

SPACE LIFE SCIENCES SYMPOSIUM (A1)  
Medical Care for Humans in Space (3)

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## SURGERY IN SPACE: WHERE ARE WE NOW?

**Abstract**

**Introduction:** As we continue our path of space exploration beyond Earth's orbit in the coming decades, we must be able to provide sound medical and surgical care for the safety of all space travelers. A few investigations have taken place in the field of surgery in space. In this review, the authors summarize the current literature to identify potential limitations that could inhibit our ability to provide surgical care during spaceflight (pre-operative to the post-operative period).

**Methods:** Current literature was reviewed for articles relevant to the field of "surgery" in "microgravity", "weightlessness" and "spaceflight". Discussions with active microgravity investigators as well as review of published bibliographies for further relevant citations supplemented the PubMed literature search. Areas with deficiencies that could limit the effective provision of surgical care during a space exploratory mission were noted.

**Results:** The surgical risks of the space environment include the concern for blunt and penetrating trauma (debris, during extra-vehicular activity, construction/repair, vehicle docking and refueling, servicing payloads), chemical contamination and burns (electrical equipment repair, chemical/biological research, orthopedic injuries (particularly in the setting of bone and muscle loss), minor injuries and dental complaints, as well as "standard" surgical pathologies (i.e. appendicitis, cholecystitis). At the present time, diagnostic capability is limited to ultrasound. The capability to provide basic life support that includes obtaining an airway and ventilation, as well as the performance cardio-pulmonary resuscitation has been established in analogue environments of weightlessness. Local and intravenous anesthetic agents appear to be the preferred methods for major operations during spaceflight because of potential risks associated with inhalational anesthetics and spinal anesthetics. With the proper equipment (sterile drapes, sutures, instruments, operating table) and restraining system (for patient, surgeon and equipment), surgical techniques can be performed in microgravity. Some critical aspects however have remained poorly investigated and may represent challenges for successful surgical care. These include aspects related to pharmacodynamics, pharmacokinetics and bioavailability (particularly in the setting of fluid shifts known to occur in microgravity), wound healing, and the effects of immune-suppression and radiation on post-operative infection. Finally, the most appropriate training and skill-set maintenance for the future space surgeon is also unclear.

**Conclusions:** Although several important milestones have been attained with regards to surgical care in space, many areas remain to be developed to ensure the provision of adequate surgical care. It will be critical to address these issues in the coming years and decades to ensure a safe exploratory journey.