Anesthetic Considerations for Cerebrovascular Neurosurgery

Ajith J. Thomas, MD
Associate Professor of Neurosurgery
BIDMC Brain Aneurysm Institute

Mohamed M. Salem, MD
Krishnan Ravindran MD
Neurovascular Surgery/Endovascular Neurosurgery Research Fellows
Disclosures / Conflicts of Interest

• DSMB – SCENT flow diverter trial
Background

- Rapid expansion of surgical techniques for neurovascular procedures has required adaptation on both sides of the drapes.
- More and more lesions are able to be safely and effectively treated endovascularly.
- Effective communication between both parties required for optimizing outcomes.
Vascular neurosurgery: unique anesthetic challenges

- Combination of elective and emergent procedures
- Prolonged procedural durations
- Familiarity with demands of both open craniotomy and endovascular techniques required
- Risk of intra-procedural rupture
Endovascular neurosurgery: further unique anesthetic challenges

• Dim lighting
• Maintenance of patient immobility
• Interventional neuroradiology (INR) suites: unfamiliar environments
• Requirement for patient transfers between OR/INR suite/MRI/CT
  • Effect on arterial/venous access lines
• Radiation and contrast
The interventional neuroradiology suite

- Crowded workspace
- Access to resuscitation and airway equipment
- Patient positioning
- Obstructed view
- Potentially isolated from back-up if required
Radiation safety for endovascular procedures

- Exposure decreases proportionally to the inverse of the distance squared from radiation source
- Difference of a few feet drastically reduces exposure
- Digital subtraction angiography >> fluoroscopy regarding radiation
- Lead aprons, thyroid shields, radiation exposure badges, eye protection
Induction and maintenance for endovascular therapy

- General principles same as for open cerebrovascular surgery
- Brain relaxation critical
- Orogastric tube placement post-intubation for delivery of oral anti-platelet medications
- Intra-arterial blood pressure monitoring required
  - Presence of existing femoral sheath may preclude need for peripheral arterial line
Induction and maintenance for endovascular therapy

• Cerebral protection: systolic blood pressure targets
• Normocapnia
• Temperature control
• Nasogastric tube insertion for potential intra-op anti-platelet loading dose administration
• Maintenance
  • iv or inhaled agent with intermittent neuromuscular blockade
  • Avoidance of nitrous oxide
Deliberate hypertension

- During acute arterial occlusion or vasospasm, increasing systemic BP can increase collateral blood flow
- The extent of BP increase depends on the condition of the patient and the nature of the disease
  - Systemic BP is increased by 30-40% > baseline in absence of symptoms resolution or improved perfusion.
- IV phenylephrine: 1st line agent
Anesthesia options

- General anesthesia
- Intravenous sedation
- Ultimately depends on the procedure
General anesthesia

Advantages:

• Patient comfort
• Minimizes motion artifacts (improves image quality)
• Better control of the respiratory and hemodynamic status

Disadvantages:

• Intra-procedural neuro-assessment
• Consequences of endotracheal intubation and extubation producing hypertension, coughing or straining which can increase ICP
Choice of anesthetic agent: volatiles

- Neuroprotective
- Decreased cerebral oxygen demand
- Decreased glutamate production
Intravenous sedation

Advantages:
- Continuous neurological assessment during procedure
- Avoidance of hemodynamic changes associated with intubation and emergence

Disadvantages:
- Airway security
- Higher end-tidal CO₂
- Preserved pain sensation, anxiety
Intravenous sedation

- Commonly used: Dexmedetomidine.
  - Patients are arousable and co-operative when stimulated
  - No respiratory depression

- Can decrease cerebral blood flow by inducing a degree of vasoconstriction within the brain

- Side Effects:
  - Hypotension: should be used cautiously in subarachnoid hemorrhage patients
  - Prolonged Sedation due to long duration of action

Randomized multicenter study comparing the speed of recovery after maintenance of anaesthesia for neuroradiology with sevoflurane or Propofol, revealed that sevoflurane was associated with more rapid recovery.
Contrast Reaction

- Reactions can be due to contrast hypertonicity, direct cardiac depression, or idiosyncratic anaphylactoid reactions.

- Prophylactic steroids and anti-histamines should be recommended for patients with history of a previous reaction.

- Precautions to decrease AKI risk:
  - Using diluted/small contrast volumes
  - Adequate hydration

- Monitor renal function regularly up to 72 hrs post-procedure.
Key endovascular neurosurgery procedures

- Digital subtraction angiography (DSA)
- Arteriovenous malformations (AVMs)
  - embolization
- Ischemic stroke
  - thrombectomy
- Intracranial aneurysms (endovascular and open intervention)
  - Ruptured
  - Unruptured
  - Coil embolization and flow diverting stent deployment
Digital subtraction angiography

- Diagnostic procedure: ‘catheter’ angiography using contrast
- Majority of workload in the INR suite
- Importance of patient immobility in quality of obtained images
- Typically done with patient awake, unless GA required for neurological state or airway security
Endovascular treatment of AVMs

- Treated embolization of either glue or non-adhesive polymer (tradename: Onyx)
- Goal of therapy: obliteration of fistulae and feeding arteries
Anesthetic considerations for AVM embolization

- Transient desaturation reported following Onyx injection
- Request for deliberate hypotension during polymer injection
  - To stagnate flow through feeding artery and reduce passage into draining veins
  - Facilitate deposition within AVM nidus
Anesthetic considerations for AVM embolization: complications

- Potential risk of embolizing agent entering draining vein and venous circulation → R heart → pulmonary circulation
- Embolization of normal cerebral arteries
- Restoration of systolic pressure following hypotension → risk of overwhelmed cerebral autoregulation → hemorrhage
Endovascular management of acute ischemic stroke

• Mechanical thrombectomy: benefit been shown over sole iv tPA in numerous recent clinical trials (MR CLEAN, EXTEND-IA SWIFT PRIME, THRACE)

• Two recent trials have shown benefit beyond initial time window of 6 hrs post-symptom onset (DAWN, DEFUSE-3 NEJM 2018)

• Neurointervention: requires stent-retriever +/- aspiration
Conscious sedation vs General anesthesia for endovascular thrombectomy

- Higher mortality and poorer outcomes with GA (observational data)
- 3 recent trials directly comparing CS vs GA for thrombectomy
- Ongoing debate
RCTs comparing GA vs CS for endovascular thrombectomy

- SIESTA (Schonenberger et al JAMA 2016)
  - N=45 GA and CS, respectively
  - No differences in degree of successful recanalization, 24hr NIHSS, PaCO2, infarct volume, mortality between GA and CS arms
- AnStroke (Lowhagen et al Stroke 2017)
  - n=65 GA, n=63 CS
  - Higher successful reperfusion in GA arm vs CS arms (p=0.04)
  - No difference in growth of infarct volume
The SIESTA trial

- N=73 GA, n=77 CS
- No difference in primary outcome (NIHSS after 24 hrs)
- Significantly (p=0.008) less frequency of pt movement with GA
- 37% mRS 0-2 at 3 months in GA arm, 18.2 % in CS arm (p=0.01)

BUT higher complications in GA arm (pneumonia, hypothermia)
The SIESTA trial

Effect of Conscious Sedation vs General Anesthesia on Early Neurological Improvement Among Patients With Ischemic Stroke Undergoing Endovascular Thrombectomy: A Randomized Clinical Trial

Silvia Schönberger, MD; Lorenz Uhlmann, MSc; Werner Hacke, MD, PhD; Simon Schieber, MD; Sibu Mundiyapurath, MD; Jan C. Purrucker, MD; Simon Nagel, MD; Christina Klose; Johannes Pfaff, MD; Martin Bondzus, MD; Peter A. Ringleb, MD; Meinhard Kieser, PhD; Markus A. Möhlenbruch, MD; Julian Bösel, MD, FNCS

• Conclusion: “The study findings do not support an advantage for use of conscious sedation.”
HERMES collaboration

- Endovascular thrombectomy vs standard care in anterior circulation ischemic stroke
- Pooled individual patient data from 7 randomized trials
- N=1764 total patients
- 871 thrombectomy, 893 standard care
- N=236 GA, n=561 no GA
Delayed reperfusion with GA use

- Due to greater time required for induction
- Implications for penumbra

<table>
<thead>
<tr>
<th></th>
<th>All standard care (n=893)</th>
<th>All patients receiving endovascular therapy (n=871)</th>
<th>GA (n=236)</th>
<th>No GA (n=561)</th>
<th>p-value GA vs no GA</th>
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<tbody>
<tr>
<td>Onset to randomisation, min</td>
<td>184 (140-250)</td>
<td>181 (141-241)</td>
<td>179 (137-238)</td>
<td>184 (144-246)</td>
<td>0.04</td>
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<tr>
<td>Randomisation to reperfusion, min</td>
<td>NA</td>
<td>92 (61-128)</td>
<td>105 (80-149)</td>
<td>85 (51-118)</td>
<td>&lt;0.0001</td>
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<tr>
<td>Onset to reperfusion, min</td>
<td>NA</td>
<td>291 (231-357)</td>
<td>302 (246-357)</td>
<td>288 (222-358)</td>
<td>0.57</td>
</tr>
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Outcomes and Complications

- Better functional outcomes with non-GA vs GA:
  - mRS 0-2 (OR=1.65, p=0.0078)
  - mRS 0-1 (OR=1.68, p=0.013)
  - 8 pt NIHSS reduction (OR=1.75, p=0.0020)
- Vessel perforation
  - <1% in GA group, 2% in non-GA (p=0.30)
- Pneumonia
  - 11% in GA group, 8% in non-GA group (p=0.18)
Endovascular treatment of intracranial aneurysms

- Coil embolization
  - Assisted with balloon-expandable stents
- Flow diverting stents
- Increasing numbers of aneurysms amenable to endovascular treatment
Anesthetic considerations for endovascular treatment of ruptured aneurysms

• Aneurysmal subarachnoid hemorrhage management principles similar to open cerebrovascular surgery
• General anesthetic preferred
  • Intracranial pressure monitoring
  • Blood pressure control critical
  • Heparin reversal with protamine
• Potential need for craniotomy
• Vasospasm prophylaxis
Complications

- Aneurysm sac manipulation → distal thromboembolus
- Aneurysm perforation (2.3-3%)
- Thrombus formation along catheter, guide wire (<0.5%)
- Coil displacement (<2.5%)
Endovascular treatment of unruptured aneurysms

• Sedation: may be safe and feasible in unruptured aneurysms and low-grade ruptured aneurysms.

• Single-center series of 496 attempted coiling procedures for unruptured aneurysms under local anesthesia:
  • 25.4% of the procedures were either aborted or associated with medical or technical events
Anesthetic considerations: aneurysm rupture

• Signs of rupture:
  • Sudden onset bradycardia or hypertension (due to increased ICP)

• Management:
  • Arterial pressure control
  • Deepening of anesthesia
  • Heparin reversal
Crisis management in the INR suite

- Hemorrhage
- Occlusion
- Vasospasm
Hemorrhage

Management:

• Reversal of heparin (1 mg protamine for each 100 units of heparin given)
• Lowering of the systemic arterial pressure.
• PaCO2 should be maintained between (33.75-37.5 mmHg)
• Mannitol to reduce cerebral edema.
• Packing the defect with coils in cases of aneurysmal perforation
Occlusion

Management:

- BP increase 30-40%> baseline to augment collateral blood flow and maintain normocarbia

- Mechanical lysis of angiographically visible thrombi by a guide wire or local infusion of saline

- ± Direct thrombolysis via tissue plasminogen activator or abciximab

- Endovascular removal of malpositioned coils or catheter
Vasospasm

Management:

- Hypertension + euvoelemia
- SBP target of 160-180 mmHg in secured aneurysms and 140-160 mmHg in unsecured aneurysms.
- Transluminal balloon angioplasty with local intra-arterial injection of verapamil or papaverine to improve perfusion.
Other complications to consider:

- Hemorrhage at puncture site
- Groin hematoma
Thank you!