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EFFECT OF THE MAGNETIC FIELD OF A SOLENOID ON THE CENTRAL NERVOUS SYSTEM

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[Text] The process of the development of magnetotherapy does not differ from the development of other areas of physiotherapy: its scientific basis is lagging behind practical application. However, for the clinical-physiological basis of the therapeutic application of various magnetic fields it is necessary to have data about the effect on the organism of a constant, sinusoidal and pulsating magnetic field, its intensity, localization, duration of effect, and data on the dependence of the reaction of the organism subjected to the effect on its functional state.

In spite of the fact that the majority of experimental papers in the field of magnetobiology are devoted to the effect of a constant magnetic field [6, 10, 15] and published data are available on the defined prospects for its therapeutic application [8, 14] , basically continuous sinusoidal fields [2, 4, 12] , continuous pulsating fields [5, 7] or the combination of continuous and discontinuous fields [16, 17] are used in magnetotherapy.

The use of the sinusoidal and pulsating field can be considered well founded from the physiological point of view in connection with the great deficiency of the effect of a variable magnetic field by comparison with a constant one [1, 3, 11] .

In the known magnetotherapeutic procedures, both a general and local effect are used. In Romania, the effect from solenoids is widely used [16, 17]. In studying the effect of such a magnetic field on the central nervous system at the All Union

Scientific Research Institute of Medical Instrument Making a solenoid designed for experiments on animals was built.

The solenoid with an inside diameter of 130 mm, a thickness of 30 mm and 20 mm high received a continuous or discontinuous (a 2 second effect, a 2 second pause) sinusoidal current of industrial frequency from the Polyus equipment. In Fig. 1 we have the vectors of the magnetic field intensity (the peak values) in the plane passing through the axis or symmetry of the solenoid. The data are presented for distances exceeding 10 mm from the solenoid surface[1]. The greatest amplitude of the intensity of the sinusoidal magnetic field did not exceed 200 oersteds.

The measurements were performed by the induction method [9] using a measuring coil with a constant 940 cm^2. The coil diameter was 13 mm and it was 2 mm high.

The effect of the magnetic field on the central nervous system was investigated using the conditioned reflex and electroencephalographic methods.

The applied conditioned reflex procedure goes as follows. In generating the conditioned reflex of active evasion in white mice they were placed in the beginning of the corridor of a T-type labyrinth, and if the mouse did not move to a defined branch in five seconds he was given an electric stimulus through the metal lattice floor. The tests were repeated every 1-2 minutes. The criterion for generating the reflex was considered to be 10 proper successive turns without reinforcement. Maintenance of the reflex was checked 24 hours later, subjecting the experimental animals to a general magnetic field effect during this interval.

For the general effect, the above described solenoid was used. It was arranged concentrically around a glass jar 90 mm in diameter. The lower edge of the solenoid was raised to 40 mm above the bottom of the jar. The mouse was released in the jar and was subjected to the total effect of a variable continuous field for two hours. The amplitude of the field intensity in the same part of the mouse's body varied as a function of its position in the jar within the limits of 50 to 150 oersteds. The control mouse was placed in the same jar, but was not subjected to a field. In the experiments 59 white mice were used: in the control there were 40.

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[1] See the article by G. R. Solov'yeva and V. A. Yeremin EKSPERIMENTAL'NYY APPARAT DLYA MAGNITOTERAPII (Experimental Equipment for Magnetotherapy) published in this collection.

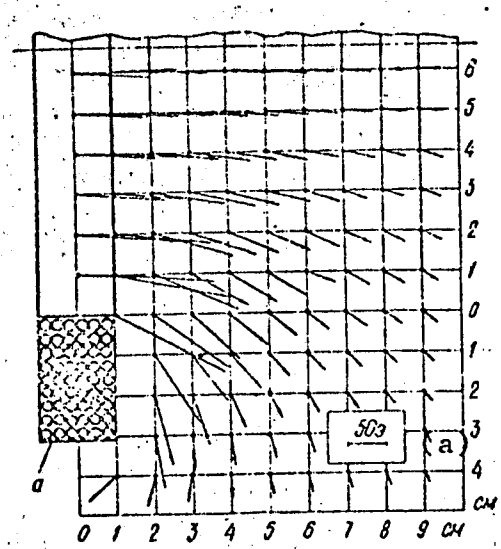

Fig. 1. Vectors of the Solenoid Magnetic Field Intensity

Key: a. 50 oersteds

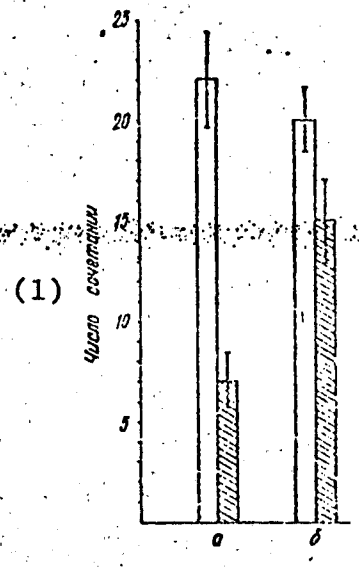

Fig. 2. Average Number of Trials Necessary to Achieve the Reflex Generation Criteria (The White Columns) and When Checking the Training (The Cross Hatched Columns): a -- in the Control Animals; b -- in the Animals Subjected to the Effect of a Sinusoidal Magnetic Field.

Key: 1. Combination Number

In the majority of the experiments in the experimental mice by comparison with the control mice conditioned reflexes were inhibited (Fig. 2): therefore the conclusion is drawn of a predominantly inhibitory effect from a continuous sinusoidal magnetic field.

When studying the effect of the magnetic field on the central nervous system by EEG, the solenoid was fitted to the neck of a rabbit (similarly to how the solenoid was fitted to the neck of the patient in magnetotherapy in Romania[16,17]). In this way the vectors of the magnetic field intensity were basically directed along the body of the rabbit.

The EEG was recorded using the 4EEG-1 pen-recording electroencephalograph before the effect and immediately after it. The EEG from the visual and sensomotor regions of the cerebral hemispheres was recorded by the monopolar procedure (an indifferent electrode in the nasal bones) using silver electrodes epidurally implanted in the bone.

The sinusoidal magnetic field, discontinuous and continuous, usually caused the EEG-reaction expressed in an increase in the number of slow waves (3 per second and less) and spindles in the electrical activity of the brain (Fig. 3). This reaction is frequently connected with the occurrence of an inhibitory process which agrees with our data obtained experimentally. It is appropriate to note that similar nonspecific reactions are obtained both under the effect of a constant magnetic field and under the effect of an ultra high frequency electric field (using the UVCh-2m equipment) and an electromagnetic super high frequency field (the LUCh-58 equipment) on the brain of the rabbit [13].

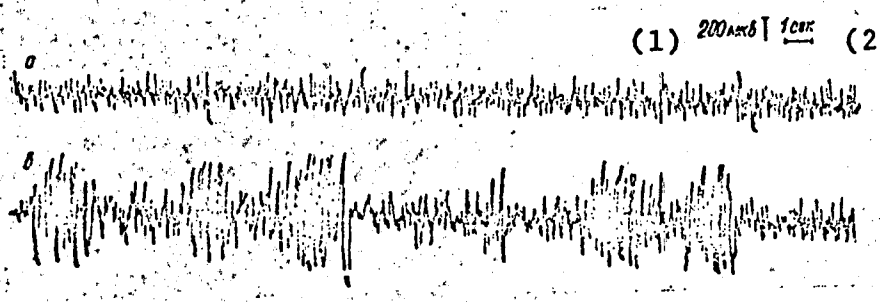

Fig. 3. EEG of the Sensomotor Regions of the Cerebral Cortex of Rabbits in the Case of the Monopolar Lead Before the Effect (a) and Immediately after the Effect (b) from a Sinusoidal Magnetic Field.

Key:
1. 200 microvolts
2. 1 second

However, the magnetic field, continuous or discontinuous, can sometimes cause the opposite EEG-reaction expressed in an increase in the frequency of the biopotentials and in a decrease in their amplitude. This variation of the EEG is frequently connected with the occurrence of the excitation process in the central nervous system. These data agree with the results of the effect from a discontinuous magnetic field on the head of a rat when the authors basically observed an increase in the high-frequency fields in the EEG[1].

Sometimes the effect of the magnetic field explicitly caused an excitation reaction. Epileptic (convulsive) discharges were recorded in 8 cases out of 110 in the presence of a continuous sinusoidal field and in 10 cases out of 60 in the presence of a discontinuous field. Similar but less frequently encountered results were obtained earlier under the effect of a constant magnetic field.

Thus, the reaction to the effect of the magnetic field can be different (inhibition, excitation), and this confirms the general law of the dependence of the reaction on the functional state of the organism, the species of animal, the field parameters, and so on. The ambiguity of the field effect can find various regions of application in magnetotherapy, but in this case the question arises of the presence of contraindications. The customary opinion of absolute harmlessness of the magnetic procedures must be changed, and in the presence of a number of associated diseases, for example, in the case of epilepsy, definite caution must be exercised.

The identical effect of a magnetic field does not always cause the recorded reaction. Thus, for experiments on nine rabbits subjected to 110 effects of a variable field, the visual EEG-reactions were recorded in 61% of the cases. This indicates the relative weakness of the magnetic field as a stimulus and the necessity of repeated effects to obtain a stable effect. The same thing is indicated by the experiments on the mice. In the case of 5-10 minute exposures to the magnetic field the reaction of active evasion is not detected. On the other hand, with an increase in the duration of the effect from 20 minutes to 2 hours no noticeable variation of the effect is observed. Consequently, there is a time threshold of accumulation and optimal duration of the effect.

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[1] See the article by Ye. B. Kvakina et al., VLIYANIYE PEREMENNOGO MAGNITNOGO POLYA NA FUNKTSIONAL'NUYU AKTIVNOST' TSNS (The Effect of a Variable Magnetic Field on the Functional Activity of the Central Nervous System) published in this collection.

Thus, the study of the biological effect of a sinusoidal magnetic field in experimental animals demonstrated the presence of a nonspecific EEG-reaction, a cumulative effect and ambiguity of the effect.

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