Endovascular Embolization of Intracranial Dural AV Fistula—Benign?

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Case presentation

• 50 y/o male
• Presents to the hospital with severe headache along with stabbing pain behind R eye, R ear ringing and R side face numbness. Nausea +
• Vital signs: BP: 114/68 mmHg Pulse: 89/min Resp: 17/min Temp: 97.9 °F (36.6 °C) SpO2: 98 % Weight: 79.3 kg (174 lb 13.2 oz) Height: 182.9 cm (6')
• No significant past medical history
• Neurologically stable - Moves all extremities with good equal strength.
• Pupils 3 mm bilaterally/briskly react.
• Speech clear and appropriate
• Minimal numbness to R lip area
• Intermittent headaches.

For the following questions, there may be more that one correct answer. Please select the ONE BEST answer
What is the Glasgow Coma Scale score (GCS) of the patient?

- A. 3
- B. 7
- C. 15
- D. 12
Sorry – I disagree

Try again
CORRECT !!
Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Glasgow coma scale</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td></td>
</tr>
<tr>
<td>spontaneously</td>
<td>4</td>
</tr>
<tr>
<td>to speech</td>
<td>3</td>
</tr>
<tr>
<td>to pain</td>
<td>2</td>
</tr>
<tr>
<td>none</td>
<td>1</td>
</tr>
<tr>
<td><strong>Verbal response</strong></td>
<td></td>
</tr>
<tr>
<td>orientated</td>
<td>5</td>
</tr>
<tr>
<td>confused</td>
<td>4</td>
</tr>
<tr>
<td>inappropriate</td>
<td>3</td>
</tr>
<tr>
<td>incomprehensible</td>
<td>2</td>
</tr>
<tr>
<td>none</td>
<td>1</td>
</tr>
<tr>
<td><strong>Motor response</strong></td>
<td></td>
</tr>
<tr>
<td>obeys commands</td>
<td>6</td>
</tr>
<tr>
<td>localises to pain</td>
<td>5</td>
</tr>
<tr>
<td>withdraws from 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>none</td>
<td>1</td>
</tr>
<tr>
<td><strong>Maximum score</strong></td>
<td>15</td>
</tr>
</tbody>
</table>

GCS of $\geq 13$ correlates with a mild brain injury, 9-12 is a moderate injury and $\leq 8$ a severe brain injury

CT of Head

- Enlarged vascular structures in the right CP angle, pre-pontine cistern, interpeduncular fossa and visualized upper ventral cervical spine.
- Scattered subarachnoid hemorrhage in the basal cisterns and superior cerebral convexities.
- Small intraventricular hemorrhage.
CTA findings

- Numerous dilated serpiginous vessels in the posterior fossa, ventral to the brainstem, along the tentorial margins, and within the imaged upper cervical spinal canal.

- Prominent left PICA feeding the adjacent serpiginous vessels.

- Given the absence of definite parenchymal nidus findings were most compatible with dural AV fistula
Intracranial dural AV fistula

• Intracranial dural AV fistulas are vascular shunts fed by meningeal arteries with drainage into either a major sinus or a leptomeningeal vein

• Account for 10-15% of all intracranial AV malformations

• Dural AV fistulas are described as either direct or indirect.
  – Direct DAVFs (nonsinus type) have a well-defined arteriovenous shunt and involve only a few vessels.
  – Indirect DAVFs (sinus type) are more complex with numerous, small arterial feeders that travel in the dura and drain into a venous sinus.
• The patient received –

Phosphenytoin 1600 mg for seizure prophylaxis
Nimodipine 60 mg & labetalol 10 mg for SBP >130 mmHg
Ondansetron 4 mg X 2 for nausea
Morphine 8 mg and fentanyl 50 mcg for headache

• Treatment plan - diagnostic cerebral angiography and embolization of dural AV fistula- under general anesthesia.
Angiography

- Confirmed dural AV fistula.

- Nidus - 3 cm in maximum diameter, supplied by meningohypophyseal trunk and inferolateral trunk branches from the right internal carotid artery.

- **Venous drainage** - through a large ectatic venous varix following a caudal outflow to the epidural venous plexus as well as cephalad outflow through the lateral mesencephalic vein as a tributary to basal vein of Rosenthal and vein of Galen.

- **Substantial contribution** - from branches of the right middle meningeal artery. At least 6 pedicles in the petrous squamosal branch of the right middle artery serves the fistula.

- **Small contribution** - from dural anastomoses from the neuro meningeal trunk hypoglossal branch, dural branches of the right anterior inferior cerebellar artery.
What is the Borden/Cognard scoring in this patient?

- A. I/ I
- B. II/ II
- C. III/ III
- D. III/ IV
- E. III/ V
Sorry – I disagree

Try again
CORRECT !!
Classification of dural AV fistulas

**Borden classification of DAVFs**

- Type I: “Benign”, draining into dural sinus / meningeal vein
- Type II: “Aggressive”, draining into dural sinus with CVD and retrograde flow into subarachnoid veins
- Type III: “Aggressive”, draining directly into subarachnoid veins

(CVD = cortical venous drainage)

**Classification Cognard, et al.**

- Type I: free-flow drainage into a sinus;
- Type II: drainage into a sinus, with retrograde flow into sinus (IIa) or cortical vein (IIb);
- Type III: cortical venous drainage
- Type IV: cortical venous drainage with giant venous ectasia
- Type V: perimedullary venous drainage


• The risk of hemorrhage for DAVFs depends on
  – venous drainage pattern, particularly cortical venous reflux
  – presence or absence of aggressive symptoms on presentation
• Low grade DAVFs (Grade I–IIa Cognard, Grade I Borden) have an annual risk of hemorrhage of 0%,
• Intermediate lesions (Grade IIb, IIa+b Cognard, Grade II Borden) have a 6% annual hemorrhagic risk,
• High-grade lesions (Grade III–V Cognard, Grade III Borden) have an annual risk of hemorrhage of 10%

Endovascular Treatment of vascular shunts

• Complete elimination of the AV shunt— if there is partial obliteration then there is a persistent risk of hemorrhage due to ongoing recruitment of collateral vessels.

• Selective obliteration of Cortical Venous Drainage is considered when complete occlusion of the shunt is not feasible or considered too risky, and can be as efficacious as Dural AV fistula obliteration in preventing neurologic morbidity with lower levels of procedural risk.
What would be your goals for anesthetic management?

• A. Induced hypotension
• B. Maintaining hypervolemia
• C. Avoid muscle relaxation
• D. Titratability
Sorry – I disagree

Try again
CORRECT !!
• High flow through a low resistance system leads to hypotension in the feeding artery and high pressure in the draining veins. The normal brain suffers from low cerebral perfusion pressure → Steal phenomena → chronic hypoperfusion → autoregulation curve shifts to left. With induced hypotension the areas around the shunt can become more ischemic.

• Hypervolemia and dilutional anemia which can occur due to the osmotic effects of the radiopaque contrast dye. IV fluids should be carefully administered.

• Anesthetic technique including muscle relaxation prevents patient movement which allows easy titratability and quick emergence at the end of the procedure for assessment of neurological status.

• Emergence should be smooth without any coughing or bucking and prevention of any rise in blood pressure.
What are the advantages of GA over MAC?

- A. Minimize patient movement
- B. Can pause ventilation at crucial periods
- C. Hemodynamic stability
- D. All are correct
Sorry – I disagree

Try again
CORRECT !!
The embolization of intracranial Dural AV fistula is best conducted under General anesthesia

- Provides motionless patient for improved mapping and images.

- Airway control.

- Better control of blood pressure- either brief hypotension to decrease flow to prevent forward flow of glue to distal part of the vessel, or hypertension in case of a thrombotic event.

- Allows facilitation of interventions in any neurological emergencies- like EVD placement, or for emergent craniotomy.
Intraoperatively

• After placement of standard ASA monitors, anesthesia was induced with propofol-150 mg, fentanyl- 150mcg, lidocaine 50 mg, rocuronium 50 mg. After a smooth intubation, anesthesia was maintained with sevoflurane.

• An arterial line was placed for close blood pressure monitoring.

• Patient was hemodynamically stable during the case.

• After 7 hours the procedure was deemed done.
• Findings: Dural AV Fistula feeding predominantly via Right Middle Meningeal Artery.

• Glue embolization of the Right MMA was achieved.

• Postembolization angiography – partial devascularization of the arterial supply to the dural AVF from the right middle meningeal artery resulting in slowed flow into the fistula.

• There was no evidence of arterial injury. Scattered distal embolization to venous structures was observed.
• Patient was extubated in the IR suite. During extubation the systolic BP briefly rose to 160 mmHg


• Patient was taken to the NICU with oxygen mask and monitoring. He had a single episode of emesis on arrival to NICU. Received 4 mg IV Ondansetron.

• Vitals on arrival to NICU - BP: 134/64mm Hg, Temp: 99.8 °F, HR: 60/min SpO2: 99%, RR: 14/min
All are signs and symptoms of increased ICP/ rebleed except -

- A. Hypertension
- B. Tachycardia
- C. Headache
- D. Nausea/vomiting
- E. Increasing somnolence
Sorry – I disagree

Try again
CORRECT !!
• Half hour after ICU arrival - patient sleepy but following commands and oriented. Received 50 mcg of fentanyl for headache. He continued to be sleepy and began to develop snoring sounds.

• Half hour later, patient developed respiratory distress with oxygen desaturation to 47%, Assuming this to be narcotic related, 40mcg IV naloxon was given to reverse the effect of fentanyl related respiratory depression.

• There was no improvement in symptoms. Blood pressure elevated to SBP 220 mm Hg. Briefly bradycardic to 40s. He was emergently intubated and sedated. Taken for emergent CT of head.
Postoperative emergent CT of Head
CT of Head depicts all findings except-

- **A. Intraventricular hemorrhage**
- **B. Ventriculomegaly**
- **C. Intraventricular catheter**
- **D. Post-surgical changes**
Sorry – I disagree

Try again
CORRECT !!
Findings of emergent CT head

• Postsurgical changes of glue embolization.

• Increase in previously noted subarachnoid hemorrhage.

• Mild hydrocephalus.

• Downward displacement of the tonsils related to edema/mass effect, questionable brainstem edema.

• Intraventricular hemorrhage within the lateral, third and fourth ventricle. Mild ventriculomegaly & sulcal effacement.
• Neurosurgery was consulted.
• In the meanwhile - 50g of mannitol given.
• SBP in 200s → Nicardipine infusion started
• External ventricular drain (EVD) was placed emergently, large amount of sanguinous output noted (approx 40 cc in first couple minutes).
• After EVD placement, SBP in 80s-70s → Nicardipine drip was stopped. Patient was given 500cc normal saline bolus.
• Patient unresponsive on the ventilator after intubation. Pupils sluggish, withdrawing in right upper extremity, posturing in left lower extremity and no movement in bilateral lower extremity.
• No Improvement after EVD placement.
• Patient was taken emergently to the operating room for craniotomy.
• On craniotomy, significant posterior fossa swelling, intraventricular hemorrhage with hydrocephalus noted.
• Craniectomy urgently performed in order to decompress the posterior fossa.
• Patient continued to do poorly with no signs of recovery over the next few days.
• Care was withdrawn on the 6th POD
Complications of endovascular treatment of Dural AV fistula could be?

- A. Cerebral edema
- B. Hyperemia
- C. Thrombosis
- D. Hemorrhage
- E. All of the above
Sorry – I disagree

Try again
CORRECT!!
Hemorrhage after AV fistula embolization

• Possible causes of intra/postembolization hemorrhage-
  – Complete fistula obliteration may result in extensive thrombosis of the draining veins initially arterialized and a risk of venous infarction, cerebral edema and hemorrhage
  – Embolization can cause sudden changes in intravascular pressure leading to hyperemia.
  – Secondary to perforation by the guide wire.
  – Hyperperfusion syndrome (Following the occlusion of feeder arteries, blood flow is diverted to chronically hypoperfused neighboring brain tissue. The acute change in blood flow can result in hyperemia, edema, and hemorrhages, due to local capillary breakthrough).
  – Inadequate blood pressure control, incomplete obliteration of feeding artery with residual flow, venous thrombosis

• Treatment of Hemorrhage-
  – Blood pressure reduction (Nicardipine infusion)
  – Reversal of heparin with protamine
Summary

- Intracranial Dural AV fistulas (DAVFs) are rare vascular lesions.
- About 35% of patients with a high grade DAVF present with intracranial hemorrhage.
- Embolization may cause significant changes in distribution of cerebral blood flow, with potential for cerebral edema and hemorrhage. Intraventricular hemorrhage could be a serious complication.
- With progressive occlusion of the DAVF and increase in perfusion pressure to the surrounding tissue, blood pressure should be lowered to prevent hyperemia.
- The anesthesiologist should be vigilant for hemodynamic signs of intracranial hypertension.
- Close postoperative surveillance and monitoring allows early diagnosis and treatment.
Further reading

• Anesthesia Considerations and Intraoperative Monitoring During Surgery for Arteriovenous Malformations and Dural Arteriovenous Fistulas Christina Miller, MD, Marek Mirski, MD, PhD Neurosurg Clin N Am 23 (2012) 153–164


• Early rebleeding from intracranial dural arteriovenous fistulas: report of 20 cases and review of the literature Hugues Duffau, M.D Journal of Neurosurgery January 1999 / Vol. 90 / No. 1 / Pages 78-84

• Natural history, current concepts, classification, factors impacting endovascular therapy, and pathophysiology of cerebral and spinal dural arteriovenous fistulas Lotfi Hacein-Beya, Angelos Aristeidis Konstas, John Pile-Spellman Clinical Neurology and Neurosurgery Volume 121, June 2014, Pages 64–75