Spaceflight-Induced Intracranial Hypertension An Overview

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Historical

- Gemini 5 (8 day mission)
  - Visual Tester in-flight
  - Visual acuity measurement program
  - Large rectangles at ground sites in Texas and Australia.
  - No changes noted in astronaut visual acuity postflight.
  - Duntley et al, 1966
- Apollo
  - Retinal vascular photography reveals retinal vessels “decreased in size” at 3.5 hours into flight.
  - 100% oxygen atmosphere
  - No visual acuity changes
  - Hawkins and Zieglschmid, 1975

Shuttle

- 10-14 day missions
- Anecdotal reports of vision changes, but return to baseline.
- 1 astronaut with bilateral lens implants
- No papilledema cases, but an occasional choroidal fold.
- 122 crewmembers between 1995 and 1998, 15% indicated decrements in near vision on orbit. Returns to baseline.
- Paloski et al 2008

Differences Between Historical and Present

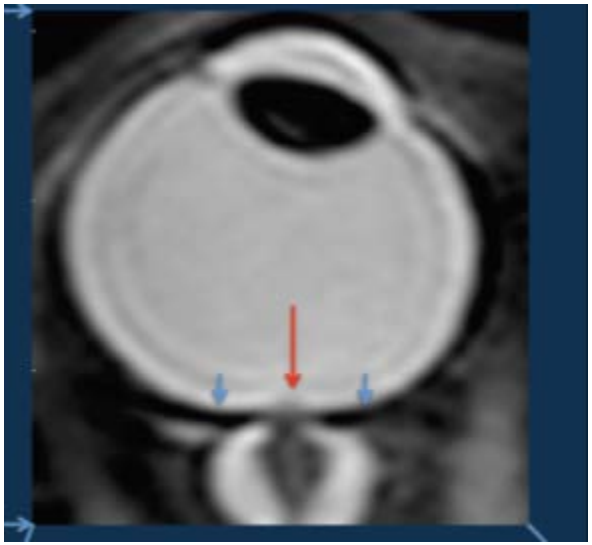
- Missions were 5 to 17 days generally (Skylab a notable exception)
- Astronaut age was mean of 38
- MRI and OCT not available
- Spacecraft ranged from 5.0 psi to 10.7 psi to 14.7 psi with varying oxygen concentrations
- Missions average 6 months on ISS
- Astronaut mean age 46.7
- MRI, OCT, Telemedicine fundoscopy
- 14.7 psi, 21% oxygen
- Robust exercise suite

Spectrum

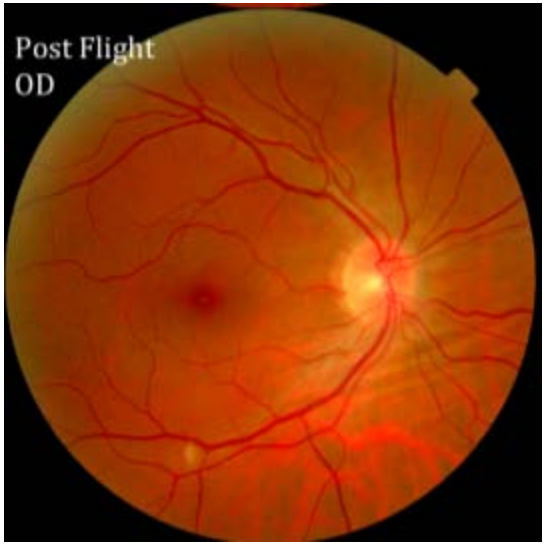
- **What is the problem?**
  - Optic Disc Edema, Globe Flattening, Choroidal Folds, Hyperopic Shifts and Raised Intracranial Pressure has occurred in Astronauts During and After Long Duration Space Flight

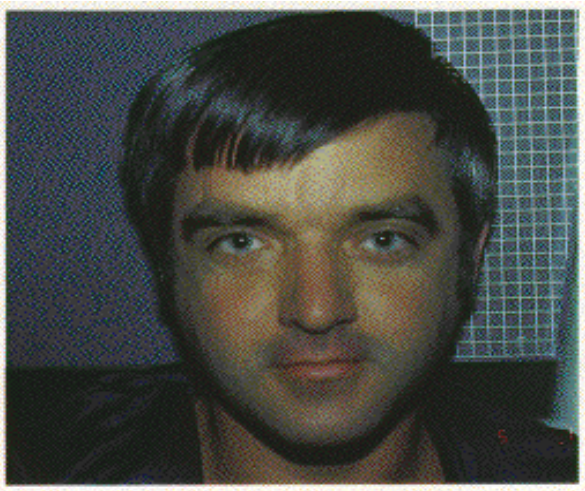
Optic Disc Edema

Globe Flattening



Choroidal Folds



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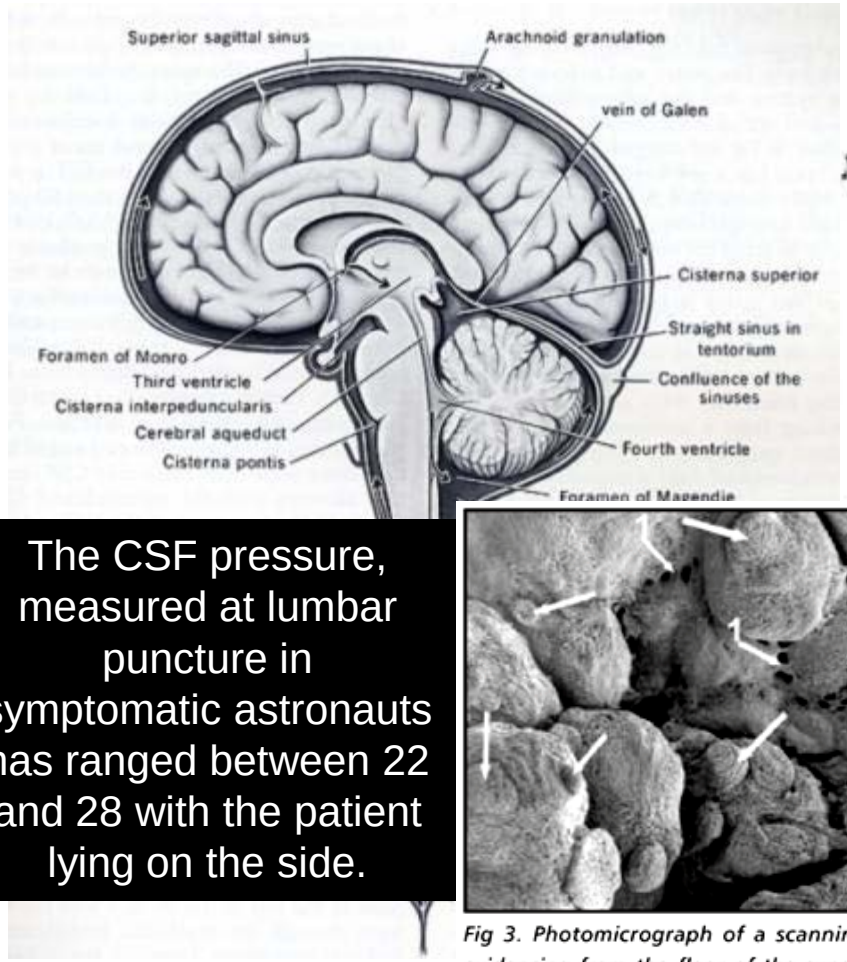
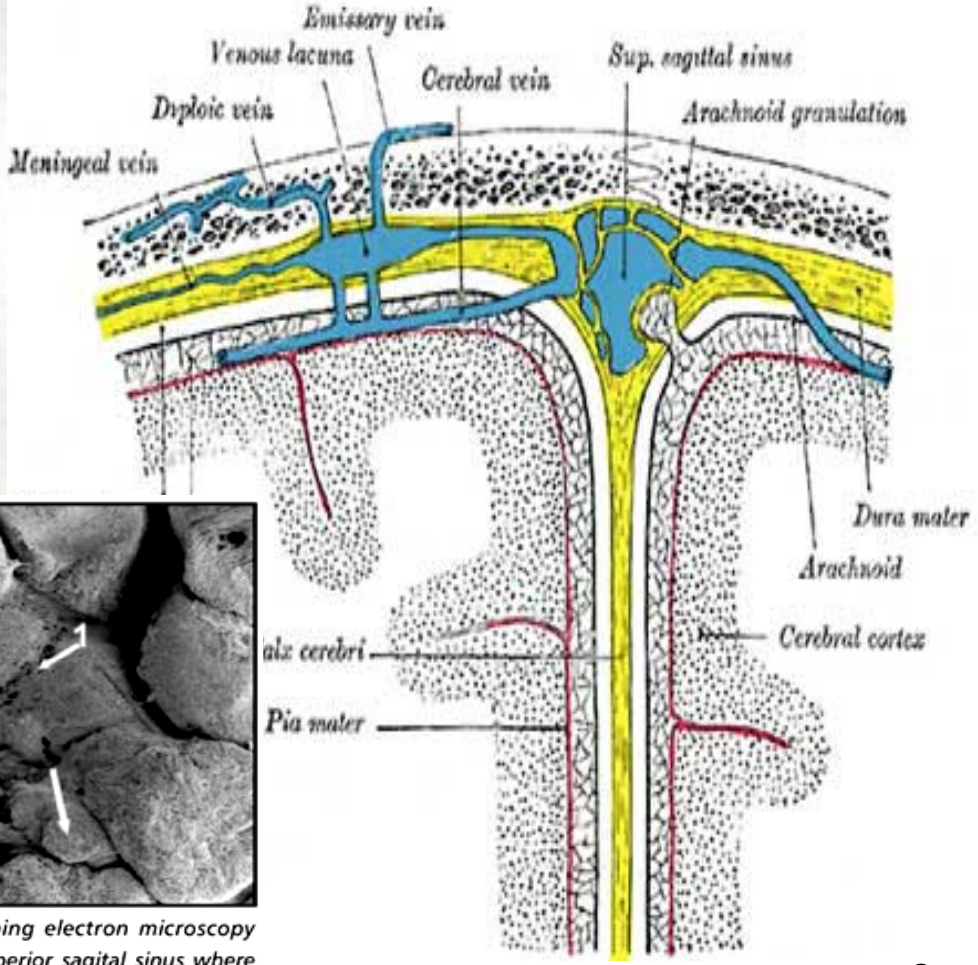
Arachnoid Granulations and Venous Return





The CSF pressure, measured at lumbar puncture in symptomatic astronauts has ranged between 22 and 28 with the patient lying on the side.

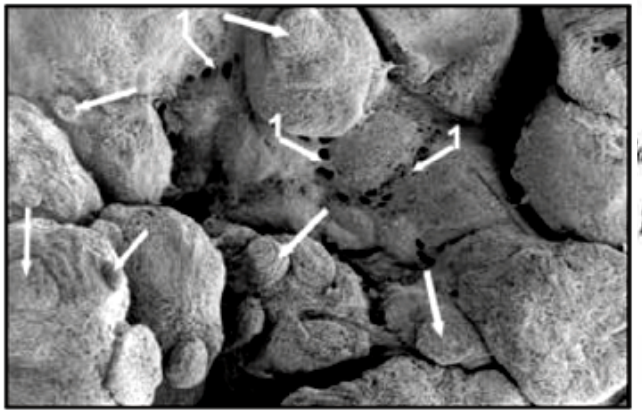
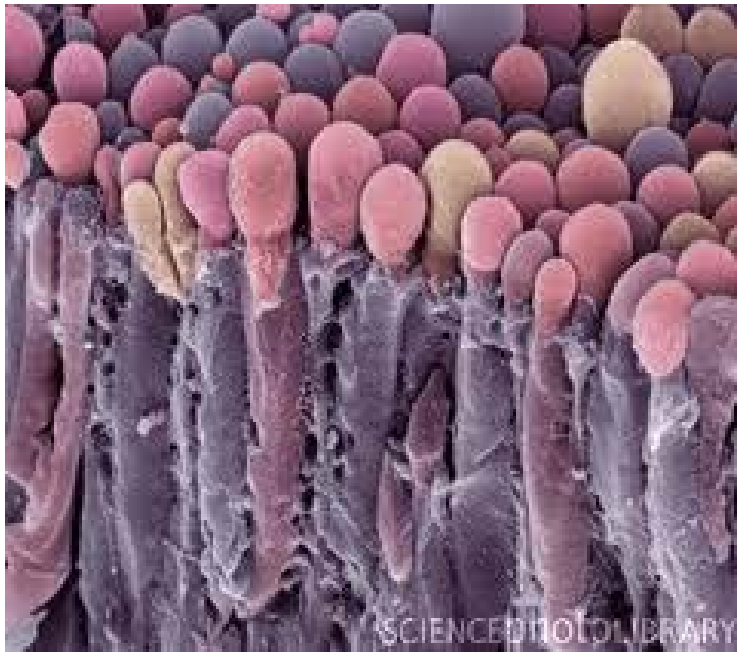


Fig 3. Photomicrograph of a scanning electron microscopy evidencing from the floor of the superior sagital sinus where clustered arachnoid granulations are preent. Observe different sizes and shapes of the lobules (arrows) and small bundles of collagen fibers linking the granulations. 20x.

Spinal or Venous Compliance Issue?

Choroid Plexus?



- Does the increase in blood flow, either through fluid shift, CO2 vasodilatation, or other mechanism increase CSF flow or production?

Potential Plateau Effect Versus Continued Evolution

- Of the observed on-orbit papilledema, it seemed to stop at the grade 1 to 2 level and did not progress over the next month or two before de-orbit. May be a function of plateau homeostasis at the higher level of Intracranial Pressure.
- However, one crewmember continued an evolution of pathology, and developed a cotton wool spot on exam several weeks after returning to Earth.

Current Evidence Base

- Summary
  - 7 long duration male astronauts have experienced in flight and post flight symptoms including optic disc edema, globe flattening, choroidal folds, hyperopic shifts and raised intracranial pressure (summary in the following slide)
  - In some of the cases these changes were transient and in others the changes are persistent with varying degrees of visual impairment
  - 3.0 Tesla MRI showed some evidence of thickening in asymptomatic individuals, including one female astronaut, but without significant hyperopic shift of papilledema
  - There are also indications that visual and eye anatomy alterations have occurred on shuttle flights: not well defined and lack consistent data…

Cases in Review

- 7 cases, 3/7 had a total of 5 spinal taps. All taps had high opening pressures. Opening pressures remained above 20 for periods of greater than 18 months.
- 2/7 were treated. 1 responder, 1 non-responder, with same dosage of Diamox. One also failed steroid therapy.
- 7/33 for an incidence rate of 21%.
- Pertinent negatives: 2 astronauts (one male and one female) with dual 6 month missions, without papilledema or choroidal folds.

Current Treatment Options, Risk Trades

- Acetazolamide
  - Oral twice daily
  - Effective in pressure related ICP rises (altitude sickness)
  - Studies have shown limited effectiveness in ICP secondary to venous causes
  - Increases risk of kidney stones
- Octreotide
  - Daily subcutaneous injections
  - Effective in pressure related ICP rises in small n studies, but has not had large scale studies.
  - Increased risk of gall stones.

The Elephant in the Room

- Is Vision the only system? Is it permanent?
- Hearing?
- White matter decay?
- Leukoencephalopathy?

- Ie- What is the long-term effect of low grade intracranial hypertension/

Clinical Implications

- Potential disability secondary to vision loss in astronauts susceptible to papilledema or choroidal folds
- Potential for long-term sequelae if optic nerve cells ischemic
- Potential effect on white matter
- Decreased functional ability due to IIH
- Unknown contribution to space motion sickness, asthenia, or functional impairments
- Potential to worsen with repetitive flights or long term space missions

Does
Spaceflight Induced Intracranial Hypertension
= Idiopathic Intracranial Hypertension?
Or
are the separate entities with a common outcome?