Neurosonology in Neurological Intensive Care Units

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Content

01 TCD For Vasospasm
02 TCD for ICH Monitoring
03 TCD for Circulatory Arrest

SAH in 44 y.o. F

What caused deterioration?

• Vasospasm?
• Hydrocephalus?
• Edema?
• Sepsis?
• Electrolyte disturbance?
• Seizures?

On the 5th day deteriorates (develops acute confusional state)
Monitoring of intracranial status in comatose patients

**Momentary methods**
- Neuroimaging:
  - Invasive: DSA
  - Non-invasive: CT/CTA, MR/MRA

**Continuous methods**
- Invasive: ICP monitor
- Non-invasive: TCD / TCCD

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TCD insonation technique

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CCA and proximal ICA insonation method

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Day 1

Day 1

Day 2

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Vasospasm in SAH

- MCA diameter = 3 mm
- ≤1 mm = DIND
- MV > 200 cm/s

Lindegaard, 1988

Neurosonology in NICU

Hyperemia

- Hyperemia is suspected with elevated velocities in the intracranial and feeding extracranial vessels
- Lindegaard Ratio:
  - ACM MV / eACI MV

Stages of Vasospasm

<table>
<thead>
<tr>
<th>Vessel narrowing</th>
<th>TCD velocity</th>
<th>CBF</th>
<th>DIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>↑</td>
<td>⇑</td>
<td>No</td>
</tr>
<tr>
<td>Stage II</td>
<td>↑↑</td>
<td>⇑</td>
<td>No</td>
</tr>
<tr>
<td>Stage III</td>
<td>↑↑↑</td>
<td>⇑</td>
<td>No</td>
</tr>
<tr>
<td>Stage IV</td>
<td>↑↑↑↑</td>
<td>⇑</td>
<td>Yes</td>
</tr>
</tbody>
</table>

↑, mild; ↑↑, moderate; ↑↑↑, severe; ↑↑↑↑, very severe; ⇑, no change.

Lindegaard Ratio:
- ACM MV / eACI MV

Criteria for Proximal Middle Cerebral Artery Vasospasm

<table>
<thead>
<tr>
<th>Mean velocity (cm/s)</th>
<th>MCA/ICA mean velocity ratio</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>≥2</td>
<td>Hypertension</td>
</tr>
<tr>
<td>≥100</td>
<td>1-2</td>
<td>Moderate hypertension</td>
</tr>
<tr>
<td>≥300</td>
<td>4-6</td>
<td>Severe hypertension</td>
</tr>
<tr>
<td>≥600</td>
<td>8-10</td>
<td>Critical destruction</td>
</tr>
</tbody>
</table>


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Mean Velocity Criteria for Grading Vasospasm in Intracranial Arteries

<table>
<thead>
<tr>
<th>Artery</th>
<th>Possible Vasospasm/ (cm/second)</th>
<th>Probable Vasospasm/ (cm/second)</th>
<th>Definite Vasospasm/ (cm/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA</td>
<td>&gt; 80</td>
<td>&gt; 110</td>
<td>&gt; 120</td>
</tr>
<tr>
<td>ACA</td>
<td>&gt; 80</td>
<td>&gt; 110</td>
<td>&gt; 120</td>
</tr>
<tr>
<td>PCA</td>
<td>&gt; 60</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
</tr>
<tr>
<td>SA</td>
<td>&gt; 70</td>
<td>&gt; 90</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>VA</td>
<td>&gt; 50</td>
<td>&gt; 30</td>
<td>&gt; 50</td>
</tr>
</tbody>
</table>

*Optimized criteria were modified from the review by Sloan (1996).

Sloan MA, 1996

Neurosonology in NICU

Predictors of Adverse Outcomes in Patients with Subarachnoid Hemorrhage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TCD Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>Early appearance of MCA mean velocity ≥ 160 cm/sec</td>
</tr>
<tr>
<td></td>
<td>Rapid (&lt;30% or &gt;90% + trend) increase in mean velocity daily during critical days 3–7</td>
</tr>
<tr>
<td>Ratio</td>
<td>MCA/ICA ratio ≥ 0.6</td>
</tr>
<tr>
<td>PI</td>
<td>Abnormal appearance of high resistance PI ≥ 1.2 due to increased ICP (hydrocephalus) Appearance of PI ≥ 1.2 due to distal spasm</td>
</tr>
</tbody>
</table>

Abbreviations: MCA: middle cerebral artery; ICA: internal carotid artery; ICP: increased intracranial pressure; PI: pulsatility index; TCD, transcranial Doppler. Lao, Sharma, Katz, Alexandrov in McGahan, 2007

Neurosonology in NICU
TCD in SAH Protocol

- Perform baseline TCD on arrival
- Control TCD every day or every other day
- Measure distal extracranial ICA MV
- Perform complete TCD examination to evaluate vasospasm in BA, PCA or ACA

Summary of findings
Subarachnoid Hemorrhage (SAH):

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>SENSITIVITY (%)</th>
<th>SPECIFICITY (%)</th>
<th>REFERENCE STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasospasm after Spontaneous Subarachnoid Hemorrhage</td>
<td></td>
<td></td>
<td>Conventional angiography</td>
</tr>
<tr>
<td>Intracranial ICA</td>
<td>25-30</td>
<td>83-91</td>
<td></td>
</tr>
<tr>
<td>MCA</td>
<td>39-94</td>
<td>70-100</td>
<td></td>
</tr>
<tr>
<td>ACA</td>
<td>13-71</td>
<td>65-100</td>
<td></td>
</tr>
<tr>
<td>VA</td>
<td>44-100</td>
<td>82-88</td>
<td></td>
</tr>
</tbody>
</table>

Recommendations: TCD is useful for the detection and monitoring of angiographic VSP in the basal segments of the intracranial arteries, especially the MCA and BA, following sSAH (Type A, Class I-II evidence).

More data are needed to show if TCD affects clinical outcomes in this setting (Type U).
ICH - TCD

Content

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Development of Circulatory Arrest
Technical Limitations

- Suboptimal bone window in 3-5% of the patients – do initial TCD at pt. arrival

- Clinical diagnosis of brain death and TCD finding of circulatory arrest sometimes do not match
  - Clinical diagnosis might be confirmed 24h after TCD finding (posterior circulation)
  - Always use TCD as a confirmatory tool after clinical diagnosis has been established

- Radioisotopes might be detected intracranially although TCD was positive for circulatory arrest? 8 cases so far (until 2006.)


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