ANESTHETIC CHOICES FOR THE OCCASIONAL NEUROANESTHESIOLOGIST

Paul D Mongan MD

Outline – Common Questions

• Which anesthetic agent is the best?
• How much blood loss will there be?
• Will there be neuromonitoring?
• What is the ICP?
• Craniotomy – Is there a magic recipe?
• You want me to do what in IR?

IDEAL NEUROANESTHETIC AGENT

• 1. Rapid onset and rapid offset
• 2. Maintains hemodynamic stability
• 3. Does not increase CBF
• 4. Does not alter CSF production or reabsorption
• 5. Decrease ICP
• 6. Maintains CO2 reactivity
• 7. Maintains cerebral autoregulation
• 8. Allows EEG/EP monitoring
• 9. Does not increase cerebral metabolic rate
• 10. Anticonvulsant
• 11. Decrease edema
• 12. “Protects” the brain

Anesthetic Drugs of Interest

• Drugs
• Propofol
• Desflurane
• Sevoflurane
• Fentanyl
• Sufentanil
• Remifentanil
• Dexmedetomidine

Rapid onset and recovery

<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Propofol</th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>Sufentanil</th>
<th>Remifentanil</th>
<th>Dexmedetomidine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+/-</td>
<td>Y</td>
<td>Y</td>
<td>+/-</td>
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</tbody>
</table>

Disclosure

• None

CRASH 2013
Dexmedetomidine infusion at 0.1 – 0.2 μg/kg/hr achieves a tranquil state sufficient to complete neuropsychiatric testing required for mapping of the cortical speech area, as well as to perform an awake tumor resection.

A lack of respiratory depression offers an advantage over other techniques.
Clinical Experience: Carotid Endarterectomy

- A combination of superficial and deep cervical plexus blocks is the most common regional anesthetic technique in the NYU medical center.
- Sedation with dexmedetomidine (0.2-0.4 mcg/kg/hr) offers a comfortable and cooperative patient during the operation.
- Less agitation and respiratory depression than with a continuous infusion of propofol or repeated doses of fentanyl and/or midazolam.

Rapid onset and recovery

<table>
<thead>
<tr>
<th>Propofol</th>
<th>Desflurane</th>
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<th>Sufentanil</th>
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<th>Dex</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/-</td>
<td>Y</td>
<td>Y</td>
<td>+/-</td>
<td>Y</td>
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Does Not Increase CBF

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</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>N</td>
<td>+/-</td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
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</table>

Maintains Autoregulation

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<th>Propofol</th>
<th>Desflurane</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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</tr>
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</table>

Effects of Volatile Agents

- Desflurane
- Sevoflurane
- Isoflurane
- Enflurane
- Halothane

Effects of Subanesthetic Dose of Nitrous Oxide on Cerebral Blood Flow and Metabolism: A Multimodal Magnetic Resonance Imaging Study in Healthy Volunteers

Nitrous oxide in 40% oxygen, but not 40% oxygen alone, significantly increased gray matter cerebral blood flow (22%; P < 0.05) and arterial blood volume (41%; P < 0.05).
Effects of Intravenous Agents

Hemodynamic Stability

Ideal Neuroanesthetic Agent
What’s Important for a Procedure

- What’s the diagnosis and the operation?
- What position?
- **How much blood loss?**
- Do you anticipate any ischemia?
- Will there be neuromonitoring?
- Is the ICP elevated?
- Where will the patient go afterwards?

How much blood loss will there be?

What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- **How much blood loss?**
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## What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- How much blood loss?
- Do you anticipate any ischemia?
- **Will there be neuromonitoring?**
- Is the ICP elevated?
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## Neurophysiologic Monitoring

- Electromyography (EMG)
- Somatosensory (SSEP)
- Motor Evoked Potentials (MEP)
- Brainstem Auditory Evoked Potentials (BAER)

## SSEP

![SSEP Diagram]
Changes in MEP/SSEP

SSEP
- > 50% amplitude
- > 10% latency

MEP
- > 50% amplitude
- Loss of MEP
- Increase in stimulation threshold

Anesthetic Issues
- Anesthetic agents suppress
  - MEPs in patients with Myelopathy:
  - Harder to obtain
  - Greater suppression by anesthesia

Anesthesia

<table>
<thead>
<tr>
<th>SEP</th>
<th>MAC OK</th>
<th>Propofol infusion OK</th>
<th>Narcotic infusion OK</th>
<th>Ketamine OK</th>
<th>Etomidate OK</th>
<th>Dexmedetomidine OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75%</td>
<td>??</td>
<td>??</td>
<td>??</td>
<td>??</td>
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What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- How much blood loss?
- Do you anticipate any ischemia?
- Will there be neuromonitoring?
- Is the ICP elevated?
- Where will the patient go afterwards?
Is the ICP elevated

ICP

It is a change in VOLUME that causes a change in ICP

Reduction of ICP

- Intravenous anesthetics
- Hyperventilation (30-35 mmHg)
- Mannitol (0.5-1.0 gm/kg, 320 mOsm/kg), (hypernatremia, hypokalemia, hypovolemia)
- Hypertonic saline
- Lasix
- CSF drainage
- Avoid hypoxia, hypovolemia
- Head position (venous drainage)
- Increase MAP

Determinants of ICP (What We Can Control)

- Brain tissue
- Intra- and extracellular fluid (edema)
- CSF
- Blood (arterial/venous)
- Airway or intrathoracic pressure
- Jugular venous pressure
- \( P_{CO_2} \)
- \( P_{O_2} \)
- Anesthetics
- Vasodilators
- Seizures
- Temperature
- Arousal
- Pain

Major Constituents of ICP
Head Elevation

- Decrease PaCO2 from 40-25

-Same change in CBV and ICP

- Decrease CVP 3 mmHg

ICP Control

- Mild controlled hypertension
  - MAP maintained around 100 mm Hg in order to decrease CBV and ICP
  - Normovolemia; no vasodilators
  - Together with:
    - Adequate head-up positioning
    - Free venous drainage; no compression of the jugular veins
    - No PEEP, no ventilator fight (myorelaxants)
    - CSF drainage

ICP Control

- Mild hyperosmolality
  - NaCl 0.9% (304 mOsm) as baseline infusion
  - Mannitol (1319 mOsm) 0.5 to 1.0 g/kg
  - Hypertonic saline
    - 23.4% (4000 mEq/L) 30 ml
    - 7.5% (1282 mEq/L) 3 to 5 ml/kg
    - 3% infusion (514 mEq/L) 75ml/hr

Tight Brain

- Hyperventilate (ET CO2 25-30 mmHg)
- Venous drainage (head up, head position)
- Relaxation (Intrathoracic pressure low)
- Mannitol (320 mOsm/kg) (lasix ?, HTS?)
- Propofol bolus
- Delete N2O (if you even tried to use it)
- Turn inhalation agents off (propofol/oxygen)
- Ventilation (oxygenation)
- MAP > 100 mmHg
- CSF drainage

Hypertonic Saline

- 0.9% to 3% to 23.8% NaCl solutions
- Shown to be effective in neurotrauma by shrinking brain and thus reduce ICP
  - can do so and maintain intravascular volume
  - Goal is to increase osmolarity not dehydrate
- May not be effective in stroke
  

Hypertonic Saline - Clinical Approach

- Establish central venous access
- Bolus 30ml to 23.8% NaCl solution
- Initiate therapy with 3% saline at 75 cc/hr (or higher if requiring fluid resuscitation)
  - use 50% chloride/50% acetate to minimize risk of hyperchloremia
- Infuse to a goal Na (ex. 145-150)
- Check serum Na frequently (q 4-6 hrs)
  - “ballpark” serum osm will be double serum Na
Craniotomy Basics

- **Induction**
  - Prevent coughing
  - Prevent hypertension
- **Maintenance**
  - Position
  - Brain bulk management
  - Cerebral perfusion pressure (CPP 60-70 mmHg)
  - Glucose management
  - Fluid management
- **Emergence**
  - Prevent/minimize coughing
  - Prevent hypertension
  - Neuro exam capacity
    - Delayed awakening >30 min may result into a trip to CT scanner.

Preop

- One IV
- Premedicate with up to 2 mg of midazolam if normal mental status.
- No premed if altered mental status/risk of increased ICP

Induction

- Routine monitors
- Propofol 1-1.5mg/kg
- Fentanyl 3-5 ug/kg in divided doses prior to intubation
- Muscle relaxant (rocuronium or vecuronium).
- Hyperventilate spontaneously prior to induction if ICP high. Mild hyperventilation immediately after induction.
- More drugs for pinning

Anesthetics

- Intravenous anesthetics (not ketamine) are cerebral vasoconstrictors
  - Reduce CMR
  - CO₂ reactivity intact
- Volatile anesthetics are cerebral vasodilators
  - Increase ICP
  - Reduce CMR
  - CO₂ reactivity intact (offsets ICP increases)

Procedures and Adjuncts

- 4-10 mg decadron, 0.5-1 gm/kg mannitol, +/ lasix
- levetiracetam 1gm (Koppra)
- Tape eyes with tegaderms (prep solution)
- Temp probe, foley
- A-line (ABG, CPP)
- Additional IV (limited access, 300 cc blood loss)
- Bair Hugger
- Compression stockings
Positioning

- Complications:
  - Ventilatory & Hemodynamic Changes
  - Loss of Airway, Monitors, Catheters
  - Venous Air Embolism
  - Injury to Eyes, Nose, Ear
  - Injury to Neurovascular Bundle

Maintenance

- Control CMR, CBF
- Good depth of anesthesia
  - Volatile (0.5-0.75 MAC) (too much-slow awakening, brain swelling)
- Narcotics
  - Fentanyl infusion (2ug/kg/hr) (too much slow awakening)
  - Fentanyl 500-750 mcg total
  - Remifentanil infusion 0.15-0.1 mcg/kg/min
  - Dexmedetomidine 0.4-7 mcg/kg/hr
- Muscle relaxation (vecuronium, rocuronium)
- Adequate CPP (MAP > 90mmHg)
- Mild hyperventilation (ETCO2 30-35 mmHg)
- Aim for rapid awakening

Awakening

- Neurosurgical awakening should avoid:
  - Coughing (opioids/dexmedetomidine)
  - Attenuate stress response (autoregulation impaired/labetalol, opioids/dexmedetomidine)
  - Tracheal suctioning
  - Airway overpressure during extubation
  - Hypercarbia, hypoxia (opioids)
- Neurosurgical awakening should provide:
  - Optimal conditions for neurologic examination (opioids, CT)

Recovery

- Wake patient up as soon as possible
- Extubate if possible
- Prevent post op hypertension (bleed)
  - Labetalol, pain control
- Transport to ICU with monitor and oxygen
- Head up position
- Pain Management

Potential Complications

- Postop seizures
- Delayed awakening from anesthesia
- Intracranial bleeding
- Brain swelling

Neuroendovascular Procedures

- Brain aneurysm coiling
- Carotid artery stenting
- Intracranial stent placement
- Clot-dissolving drugs
- Clot removal
- Embolization for arteriovenous malformation (AVM)
- Tumor embolization
Neuroendovascular Concerns

- Maintain Physiological Stability
- Manage Anticoagulation
- Manipulate Systemic or Regional Blood Pressures
- Treat Unexpected Complications
  - ICP
  - Bleed
- Rapid Recovery (neuro evaluation)

Disasters

- Vasospasm
- Occlusion
- Dissection
- Thromboembolism
- Stent misplacement
- Vessel rupture and hemorrhage
- Access site hematoma
- Arrhythmia
- Death

Room Size

- General surgical procedure rooms
  - commonly sized at 500 to 650 sf
- Cardiothoracic surgery procedure rooms
  - typically 650 to 800 sf
- Interventional radiography (angiography) and cardiology (catheterization and electrophysiology labs)
  - commonly sized at 500 to 650 sf
- Hybrid procedure rooms
  - designed to accommodate (a) open procedures, (b) closed procedures, and/or (c) hybrid open and closed procedures
  - frequently sized within a range of 800 to 1000 sf, or even larger.

CEA vs. BMT

<table>
<thead>
<tr>
<th>Trial</th>
<th>Ipsilateral stroke, periop stroke, death</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CEA</td>
</tr>
<tr>
<td>Nascet 70-99% (1991)</td>
<td>9%</td>
</tr>
<tr>
<td>ECST 70-99% (1991)</td>
<td>9.5%</td>
</tr>
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</table>

Asymptomatic Carotid Atherosclerosis Study

- 1662 patients, 60-99% stenosis
- 1993-2002 with 10 year follow-up
- BMT vs BMT + CEA
- Study stopped after 2.7 years of follow-up
  - Ipsilateral stoke (5 year projected rate)
    - CEA vs BMT 5.1%
    - BMT 11%
### GALA TRIAL

<table>
<thead>
<tr>
<th></th>
<th>General 1752</th>
<th>Local 1771</th>
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<tbody>
<tr>
<td>Stroke</td>
<td>70 (4.0%)</td>
<td>66 (3.7%)</td>
</tr>
<tr>
<td>fatal</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>non-fatal</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Modified Rankin 6 months after stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2</td>
<td>41</td>
<td>40</td>
</tr>
<tr>
<td>3-5</td>
<td>14</td>
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<tr>
<td>dead</td>
<td>15</td>
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GALA Trial Lancet, 2008: 372-2132

### CEA vs Carotid Artery Stent

### Specialties Performing Carotid Stenting

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Percent</th>
</tr>
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<tbody>
<tr>
<td>Interventional Cardiologist</td>
<td>60</td>
</tr>
<tr>
<td>Interventional Radiologist</td>
<td>15</td>
</tr>
<tr>
<td>Interventional Neuroradiologist</td>
<td>10</td>
</tr>
<tr>
<td>Interventional Neursurgery</td>
<td>5</td>
</tr>
<tr>
<td>Interventional Vascular Surgery</td>
<td>5</td>
</tr>
<tr>
<td>Interventional Neurology</td>
<td>2</td>
</tr>
<tr>
<td>Interventional Medicine</td>
<td>3</td>
</tr>
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### Anesthesia for CAS

- Minimal to moderate sedation
  - Propofol infusion
  - Dexmedetomidine infusion
- ACT monitoring
- Balloon dilation
  - Neck pain, cough
  - Bradycardia (25%)
  - Labile BP (20-50%)

### Questions???