Volumetric DESH vs Aqueductal CSF Stroke Volume in NPH

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

- Diagnosis of idiopathic normal pressure hydrocephalus is supported by MRI-based scheme: a prospective cohort study.
- Hashimoto M¹, Ishikawa M, Mori E, Kuwana N; Study of INPH on neurological improvement (SINPHONI).
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


• The value of the cerebrospinal fluid tap test for predicting shunt effectiveness in idiopathic normal pressure hydrocephalus.

• Ishikawa M¹, 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
- $V_{enc} = 10, 20, 30 \text{ cm/sec (NPH)}$
- $V_{enc} = 5 \text{ cm/sec (shunt malfunction)}$
Quantitative CSF Velocity Imaging
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

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)

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

Not expected. As Syl/high goes up, SV should go up
Midcoronal: Sylvian/high convexity volume vs ACSV

Ratio: Sylvian/High Convexity vs Stroke volume

Better on single slice but still....

\[ y = 0.0026x + 1.4076 \]

\[ R^2 = 0.0107 \]
Volume: \((\text{lateral vents+Syl})/\text{high convexity}\)
Midcoronal: Lat vent vs ACSV

Lateral Ventricle volume vs Stroke volume

\[ y = 0.0099x + 50.79 \]
\[ R^2 = 0.2427 \]

Larger ventricular drum head
Midcoronal: Lat + Sylvian vs ACSV

Larger ventricular drum head again; surprising that adding Sylvian cistern volume improves correlation
Would have expected increased SV to correlate with *smaller* convexity vol.
Midcoronal: High Convexity vs ACSV

High Convexity vs Stroke volume

Now it is going down on single slice, ie, increased SV correlates with tight convexities
Midcornal: Sulcal Volume vs ACSV

Sulci volume vs Stroke volume

Expected: stroke volume goes down with atrophy
Volume: Superior Sulcal Volume vs ACSV

Sulci vs Stroke

\[ y = -0.0007x + 140.13 \]
\[ R^2 = 0.0235 \]

Same thing with full volume
## P values

<table>
<thead>
<tr>
<th>Volume</th>
<th>Pearson</th>
<th>P-value</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat+Sylvian vs Stroke volume</td>
<td>.354</td>
<td>.051</td>
<td>0.12526</td>
</tr>
<tr>
<td>High Convexity vol/Stroke Volume</td>
<td>.123</td>
<td>.509</td>
<td>0.01518</td>
</tr>
<tr>
<td>Lateral ventricle vs Stroke volume</td>
<td>.424</td>
<td>.018</td>
<td>0.17953</td>
</tr>
<tr>
<td>Ratio:Sylvian/High Convex vs Stroke volume</td>
<td>-.067</td>
<td>.720</td>
<td>0.0045</td>
</tr>
<tr>
<td>Ratio: Sulci vol/High Convex vs Stroke volume</td>
<td>-.081</td>
<td>.666</td>
<td>0.0065</td>
</tr>
<tr>
<td>Lat.+ Sylvian/High Convexity vs Stroke volume</td>
<td>.077</td>
<td>.671</td>
<td>0.00592</td>
</tr>
<tr>
<td>Sulci CSF volume Vs Stroke volume</td>
<td>-.151</td>
<td>.417</td>
<td>0.02289</td>
</tr>
<tr>
<td>Sylvian Fissure volume vs Stroke volume</td>
<td>-.045</td>
<td>.081</td>
<td>0.00203</td>
</tr>
</tbody>
</table>
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

Sylvian Fissure vs Stroke volume

\[ y = -0.0004x + 127.68 \]
\[ R^2 = 9 \times 10^{-05} \]

Series1
Linear (Series1)
Full Volume:
Sylvian Cistern vs ACSV

Sylvian vs Stroke

\[ y = -0.0003x + 133.49 \]
\[ R^2 = 0.0017 \]
Volume: Sulci/ high convex SAS vs ACSV

Sulci/High vs Stroke volume

y = -0.0041x + 1.6675
R² = 0.1479

Not sure what to do with this