Paper ID: 72207
student

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

Author: Ms. Rachael L'Orsa
University of Calgary, Canada, ralorsa@ucalgary.ca

Dr. Sanju Lama
University of Calgary, Canada, slama@ucalgary.ca
Prof. David Westwick
University of Calgary, Canada, dwestwic@ucalgary.ca
Prof. Garnette Sutherland
University of Calgary, Canada, garnette@ucalgary.ca
Dr. Katherine J. Kuchenbecker
Germany, kjk@is.mpg.de

TOWARDS SEMI-AUTOMATED PLEURAL CAVITY ACCESS FOR PNEUMOTHORAX IN AUSTERE ENVIRONMENTS

Abstract

Pneumothorax, a condition where injury or disease introduces air between the chest wall and lungs, can impede lung function and lead to respiratory failure and/or obstructive shock. Chest trauma from dynamic loads, hypobaric exposure from extravehicular activity, and pulmonary inflammation from celestial dust exposures could potentially cause pneumothoraces during spaceflight with or without exacerbation from deconditioning. On Earth, emergent cases are treated with chest tube insertion (tube thoracostomy, TT) when available, or needle decompression (ND) when not (i.e., pre-hospital). However, ND has high failure rates (up to 94%), and TT has high complication rates (up to 37.9%), especially when performed by inexperienced or intermittent operators. Thus neither procedure is ideal for a pure just-in-time training or skill refreshment approach, and both may require adjuncts for safe inclusion in Level of Care IV (e.g., short duration lunar orbit) or V (e.g., Mars transit) missions.

Insertional complications are of particular concern since they cause inadvertent tissue damage that, while surgically repairable in an operating room, could result in (preventable) fatality in a spacecraft or other isolated, confined, or extreme (ICE) environments. Tools must be positioned and oriented correctly to avoid accidental insertion into critical structures, and they must be inserted no further than the thin membrane lining the inside of the rib cage (i.e., the parietal pleura). Operators identify pleural puncture via loss-of-resistance sensations on the tool during advancement, but experienced surgeons anecdotally describe a wide range of membrane characteristics: robust tissues require significant force to perforate, while fragile tissues deliver little-to-no haptic sensation when pierced. Both extremes can lead to tool overshoot and may be representative of astronaut tissues at the beginning (healthy) and end (deconditioned) of long duration exploration class missions. Given uncertainty surrounding physician astronaut selection criteria, skill retention, and tissue condition, an adjunct for improved insertion accuracy would be of value.

We describe experiments conducted with an intelligent prototype sensorized system aimed at semi-automating tool insertion into the pleural cavity. The assembly would integrate with an in-mission medical system and could be tailored to fully complement an autonomous medical response agent. When coupled with minimal just-in-time training, it has the potential to bestow expert pleural access skills on non-expert operators without the use of ground resources, in both emergent and elective treatment scenarios.