PARABOLIC FLIGHT EVALUATION OF A HERMETIC SURGICAL SYSTEM FOR REDUCED GRAVITY

NASA Flight Opportunities Program: Payload 49-P

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Introduction: Exploration space flight is fraught with significant risks to human health, yet current capabilities for in-flight medical treatment are rudimentary at best. To address several of the basic challenges of surgical care in reduced gravity, we are developing an Aqueous Immersion Surgical System (AISS) which is a clear enclosure that hermetically seals to the skin to permit minimally invasive and open surgical procedures within a localized aqueous environment. The AISS prevents contamination of the spacecraft with blood and tissue debris, reduces intraoperative blood loss, and maintains clear visualization of the operative field. At the same time, the AISS prevents accidental contamination of the surgical field from debris floating in the spacecraft cabin. We report progress completed in Year 2 of this technological research and development effort.

Methods It is preferred that the application of suction inside the AISS to remove blood and debris not lower the pressure to subatmospheric levels which may unintentionally promote bleeding. To counter this phenomenon, a coordinated infusion-withdrawal pumping control system has been developed so that as the suction wand removes fluid from the AISS with a withdrawal pump, at the same time and rate, an infusion pump adds fluid to the AISS. This fluid management system will also be designed to rapidly fill or empty the AISS. Key to supporting this process is that the instrument ports create a leak-free seal so that the pressure inside the AISS can be reliably regulated and so that the immersion fluid inside the AISS cannot leak out at any time. Custom designed instrument ports making use of critically placed valves and seals were designed to permit leak-free instrument insertion and withdrawal. Also key to supporting this process is establishing a hermetic seal between the AISS flange and the skin that sustains pressure, but does not injure the skin. Numerous hypoallergenic, adhesive material combinations were evaluated using *in vitro* and *in vivo* leak tests. The behavior of bleeding in normal and reduced gravity, into air and into saline immersion fluid is also being investigated.

Results: A data acquisition board controlled infusion/withdrawal system has demonstrated the ability to balance fluid removal by suction with replacement fluid infusion to maintain a stable pressure inside the AISS. Custom designed instrument ports have demonstrated leak-free operation up to 200 mm Hg. The use of a surgical adhesive drape adhered to the AISS flange has achieved a hermetic seal with transient pressure rises up to 74 mm Hg. Bleeding into a chamber of saline resists the blood flow and keeps it localized for removal by suction.

Discussion: Incremental progress has been made on several key performance features of the AISS. AISS performance of suction, rapid filling and emptying, and leak-free instrument port operation in 1-G have been demonstrated. Component and subsystem performance in reduced gravity will be evaluated in a parabolic flight campaign anticipated by the end of February 2014. The project remains on track with the Technology Maturation Plan with the anticipation of having fully functioning system by 2015.