Impact of Selected Electromagnetic Fields on Prooxidant/Antioxidant Balance in Liver of Rats

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Abstract— **In this study the impact of electromagnetic field generated by mobile phone (f=900 MHz), electromagnetic field with industrial frequency generated by high voltage alternating current transmission lines (f=50 Hz, E=10 kV/m), and also simultaneous action of those fields on the prooxidant/ antioxidant balance in liver tissue of male rats was estimated by means of analysis of the contents of markers of oxidative stress and lipid peroxidation as well as the activity of selected antioxidant enzymes. It was concluded that 4-week lasting exposure of rats to electromagnetic field with physical parameters generated by mobile phones and to electromagnetic field with physical parameters generated by high voltage electric current transmission lines causes only a slight inhibition of oxidant processes in liver tissue with accompanying compensatory, multidirectional changes in antioxidant enzymes activity, enabling the maintenance of prooxidant/antioxidant balance. The most expressed changes in form of decrease in activity of the majority of antioxidant enzymes were observed in rats exposed to simultaneous action of both fields.**

Keywords—electromagnetic field; mobile phone; industrial frequency electric current; oxidative stress and lipid peroxidation markers; antioxidant enzymes

I. INTRODUCTION

Actually human population is permanently exposed to electromagnetic fields with industrial frequency generated by high voltage alternating current transmission lines and to electromagnetic fields with high frequency of 900-1800 MHz generated by mobile phones. Sometimes, especially in case of people working in substations of energetic power industry, a simultaneous exposure to both fields occurs, during phone connections realized in occupational conditions. It was proved in many experimental studies that electromagnetic fields with various physical parameters could intensify a generation of reactive oxygen species with subsequent disturbances of a balance between an intensity of oxidant processes and capacity of antioxidant defense system depending on the activity of antioxidant enzymes. This toxic phenomenon called oxidative stress, results in stimulation of the process of membrane lipids peroxidation, leading in a consequence to development of apoptosis and cell death [1], [2], [3], [4]. So far in attainable literature there are lacking papers dealing with the synergistic influence of the mentioned above most common forms of electromagnetic field on prooxidant/antioxidant balance in tissues of living organisms, including the activity of antioxidant enzymes.

II. AIM OF STUDY

The aim of the study was to estimate the impact of electromagnetic field generated by mobile phones (f=900 MHz), electromagnetic field with industrial frequency generated by high voltage alternating current transmission lines (f=50 Hz, E=10 kV/m), and also simultaneous action of those fields, on prooxidant/antioxidant balance in liver of male rats, by means of analysis of the contents of markers of membrane lipid peroxidation and oxidative stress: malone dialdehyde (MDA) and total oxidant capacity (TOC), respectively, as well as the activity of antioxidant enzymes: superoxide dismutase (SOD) (EC 1.15.1.1), catalase (CAT) (EC 1.11.1.6), glutathione peroxidase (POX) (EC 1.11.1.9.), glutathione reductase (GR) (EC 1.6.4.2) and glutathione S-transferase (GST) (EC 3.1.2.7.).

III. MATERIAL AND METHODS

A. Experimental Animals

The experiment was performed on 40 male Wistar rats, in mean age of 10 weeks with mean initial body mass of 180±7,5 g before the beginning of the experiment. In order to estimate the impact of electromagnetic field with frequency of 50 Hz generated between two electrodes of experimental system supplied with an alternating current, as well as electromagnetic field with frequency of 900 MHz generated by mobile phone (model Nokia 5110) placed directly below the cage in which animals stayed during the exposure, the rats were divided into 4 equal groups (consisting of 10 animals) subjected to long-term exposure to electromagnetic fields with different physical parameters and different procedure of exposure or to sham-exposure. During the experiment the animals stayed in a special plastic cages, in optimal environmental conditions (stable humidity of air: 60% and temperature: 21ºC, 12-hour light-dark cycle)

B. Procedure of Exposure to Electromagnetic Field

Rats from examined group $B_{1(s)}$ were exposed to electromagnetic field with physical parameters generated by typical high voltage electric current transmission lines (f=50 Hz, E=10 kV/m), 22 hours a day (with a break between 8^{00} and 10^{00}) for 28 succeeding days. Rats from examined group $B_{2(s+m)}$ were expose to electromagnetic field with identical parameters as in previous group (f=50 Hz, E=10 kV/m), that was also generated 22 hours a day for 28 succeeding days, and additionally during whole period of exposure cycle (28 days), every ½ hour by 8 hours daily, a mobile phone Nokia 5110 working in frequency range

f=900 MHz, placed under a cage with animals, was turned on and emitted a signal for 15 s. The mean value of power density of the electromagnetic field E_1 registered during initializing of connection was 85,3 $\mu W/m^2$, while the mean value of power density of the electromagnetic field E_2 registered during lasting connection was 17,0 $\mu W/m^2$. Rats from examined group $B_{3(m)}$ were exposed for 28 succeeding days solely to electromagnetic field with frequency of 900 MHz generated by mobile phone, that was turned on similarly as in group $B_{2(s+m)}$ every ½ hour by 8 hours daily and emitted for 15 s signal with physical parameters identical as in previous group. Rats from control group were exposed for 28 succeeding days to sham-exposed, during which they stayed in identical as examined animals environmental conditions, excluding the influence of electromagnetic field.

C. Procedure of Laboratory Analyses

After the end of a cycle of 28 daily exposures to electromagnetic field with physical parameters fixed for particular groups of exposed rats ($B_{1(s)}$, $B_{2(s+m)}$ and $B_{3(m)}$ or sham-exposures (control rats), animals were starved by 24 hours and then anaesthetized with use of a mixture of *xylazine* (10 mg/kg *ip*) and *ketamine* (100 mg/kg *ip*). Next after surgical opening of chest and collecting total amount of blood from the left heart ventricle, the abdominal cavity was opened and liver samples were taken. In the homogenates prepared from the obtained liver samples the contents of markers of oxidative stress (TOC) and membrane lipid peroxidation (MDA) as well as the activity of selected antioxidant enzymes: SOD, CAT, POX, GR and GST were measured. The biochemical analyses were performed by means of routine spectrophotometric and kinetic methods by Ohkawa, Ohishi and Yagi [5], Erel [6], Oyanagui [7], Aebi [8], Paglia and Valentine [9], Meister and Anderson [10] and Habich [11], respectively. The obtained results were elaborated statistically by means of analysis of variance (Kruskal-Wallis ANOVA test) with subsequent detailed analysis of differences between particular groups by means of post-hoc U-Mann-Whitney test.

IV. RESULTS

The contents of malone dialdehyde in liver homogenates in rats from groups $B_{2(s+m)}$ and $B_{3(m)}$ was significantly lower by 28% in comparison with control sham-exposed group, while in rats from group $B_{1(s)}$ no significant difference of malone dialdehyde contents was observed, as compared to control rats. The contents of total oxidant capacity in liver homogenates in rats from group $B_{3(m)}$ was significantly lower by 30% in comparison with control, sham-exposed group, while in rats from groups $B_{1(s)}$ and $B_{2(s+m)}$ no significant differences of total oxidant capacity contents were observed, as compared to control rats. The activity of superoxide dismutase in liver homogenates in rats from group $B_{2(s+m)}$ was significantly lower by 16% in comparison with control, sham-exposed group, while in both other groups $B_{1(s)}$ and $B_{3(m)}$ no significant differences of superoxide dismutase activities were observed, as compared to control rats. The activities of catalase in liver homogenates in rats from groups $B_{2(s+m)}$ and $B_{3(m)}$ were significantly lower by 18% in comparison with control, sham-exposed group, while in group $B_{1(s)}$ no significant difference of catalase activity was observed, as compared to control rats. The activity of glutathione peroxidase in liver homogenates in rats from group $B_{2(s+m)}$ was significantly lower by 16% in comparison with control, sham-exposed group, while in both other groups $B_{1(s)}$ and $B_{3(m)}$ no significant differencies of glutathione peroxidase activity were observed as compared to control rats. The activities of glutathione reductase in liver homogenates in rats from groups $B_{1(s)}$ and $B_{3(m)}$ were significantly higher by 18% and 26% respectively, in comparison with control, sham-exposed group, while in rats from group $B_{2(s+m)}$ no significant difference of glutathione reductase activity was observed as compared to control rats. The activities of glutathione S-transferase in liver homogenates in rats from groups $B_{1(s)}$ and $B_{2(s+m)}$ were significantly lower by 25% and 18%, respectively, in comparison with control, sham-exposed group, while in rats from group $B_{3(m)}$ the activity of glutathione S-transferase was significantly higher by 19% as compared to control rats.

V. CONCLUSIONS

On the basis of the obtained results it was found, that 4-week lasting exposure of rats to electromagnetic field with physical parameters generated by mobile phones and to electromagnetic field with physical parameters generated by high voltage electric current transmission lines causes only a slight inhibition of oxidant processes in liver tissue with accompanying compensatory, multidirectional changes in antioxidant enzymes activity, enabling the maintenance of prooxidant/antioxidant balance. The most expressed changes in form of decrease of activity of the majority of antioxidant enzymes were observed in rats exposed to simultaneous action of both fields.

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