THE VISUAL IMPAIRMENT INTRACRANIAL PRESSURE SYNDROME IN LONG DURATION NASA ASTRONAUTS: AN INTEGRATED APPROACH

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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 (hypometric shifts, scotomas), changes in eye structure (optic disc edema, choroidal folds, cotton wool spots, globe flattening, and distended 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, altered fluid shifts related to the effect of cephalad fluid shift on the vascular system and the central nervous system are thought to be secondary reasons for increased ICP postflight.

The leading hypotheses for the development of VIIP involve microgravity induced head-down 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.

Suspected pathophysiologic mechanisms leading to VIIP clinical manifestations:
1) Cephalad fluid shifts and loss of gravity assisted venous drainage from the brain leads to:
2) Increased ICP, which is manifested with:
3) Structural and functional changes to the eye.
4) Increased ICP, which is transmitted to the optic nerve causing:
   - Reduced Optic Nerve Sheath Diameter
   - Increased Optic Disc Edema
   - Wool spots

The operational and research communities at NASA are working collaboratively in an effort to understand the mechanisms causing the VIIP syndrome and to provide mitigation and countermeasures. The Medical Operations division (MedOps) has instituted extensive preflight, in-flight and postflight testing as part of occupational surveillance. Pre- and postflight tests include functional eye exams (vision testing), structural eye exams (fundoscopy, ocular ultrasound, optical coherence tomography [OCT] and biomicroscopy), intracranial pressure monitoring, and eye exams, and brain and cerebrovascular anatomy via magnetic resonance imaging (MRI). The Ocular Health study, a prospective investigation, aims to define the temporal pattern for the appearance of signs and symptoms, delineate the association between duration of weightlessness and severity of symptoms (i.e., the dose-response), establish preflight baseline characteristics, characterize the nature of in-flight changes, and document changes from pre to postflight. The study examines upon in-flight medically required data collection with the addition of additional time points, cardiovascular compliance (via ultrasound with concurrent ECG and blood pressure), and noninvasive intracranial pressure (via pulsatility index, measured by transcranial Doppler [TCD]).