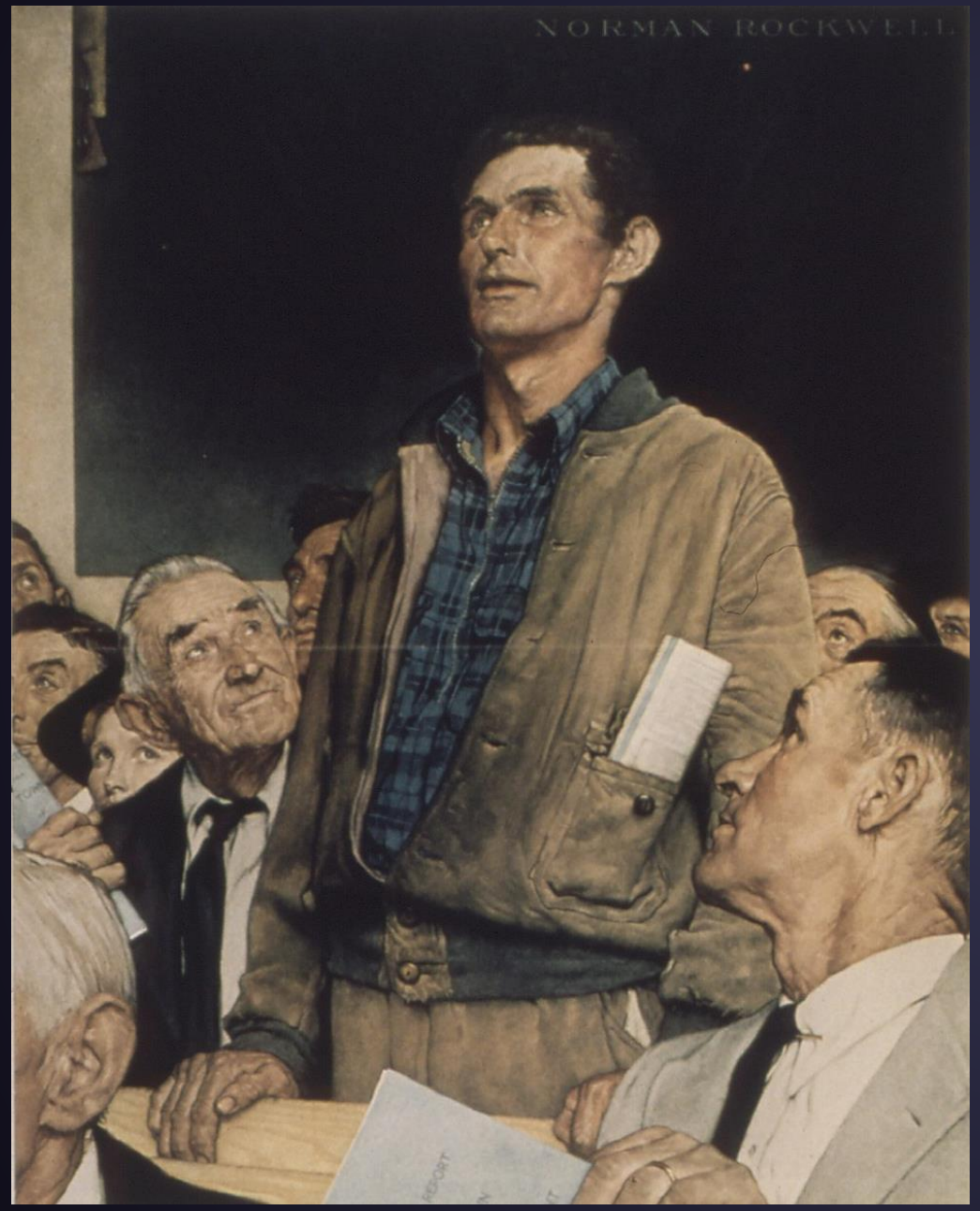


What happens when you stand up:

physiology of skull base vs spinal CSF leak

Peter G. Kranz, M.D.
Associate Professor of Radiology
Division Chief, Neuroradiology
Duke University Medical Center
peter.kranz@duke.edu

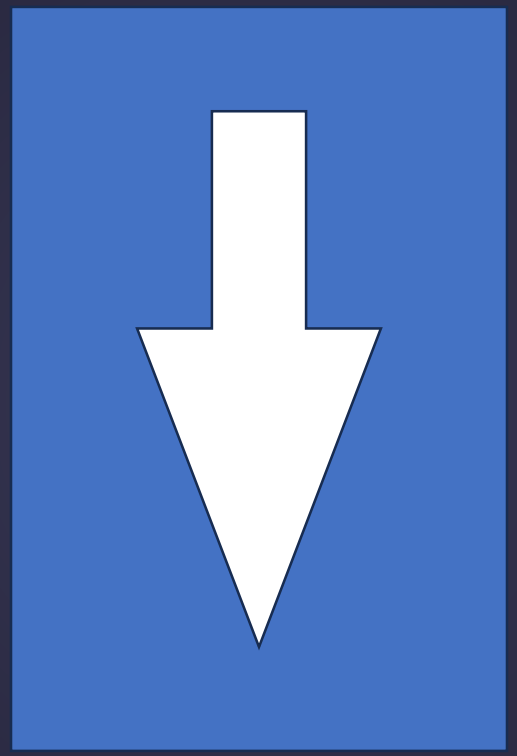
Duke Radiology

Disclosures

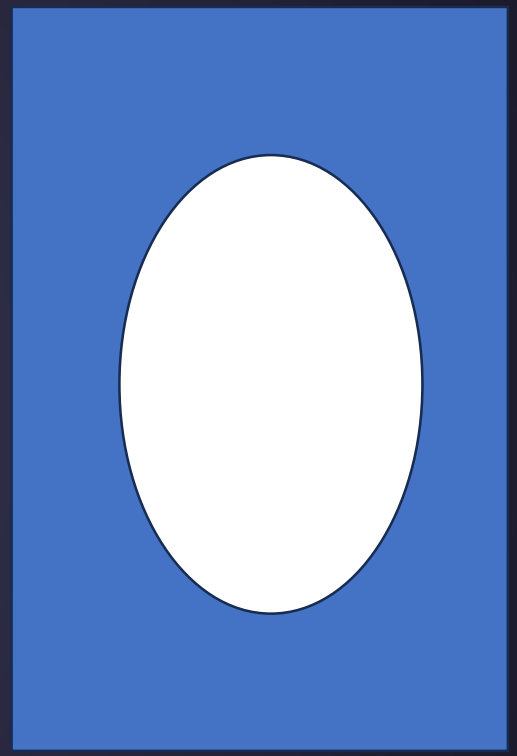
No financial conflict of interest to disclose

Contributors to CSF Pressure

Arterial inflow



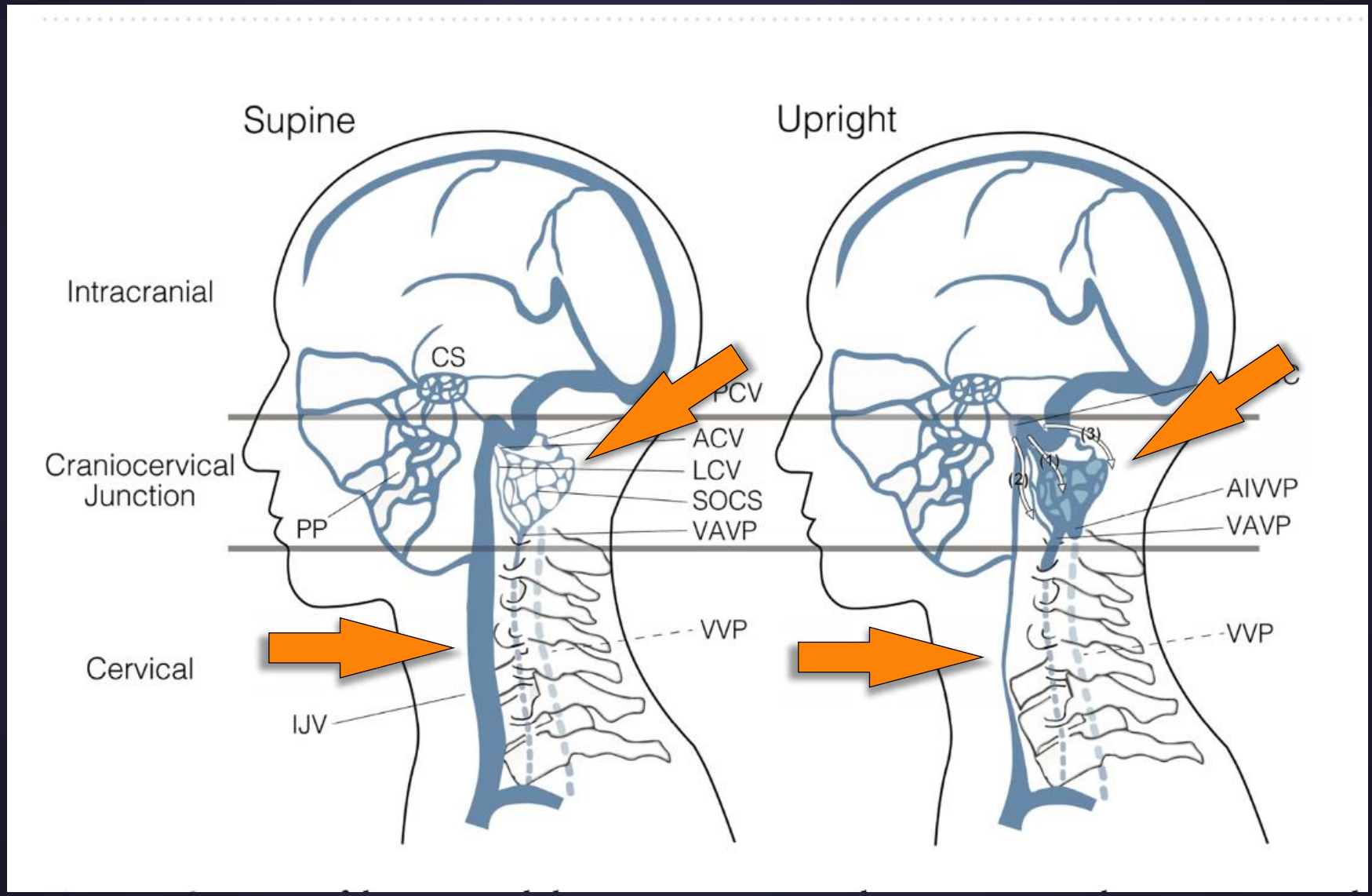
Venous outflow



CSF hydrodynamics

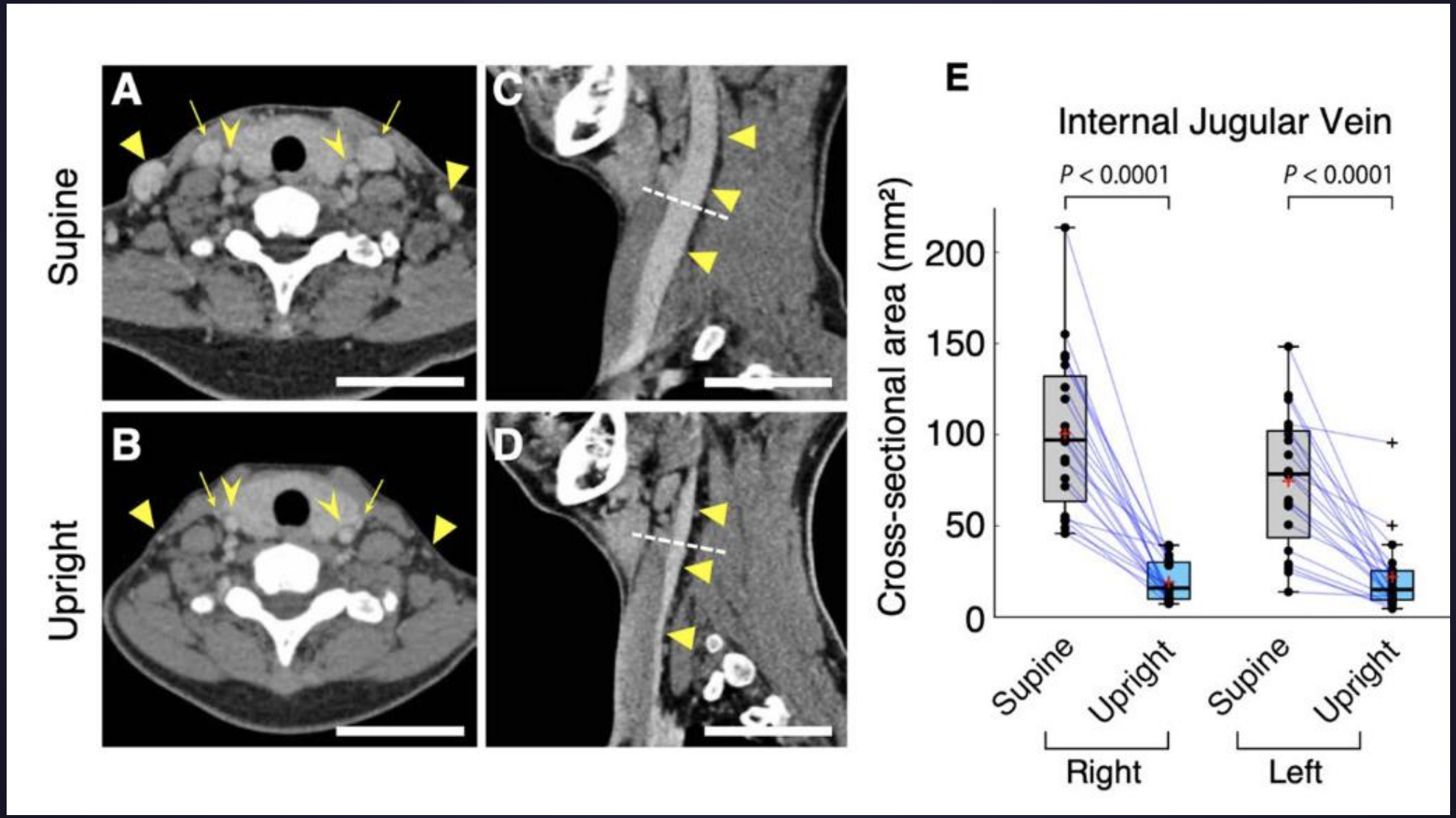
Venous Outflow

Kosugi K, et al. Posture-induced changes in the vessels of the head and neck: evaluation using conventional supine CT and upright CT. Sci Rep 2020;10:16623.



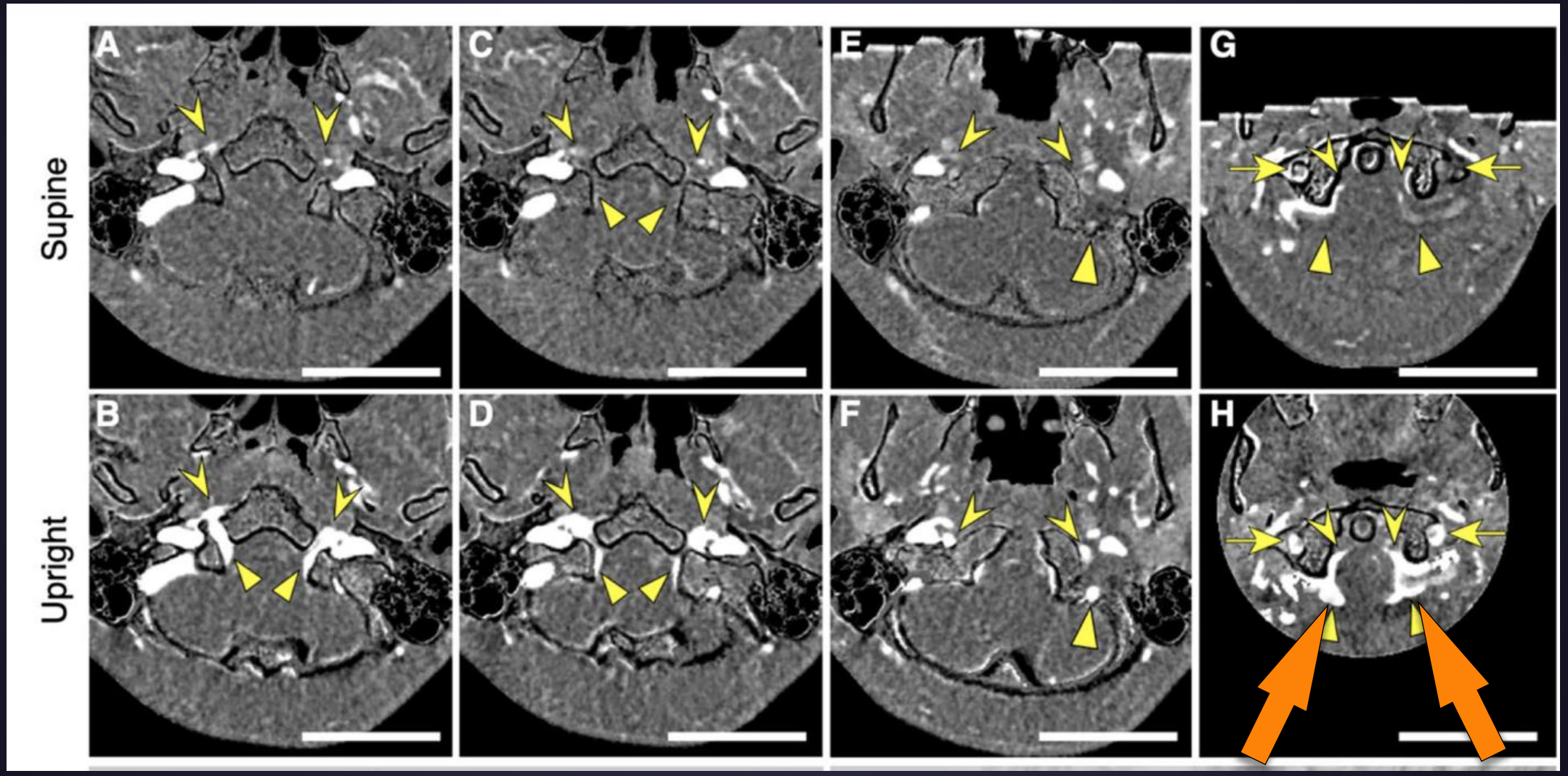
Venous Outflow

Kosugi K, et al. Posture-induced changes in the vessels of the head and neck: evaluation using conventional supine CT and upright CT. Sci Rep 2020;10:16623.



Venous Outflow

Kosugi K, et al. Posture-induced changes in the vessels of the head and neck: evaluation using conventional supine CT and upright CT. Sci Rep 2020;10:16623.



Venous Outflow

Alperin N, Lee SH, Sivaramakrishnan A, et al. Quantifying the effect of posture on intracranial physiology in humans by MRI flow studies. Journal of Magnetic Resonance Imaging 2005;22:591–6.

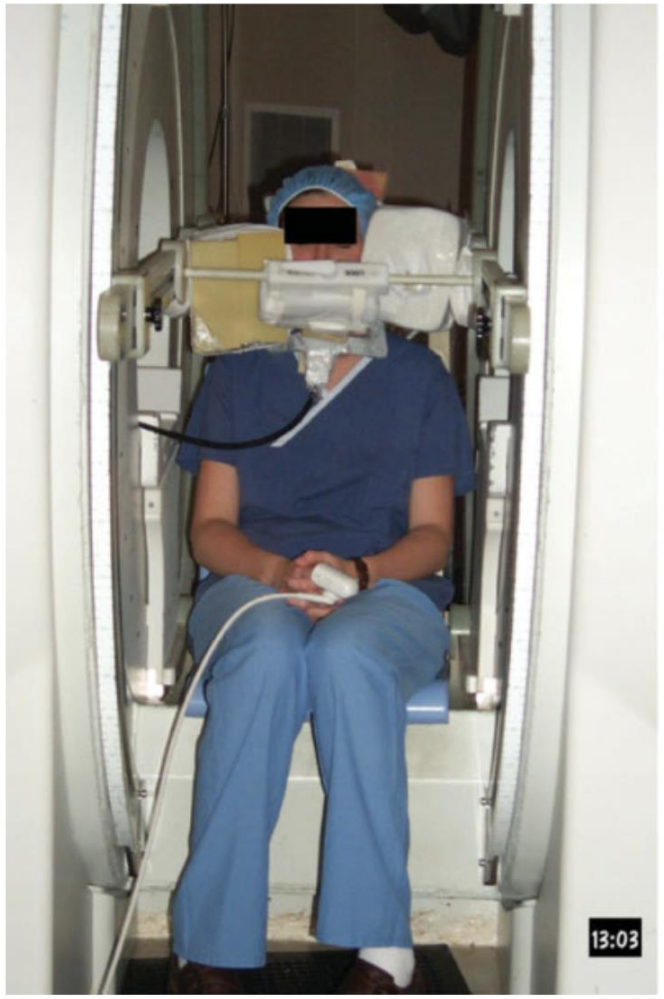
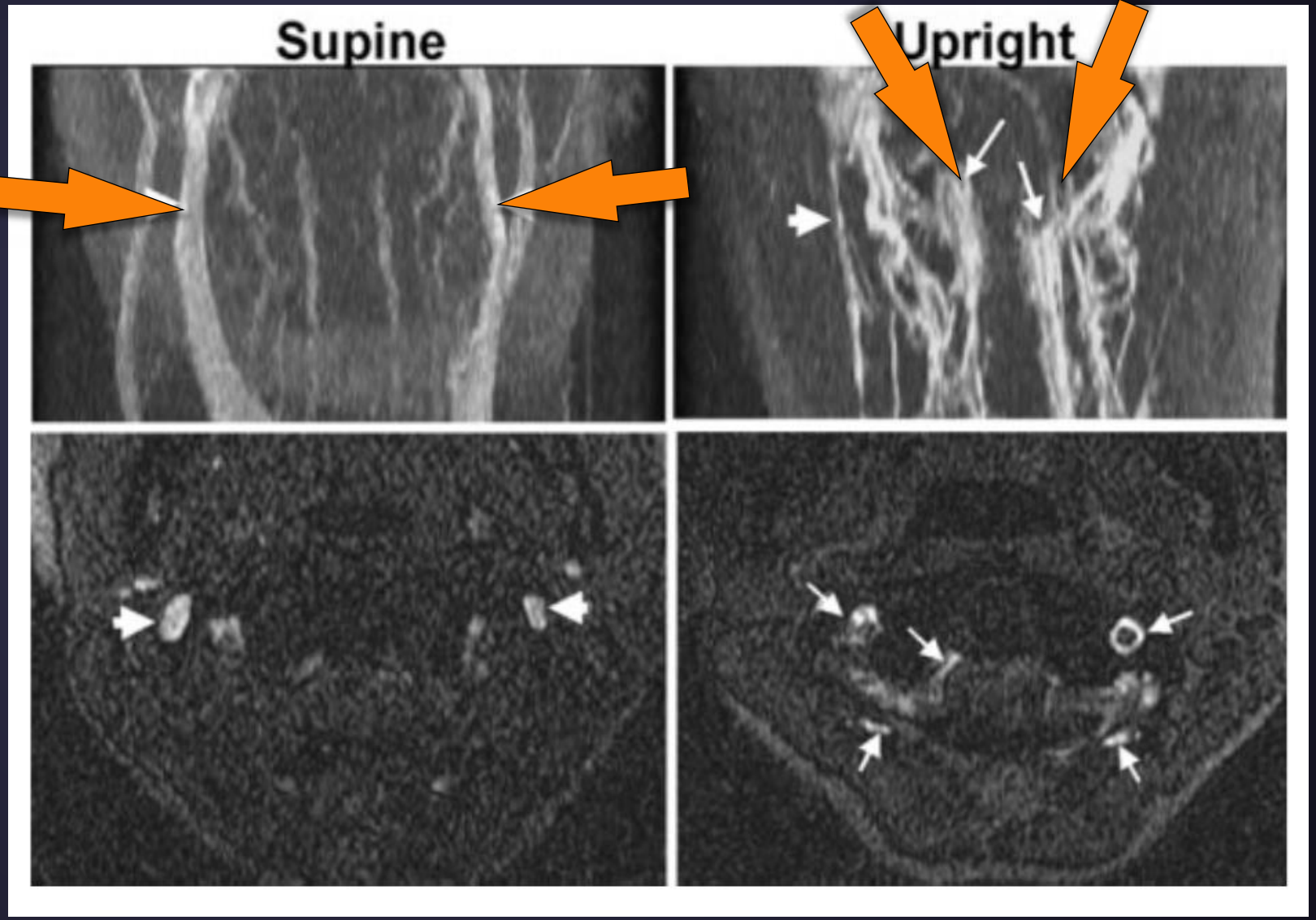
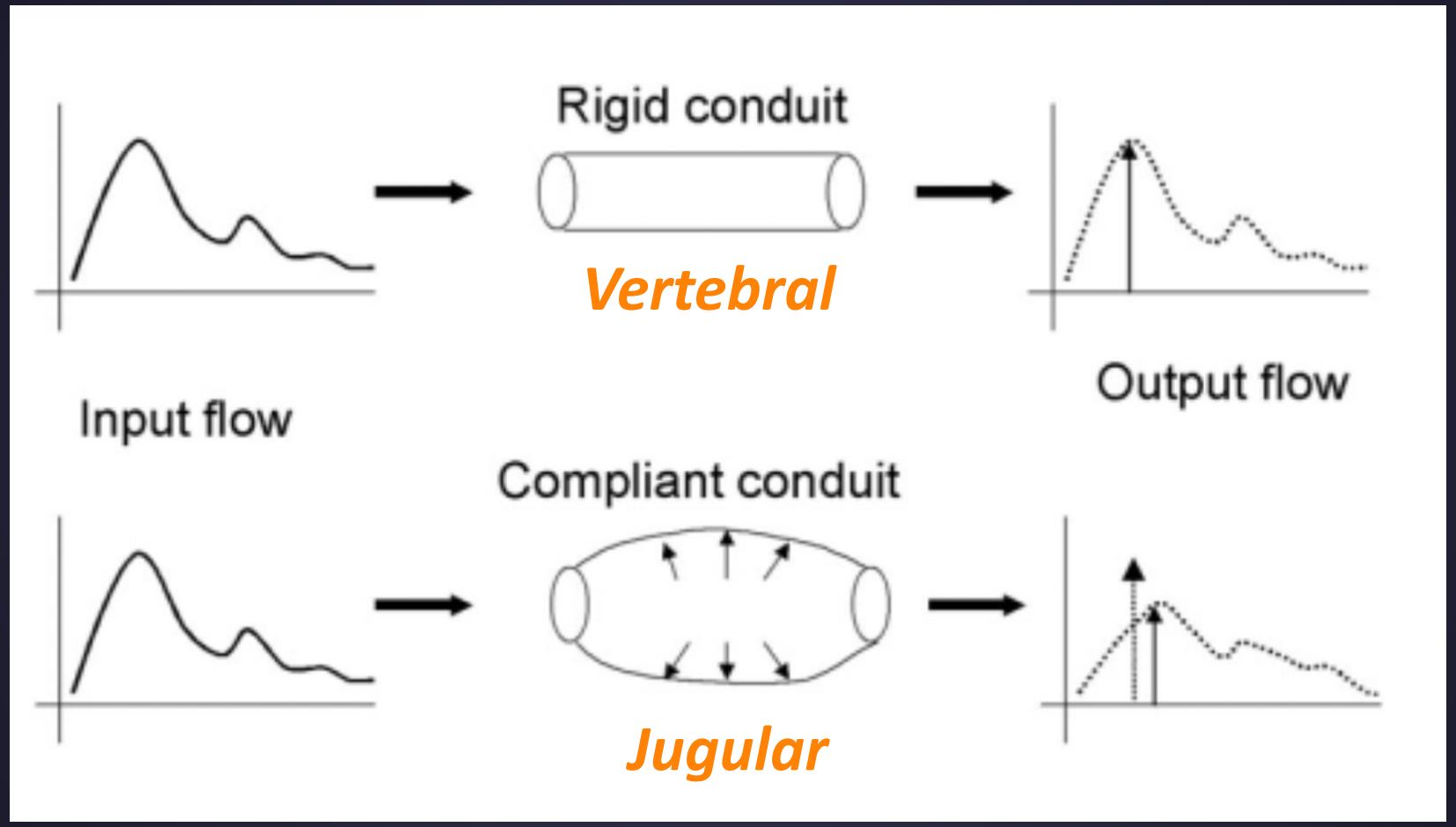


Figure 1. A subject in a sitting position inside the vertical gap of an open MRI scanner.



Venous Outflow

Alperin N, Lee SH, Sivaramakrishnan A, et al. Quantifying the effect of posture on intracranial physiology in humans by MRI flow studies. Journal of Magnetic Resonance Imaging 2005;22:591–6.

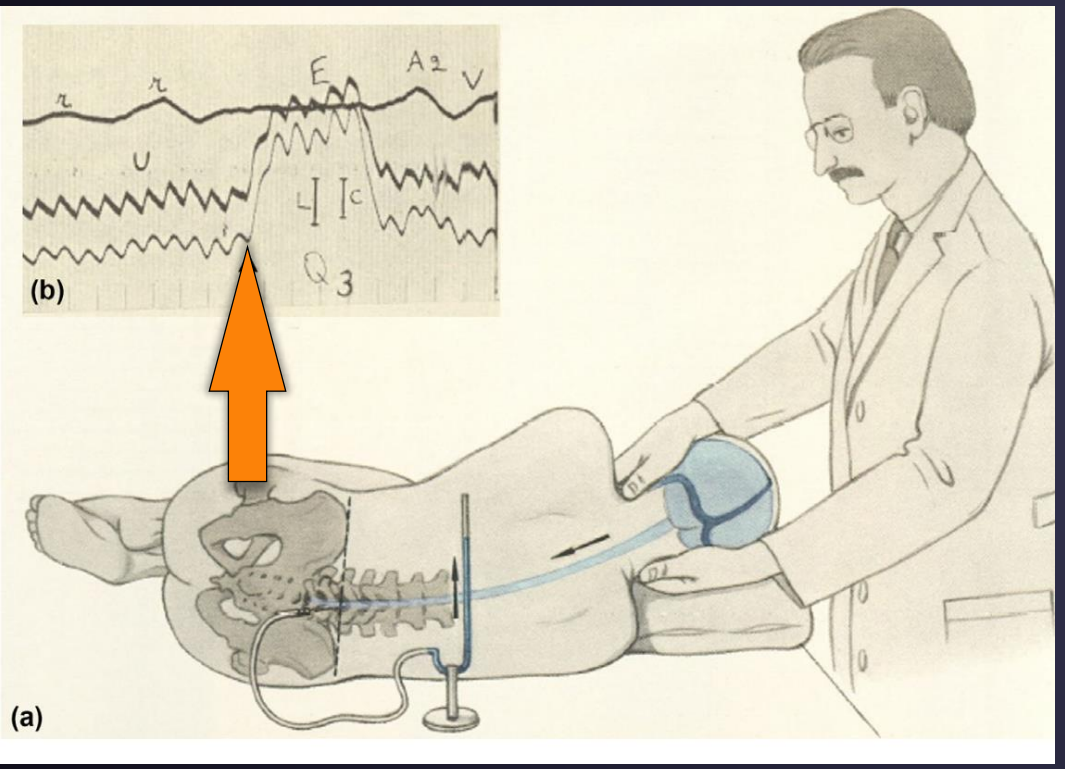


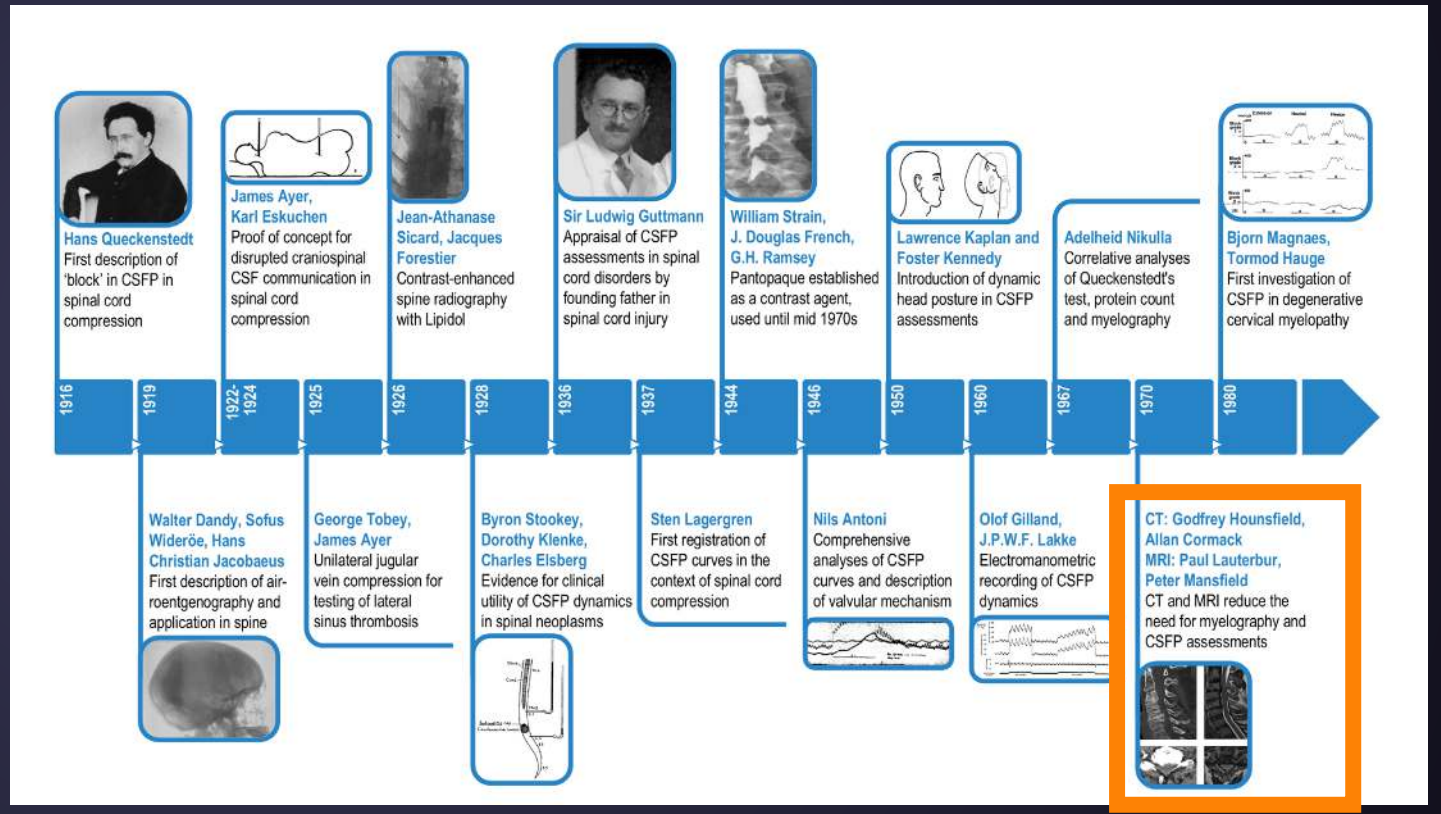
Venous Outflow

- Horizontal – predominant outflow through IJV
- Upright – IJV collapse, shift to higher resistance vertebral veins
- Disconnects ICP from central venous pressure, protects against sharp falls in ICP

CSF-Venous connection

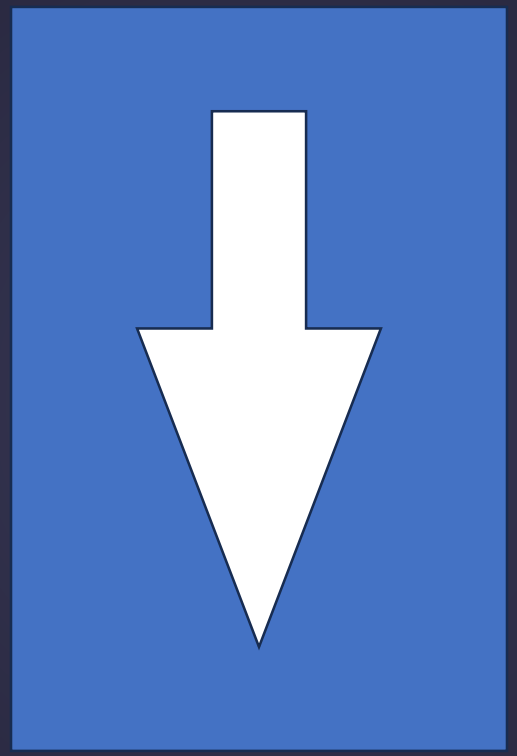
Curt A, Zipser CM. The rise and fall of Queckenstedt's test between 1916 and 1970, a milestone in spinal cord diagnostics and why it matters. Eur J Neurol 2025;32:e16556.



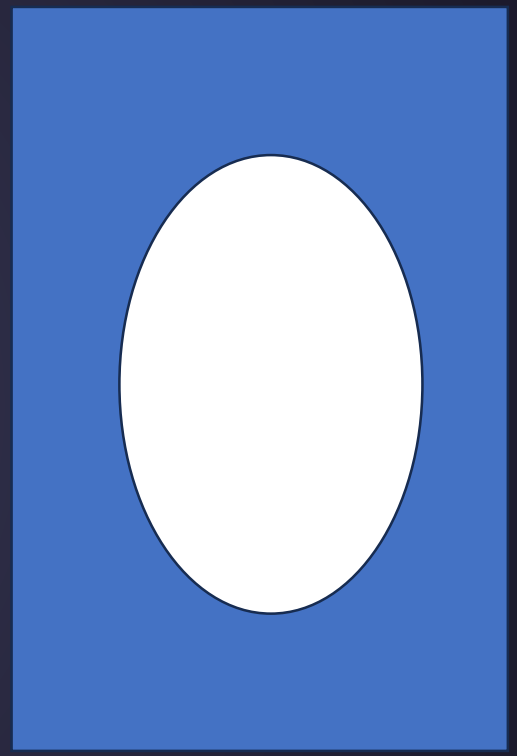


Contributors to CSF Pressure

Arterial inflow



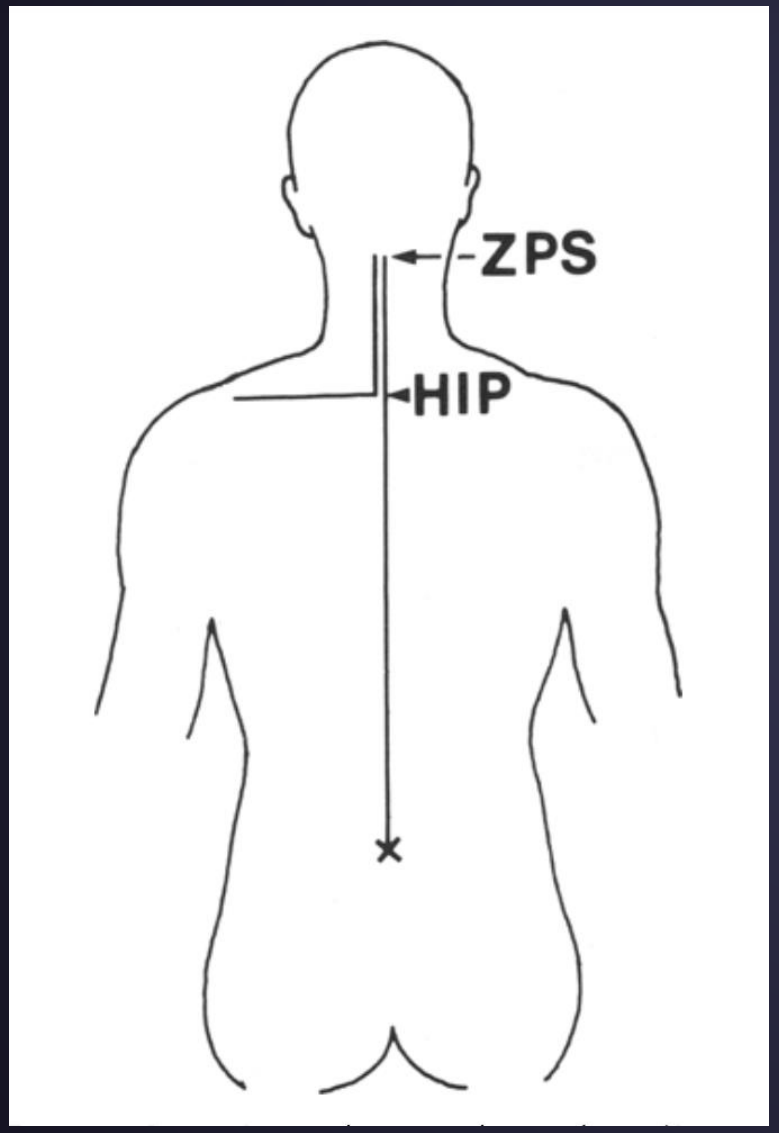
Venous outflow



CSF hydrodynamics

CSF Hydrodynamics

Magnaes B. Body position and cerebrospinal fluid pressure. Part 2: clinical studies on orthostatic pressure and the hydrostatic indifferent point. Journal of neurosurgery 1976;44:698–705.



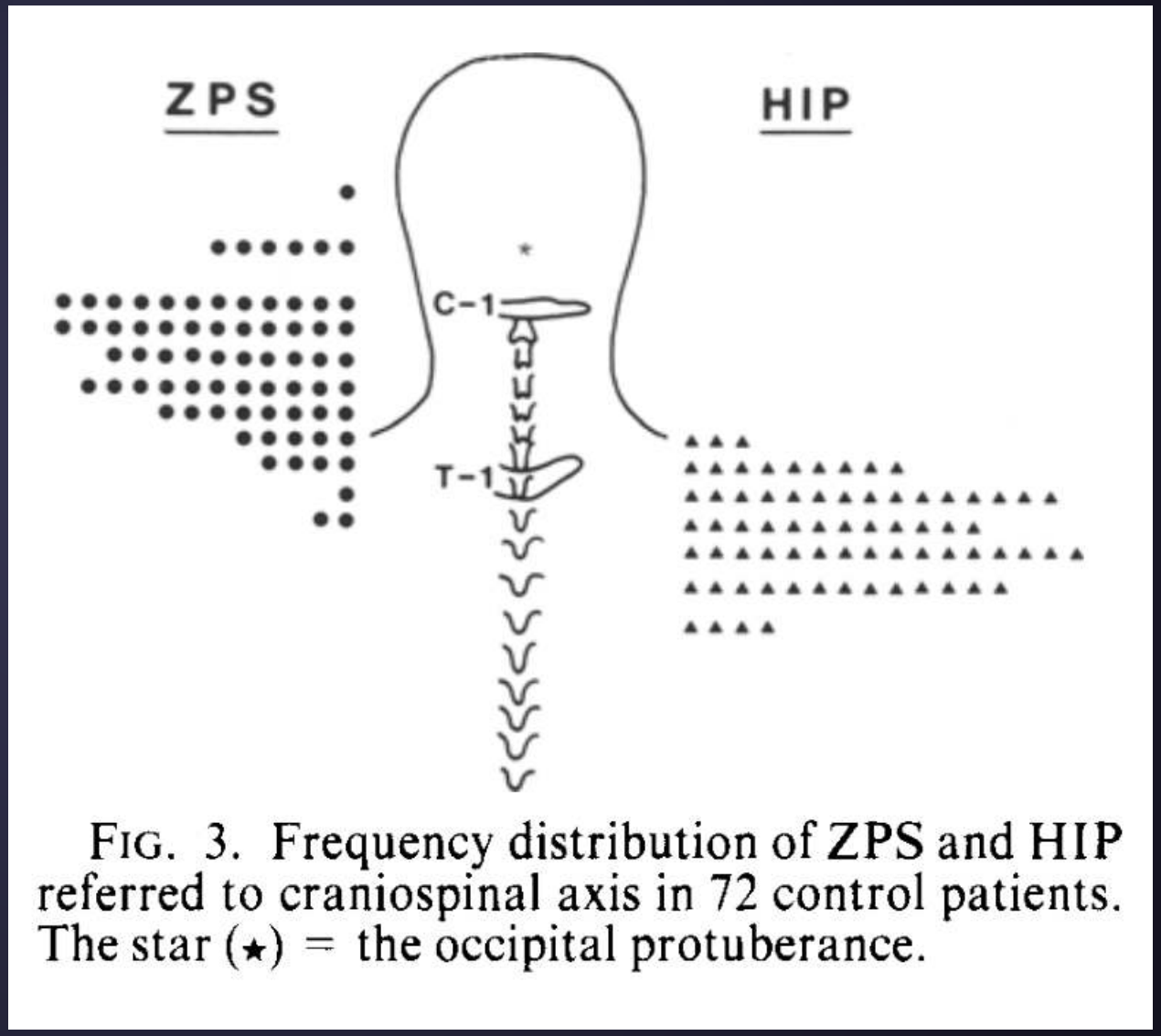


FIG. 3. Frequency distribution of ZPS and HIP referred to craniospinal axis in 72 control patients. The star (★) = the occipital protuberance.

CSF Hydrodynamics

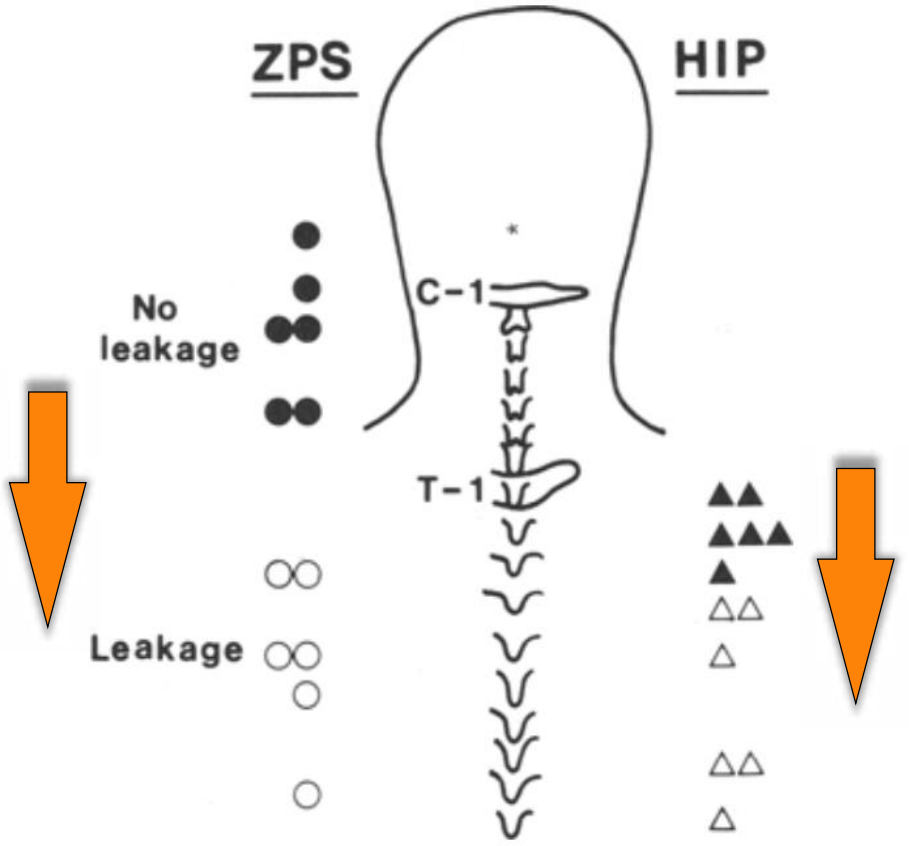


FIG. 7. Measurements in patients with CSF leakage indicate that the ZPS and HIP shifted caudally. The star (★) = the occipital protuberance.

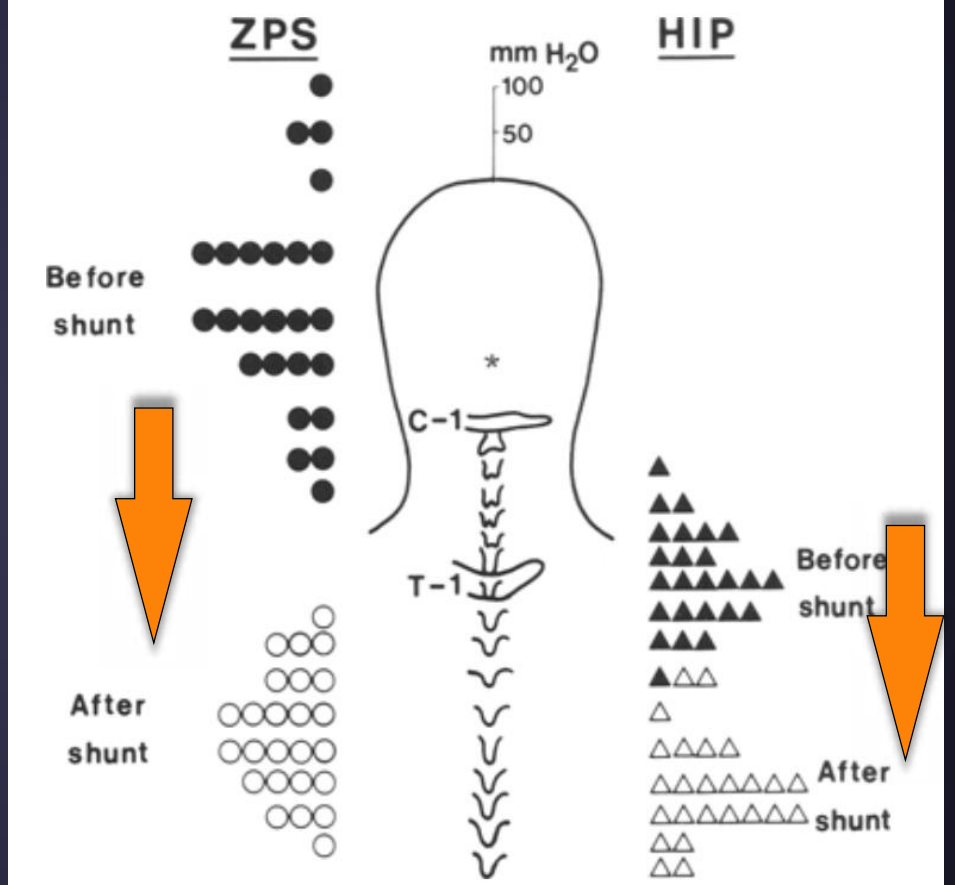


FIG. 5. Measurements of caudal shift of ZPS and HIP in 25 hydrocephalic patients on CSF shunting. The star (★) = the occipital protuberance.

CSF Hydrodynamics

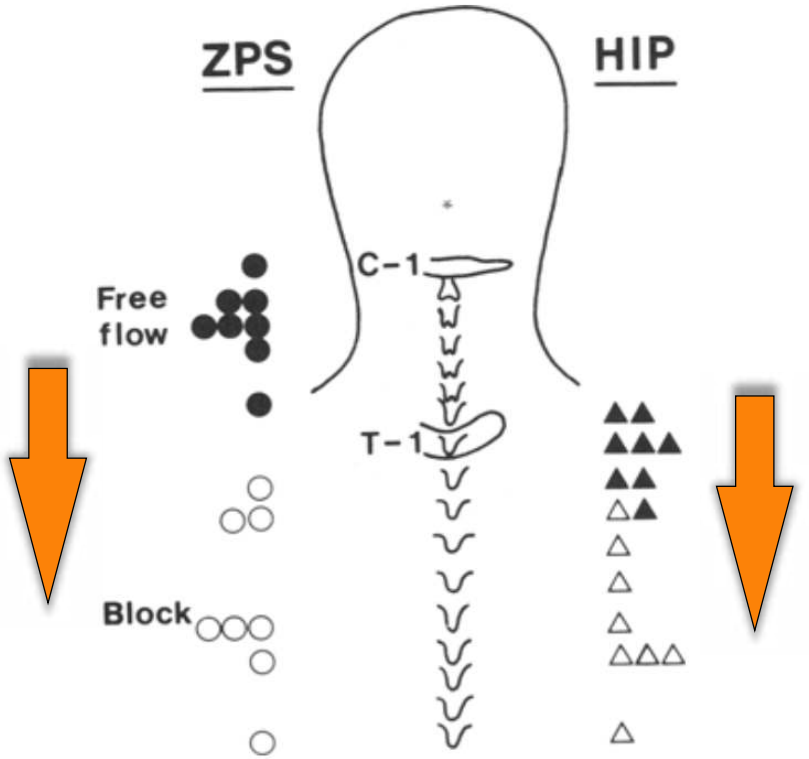
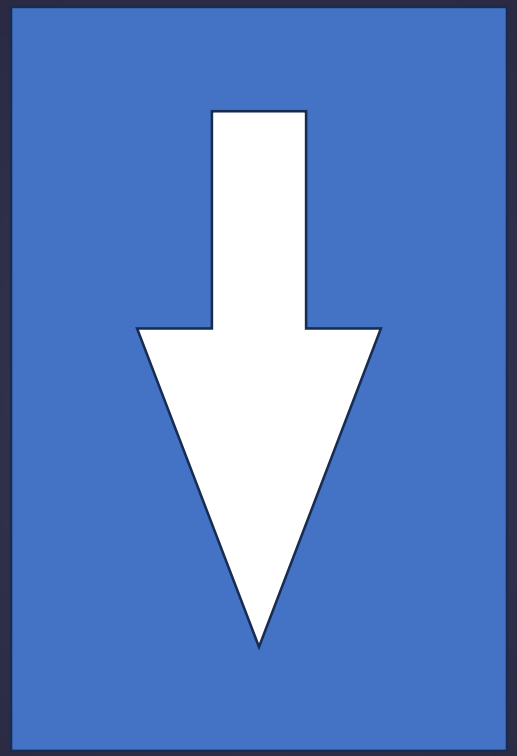


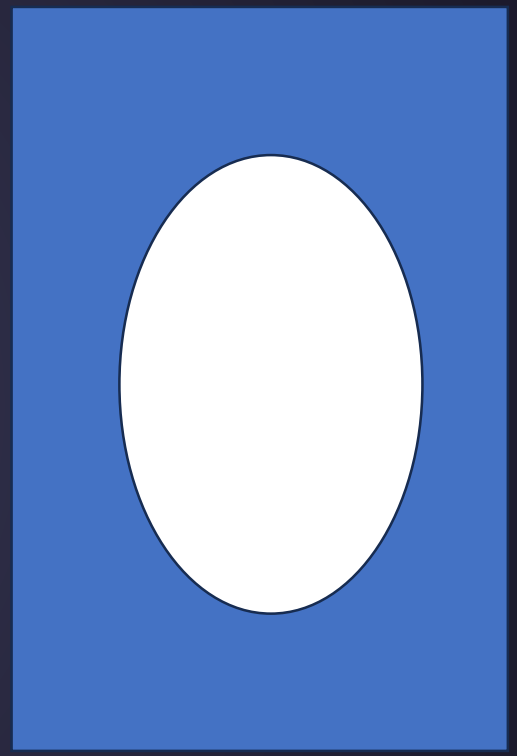
FIG. 9. Measurements in patients with complete cervical subarachnoid block show that the ZPS and HIP were located caudally. Before laminectomy these patients had a double set of ZPS and HIP, and by lumbar CSF pressure recording only the lower set was determined. The star (★) = the occipital protuberance.

Contributors to CSF Pressure

Arterial inflow

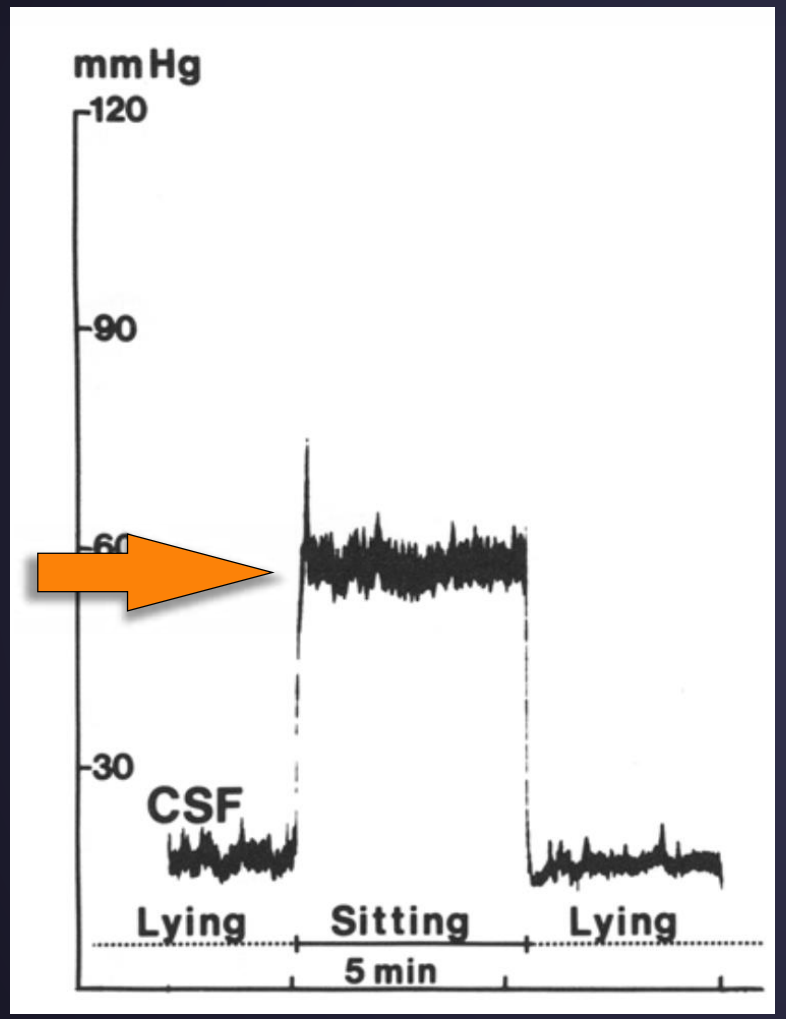


Venous outflow

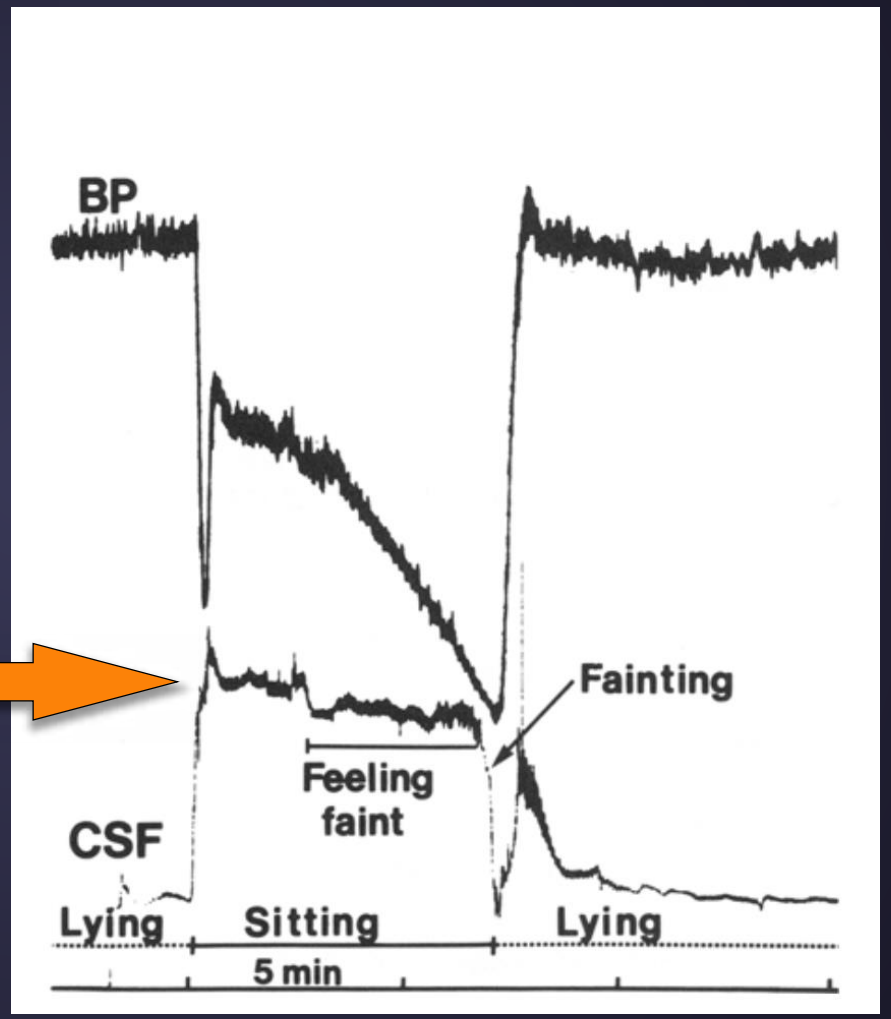


CSF hydrodynamics

Orthostatic intolerance



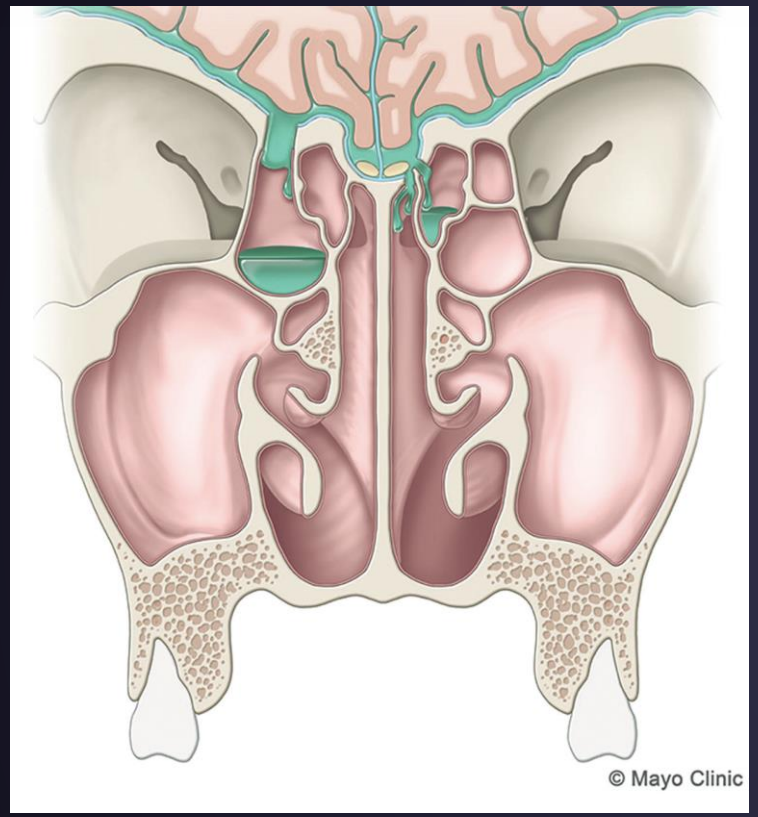
Normal

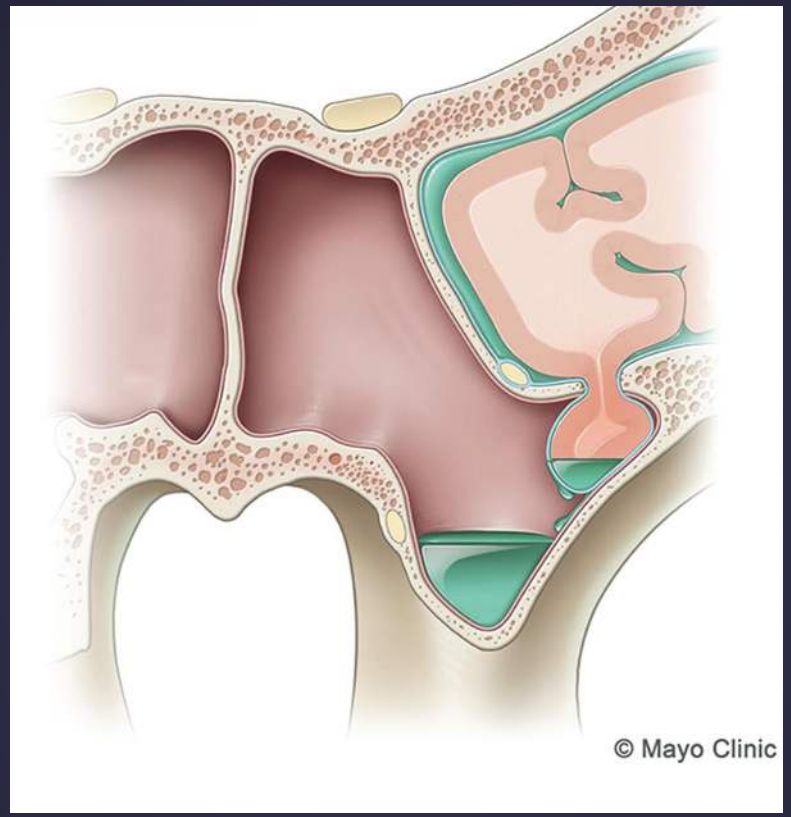


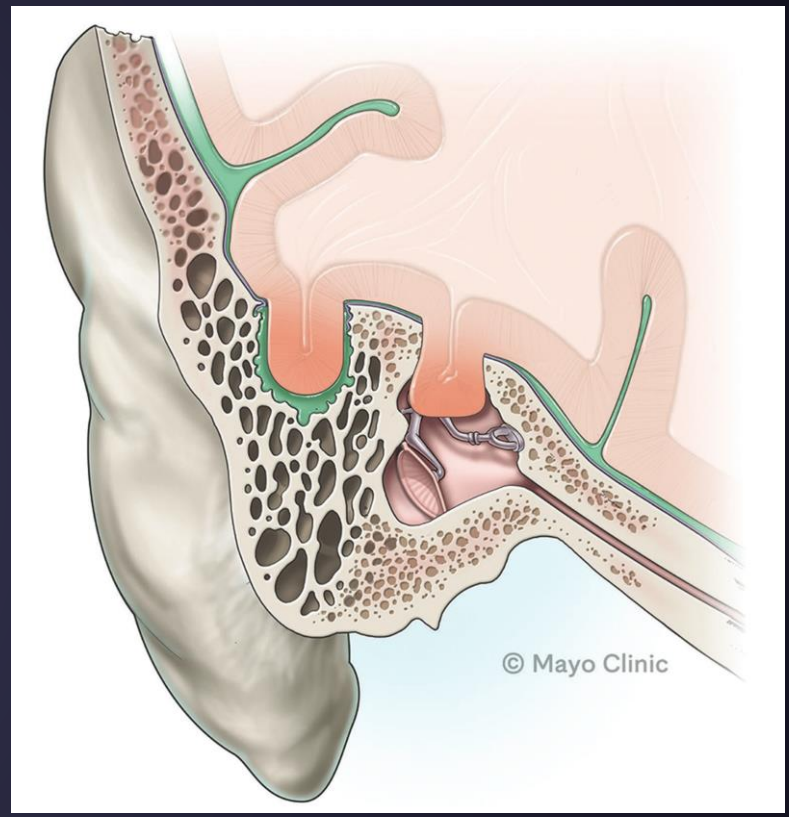
OI

Skull base CSF leaks

O'Brien EK, Celda MP. Atraumatic Cranial CSF Leaks. *Contin: Lifelong Learn Neurol* 2025;31:757–68.







"Spontaneous or idiopathic skull base CSF leaks are increasingly recognized as an associated symptom of IIH, as reviewed in the International Consensus Statement on spontaneous CSF rhinorrhea."

Skull base CSF leaks

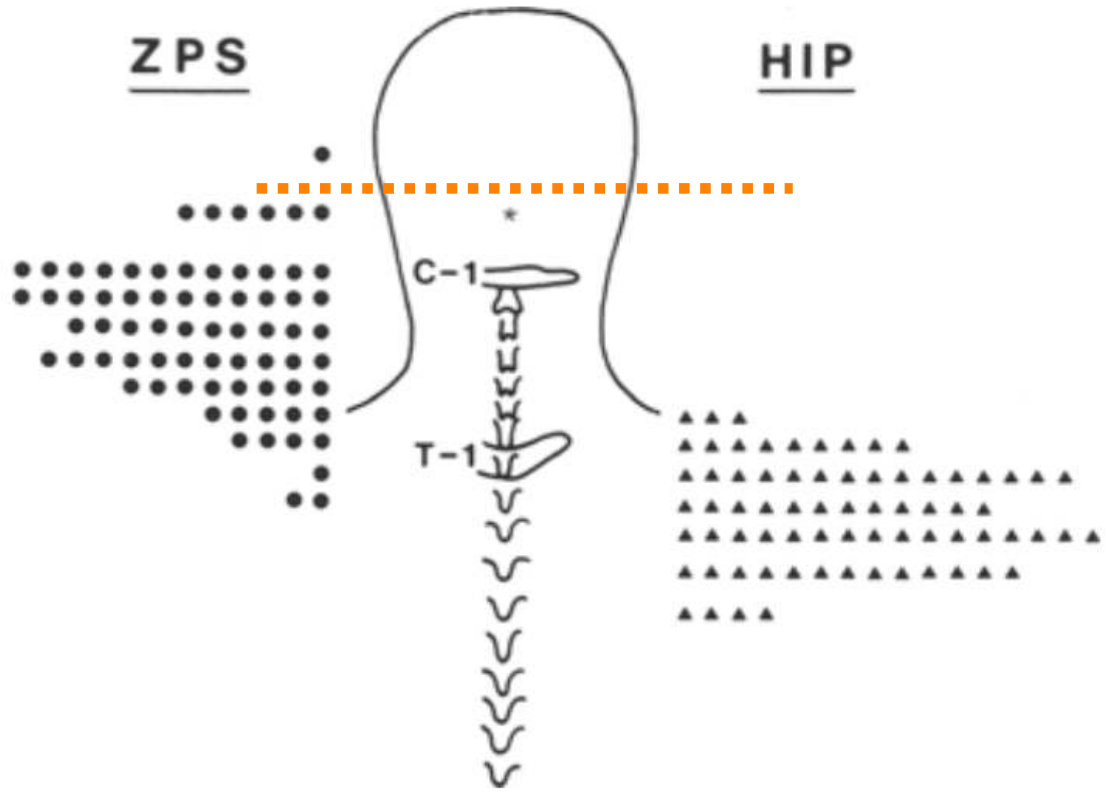
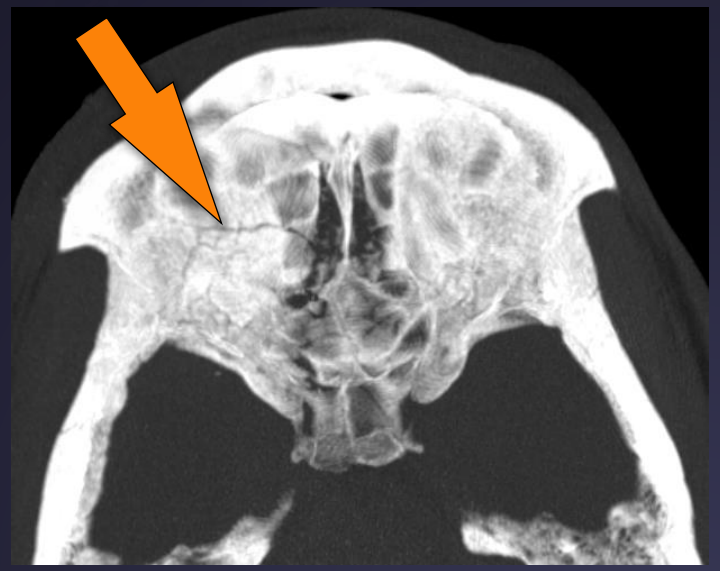
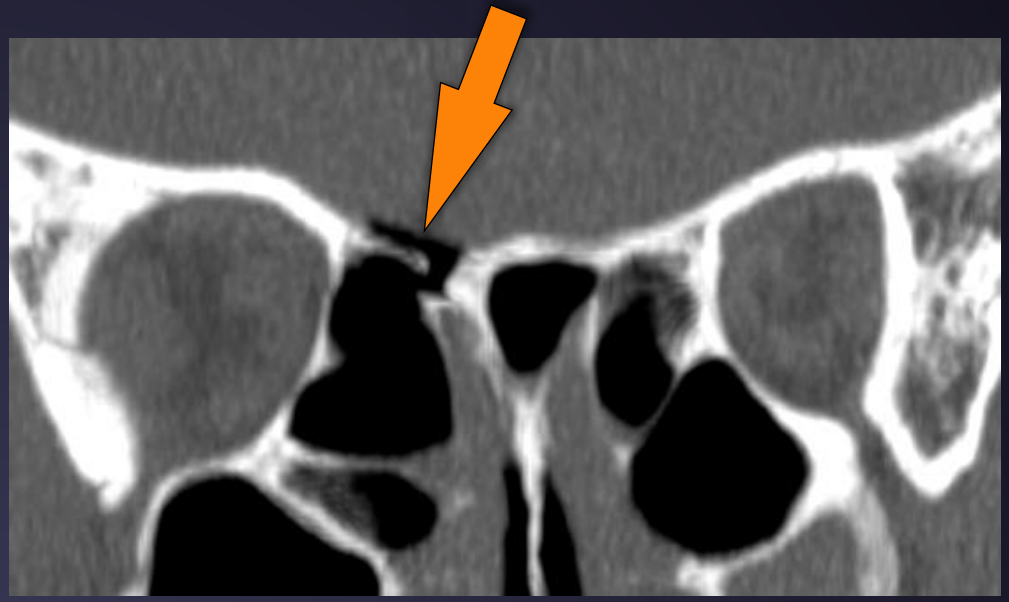


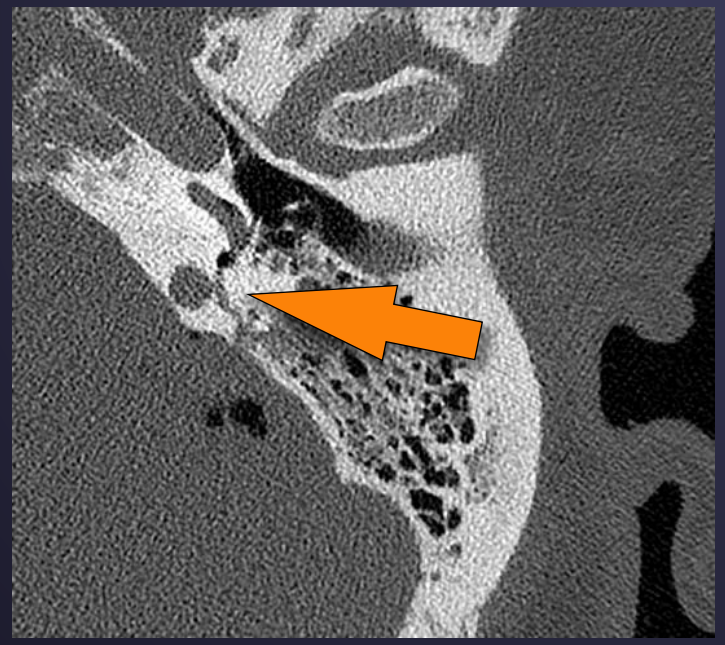
FIG. 3. Frequency distribution of ZPS and HIP referred to craniospinal axis in 72 control patients. The star (★) = the occipital protuberance.

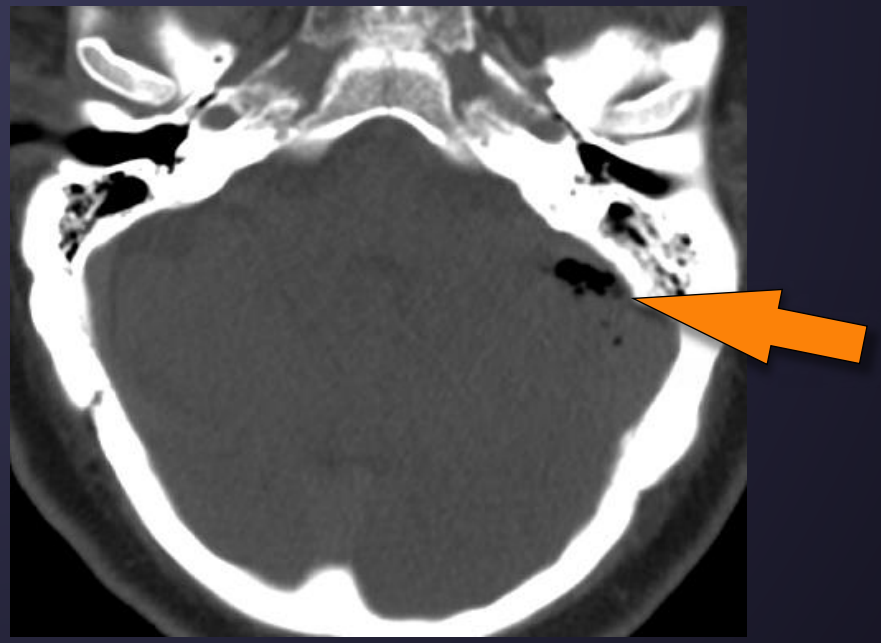
- Pneumocephalus in some cases
- Meningitis – outside coming in
- Provocation by head down position

Traumatic skull base defects



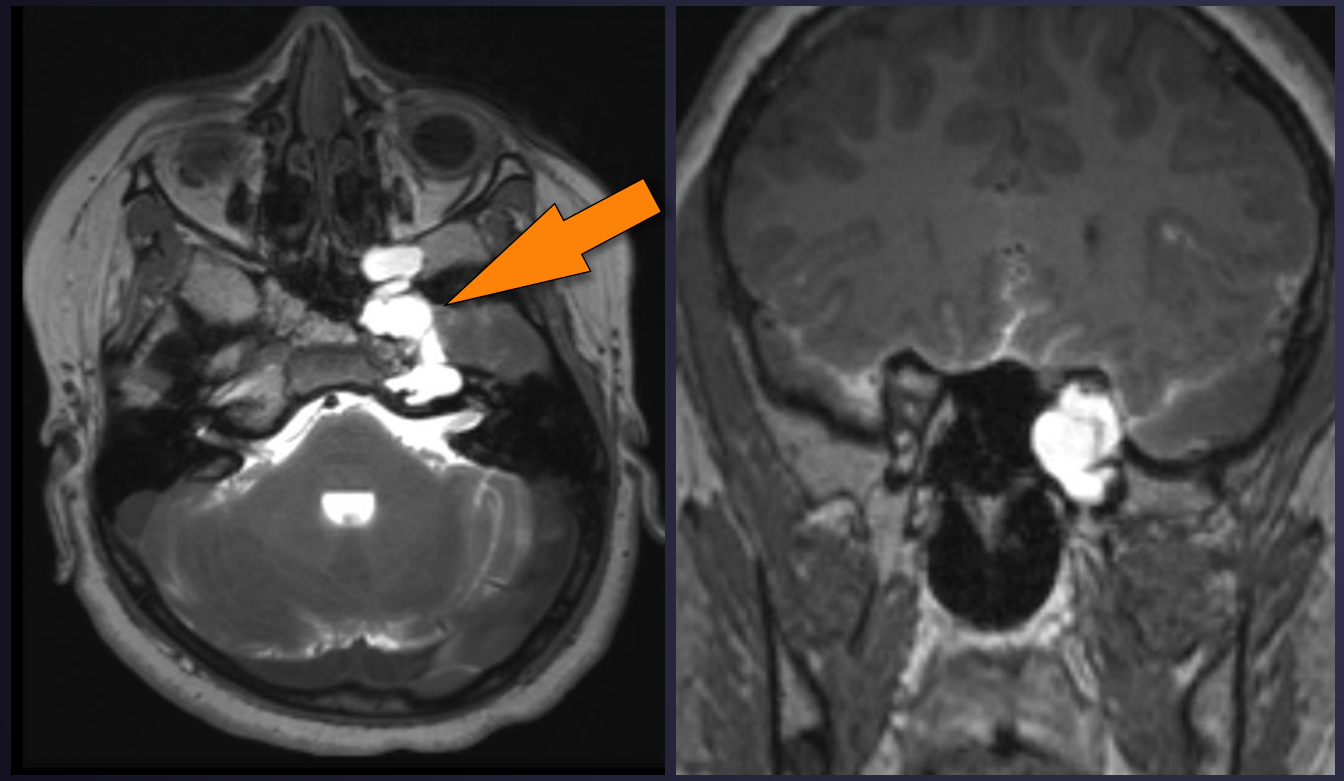




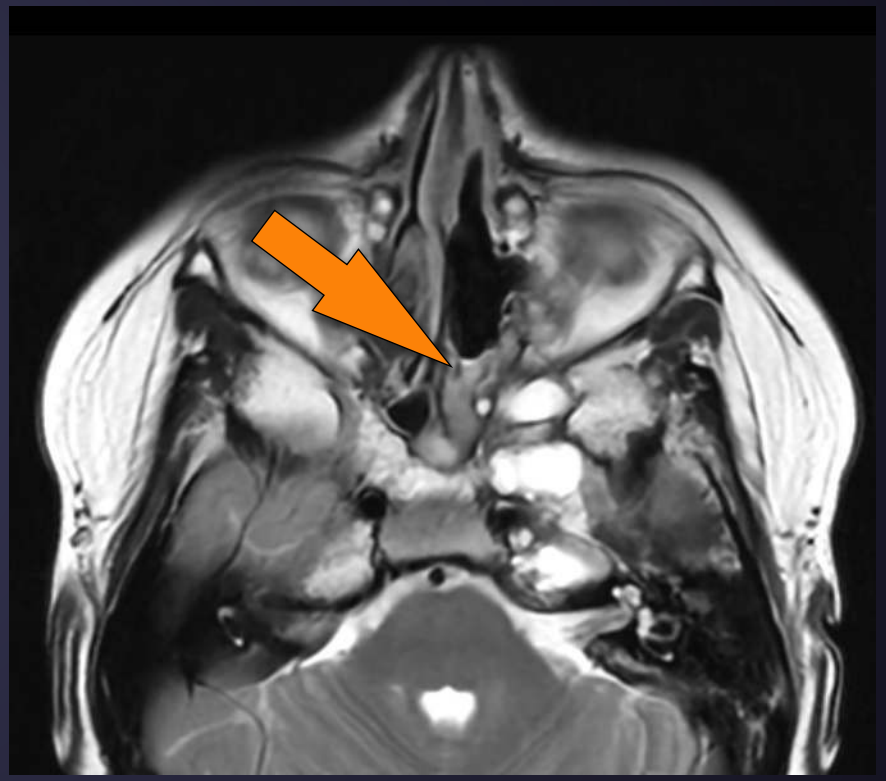


Exceptional case

10 y.o. – hx of recurrent meningitis

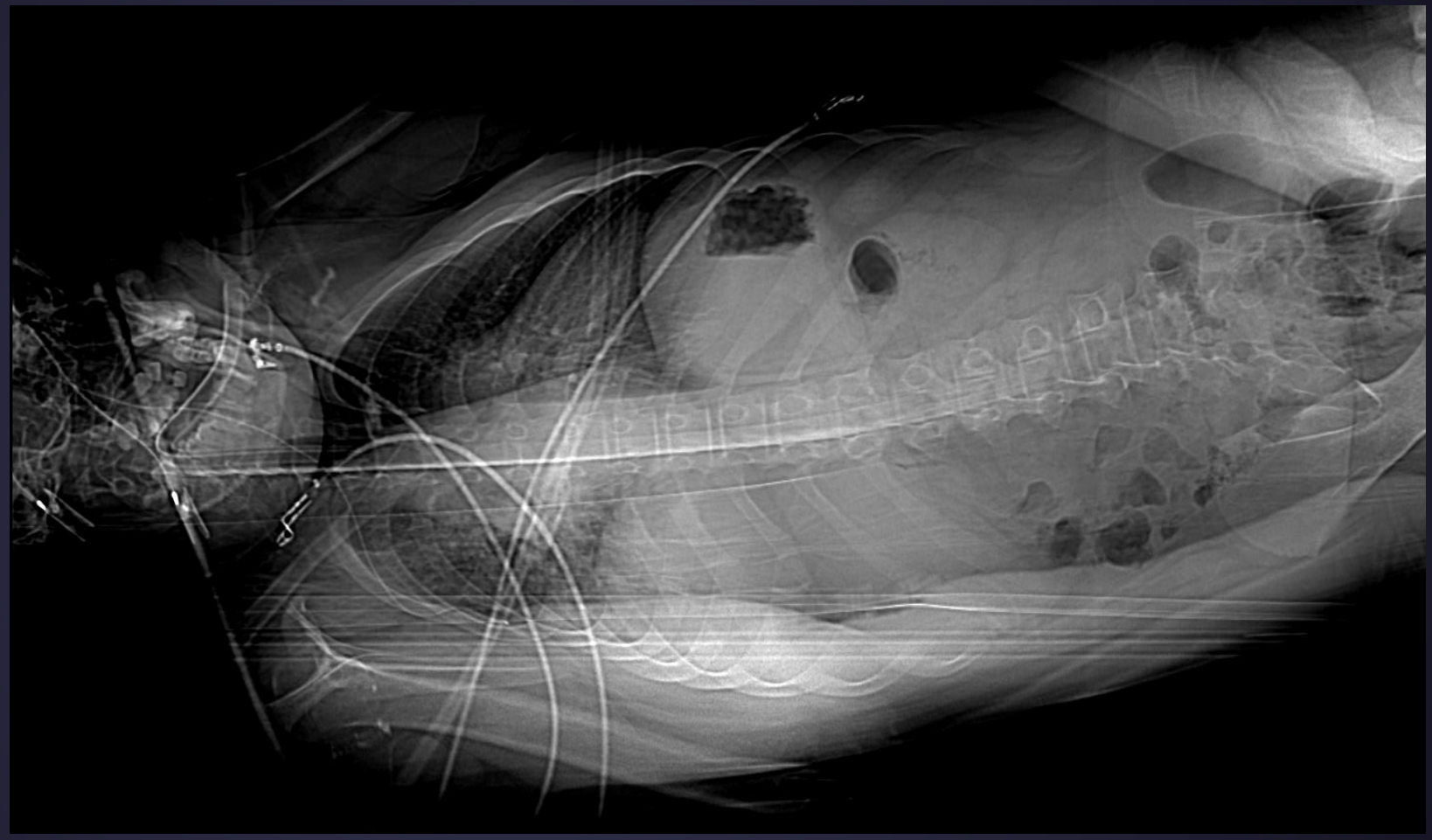


Presentation: meningocele



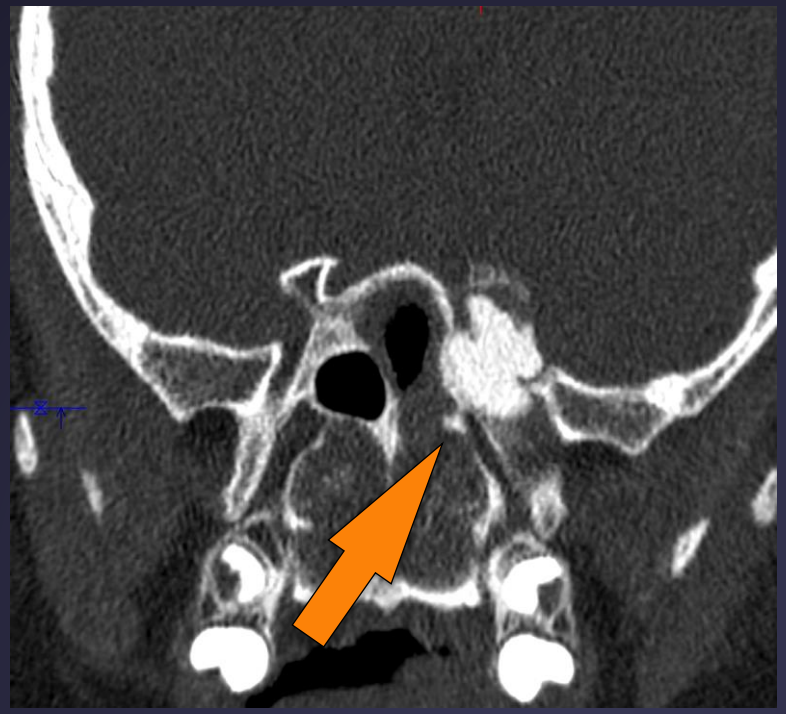
Surgical repair – nasoseptal flap

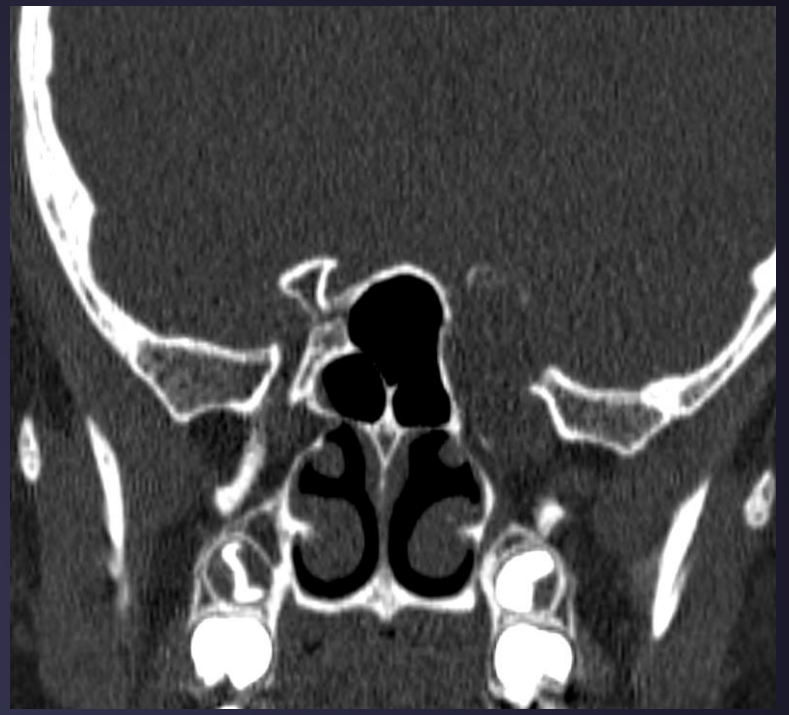
Post-repair: Orthostatic Headache

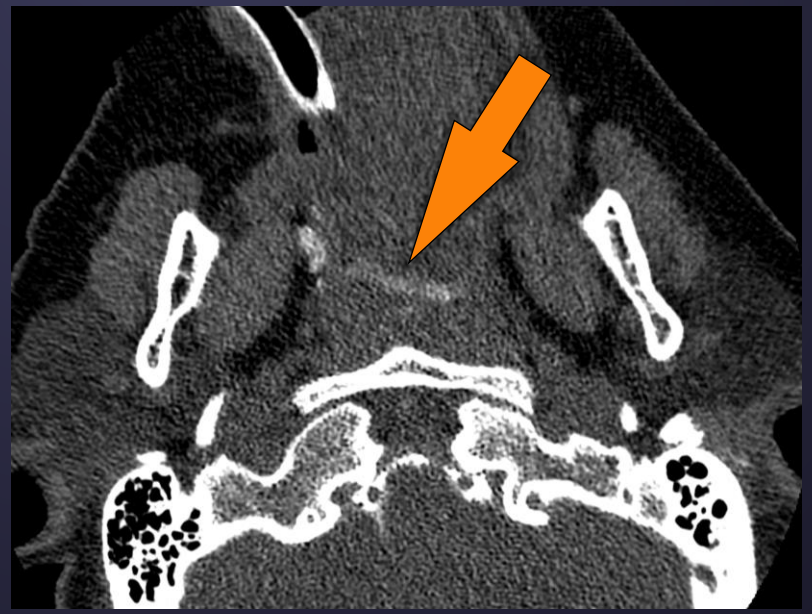


No spinal leak

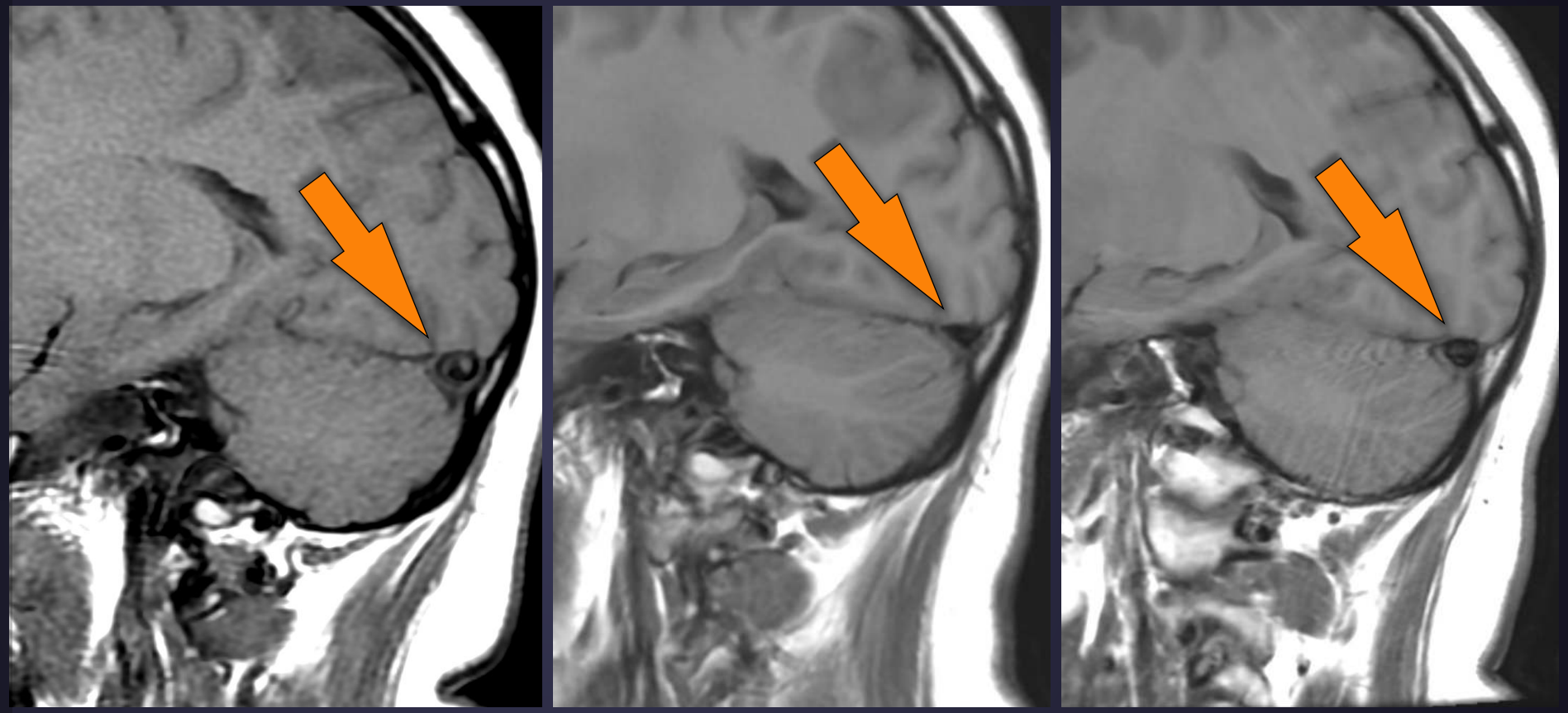
Post-repair: Orthostatic Headache







Venous distension



Pre-repair

Post-repair

Orthostatic HA

Never had dural enhancement

Skull base CSF leaks

J Neurosurg 116:749–754, 2012

Lack of causal association between spontaneous intracranial hypotension and cranial cerebrospinal fluid leaks

Clinical article

Wouter I. Schievink, M.D.,[1] Marc S. Schwartz, M.D.,[1,2] M. Marcel Maya, M.D.,[3] Franklin G. Moser, M.D., M.M.M.,[3] and Todd D. Rozen, M.D.[4]

Departments of [1]Neurosurgery and [3]Radiology, Cedars-Sinai Medical Center; [2]House Clinic, Los Angeles, California; and [4]Department of Neurology, Geisinger Specialty Clinic, Wilkes-Barre, Pennsylvania

Object. Spontaneous intracranial hypotension is an important cause of headaches and an underlying spinal CSF leak can be demonstrated in most patients. Whether CSF leaks at the level of the skull base can cause spontaneous intracranial hypotension remains a matter of controversy. The authors' aim was to examine the frequency of skull base CSF leaks as the cause of spontaneous intracranial hypotension.

Methods. Demographic, clinical, and radiological data were collected from a consecutive group of patients evaluated for spontaneous intracranial hypotension during a 9-year period.

Results. Among 273 patients who met the diagnostic criteria for spontaneous intracranial hypotension and 42 who did not, not a single instance of CSF leak at the skull base was encountered. Clear nasal drainage was reported by 41 patients, but a diagnosis of CSF rhinorrhea could not be established. Four patients underwent exploratory surgery for presumed CSF rhinorrhea. In addition, the authors treated 3 patients who had a postoperative CSF leak at the skull base following the resection of a cerebellopontine angle tumor and developed orthostatic headaches; spinal imaging, however, demonstrated the presence of a spinal source of CSF leakage in all 3 patients.

Conclusions. There is no evidence for an association between spontaneous intracranial hypotension and CSF leaks at the level of the skull base. Moreover, the authors' study suggests that a spinal source for CSF leakage should even be suspected in patients with orthostatic headaches who have a documented skull base CSF leak.
(http://thejns.org/doi/abs/10.3171/2011.12.JNS111474)

Key Words • **cerebrospinal fluid leak** • **cerebrospinal fluid rhinorrhea** • **headache** • **intracranial hypotension**

ORIGINAL RESEARCH
HEAD AND NECK IMAGING

Skull Base CSF Leaks: Potential Underlying Pathophysiology and Evaluation of Brain MR Imaging Findings Associated with Spontaneous Intracranial Hypotension

Ian T. Mark, Jeremy Cutsforth-Gregory, Patrick Luetmer, Ajay A. Madhavan, Michael Oien, Paul Farnsworth, Girish Bathla, Steve Messina, Michael Link, and Jamie Van Gompel

ABSTRACT

BACKGROUND AND PURPOSE: CSF leaks of the skull base and spine share a common process of CSF volume loss, and yet only the latter has been associated with spontaneous intracranial hypotension (SIH). Despite published claims that only spinal leaks cause SIH, no prior studies have evaluated brain MR imaging in patients with skull base leaks for findings associated with SIH, such as dural enhancement. The purpose of our study was to use a validated brain MR imaging scoring system to evaluate patients with skull base CSF leaks for findings associated with SIH.

MATERIALS AND METHODS: We included patients with confirmed skull base CSF leaks and contrast-enhanced preoperative brain MRI. The preoperative MR images were reviewed for findings associated with SIH by using the Bern score. Patient age, presenting symptoms and their duration, and leak site were also recorded.

RESULTS: Thirty-one patients with skull base CSF leaks were included. Mean Bern score was 0.9 (range 0–4, standard deviation 1.1), and only 1 patient (3%) had dural enhancement. Mean age was 53 years (range 18–76). Mean symptom duration was 1.3 years, with 22 patients presenting within 1 year of symptom onset. Twenty-three patients (74.2%) had intraoperative confirmation of leak from the middle cranial fossa, involving the temporal bone, while 7 (22.6%) had leaks from the anterior skull base. One patient, who had dural enhancement, had an infratentorial CSF leak along the petrous segment of the internal carotid artery.

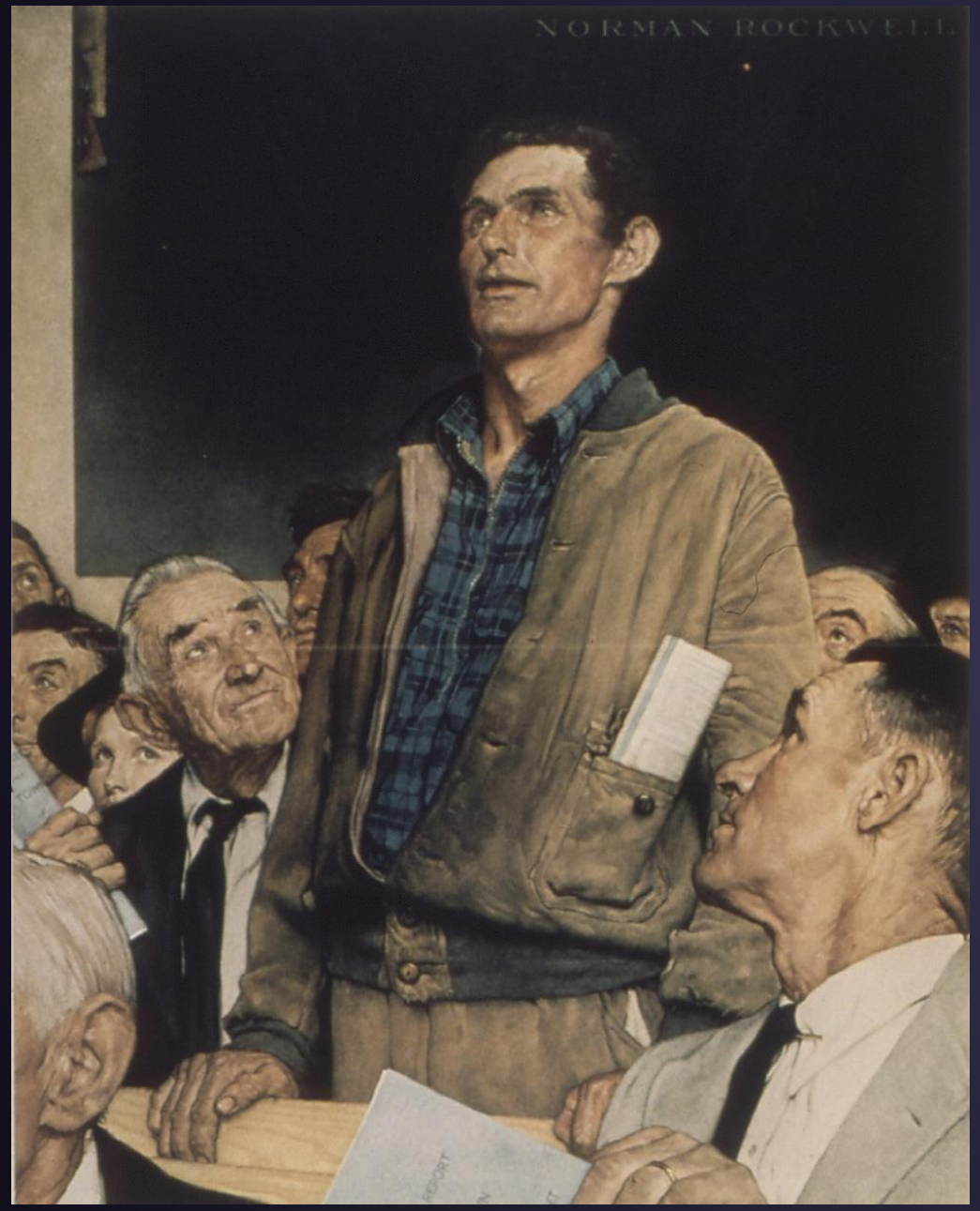
CONCLUSIONS: Our study provides further evidence that skull base and spinal CSF leaks represent distinct pathophysiologies and present with different brain MRI findings.

ABBREVIATIONS: IIH = idiopathic intracranial hypertension; SIH = spontaneous intracranial hypotension

"The 1 patient with skull base CSF leaks in our cohort with dural enhancement had an infratentorial CSF leak. Before surgical repair of the skull base CSF leak, the patient underwent a conventional CT myelogram that did now show extradural fluid. Three years later, the patient was found to have a ventral spinal CSF leak from a calcified disk osteophyte complex. It is unknown whether the patient's symptoms were due to an occult spinal CSF leak or if this occurred after the skull base leak repair. All other patients in this study without dural enhancement had supratentorial CSF leaks, suggesting that supra- versus infratentorial leak location could contribute to the brain MRI findings."

Summary

- CSF hydrodynamics changes between supine and upright positions
- These changes make CSF volume depletion less likely in skull base CSF leak
- Skull base leaks with intracranial hypotension do happen, but are the rare exception rather than the rule



What happens when you stand up:

physiology of skull base vs spinal CSF leak

Peter G. Kranz, M.D.
Associate Professor of Radiology
Division Chief, Neuroradiology
Duke University Medical Center
peter.kranz@duke.edu

Duke Radiology