ANALYSES OF MAGNETIC RESONANCE IMAGING OF CEREBROSPINAL FLUID DYNAMICS PRE AND POST SHORT AND LONG-DURATION SPACE FLIGHTS

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Material and Methods

Preliminary results are based on analyses of data from 17 crewmembers. The initial analysis compares pre- to postflight changes in total cerebral blood flow (CBF) and cranio-spinal CSF flow volume. Total CBF is obtained by summation of the mean flow rates through the 4 blood vessels supplying the brain (right and left internal carotid and vertebral arteries). Volumetric flow rates were obtained using an automated lumen segmentation technique shown to have 3-4-fold improved reproducibility and accuracy over manual lumen segmentation (6). Two cohorts, 5 short-duration and 8 long-duration crewmembers, who were scanned within 3 to 8 days post landing were included (4 short-duration crewmembers with MRI scans occurring beyond 10 days post flight were excluded). The VIIP Clinical Practice Guideline (CPG) classification is being used initially as a measure for VIIP syndrome severity. The CPG classification is shown in the table below:

Class 1
- No evidence of papilledema
- No evidence of papilledema, optic disc edema

Class 2
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot

Class 3
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot

Class 4
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot
- ≥ 50 dioptry cycloplegic refractive change and/or cotton wool spot

The Current Study:

This limited directed retrospective study focuses on quantitative analysis of specialized magnetic resonance imaging (MRI) scans of NASA crewmembers performed before and after the completion of their spaceflights. The MRI scans were obtained between October 2010 and early 2014. At present, seventeen imaging (MRI) scans of NASA crewmembers performed before and after the completion of their spaceflights. The MRI study protocol included dynamic velocity-encoded imaging of the pulsatile blood and CSF flow to and from the cranial cavity during the cardiac cycle (Figure 3) from which important cerebral hemodynamics and cranio-spinal hydrodynamics measures can be calculated (3,4). The study aims to compare pre- to postflight changes in the short and long-duration spaceflight cohorts. Second, the study attempts to identify association between the magnitude of pre- to postflight change in specific quantitative MRI measures and the presence and severity of signs and symptoms indicative of the VIIP syndrome. The main quantitative cerebral hemodynamics and cranio-spinal hydrodynamics measures include 1) total cerebral blood flow, 2) venous outflow, 3) cranio-spinal CSF flow and stroke volume, 4) cranio-spinal compliance distribution, and 5) MR-derived intracranial pressure (MRICP).

Measurements of blood flow are an integral part of investigations of the CSF flow dynamics because the cranio-spinal CSF flow is driven by the difference between the arterial inflow and venous outflow to and from the brain (5).

Results

Median CPG scores of the short and long-duration cohorts were similar. 2. Mean preflight total CBF for the short and long-duration cohorts were similar, 863±144 and 747±119 mL/min, respectively. Percentage CBF changes for all short duration crewmembers were 11% or lower, within the range of normal physiological fluctuations in healthy individuals. In contrast, in 4 of the 8 long-duration crewmembers, the change in CBF exceeded the range of normal physiological fluctuation. In 3 of the 4 subjects an increase in CBF was measured. Large pre- to postflight changes in the cranio-spinal CSF flow volume were found in 6 of the 8 long-duration crewmembers. Box-Whisker plots of the CPG and the percent CBF and CSF flow changes for the two cohorts are shown in Figure 4. Examples of CSF flow waveforms for a short and two long-duration (CPG 0 and 3) are shown in Figure 5.

Conclusion

Changes in CBF and CSF flow dynamics larger than normal physiological fluctuations were observed in the long-duration crewmembers. Changes in CSF flow were more pronounced than changes in CBF. Decreased CSF flow dynamics were observed in a subject with VIIP signs. Study limitations include a slightly longer landing-to-MRI scan period for the short-duration cohort and limited sensitivity of the subjective discrete ordinal CPG scale. This limitation can be overcome by using imaging based parametric measures of VIIP severity such as globe deformation measures (7).

References and Acknowledgements

1. Hargens AR, Richardson S. Cardiovascular adaptations, fluid shifts, and countermeasures related to space flight. Respiratory physiology & neurobiology, 2009 169 Suppl 1 S30-1