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A REVIEW OF SPACE SURGERY - WHAT WE HAVE ACHIEVED, CURRENT CHALLENGES AND FUTURE PROSPECTS

Abstract

INTRODUCTION: Increasing crew size and mission duration has rekindled interest in the various disciplines of aerospace medicine including surgery. Current knowledge is limited by short duration missions, small subject set and limited space on board for medical equipment. Repatriation back to Earth is not an option during long duration missions. Planned future missions to the moon, mars and further would have to consider delivery of health care by crew members to a wide variety of health risks including surgical care in an increasingly autonomous manner without much assistance from the ground. This review aims to look at the published work in surgical care in space, the inherent challenges and identify scope for future studies. METHODS: Data for the review was identified from MEDLINE, PubMed and EMBASE database between 1960 to February 2020 using the terms "space surgery", "microgravity", "zero gravity", "weightlessness", "parabolic flight", "neutral buoyancy" and "spaceflight". Only articles in English were selected and references cited in selected publications were identified and used where appropriate. We also included documents on public domain and/or archives of National Space agencies. RESULTS: Till date no human has been operated on in space. In 1988, Satava documented the 1st results of surgery in analogue environment. This review evaluates and analyses results from a few landmark experiments covering the important technical aspects of basic surgical skills, laparoscopic surgery, robotic surgery and tele surgery. These include but are not limited to the complex medical operations performed on live rats on board the Neurolab STS-90 Life Sciences mission (1998), evaluation of basic surgical skills on board NASA's KC 135 parabolic flights (2005) and DC 9 (2008), basic laparoscopic skills on board KC 135 (2006) and Falcon 20 (2009), robotic surgery simulation onboard DC 9 using M7 in 2007 and 2011 and NEEMO missions for telerobotic surgery (2009). The review also looks at studies evaluating other aspects of surgical care like trauma, anaesthetics, surgical enclosures, fluid administration and haemorrhage. Finally, the review critically analyses the possibilities in the future namely AI based surgical care, humanoid surgical assistants, 3D printing of surgical equipment etc CONCLUSION: Despite the progress in space surgery in the last 30 years, there are several challenges to a fully functional surgical care system for any mission outside Low Earth Orbit. 3D printing and AI based surgical assistant coupled with robotic surgery have shown promise, but their real efficacy and functionality remain to be tested.