nonthermogenic intensity (75 sessions) remained at the same level.

Examination of the data given in Tables 1 and 2 clearly shows that the magnitude of the changes depends on the intensity of the electromagnetic field and the duration of its action. After exposure to a uhf field of intensity 400 W/m, no changes in the indices of carbohydrate metabolism investigated were found in the brain of the experimental rats. After exposure to a field of 800 W/m the changes were well marked, and after a longer exposure to a field of this same intensity the lactic acid concentration in the brain was more than doubled and had not returned to normal one month after the end of exposure. It is an interesting fact that all the doses used in this experiment were much below the threshold level causing a minimal thermogenic effect (1200 W/m).

The chief substrate of oxidation in the brain supplying it with energy is known to be glucose. During exposure to a uhf electromagnetic field of frequency 48 MHz and of nonthermogenic intensity, accumulation of intermediate oxidation products of glucose and a decrease in the glycogen reserves were detected in the nerve tissue of the rats. The character and severity of these disturbances, taken in relation to the intensity and duration of exposure to the field, can be directly associated with the disturbance of brain function occurring during exposure to this factor.

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