CHANGES IN THE ELECTRICAL ACTIVITY OF THE RABBIT'S CEREBRAL CORTEX RESULTING FROM EXPOSURE TO A UHF ELECTROMAGNETIC FIELD

REPORT 1. THE EFFECT OF A UHF FIELD ON THE ELECTROENCEPHALOGRAM OF INTACT RABBITS

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It has been suggested that besides its reflex action, the UHF field has a direct action on the central nervous system [5, 7]. This conclusion has been reached by means of indirect methods of investigation of the function of the central nervous system. Meanwhile it is evident that too little use has been made of electrophysiological methods, capable of detecting functional changes in the central nervous system directly, in the study of this problem. Changes in the encephalogram have been observed in man [10] and also in rabbits and cats [2] and monkeys [9] under the influence of SHF, and in rabbits under the influence of UHF [6].

The object of our research was to study the electrical activity of the cerebral cortex of rabbits as a criterion of the functional state of the central nervous system during exposure of the UHF field.

EXPERIMENTAL METHOD

The source of the UHF field was a UVCh-2m-40 generator, constructed to work on direct current. By this means we could record the EEG during exposure lasting 3 min. The disk electrodes of the UHF generator, 10 cm in diameter, were placed bitemporally at a distance of 12 cm from each other, so that the entire rabbit's head was in the interelectrode space. The intensity of the interelectrode field was approximately 1000 W/m.* The EEG of both hemispheres of the rabbit, the respiration rate and the ECG were recorded simultaneously. Tracings were made on VNIIMIiO or Alvar electroencephalographs of the ink-recording type, and also by means of a UNCh-6 amplifier constructed at the experimental factory of the Academy of Medical Sciences in conjunction with a Siemens 9-loop oscillograph. When recording the EEG both unipolar and bipolar leads were used, with needle or thread electrodes. The potentials were recorded from different parts of the cortex; the reaction to UHF was seen most clearly in the optic region. In some rabbits the curve of the reactivity of the animals to a rhythmic light stimulus of increasing brightness was recorded before, during, and 1 min after the beginning of exposure to the electromagnetic field (by M. N. Livanov's technique). In one series of experiments the rabbit's head was exposed for 3 min to a strong UHF field from a UVCh-300 generator, with an intensity of 5000 W/m. In this case the potentials were recorded only after the generator had been switched off.

EXPERIMENTAL RESULTS

Exposure to the UHF field caused no motor reactions nor changes in the skin temperature, respiration or pulse. Its only visible results were an increase in the amplitude and a decrease in the frequency of the cortical potentials (Fig. 1), and these were observed only when the UHF field acted directly on the head.

The development of the reaction was dependent on the individual peculiarities of the rabbits and the initial functional state. We may define this aspect of the reaction quantitatively by employing the concept of stability, understanding by this term the ratio between the number of reactions and the total number of applications of the UHF field, expressed as a percentage.

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*The dosimetric investigations were carried out with the aid of colleagues from the physical hygiene laboratory (Head, Z. V. Gordon) of the Institute of Work Hygiene and Occupational Diseases (B. I. Stepanov and E. I. Kurakin).

The stability of the reaction varied among the 34 rabbits we examined from 25 to 76%, and its average value was 47 ± 2%. If the strength of the UHF field was increased, the stability of the reaction increased to 80%.

Each individual reaction consisted of changes in the amplitude and frequency of the potentials. In Fig. 2 we show the pattern of the changes in the mean values of these criteria during exposure to a UHF field, plotted from 66 reactions in 23 rabbits. The amplitude of the potentials varied more obviously than their frequency, which changed

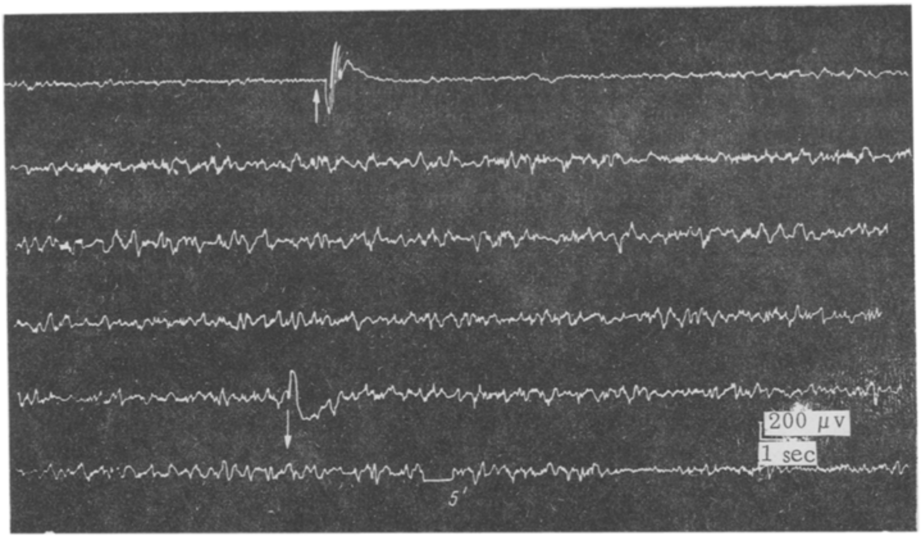

Fig. 1. Changes in the EEG of the rabbit after exposure to a UHF field. Continuous recording of the EEG: background (15 sec), exposure to UHF field (180 sec), recording after switching off the generator (60 sec) and EEG 5 min after cessation of exposure (20 sec). The arrows denote the times of starting and stopping the UHF generator.

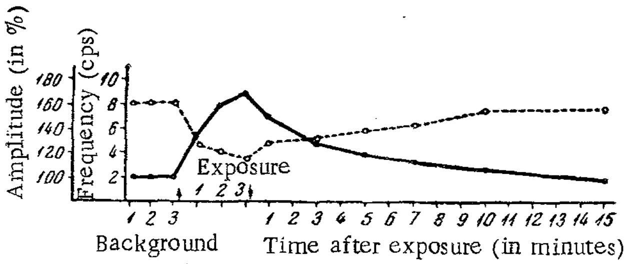

Fig. 2. Graph showing the changes in the mean amplitude (continuous line) and mean frequency (broken line) of the cortical potentials of rabbits during exposure of the animal's head to a UHF field.

only very slightly or was not reduced at all if slow waves were present in the background EEG. The coefficient of correlation between these two indices was 0.56 ± 0.08 during exposure to UHF. Hence, an increase in amplitude was the most sensitive criterion of the electrical reaction of the brain to exposure to the UHF field.

The increase in the amplitude of the potentials, characterizing the intensity of the reaction, reached an average value of 170% at the 3rd minute of exposure. After the generator had stopped, the amplitude slowly returned to normal. The after-effect lasted for 10-15 min.

It is interesting to note that during the first minute of exposure the amplitude of the potentials rose by 35%, during the 2nd minute by 25%, and during the 3rd by 10%. The most marked slowing of the rhythm also took place during the first minute of exposure. These results suggest that the reaction to the UHF field began in the first minute of exposure, but the time of onset of the reaction could be judged more precisely only after analysis of the latent period.

In Fig. 3 we give an empirical curve of the distribution of the latent periods of 100 reactions to the UHF field obtained in 34 rabbits. This curve may be formally described as the sum of two theoretical curves of normal distribution.

The two possible empirical summations were characterized by the following parameters: $n_1 = 82$, $m_1 = 42 \pm 1.6$, $\sigma_1 = 14.5$; $n_2 = 18$, $m_2 = 87 \pm 4$, $\sigma_2 = 15$, and agreed reliably when tested by the criterion of association (X^2) with the two theoretical curves of normal distribution.

Hence, according to their latent periods, the reactions to the UHF field could be divided into two groups: the first, with a mean latent period of 40 sec, accounting for 82% of all the reactions; the second, with a mean latent period of 87 sec, accounting for 18% of the reactions. It thus became clear why the changes in the intensity of the reaction took place mainly in the first minute of exposure. Since two types of reactions were observed in the same rabbit, and the changes in the potentials sometimes appeared at the 40th and 90th second when the UHF field was applied only once, it may be suggested that two mechanisms were concerned in the reaction of the rabbit to the UHF field.

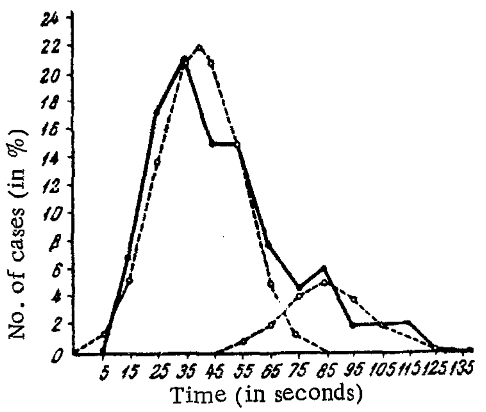

Fig. 3. Empirical curve of distribution (continuous line) of values of the latent period of the electrical reaction of the cerebral cortex of rabbits to exposure to a UHF field. The broken line depicts the theoretical curves of normal distribution from which the empirical curve is derived by summation.

It was shown that a strong UHF field caused a reaction more frequently than a weak field, but the character of the change in the potentials was the same during exposure to both, i.e., the amplitude was increased and the frequency decreased. For instance, of 100 reactions in 15 rabbits, in 81 cases we observed a reaction of this type, and only 19 reactions showed a decrease in amplitude and an increase in the frequency of the potentials in the EEG. It is important to mention that the latter form of electrical changes was frequently accompanied by motor reactions.

Analysis of these reactions showed that the UHF field gave rise to pain, concentrated in the projecting parts of the irradiated region of the animal's body (in the ears or the forelimbs). If the rabbit's ears were bound firmly to its head, and the forelimbs were fixed behind its spine, the electrical reaction to a strong field was shown only by an increase in the amplitude and a decrease in the frequency.

The appearance of slow waves in the EEG is often associated with the onset of inhibition in the cortex. We therefore decided to determine the excitability of the cortical end of the optic analyzer during exposure to a weak UHF field using the technique of reactivity curves. As a result of 40 exposures in five rabbits it was found that the mean latent period of the reaction of assimilation of light stimuli before exposure to the UHF field was 20.3 ± 0.4 sec, during exposure 17.5 ± 0.3 sec, and 1 min after exposure 18.7 ± 0.3 sec. The difference between the mean latent periods of the reactions before and during exposure, evaluated in terms of Student's criterion, was statistically significant (level of significance less than 0.05).

Consequently, during exposure to the UHF field an increased excitability of the cortical end of the optic analyzer was observed, and this persisted for a short time after cessation of the exposure.

The principal conclusion to be drawn from this research is the statement that changes in the EEG take place during exposure to a UHF field. It is interesting that electrical changes appeared at a time when, according to other criteria, no reaction was present. Consequently, the EEG may be regarded as the most sensitive of all known criteria of the effect of exposure to the UHF field. A characteristic feature of the reaction of the EEG was the appearance of slow waves of high amplitude.

It should be noted that in the work of Pardzhanadze [6] (known to us only in thesis form, giving no account of the conditions of irradiation and not illustrated with EEG tracings) the appearance of fast waves of high amplitude in rabbits is described after exposure to UHF field. The development of slow waves in the EEG of human subjects during exposure to the SHF field [10] and after repeated exposure [3] has been reported. In monkeys, slow waves have also been observed in the EEG during irradiation of the head [9]. In rabbits, highly varied changes appeared in the EEG depending on the strength of the SHF field and the duration of exposure [2].

Hence, an increase in the amplitude of the potentials has been reported most frequently. The appearance of slow waves has been described less often in the literature. In the case of studies of the stability of the reaction, this did not reach 100%. For instance, after exposure of the human head to a UHF electromagnetic field, the auditory [1, 8] and visual [4] sensations were modified in only 20-30% of cases.

The statistical character of the reactions to the electromagnetic field may be explained by the properties of both the stimulus and the receptor (some workers suggest that the electromagnetic field acts directly on the central nervous system). Later experimental investigations of the mechanism of action of the UHF field on the organism will enable a more detailed account to be given of the properties of this stimulus.

SUMMARY

It was shown in experiments on 40 rabbits that during the three minute action of the UHF electromagnetic field with the intensity of about 1000 V/m on the animal's head, a rise of the amplitude and reduction of the frequency of potentials in the EEG was observed in 47% of the cases. After the action of a strong UHF field (about 5000 V/m), in 80% of the cases a similar EEG reaction was noted. The majority of reactions had an average latent period of 40 sec; reaction with an average latent period of 87 sec occurred more rarely. The after effect lasted for 10-15 min. During the action of the weak UHF field, the excitation of the cortical end of the visual analyzer rose.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**