UDC 581.142 https://doi.org/10.26577/2218-7979-2017-10-1-15-18

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Protective and damaging role of electromagnetic influences on biomembranes

Abstract. The paper presents the results of studies of the effect of an alternating low-power electromagnetic field and light irradiation with monochromatic light from a laser source on the state of biological membranes. It was shown that the effect of these factors on the erythrocyte membrane causes a different effect and affects its resistance differently, which is reflected in the change in the erythrogram of acid hemolysis in the experiment. It has been established that the action of an ultrahigh-frequency electromagnetic field leads to a decrease in the resistance of erythrocytes and an increase in the rate of lysis of red cells. Laser irradiation with a low-power helium-neon laser at low exposure increases the resistance of red blood cells to acid hemolysis. Increasing exposure reduces the effect noted. With simultaneous processing of blood samples by UHF (ultra high frequency electromagnetic fields) source and laser light, a significant decrease in the negative effect of the UHF field on the resistance of biomembranes is noted. Possible mechanisms of marked biological effects are discussed.

Key words: laser, electromagnetic fields, blood, erytrocytes, biomembrane.

The functional state of a living cell is mainly determined by the structure and associated work of cell membranes. This dependence becomes clear when one considers that the structure of a cell is a set of membranes that form all intracellular structures of the organism interacting with each other in the volume of the cytosol.

Factors of the external environment affecting the body change functional characteristics of the function of various systems and organs, which ensures the adaptation of the organism to these factors. At the heart of all the adaptive, physiological and pathological reactions of the body is always the changes occurring at the cellular subcellular level. Therefore, it is the change in the characteristics of cell membranes that is one of the defining moments in the development of physiological and biochemical abnormalities in the body.

Among the factors influencing the organism, the study of the action of alternating electromagnetic fields has recently taken on great importance. This is due to the fact that in the last century the influence of electromagnetic fields of artificial origin on the nature of our planet has increased manyfold [1-3].

Electromagnetic fields are created by numerous electric motors, transformers, computer systems, and communication devices, electrical devices. All that makes modern life comfortable and without which we do not represent our normal existence [1; 2].

The study of the effect of electromagnetic fields on biological objects began almost simultaneously with the introduction of electricity in technology and life.

For a long time it was believed that electromagnetic fields do not have any significant effect on living structures. However, a deeper understanding of the structure of the tissues, the development of biophysical studies and the facts noted by specialists from various clinical disciplines made it necessary to look at the problem differently [5-7].

It turned out that the electromagnetic fields have a pronounced effect on virtually all living organisms. However, the effect value depends on many chartes characterizing this factor. These characteristics include wavelength, radiation intensity, frequency response, radiation mode (intermittent, impulsive), area of irradiated surface and exposure. Specific and individual differences influe on observed effects.

The reason for the influence of variable electromagnetic fields is that biological fluids that fill the intracellular space have the properties of electrolytes. Under the action of a periodically changing field voltage, the charged particles advance and the polarization characteristic of the subcellular structures changes [3; 4].

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Depending on the parameters of the current field and the characteristics of the irradiated biological object, both the stimulation of the systems and organs of the animal organism and the suppression of their functional characteristics can occur. It turned out that at the cellular and tissue levels, a variety of and sometimes an opposite reaction is possible.

Under certain irradiation regimes, the regeneration process can increase, while changing the parameters of the effect can lead to changes in the genetic apparatus of the nucleus and change the nature of the cellular metabolism, leading to cell death and the development of degenerative changes at the tissue level.

So we have sad before, the intensity of the impact on the human body of various variable electromagnetic fields with a varied power and frequency response has increased tens of times [1; 4].

Actually, the influence of variable fields on living organisms is a natural component of our natural environment. Living beings for a million years have adapted to the effects of electromagnetic fields, as a natural component of the environment.

However, the anthropogenic electromagnetic pollution of the environment occurring in recent decades is one of the factors whose consequences can not currently be predicted.

The most widespread and least studied is the effect of low-power high-frequency electromagnetic fields.

This problem on the one hand attracts great attention from both scientists and the public. This is due to the widespread use of cellular telephony. At present it is difficult to meet a person who does not use this system of communication.

However, as it is not paradoxical, there is still no consensus on the nature of the effect of such irradiation on biological structures [7].

We decided to analyze the effect of UV radiation on the structure of biomembranes. As a test system, erythrocyte membranes were used, and as an analysis method, an analysis of the kinetics of acid hemolysis was used.

This choice is due to the fact that the structure of the erythrocyte membrane is largely identical to the structure of other cell membranes of the body and for this reason is used as an integral indicator of the influence of various factors on biomembranes.

Irradiation was carried out by a source of electromagnetic oscillations with a frequency of 47 MHz for 15 seconds and 60 seconds for distances of 5 cm.

Studies were performed on blood samples taken from nonlinear rats in the morning before feeding from the tip of the tail.

20 µl of blood was mixed with 20 ml of saline, thus obtaining a suspension of erythrocytes in a dilution of 1:1000.

Sampling and work with them was carried out at room temperature.

The measurement of the optical density of the test sample of the erythrocyte suspension was carried out on CKK-2 at a wavelength of 670 nm.

To determine the rate of acid hemolysis, 2 ml of erythrocyte sediment were placed in a cuvette of working width of 10 mm and 2 ml of a solution of HCl in a concentration of 0.004 N.

After placing the cuvette in the cuvette holder, measurements were taken every 30 seconds.

The change in extinction caused by a decrease in the number of blood elements due to developing hemolysis was recorded as a difference between the initial (E_0) and the next result. Measurements were carried out until two identical values were obtained, i.e. until the end of hemolysis (E_n).

The resulting series of decreasing extinctions characterizes the degree of hemolysis at the time of measurement. The difference $E_0 – E_n$ was taken as 100%.

On the basis of the data obtained, erythrograms of acid hemolysis and graphs of kinetics of erythrocyte destruction have been compiled.

To construct the erythrogram, the percentage of erythrocytes subjected to hemolysis was calculated by the formula

$$E = (D_0 - D_n) / \Delta Di * 100\%,$$

where:

E – the number of erythrocytes subjected to hemolysis, %

ΔDi – difference of the two following values of optical density

ΔDi = Di – Di + 1, where:

D_0 is the initial value of the optical density,

D_n is the final value of the optical density

The results of the experiments are shown on Figure 1.

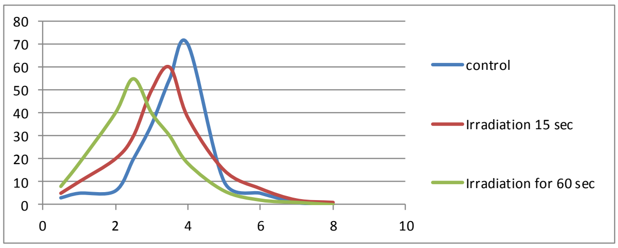

Figure 1 – Acid erythrograms upon irradiation of the same duration

As can be seen from the presented graphs, blood irradiation with the selected field parameters lead to a shift of the erythrogram to the left. This shift is not very pronounced with short-term irradiation (within 15 seconds) and is much more pronounced when irradiated within the first minute. The changes noted indicate a decrease in the resistance of the cell membrane under the influence of the UHF field.

Another widespread factor of influence on the body is the coherent monochromatic measurement of laser sources. Lasers are widely used in industry, household appliances, and their distribution in medicine has turned them into a widely used medical technology.

Despite their large amount of research in this field, there is no single concept of the mechanism of the effect of laser measurement on biological objects. It is known that the biological effect depends on the intensity of radiation, exposure, the wavelength of the light flux, power density, energy density [8.9].

The result of the action of irradiation with the use of low-power sources can be manifested in the form of stimulation of regeneration processes, an increase in the immune status, and in suppression of immune reactions, suppression of the inflammatory process. Earlier in our works, the effect of helium-neon laser irradiation on the processes of carbohydrate metabolism, cellular respiration, and immune status was shown.

Taking into account the earlier expressed thesis that any changes at the organ or tissue level have a cellular and subcellular basis, including changes in light biomembranes, it was of some interest to analyze the effect of laser radiation on the course of acid hemolysis.

The results of studies are shown on Figure 2.

As can be seen from the presented graph, the intensity of hemolysis after irradiation with a helium-neon laser with a radiation wavelength of 752 nm and a power of 20 mW decreases.

In this case, short-term irradiation promotes a marked increase in the resistance of the cell membrane, while a longer exposure gives a much less pronounced effect.

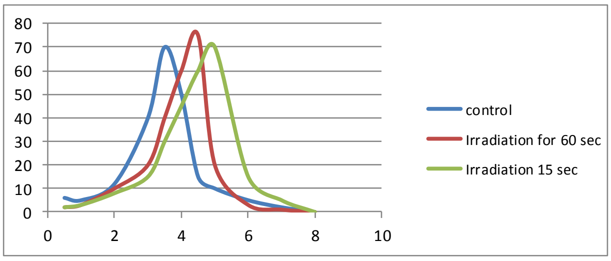

Figure 2 – Acid erythrogram at irradiation with helium-neon laser with various exposure

Taking into account the obtained results, it was of interest to analyze the simultaneous effect on the biomembranes of UHF fields and laser irradiation.

For the experts of this series, the same sources of radiation were used, as before, the duration of processing by the UHF field emitter was 60 seconds, and the helium-neon laser with a laser was 15 seconds.

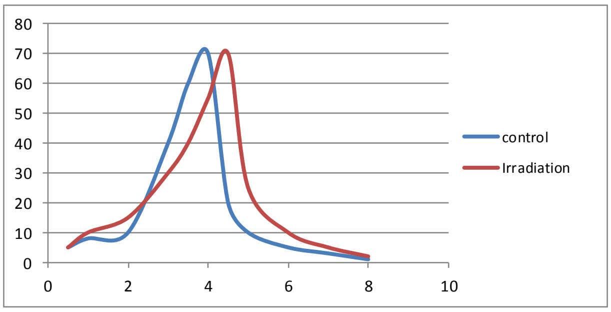

Figure 3 – Acid erythrograms in the complex effect of laser and UHF radiation

From this graph it can be seen that with the combined action of UHF radiation and laser irradiation, the hemolysis course slows down somewhat compared to the action of one UHF radiation. Moreover, the erythrogram graph is shifted to the right even in comparison with the control curve.

The reasons for the observed experimental results are related to the participation of two mechanisms of the action of the electromagnetic field. First, with the transition of electromagnetic energy into thermal energy. Such a transition is associated with the excitation of the molecule's rotations due to the absorption of quantum energies. The energy of quanta is much lower than the kinetic energy of the molecules, and therefore such a result of this absorption is fundamental. Secondly, the electromagnetic field can cause a reorientation of molecules, which is possible only in the constant, or its power should be sufficiently [10-12].

The manifestation of the thermal effect is related to the output power of the source and the flux density (the intensity of the electromagnetic field). The degree of heating is related to the frequency of the field. This to some extent explains the observed effect of reducing the resistance of membranes shown in the experiment. This decrease may be due to an increase in the activity of oxidizing processes and the movement of the concentration of peroxides.

At the same time, to explain protective laser irradiation, we need to recall the features of the organization of biomembranes. The liquid crystal structure of biomembranes is formed by separate clusters (membrane "rafts").

It should be emphasized that water, which is the main component of intracellular content and forms extracellular space, also has a cluster organizing structure [8].

Among the hypotheses for explaining the biological effect of low-intensity laser radiation, two are distinguished. One of them is the stimulation of biological processes through a photoregulatory system, that is, a quantum-mechanical approach [9-12].

Another suggests that laser radiation realizes the process of biostimulation by absorbing the energy of laser radiation (Inyushin V.M. – energy-information approach) [12; 13].

In our opinion, an increase in the resistance of biomembranes when irradiated with laser light is associated with the ordering of the cluster structure of biomembranes involving water molecules when light-quantum energy is absorbed.

This conclusion is supported by the results of experiments with irradiation of water which introduced a suspension of erythrocytes. In this case irradiation of the aqueous medium, rather than cells, increased the resistance of erythrocytes in hypotonic hemolysis [14-16].

The role of the water component in maintaining the stability of membranes was also confirmed in experiments with the determination of the optical characteristics of biomembranes in connection with the change in their functional characteristics [17; 18].

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