

COMMENTARIES

MEDICAL CHALLENGES – IN SPACE

Earth is the cradle of mankind, but one cannot stay in the cradle forever.

Konstantin Tsiolkovsky

The history of aviation medicine can be traced back to the beginning of the 20th century, with the advent of powered flight. At that time, there was a need to select healthy pilots, mainly for the purposes of war. World War II saw the development of aeromedical research, with the aim of extending man's ability to cope with the ever increasing physiological demands made possible by improved technology (e.g. low oxygen during high-altitude flights and high G-forces in fast, highly maneuverable aircraft). In 1961, another step was made when Russia ventured into a yet more challenging environment – outer space. This is when aviation medicine evolved into aerospace medicine. The evolution continues as humankind attempts to spend longer and longer periods of time in space; some of the problems of short-duration space flight are exacerbated while new problems will surely pose additional challenges.

Imagine this scenario…the year is 2025. The first human mission to Mars is taking place. You and thirty other health care professionals have been chosen to oversee the health and safety of the international crew of astronauts and cosmonauts, comprising two women and two men. Their voyage will be long and challenging, with three years spent in the hazardous and unfriendly environment of space. What medical challenges would you anticipate for such a journey?

An obvious place to start is by considering the consequences of the microgravity environment of space. The effects, known as "deconditioning", involve multiple body systems and can be debilitating (1). First, the cardiovascular system undergoes fluid redistribution to the upper torso and head, which is perceived as a volume overload and in turn leads to a decrease in plasma volume, or hypovolemia. Consequences include orthostatic dysfunction when astronauts return to earth. Other effects include reduced cardiac volumes and mass, decreased exercise tolerance, and arrhythmias. In addition, bone demineralization occurs as a consequence of decreased osteoblast activity, similar to osteoporosis, leading to decreased bone density and increased risk of fractures. This is accompanied by muscle atrophy secondary to the lack of use of postural

Mars surface (artist's interpretation). Artist: Pat Rawlings. Reproduced from NASA's Planetary Projects Office, Johnson Space Center (http://spaceflight.nasa.gov/gallery/images/mars/marsvehicles/html/s91_52337.html)

muscles. The neurovestibular system is not left untouched. Changes occur in the way the body senses posture and position in microgravity, leading to motion sickness in space and to problems with balance and coordination upon return to earth. On top of this, immunosuppression, mostly of the cell-mediated type, is also found in astronauts (2). These observations have led researchers and flight surgeons to investigate the causes and treatment of deconditioning. Thus it is at least partially accounted for during long-duration missions. Other yet unidentified conditions may become the real show-stoppers in space exploration.

Considering the hazards of the environment of outer space, one problem that should be thoroughly investigated is trauma. Trauma could happen on a number of occasions: during extravehicular activity, secondary to impact with debris or meteoroids, inside the spacecraft with breakdown of the life support system, burns, etc. This leads to the question of "risk management". We may decide to treat all injuries and be equipped with the latest critical care technology, or we may opt to offer little more than basic first aid, with band-aids and aspirin. Targeting the most common medical emergencies may be the soundest way to proceed, which would still necessitate the need for basic trauma protocols and surgical care. Performing surgery in a microgravity environment is not a trivial task, but is still feasible (3).

On another note, the possibility of psychological disturbances warrants attention. Experience has shown that normal individuals placed in stressful environments, especially for extended periods, can easily experience deviant behaviour. Russians have the most experience when it comes to long-duration space flight. Cosmonauts have experienced fatigue, asthenia, sleep disturbances, and depression. This is believed to be due to the isolation and confinement of space, as well as changes in circadian rhythms, as well as man-machine and crew interactions (4). Psychological and psychiatric problems that arise during long-duration spaceflight may in fact be the real limitations of exploratory missions.

Yet another problem is radiation (5). We have seen the effects of acute and chronic exposure to radiation on earth after tragedies like Chernobyl and Hiroshima. At this point in time, we have few tools to measure the amount of radiation one would be exposed to outside the atmosphere and magnetosphere, earth's protective layers, making it hard to estimate the cumulative exposure that would occur during an extended mission. Furthermore, the issue of radiation becomes even more important when we consider the immunosuppression experienced by astronauts. Proper measurements of radiation exposure as well as adequate shielding will need to be provided to decrease this risk to an acceptable level.

Human space exploration and colonization might be the key to assuring our survival as a species. We will face some great uncertainties in the coming centuries, like the availability of food to supply world's burgeoning population, the reserves of energy sources for our expanding economies, and the effects of pollution on our environment (6). Space exploration may seem like an extravagance now, but it may soon become a necessity. This is why we need to develop aerospace medicine, so that humankind's leap out of its cradle will be a safe one.

Marlène Grenon, M.D.C.M.
Faculty of Medicine, McGill University

Carol Chahine
Faculty of Dentistry, McGill University

REFERENCES

1. Davis JR. Medical issues for a mission to Mars. Aviation, Space and Environmental Medicine 70: 162-168; 1999.
2. Levine DS, Greenleaf JE. Immunosuppression during spaceflight deconditioning. Aviation, Space and Environmental Medicine 69: 172-177; 1998.
3. Campbell MR. Surgical care in space. Aviation, Space and Environmental Medicine 70: 181-184; 1999.
4. International Space University. Hazards to Spaceflight, Design Project Report. Cleveland: ISU SSP'98: 1998.
5. Keifer J, Kost M, Schenk-Meuser KS. Radiation Biology. In: Moore D, Bie P, Oser H, eds. Biological and Medical Research in Space. Berlin: Springer; 1996: 300-367.
6. Stebbing J. Too much life on earth? QJM 90: 597-599; 1997.

The Association for the Development of Aerospace Medicine (ADAM) was created in August 1999 at McGill University. Additional chapters of ADAM are being created around the world. Please visit the ADAM website at www.ssmu.mcgill.ca/adam or contact Marlène Grenon at greno00@med.mcgill.ca for more information about the Association or about aerospace medicine in general.

ON THE MAKING OF TOMORROW'S PROFESSIONALS

> Twin berries on one stem, grievous damage has been done to both in regarding the Humanities and Science in any other light than complemental.
>
> William Osler (1)

Attribute it, if we shall, to the momentous growth of knowledge in our field of study, to the decreasing amount of time in a fast paced civilization, or even to the decay of youths' appreciation of culture, but the Science student of the early 21st century graduates with what many may judge to be less than a complete university degree. Permitting less than a handful of elective courses throughout the undergraduate career, many of our nation's top honors biomedical curricula have become so heavily specialized that it is not uncommon for students to complete their studies without having explored any course work outside the natural sciences. Students thus

Sir William Osler's desk. Photographer: Karen Coshof. Reproduced with permission from *The Osler Library* (Montreal: Osler Library; 1979).