ELECTROPHYSIOLOGICAL CHANGES IN RATS AFTER MODULATED MICROWAVE IRRADIATION

Szabo L.D., Thuroczy G., Kubinyi G., Bakos J.
Natl."Frederic Joliot-Curie" Res. Inst. for Radiobiology and Radiohygiene, Budapest H-1775 POB.101., Hungary

ABSTRACT

The effects of modulated microwave irradiation on the electrophysiological changes in rats were studied. The response of the central nervous system (CNS) was observed simultaneously to the cardiovascular system by using quantitative polygraphic measuring system.

In acute experiments on rat the electroencephalogram (EEG), rheoencephalogram (REG) as an index of cerebral blood flow (CBF), brain tissue DC impedance and temperature, ECG were recorded in parallel before, during and after exposure of the brain localized amplitude (AM) modulated (16 Hz) and continuous wave (CW) microwave exposure. The average specific absorption rates (SAR) in the brain were 8.4 mW/g, 16.8 mW/g and 42 mW/g (CW) respectively.

At thermal level CW exposure the delta band of EEG increased. In case of low intensities modulated exposure the beta band of EEG spectrum increased. No changes were observed during athermal CW irradiation on the EEG. Moderate modulation depended changes were measured in cerebral metabolism, cerebral blood flow and cardiorespiratoric system during microwave irradiation.

INTRODUCTION

The psychophysiological background of complains of workers occupationaly dealing with microwave and radiofrequency (RF) equipments which are related to the effects of weak electromagnetic field on the central nervous system (CNS) have not been clearified nor the question: which physiological modalities are in correlations with the intensity, carrier frequency or modulation of microwave and RF radiation. The compensation factors of regulation which are involved in response to the radiation may have an important role in the mechanisms.

We suppose that effects on the brain tissue and cell membrane which are exposed of microwave and RF radiation mostly depend on the frequency and type of modulation, specially the amplitude modulation (AM) below 100 Hz [1,3,9]. Adey et al. showed a special "window" effect by using Ca^{++}-efflux measuring methods in the brain cortex of cat [1,2]. They have found frequency and intensity bands in which the Ca^{++}-efflux were changed in the presence of weak electromagnetic fields below 100 Hz (ELF) and ELF modulated RF fields.

The increase in the cerebral blood flow after microwave exposure is known to occure and these changes depend on the duration of exposure [4,5]. Otherwise it was found that the slow waves of EEG raised after RF or microwave exposure [9].

Our experiments are based on the following questions:(i) An athermal weak modulated or continuous wave (CW) electromagnetic microwave and RF field cause measurable effects

on the systemic and/or localized regulation mechanisms of the central nervous system ? (ii) Does the signal processing evaluation of measured biopotentials (ie.quantitative polygraphy) give more information on the basis of the electromagnetic fields interaction with living systems ?

METHODS

MICROWAVE EXPOSURE AND DOSIMETRY

The irradiation were performed in a waveguide system setup TE-cell. A standard WR 40 waveguide was extended up to 100X60 mm and connected a horn to the waveguide. The incident, reflected and transmitted power were measured by directional couplers and power meters in the 3.4-4.4 GHz frequency [10]. The spatial pattern of SAR distribution in the brain cortex was measured with a thermocouple (0.18 mm, 40 mV/^{O}C,). The animal head was placed toward the generator.

The average SAR in the cortex was 8.4 mW/g, 16.8 mW/g and 42 mW/g using 300 mW, 600 mW and 1500 mW incident power respectively. The microwave frequency was 4 GHz and the modulation frequency was 16 Hz sinus (mod.depth 70 %). The duration of exposure was 30 min.

ELECTROPHYSIOLOGICAL PROCEDURE AND RECORDING

On F1-hybrid male anesthezied rats (180-200 g, Nembutal 60 mg/kg ip.) standard electrophysiological procedure were performed. The NICROTHAL stainless steel metal electrodes were placed symetrically to the saggital suture. The irradiation and registration were performed 2 weeks after the surgery (n=40).

In acute experiments (5 in each group, Nembuthal 40 mg/kg ip.) the following electrophysiological modalities were registered simultaneously: EEG (70 Hz/0.3 s), DC brain tissue impedance (2.5 kohm/V), rheoencephalogram-REG (Time const.: 3s), brain tissue and rectal temperature, ECG (150 Hz/0.3 s).

SIGNAL AND DATA PROCESSING

The signal and data processing were based on the microcomputer IBM-AT with the following hardware and software: analogue memory, memory scope, recorders, A/D card (12 bit) and microcomputer aided data acquisition and processing system (A/D conversion, average, SD computation, FFT with 0.4 Hz accuracy,auto- and cross correlation, cursor operations). The obtained outputs of the data processing are the follows:

- Heart Rate (HR) beat/min.
- Pulse Delay (PD):REG ampl. max - ECG R-peak interval time.
- Amplitude of rheoencephalogram (REG ampl.)
- EEG frequency bands derived from the power spectrum by FFT analysis with 0.4 Hz accuracy. The processed interval of EEG signal were 10x2.5 sec and the power spectrum of epochs were averaged parallely. The separated frequency bands: delta (0.4 Hz-4 Hz), theta (4.4-8 Hz), alpha (8.4-14 Hz), beta (14.4-30 Hz).

Respiration frequency: beat/min

Before (baseline), during (3., 20., 30. min) and after (1., 20. min) 25 sec. of registration were processed. The results are expressed and illustrated in the figures in percent of the baseline values.

RESULTS

The signal processing and statistical evaluation of the electrophysiological modalities gave the following results:

- The CW irradiation at 42 mW/g SAR in the brain causes a significant increase in the delta band (0.4-4 Hz) and slight increase in the theta band (4.4-8 Hz) of EEG (Fig 1.). The rheoencephalogram increased simultaneously but there was no significant changes in the heart rate.
- The 4 GHz CW athermal level irradiation with 8.4 mW/g and 16.8 mW/g SAR in the brain did not cause changes in any frequency bands of the EEG, but 16 Hz modulated irradiation causes a significant alteration in the beta band of EEG (Fig.2.).
- The REG amplitude increased during CW non-thermal irradiation but the REG amplitude change during non-thermal modulated irradiation was not significant.
- The DC brain tissue impedance decreased depending on the type of modulation.
- In the slight decreased tendency of the pulse delay (PD) there were no sign.differencesbetween the CW and modulated groups.
- The ECG profile showed slight transient bradycardia during exposure to both of CW and 16 Hz modulated waves as well.
- During the alterations of 8.4 mW/g and 16.8 mW/g no temperature increase was measured in the brain tissue and the rectum (DT<0.1 ^{o}C).

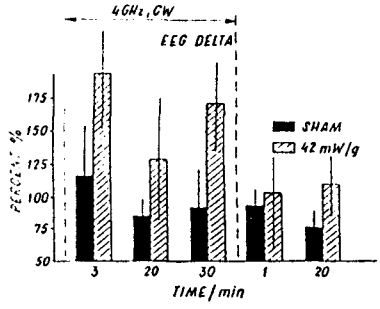

Fig.1. EEG slow waves (delta band:0.4-4 Hz) increase during (3, 20, 30 min) and after (1, 20 min) the 4 GHz, CW irradiation. Values (N=5) presented are in percent of baseline (before irradiation). The 42 mW/g SAR in the cortex of rat represents the averaged value.

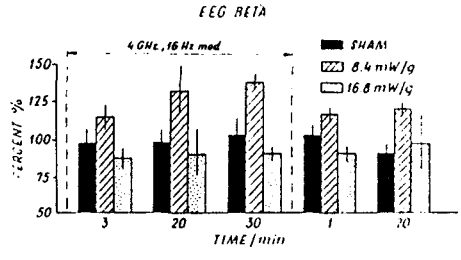

Fig.2. EEG beta band (14.4-30 Hz) during (3, 20, 30 min) and after (1, 20 min) the 4 GHz 16 Hz modulated (b) irradiation. Values (N=5) presented are in percent of baseline (before the irradiation). The SAR represents the averaged value in the brain cortex of rat.

DISCUSSION

Slight changes in cerebral metabolism and blood flow were observed during microwave irradiation. These transient alterations did not exceed the range of normal physiological regulation, but had a various involvement of compensating factors with different speed.

In the changes of EEG spectra during modulated irradiation were significant, but did not show dependence on the values of SAR in the brain. These results can not be explained by the EEG only [6,8]. The effect on cerebral circulation was quite definite which is well in agreement with results in the literature [5]. The microwave field interactions has an effect not only on the electrical activity of the brain tissue and the cerebral blood flow but also on the blood vessels. Changes in the measured tissue impedance of the vascular pulsation of the brain tissue (REG) can be explained not only as an effect on the cerebral blood flow and the wall of vessels but also is an effect on the electrical conductivity of the tissue and the rheological quality of the blood [7].

Because of the close correlation in the circulation-metabolism-function system of the brain, the low level of irradiation (ie. 8.4 mW/g, 16.8 mW/g) did not cause considerable changes in the measured polygraphic modalities, namely below the physiological regulation in the brain system the compensation mechanisms can be detectable. However, beyond the athermal level irradiation (42 mW/g) the changes remained in the range of the physiological regulation, but the effects on metabolisms and circulation were more detectable.

R E F E R E N C E S :

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