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SURFACE CHARGE DENSITY OF RAT BLOOD ERYTHROCYTES UNDER THE INFLUENCE OF MILLIMETER DIAPASON ELECTROMAGNETIC RADIATION

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In present work the effect of millimeter electromagnetic radiation on the surface charge density of rat blood erythrocytes has been studied. The experiments were carried out irradiating suspension of erythrocytes of rat blood by different frequencies. It was shown that in the case of the irradiation by water non-resonant as well as resonant frequencies the value of studying parameter decreases compared to control samples. In the case of the irradiation by water resonant frequency the decrease of the value of studying parameter is more pronounced. In both cases a reliable changes of the surface charge density value of rat blood erythrocytes take place.

Irradiation – rat blood erythrocytes – surface charge density – water resonant frequency – water non-resonant frequency

Ուսումնասիրվել է միլիմետրային էլեկտրամագնիսական ձառագայթման ազդեցությունը առնետների արյան էրիթրոցիտների մակերևութային լիցքի խտության վրա։ Ուսումնասիրություններն կատարվել են առնետների արյան էրիթրոցիտների կախույթը ձառագայթելով տարբեր հաձախություններով։ Ցույց է տրվել, որ ջրի համար ոչ ռեզոնանսային և ռեզոնանսային հաձա-խություններով ձառագայթահարման դեպքում ուսումնասիրվող պարամետրի արժեքը նվազում է ստուգիչ նմուշների համեմատ։ Ջրի համար ռեզոնանսային հաձախությամբ ձառագայթահարելու դեպքում այդ պարամետրի արժեքի նվազումն ավելի վառ է արտահայտված։ Երկու դեպքում էլ տեղի են ունենում առնետների արյան էրիթրոցիտների մակերևութային լիցքի խտության արժեքի էական փոփոխություններ։

ՀՀառագայթահարում – առնետների արյան էրիթրոցիտներ – մակերևութային լիցքի խտություն – ջրի համար ռեզոնանսային համախություն – ջրի համար ոչ ռեզոնանսային համախություն

Исследовалось влияние миллиметрового электромагнитного излучения на плотность поверхностного заряда крови эритроцитов крыс. Эксперименты осуществлялись облучением суспензии эритроцитов крови крыс разными частотами. Показано, что в случае облучения не резонансными и резонансными для воды частотами значение исследуемого параметра уменьшается по сравнению с контролем. В случае облучения резонансной для воды частотой уменьшение значения исследуемого параметра выражено более ярко. В обоих случаях имеют место достоверные изменения значения плотности поверхностного заряда эритроцитов крови крыс.

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Облучение – эритроциты крови крыс – плотность поверхностного заряда – резонансная для воды частота – частота не резонансная для воды

Millimeter electromagnetic radiation (MM EMR) composes the background of surrounding medium and intensively effects on living material [7, 11, 19]. It has been shown that the effect of MM EMR results in changing of different parameters of the blood: influencing on the plasma surface tension, the electrokinetic potential of erythrocytes as well as the resistance of erythrocytes etc., [7]. The surface charge created by the equilibrium between cell membrane components and medium components is an important parameter of erythrocyte membrane [5]. The surface charge is created by polar heads of phospholipids, glycoproteins (essentially by carboxylic groups of sialic acid and amino-acidic residues), as well as glycolipids. Due to the compounds the membrane surface is charged negatively. Sialic glycoproteins consisting of membranes of blood erythrocytes create the negative surface charge (60%) which provides the repulsion between the cells, excluding an interaction between them, particularly, aggregation of erythrocytes that has a big biological importance [1, 6]. Taking into account that sialic glycoproteins play a crucial role in the modulation of erythrocyte-erythrocyte interaction as well as erythrocyte interactions with other blood corpuscles and endothelium [13, 18] it may be insisted that the surface charge of erythrocytes plays a leading role in aggregation and disaggregation of erythrocytes [10]. Decreasing of negative surface charge density of erythrocytes may result in destabilization of suspension of blood corpuscles [14] and, as a consequence, in disturbance of blood functions. The goal of the present work is to study the effect of MM EMR on the surface charge density of membranes of erythrocytes of rat blood.

Materials and methods. White outbred rats with 80-100g mass were used in experiments (Rattus norvegicus, "vistar"). Animals were pickled and the blood was gathered into glass, where previously 1-2 ml 5% Na-citrate solution was added. The latter was prepared on the basis of physiological solution. From each animal the blood with almost 3-3.5 ml volume was taken. Animal blood was centrifuged during 10 min with 1500g acceleration (Electronic Centrifuge Capacity). Erythrocytes were separated from supernatant liquid. Physiological solution was added to the sediment of erythrocytes. The last was suspended. The obtained erythrocytes were suspended in the physiological solution for obtaining of a suspension with an optical density equal to 0.7. The obtained suspension was irradiated at =670 nm wavelength. Optic density measurement was carried out by photoelectrocolorimeter (KFK-2). Non-irradiated suspension of erythrocytes was used as a control sample. In each group – control and experimental 6 rats were used, the experiment was repeated three-times, and then obtained data were averaged. Animals were in the same-type conditions and fed by combined food. Suspension of blood erythrocytes was irradiated with the following frequencies: 41.8 GHz, 42.2 GHz, 50.3 GHz and 51.8 GHz during 20 min, 40 min, 60 min, 80 min, 100 min. MM EMR was produced with Russian-made "Istok" (Model G4-141) generator (Istok, Fryazino, Russia) with working interval of frequencies 37.5-53.5 GHz. The power flux density on the sample was equal to 64 Wt/cm2. Electromagnetic field was homogeneous, distance between sample and waveguide was equal to 180 mm. The choice of these frequencies is conditioned by the fact that 50.3 GHz and 51.8 GHz are water resonant frequencies and 41.8 GHz and 42.2 GHz frequencies have a biological application [9, 17]. The suspension of erythrocytes was used to determine surface charge density of erythrocyte membrane. It was judged about the surface charge density value of ervthrocyte membrane by their mobility in electric field. The mobility of erythrocytes was determined in constant electric field. The surface charge density was calculated by the following formula [2, 8]:

$$\sigma = \frac{\omega \eta}{k+r} \tag{1}$$

where is the surface charge density of erythrocytes (C/m²), ω – electrophoretic mobility of particle, i.e. relation of erythrocyte linear rate to electric field potential gradient, – disperse medium viscosity,

k – width of double electric layer (Å), r – radius of anti-ion. Taking into account that at ionic strength of buffer – 0.15M/l, k is approximately equal to 7.74 Å, the radius of anti-ion may be neglected. Further calculations were carried out by this consideration. The statistic treatment was carried out.

Results and Discussion. The effect of EMR with 41.8 GHz, 42.2 GHz, 50.3 GHz and 51.8 GHz on the surface charge density of membrane of rat blood erythrocytes was investigated.

The values of surface charge density changes of erythrocyte membrane of blood of irradiated rats by EMR with 41.8 GHz are presented on figure 1. It is obvious from figure 1 that after each irradiation the value of of erythrocyte membranes decreases compared with control. It should be mentioned that the degree of the change of surface charge density value differs from each other at different durations of irradiation: thus at suspension irradiation with 20 min duration the value of decreases by 13% compared to control, while at irradiation with 100 min duration – by 38%. The irradiation of rats by 42.2 GHz induces a bigger response of biological system to external physical effect (figure 2). In this case a decrease of the value of is also observed compared to control and fluctuations after each irradiation with respective duration are significant: from 37% at 20 min duration up to 46.5% at 100 min duration.



Fig. 1. Change of the surface charge density of membranes of erythrocytes at EMI EHF irradiation by 41.8 GHz.



Fig. 2. Change of the surface charge density of membranes of erythrocytes at EMI EHF irradiation by 42.2 GHz.

It is interesting that at irradiation of rat blood erythrocyte suspension with 50.3 GHz and 51.8 GHz frequencies the same regularity is observed: the value of decreases with enhancement of irradiation duration. In the case of irradiation of suspension of rat blood erythrocytes with 50.3 GHz frequency induced changes of surface density charge value alter from 44% up to 53% (fig. 3).



Fig. 3. Change of the surface charge density of membranes of erythrocytes at EMI EHF irradiation by 50.3 GHz.

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In the case of irradiation of rats by 51.8 GHz frequency, the induced changes of the surface charge density value are in the interval from 53% to 60% (fig. 4).

Therefore generalizing the above obtained data it may be noticed that the effect of EMI EHF when the suspension of erythrocytes is irradiated, causes a decrease of surface charge density value of rat blood erythrocytes which may be conditioned by the influence of irradiation on membrane proteins and plasma. On the other hand it is obvious that in the cases of irradiation with 50.3 GHz and 51.8 GHz frequencies the decrease of this value if bigger compared to the cases with 41.8 GHz and 42.2 GHz frequencies. It may be assumed that at the irradiation by 50.3 GHz and 51.8 GHz frequencies, as a consequence of water structure changes in the plasma, the concentration of protons increases which may change water buffer properties and a width of double electric layer. In its turn it changes the membrane physicochemical properties of erythrocytes, particularly, the values of surface charge density and electrokinetic potential.



Fig. 4. Change of the surface charge density of membranes of erythrocytes at EMI EHF irradiation by 51.8 GHz.

The change of structure of membrane proteins may change a density of molecule twisting in membranes which results in disorders of physicochemical properties of erythrocytes. The change of protein composition of blood plasma in its turn influences on erythrocyte membrane. It was shown that the stability of erythrocyte membrane increases with the negative charge decreasing on membrane external surface [3]. It was revealed that the stability of erythrocyte membrane decreases with the surface charge increasing on internal side of membrane [4]. It is peculiar for membranes a pronounced electrostriction: with transmembrane difference enhancement of potentials the membrane is condensed which results in thinning of hydrophobic zone and increasing of cellular membrane capacity [16]. The width of double electric layer increases and the electrokinetic potential enhances. The enhancement of electrokinetic potential is accompanied by cell surface charge increasing. The increasing of erythrocyte surface charge, conditioned by membrane structure change, results in enhancement of its permeability, reduction of erythrocyte resistance to hemolysis agent as well as acceleration of hemolysis. The obtained data indicate that MM EMR effect on suspension of erythrocytes in common results in changes of the surface charge density of membranes of blood erythrocytes of rats. The surface charge of erythrocytes is an important parameter for aggregation and disaggregation of erythrocytes. The aggregation of erythrocytes, conditioned by decreasing, leads to the increase of ESR [10]. In the statement [12] it is informed about reliable increasing of ESR

at blood irradiation by low intensity MM EMR. It was also shown that the irradiation of blood by 60 GHz frequency with 30 min duration results in ESR increasing more than twice which is considered to be a consequence of erythrocyte aggregation degree enhancement [15].

Therefore the irradiation of suspension of erythrocytes of rat blood by electromagnetic waves with extremely high frequencies induces a change of different blood criteria including erythrocyte properties. In consequence of multiple irradiations of rats by 41.8GHz, 42.2 GHz, 50.3 GHz and 51.8 GHz frequencies the surface charge density of erythrocytes changes. The multiple irradiations of animals by 41.8 GHz and 42.2 GHz frequencies result in decreasing of erythrocyte

surface charge density compared with control. Changes of the surface charge density value of erythrocytes induced by suspension

irradiation with 50.3 GHz and 51.8 GHz frequency which is resonant frequency for water are more pronounced. Water structure changes in its turn induce alterations of physicochemical properties of plasma and erythrocyte membrane of irradiated blood suspension. The observed changes are stable in the suspension and do not subjected to correction of protective regulatory mechanisms realizing by organism.

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