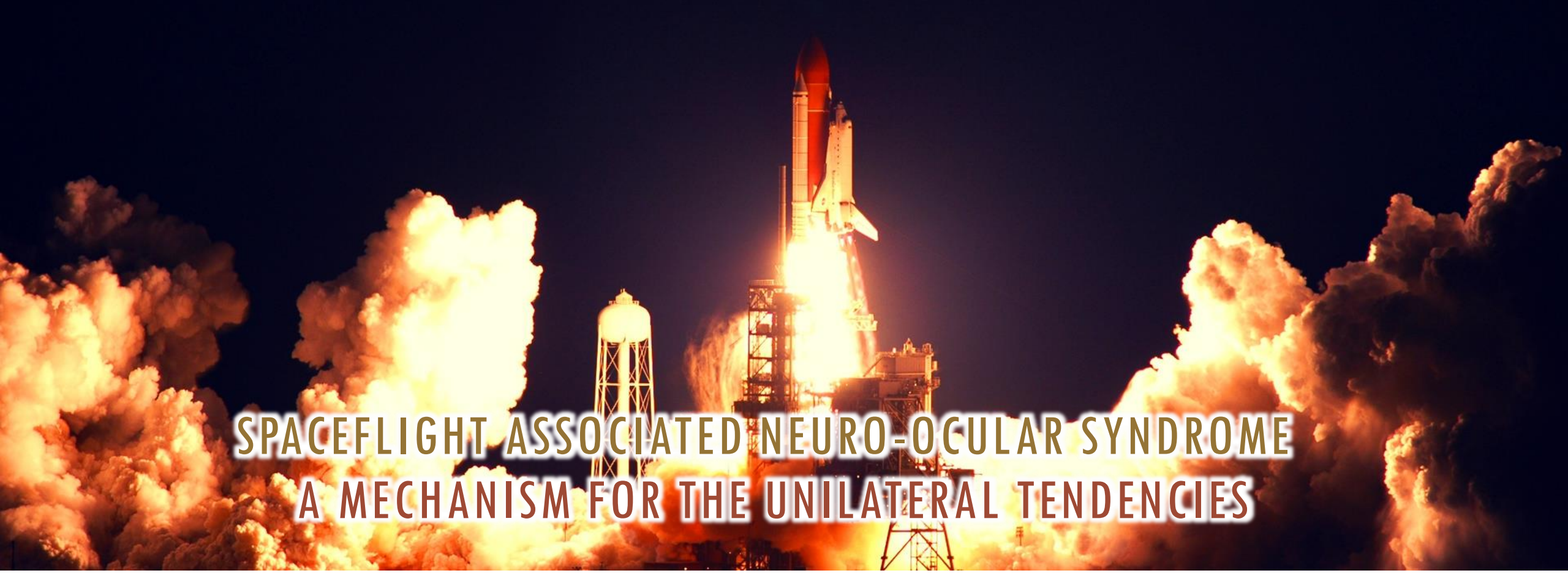

SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME A MECHANISM FOR THE UNILATERAL TENDENCIES

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DISCLOSURE INFORMATION

89TH ANNUAL SCIENTIFIC MEETING

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UNILATERAL TENDENCIES

Many of the reported cases of Spaceflight Associated Neuro-Occular Syndrome (SANS) show a bias toward the right side. (Wall et al., 1998, Mitchell et al., 1992, Lepore et al., 1992, Alperin et al., 2013, Sher et al., 1983, King et al., 1990, Huno-Baron et al., 2001, Sedwick et al., 1983)

When reviewing these cases, it becomes apparent that SANS is biased toward the right orbit about 45-75% of the time.

45-75%

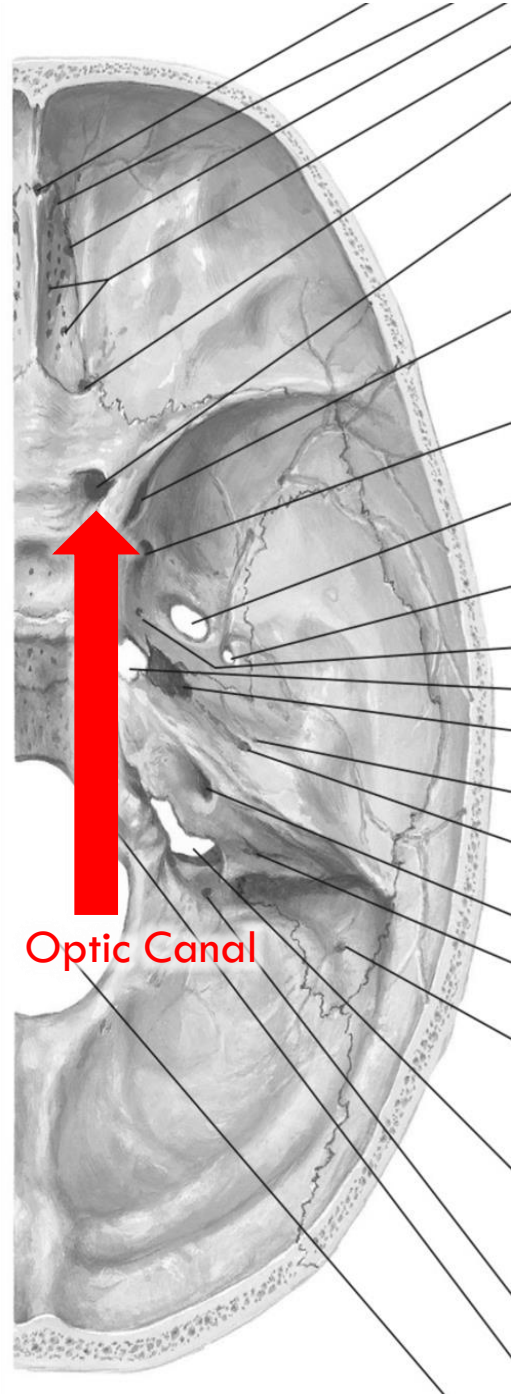
THEORY 1

Asymmetric bias is also often found in Idiopathic Intracranial Hypertension (which has some similarities to SANS).

Bidot et al.'s suggestion for IIH is that the asymmetry in IIH may be due to asymmetric optic canal diameter.

This is plausible, but unlikely, at least when it comes to SANS (Bidot et al., 2015) since IIH asymmetry can be either left or right sided, but SANS asymmetry most affects the right side.

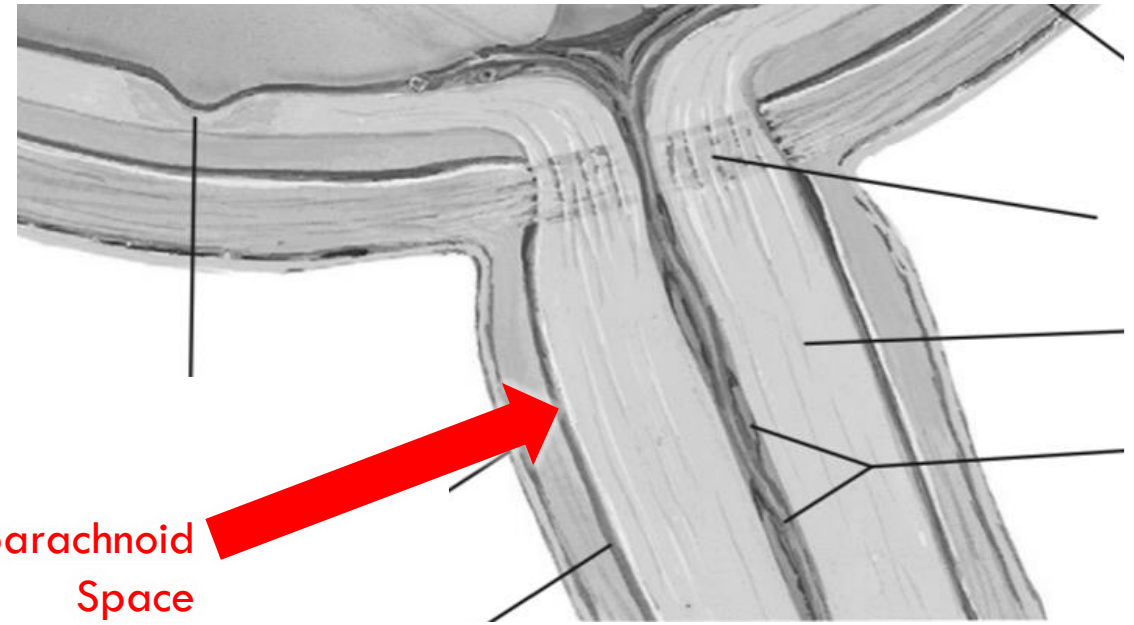
Mader et al. suggests that finding this consistency (of asymmetric optic canal diameter) in astronauts is unlikely for a few reasons including that in one "astronaut case report, a normal opening pressure on lumbar puncture was documented after a mission in the presence of asymmetric disc edema" (Mader et al., 2016).



Mader et al. says that in that same astronaut they found unilateral loss of spontaneous venous pulsations in the same eye during space flight that continued to be absent 21 months post-flight (Mader et al., 2015).

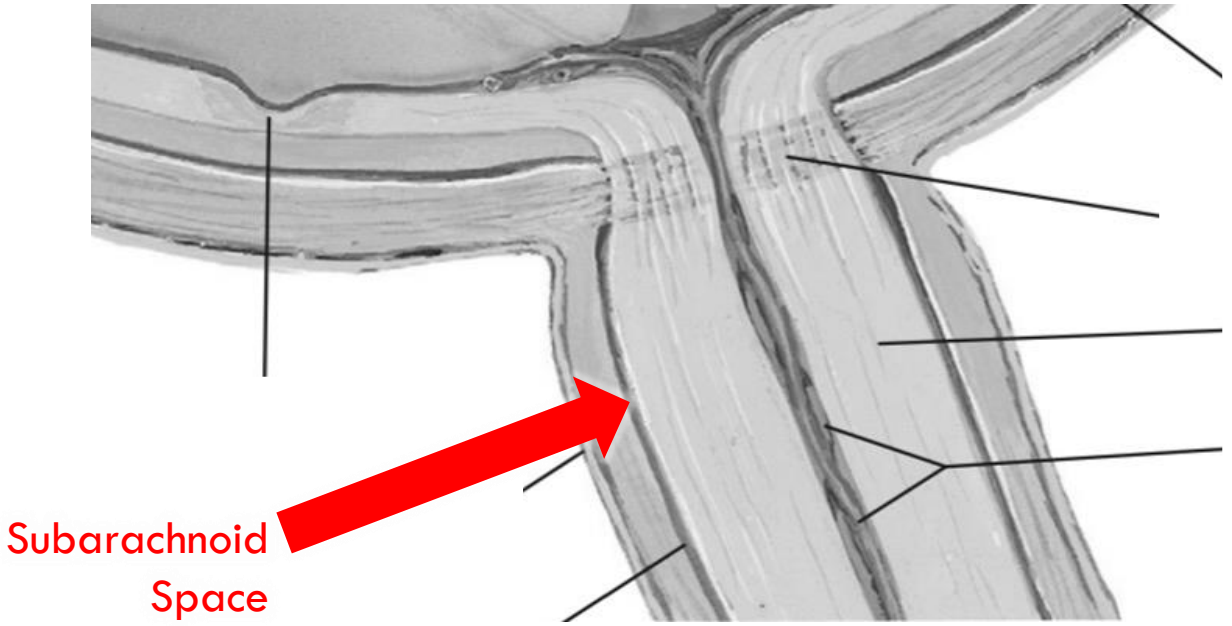
In a recent case of an astronaut with asymmetric optic disc swelling and globe flattening, Mader et al. suggested this unilateral nature of SANS may be due to asymmetric pressure changes within the perioptic subarachnoid space - this based on lumbar puncture opening pressures 7 and 365 days post-flight (Mader et al., 2017).

THEORY 2



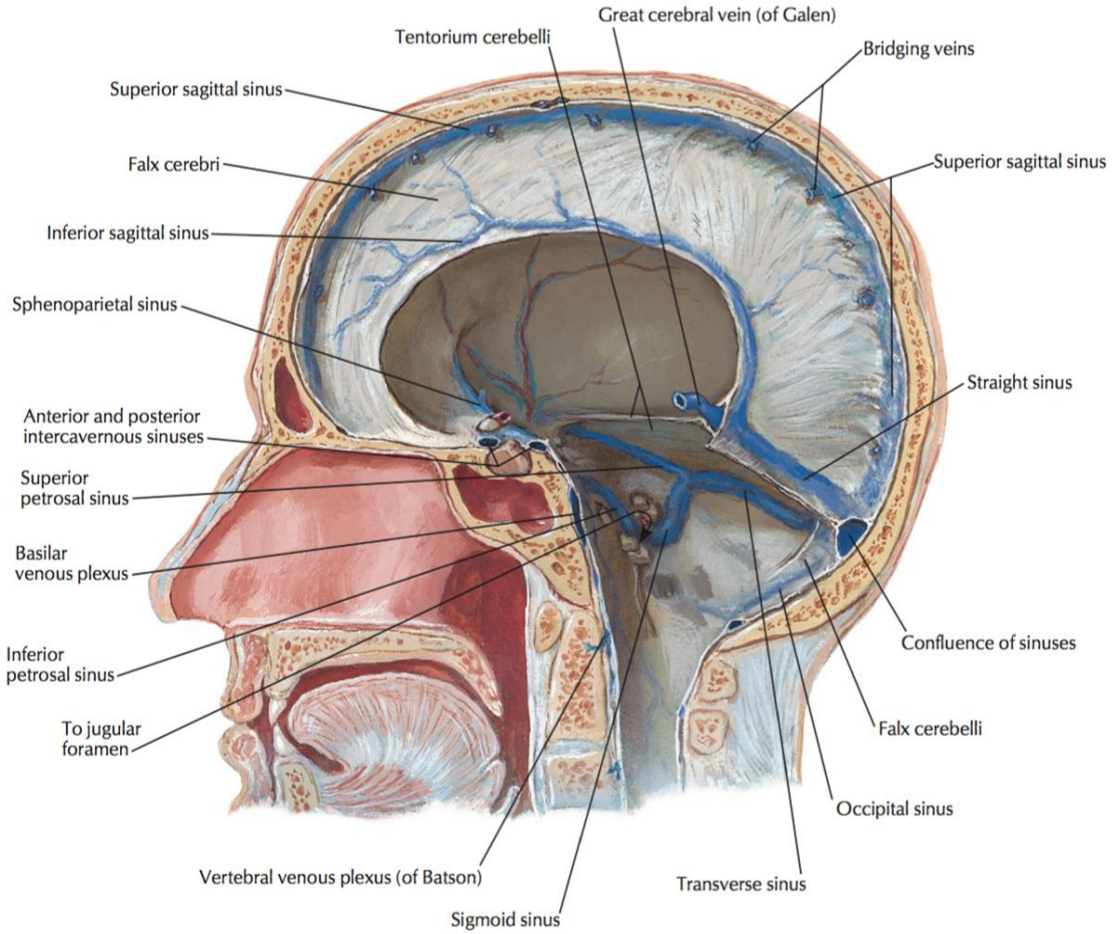
OUR THEORY

Explains Mader et al.'s theory, but digs deeper into why there may be differences between the R and L pressures in the perioptic subarachnoid space.



OUR THEORY

An asymmetry of venous drainage sinuses near the orbits may be a stronger contributing factor than asymmetric optic nerve diameter suggested by Bidot et al., 2015, and may be a major contributor to Mader et al.'s theory of asymmetric pressure changes within the perioptic subarachnoid space.



REVIEW OF ORBITAL BLOOD DRAINAGE

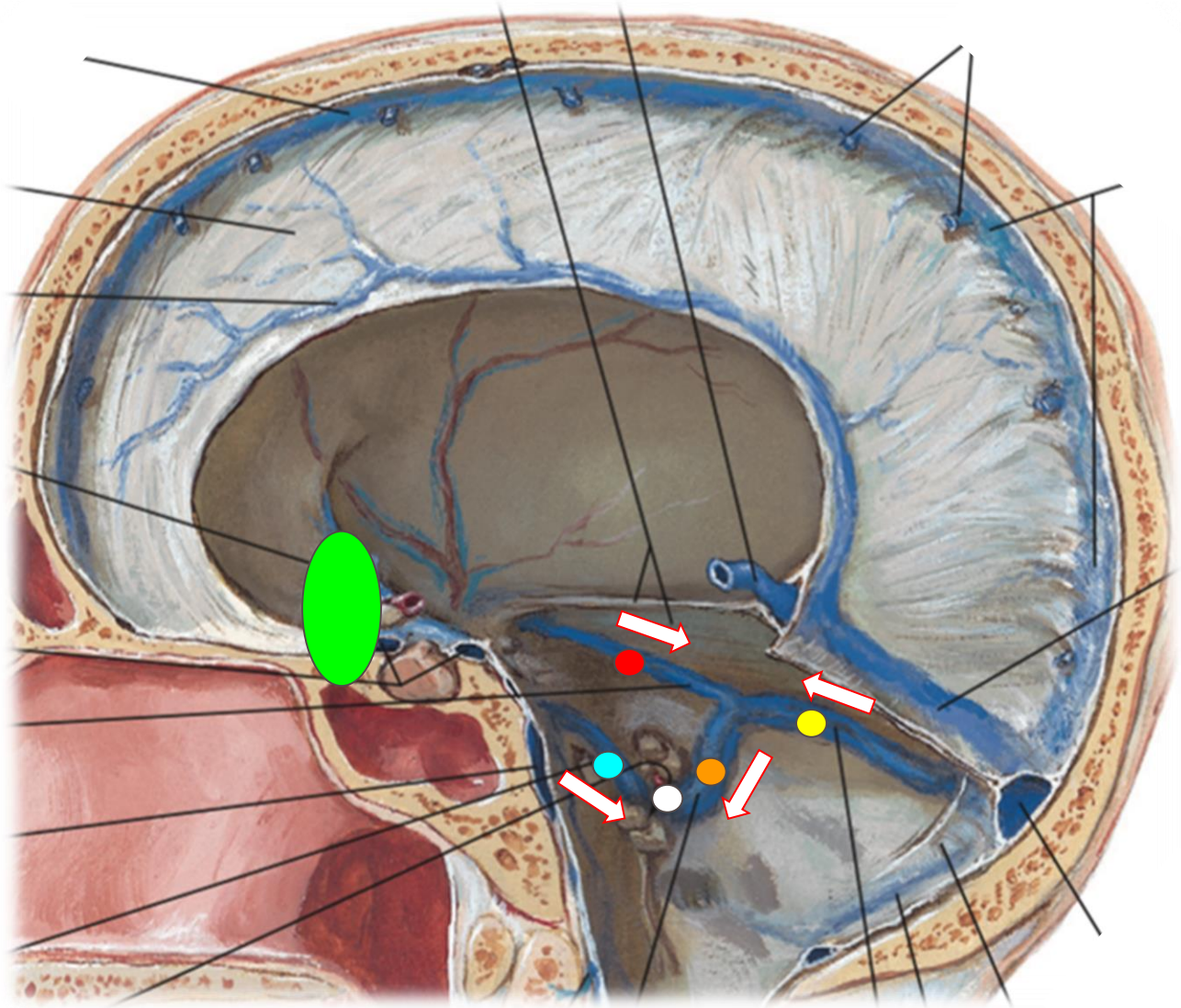
Blood from the orbit first enters the: Cavernous Sinus

From there, it goes to the: Superior Petrosal Sinus

- Where it combines with the: Transverse Sinus
- Then goes to the: Sigmoid Sinus
- And drains into the: Internal Jugular Vein.

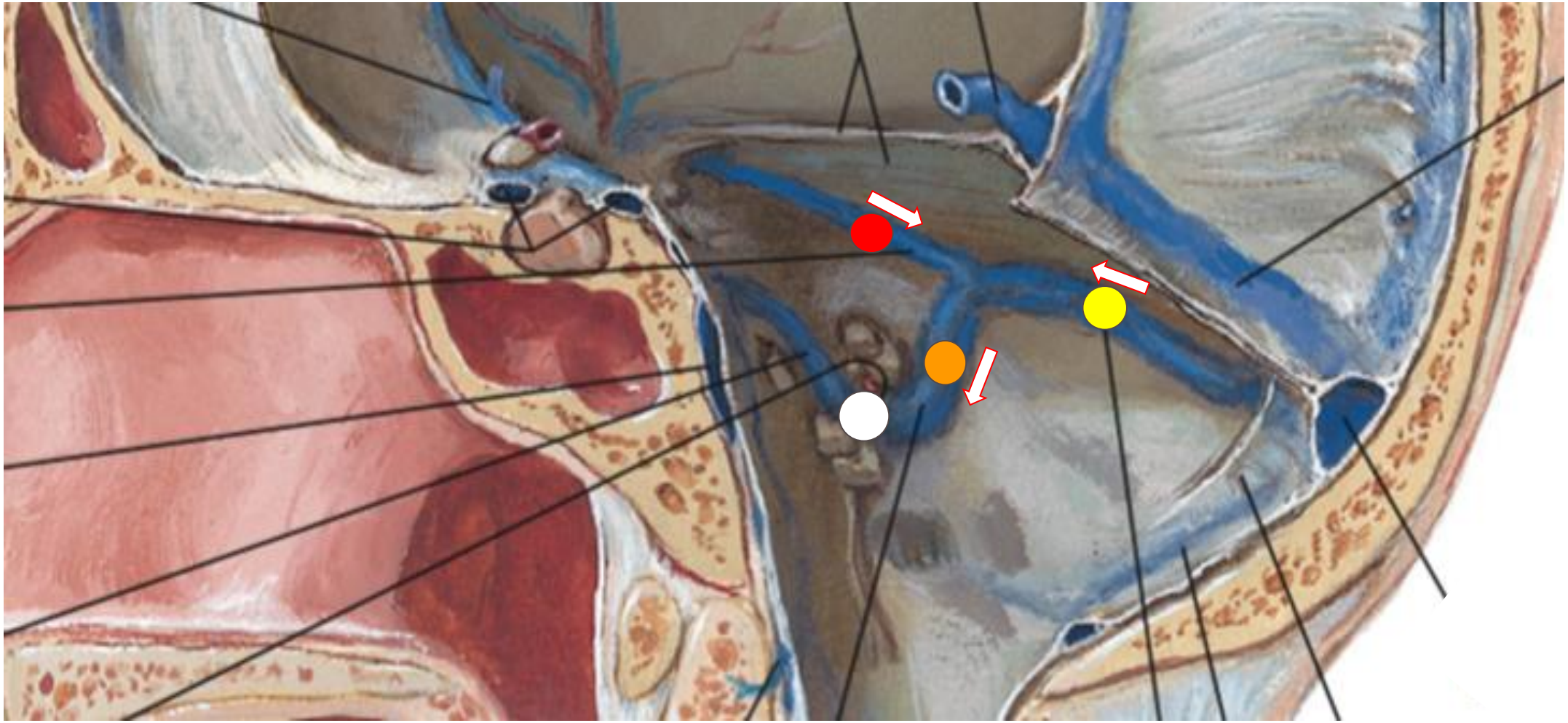
The Cavernous Sinus also drains into the: Inferior Petrosal Sinus

- Which also drains into the: Internal Jugular Vein.



Blood from the Cavernous Sinus goes to the: Superior Petrosal Sinus

- Where it combines with the: Transverse Sinus
- Then goes to the: Sigmoid Sinus
- And drains into the: Internal Jugular Vein.



TWO MRI STUDIES

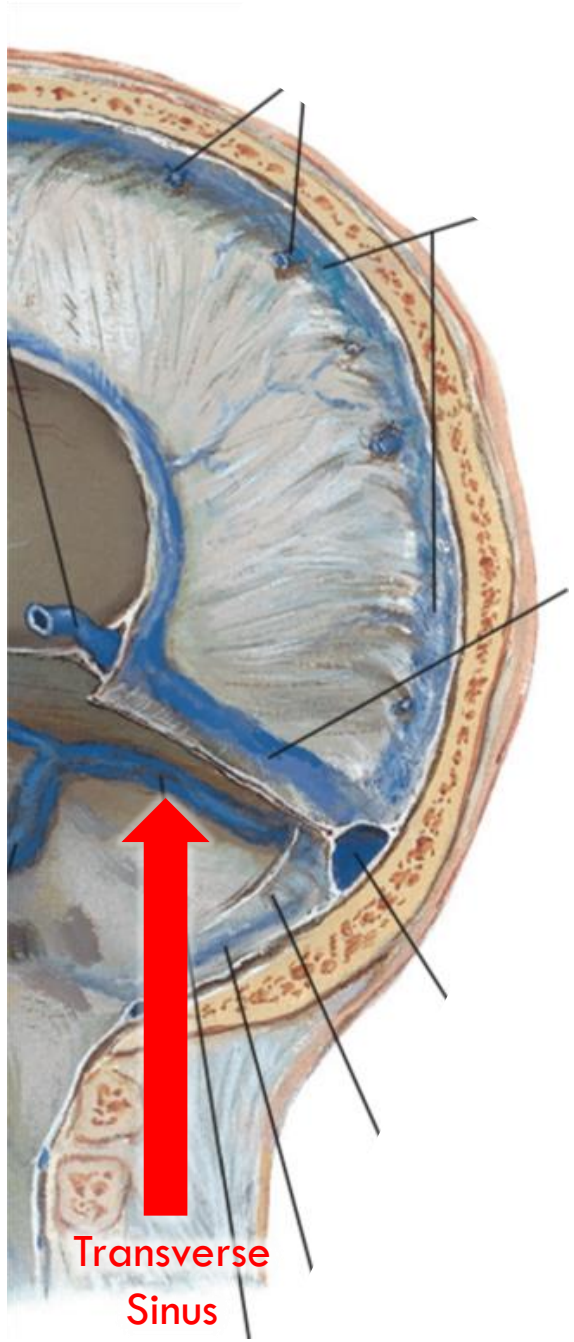
There is a well established, large populational asymmetry in the transverse sinus.

Study 1: Ayanzen et al. 2000

- 100 MRI cases, transverse sinus flow gaps were observed in as many as 31% of patients with normal MR imaging findings.
- More surprisingly, the transverse sinus was found to be right dominant 59% of the cases, left dominant in 25%, and codominant in 16%.

Study 2: Scotti et al. 1988

- 105 MRI cases, twenty-one (20%) cases had aplasias of the left sinus and 41 (39%) had hypoplasias of the left sinus.
- 33 (31%) were symmetric, 6 (6%) had hypoplasia of the right sinus, and 4 (4%) had aplasias of the right sinus.



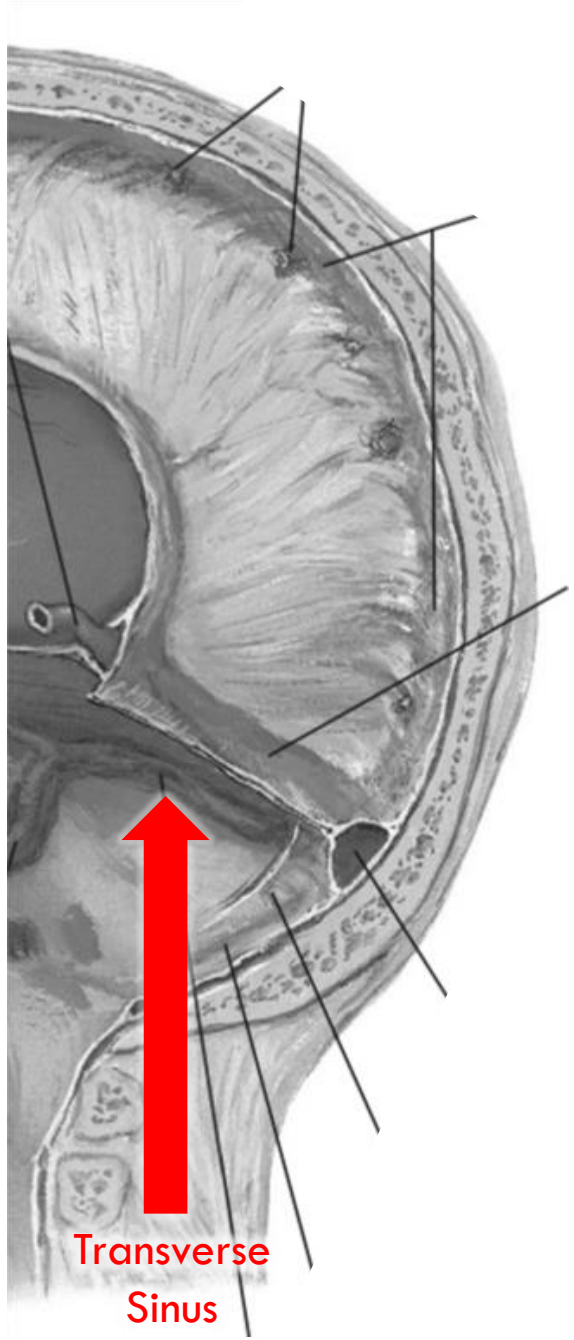
WHAT THIS MEANS

Approximately 60% of the population has a right dominant Transverse Sinus.

In this 60% of the population, the right venous sinuses are responsible for draining significantly more venous blood than the left venous sinuses.

Could the fluid shift that causes cranial venous pooling lead to too much venous volume and pressure in the dural sinuses on the right side?

- This could lead to increased strain on the right Superior Petrosal Vein
- This would explain why the right eye is more affected than the left.
- It would also support Mader et al.'s idea that there may be "asymmetric pressure changes within the perioptic subarachnoid space"

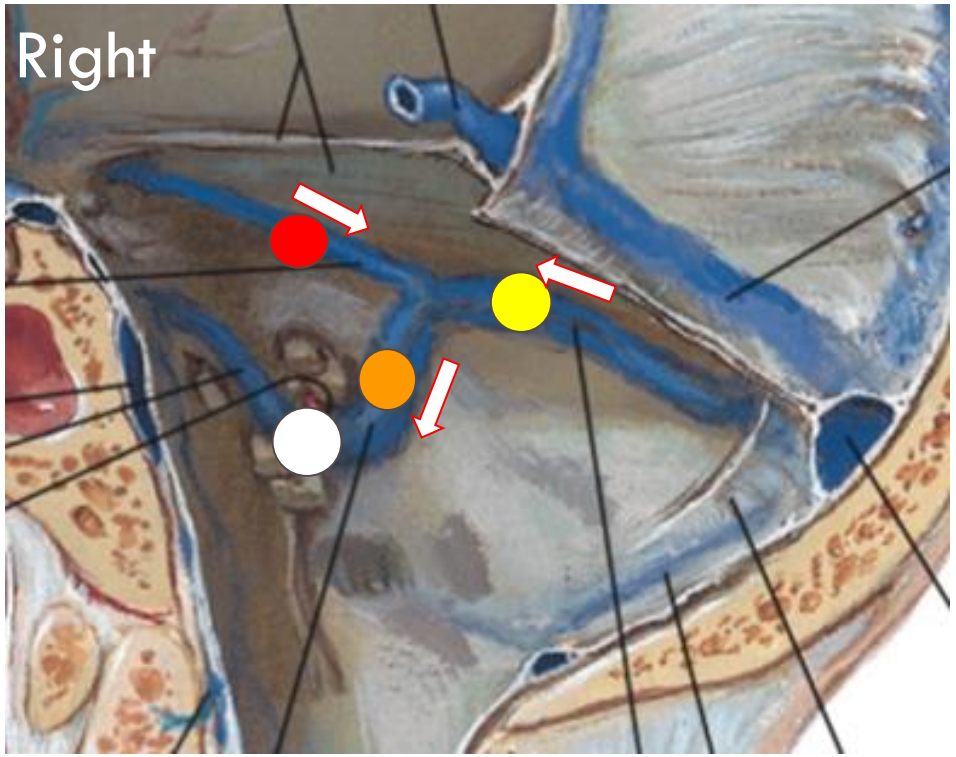


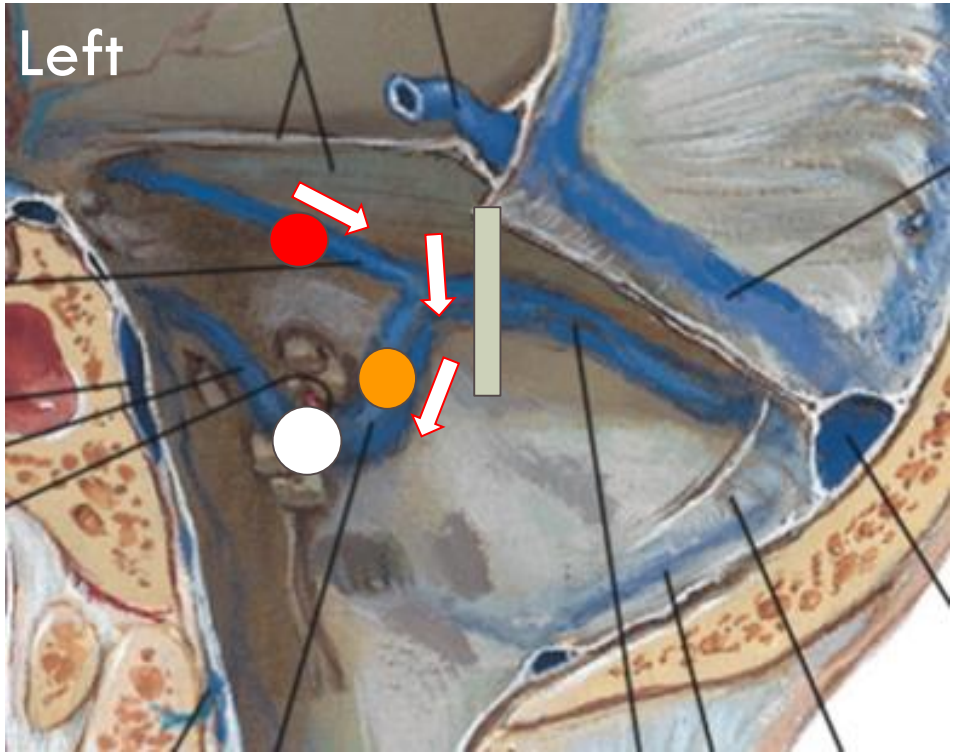
WHAT THIS MEANS

All of which is in addition to the already elevated venous pressures caused by microgravity mediated fluid shifts (which cause cranial venous pooling)

A right side dominant Transverse Sinus means:

- Less Laminar flow
- More venous drainage requirement on the Sigmoid Sinuses
- Increased Venous Pressure





ALL TOGETHER

Elevated venous pressure due to the fluid shifts of microgravity could mean:

- Elevated strain on the venous network of the brain
- Decreases in total CSF drainage

Even more elevated right sided venous pressure due to right dominant Transverse Sinus could mean:

- Additional strain on the right sided orbital venous mechanisms
- Additional strain on right sided CSF drainage mechanisms
    - Elevated right sided perioptic subarachnoid space pressures (as Mader et al. suggests)

Signs/Sx of SANS (predominant on right)

RECOMMENDATIONS

- Review astronaut MRIs retrospectively/prospectively
- Compare venous sinus drainage patterns in astronauts affected by and not affected by SANS

Right

Left

- Analyze if there is a statistically significant contribution from transverse venous sinus dominance to the development of SANS

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