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Biology in Space (8)

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INNOVATIVE ANTIOXIDANT THERAPIES FOR SPACE MEDICINE

Abstract

Permanence in space implies exposure to many biotic and abiotic stresses with harmful effects on the astronauts' health, requiring efficient and long-lasting countermeasures. The reduced gravitational load and the highly energetic irradiation are the main physical stresses exerting synergic deleterious effects on many biological targets. At cellular level, oxidative stress (OS) is a common component of different kinds of space stressors. While the molecular dynamics leading to OS are only partially understood, it is well known as OS stems from an inefficient removal of highly reactive chemicals collectively termed reactive oxygen species (ROS). In normal conditions, ROS are scavenged by endogenous antioxidant defenses in synergy with the dietary intake of antioxidants. Traditional antioxidants however require a constant administration due to their fast clearance, causing refurbishment issues during space journeys: replenishment and bioavailability problems can be overcome thanks to nanotechnologies. Cerium oxide nanoparticles (nanoceria) mimic both superoxide dismutase and catalase activities, and in the past decade many in vitro and in vivo studies demonstrated their strong antioxidant properties. Our group extensively studied their effects on many cellular models, including their protective actions on muscle cells exposed to microgravity onboard of the International Space Station. In vivo radioprotective effects on stem cells and tissue regeneration have been moreover demonstrated, using low-dose irradiated planarians as model system. Despite their excellent ROS scavenging properties, nanoceria are inorganic and non-biodegradable, and this is motivation of concerns for their future human application. At this aim, our attention is being focused on organic materials presenting analogous ROS scavenging properties, including polydopamine, a polymer deriving from the self-polymerization of the biomolecule dopamine. Polydopamine nanoparticles (PDNPs) have been increasingly attracting the attention of the research community for their excellent ability to encapsulate drugs, to convert near-infrared radiation into heat, and to act as antioxidant agents. We demonstrated the efficiency of this nanoplatform in protecting neuronal-like cells from oxidative stress and in promoting, when irradiated with near-infrared light, neuronal activation upon a localized increment of temperature. Their suitability as therapeutic agent in neurodegenerative diseases has been moreover provided, and corroborated by an extensive proteomic analysis on cells derived from patients affected by

Autosomal recessive spastic ataxia of Charlevoix-Saguenay. We have finally tested PDNPs in space, on a model of neuronal cells, and results will be available in the next months upon return on Earth of the samples currently still onboard of the International Space Station.