Abstract

Chromosome aberrations (CA) in human lymphocytes exposed to 150 MeV and spread out Bragg peak (SOBP) proton beams, 199 MeV/u carbon beam and boron ions of energy 22 MeV/u as well as to ^{60}Co γ rays were investigated at doses up to 6 Gy. Experimentally determined frequencies of exchange and non-exchange CA and the total yields presented as dose response curves were the basis for theoretical considerations devoted to the relative biological efficiency (RBE) of used radiations and the shape of the dose response curves, which is of a special importance for currently widely used hadron radiotherapy and future interplanetary journeys because of a large charged particle component of the cosmic radiation.

The dose dependent RBE values were calculated for all ion beams applying different methods. RBE≤1 was found for the 150 MeV protons, and slightly higher than unity for SOBP protons. Based on the linear-quadratic model of the dose response curves, experimental values of the linear parameter α and the quadratic one β could be determined.

To explain experimentally observed curvature of the dose-response curves a new analytical model based on assumption of overlapping ion tracks was proposed. Using the experimental β/α ratios, values of effective track radii which could explain experimental data were extracted and compared to the physical expectations. The theoretical analysis led us to conclude that no physical effects but the cellular repair mechanisms are mainly responsible for observed β/α ratios.

Efficiency of the repair mechanisms could be estimated by means of deviations from the Poisson and Neyman type A statistics found in distribution of observed chromosome aberrations. In analogy to the effects known in physics of charged particle detectors, a reduction of the experimentally determined statistical variance could be interpreted for the first time as the Fano Factor and related to the repair effects. Applying a chi-square analysis of the dose response curves, the corresponding repair coefficients describing the strength of repair mechanisms were calculated for different radiation qualities. Generality of the method was additionally demonstrated on Chinese hamster ovary cells (CHO-K1) cells exposed to gamma and carbon radiations.

Finally, the experimentally determined curvature of the dose response curves could be explained under assumption of a decrease of repair coefficients with increasing doses and LET values of the applied radiation. However, due to large statistical uncertainties, further experimental data are necessary to obtain more precise information about the suggested functional dependence.

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