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Short Commentary

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Where No Surgeon Has Gone Before

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Abstract

Long-duration manned space missions beyond Low Earth Orbit, such as the new programs for the International Space Station around the Moon and the future Mars exploration missions, present a unique set of challenges to the health and well-being of crew members. Due to the inherent risks and the remote nature of these missions, we appreciate it is crucial to have at least one dedicated medical professional, specifically a surgeon astronaut, as part of the crew.

Keywords: Space medicine; Microgravity; Space exploration; Space surgery; Astronaut recruitment; Astronaut selection.

Short commentary

Space exploration has always captured the imagination of humanity, and as our ambitions extend further into the cosmos, the need for comprehensive medical care during long-duration space missions becomes increasingly important [1]. New manned missions targeting destinations beyond Low Earth Orbit, such as Mars and extended stays on Gateway, the new International Space Station around the Moon, poses a unique set of challenges to the health and well-being of crew members. Recently, European and Japanese Spatial Agencies has chosen their new astronaut candidates. The European selection process renews its astronaut team every 15 years, so we expect the new group to face long manned Space Missions. From more than 22,500 applicants from across its Member States, only three of the selected candidates are Doctors of Medicine, and only two are specialized in surgery.

Identifying a suitable candidate for the role of a surgeon astronaut requires a rigorous selection process. The candidate must possess both exceptional surgical skills and the physical and mental aptitude for space travel. However, the current situation is quite surprising, as far as it has been widely recognized that having surgeon astronauts as part of the crew becomes a critical component to long manned space missions' success [2], all the rest of selected candidates are engineers without medical knowledge.

The Deep Space environment is quite hostile for human body. Microgravity, ionizing radiation exposure and the isolated environment of a small spacecraft are three of the most significant factors which degrade our physiology [3]. Prolonged exposure to microgravity results in a myriad of physiological changes, including bone density loss, muscle atrophy, and cardiovascular deconditioning, which have been well-documented in astronauts during long-duration spaceflights in the present-day International Space Station [4,5]. Fluid management, wound closure, and infection control are further complicated by the lack of gravity. Space radiation poses a significant risk to astronaut health, leading to an increased likelihood of cancer, central nervous system damage, and degenerative tissue disorders [6]. Furthermore, the risk of traumatic injuries, such as lacerations or fractures, increases in the confined and hazardous environment of a spacecraft [7].

On a space mission, the distance between the spacecraft and Earth may be too great to receive real-time guidance and assis-

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tance from surgeons and medical specialists on Earth because of communication latency (which can be longer than 20 min from Mars to Earth). This means that astronauts would have to be able to perform complex medical procedures (like surgeries) on their own.

Additionally, the psychological stressors associated with isolation, confinement, and demanding work schedules in long-duration missions can lead to mental health issues, including depression, anxiety, and interpersonal conflicts [8]. These physical and psychological need medical explorations and a correct treatment in order to address both acute and chronic health issues that may arise during the mission.

The duration of a Mars mission, which could last up to 3 years, dramatically increases the likelihood of medical emergencies. The inclusion of a surgeon astronaut in the crew of long-duration space missions offers several advantages.

First, their presence ensures timely and appropriate medical intervention in case of emergencies, reducing the risk of severe complications or fatalities [9]. Immediate access to surgical expertise increases the chances of successful treatment, particularly for conditions that require prompt intervention, such as appendicitis or traumatic injuries [10]. A surgeon astronaut also minimizes the risk of complications and the need for an emergency return to Earth [11]. This is particularly important for missions targeting destinations such as Mars, where the time and resources required to evacuate an injured or ill astronaut back to Earth would be prohibitive [2].

Second, a surgeon astronaut can monitor and address the physiological changes induced by microgravity and radiation exposure, mitigating potential long-term health consequences [12]. By closely monitoring astronaut health and implementing countermeasures, such as tailored exercise programs and pharmacological interventions, a surgeon astronaut can help maintain crew health and mission performance [13]. Wound healing in microgravity may be slower, necessitating vigilant monitoring and infection control measures. Rehabilitation may require creative solutions, such as the use of resistance bands and specialized exercise equipment. Besides, a surgeon astronaut can contribute to the development of novel medical procedures and techniques specifically tailored for the space environment [14]. The unique environment of space necessitates the adaptation of conventional surgical techniques to accommodate the challenges of microgravity, such as the control of blood and body fluids, and the management of floating surgical instruments [2]. The knowledge gained by surgeon astronauts during long-duration space missions can inform the development of improved medical care for future space explorers.

Third, a surgeon astronaut can contribute to the psychological well-being of the crew by providing mental health support and fostering a sense of safety and security. The psychological benefits of having a dedicated medical professional on board should not be underestimated, as they can contribute to a more cohesive and resilient team [8].

Despite the advantages, incorporating a surgeon astronaut into the crew of a long-duration space mission presents several challenges for Space Agencies. The rigorous training required for an individual to excel as both a surgeon and an astronaut demands a significant investment of time and resources [13]. The surgical skills required to provide comprehensive medical care during space missions are extensive and must be maintained through ongoing practice and training [15]. This mixed training can be tough for the candidate, given the competing demands on an astronaut's time, both during the pre-launch training phase and while in space [16].

The limited crew size on long-duration missions necessitate that all astronauts serve multiple roles when participating in the broader mission objectives [12]. A surgeon astronaut must therefore possess not only medical expertise but also the ability to contribute to other mission-critical tasks, such as research, maintenance, and extravehicular activities. This multifaceted role requires a unique skill set and adaptability that may be difficult to find in a single individual.

Space constraints on a hypothetical Mars-bound spacecraft limit the available medical supplies and equipment. The fixed provision of medical care in the space environment presents logistical challenges, including limitations in medical equipment and supplies due to mass, volume, and power constraints [9]. Developing surgical techniques and tools that are both effective and compatible with the exceptional conditions of space travel remains an ongoing area of research and development, which may require innovative solutions and improvisation during medical emergencies [2]. Furthermore, the psychological stressors associated with long-duration space missions, such as isolation, confinement, and disrupted circadian rhythms, may impact the ability of a surgeon astronaut to perform optimally in high-pressure medical situations [17].

Conclusion

Next long-duration manned space missions challenges underscore the importance of interdisciplinary collaboration between the medical and space exploration communities. By addressing these complexities and developing innovative solutions, the inclusion of surgeon astronauts in future missions will play a crucial role by enhancing crew health, safety, and mission success. Further research and technological advancements will be essential in ensuring that surgeon astronauts can effectively meet the unique demands of their role in the Deep Space environment.

Declarations

Conflicts of interest: The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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