Volumetric DESH vs Aqueductal CSF Stroke Volume in NPH

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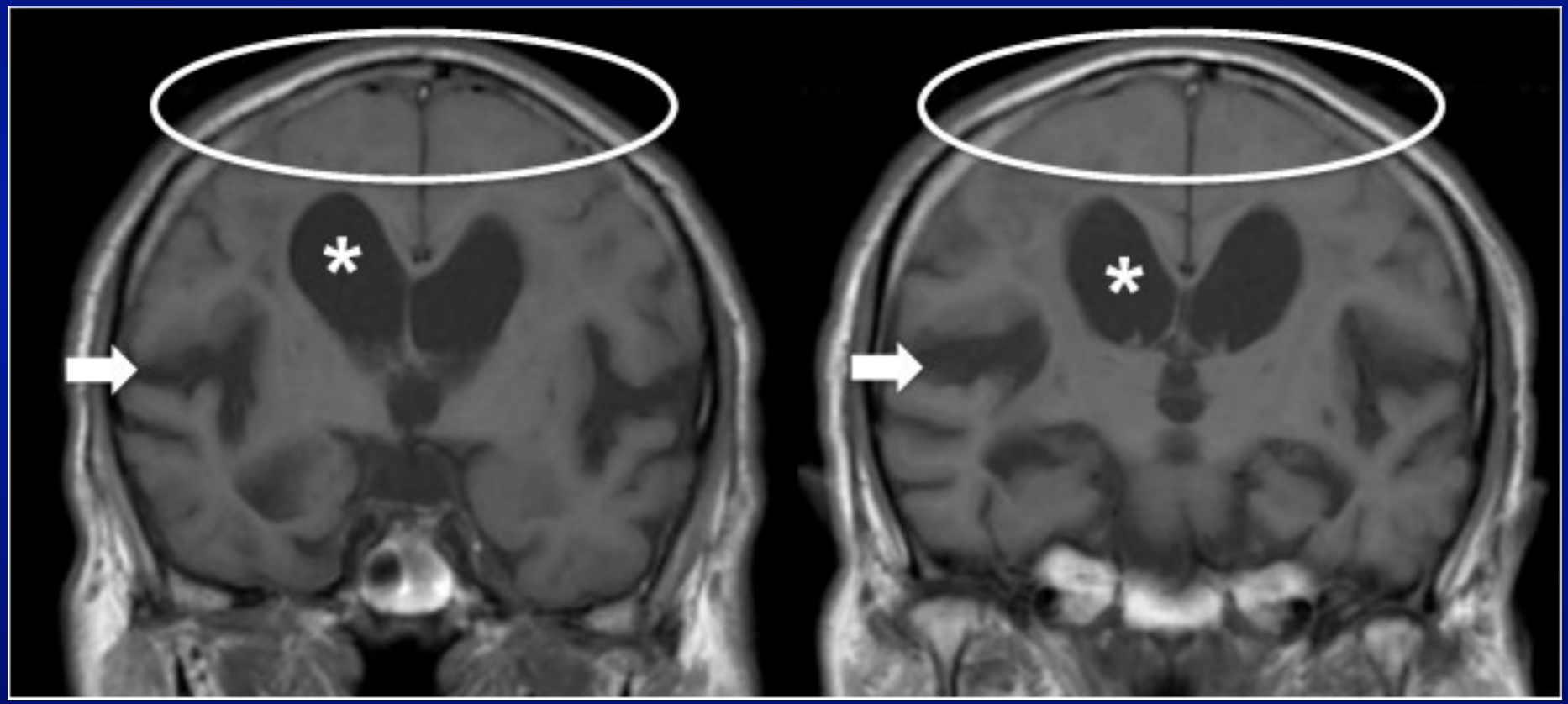
DESH

- 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.

NPH Workup at UCSD

- Clinical presentation (triad)
- Routine MRI of Brain with
  - phase contrast CSF flow study through aqueduct for Aqueductal CSF Stroke Volume (ACSV)
  - Midcoronal T1 or T2 for DESH pattern
  - midsagittal FIESTA for AS
- Tap Test

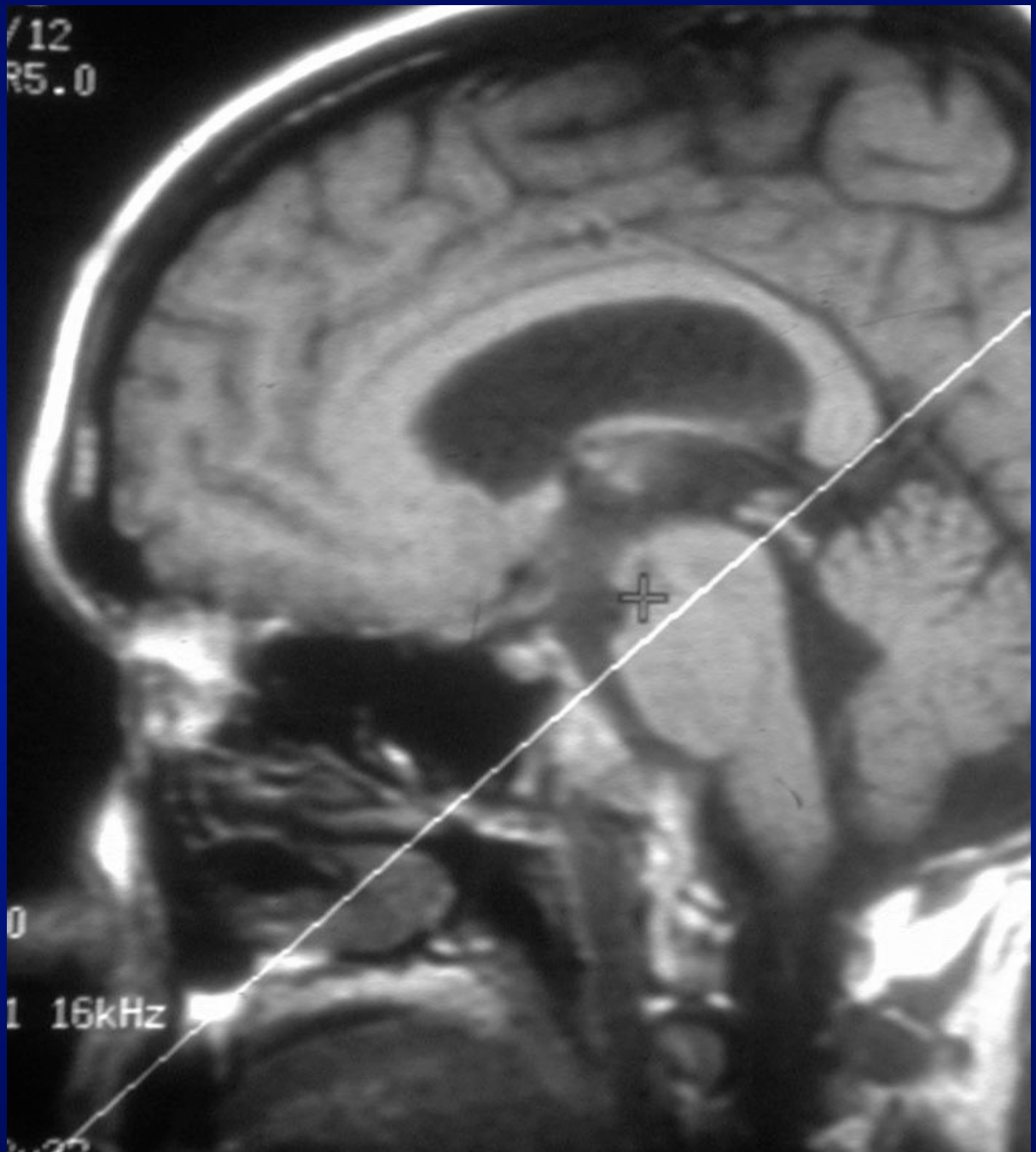
Our Experience with Hyperdynamic CSF Flow in NPH

- 30 years ago: hyperdynamic CSF flow
  - flow void from foramen of Monro through obex
  - Correlation with shunt-responsive NPH: $p<.003$
- 18 years ago: elevated ACSV had 100% PPV for shunt-response NPH
  - Elevated ACSV means they don't have atrophy
- More detail on how we calculate ACSV:

Quantitative 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)

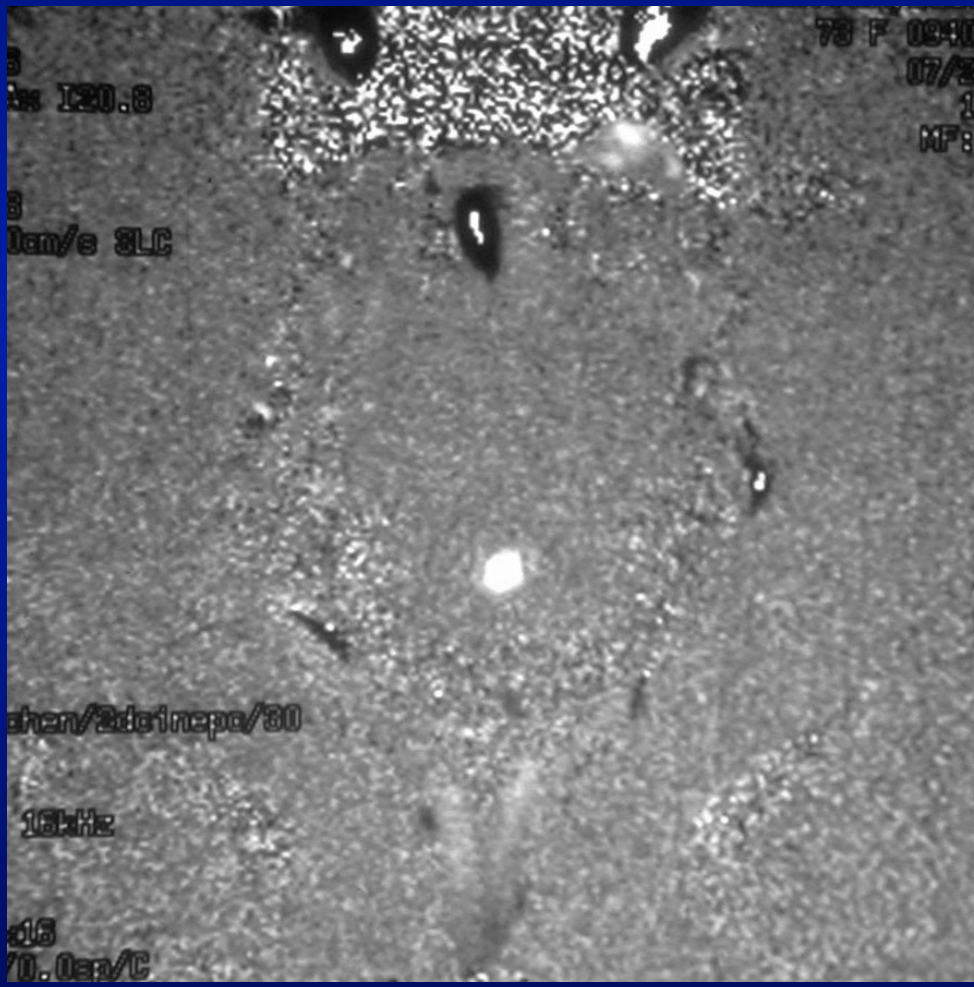
Quantitative CSF Velocity Imaging

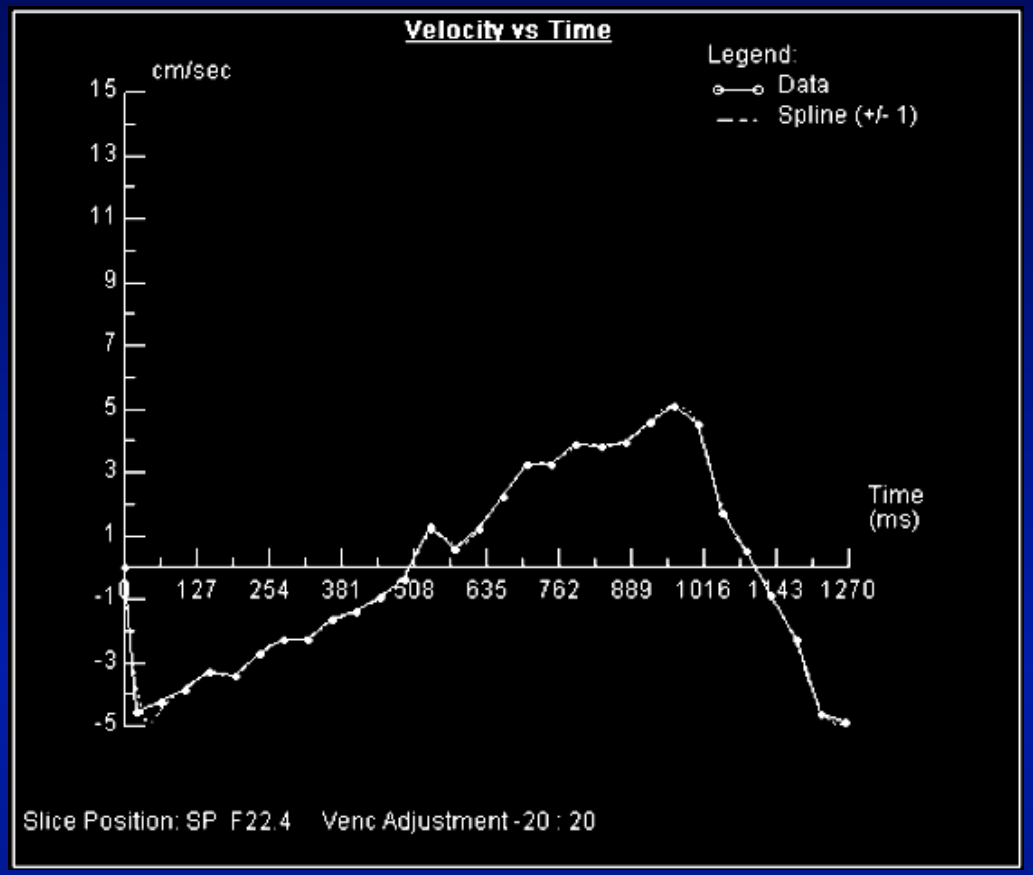


Quantitative CSF Flow Study

- 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
Mininum 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 mesurements at MR imaging" Radiology 198:523-529, 1996.

How Does DESH Compare to Aqueductal CSF Stroke Volume?

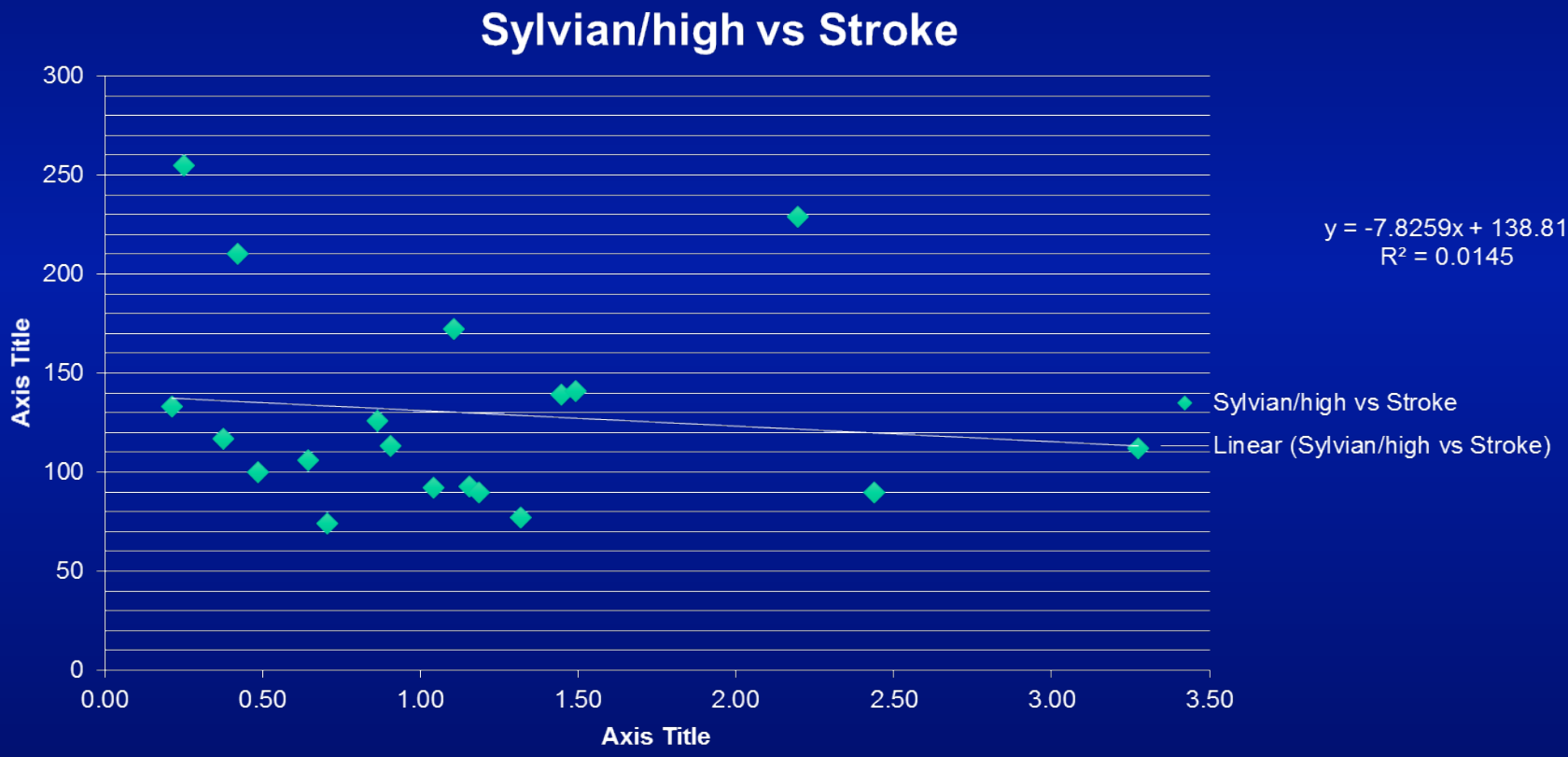
- 30 patients with clinical NPH and elevated ACSV with midcoronal T1 or T2
- How to quantify “tight superior convexity subarachnoid space”?
- Segmented CSF volumes for midcoronal slice (n=30) vs full AP extent (n=20) of Sylvian cistern
- SAS defined by line connecting superior convexity gyri; sulci measured separately

Measured Variables for DESH vs ACSV

- Stroke volume vs DESH volume (midcoronal slice and full AP volume of Sylvian cistern)
  - Sylvian cistern volume/high convexity volume
  - (Lat vent + Sylvian)/high convexity volume
  - Lateral vent + Sylvian cistern volume
  - Sylvian cistern volume
  - High convexity volume
  - Superior sulci volume

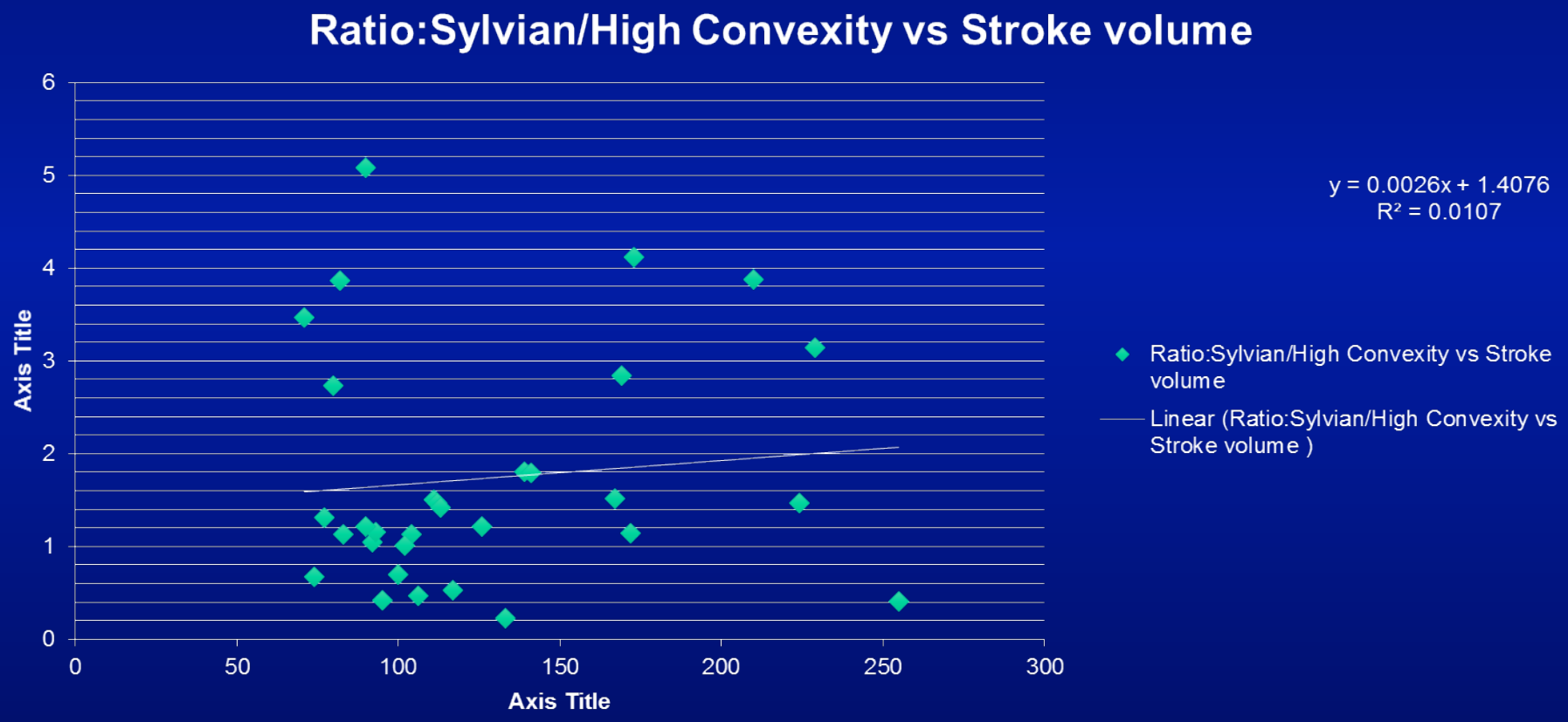
Volume: Sylvian/high convexity vs ACSV

ACSV



Not expected. As Syl/high goes up, SV should go up

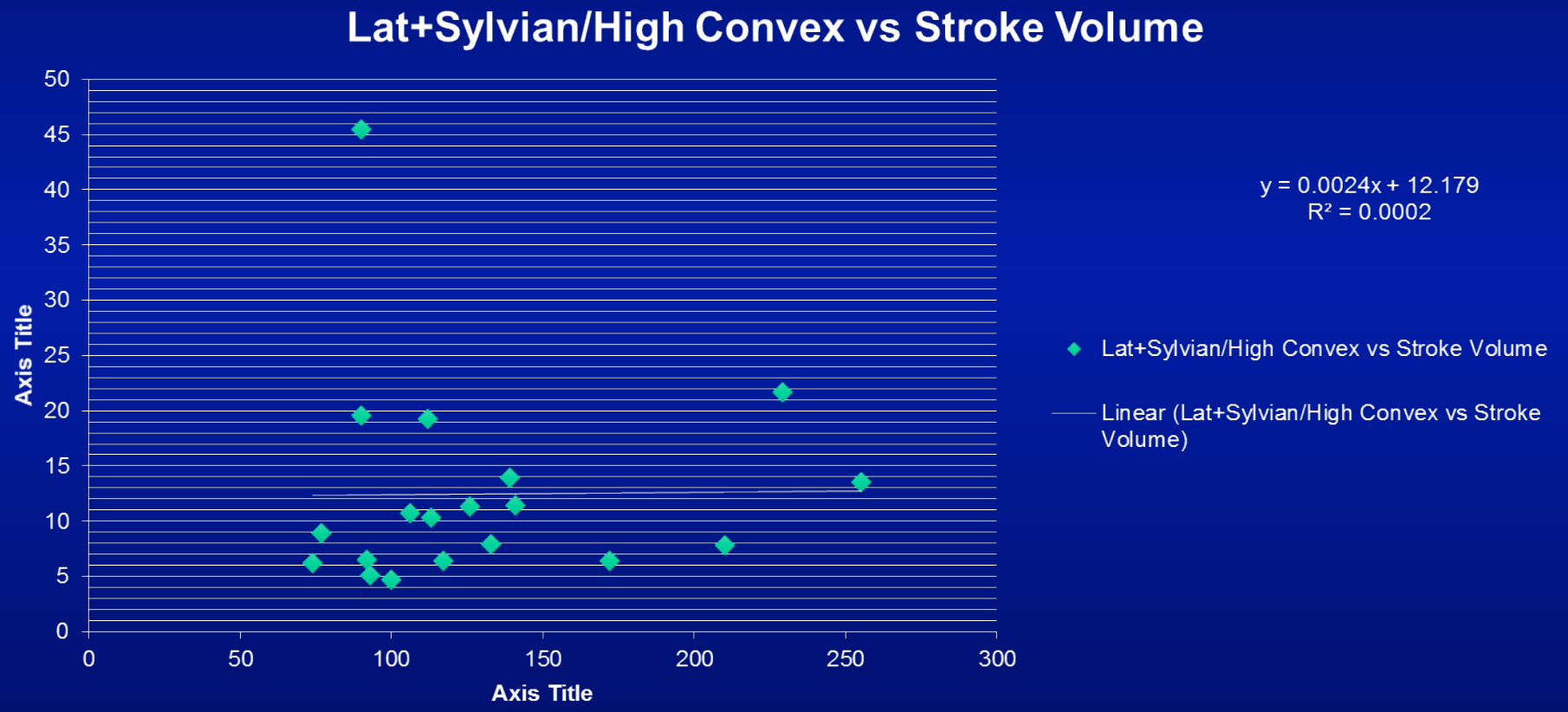
Midcoronal: Sylvian/high convexity volume vs ACSV



ACSV

Better on single slice but still….

Volume: (lateral vents+Syl)/high convexity

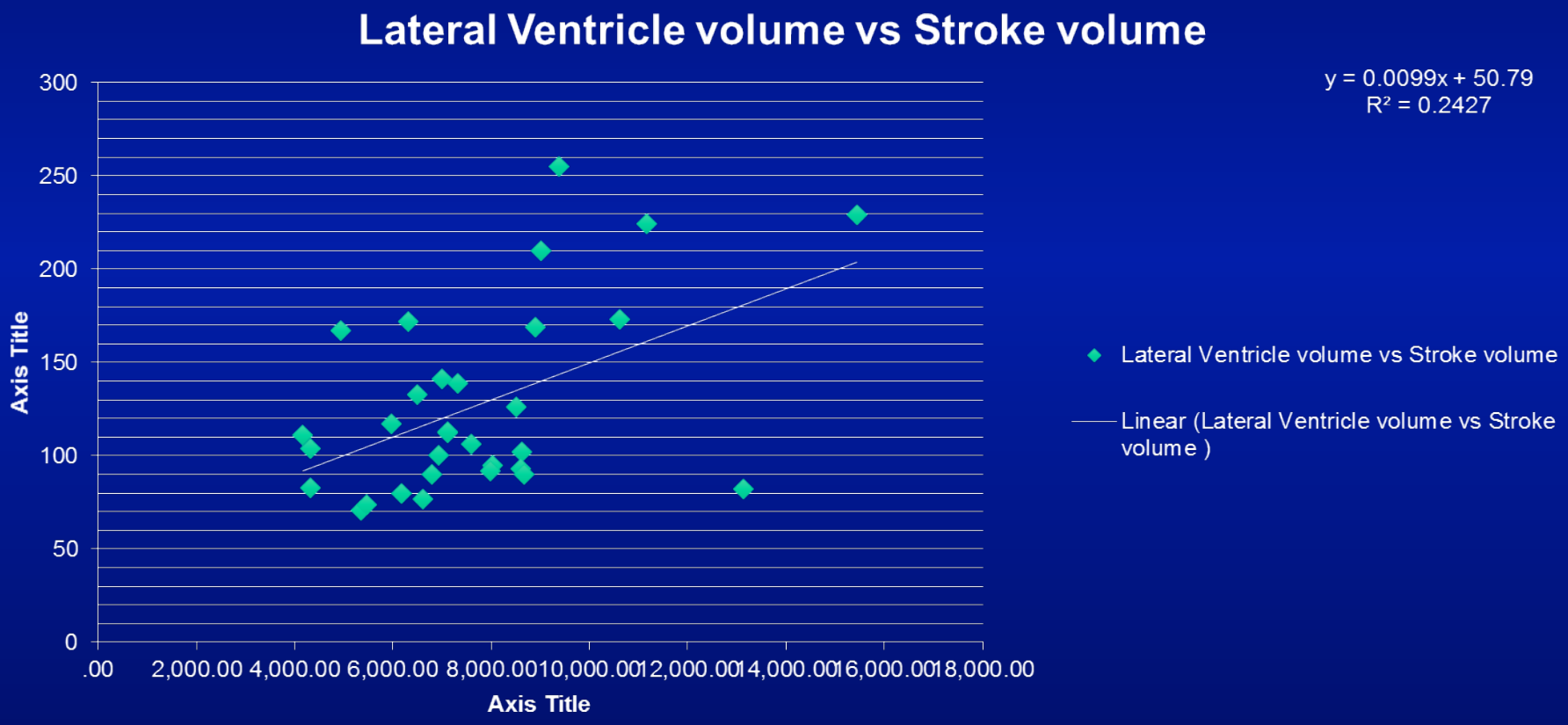


ACSV

Surprisingly worse

Midcoronal: Lat vent vs ACSV

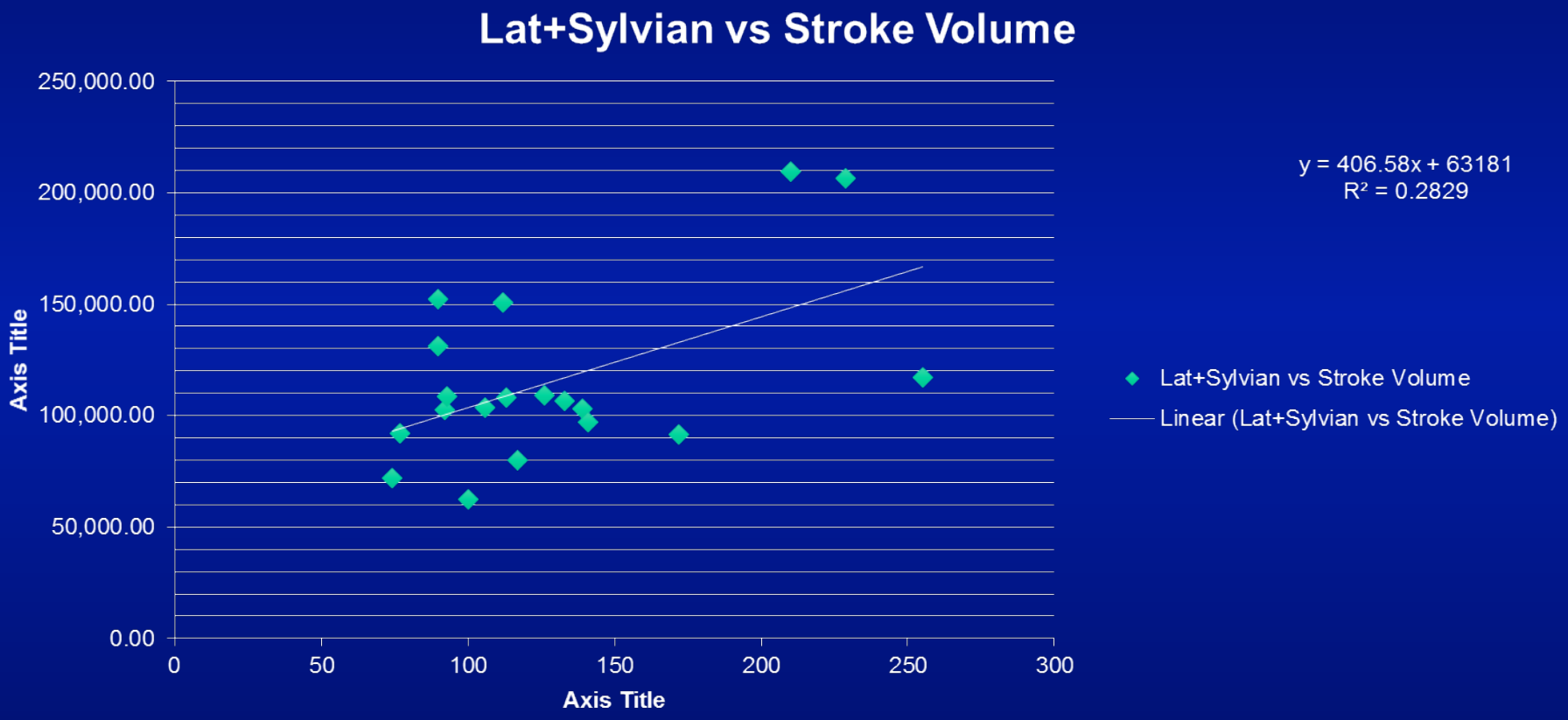
ACSV



Larger ventricular drum head

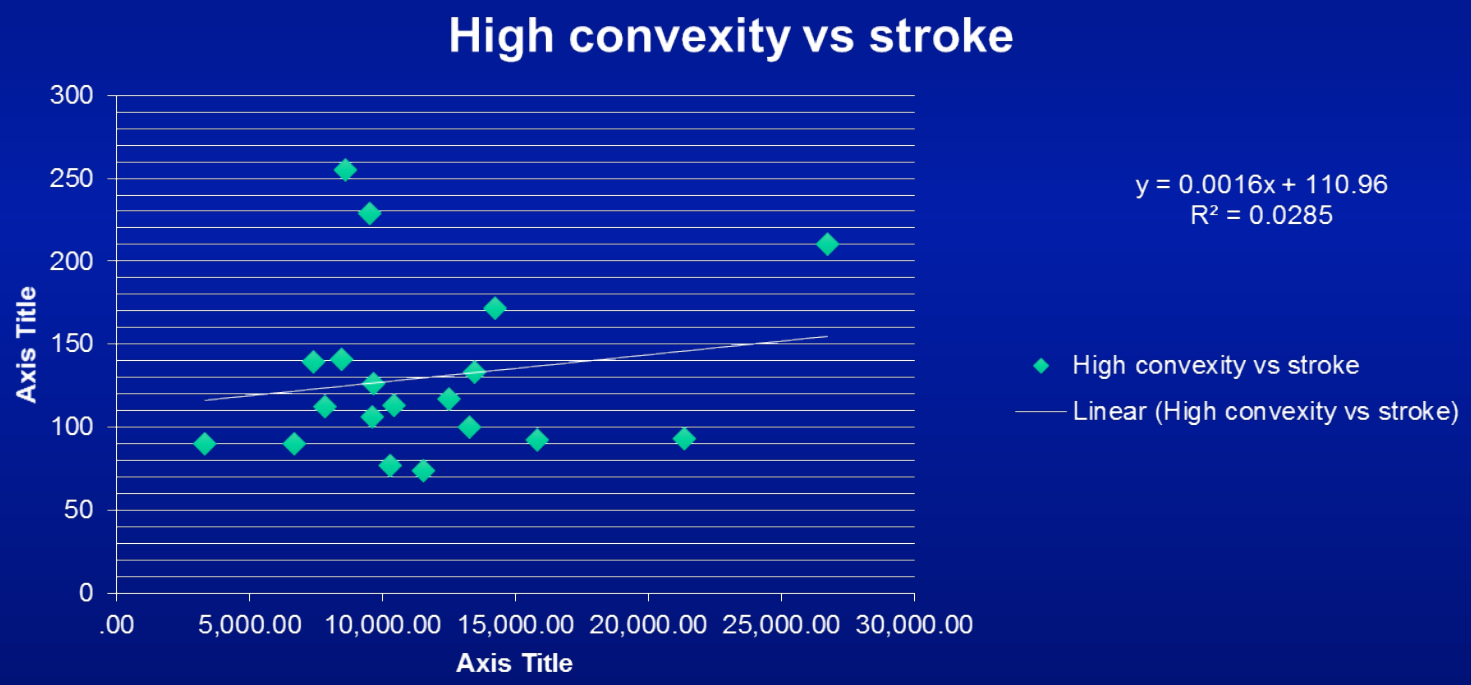
Midcoronal: Lat + Sylvian vs ACSV

ACSV



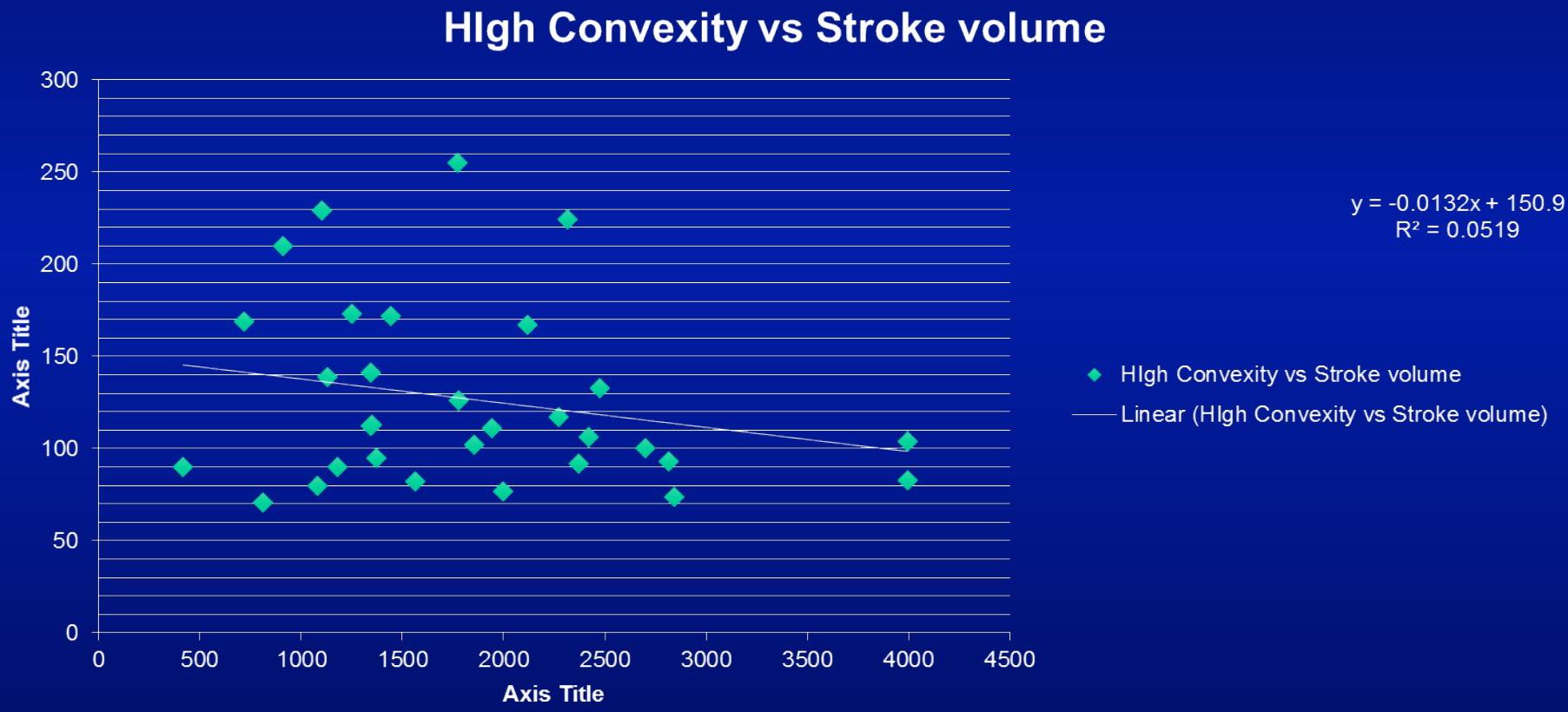
Larger ventricular drum head again;
surprising that adding Sylvian cistern volume improves correlation

Volume: High Convexity vs ACSV



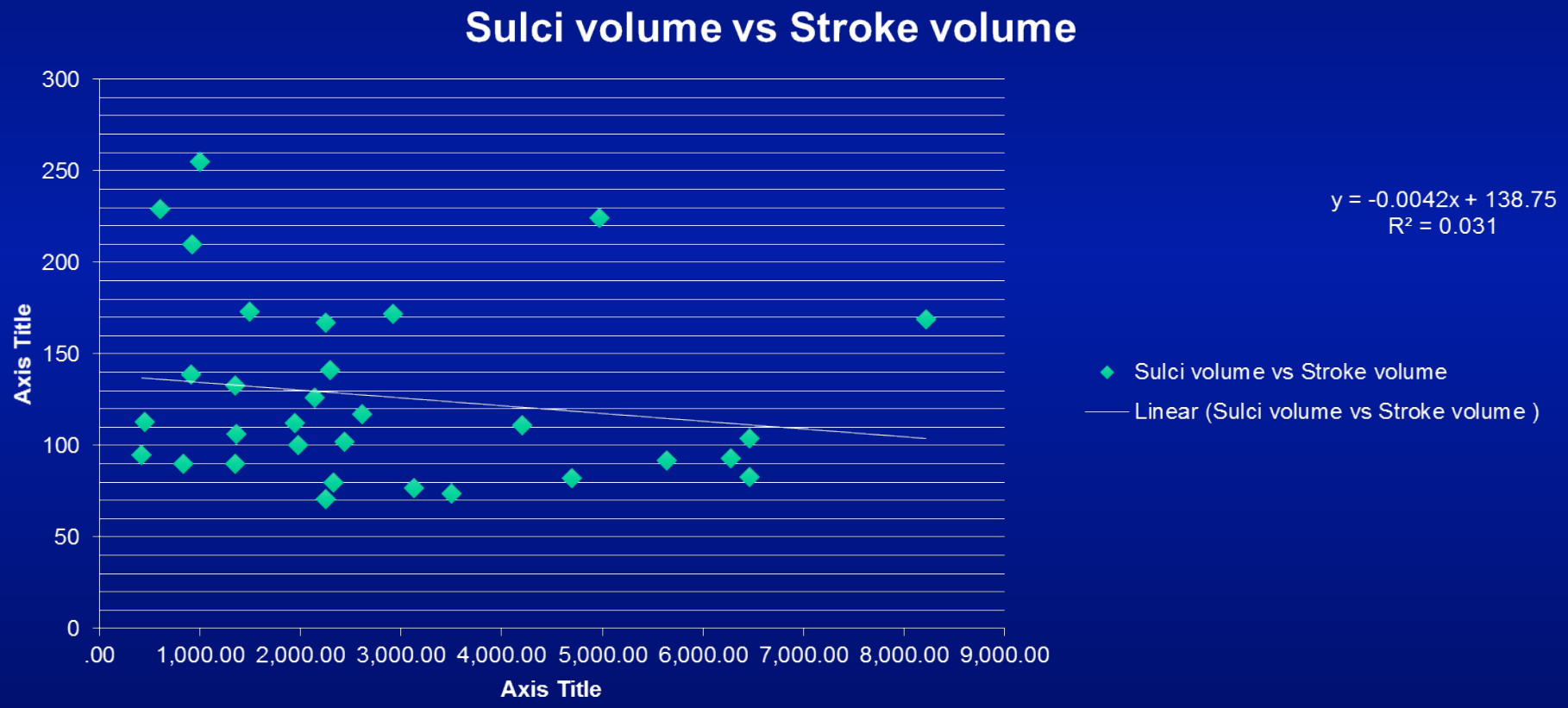
Would have expected increased SV to correlate with **smaller** convexity vol

Midcoronal: High Convexity vs ACSV



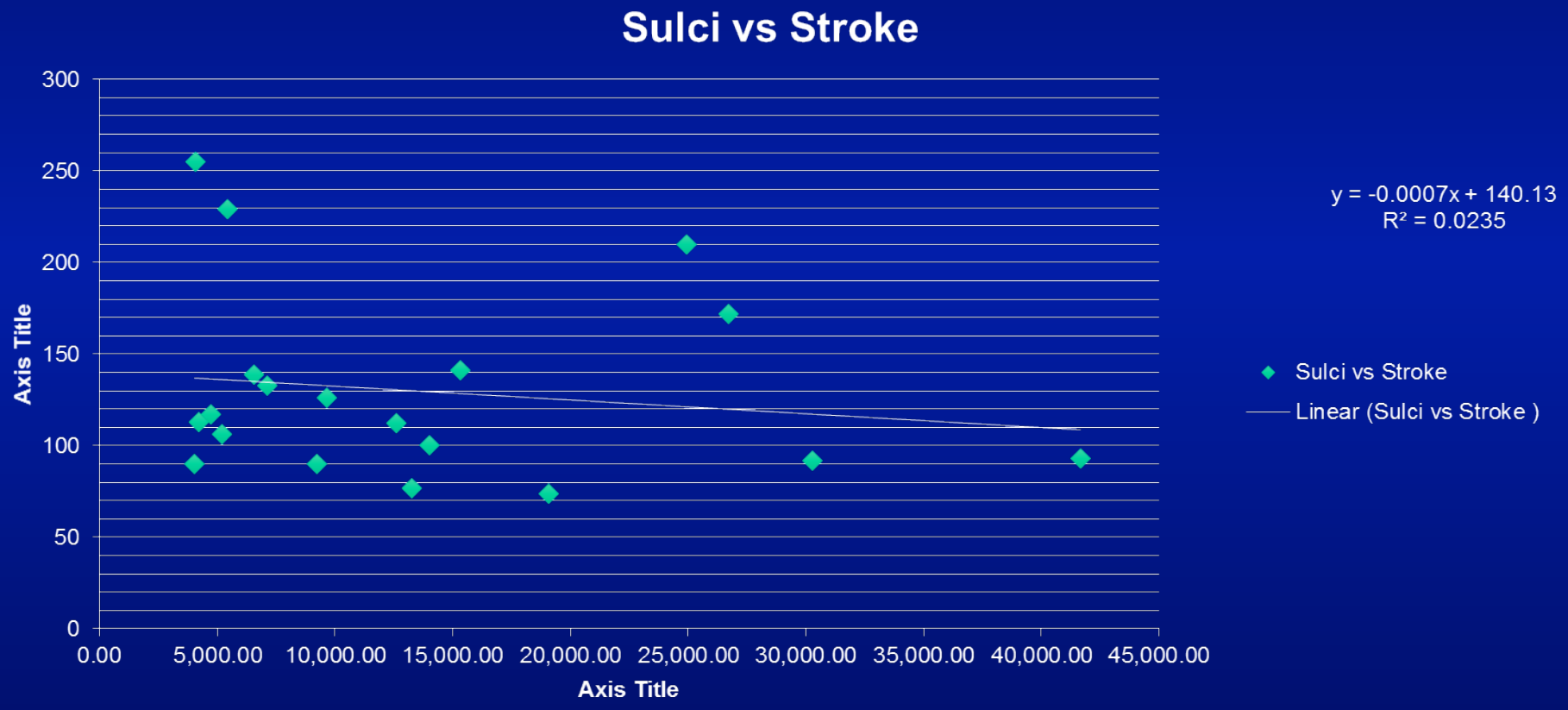
Now it is going down on single slice, ie, increased SV correlates with tight convexities

Midcornal:
Sulcal Volume vs ACSV



Expected: stroke volume goes down with atrophy

Volume: Superior Sulcal Volume vs ACSV



Same thing with full volume

Table

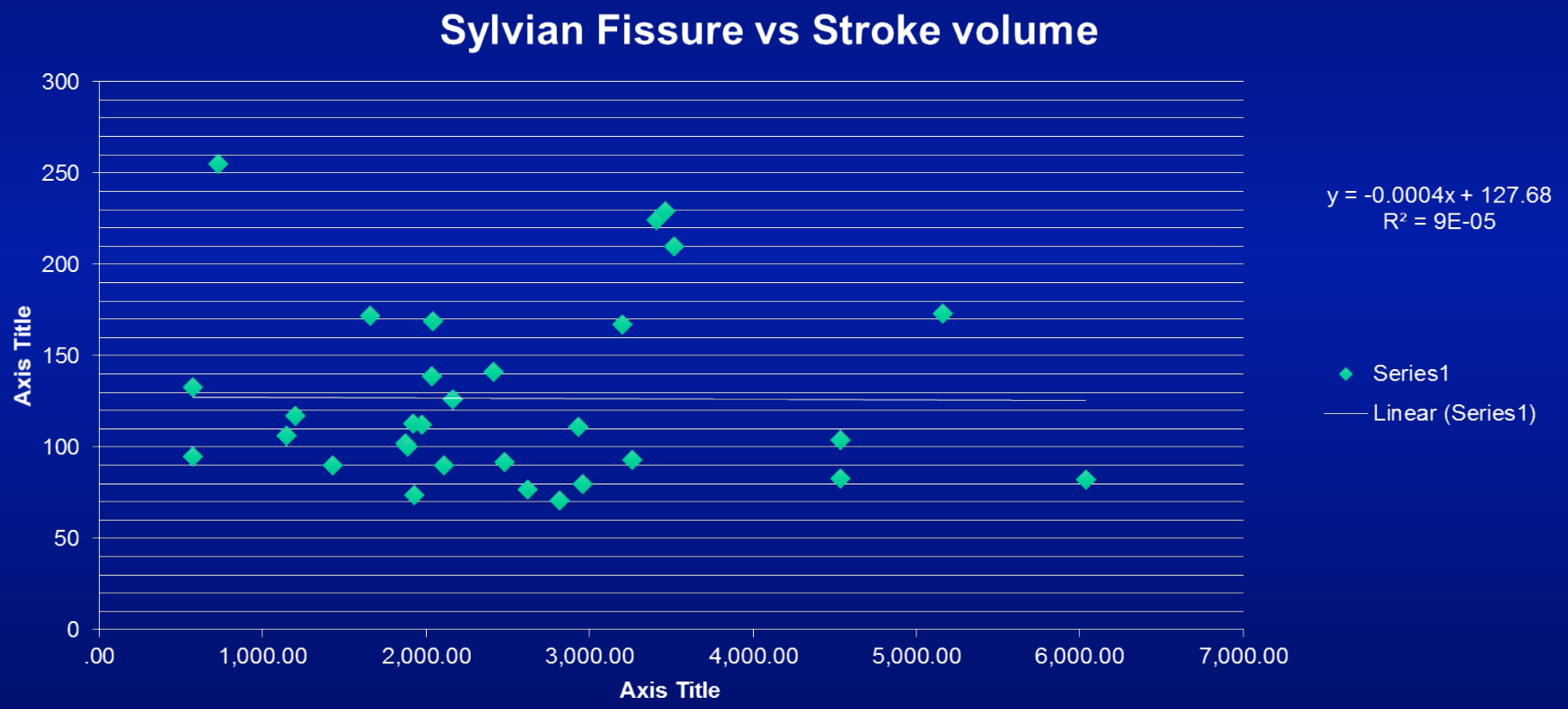
P values

Volume	Pearson	P-value	R^2
Lat+Sylvian vs Stroke volume	.354	.051	0.12526
High Convexity vol/Stroke Volume	.123	.509	0.01518
Lateral ventricle vs Stroke volume	.424	.018	0.17953
Ratio:Sylvian/High Convex vs Stroke volume	-.067	.720	0.0045
Ratio: Sulci vol/High Convex vs Stroke volume	-.081	.666	0.0065
Lat.+ Sylvian/High Convexity vs Stroke volume	.077	.671	0.00592
Sulci CSF volume Vs Stroke volume	-.151	.417	0.02289
Sylvian Fissure volume vs Stroke volume	-.045	.081	0.00203

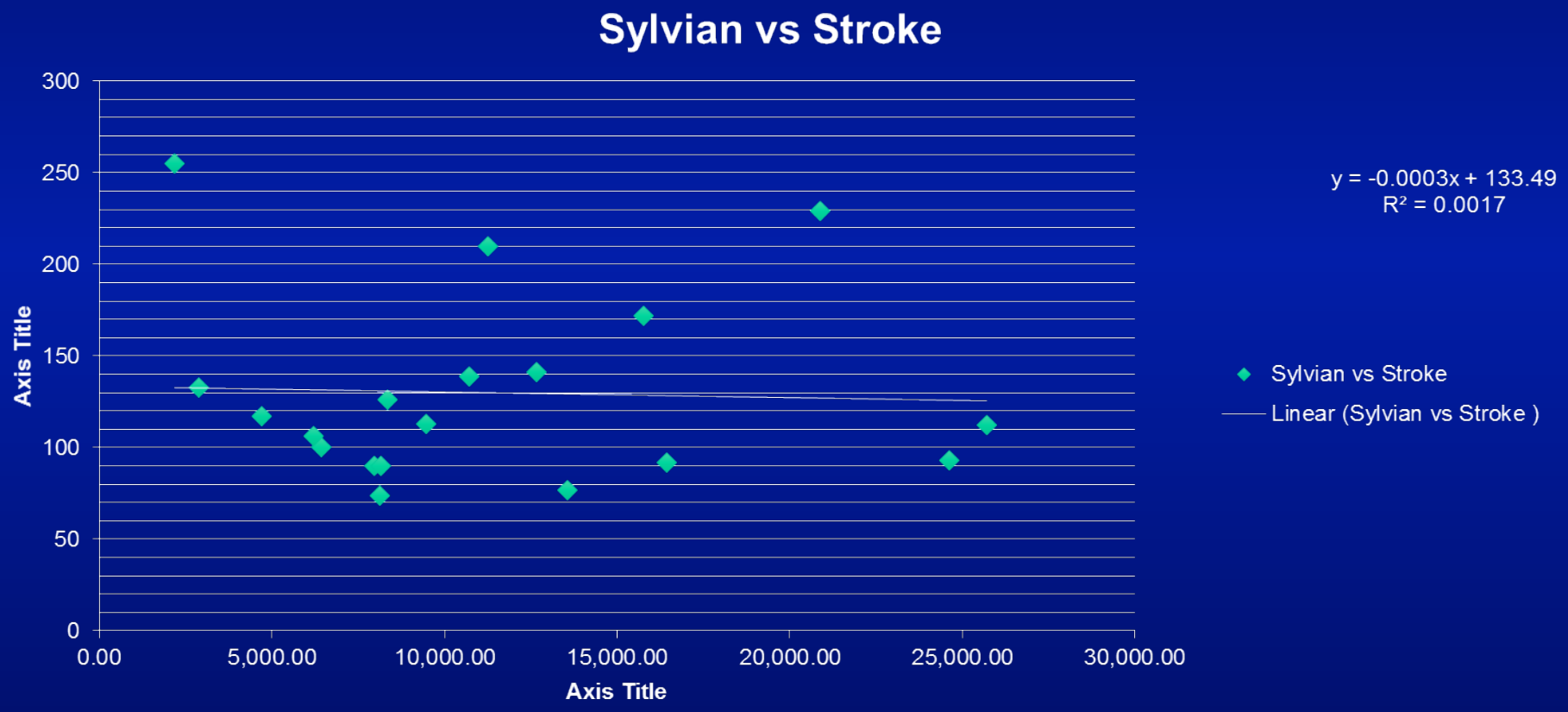
Conclusions

- The combination of large Sylvian cisterns and tight superior subarachnoid space (DESH pattern) does not appear to correlate with Aqueductal CSF Stroke Volume for predicting shunt-responsiveness in NPH
  - Using segmented volumes from mid-coronal slice or
  - Using volumes from Sylvian cistern front to back
- Reason: different populations?, small sample size?

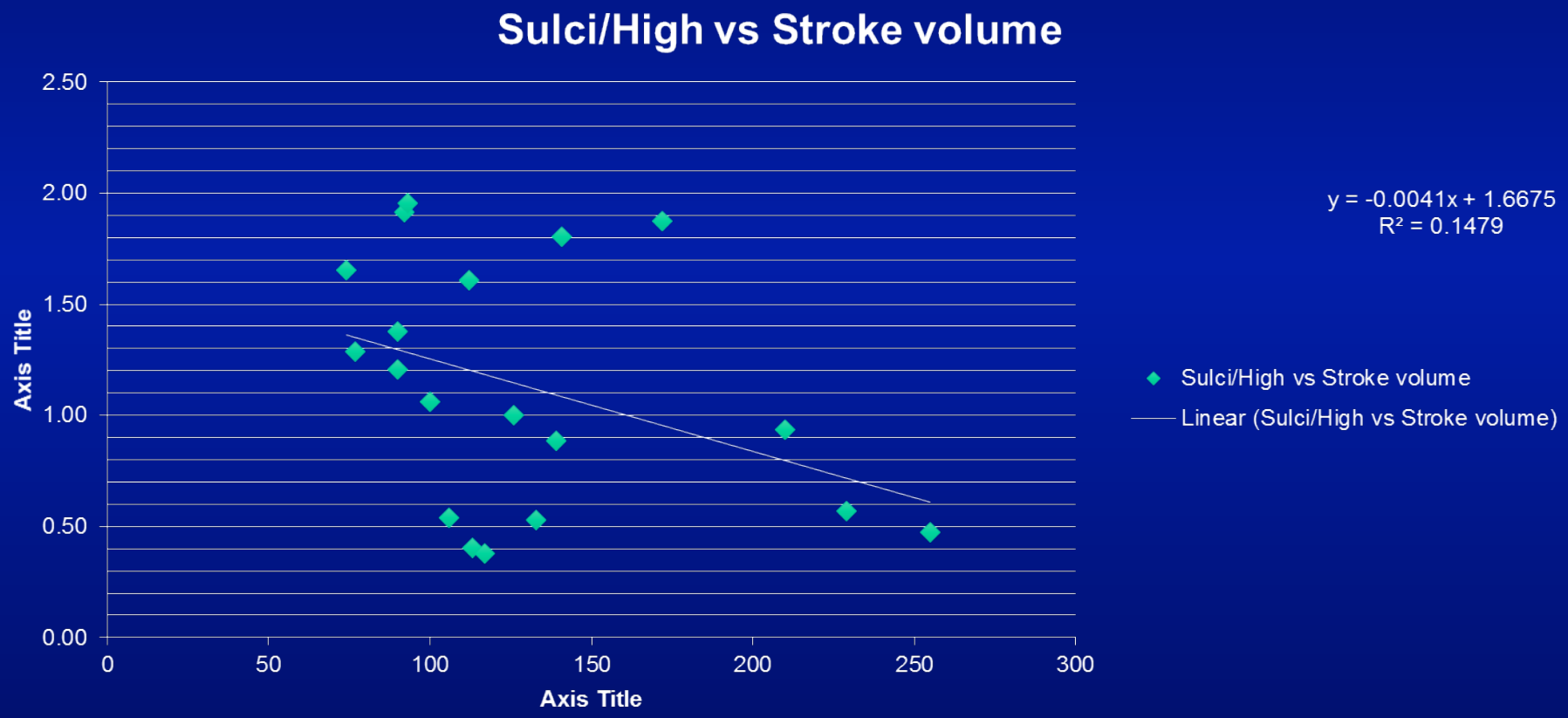
Midcoronal: Sylvian vs ACSV



Full Volume: Sylvian Cistern vs ACSV



Volume: Sulci/ high convex SAS vs ACSV



Not sure what to do with this