

The mechanism of the effect of microwave radiation on the parameters of homeostasis in living systems

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One of the actual directions of modern Biomedicine is the study of physical and chemical mechanisms of action of electromagnetic radiation (EMR) on biological systems of various levels of organization [1,2]. An important aspect of the terahertz (THz) range is the presence of molecular spectra of radiation and absorption of the main molecules-metabolites (NO, O₂, H₂O), as well as large organic molecules: DNA, protein, etc., involved in the pathogenesis of various diseases, regulation of biochemical processes and physiological functions of the body [3,4]. Therefore, of particular interest is the study of the effect of EMR of the THz range on living systems [5-7].

The aim of the work was to experimentally study the effect of low-intensity electromagnetic radiation of the broad-band terahertz range on the metabolic parameters of rat blood in the process of reparative regeneration and the cellular system of hemostasis.

Materials and methods

The experiments were carried out on 15 male Wistar rats weighing 250-300 g. in accordance with the requirements of the Geneva Convention "International Guiding Principles for Biomedical Research Involving Animals" (Geneva, 1990) and blood cells of healthy volunteers (15 people) and 35 patients with burn disease. The impact of EMR was carried out in the direct sound irradiation EMR THz (110-170GHz) from the experimental emitter apparatus "AMFIT" (N.Novgorod).

Animals were divided into 3 equal groups: 1 – intact healthy rats, 2 – control – operated animals without any effects, 3 – operated animals with irradiation EMR THz at a dose of 0.12 MJ within the next 7 days (10 minutes 1 time per day). The impact was carried out on the base area of the displaced flap, coinciding with the localization of the skin projection of the center of vegetative regulation. Surgical intervention in 2 and 3 groups of rats and withdrawal from the experiment on day 7 after the operation was carried out under intramuscular anesthesia (Zoletil + Xyla).

Blood stabilized with sodium citrate (1:9) was used for the studies. In plasma and erythrocytes, the activity of free radical oxidation processes was studied using the induced biochemiluminescence method on the biochemiluminometer BHL-06 (N. Novgorod). Chemiluminogenic evaluated total antioxidant activity (TAA) and the ability of a

biological object to lipid peroxidation (LPO) with its intensity by the level of malondialdehyde in plasma and hemolysate of washed erythrocytes (1:10), activity of superoxide dismutase (SOD) in hemolysate of washed erythrocytes (1:10) and catalase in erythrocytes by spectrophotometry [8,9]. Glucose and lactate concentrations were measured on a Super GL ambulance device (Germany) in plasma and red blood cells. The activity of lactate dehydrogenase (LDH) was determined on the spectrophotometer Power Wave XS (Bio-Tek, USA).

In the second series of experiments coagulation and platelet units of hemostatic system were studied in 35 patients with thermal trauma and in 15 healthy people in vitro. The effect of EMR on blood cells was carried out in the mode of direct exposure to noise EMR THz (110-170GHz) ranges with exposure 1, 2, 3, 5, 10, 15, 20, 30 and 60 minutes. To assess the plasma level of hemocoagulation system, thromboelastography (TEG in citrated kaolin mode) was used on the TEG 5000 thromboelastograph ("Haemoscope Corporation", USA). Spontaneous platelet aggregation was studied using a laser aggregometer "Biola 230 LA" [6].

Statistical processing was carried out using the program Statistica, version 6.0, using the student and Wilcoxon criteria. Differences were considered statistically significant at $p < 0.05$.

Result

In animals of the experimental group under the influence of EMR 110-170 GHz, in the range of which the spectra of nitric oxide and oxygen are located, a pronounced vascular effect was registered, which manifested the smallest zone of ischemia and necrosis in the flap compared to the control group of operated animals (necrosis zone was 23% of the flap area compared to 46% in the control). After the operation, the animals that did not receive radiation were found to have an increase in glucose and total cholesterol, as well as urea concentration in comparison with intact animals. When exposed to EMR 110-110GHz a significant homeostasis effect on biochemical metabolism parameters (total bilirubin, urea, total cholesterol and glucose) was registered).

Under the influence of THz irradiation in animals of the experimental group there was a significant decrease in intensity of LPO by 14% ($p=0.003$), an increase in blood TAA (8% and 13% respectively) and activation of enzymes of bioradical protection: SOD (30%) and catalase (12%). This inactivates peroxidation of lipids and helps to reduce free

radical forms of oxygen, which inhibit the release of catecholamines from the nerve endings and adrenal glands [10]. At the same time, it is possible that one of the mechanisms of EMR THz is the suppression of hyperactivity of one of the most important stress-implementing systems of the sympathoadrenal system.

Thus, in the experimental group of animals, the prevalence of TAA over lipid peroxidation processes was observed, which may indicate the inhibition of the biological oxidation system due to the suppression of reactive oxygen species under the influence of EMR THz. In response to the irradiation of the vegetative regulation center projection, neurohumoral activation of the antioxidant system appears to occur, which blocks the processes of LPO. The revealed change in the direction of LPO processes under irradiation may be due to changes in the structure (conformation) of the cell surface of membrane components due to the weakening of hydrophobic bonds [11].

Exposure to EMR of THz in the noise range 110-170 GHz also contributed to a decrease in lactate concentration in plasma and red blood cells by 34% and 51%, respectively, compared with the control group animals. In parallel, LDH activity increased (by 47% and 23%) compared to the control group.

In addition, it is possible that electromagnetic radiation promotes the use of lactate in carbohydrate metabolism in the formation of 2,3-diphosphoglycerate, the main source of energy in the body.

Analysis of hemostasiological parameters dynamics under the influence of broadband radiation mode revealed activation of plasma hemostasis at 1 and 2 minutes of exposure ($p=0.004$ and 0.02 , respectively). Dynamics of changes in coagulation activity in the period from 5 to 60 minutes recorded a gradual decrease in blood coagulation potential, reaching significant differences by 30 minutes compared to the baseline ($p=0.04$). The study of spontaneous aggregation of platelets was demonstrated in the first minutes of exposure to hypercoagulation effect after 30 minutes – hypocoagulation that corresponds to the physiological laws of development of responses of an organism to short the weak and long-strong incentives. A comparative study of the effect of broadband EMR of THz on coagulation and platelet system of hemostasis in patients with thermal injury and healthy people showed no significant differences. Study of the effect of EMR THz on spontaneous platelet aggregation.

Negative effects on the state of tissue blood flow, biochemical and hemostasiological parameters from the studied physical factors were not found.

Conclusion

Exposure to electromagnetic waves of the submillimeter range in the noise mode of radiation plays the role of control signals in the development of biological effects in the body. Based on the results obtained, it follows that low-intensity EMR of THz with a noise range of 110-170GHz in ischemic

conditions leads to an increase in the antioxidant status of the blood, as well as inhibition of peroxide States. It is shown that EMR THz noise range of 110-170GHz increases the energy exchange of blood with tissue ischemia. The safety of EMR exposure to THz is evidenced by the absence of a negative side effect on the body of experimental animals.

The results are important for the development of methods of correction of poststress ischemic disorders, which can be successfully used in the process of medical rehabilitation.

Literature

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