INTRODUCTION

The Visual Impairment Intracranial Pressure (VIIP) syndrome is currently NASA’s number one human space flight risk. The syndrome, which is related to microgravity exposure, manifests with changes in visual acuity (hyperopic shifts, scotomas), changes in eye structure (optic disc edema, choroidal folds, cotton wool spots, globe flattening, and distorted optic nerve sheaths). In some cases, elevated cerebrospinal fluid pressure has been documented postflight reflecting increased intracranial pressure (ICP). While the eye appears to be the main affected end organ of this syndrome, the ocular affects are thought to be related to the effect of cephalad fluid shift on the vascular system and the central nervous system. The leading hypotheses for the development of VIIP involve microgravity induced head-ward fluid shifts along with a loss of gravity-assisted drainage of venous blood from the brain, both leading to cephalic congestion and increased ICP. Although not all crewmembers have manifested clinical signs or symptoms of the VIIP syndrome, it is assumed that all astronauts exposed to microgravity have some degree of ICP elevation in-flight. Prolonged elevations of ICP can cause long-term reduced visual acuity and loss of peripheral visual fields, and has been reported to cause mild cognitive impairment in the analog terrestrial population of Idiopathic Intracranial Hypertension (IIH). These potentially irreversible health consequences underscore the importance of identifying the factors that lead to this syndrome and mitigating them.

METHODS

The Ocular Health experiment will expand on the required in-flight medical testing of long-duration crewmembers who are assigned to an International Space Station (ISS) mission. The current required testing includes 5 sessions over a two year period, and those will be expanded to 13 sessions over a three-year period. Pre- and postflight evaluations will include functional eye exams (visual testing), structural eye exams (fundoscopy, ocular ultrasound, ocular coherence tomography and biomicroscopy), intraocular pressure (tonometry), cardiovascular compliance (via ultrasound with concurrent ECG and blood pressure), noninvasive intracranial pressure (via pulsatility index, measured by transcranial Doppler (TCD)), and brain anatomy via Magnetic Resonance Imaging (MRI). In-flight evaluations will include visual testing, fundoscopy, tonometry, cardiovascular compliance and transcranial Doppler. Both vascular compliance and TCD are additions to the study, and are not a standard component of the medically required testing. Ocular coherence tomography will be added when the hardware becomes available onboard the ISS in 2014.

STUDY TIMELINE


Example of a tonometer and a tonometry exam being conducted in-flight.

DISCUSSION

This prospective study aims to define the temporal sequence for the appearance of signs and symptoms, delineate the interaction between duration of weightlessness and severity of symptoms (i.e. the dose-response), establish preflight baseline characteristics, characterize the nature of in-flight changes, document changes from pre- to postflight, document postflight time course for recovery to baseline, and determine the impact of prolonged changes on crew health. Data from this study will improve the understanding of VIIP incidence, signs, symptoms, susceptibilities, timeline for development and recovery, and aid in guiding development of countermeasures and targeted treatments for preventing the VIIP syndrome and its complications.

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