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Modeling the survival rate of a heterogeneous population of neural stem cells in response to irradiation with 56Fe particles

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Some radiation-induced disorders characterized by memory and learning impairments are associated with a decrease in the number of neural stem cells (NSCs) in the dentate gyrus of the hippocampus after irradiation with ⁵⁶Fe particles [1, 2]. There are several types of neural stem cells, which differ in their morphology and activation rate of division [3, 4]. At the same time, mathematical models that simulate the dynamics of neural stem cells death after irradiation assume the population of NSCs to be homogeneous [5, 6], that allows for long-term predictions of cell response, but not for short-term responses.

In order to improve the accuracy predicting changes in the neural stem cell population after radiation exposure we have developed a mathematical model that considers the heterogeneity of NSCs based on differences in activation rate of division. The model consists of eleven ordinary differential equations whose parameters were derived from an experiment of chronic intravital imaging to follow individual NSCs [4]. In results, we were able to replicate experimental data on NSCs survival at various time points after exposure to ⁵⁶Fe particles with a dose of 1 Gy and linear energy transfer of 148 and 240 keV/μm [1, 2]. Further developing of mathematical models that simulate the dynamics of neural stem cells death after irradiation it will allow enhanced therapies for radiation-caused cognitive impairments.

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