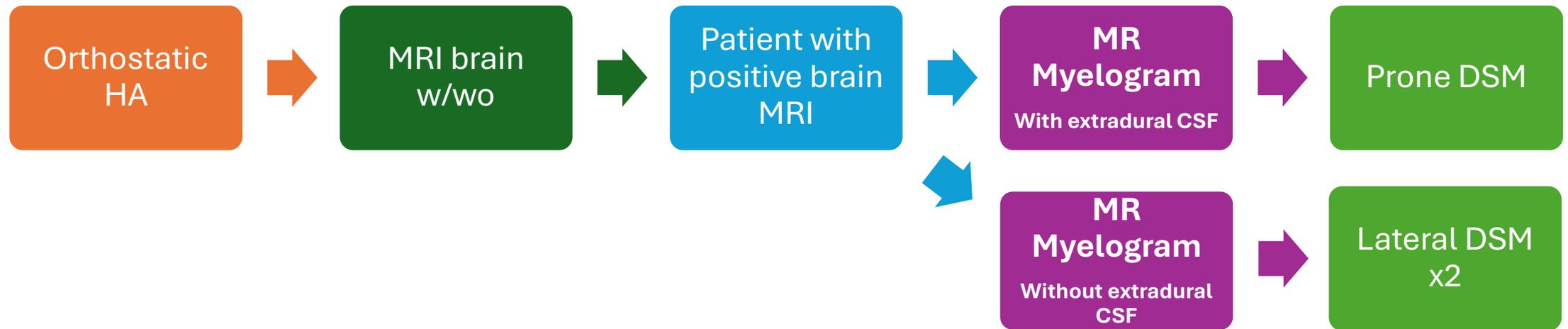


2025 Intracranial Hypotension Conference

Angelique Sao-Mai Tay, MD

Systematic Review of negative brain MRI in patients with CSF venous fistulas

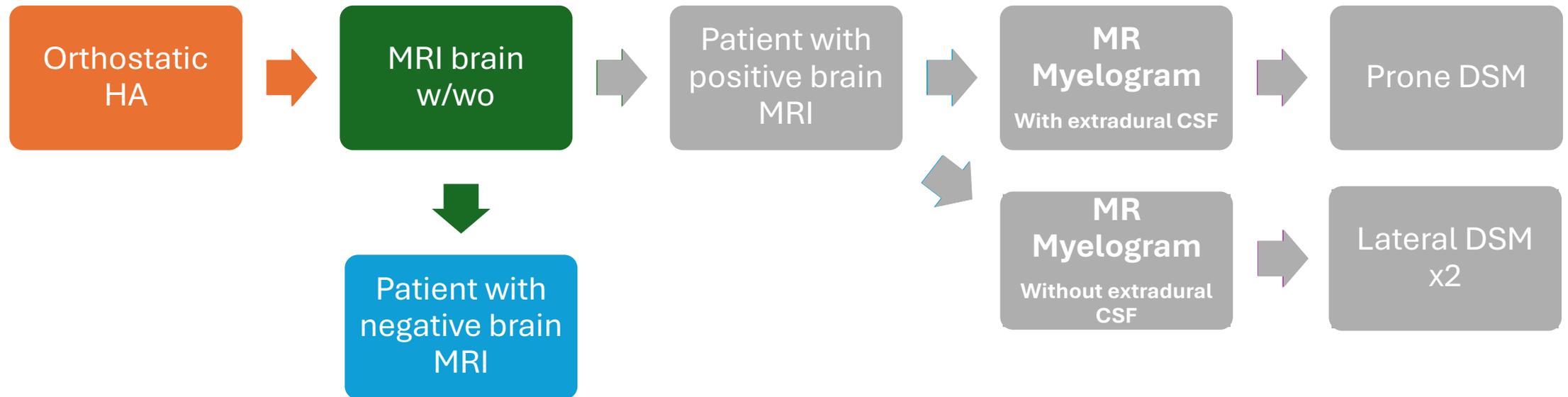
SIH Pathway



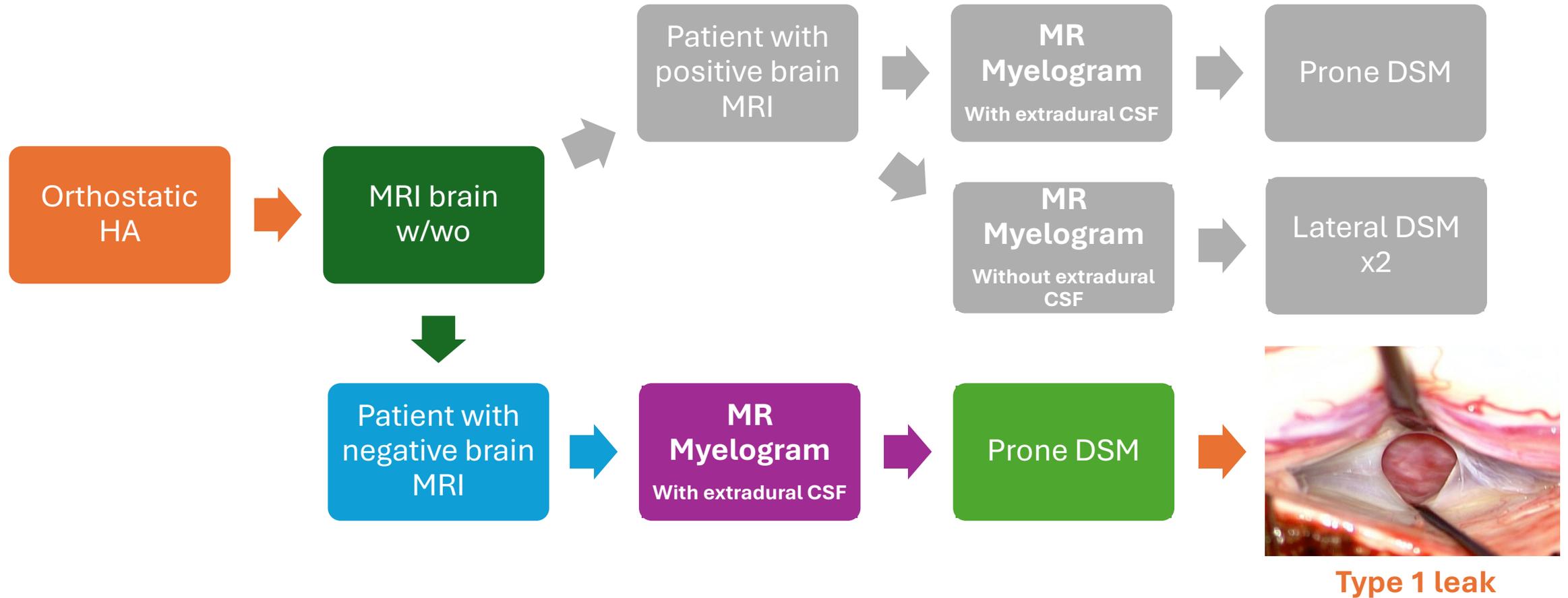
How many of the patients with positive brain MRI are found to have a CSF leak?

- Ventral leaks:
 - 76% DSM¹
- CSF venous fistula:
 - 74% DSM²
 - 73% dCTM³

What if the brain MRI is negative?

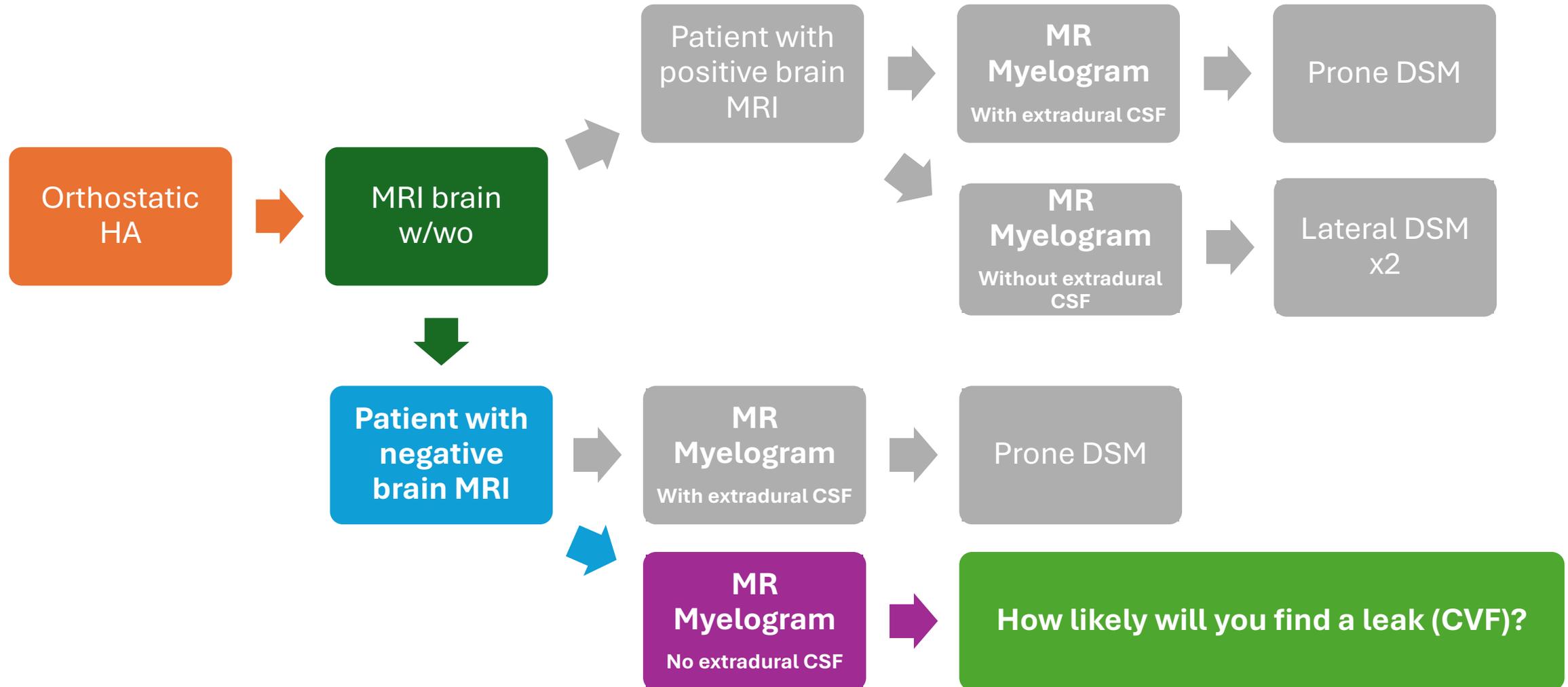


What if the brain MRI is negative?



~20% of patients with SIH and extradural CSF have a negative brain MRI.^{3,4}

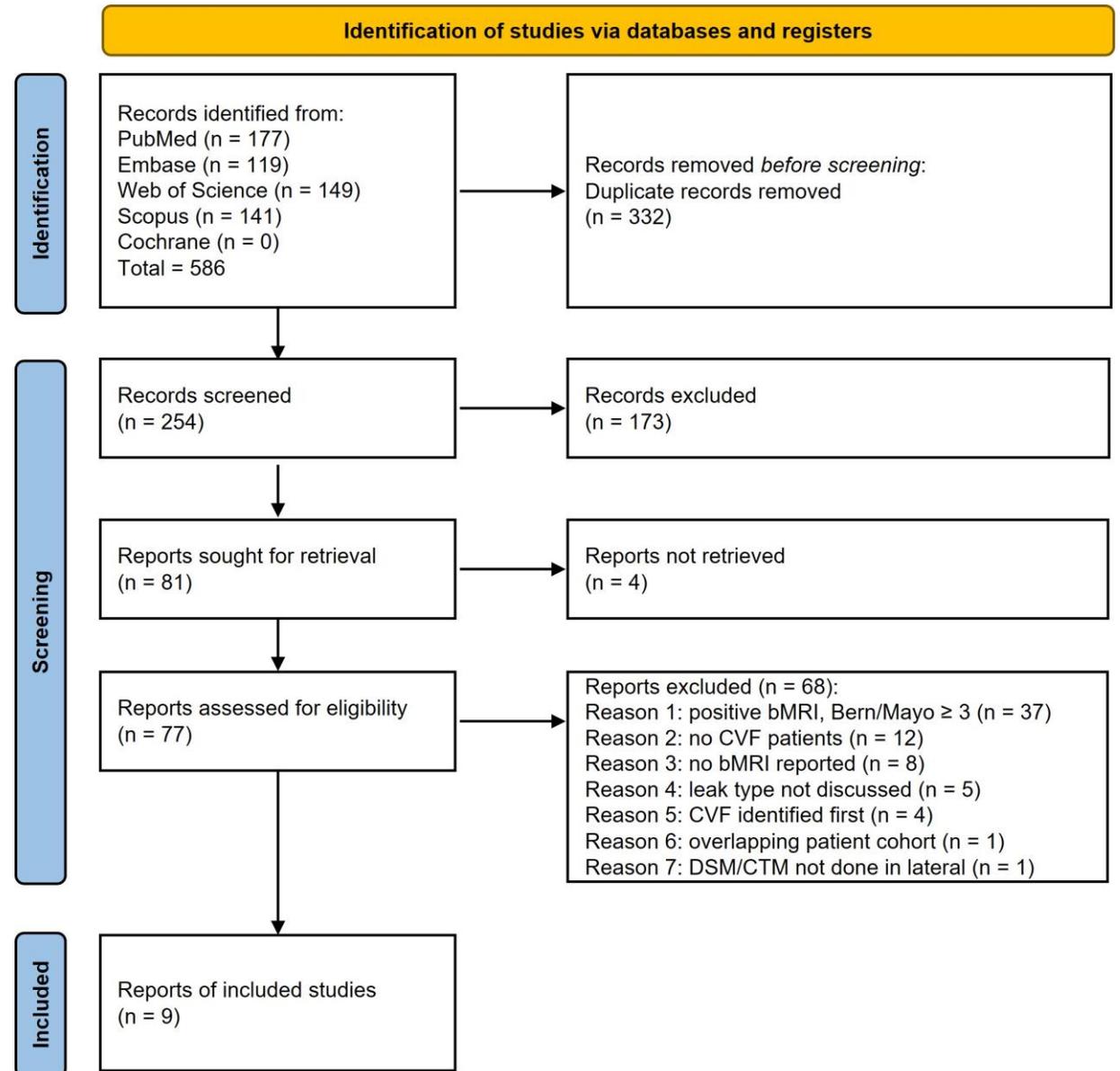
What about these patients?



How many patients with negative bMRI have a CVF?

'csf venous fistula' AND 'spontaneous intracranial hypotension'

'digital subtraction myelogram' AND 'brain MRI'.



What is a positive brain MRI?

- Subdural fluid collections
- Enhancement of pachymeninges
- Engorgement of venous structures
- Pituitary hyperemia
- Sagging of the brain

	SDH	Pachy-meningeal enhancement	Venous Distension Sign	Pituitary Enlargement	Brain Sagging – MPD	Brain Sagging – SSC	Brain Sagging – Cerebellar Tonsillar Herniation	Other
Schievink (2021)								Signs of SIH
Gibby et al. (2024)		X	X		Mammillary bodies at level of dorsum sella			
Schievink (2024)	X	X	X	X	≤ 5.5 mm		≥ 5.0 mm	<ul style="list-style-type: none"> • PMA ≤ 45° • Infratentorial superficial siderosis • Calvarial hyperostosis
Madhavan (2024)	X	X	X	X				Signs of brain sagging

bMRI negative Studies			
<i>Study</i>	<i>bMRI- patients</i>	<i>bMRI- + CVF patients</i>	<i>Mode of Imaging</i>
Schievink et al. (2021)	60	6	Lateral DSM
Gibby et al. (2024)	74	0	Decubitus CTM
Schievink et al. (2024)	93	15	Lateral DSM
Madhavan et al. (2024)	25	6	Lateral DSM+CB-CTM
Total	252	27 (10.7%)	
Bern Score Studies			
<i>Study</i>	<i>Bern 0-2 patients</i>	<i>Bern 0-2 + CVF patients</i>	<i>Mode of Imaging</i>
Kim et al. (2021)	9	0	Lateral DSM
Madhavan et al. (2023)	25	14	PCD-CTM
Huynh et al. (2024)	19	0	dCTM-BT
Petrucci et al. (2024)	29	1	Lateral DSM
Total	82	15 (18.3%)	
Mayo Score Studies			
<i>Study</i>	<i>Mayo 0-2 patients</i>	<i>Mayo 0-2 + CVF patients</i>	<i>Mode of Imaging</i>
Benson et al. (2023)	109	38	Lateral DSM
Total	109	38* (34.8%)	

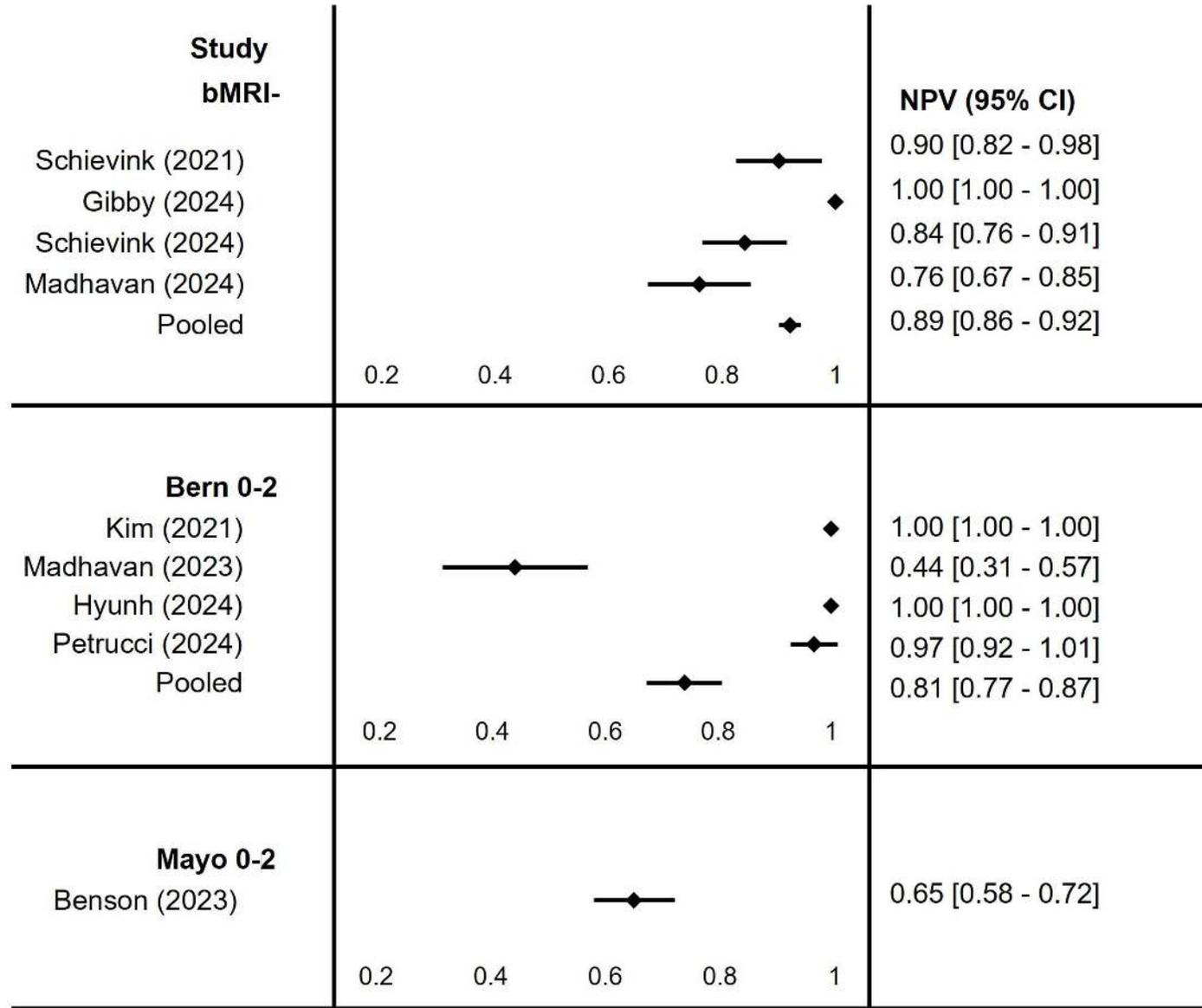
bMRI- – negative brain magnetic resonance imaging

CB-CTM – cone beam CT myelography

PCD-CTM – photon-counting detector CT myelography

dCTM-BT – lateral decubitus dynamic CTM protocol using real-time bolus-tracking

Systematic review accepted at AJNR, Tay 2025 et al.

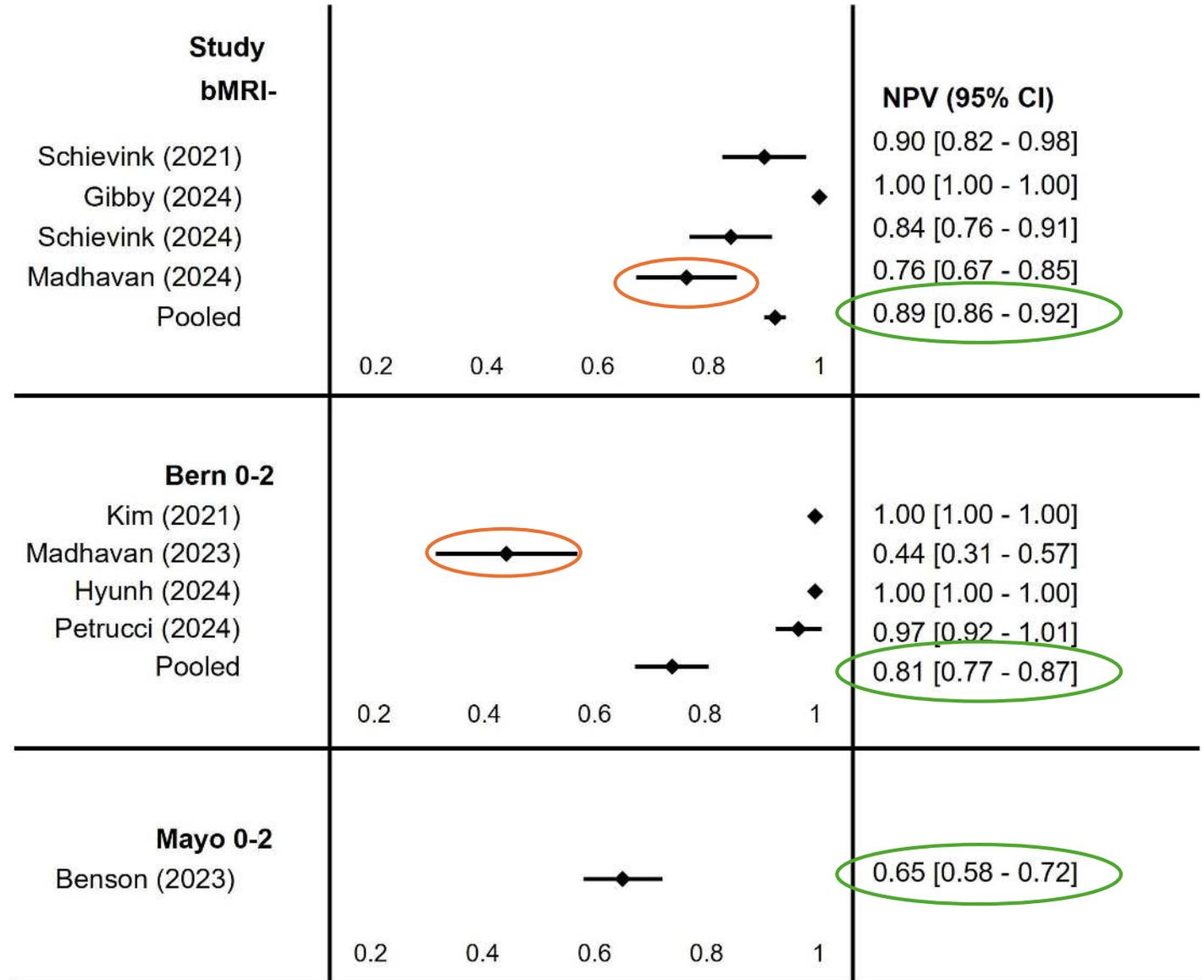


NPV = (True Negatives) / (True Negatives + False Negatives)

Systematic review accepted at AJNR, Tay 2025 et al.

Questions that arise from this data?

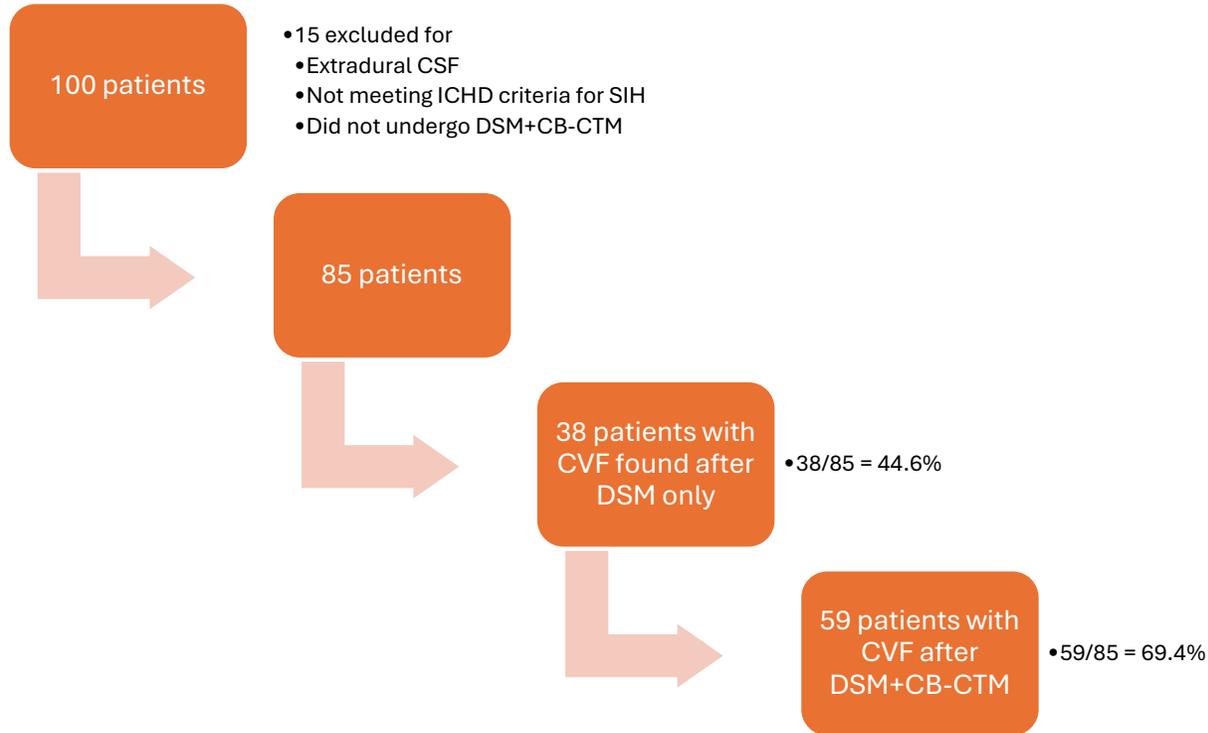
- What about these outliers?
- Why are there differences between entirely negative brain MRI and Bern or Mayo score of 0-2?



What about these outliers?

- No true gold standard imaging for detection of CVF
- Aside from DSM, different techniques of dynamic CTM have been evaluated in the literature. Differences in
 - How the images are captured
 - Timing of contrast medium injection
 - Type of anesthesia done (sedation versus general anesthesia for clearer images)
 - Whether or not saline is injected for positive pressurization prior to myelography
 - Whether respiratory maneuvers are employed during image capture

Combining Modalities to increase diagnostic yield: DSM+CB-CTM



*4 of these patients were only identified on DSM+CB-CTM

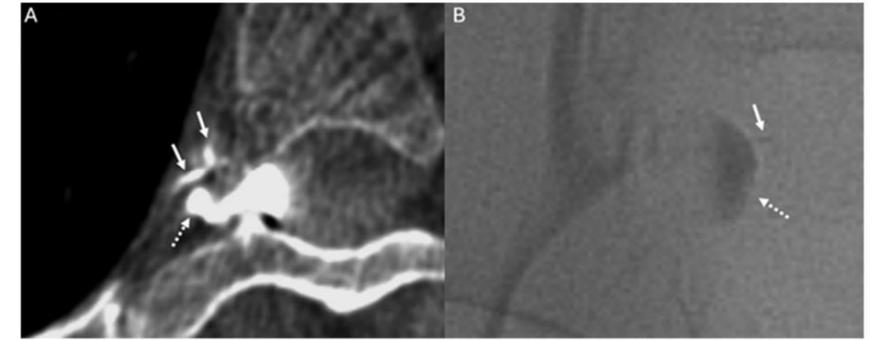
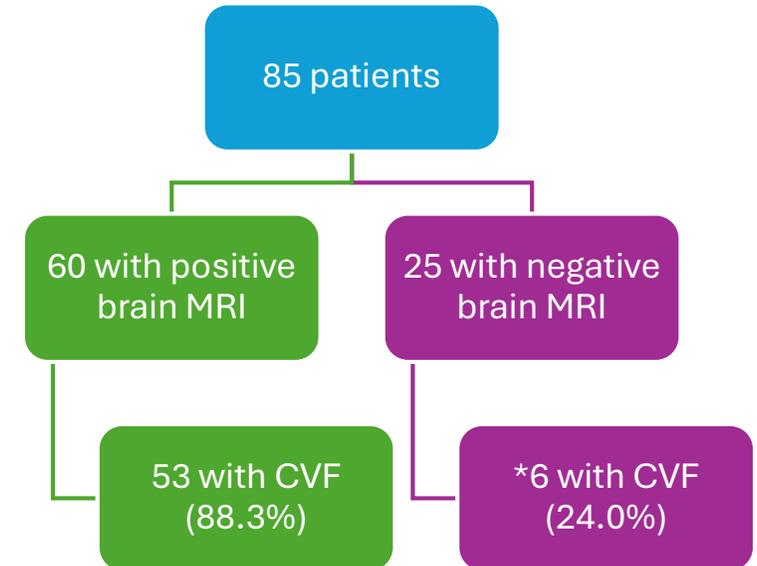


FIG 2. Right T7 CSF-venous fistula that was initially deemed occult on DSM by both image reviewers but ultimately felt to be subtly present on secondary review after seeing CB-CTM findings. The CB-CTM (A) demonstrates a clear right T7 CSF-venous fistula (A, arrows) immediately anterior to a contrast opacified meningeal diverticulum (A, dashed arrow). The DSM (B), performed during the same session, had shown a very subtle flickering density over a few frames (B, solid arrow) adjacent to the diverticulum (B, dashed arrow).



Why are there differences between entirely negative brain MRI and Bern or Mayo score of 0-2?

- Bern Score⁶ – developed for predicting the likelihood of finding an epidural leak on spine imaging
 - Likely not entirely applicable to CVF patients.
- Mayo Score⁷ – developed with only patients without SLEC
 - This could include a dural tear with a small localized extradural fluid collection
- Low Bern or Mayo score of 1 or 2 ≠ entirely negative MRI
- Not all the points are equal

Table 2. Six Imaging Signs With Good Discriminative Power and Interrater Agreement That Were Included in the Final Diagnostic Score and Assigned Score Points

Characteristic	Coefficient (95% CI)	Odds Ratio (95% CI)	P Value	Score Points
Engorgement venous sinus	2.95 (1.18-4.72)	19.12 (3.26-112.30)	.001	2
Pachymeningeal enhancement	4.04 (2.50-5.59)	57.01 (12.18-266.78)	<.001	2
Subdural fluid collection	1.54 (-0.10 to 3.17)	4.65 (0.90-23.92)	.07	1
Suprasellar cistern ^a	3.48 (2.36-4.60)	32.32 (10.55-99.02)	<.001	2
Prepontine cistern ^b	1.47 (0.41-2.52)	4.34 (1.51-12.47)	.007	1
Mamillopontine distance ^c	1.13 (0.07-2.19)	3.08 (1.07-8.90)	.04	1

^a ≤4 mm.
^b ≤5 mm.
^c ≤6.5 mm.

Table 2: Scoring system based on 7 intracranial imaging findings

Finding	Points
Smooth dural enhancement	1
Dural enhancement in the IACs	1
Pituitary engorgement	1
Non-Chiari cerebellar descent of >5 mm	1
Dural venous sinus engorgement	1
Cerebral aqueduct iter below incisural line	1
Suprasellar cistern ≤2.5 mm	1

Not all points are equal.

- 90 epilepsy patients that were not clinically suspected for SIH
 - Average Bern Score was 1.5
 - Average Mayo Score was 0.0

1: Summary of Bern and Mayo scores

	Bern Score	Mayo Score
Total Score	Number of patients (%)	Number of patients (%)
0	26 (29%)	86 (96%)
1	25 (28%)	4 (4%)
2	19 (21%)	0 (0%)
3	9 (10%)	0 (0%)
4	11 (12%)	0 (0%)
5 or above	0 (0%)	0 (0%)

	Bern	Mayo
Low	70/90 (78%)	90/90 (100%)
Intermediate	20/90 (22%)	0/90 (0%)
High	0/90 (0%)	

Kang CH, Madhavan AA, Benson JC, Mark IT, Johnson-Tesch BA, McDonald RJ, Verdoorn JT. Evaluation of Spontaneous Intracranial Hypotension Probabilistic Brain MRI Scoring Systems in Normal Patients. AJNR Am J Neuroradiol. 2025 Feb 20:ajnr.A8713. doi: 10.3174/ajnr.A8713. Epub ahead of print. PMID: 39979026.

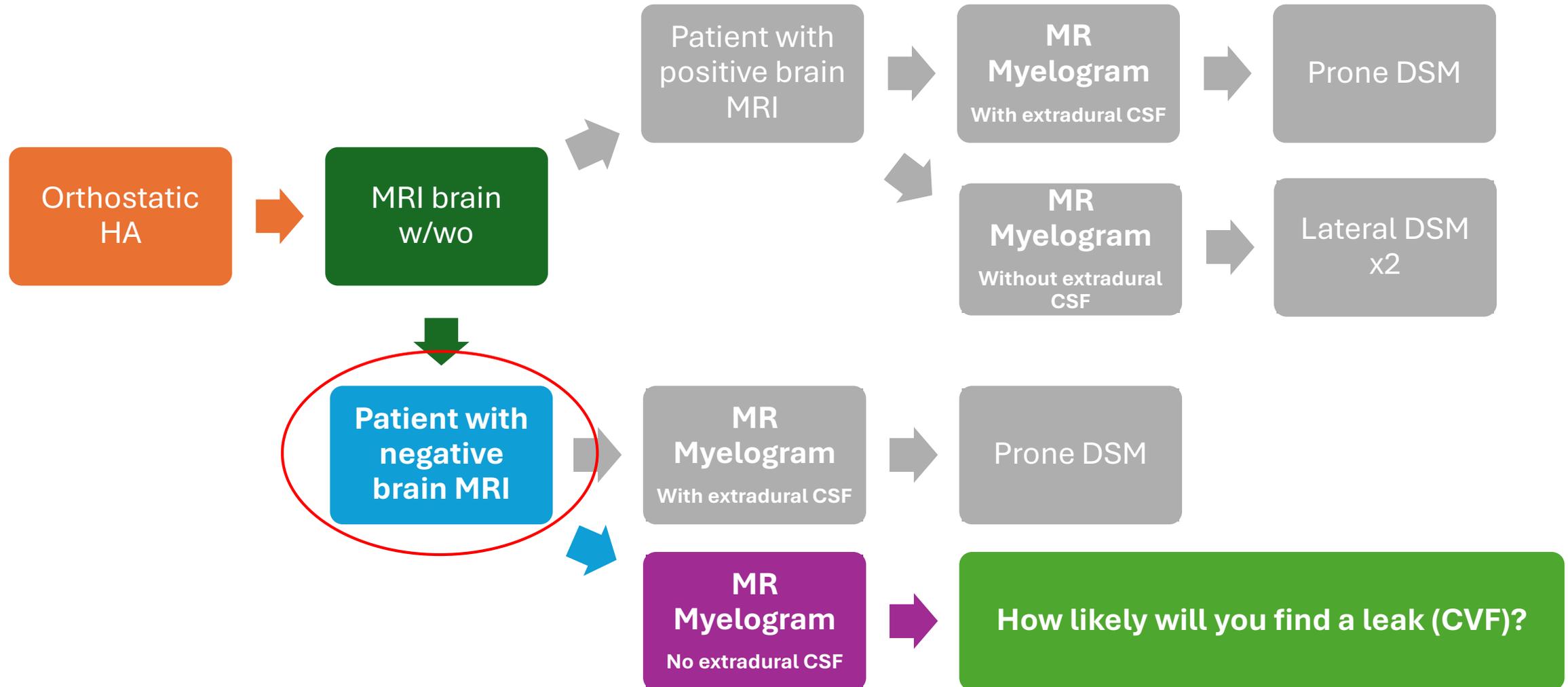
Not all points are equal.

- All the patients with intermediate probability were due to the measurements of the prepontine cistern, suprasellar cistern and the mammilopontine distance.

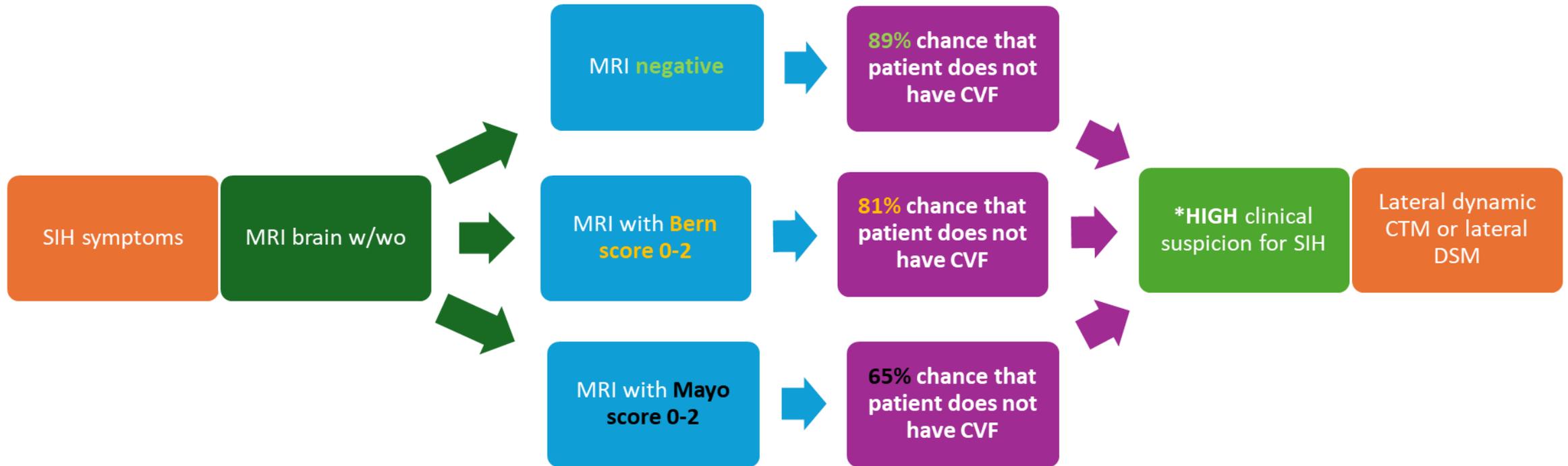
Table 2: Rates of positivity of Bern and Mayo score criteria

Points	Bern Score Criteria		Mayo Score Criteria	
		Positivity Rate		
2	Pachymeningeal enhancement	0 (0%)	Smooth dural enhancement	0 (0%)
2	Suprasellar cistern effacement of 4.0 mm or less	25 (28%)	Dural enhancement in the internal auditory canals	0 (0%)
2	Venous sinus engorgement	0 (0%)	Pituitary engorgement	2 (2%)
1	Subdural fluid collection	0 (0%)	Non-Chiari cerebellar tonsillar descent of more than 5 mm	0 (0%)
1	Prepontine cistern effacement of 5.0 mm or less	48 (53%)	Venous sinus engorgement	0 (0%)
1	Mamillopontine distance of 6.5 mm or less	36 (40%)	Iter below the incisural line	2 (2%)
			Suprasellar cistern effacement of 2.5 mm or less	0 (0%)

What about these patients?



How likely will you find a leak (CVF)?



So when do we proceed to more invasive imaging with a negative brain MRI for CVF?

- High clinical suspicion
- Presence of meningeal diverticula on spine imaging.
 - It was shown that 20% of the patients positive for meningeal diverticula were found to have CVF versus none of the patients without diverticula⁹.
- Reduced optic nerve sheath diameter could increase the chances of finding a CVF in a patient with negative brain MRI¹⁰.
 - CVF was detected in about 50% of patients with ONSD < 4.4 mm and perioptic subarachnoid space < 1.0 mm vs. less than 2% of patients with measurements above these values.
 - If ONSD abnormality was considered as a positive MRI, the NPV of a negative MRI would presumably increase.

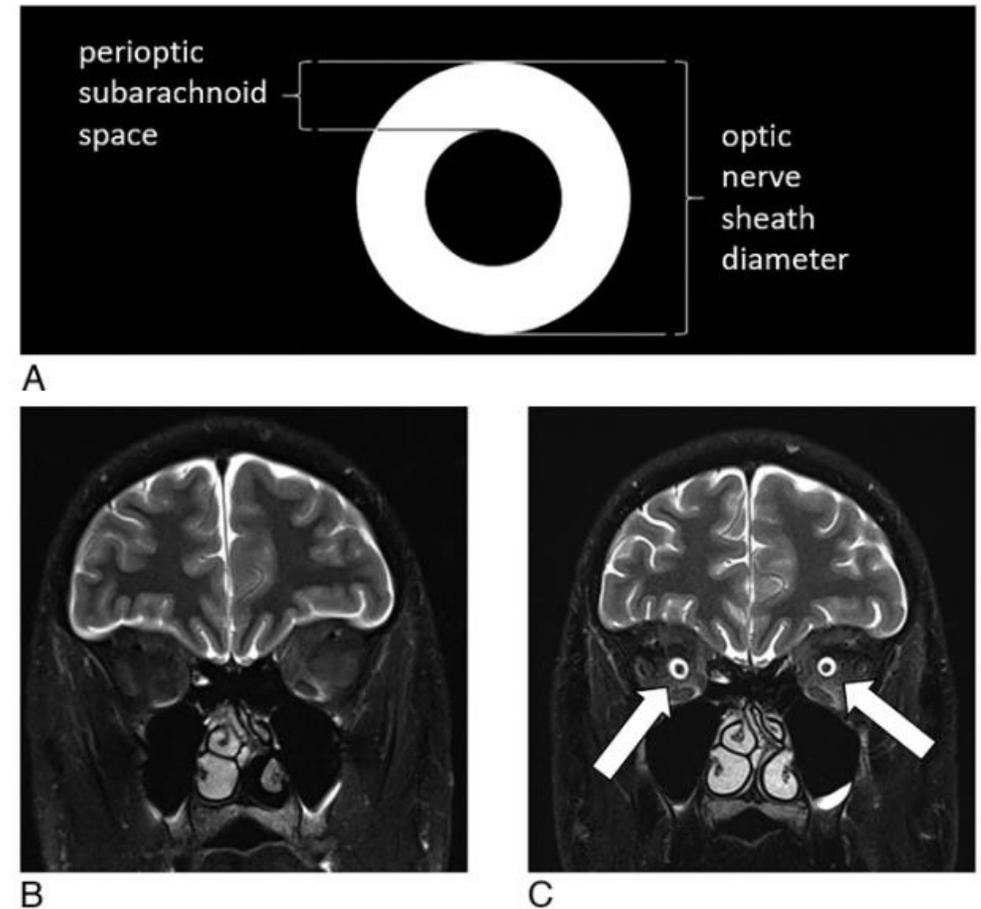
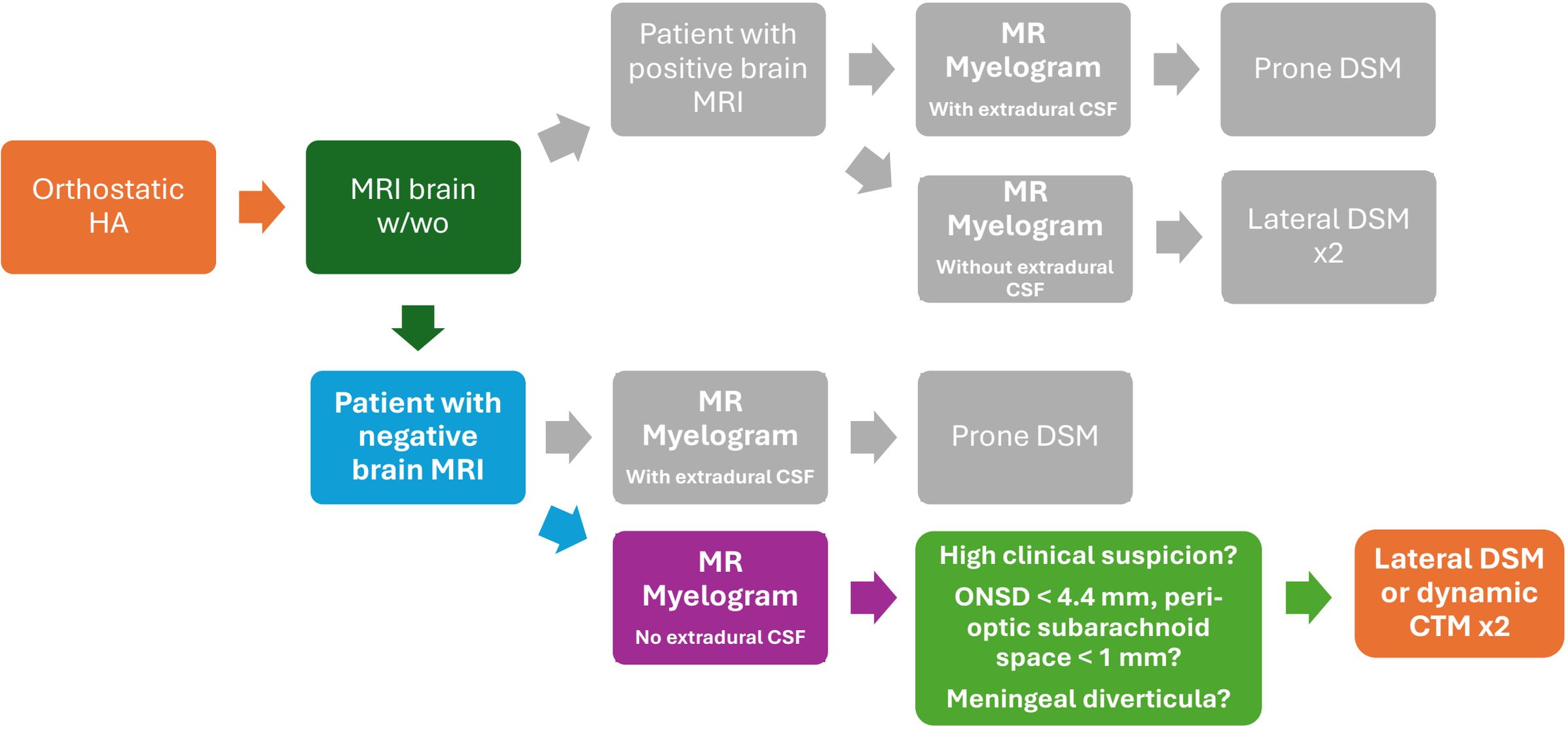


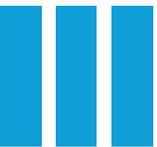
FIG 1. How to measure the ONSD and perioptic subarachnoid space. Illustration (A) depicting the measurements for the ONSD and the perioptic subarachnoid space. Pre- (B) and post- (C) operative coronal fat-suppressed T2-weighted MR imaging shows restoration of the perioptic subarachnoid space (arrows) following ligation of a spinal CSF-venous fistula.

What about these patients?



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Questions?

