Dose-Enhancing Agent for Radiotherapy at Orthovoltage X-Rays Irradiation

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Photon-capture therapy (PCT) or contrast-enhanced radiotherapy (CERT) is a promising development direction of binary radiation therapy, which is applied in order to increase the treatment efficiency that may be caused by the local energy deposition in the tumor [1]. The basic principle of PCT is the generation of a large number of the characteristic X-rays and low-energy Auger-electrons due to interaction between photons and nuclei of heavy elements ($Z \geq 53$). In biological tissue this secondary low-energy radiation ionizes nearby atoms and leads to the occurrence of highly active radical series, which causes the destruction of the macromolecules of DNA and RNA as well as other cell structures[2].

The results of previous radiobiological studies based on orthovoltage X-rays irradiation have shown that the presence of cisplatin (Pt, Z = 78) reduces the survival of the HeLa cells[3].

The purpose of this research is to study and evaluate the dependence of dose increase on DEA concentration at orthovoltage X-rays radiation using Monte-Carlo simulation methods.

As part of this study the simulation of 60, 120, 180, 250 keV photon beams at different concentrations cisplatin in tumor volume was simulated by Geant4 and Computer Lab (PCLab). At the first stage of this research we performed simulation of dose distribution in the water (Blue Phantom) from Xstral300 X-ray tube that was previously measured at Tomsk Regional Oncology Centre. In the second stage we performed simulation of dose depth curves in the presence of cisplatin in the target volume. Cisplatin concentrations from 3 μM to 0.03 M were studied. 3 μM concentration is the minimal concentration, which had a visible effect during the radiobiological experiments [3]. The simulation results showed that the dose escalation can be caused by PCT. There is a dose enhancement in the volume where cisplatin is accumulated. The higher is concentration, the higher is the effect. However, the photon energy increase from 60 to 250 keV and increase of depth of target reduces the effect of PCT due the decrease of the photoelectric effect cross-section.

References

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