THE STUDY OF THE RATE OF OXYGEN UPTAKE AND LIPID PEROXIDATION REACTIONS IN THE BRAIN TISSUES AND THE LENS OF THE EYE OF RATS UNDER THE INFLUENCE OF ELECTROMAGNETIC RADIATION OF NON-THERMAL INTENSITY IN THE PRENATAL PERIOD (RATTUS WISTAR).

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Abstract. **The study of the state of redox homeostasis in biological tissues exposed to EMR remains an urgent scientific problem. In this work, we studied the rate of oxygen uptake (ORS) in brain tissues, as well as lipid peroxidation (LPO) reactions in these tissues and in the lens of the eye in rat pups (Wistar line, mature females), which were exposed to decimeter EMR during prenatal development range. The source of EMR was the "Volna-2" installation (output power of the device 60 W, frequency 460 MHz, energy density 30 meq/cm2).**

The cubs of irradiated females and pups from the control group were slaughtered on the 20th, 30th and 45th day after birth. In slaughtered animals, the brain and eye lenses were removed, which were homogenized in saline (ratio 1:10). Tissue samples were taken to study the concentration of malondialdehyde (MDA), and brain tissue was also taken to measure the SEC. The results of the experiments showed that in rat pups exposed to decimeter EMR radiation in the prenatal period of life, the intensity of lipid peroxidation increases in the nervous tissue and lens and the SOC decreases (significant differences with the control group at $p<0.05$ and $p<0.01$).

With an increase in life expectancy, the shift in the status of redox homeostasis increases. Indirect data indicate that the observed changes are associated with the depletion of the antioxidant potential in the studied tissues and the reason for this is the irradiation received in the prenatal period of the life of the studied animals. However, for a more detailed interpretation of the mechanism of the identified violations, further study of the issue is required.

Key words: **lipid peroxidation, oxygen uptake rate, cerebral cortex.**

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Introduction. Since the 20th century, electromagnetic radiation (EMR) of the radio and microwave ranges has become one of the elements of the modern human habitat. Of course, changes in the natural habitat cannot but affect both ecosystems and human health. In this aspect, work on the study of the physiology of animals under the intense influence of EMR has been carried out for quite a long time [1, 2]. We and our colleagues in previous studies also obtained certain results in the outline of this topic [3, 4, 5]. In the present work, we continued research in this area and studied the state of redox homeostasis in the structures of the brain and the

lens of the eye in rat pups exposed to non-ionizing EMR during fetal development. The purpose of this work was to study the rate of oxygen uptake (OSC) in brain tissues, as well as lipid peroxidation (LPO) reactions in these tissues and the lens of the eye in rat pups (at the age of 20, 30 and 45 days), which during prenatal development exposed to decimeter EMR.

Materials and methods. Experiments were carried out on cubs of 4-month-old white rats. Sexually mature females (Wistar line) in the amount of 14 individuals were divided equally into the control and experimental groups. The source of EMR for the experimental group was the physiotherapy unit "Volna-2". After mating (3 days of keeping together with males), females were irradiated daily for 20 minutes in a special metal chamber (device output power 60 W, frequency 460 MHz, energy flux density 30 meq/cm2). Control animals were placed in the same chamber, but with an inactive setting. The procedures were carried out for 7 days in the morning.

After the birth of the cubs, the studied females already formed new groups consisting of their cubs. The cubs of non-irradiated females made up the control group, and the cubs exposed to radiation before birth were combined into the experimental group. In both groups, we managed to collect 45 rat pups (part of the offspring did not survive), which were kept under the same conditions. On the 20th, 30th and 45th days after birth, 15 individuals from each group were slaughtered, their brain and eye lenses were removed. The procedure for killing animals complied with the requirements of the international convention for the protection of animals.

The brain tissue and the lens were homogenized in saline at a ratio of 1:10. Tissue samples were taken to study the concentration of malondialdehyde (MDA), and

brain tissue was also taken to measure the rate of oxygen uptake. SPK was measured using a Clark electrode on an OH-3 polarograph and expressed in arbitrary units (AU per milligram of tissue multiplied by 1000). According to the content of MDA (the end product of LPO), the intensity of LPO in the studied tissues was judged. MDA was determined according to the method of Asakawa and Matsushita [6]. This method involves the determination in parallel of two intermediate LPO products - lipid hydroperoxides (HP) and MDA. The calculation of the content of MDA and GP was carried out according to the formula:

$$C = D/ \varepsilon \times L$$

where, C - concentration of MDA and GP; D is the optical density of the test sample; ε - molar extinction coefficient, equal to 1.56x105 M-1xcm -1; L is the length of the optical path, equal to 1 cm.

Results. The concentration of MDA was expressed in nmol/mg protein. Statistical processing of digital data was carried out using the EXCEL program (version 2016). The significance of differences between experimental and control values was assessed using Student's t-test [7].

Parameter	Status	Age of cubs (days)		
		20	30	45
MDA, mmol/mg	An experience	1,1±0,2	1,6±0,2	1,7±03*
	Control	1,0±0,2	2,0±0,3	0,7±0,1*
Oxygen uptake rate (conventional units)	An experience	3,4±0,7*	1,0±0,4	0,7±0,2*
	Control	6,2±1,1*	1,2±0,3	1,7±0,4*

Table 1. Changes in SPK and MDA concentration in the brain tissue of rat pups exposed to decimeter EMR radiation during prenatal development

Differences between similar indicators in the experimental and control groups are significant at a significance level of $p<0.05$.

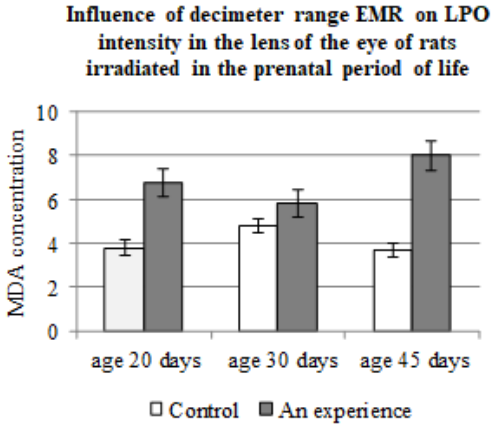
The table presents data on the average indicators obtained for each group of animals slaughtered at different times. The most conspicuous in the table is the difference in SPK in the CNS between 20-day-old rat pups exposed and not exposed to radiation in the embryonic period. Here we observed an almost twofold difference between the groups, and it is significant. However, in 30-day-old rat pups from the experiment and control, the results of SPC differed little in terms of average values and the differences were not significant,

However, in rat pups slaughtered on the 45th day after birth, the values of SPC varied greatly and were significant. The SPC in the brain tissues of rat pups irradiated in the prenatal period of life was almost 2.5 times less than in non-irradiated pups from the experiment. It should also be noted that the SPK in the control group in 45-day-old animals also significantly differs from the indicators of 30-day-old rat pups (an increase of almost one and a half times). The change in the concentration of the POL MDA product shows somewhat different dynamics. There are almost no differences between the experiment and control in terms of average values both in the group of 20-day-old rat pups and in the group of 30-day-old ones.

Small discrepancies were not significant when applying the two-sample test. However, the scores for 45 day old pups differed even at $p<0.01$. At the same time, the level of lipid peroxidation reactions in the control group in 45-day-old rat pups significantly decreased compared to 30-day-old pups, while in experimental animals there were no significant differences between rat pups of these age groups in terms of MDA. That is, in rat pups irradiated in the prenatal period, starting from about 20 days of age, there is an increase in the intensity of lipid peroxidation in the brain tissues, which remains stable at least up to 45 days of age.

In the course of the work, we also studied data on the concentration of MDA in the lens homogenate taken from rat pups of different ages. The corresponding numerical indicators obtained during the experiment are shown in Figure 1.

Figure 1.



In 20-day-old rat pups irradiated in the prenatal period of life, the MDA concentration averaged 6.81±0.78 nmol/mg, while in the control group rat pups were much lower, 3.81±0.45 nmol/mg. Significance of differences was recorded at $p<0.01$. In the group of irradiated animals of 30 days of age, the concentration of MDA also remained high (5.76±0.67 nmol/mg), although the average value differed little from both the control values (4.58±0.55 nmol/mg) and the previous one. values for the experimental group

The significance of differences between groups in this case was unreliable. However, in the group of 45-day-old rat pups from the experimental group, the concentration

of MDA in the lens homogenate increased sharply and averaged already 8.03 ± 0.99 nmol/mg. In the control group, on the contrary, the MDA concentrations significantly decreased (3.41±0.39 nmol/mg). The significance of differences between the same indicators in the experimental and control groups was very high ($p<0.001$). The indicators in the experimental group also significantly differed from the indicators of irradiated 30-day-old rat pups ($p<0.05$).

That is, in 45-day-old rat pups irradiated in the prenatal period of life with high-intensity EMR, a clear shift in redox homeostasis was observed, accompanied by an increase in the intensity of LPO reactions.

Summarizing, we can say that in the brain tissue of rat pups exposed to EMR radiation in the prenatal period of life, by the 20th day of life, a shift of redox homeostasis towards oxidation is observed. This imbalance gradually increases, and in 45-day-old irradiated rat pups, the concentrations of lipid peroxidation products qualitatively differ from those of the control. SEC in the first weeks of life in both groups is slightly increased, but in irradiated rats, the indicators are almost two times lower.

Despite the fact that in 30-day-old rat pups the difference in indicators between groups is unreliable, by the 45th day of life, the SEC in non-irradiated animals normalizes and exceeds the experimental values by more than 2 times. Moreover, the SEC in the brain tissues of irradiated animals continues to decrease. That is, with the existing differences, by the 45th day, the indicators of LPO and SPK in irradiated rat pups show a certain synchronism by the shift. Minor deviations in dynamics may be due to unaccounted for side stress factors (for example, the resettlement of young animals, the cessation of milk feeding, etc.).

Our colleagues have obtained results similar in relationship (increase in SEC against the background of a decrease in the concentration of malondialdehyde) in adult animals [3]. Apparently, in this situation, a decrease in SEC further exacerbates oxidative processes in LPO reactions and a shift in redox homeostasis occurs. Thus, the antioxidant system of brain tissue in rats exposed to radiation in the prenatal period is unable to provide protective functions.

The damage of the antioxidant system under the action of decimeter EMR in the embryonic period is even more clearly demonstrated by the results of studying the concentration of MDA in the lens homogenate.

Already in the first weeks after birth, irradiated rat pups show a significant increase in the level of lipid peroxidation products in the lens homogenate. However, by the 30th day, the differences in the indices level out and the differences, as in the nervous tissue, are unreliable. The similarity of the results in different tissues for this age interval indicates, as we have already noted, the action of some other factors. But by the 45th day, the increase in the concentration of MDA in irradiated rats increases very sharply and significantly differs both from the results for the control group and from the indices of 30-day-old animals. In this case, probably, there is an even faster depletion of the antioxidant potential of the lens compared to the brain tissue.

Previously, when conducting a similar experiment on rabbits, we also obtained data indicating a shift in redox reactions in the lens tissues towards oxidation in animals that received high-intensity EMR irradiation in the prenatal stage of life [8]. In that experiment, with an increase in life expectancy, the intensity of LPO reactions also increased.

Discussion. The results of the study were not entirely unambiguous. In general, it can be argued that in rat pups exposed to decimeter EMR radiation in the prenatal period of life, the intensity of lipid peroxidation in the nervous tissue and lens increases and the SPK decreases.

The negative consequences of irradiation during the prenatal period of life, leading to a failure in the antioxidant system, continue to have a negative effect in the postnatal period, and with a tendency to increase. In this format, similar data were obtained by E.I. Tyulkova [9], who experimentally proved that changes in the ratio of pro- and antioxidant systems in the brain of rats at different stages of postnatal ontogenesis lead to the development of pathological conditions of the CNS.

At the same time, our results showed that the dynamics of the increase in redox homeostasis shift is non-linear and the biochemical background of these reactions is not yet clear. One of the interesting explanations for this type of reactions is given in the work of Yu.V. Nikitina and I.V. Mukhina [10]. These authors believe that the accumulation of lactic acid in the CNS tissue (they studied the nervous tissue of rats after hypoxia in early ontogenesis) leads to a decrease in pH and the development of metabolic acidosis. This, in turn, activates mitochondria and, as a result of increased energy production, oxygen deficiency increases and functional hypoxia develops. At the same time, as a compensation, in response to hypoxia, the proportion of anaerobic processes increases [11].

If these data are adapted to our results, then it can be assumed that exposure of animals to EMR is possibly the trigger mechanism for the disruption of normal processes in mitochondria, resulting in proteolysis and intracellular acidosis. However, as we have pointed out, the damage of the antioxidant system under the influence of EMR is of no less importance. Moreover, it is possible that such antioxidants as, for example, glutathione and the enzymes of its metabolism, which are present in the corresponding tissues, play an important role in these processes

Of course, these questions require careful study and pose new challenges in the study of this issue.

Conclusions. Irradiation of white rats of the Wistar line with EMR of the decimeter range in the prenatal

period of development after birth leads to a shift in redox reactions towards oxidation, which is observed in the tissues of the lens and brain.

the shift of redox homeostasis towards oxidation is associated with a weakening of the mechanisms of antioxidant protection, however, the exact elucidation of the mechanism of these disorders requires further research.

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The negative effect of irradiation in the prenatal period on redox homeostasis in these tissues continues after birth and tends to increase with increasing life expectancy. There is reason to believe that

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