INTRACRANIAL
SACCULAR ANEURYSMS

CASE BASED STUDY OF COMPLICATIONS AND
NOVEL WAYS OF MANAGEMENT

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AGENDA

1. Patient
2. Intracranial Saccular Aneurysms
   1. Epidemiology
   2. Location
   3. Risk Factors
   4. Management
   5. Rupture
3. Subarachnoid Hemorrhage
   1. Manifestations
   2. Diagnosis
   3. Complications
   4. Management: Traditional and Novel Approaches
4. Back to patient
Mr. X is a 46 yo M found down in the kitchen by his son. He was in his usual state of good health until ~10 days ago, when he began to experience worsening headaches that he attributed to migraines. This morning, his son heard a loud thud in the kitchen. He found his father unconscious and unresponsive.
OUR PATIENT: PRESENTATION

- Physical Exam:
  - Neurological Status:
    - Hunt and Hess grade: 5
    - Glasgow Coma score: 3
# Neurological Status: Hunt and Hess

## Hunt and Hess Grading System for Patients with Subarachnoid Hemorrhage

<table>
<thead>
<tr>
<th>Grade</th>
<th>Neurologic Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asymptomatic or mild headache and slight nuchal rigidity</td>
</tr>
<tr>
<td>2</td>
<td>Severe headache, stiff neck, no neurologic deficit except cranial nerve palsy</td>
</tr>
<tr>
<td>3</td>
<td>Drowsy or confused, mild focal neurologic deficit</td>
</tr>
<tr>
<td>4</td>
<td>Stuporous, moderate or severe hemiparesis</td>
</tr>
<tr>
<td>5</td>
<td>Coma, decerebrate posturing</td>
</tr>
</tbody>
</table>

*Based upon initial neurologic examination; adapted from: Hunt W, Hess R, J Neurosurg 1968; 28:14.*
# Neurological Status: Glasgow Coma Scale

## Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Eye opening</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>Response to verbal command</td>
<td>3</td>
</tr>
<tr>
<td>Response to pain</td>
<td>2</td>
</tr>
<tr>
<td>No eye opening</td>
<td>1</td>
</tr>
</tbody>
</table>

**Best verbal response**

<table>
<thead>
<tr>
<th>Expression</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oriented</td>
<td>5</td>
</tr>
<tr>
<td>Confused</td>
<td>4</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Incomprehensible sounds</td>
<td>2</td>
</tr>
<tr>
<td>No verbal response</td>
<td>1</td>
</tr>
</tbody>
</table>

**Best motor response**

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obey commands</td>
<td>6</td>
</tr>
<tr>
<td>Localizing response to pain</td>
<td>5</td>
</tr>
<tr>
<td>Withdrawal response to pain</td>
<td>4</td>
</tr>
<tr>
<td>Flexion to pain</td>
<td>3</td>
</tr>
<tr>
<td>Extension to pain</td>
<td>2</td>
</tr>
<tr>
<td>No motor response</td>
<td>1</td>
</tr>
</tbody>
</table>

The GCS is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: best eye response (E), best verbal response (V), and best motor response (M). The components of the GCS should be recorded individually; for example, E2V3M4 results in a GCS score of 9. A score of 13 or higher correlates with mild brain injury; a score of 9 to 12 correlates with moderate injury; and a score of 8 or less represents severe brain injury.
OUR PATIENT: INITIAL EVALUATION

• Imaging:
  1. CT:
     1. C-
     2. CTA
  2. Xray Angiography
Findings:
1. Blood within sulci
2. Normal hypodense appearance of sulci
Findings:
1. Blood within sulci
2. Blood settling dependently in the posterior horn of lateral ventricles
Our Patient: Non-Contrast CT, cont’d

Findings:
1. Large collection of blood in the suprasellar cistern
2. Blood in the circummensencephalic cistern
3. Blood in the quadrigeminal cistern
CEREBRAL CISTERNS:

Normal aspect on NCHCT

http://nypemergency.org/reading_emergency_images/head_ct.html
OUR PATIENT: CT ANGIO

Giant 2.4 x 1.9 cm **aneurysm** arising from the right ICA at the origin of the right PCOM. There is no associated hyperdense "jet" to suggest active extravasation.
OUR PATIENT: X-RAY ANGIO

19 x 18mm posteriorly directed right communicating segment ICA aneurysm with a 6mm neck.
OUR PATIENT: DIAGNOSIS

- Subarachnoid Hemorrhage (SAH) due to ruptured Intracranial Saccular Aneurysm (ISA) of the Internal Carotid Artery (ICA) at the bifurcation of the Posterior Communicating Artery (PCOM)
ANATOMY: ORIGIN OF PCOM

http://medicalterms.info/anatomy/External-Carotid-Arteries/
ISA: EPIDEMIOLOGY

- Meta-analysis, 83 study populations, 21 countries, 1450 UIAs, 94,912 patients:
  - 3.2% in those w/o comorbidity
  - 3.4% in those w/ FH of intracranial aneurysm or SAH
  - 6.9% in those w/ ADPKD
  - 1.61 PR for women comp. to men

ISA: LOCATION

- 85% are in anterior circulation, predominantly Circle of Willis:
  - Junction of the ACOM and ACA ~30%
  - Junction of the PCOM and ICA ~25%
  - Bifurcation of MCA ~20%

ISA: LOCATION, cont’d

ISA: RISK FACTORS

1. Genetics:
   - Ehlers-Danlos and Pseudoxanthoma Elasticum (but not Marfan)
   - Autosomal Dominant Polycystic Kidney Disease (ADPKD)
   - Familial Aldosteronism type I (Glucose-Remediable Aldosteronism, linked to chronic hypertension)

2. Family History (9.1% in individuals >30, not necessarily accounted for by ADPKD)*

3. Cigarette smoking
   - 3 and 4.7 RR for men and women respectively
4. Hypertension
5. Estrogen deficiency (estrogen deficiency of menopause causes a reduction in the collagen content of tissues)
6. Coarctation of Aorta
ISA: SCREENING RECOMMENDATIONS

1. >2 first degree relatives w/ SAH:
   a. Yearly for 3 years
   b. Every 5 years for those w/ no aneurysms on initial 3 scans

2. ADPKD, plus one of the following:
   • previous rupture
   • positive family history
   • warning symptoms
   a. Yearly for 2-3 years
   b. Every 2-5 years thereafter if the aneurysm is clinically and radiographically stable
   • high-risk occupation
   • prior to surgery that is likely to be associated with hemodynamic instability
ISA: NATURAL HISTORY

- International Study of Unruptured Intracranial Aneurysms (ISUIA):
  - Centres in the USA, Canada, and Europe enrolled patients for prospective assessment of unruptured aneurysms.
  - Investigators recorded the natural history in patients who did not have surgery, and assessed morbidity and mortality associated with repair of unruptured aneurysms by either open surgery or endovascular procedures.

ISA: NATURAL HISTORY

ISUIA findings:

• **Size, site, and risk of rupture:**
  
  • 5-year rates of rupture for aneurysms in the Anterior and Posterior circulation respectively:

  • 7-12mm: 2.6%, 14.5%
  • 13-24mm: 14.5%, 18.4%
  • >25mm: 40%, 50%

ISA: MANIFESTATIONS

- Most asymptomatic unless ruptured, leading to SAH
- Some may present with symptoms:
  - Headache (severity comparable to SAH; many times misdiagnosed as migraine)
  - CN III palsy
  - Ischemia from embolus developed at site
ISA: DIAGNOSIS

• **MRA:**
  1. 3D time-of-flight MRA w/ volume rendering at 3.0 Tesla
  2. 99% sensitivity and 97% specificity for aneurysm size < 3 mm to > 10 mm

• **CTA:**
  1. Single-detector up to 64-detector CT
  2. 97.2% sensitivity and 97.9% specificity for aneurysms >4mm, regardless of number of CT detectors
  3. 94% sensitivity for aneurysms <4mm w/ 64-detector CT

ISA: MANAGEMENT PRIOR TO RUPTURE

1. Expectant management
2. Surgical approach
3. Endovascular approach
ISA: EXPECTANT MANAGEMENT

- CTA or MRA annually for two to three years, and every two to five years thereafter if the aneurysm is clinically and radiographically stable.
- Avoid:
  - Smoking
  - Heavy alcohol
  - Stimulant medications
  - Illicit drugs
  - Excessive straining and Valsalva maneuvers

ISA: SURGICAL MANAGEMENT

- **Technique:**
  - Surgical clipping

- **Outcomes:**
  - Surgery-related death or poor neurologic outcome was 13.7% at 30 days and 12.6% at one year. *

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ISA: SURGICAL MANAGEMENT

Clipping Treatment for Cerebral Aneurysm

Ruptured Aneurysm
Surgical Clip
Artery

http://www.massgeneral.org/conditions/condition.aspx?id=87

ISA: ENDOVASCULAR MANAGEMENT

• Options
  1. Traditional approaches:
     1. Coil embolization
     2. Liquid embolization
  2. Novel approach:
     1. Flow diversion
     3. Combination of both

• Outcomes:
  • Therapy-related death or poor neurologic outcomes was 9.3% at 30 days and 9.8% at one year.*


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ISA: ENDOVASCULAR MANAGEMENT
COIL EMBOLIZATION

http://www.massgeneral.org/conditions/condition.aspx?id=87
http://www.ev3.net/assets/005/5513_w600h.jpg
ISA: ENDOVASCULAR MANAGEMENT
LIQUID EMBOLIZATION

http://www.ev3.net/assets/005/5493_w600h.jpg
http://www.ev3.net/assets/005/5494_w600h.jpg
http://www.ev3.net/assets/005/5495_w600h.jpg
Pipeline Embolization Device (PED)

http://www.ev3.net/assets/006/5656.jpg
http://www.youtube.com/watch?v=W6njop9QjAQ
• Received FDA approval on April 6, 2011 for the endovascular treatment of adults (> 22 yo) with large or giant wide-necked intracranial aneurysms of the ICA from the petrous to superior hypophyseal segments.

• Made of 48 braided strands of woven wire mesh containing 25% platinum and 75% cobalt-nickel alloy.

• When fully expanded it provides approximately 30-35% metal surface area coverage, significantly more than that seen with other currently marketed stents for use in the intracranial circulation. ¹

• Its high density of coverage is designed to alter flow and, even without intrasaccular coils, induce aneurysm occlusion. ²

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PED: THE BASICS, cont’d

• In theory:
  • It forms a scaffold upon which endothelial regrowth can occur, leading to the full coverage of the implant and the aneurysm neck.
  • When compared with selfexpanding or balloon-expandable stents, the PED has higher metal surface area coverage, which greatly facilitates the occlusion of the aneurysm neck and neointimal regrowth.

• In reality:
  • True effect on neointimal remodeling is unknown.

PED: EFFICACY

- Systematic literature review published in 2012 yielded:
  - 414 patients with 448 intracranial aneurysms (IA)
  - 78.3% were saccular or blister-like
  - 83.5% of IAs were in the anterior circulation, 16.5% in the posterior one
  - Mean size was 12 mm (largest being 18.2 mm)
  - Mean number of PEDs per IA was 2.0
  - Deployment was successful in ~95% of procedures
  - Obliteration was achieved in 82.9%

PED: SAFETY

- Periprocedural intracranial vascular complication rate: 6.3%
- Mortality rate: 1.5%
- Complications:
  - TIA
  - SAH
  - ICH
  - Worsening of mass effect
  - IA rupture
  - Emboli

Given the apparent low risk of hemorrhage from incidental, small (<7 mm) aneurysms in patients without previous SAH, observation rather than intervention is generally advocated. However, special consideration for treatment should be given to young (<50 years) patients in this group.

Asymptomatic aneurysms ≥7 to 10 mm in diameter warrant strong consideration for treatment, taking into account patient age, existing medical and neurologic conditions, and relative risks for treatment.

BACK TO ISAs: COMPLICATIONS

• Most dreaded complication of ISA...

Rupture leading to Subarachnoid Hemorrhage (SAH)
SAH

- Outcomes:
  - Overall case fatality 51%\(^1\)
  - 10% die prior to reaching Hospital
  - 25% die within 24h
  - 45% die within 30 days \(^2\)
  - ~30,000 persons/year affected in North America

SAH: CLINICAL MANIFESTATIONS

• Headache

1. Onset headache ("worst headache of my life", "thunderclap headache")
   - 19-25% of "worst headaches of my life" have SAH
   - 30% of cases it lateralizes to side aneurysm.
   - +/- brief loss of consciousness, seizure, nausea or vomiting, and meningismus

2. Sentinel headache ("warning leak")
   - 10-43% of cases
   - Precedes SAH by 6-20 days

SAH: DIAGNOSIS

- **NCHCT**
  - 100% sensitivity and specificity within the first 6 hours *
- **Lumbar puncture**
  - Mandatory if high suspicion but normal CT
- **MRI**
  - FLAIR + T2 useful sub acutely (>4 days)

SAH: COMPLICATIONS

1. Vasospasm
   - LEADING CAUSE OF DEATH & DISABILITY AFTER SAH
   - 20-30% of cases
   - Usually no earlier than day 3
   - Results from spasmogenic substances released during lysis of subarachnoid blood clots

2. Rebleeding
   - 6.9-8.6% of cases
   - Highest risk during first 24 h

3. Hydrocephalus
   - 15% of cases

4. Increased ICP
   - 54% of cases
SAH: MANAGEMENT

1. Admission to ICU
2. DC anticoagulation if present
3. Vasospasm
   1. TCDUS to monitor
   2. Nimodipine to prevent poor outcome *
   3. Angioplasty to treat
4. +/- Seizure Prophylaxis
5. Monitor ICP
   1. Balance between risk of ischemia and rebleeding
6. Most importantly, treat aneurysm!!

1. Admitted to ICU
2. Medical:
   1. Nimodipine (to prevent poor outcomes related to vasospasm)
   2. Levetiracetam (seizure prophylaxis)
3. External Ventricular Drain placed on immediate arrival to ED (to monitor and maintain ICP)

http://www.uptodate.com/contents/image?imageKey=NEURO/56391&topicKey=NEURO%2F1116&source=outline_link&search=external+ventricular+drain&udtPopup=true
4. Treated aneurysm endovascularly:
   1. Coil embolization
   2. PED placement
BACK TO OUR PATIENT: MANAGEMENT, cont’d

s/p Coil embolization
1. Experienced increased ICP requiring right hemicraniectomy.
2. Daily TCDUS showed signs of vasospasm in two separate occasions requiring angioplasty.
BACK TO OUR PATIENT: OUTCOME

- Neurosurgery f/u 4 months after event
  - Alert and oriented x 3
  - Attention and concentration appropriate
  - No memory deficit noted
  - Appropriate language and fund of knowledge
  - Cranial nerves intact
  - Gait and coordination normal
TAKE HOME POINTS

1. A great majority of ISAs arise around the Circle of Willis.

2. Three approaches for management of ISAs, analysis of the risks and benefits of asymptomatic intervention is important.

3. Flow diversion is a novel approach to endovascular management of ISAs that so far displays better results and decreased rates of complications in comparison to other conventional surgical and endovascular approaches.
4. Most dreaded complication of ISAs is rupture leading to SAH -> ~50% mortality rate
5. 19-25% of patients c/o the “worst headache of my life” have a SAH.
6. If SAH is suspected, performe NCHCT stat.
7. Vasospasm is the leading cause of death & disability after SAH, prevent poor outcomes with Nimodipine.
REFERENCES

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Dr. Gillian Lieberman, for putting your heart and soul into our clerkship and for providing us with a radiology experience worthy of envy, one which will certainly contribute to us becoming better physicians in the near future.