Surgical Capabilities Development for Reduced Gravity

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Introduction

The ability to surgically treat trauma and other disorders in reduced gravity requires reliable wound containment. The aqueous immersion surgical system (AISS) is a clear chamber attached to the skin over the surgical site that is filled with an immersion fluid (e.g. saline) to control bleeding, cleanse the wound, and maintain a clear visual field during surgical treatment (Figure, left). Parabolic flight testing of the AISS has been used for subsystem evaluation. Preparations for a suborbital flight evaluation of the integrated AISS fluid management systems on the Virgin Galactic SpaceShipTwo in 2020 are in progress.

AISS Fluid Management System Operation

The fluid management systems (FMS, center figures) are used to control filling, purging of debris, providing therapeutic tamponade, and emptying of immersion fluid from the AISS dome by operating the coordinated action of pumps and valves with input from accelerometers, and pressure, flow, and optical sensors. Inserted into the dome via a leak-free trocar is a 3-D printed, multi-function surgical wand that provides fluid suction and irrigation, as well as illumination via a fiber optic cable incorporated into the wall of the wand (Figure, right). Two different versions of the FMS are being evaluated. One version uses a National Instruments myRIO microprocessor to manage fluid in the rigid AISS dome. The compliant version of the AISS dome uses an Atmel 328p microprocessor to control fluid management. Both versions control filling, pressure for therapeutic tamponade, purging, and emptying, while accommodating inflow and outflow of fluid via the multi-function surgical wand. The ability for the FMS to correctly complete all of these functions during microgravity will be considered a success.

Experiment Protocol Initiation

High-definition surveillance cameras mounted inside the payload with LED lighting will record experiment status throughout the entire flight from takeoff to landing. Experiment initiation upon entry into microgravity occurs when the accelerometers in the myRIO and Atmel 328p microprocessors detect a sustained resultant acceleration of < 0.05 g for 2 seconds. This experiment initiation strategy was validated during drop tower tests at the NASA Glenn Research Center and during parabolic flight.

Suborbital Flight Payload Container

A custom-designed glovebox, made of aluminum and polycarbonate, will contain the two different AISS evaluation experiments. The glovebox is the equivalent size of two stacked ISS stowage lockers (18.5" x 23" x 21.5") and contains 10" x 17" mounting boards for each of the AISS systems to be evaluated. The glovebox features side doors that hinge down for experiment installation, servicing, and removal, as well as three pairs of arm access ports to permit interaction with the experiment. External electrical connectors are located in the front corners of the glovebox to receive spacecraft power that is distributed to the experiments inside of the glovebox via cable feed-through ports. A Nomex® cover fits over the canopy preventing light interference with adjacent payloads. The glovebox has undergone design review and performance testing during parabolic flight to assure adequate accommodation and secondary containment of experiments. Glovebox mating to mounting structures in SpaceShipTwo and New Shepard is being implemented.

Acknowledgement

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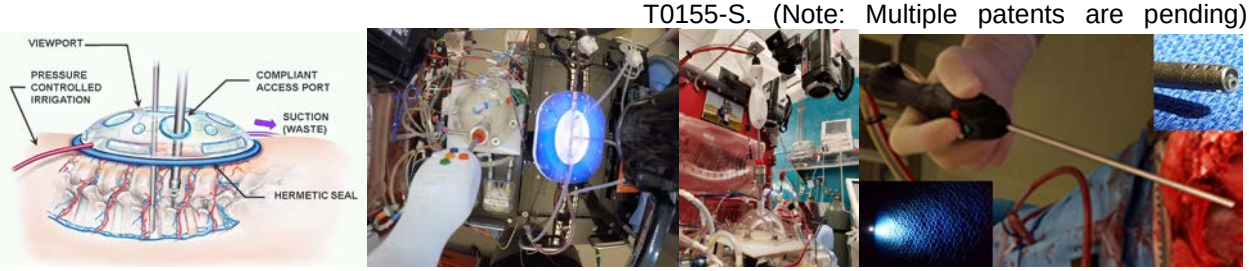

Figures: AISS concept diagram (left), AISS experiments (center), and surgical wand (right)