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Radiation Fields, Effects and Risks in Human Space Missions (5)

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ENGINEERED STEM CELLS AND THE SPACEFLIGHT ENVIRONMENT: WHAT HAPPENS WHEN EXPOSED TO COSMIC RADIATION?

Abstract

Purpose: A human mission to Mars is exciting and revolutionary but also accompanied with great health hazards and unknown risks, especially with the exposure of humans to cosmic radiation including high and low energy particles. Galactic cosmic ray (GCR) radiation is a major barrier to human space exploration beyond Earth's magnetic field protection. Mesenchymal stem cells (MSCs) are found in all organs, and they play an essential role in the repair and regeneration of tissue to preserve function. They are primarily found in the bone marrow and can differentiate into many different cell types like bone cells, cartilage cells, muscle cells, fat cells and other important cells. In our study, we specifically use engineered bone marrow derived MSCs as a model to evaluate the effect of radiation exposure during deep space travel and long-duration spaceflight. Numerous studies have already shown that MSCs exposed to simulated solar energetic particles (SEP) and GCR radiation experience dramatic changes in their differentiation potential and induce DNA damage and mutations which lead to leukemic transformation within the hematopoietic system. Therefore, ensuring the protection of MSCs from radiation in space is important with the prospects of deep space travel, where stem cells experience sustained exposure to radiation. Methodology: We engineered MSCs to include radioresistant genes and tested the radioprotective effects of these genes towards MSCs when exposed to different doses of x-ray. Gene expression, protein production, MSC surface marker expression and MSC morphology analyses were conducted. Results: When analyzing the effects of radiation exposure on MSCs, we observed compromised morphology and cell proliferation abilities with increased x-ray dose rates. However, the differences between control MSCs and engineered MSCs in cell proliferation at day 7 after irradiation suggest that perhaps engineered MSCs are more radioresistant or can heal themselves better following exposure to low radiation doses (1 – 8 Gy). Conclusions: Engineered MSCs appear to show an advantage over control MSCS in protection against x-ray irradiation at low doses. We hope that our study establishes for the first time the feasibility of efficiently generating engineered MSCs with overexpression of radioresistant genes as a model for enhancing the human body to tolerate and recover from radiation injury in long-term manned space travel. Also, our work encourages the investigation of other radioresistant genes in MSCs, and to explore the radioprotection of other stem cells in the body.