

Subarachnoid Hemorrhage

SAH: Background

- Accounts for only 3% of all strokes, but contributes to 27% of all stroke-related years of potential life lost
- Rebleeding leads to 50-80% mortality
- Cerebral vasospasm accounts for up to 23% of death or disability
- Fisher grade 3 confers 35% risk of vasospasm, while Fisher grade 4 is associated with 21% risk
- Hunt and Hess 4 and 5 presentations are associated with 70-100% mortality
- May have neurocardiogenic manifestations

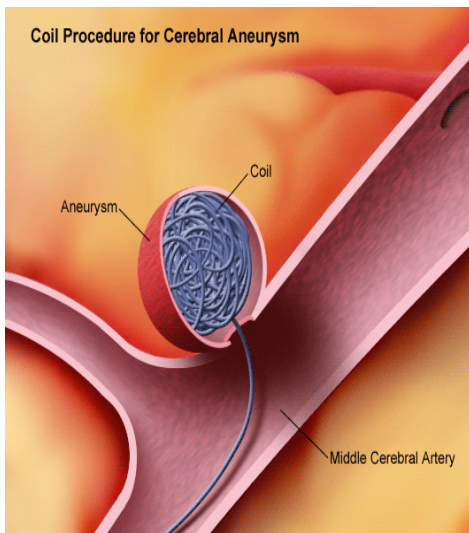
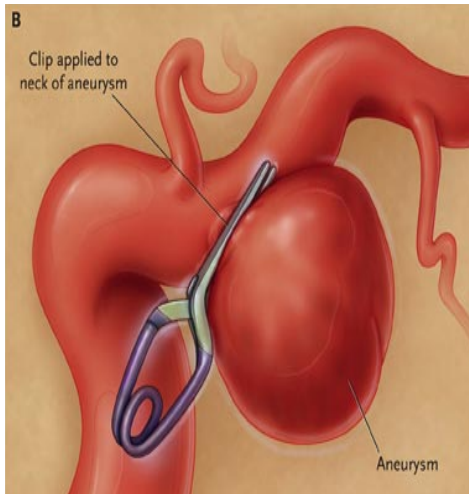
SAH: Diagnosis

- Acute workup includes non-contrast CT, followed by lumbar puncture if non-diagnostic
- CT angio can be used to detect aneurysms or AVMs, but if inconclusive, digital subtraction angiography is still recommended
- MRI can also be used, but should not preclude LP if negative
- TCD is a reasonable monitor for arterial vasospasm
- CT/MR perfusion can be used to detect potentially ischemic regions
- Evaluate cardiac function if hypotensive

Medical Measures to Prevent Rebleeding

- Between symptom onset and securement of aneurysm, **BP should be controlled** to balance the risk of rebleeding with the risk of stroke and maintenance of cerebral perfusion
- Though it is has not been studied, consensus of experts agree that **SBP < 160** is reasonable
- If securement is expected to be delayed > 72 hours, antifibrinolytics (TXA/EACA) can be used to reduce risk of early rebleeding

Surgical and Endovascular Securement



- Securement should be performed as soon as possible, followed by confirmatory imaging
- Complete obliteration is preferred – if remnant remains, it should be addressed
- **Clipping** may be preferred in those with > 50 mL of intraparenchymal hematoma and MCA aneurysms
- **Coiling** may be preferred in the those > 70 y/o, those with high grade bleeds, and basilar aneurysms
- Stenting is associated with increased morbidity and mortality so should only be considered when less risky options have been excluded

Anesthetic Management During Securement

- **Avoid intraoperative hypotension**
- Consider induced hypertension during temporary vessel occlusion
- Induced hypothermia is not recommended but may be considered in some cases
- **Avoid intraoperative hyperglycemia**
- GA for endovascular coiling may be beneficial

Management of Cerebral Vasospasm/ Delayed Cerebral Ischemia

- Oral **nimodipine** should be given to all patients because it improves neurologic outcomes (but not vasospasm)
- Maintain **euvolemia** to prevent delayed cerebral ischemia
- Prophylactic hypervolemia or balloon angioplasty before development of angiographic spasm is not recommended
- **Induced hypertension** is recommended with DCI
- Cerebral angioplasty and/or selective intra-arterial vasodilator therapy is reasonable if there is symptomatic vasospasm, especially if induced hypertension is ineffective

Management of Medical Complications

- Prophylactic anticonvulsants can be used in the immediate post-hemorrhagic period
- **Do not** give hypotonic fluids
- **Do not** allow intravascular volume contraction – **treat with IVFs**
- Fever should be treated aggressively
- Careful glucose management is recommended
- Transfusion of pRBC in anemic patients is reasonable if they are at risk of cerebral ischemia, but optimal Hgb has not been determined
- Fludrocortisone and hypertonic saline can be used for hyponatremia
- Heparin-induced thrombocytopenia and DVT are relatively frequent complications

Putting it All Together: Preop Assessment

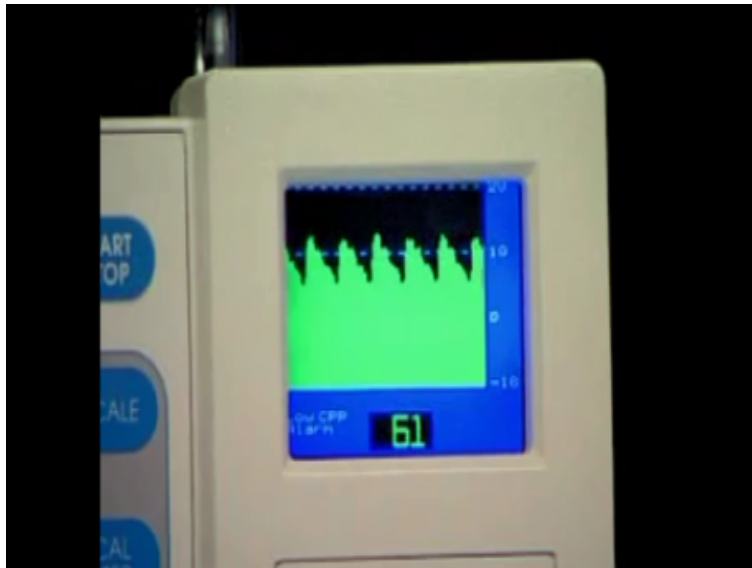
- Severity
 - Higher Hunt and Hess and Fisher grades have worse prognosis
 - Baseline neurologic deficits
 - **Intracranial hypertension** from bleeding or cerebral edema
 - May need **central access** for hypertonic saline
- Cardiac Involvement
 - Check EKG, troponins, echo if available
 - Most likely **stunned myocardium**, which recovers over 2 weeks and does not require further workup
 - May need inotropic support
- Window for vasospasm
 - Highest risk at 4-14 days post rupture
 - Makes BP management even trickier (rebleed vs vasospasm)

Putting it All Together: Intraop Plan

- For securement of aneurysm, the main goals are to prevent rebleeding without causing ischemic stroke
 - **Keep SBP < 160**
 - Consider stimulating parts of procedure like intubation, Mayfield pin placement, incision
 - Keep the patient from moving (**paralytic**)
- **Avoid long-acting medications**
- If an ICP monitor is in place, use it

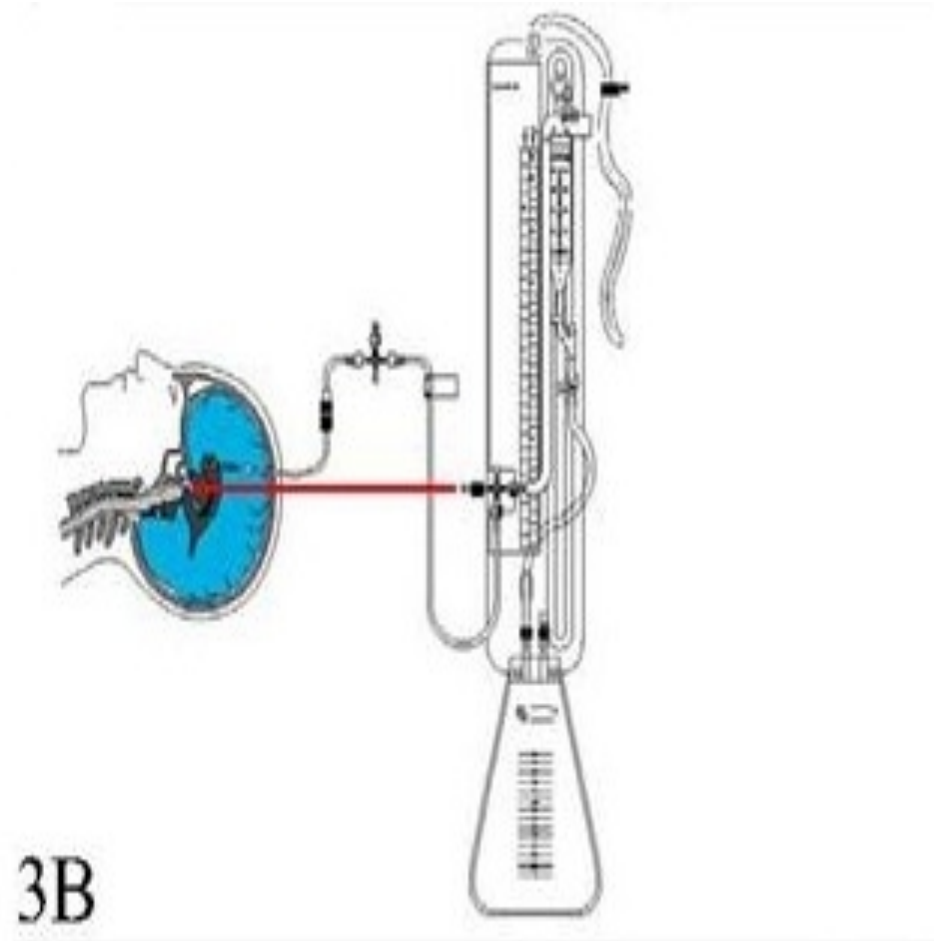
Putting it All Together: ICP Monitors

- **Camino bolts** are **intraparenchymal**, typically have their own monitor (do not just leave it behind in the ICU) and do not need to be leveled or zeroed



Putting it All Together: ICP Monitors

- External ventricular drains need to be **leveled** with the bubble indicator between the **foramen of Monro** (ear) **and 0** on the manometer



Putting it All Together: ICP Monitors

- The pressure transducer is connected to the monitor and **zeroed** just like an arterial or central line is
- EVD drainage occurs whenever ICP exceeds the pressure set on the manometer
- In this setup, CSF will drain into the reservoir if the stop-cock is opened to the reservoir and the ICP is > 21
- If you want to drain some CSF, **open the stop-cock** (can't measure and drain at the same time)



Putting it All Together: Intraop Plan

- Treat sustained intracranial HTN (ICP > 20-25 x 15 min)
 - Ensure adequate drainage
 - Drain **CSF 30 ml at a time from EVD or 15-20 ml if lumbar**
 - Hypertonic saline
 - Mannitol 0.5-1 mg/kg
 - Furosemide may cause too much diuresis for too long
 - If patient is about to herniate, can increase RR, but do not drive PaCO₂ < 30 because this risks ischemia
 - Aim for eucapnia and definitely treat hypercapnia
 - Can give propofol or barbiturate to achieve burst suppression
 - Consider mild hypothermia (33-34°C)

Putting it All Together: Intraop Plan

- Remember that if the ICP is > 20 , cerebral autoregulation is lost and your cerebral perfusion becomes pressure dependent
- Remember that while the dura is open, the ICP should be 0
- If you are in neuro-IR – consider why the ICP is suddenly so high and hope you have blood in the room
 - Eyeball the interventionalist – is he calm or in a panic?
 - Check the EVD for blood, check pupils
- If you just intubated the patient and the ICP suddenly spikes
 - Check the EVD for blood, check pupils
 - Yell for the surgeon
 - Find someone to take over the case



Putting it All Together: Intraop Plan

- Management of intraoperative rupture
 - Occurs in 11% of previously ruptured aneurysms
 - Up to 8% may go into hemorrhagic shock
 - Give blood and call for help
 - Maintain euvolemia
 - Lower the MAP to 40-50 to reduce bleeding and further shear stress
 - Temporary clips can be placed for 15-20 min
 - Consider driving up BP to improve collateral perfusion after placement



Fusiform Aneurysm



Saccular Aneurysm



Ruptured Aneurysm

Putting it All Together: Postop Plan

- If the patient had good mental status preoperatively and the surgery was uneventful, extubate if no other contraindications
- If the patient had GCS < 8 before surgery, they probably we will not perk up enough so leave intubated (esp if high Hunt and Hess and/or Fischer grade)
- After securement is confirmed, allow BP to autoregulate
- Again, transport patient safely and give good sign out to the ICU resident