Neurosurgical Management of Cerebellar Hemorrhagic and Ischemic Stroke

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Cerebellar ICH

- 10-15% of all ICH
- PMH of HTN present in 60-90% of cases
  - Charcot Bouchard microaneurysms
- Often begin in area of dentate nucleus and then spread throughout hemisphere and vermis, possibly into 4th ventricle

Cerebellar ICH

- Clinical deterioration in up to 50% (Auer et al, 1986)
  - Most commonly 3 days after onset
- When deterioration occurs, high mortality (25-100%) regardless of treatment

Surgery for Cerebellar Stroke

- First performed successfully by Balance in 1906
- Controversial ever since

Role of Neurosurgical Intervention in Cerebellar Stroke

"I shall not today attempt further to define the kinds of material I understand to be embraced within that shorthand description and perhaps I could never succeed in intelligibly doing so. But I know it when I see it….”

Supreme Court Justice Potter Stewart, concurring opinion in Jacobellis v. Ohio 378 U.S. 184 (1964), regarding possible obscenity
Issues to Consider: Hemorrhagic versus Ischemic Cerebellar Stroke

- Hemorrhage:
  - Toxic effects of blood products, inflammation, etc.
  - Not just mass effect / compression of adjacent tissue
  - More likely to cause IVH, leading to hydrocephalus
  - Less likely to extend into brainstem
- Infarct:
  - Less likely to cause hydrocephalus than hemorrhagic stroke
  - More likely to extend into brainstem
  - Even DWI positive tissue may show functional recovery
- Therefore, should surgical management be the same for both?

Issues to Consider: Preoperative CTA or DSA

- Subarachnoid blood, calcification, unusual (noncircular) shape, prominent vascular structures, etc.
  - In high suspicion cohort, DSA positive in 32/38 cases (84%)
  - In low suspicion cohort, DSA positive in 10/42 cases (24%)
  - 110 cerebellar ICH
  - 5 found to have cerebellar AVM, 2 had cerebellar tumor
  - Low yield of DSA in patients > 45 years old with history of HTN and cerebellar ICH
- CTA potentially useful

Issues to Consider: Preoperative MRI

- 31 patients, all with GCS 8 or less
- All underwent surgical intervention followed by postoperative MRI
- No significant differences between groups in preoperative CT findings (hematoma size, hydrocephalus, or obliteration of cisterns)
- Incidence high signal intensity in pons and midbrain on T2 MRI significantly higher in poor outcome group
- Value of preoperative MRI for patient selection?

Issues to Consider: Role of External Ventricular Drain

- Therapeutic
  - For hydrocephalus, some still advocate open surgery over EVD
- Prophylactic
  - Threshold of drainage, risk of upward herniation

Issues to Consider: Criteria for Craniotomy

- Size threshold
  - 3 cm vs. 4 cm
- Radiographic evidence of brainstem compression
  - Accounts for edema
- Clinical examination

Issues to Consider: Timing of Surgical Intervention

- “Prophylactic” vs. at time of deterioration
- Value of delayed aspiration (Auer et al., 1986)
  - 2 patients with focal signs of posterior fossa lesions but no impaired consciousness treated conservatively
  - Since no improvement, evacuation of the hematoma performed on days 23 and 54
  - Both recovered fully

Yanaka et al, Neurosurgery 45:1323-1328, 1999

Issues to Consider:  
*What Constitutes Futility?*

- Postoperative outcomes generally correlate with preoperative status


- Pathoanatomic studies reveal surprisingly few structural changes due to brainstem compression in patients dying from cerebellar herniation

- Is any exam "too poor" to forego treatment?

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Table 1: Correlation Between Initial Situation and Outcome

<table>
<thead>
<tr>
<th>Glasgow Score</th>
<th>n</th>
<th>Died</th>
<th>Mortality (%)</th>
<th>Outcome</th>
<th>KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6</td>
<td>5</td>
<td>3</td>
<td>60%</td>
<td>26</td>
<td>65</td>
</tr>
<tr>
<td>6-10</td>
<td>15</td>
<td>5</td>
<td>35%</td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>15</td>
<td>5</td>
<td>20%</td>
<td>60</td>
<td>34</td>
</tr>
</tbody>
</table>

*K* Karnofsky outcome index total, *KS* for survivors


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Issues to Consider:  
*Craniotomy vs. Craniectomy*

- Remove vs. fixate vs. float the bone
- Size of bony removal
  - Risk of brain sag

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Issues to Consider:  
*Role of Other Interventions*

- Stereotactic aspiration
- Endoscopic burr hole evacuation (Auer et al, 1988)
- TPA infusion
Cerebellar Stroke Literature

- 4 randomized trials of surgery for ICH
  - Overall, no benefit to surgery
  - Some exceptions in post-hoc subgroup analysis
- Cerebellar ICH excluded from all 4 randomized trials
  - Clinical equipoise thought to be absent
- Data mostly from uncontrolled, single institution retrospective case series

Literature Meta-analysis

- 8 series of surgery for infratentorial ICH comprising total of 405 patients
  - 1 study suggesting overall benefit
  - 2 studies reported benefit only in subgroups (conscious or drowsy but deteriorating patients)
  - 5 studies inconclusive or no benefit of surgery


- 49 patients with cerebellar ICH
- Treatment protocol based upon degree of quadrigeminal cistern obliteration and GCS
- EVD placed for poor neurological status
- Craniotomy reserved for those not responding to EVD


- High correlation between quadrigeminal cistern obliteration and admission GCS
- High correlation between grade of cisternal compression and outcome
  - Patients with totally obliterated cisterns had poor outcome, regardless of treatment

- 50 patients with cerebellar ICH
- Treatment protocol based on appearance of 4th ventricle (normal, compressed, or effaced)
- Surgical evacuation for all grade III patients and for grade II patients with poor neuro status not due to hydrocephalus
- Rationale
  - Mass effect of surrounding edema is underestimated by hematoma size alone
  - 60% of patients with hematoma >3 cm did not require evacuation
  - Taneda et al: size of hematoma unrelated to degree of cisternal compression
  - Degree of cisternal compression is related to hydrocephalus and less so due to hematoma / edema

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**Table 1.** Outcome after the operation

<table>
<thead>
<tr>
<th>Grade</th>
<th>Dead</th>
<th>Severe</th>
<th>Moderate</th>
<th>Minimal</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>


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- 4th ventricle grade correlated with hematoma size and likelihood of deterioration

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**Table 2.** Clinical deterioration in the various grades of 4th ventricle compression

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Patients</th>
<th>% of Patients</th>
<th>% of 4th Ventricle Compressed</th>
<th>% of Cisternal Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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- Outcomes dependent on degree of 4th ventricle compression and clinical exam at time of deterioration
  - No patient with grade III compression and GCS < 8 experienced good outcome
- Authors emphasize aggressive early surgical evacuation of hematoma for grade III patients, *before* deterioration


- 57 patients who underwent surgical evacuation of cerebellar ICH
- Initial neurological condition highly predictive of outcome
- Patients with good initial condition who deteriorated had good outcomes after surgery
- Preventive evacuation of cerebellar hemorrhage *NOT* recommended


- Comparison of neurosurgical management of hemorrhagic (n=48) vs. ischemic (n=71) cerebellar stroke
- Patients with hematoma
  - more likely to be in coma
  - more likely to have brainstem compression
  - more likely to have hydrocephalus
- 75% of patients with ICH required surgery; only 24% for infarct
- Of patients with ICH initially treated with EVD, more than half subsequently required craniectomy
  - EVD more successful in treating cerebellar infarct
- In ICH patients treated initially with craniectomy, none required subsequent EVD or VPS


- 42 patients with cerebellar infarction
  - 25 managed medically
  - 17 underwent neurosurgical intervention
    - 13 initial placement EVD
    - 4 initial craniectomy
- Ventricular drainage as first treatment for impaired consciousness
  - 8 of 13 needed only EVD
  - 5 patients needed craniectomy after EVD


- 84 patients with massive cerebellar infarct
- Treatment at discretion of provider (unrandomized)
- In logistic regression model, only level of consciousness after deterioration predicted outcome
  - No benefit to surgery in awake/drowsy or somnolent/stuporous patients

<table>
<thead>
<tr>
<th>TABLE 1: Treatments and outcomes in the present series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Conventional</td>
</tr>
<tr>
<td>C + A</td>
</tr>
<tr>
<td>C + I</td>
</tr>
<tr>
<td>C + M</td>
</tr>
</tbody>
</table>


2007 AHA Guidelines: Preoperative Imaging

Angiography is not required for older hypertensive patients who have a hemorrhage in the cerebellum and in whom CT findings do not suggest a structural lesion (level of evidence V, grade C recommendation).

2007 AHA Guidelines: Indications for Surgery

Patients with cerebellar hemorrhage > 3 cm in diameter who are neurologically deteriorating or who have brainstem compression and hydrocephalus from ventricular obstruction should have surgical removal of the hemorrhage as soon as possible (levels of evidence III through V, grade C recommendation). Stereotactic aspiration may be associated with better outcomes than standard craniotomy for moderate-sized cerebellar hemorrhages, but this hypothesis has yet to be tested in a randomized study (no recommendation).

2010 AHA Guidelines: Preoperative Imaging

CT angiography and contrast-enhanced CT may be considered to help identify patients at risk for hematoma expansion (Class IIb; Level of Evidence: B), and CT angiography, CT venography, contrast-enhanced CT, contrast-enhanced MRI, magnetic resonance angiography, and magnetic resonance venography can be useful to evaluate for underlying structural lesions, including vascular malformations and tumors when there is clinical or radiological suspicion (Class III; Level of Evidence: B). (New recommendation).

2010 AHA Guidelines: Indications for Surgery

Patients with cerebellar hemorrhage who are deteriorating neurologically or who have brainstem compression and/or hydrocephalus from ventricular obstruction should undergo surgical removal of the hemorrhage as soon as possible (Class I; Level of Evidence: B). (Revised from the previous guideline). Initial treatment of these patients with ventricular drainage alone rather than surgical evacuation is not recommended (Class III; Level of Evidence: C). (New recommendation).
“There is an interesting protocol, and the study is well designed, well executed, and beautifully documented..... The authors of this study had the ability to observe patients very closely, and their successful clinical outcomes are to be credited to this strategy. I feel strongly, however, that, these results notwithstanding, patients with any hint of neurological compromise and cerebellar hematoma should undergo urgent surgical intervention..... Articles such as this, while they do represent a scientific study of the problem, do little to dissuade me from this instinctive reaction to a critical and life-threatening problem.”

“It is impossible to begin to learn that which one thinks one already knows.”
Epictetus, 55-135 AD

Clinical History

• 56 year old male
• Developed vomiting, headache
• Presents 8 hours after onset; GCS 13 at that time

Points for Discussion

• What is the best management?
  – A) Observation
  – B) EVD
  – C) Craniotomy
• What is the best timing of intervention?
  – A) Now
  – B) Only if the patient deteriorates further

Case # 1

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Case # 2

Clinical History

- 32 yo female
- PMH migraines
- Awoke with HA, N/V, RUE clumsiness
- Exam: GCS 15; right facial droop, right gaze horizontal nystagmus, left sided numbness

CT shows right cerebellar hypodensity consistent with infarct

3D Vitrea reconstruction of CTA showing absent right PICA
Clinical Progression

• 36 hours later: worsened mental status (opens eyes to voice only, etc)
• Repeat CT performed

Management

• Decision to proceed with surgical evacuation
• No EVD placed
• Suboccipital craniectomy, C1 laminectomy, partial resection of necrotic tissue

Discussion

• Was surgery indicated
  – A) Yes
  – B) No

Case #3
Clinical History

- 56-year-old male with mitral regurgitation
- Presented for elective cardiac procedure
- Next day, developed confusion followed by progressive decrease in responsiveness

Large right cerebellar early subacute infarct with mass effect and hydrocephalus

Management Options

- Medical management alone
- External ventricular drain
- Surgical decompression

S/P suboccipital craniotomy and partial removal of infarcted tissue; augmentation duraplasty; EVD placement. Bone flap left floating.

Topics for Consideration

- Was bone flap adequate?
  - A) Craniectomy should have been performed
  - B) Craniotomy was sufficient
  - C) Craniotomy was sufficient but bone flap should have been secured instead of left floating
- Was extent of tissue resection adequate?
  - A) Yes
  - B) No (anticipating edema, possible hemorrhage, etc)

Postoperative DWI showing persistent widespread edema. Multiple infarcts scattered throughout brain consistent with cardioembolic source.
POD 3 FLAIR showing persistent edema and mass effect (top left). GRE sequence shows hemorrhagic transformation (top right). Sagittal T1 shows ascending transtentorial herniation and tonsillar herniation through foramen magnum (bottom row).

CT scan on POD 17 shows improved edema and mass effect; improved hydrocephalus after EVD removal.

Case # 4

Clinical History

- 77 year old female, PMH significant for HTN, heart murmur and Crohn’s disease requiring large doses of aspirin
- Awoke with headache, dizziness, and incoordination of the right arm

Topics for Consideration

- Risk Factors for ICH:
  - HTN, cardiac embolism (heart murmur), aspirin use
- Is evacuation indicated
  - A) Yes
  - B) No
- Is further workup indicated?
  - A) Yes
  - B) No
Acute hemorrhage of right cerebellum extending to tentorial surface and across vermis to left hemisphere. Questionable prominence of vessels near vein of Galen.

Catheter angiogram demonstrating AVM of cerebellar vermis supplied primarily by bilateral superior cerebellar arteries. High risk features include feeding artery aneurysms bilaterally and venous outflow restriction of draining vein coursing to straight sinus.

Management Strategy

- Staged liquid adhesive embolization of AVM to protect against rebleed
  - Target feeding artery aneurysms
  - Reduce flow through venous restriction
- Followed by stereotactic radiosurgery
  - Considerations of patient age, lesion location

Catheter angiography post-embolization reveals elimination of feeding artery aneurysms and significantly reduced flow through nidus in preparation for stereotactic radiosurgery.

Clinical History

- 43 year old male, no PMH
- Awoke with HA, N/V, dizziness
- BP 109/54
- "Awake, somnolent, minimally slurred speech"

Case # 5
Points for discussion

- Is craniotomy indicated?
  - A) Yes, now
  - B) Yes, only if clinical status deteriorates
  - C) No, there is not sufficient mass effect

- Is vascular imaging indicated?
  - A) Yes
  - B) No