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Hydration changes of the red blood cell membranes of gastric cancer patients evoked by radiation therapy

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Cancer is one of the most essential medical and social problems in the world due to its significant prevalence and serious consequences: the loss of efficiency, disability and the high percentage of death. One of the leading therapeutic methods for malignant tumors is radiation therapy [1]. The heterogeneity of the red blood cell (RBC) membrane composition, its ability to quickly change the nature of the interaction between the components determine the presence of a wide range of structural and functional reactions of the cell to its adaptation to environmental conditions. Analysis of the dielectric characteristics of the RBC in cancer patients provides additional information on the tumor development and treatment processes that is of great interest in connection with elaboration of more efficient methods for the early diagnosis of cancer [2]. In the present study the suspensions of red blood cells (RBC) and RBC shadows of gastric cancer patients (20 people) have been used. The control group consisted of 25 healthy donors. According to the international classification system TNM (tumor, nodus and metastasis), the patients were distributed as follows: T2N1O (second stage of the disease without signs of distant metastases) – 45% and T3N1MO (third stage, without signs of distant metastases) – 55%. The median age was 47 years. A group of patients received radiotherapy as an independent treatment course in the mode of classical fractionation, with a total focal dose of 45 Gy. Blood sampling was driven by a vein puncture after irradiation. The dielectric properties of the RBC have been studied by microwave dielectrometry at the frequency f=9.2 GHz in the wide temperature range T=0-46°C. The dielectric relaxation time of water molecules, the change in the free energy of activation of the dipole relaxation of water molecules were study and the hydration of cells before and after radiation therapy was evaluated. Since the obtained data showed a non-parametric nature of the distribution, the Wilcoxon criterion was used to estimate the significant difference in the results of treatment, and Fisher's exact method was used for the data analysis with $p < 0.05$.

The results of the study indicate the existence of a thick layer of hydrated water over the surface of RBC in cancer patients with gastric cancer. It has been shown by numerical estimations that each water molecule in the layer forms up to two hydration bonds, approximately. Probably bound water fills the entire space between the glycoproteins of the cell receptors. A number of structural transitions in RBC membranes in the 6, 8-15, 15-20, 36-40 and 42-46° C temperature ranges have been observed. These transitions are accompanied by a change in the activation energy of the dielectric relaxation of water molecules. Similar changes have been detected on the RBC ghosts. Therefore, the observed effect is mostly connected with cellular membrane, not with haemoglobin solution.

Radiotherapy leads to a decrease in the concentration of strongly bound water. Probably, as a result of therapy, the irreversible adsorption of glycoproteins that are part of cellular receptors occurs; this may partially lead to loss of integrity of the cell membranes and cell rupture. Therefore, dielectric parameters of the RBC membranes can be used for quantitative estimation of the stage of disease and control over the anticancer radiation therapy.

References

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