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Comparison of direct DNA damage by protons and oxygen, carbon, and helium ions using Geant4-DNA code

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Abstract

Ionizing radiations can directly affect cells by inducing DNA breaks. This impact includes single-stranded and double-stranded failures; which may cause cell death and mitotic failure. In the present study, with the help of an atomic DNA model built in the Geant4-DNA code and its initial validation, direct DNA damage by interaction with carbon ions 114/u2 MeV, 134/21 MeV/u oxygen, 62/83 MeV/u helium and radiation 62MeV protons have been investigated. For this purpose, after the initial validation, the results of single-stranded, double-stranded fractures and double-stranded fracture efficiency at depths of 5 to 30.7 mm were evaluated for the mentioned ions. The ratio of single strand breaks for oxygen ions at 5 mm (and the location of the Bragg peak: 30.7 mm), 1.85 (1.55), 4.19 (9.42), and 10.6, respectively. (22/24) is more than carbon ions, helium and proton rays. On the other hand; The two-strand break at a depth of 5 mm for oxygen, carbon, helium and proton ions is equal to 0.09, 0.05, 0.01 and 0.005 respectively. These values were calculated as 2.09, 1.34, 0.22, and 0.03 at the place of the Bragg peak (with a significant increase). The results show heavy ions behave much more effective than light ions and protons in terms of biological effects (in the form of single- and double-strand breaks), therefore, they are more effective options for inhibiting or controlling cancer cells.

Keywords: double-strand break, single-strand break, Geant4-DNA, DNA damage

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