Abstract

Double-strand DNA damage is a particularly cytotoxic form of damage that can vary in complexity depending on the inducing factor. In response to such damage, cells initiate a multistep process of biological response. The α particles, characterized by high ionization density, induce complex damage concentrated in a small volume. Indirectly ionizing γ radiation induces scattered, simple damage, primarily through the production of reactive oxygen species. Studies on the impact of ionizing radiation on biological material remain an area of intensive investigation, especially when irradiation involves the simultaneous use of different types of radiation.

The aim of the study was to investigate the effect of sequential mixed beams of ionizing radiation on the biological response of osteosarcoma tumor cells. To examine the effect of the interaction of two types of radiation and its impact on the induction of DNA damage, a radiobiological test involving the analysis of repair foci of the NBS1 protein was used. The observations included an analysis of the formation and disappearance of foci, their size, intensity and mobility. The effects of cell irradiation with α and γ radiation used separately and sequentially were compared, considering the order of exposure. A fluorescence microscope for real-time imaging to observe the repair foci.

Before performing radiobiological experiments, dosimetry of the sources available in the Department of Molecular Biosciences at the Stockholm University was conducted. These sources were used for irradiating biological material. To verify the spatial distribution of the absorbed dose from the γ radiation source, certified active and passive dosimeters, as well as a silicon dosimeter developed in collaboration with the Department of Physics of the Stockholm University, were employed. Dosimetric verification of the α radiation source was performed through computer simulations using Monte Carlo methods.

The obtained results indicate the influence of the order of irradiation, characterized by different effects on DNA induction as well as the rate and quality of their repair. Exposure to sequential mixed beams, where α radiation was delivered first, resulted in a stronger biological effect: the highest number of formed repair foci with the largest size and the slowest repair. Possible explanations suggest that chromatin opening induced by α particles may enhance damage by exposure of DNA to radicals induced by γ radiation, or the activation of the repair mechanism is stronger when the induction of damage by α particles precedes sparsely radiation-induced damage γ.

Keywords

ionizing radiation, dosimetry, Monte Carlo modeling, α particles, γ radiation, sequential mixed beams, DNA damage and repair