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THE INFLUENCE OF ELECTROMAGNETIC RADIATION OF THE EHF BAND ON BLOOD OXIDATIVE METABOLISM UNDER MODELING THE ENGRAFTMENT OF A SKIN FLAP

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ABSTRACT

The aim of the study was to evaluate the effect of electromagnetic radiation of the EHF band on the intensity of free radical oxidation processes and the activity of antioxidant enzymes in the blood of rats when modeling ischemia of the dorsal skin flap in vivo. The results of the experimental study showed that electromagnetic radiation inhibits lipid peroxidation in blood plasma due to activation of the overall antioxidant activity. In erythrocytes, the regulatory effect of irradiation on the prooxidant system was revealed by stimulating the enzymatic link of antioxidant protection.

Keywords: skin flap, blood, free radical processes, lipid peroxidation, antioxidant enzymes

INTRODUCTION

There is information in the literature about the ability of millimeter wavelengths to limit the development of a stress reaction, which is a non-specific component of any pathology, and the role of lipid peroxidation (LPO) in this process [2, 3]. The body has an antioxidant multicomponent system that protects cells and tissues from free radical oxidation. Its most important and effective link is a system of antioxidant enzymes that inhibit LPO at the stage of its initiation [4-6]. Thus, superoxide dismutase (SOD) inactivates the superoxide-anion radical; the substrates of catalase action are hydrogen peroxide and lipid hydroperoxides [6]. Despite the previously established significant decrease in the concentration of LPO products in the blood during EHF exposure, no definitive idea has yet been formed about either the pathways or the physico-chemical aspects of the mechanism of action of EHF radiation on the body. In this regard, it is relevant to identify the "application points" of this frequency range in living biological systems, including molecular, cellular and systemic mechanisms of action of this factor.

The aim of the study was to evaluate the effect of electromagnetic radiation of the EHF band on the intensity of free radical oxidation processes and the activity of antioxidant enzymes in the blood of rats when modeling ischemia of the dorsal skin flap in vivo.

MATERIAL AND METHODS

15 white male rats of the Wistar line were used in the experiment. The animals were divided into 3 groups: group 1 (intact) consists of healthy rats (n=5), group 2 (control) - operated animals without any effects (n=5), group 3 (main) - operated animals with exposure to electromagnetic EHF radiation in the postoperative period (n=5).

In the intact group, no manipulations were performed during the study. In rats of the experimental and

control groups, a 3×10 cm skin flap was cut out on a feeding leg with an axial type of blood circulation on the depilated area of the back under intramuscular anesthesia (Zoletil 60 mg/kg + Xylavet 6 mg/kg) on a feeding leg with an axial type of blood circulation, including the skin and its own skin muscle with a base on a horizontal line connecting the corners of the shoulder blades. Next, the flap was placed in place without tension and sewn with nodular seams with atraumatic suture material.

In the postoperative period, the animals of the experimental group received daily standard EHF radiation of 53.57-78.33GHz for 7 days (once with an exposure of 10 minutes) at a dose of 1.2 MJ. The device "AMPHIT-0,2/10-01" was used as a source of electromagnetic radiation, the power level (1 MW) and the signal spectrum of which are close to those emitted by the biological object itself, which dramatically reduces the likelihood of both near and distant side effects. The bell of the device was installed with a gap of 5 mm from the surface of the skin.

Before and after the operation, on the 3rd and 7th days, a clinical examination was carried out with the registration of a visual picture (photo archiving). The area of ischemic disorders was determined by applying a transparent lined stencil. Rats were taken out of the experiment on the 7th day after surgery under anesthesia. The working conditions with rats were in accordance with the rules of the European Convention ET/S 129, 1986 and Directives 86/609 ESC.

Blood stabilized with sodium citrate (1:9) was used to study the balance of pro- and antioxidant systems. In plasma and suspensions of washed erythrocytes in saline solution (1:4), the activity of free radical oxidation processes was studied using method of Fe-induced biochemiluminescence [4] on a biochemiluminometer BHL-06 (Nizhny Novgorod). The level of malondialdehyde (MDA) in plasma and hemolysate of washed erythrocytes (1:10) was determined by the method of M. Uchiyama, M. Mihara [7].

The activity of SOD was determined in the hemolysate of washed erythrocytes (1:10) by inhibiting the formation of the product of autoxidation of adrenaline [4]. A spectrophotometric method was used to evaluate catalase activity in the hemolysate of washed erythrocytes (1:100). The specific activity of enzymes was calculated by protein concentration using the modified Lowry method [7].

The results of the studies were processed according to the Statistica 6.0 program. Differences at $p < 0.05$ were considered statistically significant.

RESULTS

It was found that in the control group, postoperative hypoxia of the skin flap led to activation of the process of free radical oxidation in erythrocytes, where the concentration of MDA increased by 20% ($p=0.050$) compared with intact animals. A compensatory increase of 17% ($p=0.02$) in the specific activity of catalase was registered in the erythrocytes of control animals compared with the intact group. At the same time, there was a decrease of 16% ($p=0.003$) in the specific activity of superoxide dismutase.

At the same time, in rats of the experimental group, after a seven-day course of EHF irradiation, in parallel with a decrease in the area of marginal necrosis of the flap in plasma, a significant decrease in the intensity of the lipid peroxidation process was recorded. According to the data of induced biochemiluminescence, the corresponding indicator decreased by 14% compared to the control ($p=0.003$) and by 11% lower than the value of this index in healthy rats ($p=0.004$). In erythrocytes, there was a decrease in free radical oxidation compared to the control and the group of intact animals by 27% and 32%, respectively, which indicates an increase in the stability of cell membranes. A similar decrease in the concentration of MDA in plasma by 34% (relative to both comparison groups) under the influence of the studied factor also confirms a decrease in the intensity of free radical processes. At the same time, in the erythrocytes of animals of the experimental group, the level of the secondary product of lipoperoxidation did not statistically significantly change in comparison with the control. This may be due to the inhibition of the activity of erythrocyte aldehyde dehydrogenase involved in the utilization of MDA [1, 2, 6].

The peroxide resistance of erythrocytes depends on the resistance of erythrocytes to peroxides and reflects not only the activity of SRO occurring on cell membranes, but also the antioxidant resistance of the biosystem. In the experiment, this was confirmed in the form of a decrease in the peroxide resistance of erythrocytes with a simultaneous increase in the antioxidant activity of the blood under the influence of electromagnetic radiation of the EHF band. Thus, in the experimental group, after irradiation, the total antioxidant reserves of the blood increased (by 8% and 13%, respectively) compared to the control ($p=0.046$) and intact ($p=0.01$) groups, and the activity of bio-radical protection enzymes also increased. The most pronounced positive dynamics was observed on the part of SOD, whose activity after surgery in the experimental group of animals increased by 30% ($p=0.018$) compared with the control, reaching the indicator of healthy animals. The activity of the catalase enzyme, which increased after the operation in the control, was also stimulated by irradiation, increasing it by 12% ($p=0.025$) compared to the index of intact rats. According to a number of researchers, the biological role of catalase is to degrade hydrogen peroxide and provide effective protection of cellular structures from destruction [6, 7]. An increase in the activity of

this enzyme leads to a decrease in free radical oxygen forms (superoxide anion O_2^- and hydroxyl radical OH), which inactivates the processes of lipid peroxidation. Consequently, EHF exposure in the noise mode of radiation has an antioxidant effect through the activation of enzymes (SOD, catalase), which, in turn, inhibit the release of catecholamines from nerve endings and adrenal glands, as well as the action of these monoamines at the postsynaptic level. Therefore, it is possible that one of the mechanisms ensuring a decrease in the intensity of lipoperoxidation under the action of electromagnetic radiation of the EHF band is the suppression of hyperactivity of the sympathoadrenal system.

CONCLUSION

Thus, the results of the experimental study showed that electromagnetic radiation inhibits lipid peroxidation in blood plasma due to activation of the overall antioxidant activity. In erythrocytes, the regulatory effect of irradiation on the prooxidant system was revealed by stimulating the enzymatic link of antioxidant protection. The registered effect indicates the maintenance of anti-inflammatory and antitoxic effects.

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