

HISTORICAL NOTES
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## A SHORT HISTORY OF SURGERY AND ANESTHESIOLOGY IN SPACE

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### Abstract

*Space Medicine has grown in parallel to Space Exploration since the second half of the 20th century. Surgery and anesthesia procedures with a special focus on acute surgical conditions management have been investigated and/or performed on animal models and astronauts/cosmonauts. Although total anesthesia has been successfully performed on animal models it is considered of high risk for humans and regional anesthesia techniques have been the method of choice so far. The history of surgery and anesthesia in Space has expanded the limits of these fields and is expected to skyrocket their conjugation with modern technology such as 3D printing.*

**Keywords:** *Space medicine, surgery, anesthesiology, microgravity*

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The 12th of April 1961 marks the beginning of human history in Space. During the first decade of human space exploration safety issues have been investigated. Next, adaptation and performance during long duration missions with astronauts on the Skylab Space Station was evaluated. During the third decade operational reusable launch vehicles were used to expand our perception in spaceflight and microgravity conditions. The fourth decade's highlight is the International Space Station (ISS) and the model of collaboration that it inaugurated. During the last two decades new players including both national space agencies and commercial companies have entered in space exploration. [1]

Space Medicine (SM) has grown in parallel to this journey. SM focuses on pre-flight assessment and selection of astronauts, on their monitoring during space flight and on post-flight rehabilitation. [2] The purpose of this note is to present the main aspects of surgery and anesthesia in spaceflight conditions as evolved throughout the last decades.

Space Surgery and Anesthesia have been developed in order to tackle surgical emergencies during spaceflight. Attention has been paid to trauma and inflammatory conditions such as peritonitis or appendicitis. They can play a significant role given the amount of time (>48h) and money that is necessary in order to abort a space shuttle. The majority of the below listed investigations or operations has been performed since 2000, when the first crew arrived to the ISS. [3,4]

Surgical operations have been widely performed on animal models in parabolic flight conditions. Parabolic flight is performed within Earth's atmosphere, however for a very limited amount of time microgravity conditions are fully simulated. These experiments have focused on laparoscopic surgery and on peritoneal fluid extraction in case of peritonitis not treatable with conservative means. [2,5] Performing surgery on ISS astronauts has been limited by the plethora of flying non sterile objects and the exceptionally low risk of developing surgical conditions for

astronauts. Historically features of surgical and anaesthetical care have been incorporated in the training of the crew medical officer. These features include ATLS, stabilization techniques, intubation and anaesthesia administration. [2,6]

Anaesthesia in Space has been mainly evaluated in animal models. However, the concerns as far as the administration of oxygen and pharmaceutical agents is concerned due to the risk of fire and drug inhalation by astronauts have not been dissolved yet. Hence, regional anaesthesia has been preferred for procedures in spaceflight conditions so far. [6,7]

The history of surgery and anaesthesia in Space has illustrated several debatable aspects of SM. Firstly, all the studies have been performed in a limited number of animals or individuals. When it comes to parabolic flight, the time is also limited and as a result of it several hazards may have not been observed. Moreover, all the experiments and studies so far have been designed according to a concept of short or mediocre time of space flight. From the 48 minutes long Gagarin's flight to the launch of the ISS, the longest duration of human presence in space was fourteen months, with an average stay of up to 6 months. [7,8]

Space exploration or colonization projects that are currently under preparation have not been investigated from a surgical and anaesthetical point of view so far. The same applies to commercial space flight. These types of flight include short duration missions between Earth and Moon and will be offered to a larger number of individuals who have not undergone such a thorough preflight control as preflight astronauts. Last but not least the space and weight limitations for surgical equipment have been proved as a considerable limitation to studying and performing surgical procedures in spaceflight conditions. [9,10]

The history of Surgery and Anaesthesia in Space has demonstrated a significant potential in terms of treating emergency surgical conditions in a frame of limited equipment, space and even training. The future history of Space Surgery and Anaesthesia is expected to be shaped by 3D printing. The capacity of designing equipment

and materials on site and in a personalized way appears revolutionary. Relevant experience has been accumulated since 2018, when the first 3D printer was installed to the ISS. [2,11]

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