Do Astronauts Develop Papilledema?

Neil R. Miller, MD FACS
Professor of Ophthalmology, Neurology & Neurosurgery
Frank B. Walsh Professor of Neuro-Ophthalmology
Johns Hopkins Medical Institutions
Baltimore, MD USA
Topics to be Discussed

• What causes optic disc swelling?
• What are the symptoms of increased intracranial pressure and do the astronauts have any of them?
• What does papilledema look like?
• What do the astronaut fundi look like?
• What is the pathogenesis of papilledema?
• How can we assess the cause of the visual phenomena experienced by the astronauts?
The Problem

- Increased intracranial pressure
- Ischemia
- Inflammation/infection
- Compression
- Infiltration
- Toxic exposure
- Metabolic disorders
- Trauma

Optic Disc Swelling
Optic Disc Swelling

Optic Neuritis  Papilledema  AION
Optic Nerve Glioma
Sarcoidosis (granulomas)
Symptoms of Increased Intracranial Pressure

- Headache
- Tinnitus (usually pulsatile)
- Occ nausea/vomiting
- Lethargy/decreased consciousness
Common Characteristics of 10 Reported Cases

- None complained of headaches, transient visual obscurations, nausea, or pulsatile tinnitus
- Some developed hyperopic shift (posterior globe shifted forward)
Papilledema

- Optic disc swelling from increased intracranial pressure
- Painless
- May have transient (seconds) obscurations of vision
- Usually no loss of visual acuity or visual field until many nerve fibers have been destroyed; then rapid loss (edge of cliff analogy)
- Initially damages visual field without loss of visual acuity
- Change in refraction (eg, hyperopia) not present
- Loss of central vision occurs at end unless hemorrhages, exudates, or subretinal fluid in macula; thus, not a good measure of early severity or prognosis
Papilledema

• Several grading systems used
• Most common is by Lars Frisén (1-5)
MR Imaging in Papilledema
1) No evidence of severe disc swelling
2) No concentric folds
Pathogenesis of Papilledema

- Associated with blocked fast and slow axon transport
- But why is axon transport blocked???
Pathogenesis of Papilledema

• Mechanical
• Ischemia
• Biochemical (toxic)
Pathogenesis of Papilledema

• Mechanical
  – Occurs only when there is patency of the subarachnoid space surrounding the optic nerve
  – Blocking SAS in animal model of increased ICP prevents development
  – Transmission of raised ICP to RGC axons
Pathogenesis of Papilledema

- **Ischemia**
  - Autoregulation is abnormal in prelaminar and retrolaminar regions of optic nerve
Pathogenesis of Papilledema

- **Biological (toxic)**
  - The subarachnoid space (SAS) is trabeculated
  - CSF thus confined
  - Increase in toxic protein(s) causes toxic reaction and papilledema
Pathogenesis of Papilledema

- L-PGDS (Betatrace protein)
  - Prostaglandin D synthase
  - Belongs to the family of lipocalins responsible for binding and transporting small lipophilic molecules
Pathogenesis of Papilledema

- L-PGDS can interfere with ON metabolism in vitro through its effects on astrocytes and their mitochondria
  - Xin X et al.

- There is an increased concentration of L-PGDS in the SAS surrounding the optic nerve in patients with idiopathic intracranial hypertension
  - HE Killer et al.
Conclusions

• The ophthalmic findings are not due to increased ICP but more likely due to local fluid shifts

• Testing of visual function: VA, CV, VF unlikely to provide any more information
  – Consider electrophysiological testing: VEP, mfERG, ffERG, PERG

• Testing of structural abnormalities: MRI, OCT also unlikely to be helpful
  – Consider measuring ocular/orbital blood flow: Ocular blood flow analyzer (Paradigm Dicon)? Color Doppler (consult Alon Harris at U of Indiana?)

• The only way to determine if astronauts developed increased ICP during flight is to measure it directly or indirectly