Radiofrequency radiation may help astronauts in space missions

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Abstract The biological effects of space radiations on astronauts are the main concern in deep space missions. Many investigations have been made to find the best way to overcome those problems in extended space travels. There are some studies showing that radiofrequency radiation can induce adaptive responses in human cells and animals during which they become more resistant against challenging doses of mutagenic agents such as high levels of radiation. We suggest that radiofrequency radiation as an agent that induces adaptive response may help astronauts in space flights. Exposure to radiofrequency radiation before or during space missions while choosing the optimised dosimetric parameters such as determined power density and frequency and duration of exposure can help astronauts in their travels.

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Introduction

In space missions, astronauts are exposed to a variety of environmental hazards such as detrimental chemical and physical agents. Among them, exposure to space radiation is a primary limiting factor to the duration of time available to astronauts in deep space missions. The radiations in space are of galactic origin, from particles produced by the acceleration of the solar plasma by strong electromotive forces in the solar surface and from particles trapped within the limits of the geomagnetic field. The present technology is not capable of fully shielding astronauts from these radiations.
The biological effects of space radiation on astronauts are very complex [1]. Astronauts returning from extended space missions carry chromosomal aberrations in their blood cells [2–4]. Most of the chromosomal aberrations and other DNA damages are due to oxidative stress from the free radicals produced by cosmic radiations [5]. Oxidative injury also causes lipid peroxidation, genomic instability and mutagenesis, all of which have been implicated in the aetiology of a wide variety of chronic and acute diseases including accelerated ageing and cancer [6]. Other biological effects from radiation are cataract, [7] all types of cancers, [8–11] neurological damages, [12] degenerative tissue diseases [13] and cardiovascular and immunological effects [14].

Induction of adaptive response (AR) in mammalian cells exposed to ionising radiation (IR) is a well-established phenomenon, according to which animal or human cells pre-exposed to a low dose of IR were found to be resistant to the damage induced by subsequent exposure to a higher challenge dose (CD) of IR as well as chemical mutagens. Radiofrequency radiation (RFR) in the frequency range of 800–2000 MHz is increasingly used in wireless communication systems in recent years and the conclusion from several reviewers indicates that RF exposure is non-genotoxic [15–22].

There are several studies that show that RFR is capable of inducing AR to subsequent exposure with mutagenic agents (Table 1). According to those studies, exposure to RFR can reduce the adverse effects of mutagenic agents such as radiation and Mitomycin C [23–28].

### Hypothesis

According to AR and the fact that RFR can reduce the adverse effects of high levels of radiation or other mutagenic agents, we suggest that RFR may help astronauts in space missions. Moreover, exposure to RFR before or during a space mission can help astronauts remain more resistant to space radiation.

### Evaluation of the hypothesis

We recommend the following procedures to test the hypothesis:

1. Expose some blood samples or animals to RFR before a space flight and check the viability, survival and biological damages (such as chromosomal aberrations) after the flight.
2. Simulate and mimic the space environment conditions (such as high radiation and microgravity) on the earth and investigate the RFR AR on animals or cultured cells.
3. Compare the outcome of radiation protection induced by RFR AR with other radiation protection mechanisms and agents such as radioprotectors.
4. Conduct further in vitro and in vivo studies by different physical and dosimetric properties of RFR to achieve the highest AR.

### Discussion

Astronauts’ protection against radiation in space is one of the most challenging and complex problems in deep space missions. Many investigations have been made to find the best way of radiation protection. The use of radioprotective agents such as amiphostine [29], industrial or domestic

### Table 1

<table>
<thead>
<tr>
<th>Target</th>
<th>RF as adaptive dose</th>
<th>Challenge dose</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mice</td>
<td>Frequency: 900 MHz</td>
<td>3 Gy gamma radiation</td>
<td>Decrease in DNA damages</td>
</tr>
<tr>
<td>2 PBL</td>
<td>Frequency: 900 MHz</td>
<td>100 ng/ml Mitomycin C</td>
<td>Decrease in micronuclei incidence</td>
</tr>
<tr>
<td>3 Mice</td>
<td>Frequency: 900 MHz</td>
<td>Lethal dose of gamma radiation</td>
<td>Increase in survival time, reduction in the hematopoietic tissue damage</td>
</tr>
<tr>
<td>4 PBL</td>
<td>Frequency: 900 MHz</td>
<td>100 ng/ml Mitomycin C</td>
<td>Decrease in micronuclei incidence</td>
</tr>
<tr>
<td>5 PBL</td>
<td>Frequency: 9150 MHz</td>
<td>100 ng/ml Mitomycin C</td>
<td>Decrease in micronuclei incidence</td>
</tr>
<tr>
<td>6 Rats</td>
<td>Frequency: 900 MHz</td>
<td>Lethal dose of gamma radiation</td>
<td>Increase in survival</td>
</tr>
</tbody>
</table>

* PBL = Peripheral blood lymphocytes.
antioxidant agents [30] and many other approaches have been suggested for optimal space travel. Mortazavi et al. [31] suggested that astronauts with the highest significant ARs should be chosen for deep space missions. They also indicated that some humans living in very high natural radiation areas have acquired high AR to external radiation [32].

Although some studies have shown that RFR has adverse effects on human and animal cells, [33–37] the research that has considered those radiations as having no biological effects is numerous. In well-established articles on the adverse effects of RF radiation, these effects have been related to localised heating or stimulation of excitable tissue from intense RFR exposure.

The use of durable and non-genotoxic agents to protect astronauts against space radiation is a challenging field among many researchers. The non-ionising RFR as a non-genotoxic radioprotective agent can be a good choice for radiation protection in deep space missions. The use of RFR as an agent of induction of AR and therefore radiation protection in comparison to other agents may have some advantages. First, it is easy to generate and one can change its frequency, power density, direction of incidence and time of exposure to induce the highest AR. Second, to the best of our knowledge, there is no study to consider RFR as a known and certain genotoxic factor; studies on the biological evaluation of RFR are full of uncertainty. Moreover, space radiation can change the pharmaceutical properties of radioprotectors and convert them to unusable and toxic agents. Next, according to RFR-induced AR studies, RFR can reduce the adverse effects of whole body radiation, a situation that can occur in space; hence, it may be the best choice for radiation protection. Finally, as to ionization radiation and induction of AR, it should be considered that according to the linear no threshold theory (LNT) for radiation protection, any amount of radiation is harmful. Therefore, we are not authorized to expose astronauts to IR for induction of AR.

On the other hand, the mechanism by which RF is able to induce AR is not fully investigated and proposed mechanisms such as signal transduction due to exposure to RF and stimulatory effects on DNA repair mechanisms are not completely investigated.

Conclusion

We hypothesise that RFR can be used as a non-genotoxic agent for radiation protection in space. Exposure to RFR along with selecting the best situation to induce the highest AR may help astronauts in space missions. However, more studies are warranted to apply this therapy for space travel. Nevertheless, it will be a good choice for thinking about astronaut’s protection in space missions.

Conflict of interest

The authors have no conflicts of interest with regard to the content of this article.

Overview Box

First Question: What do we already know about the subject?
Radiation exposure to astronauts could be a significant obstacle for long duration manned space exploration because of the current uncertainties regarding the extent of biological effects.

Second Question: What does your proposed theory add to the current knowledge available, and what benefits does it have?
Radioadaptive response is a biological phenomenon during which cells become more resistant against challenging doses of mutagen agents. So it can help astronauts without any special and expensive mechanisms for radiation protection in space.

Third question: Among numerous available studies, what special further study is proposed for testing the idea?
Exposing the animals or cultured samples to radiofrequency radiation before the space flight and check the rate of some biological endpoints after the flight can show how this hypothesis is applicable. Simulation of the space environment on the earth and selection of the best physical parameters for radiofrequency radiation such as frequency, intensity, specific absorption rate (SAR), duration of exposure and orientation of the incident fields to have the highest efficiency in this field.

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References

Radiofrequency radiation and astronauts’ protection


