NASA’S CURRENT EVIDENCE AND HYPOTHESIS FOR THE VISUAL IMPAIRMENT AND INTRACRANIAL PRESSURE RISK

Christian A. Otto1, Cherie M. Oubre2, Peter Norsk3, Charles R. Gibson3,4, William Tarver1, Michael R. Barratt1, Jennifer A. Fogarty2, and David R. Francisco5
1Universities Space Research Association; 2Wyle Integrated Science & Engineering; 3Coastal Eye Associates; 4University of Houston; 5NASA Johnson Space Center

INTRODUCTION

While 40 years of human spaceflight exploration has reported visual decrement to a certain extent in a subgroup of astronauts, recent data suggests that there is indeed a subset of crewmembers that experience refraction changes (hyperopic shift), cotton wool spot formation, choroidal fold development, papilledema, optic nerve sheath distention and/or posterior globe flattening with varying degrees of severity and permanence. Pre- and postflight ocular measures have identified a potential risk of permanent visual changes as a result of microgravity exposure, which has been defined as the Visual Impairment and Intracranial Pressure risk (VIIP). The combination of symptoms is referred to as the VIIP syndrome. It is thought that the ocular structural and optic nerve changes are caused by events precipitated by the cephalad fluid shift crewmembers experience during long-duration spaceflight. Three important systems, ocular, cardiovascular, and central nervous, seem to be involved in the development of symptoms, but the etiology is still under speculation. It is believed that some crewmembers are more susceptible to these changes due to genetic/anatomical predisposition or lifestyle (fitness) related factors. Future research will focus on determining the etiology of the VIIP syndrome and development of mechanisms to mitigate the spaceflight risk.

VIIP SYNDROME: SPACEFLIGHT DATA

To date 15 confirmed cases have been identified from the NASA Longitudinal Spaceflight Astronaut Health database. Shown are examples from 3 specific cases:

<table>
<thead>
<tr>
<th>ISS Crew Member</th>
<th>Mission Duration</th>
<th>Refractive Change</th>
<th>Intracocular Pressure (mmHg)</th>
<th>Funduscopic Exam Postflight</th>
<th>Disc Edema (Frisen)</th>
<th>OCT Postflight</th>
<th>Eye MRI Postflight</th>
<th>CSF Pressure Postflight (cmH2O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE 1</td>
<td>6 months</td>
<td>Preflight: 0D: +1.50 sph OS: -2.25-0.15x135</td>
<td>Postflight: 0D: +0.25-0.5x100 OS: -2.35x2.5x160</td>
<td>Preflight: 10 OU</td>
<td>Choroidal folds OD</td>
<td>Cotton wool spot OD</td>
<td>Choroidal folds still visible to the OD disc (R+5yrs)</td>
<td>MRI not performed</td>
</tr>
<tr>
<td>CASE 3</td>
<td>6 months</td>
<td>Preflight: 0D: -0.5 sph OS: -2.5 sph</td>
<td>Postflight: OD: Plato OS: Plato</td>
<td>Preflight: 10 OU</td>
<td>Bilateral disc edema OD&gt;OS</td>
<td>Small hemorrhage OD</td>
<td>Severe NFL thickening OD&gt;OS c/w disc edema</td>
<td>Optic nerve sheath distention OD</td>
</tr>
<tr>
<td>CASE 4</td>
<td>6 months</td>
<td>Preflight: 0D: -0.75-0.50x100 OS: Plato</td>
<td>Postflight: OD: -2.25 sph OS: -2.25x2.5x160</td>
<td>Preflight: 10 OU</td>
<td>Disc edema OD&gt;OS</td>
<td>Choroidal folds OD</td>
<td>Mild NFL thickening OD&gt;OS c/w disc edema</td>
<td>Optic nerve sheath distention and choroidal folds OD</td>
</tr>
</tbody>
</table>

(OD=right, OS=left, OU=both eyes, sph=sphere, OCT=optical coherence tomography, MRI=magnetic resonance imaging, CSF=cerebral spinal fluid, NFL=retinal nerve fiber layer, R+=return to Earth; [presented by number of days, for example, R+19 is 19 days after return to Earth]).

HYPOTHESIS: POTENTIAL INTERACTION OF VASCULAR, CNS & OCULAR SYSTEMS IN SPACEFLIGHT

IMAGE GALLERY OF REPRESENTATIVE CASES

- Fundoscopy image of Case 1 showing choroidal folds (A) and a cotton wool spot (B).
- Optical Coherence Tomography (OCT) data from Case 3 showing retinal nerve fiber layer thickening of both eyes (OD and OS). (NASA image)
- 3T Magnetic Resonance Imaging (MRI) showing papilledema (grade 1), globe flattening, optic nerve sheath distention and optic nerve tortuosity in Case 4.

ACKNOWLEDGEMENTS

This work was funded by NASA. We thank Dr. Susana B Zanello (USRA) for poster composition and design.