Effects of low–level chronic irradiation on radiosensitivity of mammals: modeling and experimental studies

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Effects of low dose rate chronic irradiation on radiosensitivity of mammals (mice) are studied by experimental and modeling methods. Own and reference experiments show that priming chronic low-level short-term and long-term exposures to radiation induce, respectively, elevated radiosensitivity and lowered radiosensitivity (radioresistance) in mice. The manifestation of these radiosensitization and radioprotection effects are, respectively, increased and decreased mortality of preirradiated specimens after challenge acute irradiation in comparison with those for previously unexposed ones. Taking into account that the reason of the animal death in the experiments was the hematopoietic syndrome, the biophysical models of the critical body system, hematopoiesis, are used to simulate the dynamics of the major hematopoietic lines in mice exposed to challenge acute irradiation following the chronic one. Juxtaposition of the modeling results obtained and the relevant experimental data shows that the radiosensitization effect of chronic low-level short-term (less than 1 month) preirradiation on mice is due to increased radiosensitivity of lymphopoietic, granulocytopoietic, and erythropoietic systems accompanied by increased or close to the normal level radiosensitivity of thrombocytopoietic system which are induced by the above-indicated exposure. In turn, the radioprotection effect of chronic low-level long-term (more than 1 month) preirradiation on mice is caused by decreased radiosensitivity (radioresistance) of the granulocytopoietic system which is induced by the above-mentioned exposure. Modeling predictions concerning the duration of low-level chronic preirradiation leading to elevated and reduced radiosensitivity of mice are in agreement with experimental data. The results obtained point to importance of accounting the nonlinear effect of low-level chronic irradiation on radiosensitivity of the hematopoiesis system and organism as a whole when the radiation risk for cosmonauts and astronauts on long-term space missions is estimated. The developed models of hematopoiesis can serve, after appropriate identification, as a component of the mathematical tools for radiation risk assessment.