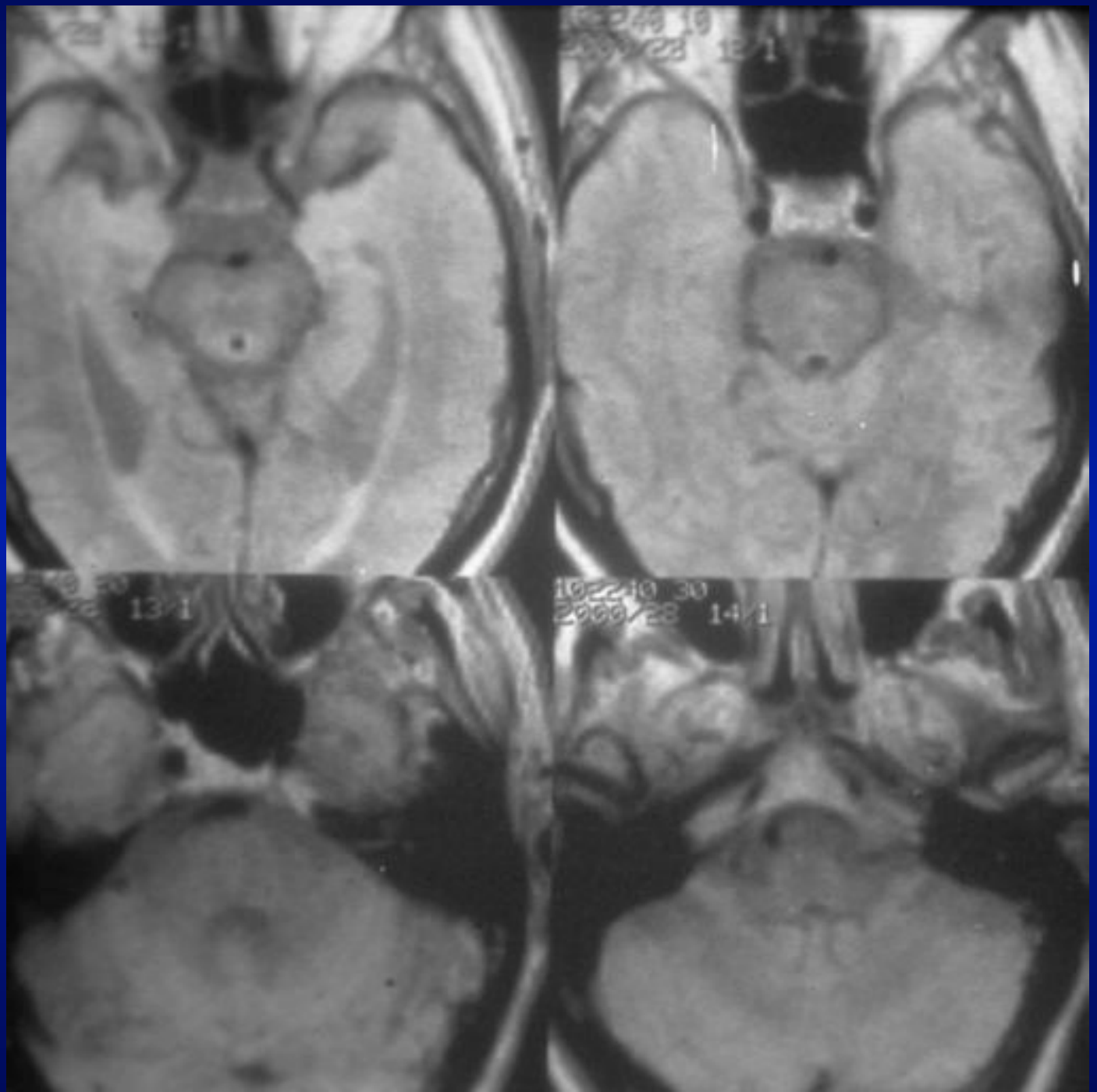
Alternate Methods: Pros and Cons (With a Focus on NPH)

William G. Bradley, Jr, MD, PhD, FACR
Professor and Chair
Department of Radiology
University of California, San Diego

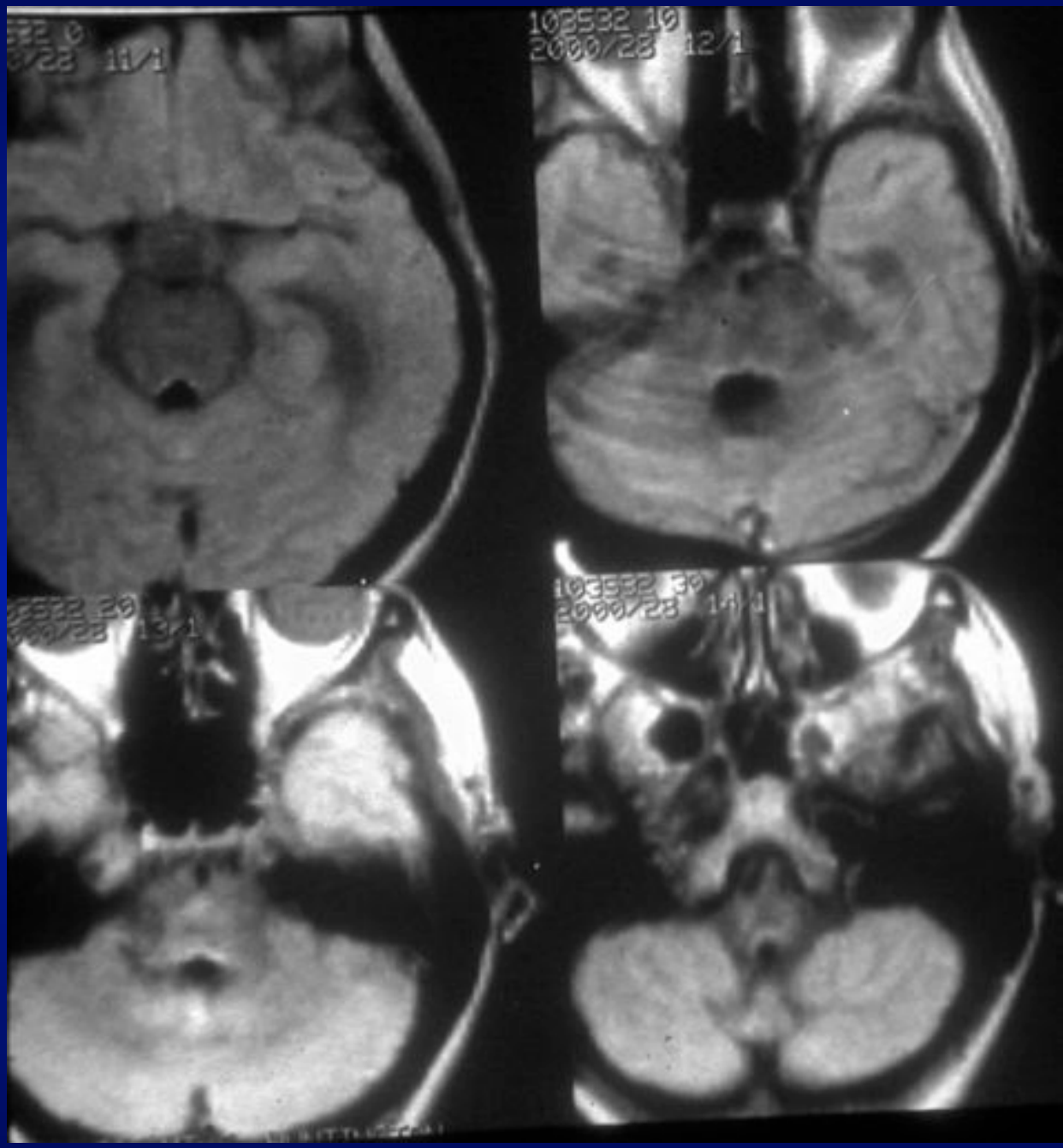
Alternate Imaging Methods for Diagnosing Shunt-Responsive NPH

- 1983-84: extent of CSF flow void = hyperdynamic flow and no atrophy
- 1990: Phase Contrast volumetric flow quantitation through the aqueduct: ACSV
- 2010: DESH pattern described
- 2012: TimeSLIP

Normal (1984)



Hyperdynamic flow (1984)

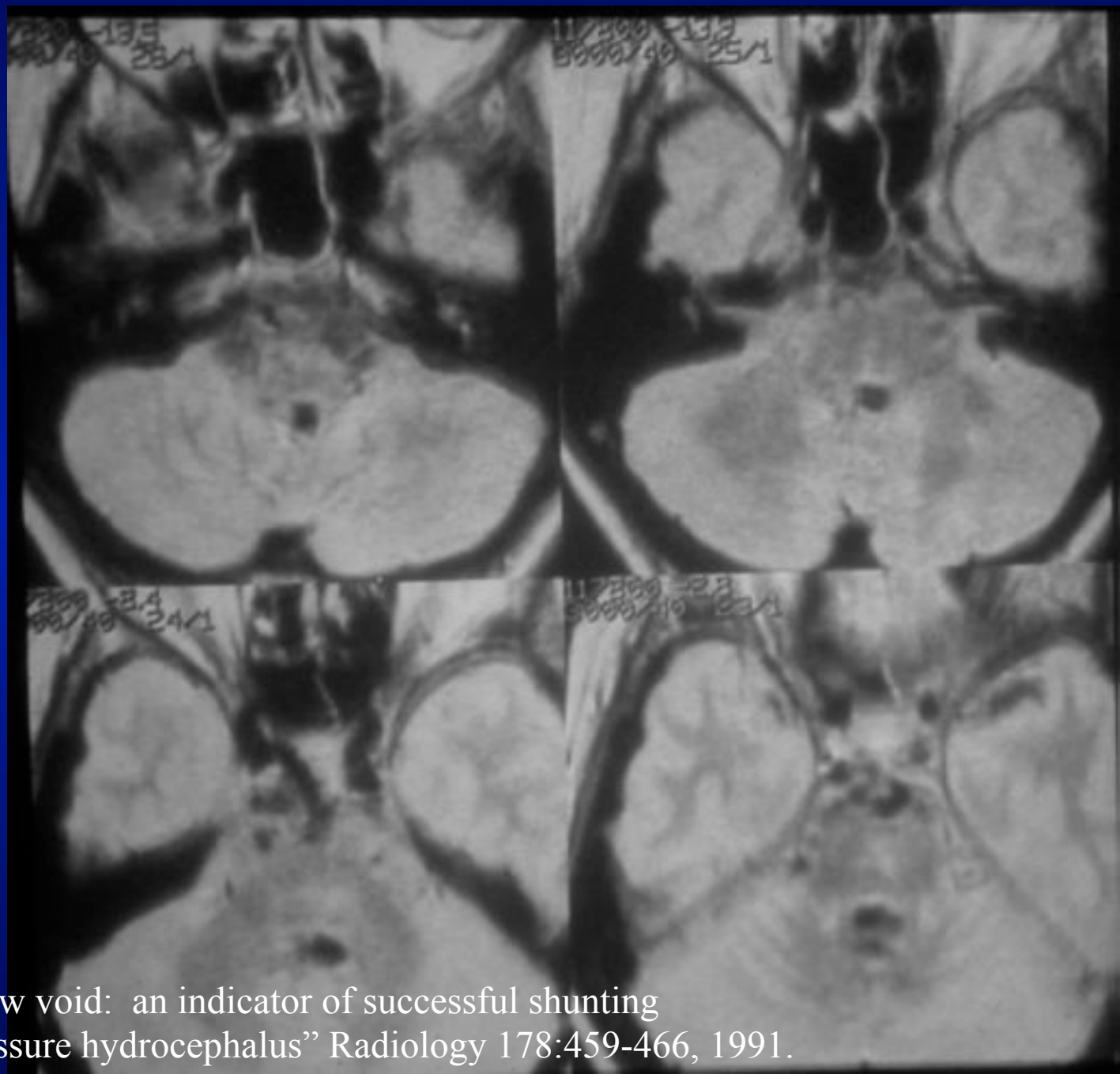


CSF Flow Void

Surgical Response	Marked	Minimal
Good	8	1
Poor	2	9

Fisher's Exact Test
$p < .003$

To shunt or not to shunt (1984)

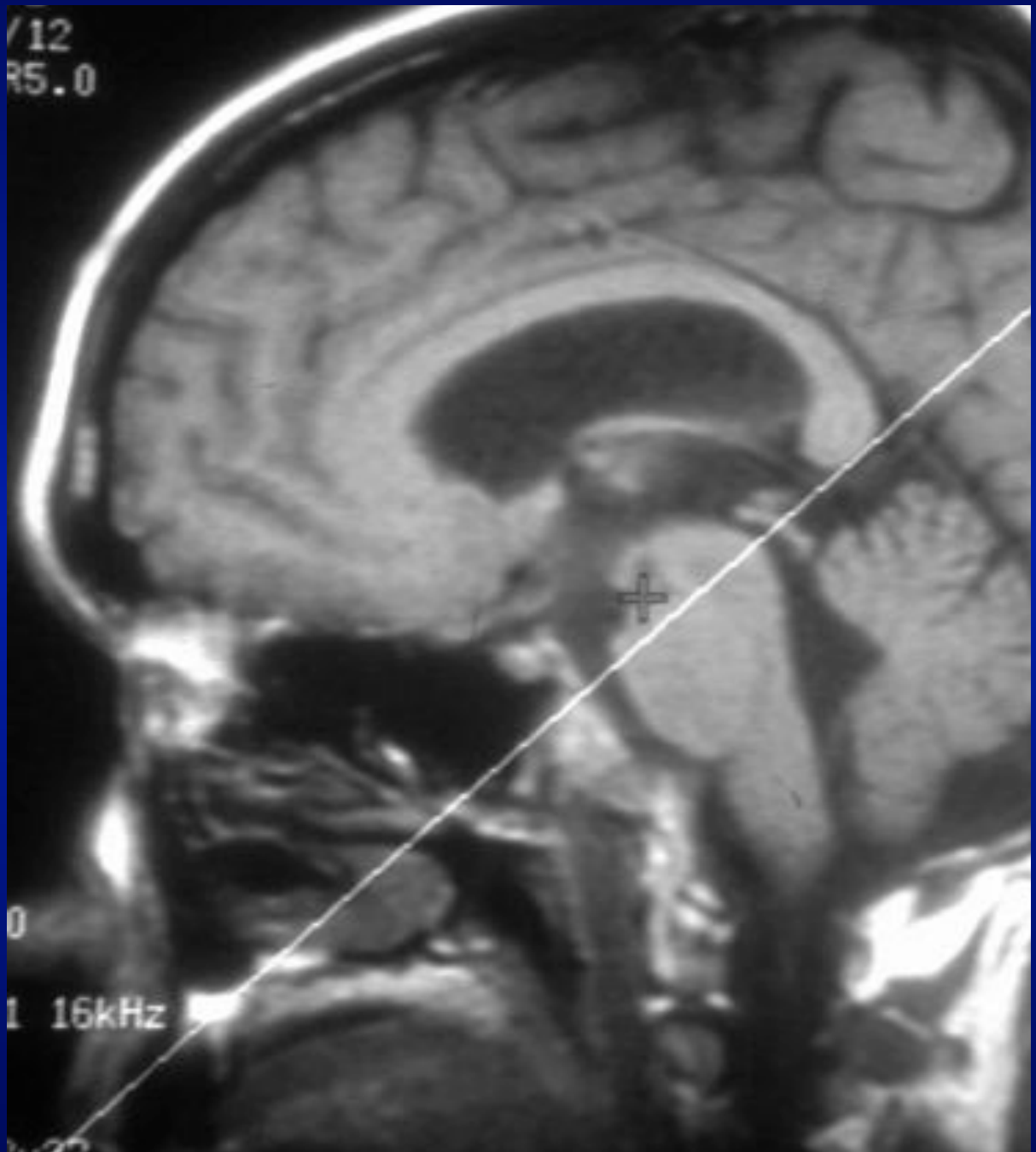


Bradley WG, et al, "Marked CSF flow void: an indicator of successful shunting in patients with suspected normal pressure hydrocephalus" Radiology 178:459-466, 1991.

Quantitative Phase Contrast CSF Flow Study

- 512x512; 16 cm FOV
- .32 mm pixels
- 4mm slice angled perpendicular to aqueduct
- Velocity-encode in slice direction
- Retrospective cardiac-gating (not EKG triggering)

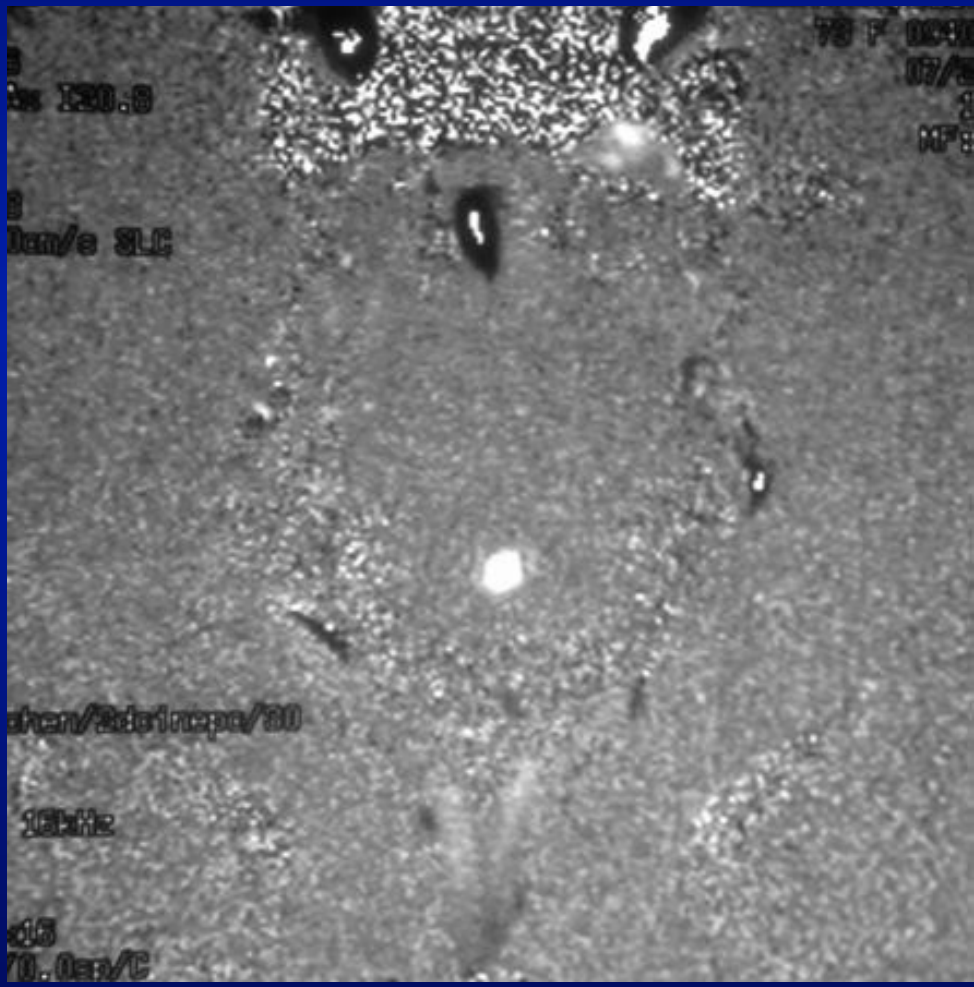
Quantitative CSF Velocity Imaging

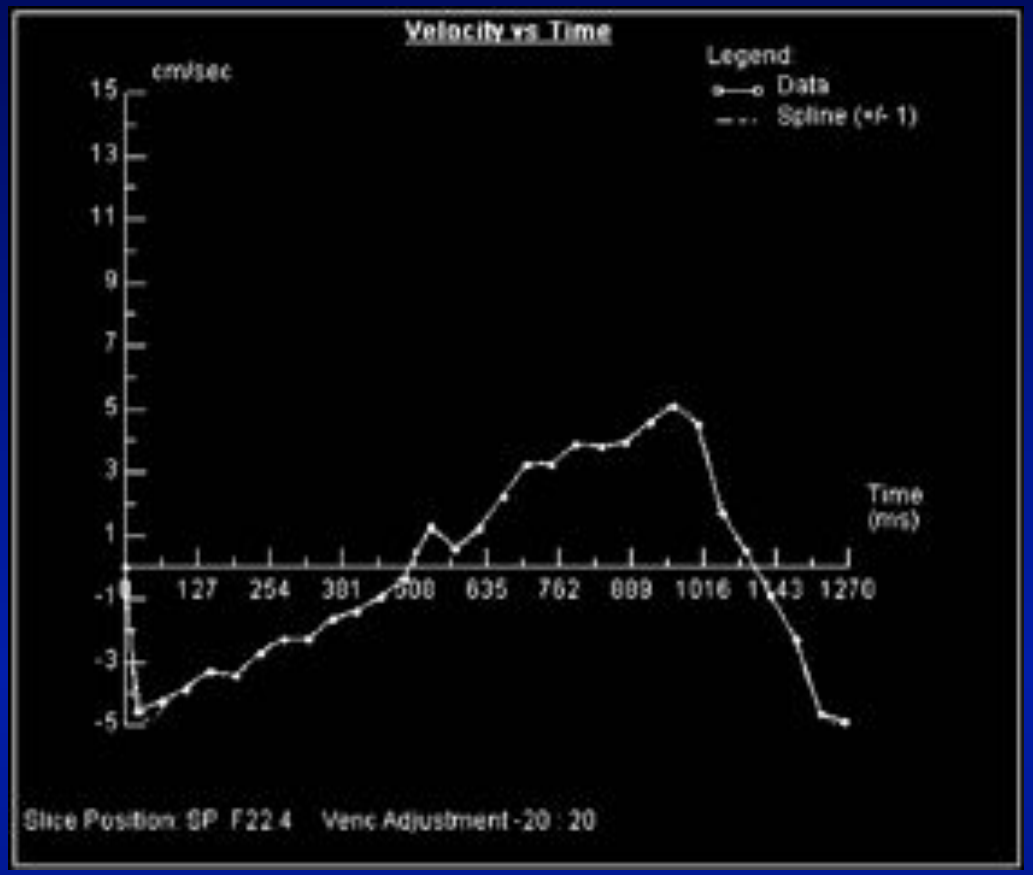


Quantitative CSF Flow Study

- Through-plane flow-encoding
- Venc= 10, 20, 30 cm/sec (NPH)
- Venc= 5 cm/sec (shunt malfunction)

Quantitative CSF Velocity Imaging





Slice Position: SP F22.4	Region: 1	
Range,ms: 0 to 1263	Venc Adjustment	-20 cm/sec 20 cm/sec
Body Surface Area (BSA):	----	m^2
Velocity		
Peak Velocity:	15.14	cm/sec
Average Velocity:	-0.004	cm/sec
Flow		
Average Flow Over Range:	-0.001	ml/sec
Average Flow Per Minute:	----	l/min
Forward Volume:	0.255	ml
Reverse Volume:	0.255	ml
Net Forward Volume:	-0.001	ml
Net Forward Volume / BSA:	----	ml/m^2
Area		
Average Area:	0.150	cm^2
Minimum Area:	0.150	cm^2
Maximum Area:	0.150	cm^2

Normal ACSV on our scanners is 0.040 ml (40 uL)
We call hyperdynamic flow when 2x normal

Materials and Methods

- 20 Patients (age 54-85)
- Suspected NPH
- Routine MRI of Brain
- Quantitative CSF Velocity Imaging
- VP Shunt
- Follow up at 1 month

Bradley WG, et al, "Normal-pressure hydrocephalus: evaluation with cerebrospinal fluid flow measurements at MR imaging" Radiology 198:523-529, 1996.

Results

- Of 20 shunted patients:
- 14 had hyperdynamic flow
  - (SV>42 microliters; NB: machine specific!)
  - 13 had a good surgical response
  - 1 did not (chronic MS)
- 6 had normal or decreased flow
  - (SV<42 microliters)
  - 3 had a good surgical response
  - 3 did not (concomitant atrophy)

Bradley WG, et al, "Normal-pressure hydrocephalus: evaluation with cerebrospinal fluid flow measurements at MR imaging" Radiology 198:523-529, 1996.

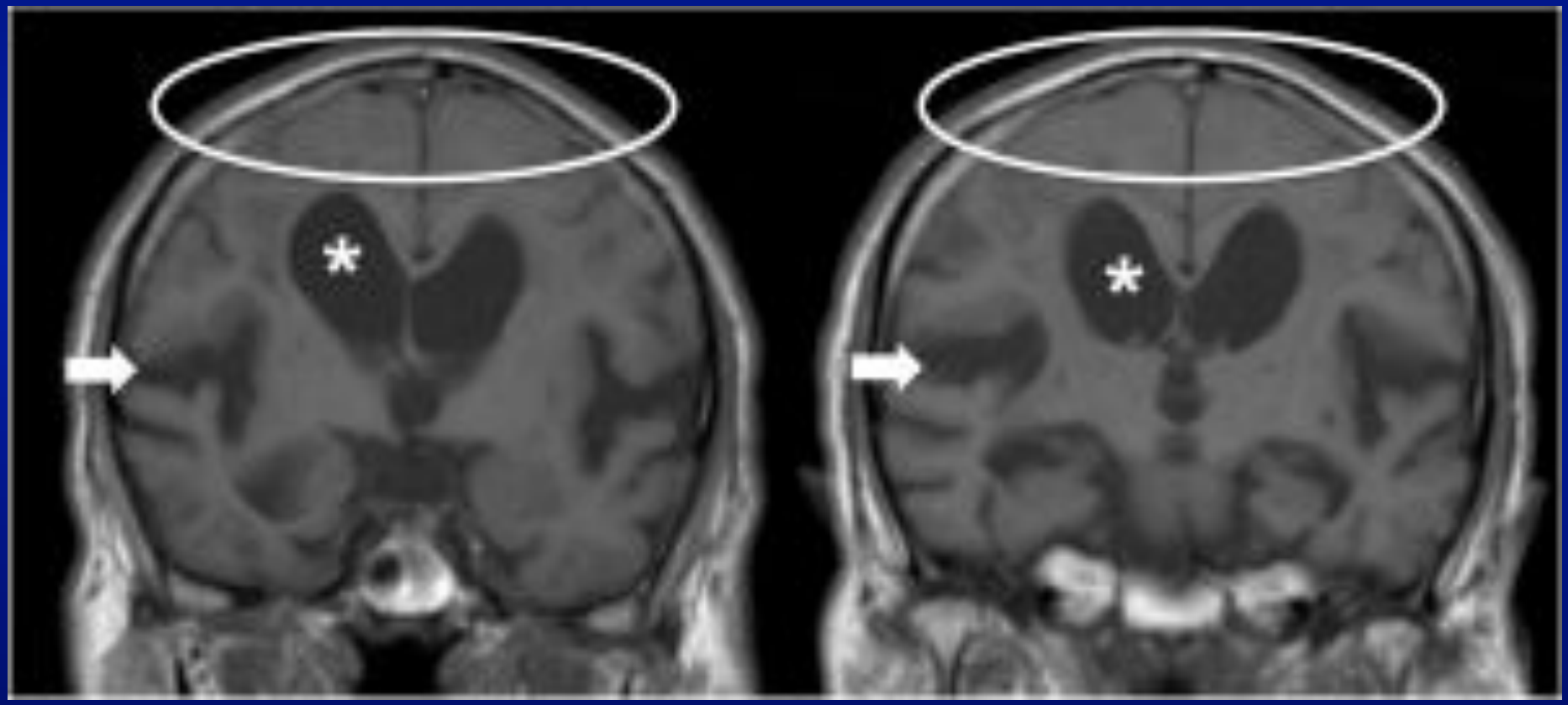
DESH

- Disproportionately Enlarged Subarachnoid space Hydrocephalus
- Combination of enlarged Sylvian cisterns and tight superior convexities on midcoronal slice “useful” for predicting response to shunting for NPH (Hashimoto, et al, SINPHONI study)

First DESH Reference

- Cerebrospinal Fluid Res. 2010 Oct 31;7:18. doi: 10.1186/1743-8454-7-18.
- **Diagnosis of idiopathic normal pressure hydrocephalus is supported by MRI-based scheme: a prospective cohort study.**
- Hashimoto M[1], Ishikawa M, Mori E, Kuwana N; Study of INPH on neurological improvement (SINPHONI).

DESH



Hashimoto M, et al, CSF Research, 2010

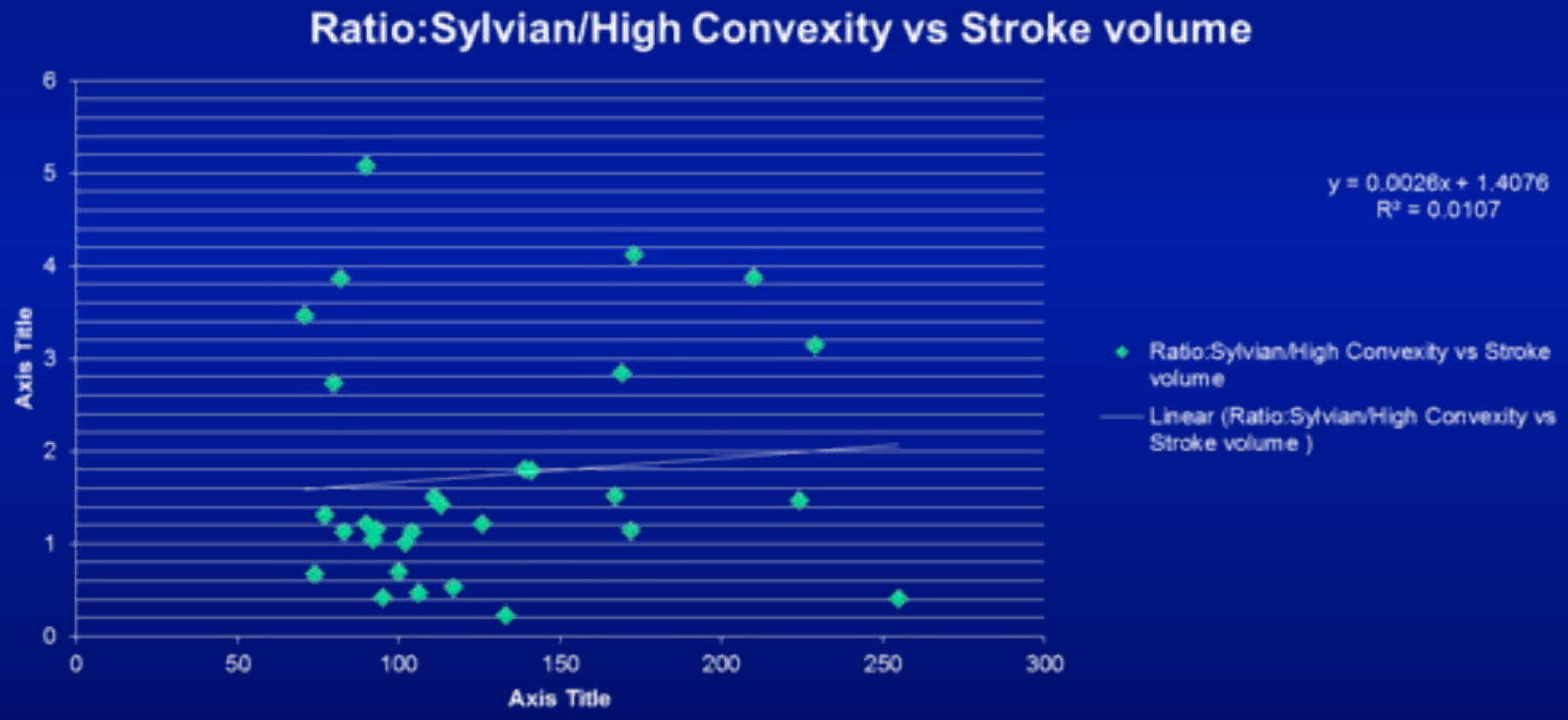
DESH vs Tap Test

- Ishikawa, et al, paper in 2012 showed Tap Test didn't add anything if Evans Index > .3 and tight superior convexities

DESH vs Tap Test

- Fluids Barriers CNS. 2012 Jan 13;9(1):1. doi: 10.1186/2045-8118-9-1.
- **The value of the cerebrospinal fluid tap test for predicting shunt effectiveness in idiopathic normal pressure hydrocephalus.**
- Ishikawa M[1], Hashimoto M, Mori E, Kuwana N, Kazui H.

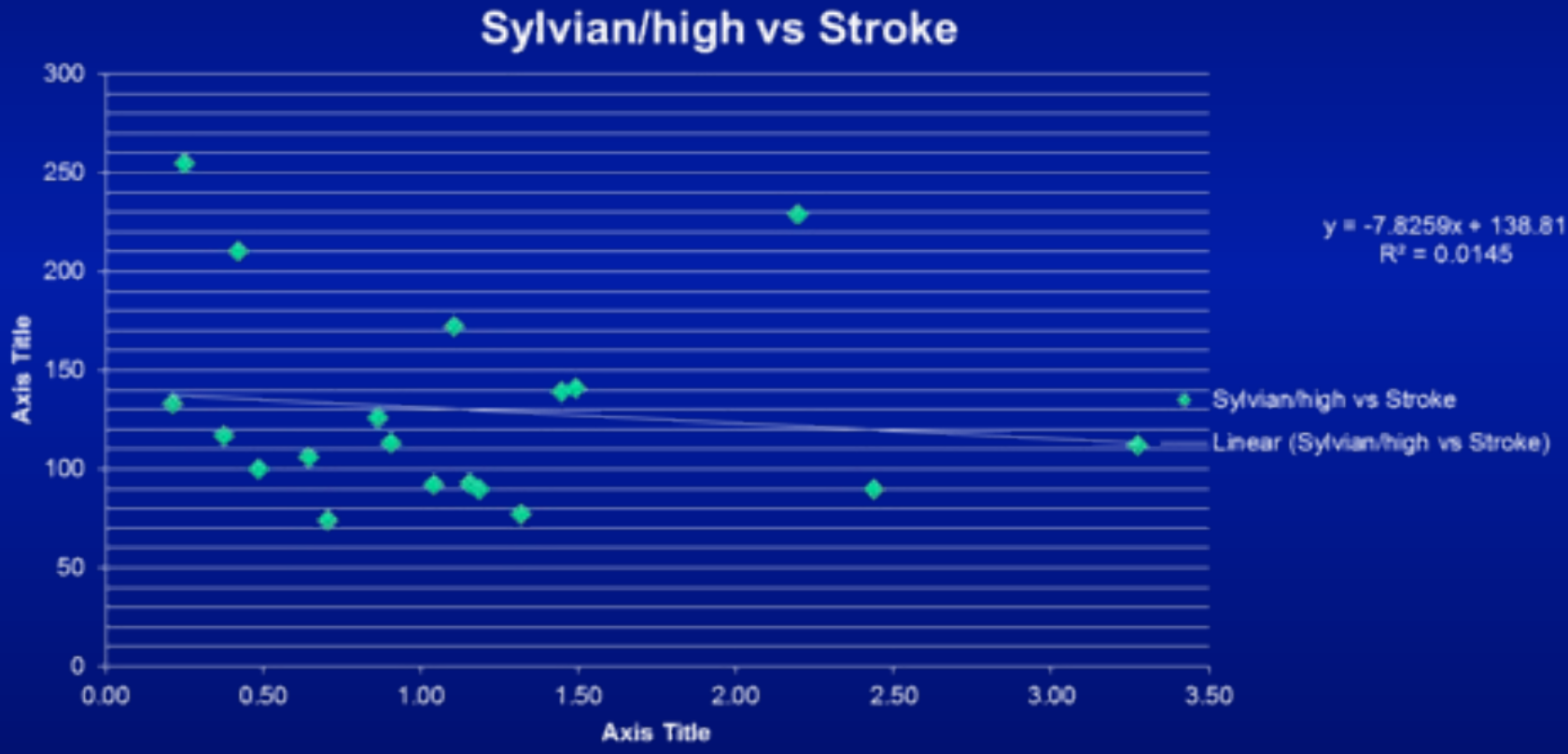
Midcoronal: Sylvian/high convexity volume vs ACSV



ACSV

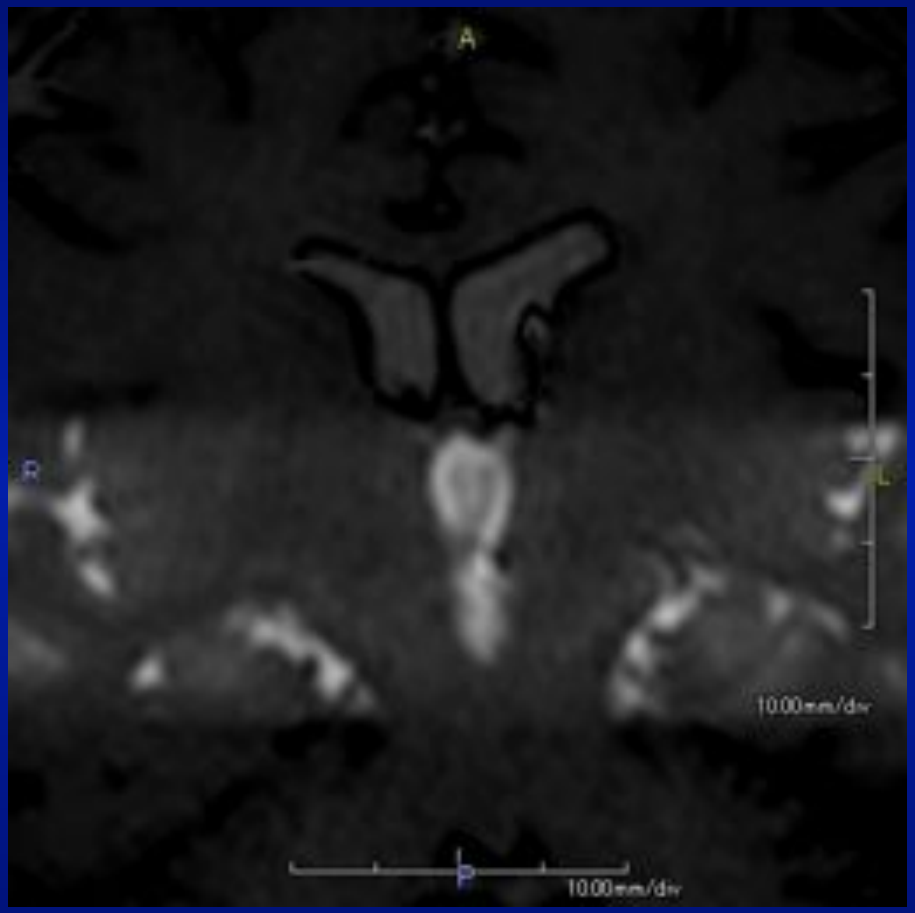
Volume: Sylvian/high convexity vs ACSV

ACSV

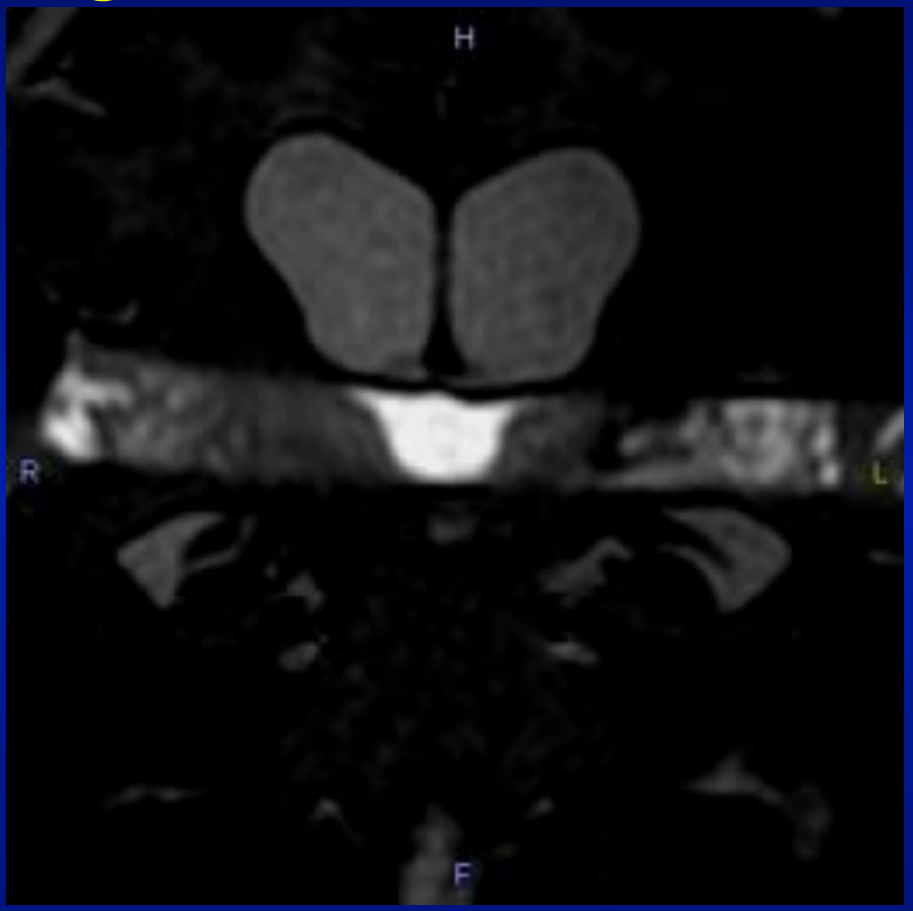


As Syl/high goes up, SV should go up

TimeSLIP for NPH



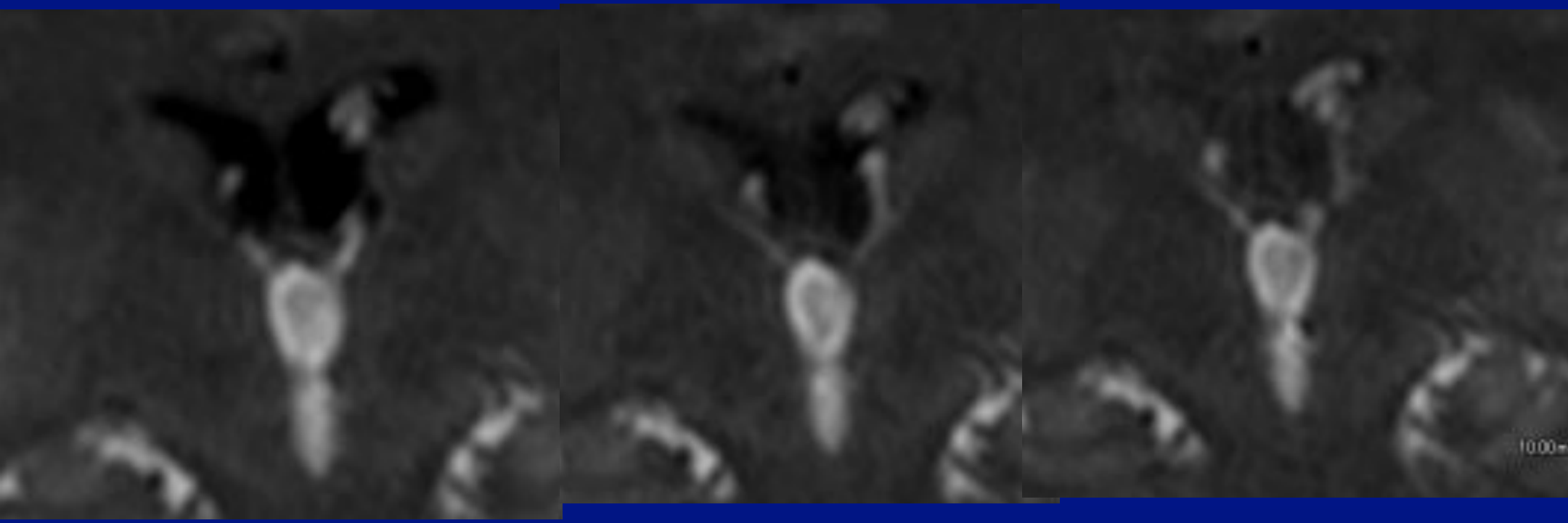
Normal



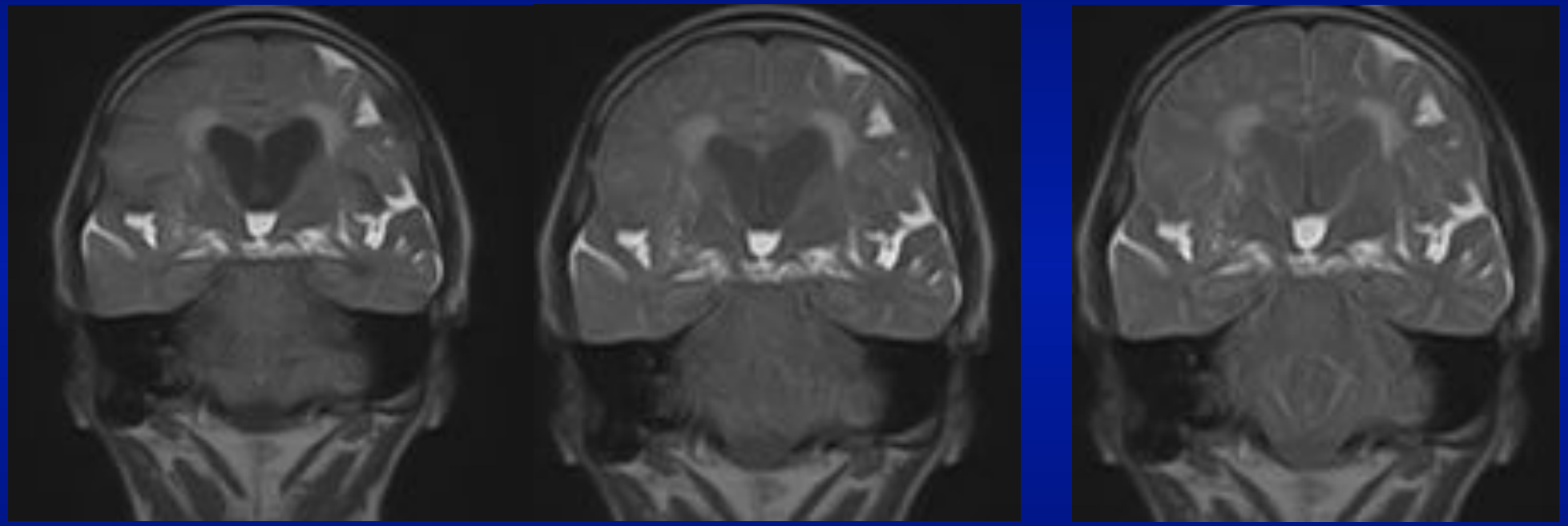
NPH

Courtesy Shinya Yamada, MD and Toshiba

TimeSLIP in Normal



TimeSLIP in NPH



TimeSLIP vs Phase Contrast

- TimeSLIP tracks CSF motion over several seconds showing bulk flow patterns
- New technique: little experience and only one or two vendors
- Qualitative vs quantitative
- Quick compared to PC (although NOVA…)
- Tagging plane can be positioned easily to maximize detection of flow
- Does not require cardiac gating