ISSMP	INTEGRATED FLUID VOLUME	Integrated Fluid Volume

Principal Investigator

Michael B. Stenger, Ph.D.
Scott A. Dulchavsky, M.D., Ph.D.
Alan R. Hargens, Ph.D.

Description

Over 30% of American astronauts have developed ocular refraction change after long duration space flight on the ISS. Recent findings have also included structural changes of the eye (papilledema, globe flattening, choroidal folds) and the optic nerve (sheath dilatation, tortuosity and kinking), as well as imaging signs and lumbar puncture data indicative of elevated intracranial pressure (ICP). Changes in vision, eye and adnexa morphology are hypothesized to be the result of space flight-induced cephalad fluid shifts and transiently elevated ICP. This hypothesis, however, has not been systematically tested. In earlier anecdotal publications, ICP elevation in long-duration space flight has been inferred but without association with structural or functional changes of the eye. Furthermore, while fluid shifts and compartmentalization during short-duration space flight (Space Shuttle missions) have been studied, the fluid distribution patterns and their effects on ICP or the structure and function of the sensory organs in the course of long-duration space flight are not well known.

This investigation will characterize the changes in fluid distribution, including intra/extracellular and intra/extravascular fluid shifts, by applying modern advanced non-invasive assessment technologies before, during and after long duration space flight. Additionally, the study will examine the relationship between the type and magnitude of the fluid shift with any effects on eye morphology and vision disturbances, intraocular pressure (IOP) and measures of ICP. Further, the study seeks to determine whether the magnitude of fluid shifts during space flight, as well as the above effects of those shifts can be predicted based upon crewmember baseline data and responses to acute head-down tilt tests performed before launch. Finally, the investigation will evaluate the effect of lower body negative pressure and thigh cuffs (Braslet) on the above parameters.

Objectives

1. To characterize fluid distribution and compartmentalization before, during and after long-duration space flight.

2. To correlate in-flight alterations of eye structure, ocular vascular parameters, and vision with headward fluid shifts, vascular dimensions and flow patterns.

3. To determine systemic and ocular factors of individual susceptibility to the development of ICP elevation and/or vision alterations.

Relevance

This investigation represents the first attempt to systematically determine the impact of fluid distribution in microgravity on a comprehensive set of structural and functional measures including those related to intracranial pressure, vision, morphology of the eye and its adnexa and the vascular systems of the head and neck, during and after long duration space flight.

BDC Summary

Data collection will occur approximately 90 days before launch,10 days after landing and two more times at 30 and 180 days after landing to track recovery.

Measures of fluid compartmentalization will be assessed through the determination of total body water, extracellular and intracellular fluid volume, and plasma volume. ICP will be monitored using non-invasive technologies.

Ultrasound will be used to determine interstitial tissue thickness, vascular filling and flow patterns in multiple upper and lower body vessels and to depict the anatomy of the entire globe and its components including multiple vascular sites.

Echocardiographic data will be collected to characterize multiple indicators of cardiovascular function, including preload, atrial dimensions, valvular competence, and diastolic function of both ventricles and cardiac output. Blood pressure will be measured and total peripheral resistance will be calculated.

Quantitative measurements of optic nerve head and macular morphology, retinal artery and vein sizes, and retinal nerve fiber layer thickness will be obtained by optical coherence tomography (OCT). IOP will be measured by tonometry.

Pre- and post-flight measures will be performed during seated upright, supine, and 25º head-down tilt postures. Pre-flight BDC is scheduled to occur over a 3-day testing schedule. Baseline measures as defined above will occur on Day 1, testing with the Braslet and LBNP will be randomized and will occur on Days 2 and 3. Post-flight BDC will consist of baseline measures only (i.e., no Braslet or LBNP testing).

Magnetic resonance imaging will be used to characterize intracranial morphology, fluid space dimensions, and the distribution of the venous outflow from the intracranial space and the head. Imaging will be performed with the subject in the upright, supine and head-down tilt position.

In-flight Operations Summary

Sessions are scheduled for early (flight day 30), mid (flight day 90) and late (flight day R-21). Blood, urine and saliva will be collected for measurement of total body water and extracellular and intracellular fluid volume.

Remote guidance ultrasound will be used to assess cardiac function and to determine vascular filling and flow patterns in multiple upper and lower body vessels and ocular ultrasound will be used to depict the anatomy of the entire globe and its components including multiple vascular sites. Blood pressure will be measured and total peripheral resistance will be calculated.

IOP, ICP and OCT measurements will be collected. All testing will be performed with and without Braslet and LBNP use during the in-flight sessions.

Subject Selection/Participation Criteria