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Author: Mr. KangSan Kim
Space Generation Advisory Council (SGAC), Korea, Republic of

Dr. Dora Babocs
University of Texas Health Science Center at Houston, United States

CHALLENGES OF SURGICAL PROCEDURES IN REDUCED GRAVITY ENVIRONMENTS AND POTENTIAL SOLUTIONS UTILIZING ROBOTIC AND ARTIFICIAL INTELLIGENCE TOOLS

Abstract

Long-duration spaceflights pose unique challenges to the field of space medicine due to the prolonged exposure to weightlessness and space radiation. These factors increase the likelihood of developing more diseases that may necessitate surgical intervention. A principal factor in determining the success of surgeries and individual processes is the availability of gravity. The impact of long-term exposure to reduced gravity on crew health and performance has been recorded since the earliest days of human spaceflight.

This study will evaluate the impact of gravity on surgical performance. Surgeries are inherently risky even in advanced, well-equipped environments due to their highly invasive nature, probability of minor and major complications, outbreaks of infection, internal and external bleeding, and extensive period of recovery. Surgery is also highly specialized, frequently requiring highly customized specialists for its success.

A complete re-evaluation of the effectiveness of current surgical instruments in microgravity is required. The application of diagnostic assistants, projected either via visual or audio aid may aid space surgeons to operate in this novel field. Advanced algorithms, such as those informed by artificial intelligence can detect anatomical locations, physiological or pathophysiological responses, changes in tissue behavior, and guide surgeons in surgical decision-making. These algorithms will work in conjunction with sensors embedded either in the surgical tools themselves or at key locations around the operating bay. These can identify organ disposition and alert the surgeon of unusual tissue behavior in cases such as wound closure.

The study evaluates a potential redesign of the traditional surgical environment into a microgravity-capable "smart surgical bay" that is equipped with robotic and artificial intelligence assistants. These bays will also be equipped with enhanced isolation and sterilization to contain medication from dispersing into the general spacecraft's fluid systems, and prevent potential infectious elements from entering the patient care environments. The bay will be specially equipped with tools for endoscopic and minimally invasive surgical procedures as their processes are most favorable to be conducted in microgravity.

The study closes with a discussion of how reduced gravity environments will require a new understanding of operative procedures and tissue behavior, and identify protocols for a new suite of training for space surgeons.