Thoracic PARG, Patient Aspiration in Reduced Gravity

Kaitlyn Hauber[1] and Steven H. Collicott[1] and C. Marsh Cuttino[2]

[1]School of Aeronautics and Astronautics, Purdue University, West Lafayette, IN
[2]Orbital Medicine Inc., Richmond, VA

Abstract

Medical devices that can function in weightlessness are becoming increasingly necessary as humans push the boundaries of spaceflight with extended missions that cannot be quickly aborted in the case of a medical emergency. Astronauts must be able to solve medical anomalies as doctors would on Earth without the luxury of working with gravity. Many current medical devices require the use of gravity to function and must be modified or completely redesigned if they will be used by astronauts. This work presents the findings from a flight experiment of a thoracic drainage device for treating collapsed lungs that can function in weightlessness.

Thoracic Evacuation

Thoracic drainage devices are used in the treatment of pneumothoraces and hemothoraces, commonly referred to as collapsed lungs. These conditions can result from physical trauma, from rapid pressure change, or occur spontaneously, in rare cases. Treatment involves inserting a drainage catheter through the wall of the chest and connecting the catheter to a series of chambers under balanced suction to evacuate the blood and air from the thoracic cavity. Removal of blood and air allows the lung to re-expand and normal respiration to continue.

Spaceflight Medical Devices

There is currently no medical thoracic drainage system and suction capability that can function in the weightlessness (or colloquially, zero-gravity, microgravity, etc.) of a space operational environment. Terrestrial models of thoracic chest drainage systems are based upon a gravity-dependent fluids system that requires an upright orientation for the device.
For the treatment of hemothorax in spaceflight, the thoracic drainage tube that is inserted into the chest can be identical to the tubes being used in current terrestrial medical applications. Medical-grade suction pumps have been shown to work in weightlessness on parabolic flight and on a pair of commercial re-usable suborbital rocket flights.

Necessity of Physical Experimentation

The use of human blood in these experiments was of great significance. Blood is a non-Newtonian fluid that is rheologically complex and computationally difficult to model. This mandates physical experimentation to ensure validity of the proposed design. In regular use, the time to suck the fluids from the patient to the separator and have the retained blood reach an equilibrium state is between three and five minutes. This makes the suborbital flight regime ideal for this type of experimentation.

Conclusions

The design, test, and implementation of medical devices that can function in microgravity are essential to the well-being and safety of future deep space explorers who will not be able to travel back to Earth in the event of a medical complication. Thus, success or failure of such missions may depend on availability and function of devices such as this one. Experiments such as this give unique and essential information that will further the development of these technologies.

Figure 1: (left) Dr. Cuttino and Purdue students preparing flight experiment and (right) Thoracic PARG experimental payload