Abstract

The doctoral dissertation addresses the topic of the possibility of analyzing the relationship between nanodosimetric quantities characterizing the track structure of the ionizing particle and the biological response of V79 cell line. The aim is to verify the applicability of parameters describing stochastic interactions at the nanoscale in determining the effectiveness of light ions in radiotherapy.

In nanodosimetric studies, gas-based counters are used, operating on the principle of counting ions produced by the passage of a single primary particle in a sensitive volume. This volume models a biological target with dimensions comparable to a single DNA segment. These processes are well-reproduced by Monte Carlo simulations, which were used to determine the nanodosimetric quantities in the modeled fragment of the DNA helix. The Geant4-DNA physics models, validated against experimental results using the Jet Counter nanodosimeter, were applied.

The biological data is derived from the PIDE radiobiological database, which compiles the results from studies on the survival of irradiated cells conducted by various research groups over decades. For the analysis, the V79 cell line of Chinese hamster lung fibroblasts was chosen, as it is commonly used in studies of DNA damage and repair processes.

Nanodosimetric and biological quantities were compared to verify the validity of applying the weighted probability of obtaining at least two ionizations in a nanometric volume as a cellular response descriptor. The potential benefits of using the mean cluster size as an alternative to linear energy transfer were examined. The hypothesis of a relationship between nanodosimetric quantities and the radiobiological description for the standard target as a model of the basic DNA unit sensitive to ionizing radiation was considered.

This study aimed to demonstrate the possibilities of an alternative description of ionizing radiation interactions with cellular material based on quantities measured at the nanoscale. It provides an opportunity to use nanodosimetric quantities in the assessment of the biological effectiveness of light ions.

Keywords

nanodosimetry, particle track structure, probability R_2, radiobiology, clonogenic assay, linear-quadratic model, inactivation cross section, V79 cell line