NASA’s Evidence Report: A New Look at Mechanisms and Risks

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Case Report*

- 57 year old male astronaut

- 6 month mission 2003
  - Noted decreased near visual acuity 6 weeks into mission
  - Choroidal folds (OD)
  - Cotton wool spot (OD)

- 6 month repeat mission 2011-12
  - Choroidal folds more widespread (OD)
  - New onset of disc edema (OD)
  - LP opening pressure 18 cmH₂O, 8 days post-mission
  - Expansion of optic nerve sheath diameter and globe flattening noted pre- and post- second mission by MRI and ultrasound (OU).
  - Normal intraocular pressures during mission (OU)

After first space mission  2003
Before second space flight
2011
Five months into 2011 flight on ISS (OD)
2 days after second (2012) space flight (OD)
OCT (A) pre-flight, (B) 2 days post flight, (C) 52 days post flight (2012)
T2 MRI (3 Tesla) pre flight (2011) and 6 days post flight (2012)
Conclusions from case report:

- **Normal LP opening pressure** in presence of disc edema and bilateral ONSD enlargement suggests increased intracranial pressure may not be the etiology.

- Microgravity induced anatomic changes that occurred during the first mission may **set the stage** for recurrent or additional changes when the astronaut was exposed to repeat space flight.

- “**Resetting**” of optic nerve sheath diameter may have occurred during first mission (Hansen et al).

- Disc edema occurred in the presence of normal IOP, so **hypotony is an unlikely cause** of his disc edema.
How Does This Case Impact the Evidence Report?

- Currently, the increased intracranial pressure hypothesis is described as most likely to account for eye/optic nerve findings. For a more balanced approach, consider including compartment syndrome as an alternative etiology.

- Perhaps optic nerve/eye anomalies on one mission should be considered risk factors for subsequent missions.
Intracranial Hypertension Theory

• Arguments for:
  • **Increased LP opening pressures** (22, 21, 28, 28.5 cm H$_2$O, performed 60, 19, 13, and 57 days post mission)
  • **Moderate concavity** of pituitary gland by MRI in 3 astronauts
  • **Terrestrial IIH** has very similar objective findings (disc edema, globe flattening, enlarged subarachnoid space, hyperopic shift)

• Arguments against:
  • Most measured post flight opening pressures in normal to borderline range
  • No IIH-like symptoms in astronauts (no chronic headaches, tinnitus, diplopia, etc.)
  • CWS not common with IIH
Optic Nerve Compartment Syndrome
Another Possible Mechanism of Disc Edema

- Usually assumed that there is **homogeneity of pressure** between intracranial CSF and CSF in the SAS of the optic nerve sheath.

- CSF flow within the SAS of the optic nerve sheath has a **fragile flow equilibrium** even on Earth (Killer, et al.)

- Perhaps microgravity fluid shifts cause alterations in CSF flow dynamics and lead to **sequestration** of CSF in the SAS of the optic nerve sheath.

- May produce a **compartment syndrome** in the absence of increased intracranial pressure.
Compartment Syndrome Theory

- **Arguments for:**
  - **Terrestrial analogy**: persistent papilledema in IIH patient despite functioning lumboperitoneal shunt.
  - **Normal** lumbar puncture opening pressure in the presence of disc edema in some astronauts.

- **Arguments against:**
  - **No confirmation** of normal LP opening pressures during space flight.
If the End Result is the Same, Why is the Etiology of Disc Edema Important?

- Treatment: Diamox, a major treatment modality for IIH, may have little effect on lowering SAS sheath pressure but will lower intraocular pressure. This scenario could worsen disc edema.

- Measuring optic nerve sheath diameter by ultrasound as a surrogate measure of ICP may be invalid.
Worsening of Eye Findings during Subsequent Mission: The Implications

- Should an astronaut with ocular findings on a previous mission fly on a repeat mission? Orbital? Interplanetary?

- Should six months’ orbital flight be purposely used as a means of astronaut selection for long interplanetary missions? (a screening tool)
Conclusions

- Consider optic nerve *compartment syndrome* as a possible etiology of disc edema.

- Microgravity-induced anatomic changes (disc edema, choroidal folds, etc.) may be *risk factors* for future missions.

- Optic nerve sheath may undergo “resetting” during long missions.

- Ocular *hypotony* is an unlikely cause of findings.