EFFECTS OF MILD HYPERCAPNIA DURING HEAD-DOWN BED REST ON OCULAR STRUCTURES, CEREBRAL BLOOD FLOW, AND VISUAL ACUITY IN HEALTHY HUMAN SUBJECTS

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BACKGROUND

The cephalad fluid shift induced by microgravity has been hypothesized to cause an elevation in intracranial pressure (ICP) and contribute to the development of the Visual Impairment/Intracranial Pressure (VIIP) syndrome, as experienced by some astronauts during long-duration space flight. Elevated ambient partial pressure of carbon dioxide (PCO_2) on ISS may also raise ICP and contribute to VIIP development. We seek to determine if the combination of mild CO_2 exposure, similar to that occurring on the International Space Station, with the cephalad fluid shift induced by head-down tilt, will induce ophthalmic and cerebral blood flow changes similar to those described in the VIIP syndrome.

HYPOTHESIS

We hypothesize that mild hypercapnia in the head-down tilt position will increase choroidal blood volume and cerebral blood flow, raise intraocular pressure (IOP), and transiently reduce visual acuity as compared to the seated or the head-down tilt position without elevated CO_2, respectively.

METHODS

Eight healthy adult subjects recruited through NASA's test subject screening facility that have successfully completed a Class III physical will participate in a single visit to the Cardiovascular Lab at NASA JSC. Subjects will undergo three 1-hour exposures separated by a 10-min break between each phase: (1) seated upright breathing room air; (2) 6° head-down tilt breathing room air; and (3) 6° head-down tilt breathing 1% CO_2, balance air. CO_2 will be delivered through a two-way non-rebreathing facemask connected to a breathing reservoir containing the CO_2 gas mixture. Throughout each exposure end-tidal CO_2 and ventilation will be continuously measured. Blood flow in the head, neck and eye; IOP, ICP, and changes of the retina, choroid, macula, and optic disc; and distance and near visual acuity will be measured during each phase.

Doppler Ultrasound

Vascular responses to increased arterial PCO_2 will be measured using Doppler ultrasound. The middle cerebral artery will be monitored to assess changes in cranial vascular resistance. The common carotid and vertebral arteries will be assessed to estimate cephalic blood flow.

IOP and ICP

Changes in IOP will be measured using rebound tonometry (Icare Pro) and ICP changes will be estimated using a novel algorithm (Non-invasive intracranial pressure framework, NICF), which elaborates data obtained from non-invasive continuous blood pressure waveforms and ECG parameters.

Optical Coherence Tomography (OCT)

Spectral-domain OCT scans of the optic nerve head, macula, and choroid will be acquired using the Spectralis OCT (Heidelberg Engineering, GmbH, Heidelberg, Germany). Built-in AutoRescan™ feature will allow for serial imaging across the 3 trials in anatomically the same location, while enhanced depth imaging will provide greater visualization of the choroid.

Visual Acuity

Distance and near visual acuity will be determined using Early Treatment Diabetic Retinopathy Study charts.

RESULTS

Data collection for this ground based study will begin in January 2015 and is expected to be completed by July 2015.