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REACHING MARS: MEDICAL RISKS AND POTENTIAL SURGICAL CONDITIONS IN THE  
MARTIAN ENVIRONMENT AND ONBOARD**Abstract**

In comparison to lunar missions, Mars missions will pose added challenges. This includes a longer duration, currently anticipated to take around three years, a hazardous and extreme environment with 0.38 Earth gravity, a thin atmosphere, and a weak magnetosphere. These factors contribute to extreme weather conditions, and significant exposure to radiation. Evacuation to Earth for medical treatment will be impractical, rendering surgical interventions absolutely necessary.

This paper is part of an ongoing comprehensive survey of relevant published scientific literature to identify medical conditions that might require operative or non-operative surgical solutions during long-duration spaceflight. To date, we have identified more than 50 potential surgical conditions. In the context of potential future Mars missions, (1) onboard acute conditions, or newly developed chronic diseases, and (2) Mars surface/environment-related surgical conditions provide relevant considerations for future mission planning and crew safety. (1) During long-duration spaceflight, exposure to space radiation and microgravity affects every organ system. This may result in a broad range of medical events requiring diverse operative or non-operative surgical intervention. The likelihood of acute life-threatening events (1a.) is increased, and newly developed, chronic diseases (1b.) may also occur. If asymptomatic, but untreated, secondary sudden surgical emergencies may result. On reaching Mars (2), reintroduction of partial gravity (0.38 G), and flight-related reduced bone mineral density, might lead to increased risk of lumbar disc herniations and traumatic injuries such as fractures. Without adequate radiation shielding, surface conditions will likely increase the risk for development of malignancies and eye diseases such as cataracts. Communication delays, as long as 24 minutes each way, will require any immediate medical emergency to be managed in-situ by the expeditioners. Remotely operated robotic surgery is not currently feasible, as any communication lag  $\geq 100$ ms will cause a perceptible delay, potentially affecting the surgical outcome.

The provision of healthcare for Mars missions will face unique challenges in terms of both a hostile and extreme environment, and a remote and isolated location without real-time Earth communications. The medical team will need to be equipped to manage a very wide range of health conditions, including low acuity, chronic, and high acuity life-threatening issues, some potentially requiring surgical intervention. Issues for the treating team include appropriate skill sets and access to medical guidance, facilities, equipment and supplies, and available pharmaceuticals. These significant challenges underlie the importance of adequate anticipation, preparation and planning for the healthcare needs of Mars explorers.