Major Aortic Reconstruction; Cerebral protection and Monitoring

NATHAEN WEITZEL MD
ASSOCIATE PROFESSOR OF ANESTHESIOLOGY
UNIVERSITY OF COLORADO SCHOOL OF MEDICINE
Disclosures

• None
Roadmap:

- Basic Definitions Stroke / NCD / Anatomy
- Discuss neurophysiologic monitors of brain
- Discuss Anesthetic and Pharmacologic approaches to brain protection
- TAAA vs Arch operations - New Tech advances
- Surgical and perfusion planning and management
What are Stroke and Neurocognitive Dysfunction?

- **Stroke**
  - Refers to an ischemic, embolic or hemorrhagic event leading to cell death
  - Can be diagnosed clinically or radiologically and manifests with neurologic deficits

- **Neurocognitive Dysfunction (NCD)**
  - A broad umbrella of symptoms that vary in severity
  - Involves impairment in concentration, information processing, visuospatial organization
  - Doesn’t always meet criteria to be considered a “neurologic injury” or stroke
  - Thought to have >80% incidence in Cardiac Surgery

Why is NCD difficult to study?

NCD is often present at varying time periods following cardiac surgery, complicating accurate diagnosis and determination of causality.
Risk Factors for Neurocognitive Dysfunction

• Advanced age***
• Prior neurologic events or chronic illness
• Non-coronary atherosclerosis
  • Aortic atherosclerosis, cerebral vascular disease, peripheral vascular disease, diabetes
• HTN
Incidence of Stroke and Neurocognitive Dysfunction in Aortic Surgery

• Observational study in 2003 observed 369 patients undergoing ascending aorta and arch repair
  • 5% incidence of stroke
  • 15% incidence of “transient neurologic injury”

• Observational study in 2005 observed 470 patients undergoing complete arch replacement
  • Circulatory arrest with either retrograde perfusion or antegrade cerebral perfusion was used
    • 4.9% incidence of stroke within 30 days
    • 6% incidence of stroke after 30 days

The Brain is Supplied from the Aortic Arch

- Right common carotid
- Right subclavian
- Brachiocephalic
- Left common carotid
- Left subclavian
Bovine Arch
Neurophysiologic Monitoring Modalities

- Electroencephalography (EEG)
- Near Infrared spectroscopy (NIRS)
EEG

• First recorded in 1924 by Berger

• EEG reflects metabolic activity in the cortical neurons related to synaptic function
  - Thus serves as a global marker of cerebral blood flow – or reduction in blood flow.

• Burst Suppression reflects near maximal neuronal suppression

• Temperature / Pharmacologic agents affect EEG
EEG during CPB

Deep anesthesia
- Tall wide waves, mix of slow and fast frequency

Early hypothermia
- Wide waves, slower frequency, smaller size

Burst Suppression
- wide, tall, low frequency and suppression

36 degrees
31 degrees
24 degrees
EEG during CPB

Deep Hypothermia

- No EEG Activity – Maximal reduction in CMRO2

Near normothermia with anesthesia

- wide, mid frequency, symmetric

Baseline
Anesthetic Agents all Impact EEG

- Propofol
- Thiopental
- Volatile Agents (Iso, Sevo, Des)
- Benzodiazepines
- Ketamine
- Etomidate
- Nitrous Oxide

All reduce Amplitude and frequency – resulting in burst suppression

Cause EEG even seizures

Opioids result in decrease frequency but maintained amplitude – Thus are neutral agents
Brain Protection: Hypothermia

Safe limit of Hypothermic Cardiac Arrest?

Near Infrared Spectroscopy

Reflection $O_2$ supply-demand balance

Normal (awake) 57-87%
- < 50% abnormal
- 20% reduction accepted as $O_2$ failure

Taillefer Can J Anesth 52:1 2005
Tan Hong Kong Med J 14:220 2008

Latronico et.al., Neurosurg 46:1131, 2000
Normal NIRS tracing  - DHCA
Abnormal Tracing

On CPB
Cool to 25°C
Hard Cooling
DHCA
Full CPB

Average SctO₂

MAP

Core Temperature

Time

SctO₂ %

Temperature °C and MAP mmHg

10:30 11:30 12:00 12:30 13:00 13:30 14:00 14:30 15:00 15:30 16:00

Semin Cardiothorac Vasc Anesth 2008;12:60-9
Conclusions:

- 13 case reports, 27 observational studies, 2 PRCTs
- Reductions in rSCO$_2$ during cardiac surgery may identify cardiopulmonary bypass cannula malposition, particularly during aortic surgery
- Low level evidence linking rSCO$_2$ to NCD
- Insufficient data to conclude that interventions aimed at improving decreased rSCO$_2$ prevents stroke or NCD.
- Anesth Analg 2013;116:663-76
NIRS vs. EEG:

- EEG ideal for seizure activity
- Hypothermia induced isolectric point indicates adequate cooling
- NIRS more sensitive to cerebral oxygen levels, thus likely better tool for cerebral hypoxia

Factors related to inadequate Cerebral Oxygenation:
- Hg Concentration
- Flow Rate
- PaCO2 (>40mmHg)

Interventions:
- Checking head position
- Pre-bypass PaCO₂ > 40mmHg
- ABG management – pH Stat during cooling and α–Stat for remainder
- MAP > 50mm Hg during CPB
Switching Gears
Thoracoabdominal Surgery
Aortic Arch Operations
<table>
<thead>
<tr>
<th>Table 2. Approved On-Label Indications in the United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic aortic aneurysm: all approved stent-grafts</td>
</tr>
<tr>
<td>Penetrating atherosclerotic ulcer: TX2, Valiant, Relay</td>
</tr>
<tr>
<td>Blunt thoracic aortic injury: C-TAG, Valiant</td>
</tr>
<tr>
<td>Type B aortic dissection: C-TAG</td>
</tr>
</tbody>
</table>
Figure 4. Cook’s investigational multibranched endograft for arch repair.
UCH Arch Planning

- Arch Light (26 °C with SACP)
  - Ascendings all get Hemiarch
    - 15 minutes of HCA or less

- Arch Heavy (EEG Silence or 22°C with SACP)
  - More than one mosis with many variations
    - Full arch aneurysm - individually sewn
      - carotid-subclavian bypass
    - Normal tissue - island technique
    - Type A Dissections
Anesthetic Monitoring – Aortic Arch Surgery

- Standard ASA monitors (ECG, SPO₂, O₂ / CO₂, Temp, BP)
- Invasive BP monitors – Radial Arterial Line, Central line, PAC*
- TEE
  - Critical for global heart assessment, volume status, confirmation of catheter placement and post bypass management
- NIRS
- EEG
Anesthetic Management: DHCA

• Local / Topical cooling ➔ Pack head in Ice – must protect Eyes
  • Some debate as to the actual utility of this due to limited transmittance of temperature to cerebral tissue
  • Cold perfusion for adequate time (>45 min) probably key

• Pharmacologic Protection
<table>
<thead>
<tr>
<th>Agent</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbituates</td>
<td>Reducing CMRO2, CBF, free fatty acids, free radicals, and cerebral edema.</td>
</tr>
<tr>
<td>Steroids</td>
<td>Decreasing pro-inflammatory response</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Reducing cerebral edema, scavenging free radicals, protecting the kidneys</td>
</tr>
<tr>
<td>Furosemide</td>
<td>Blocking renal reabsorption of sodium</td>
</tr>
<tr>
<td>Insulin</td>
<td>Controlling hyperglycemia, preventing intracellular acidosis</td>
</tr>
<tr>
<td>Calcium Channel Blockers</td>
<td>Blockade of voltage-sensitive and NMDA-activated neuronal Ca+ channels</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Ca+ Channel blocker – protective effect also tied to reduction in cerebral vasospasm</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Selective blockade of Na channels in neuronal membranes, reducing CMRO2</td>
</tr>
<tr>
<td>Dexmedetomidine</td>
<td>Inhibition of ischemia-induced norepinephrine release, protective in both focal and global ischemia</td>
</tr>
<tr>
<td>B-Blocker</td>
<td>Decreasing inflammatory response</td>
</tr>
</tbody>
</table>
## What do we employ at UCH?

<table>
<thead>
<tr>
<th>Drug</th>
<th>Effect and Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin</td>
<td>Controlling hyperglycemia, preventing intracellular acidosis</td>
</tr>
<tr>
<td>Steroids</td>
<td>Decreasing pro-inflammatory response</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Ca+ Channel blocker – protective effect also tied to reduction in cerebral vasospasm</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Selective blockade of Na channels in neuronal membranes, reducing CMRO₂</td>
</tr>
</tbody>
</table>

Perfusion Based Interventions
Antegrade Cerebral Perfusion (ACP)


- Moderate hypothermia (22-25°C)
- EEG silence
- Low cerebral temperature (6-10°C)
- Reduced morbidity
  - TND 5.5% v. 13.2% (33.3 % for DHCA alone)
- Reduced Mortality
  - 5.5% v. 15.8%
Axillary Cannulation

- Higher line pressure
- Increased blood loss
- Decreased thromboembolic incidence
Innominate Cannulation

- Lower arterial line resistance
- Reduced blood loss
  - All loss in chest
  - Available to pump suckers
- Higher thromboembolic incidence
Case Study # 1

- 61 y female, 6+ cm ascending aortic aneurysm
- Elective hemiarch replacement
- Target temperature 28°C
- Mild aortic insufficiency
  - Aortic root repair
Case Study #1

- Arterial and venous blood temperature
- Even gradients
- Long (45 minutes) cooling

- Red = Art Blood Flow
- Black = MAP
Case Study
Baseline
Channel 1 L (grey), Channel 2 R (blue)

Incision 36.0 C, 112/59, Iso 1.5%

At cannulation – notice a drop in one channel of the Invos monitor. Alerted to possibility of inadequate flow

Cannulation
Case Study

32.4°C
Early CPB, Cooling, pH Stat
pH = 7.36, pCO2 = 37

- Look for symmetry in both EEG and NIRS.
- Note burst suppression
Case Study

28 C
Neuroprotection: Solumedrol, Lidocaine, MgSO4 Mannitol

- Widening R-L NIRS delta
- Lower MAP
- Not isoelectric at 28C
Case Study
27.2°C Isoelectric > 5 min
SCAP 2L/min MAP = 47 mmHg
Case Study
Reperfusion 5 minutes
Slow rewarm while proximal graft and aortic root complete
Note: Improved symmetry
Case Study
Terminate CPB @ 36.1 Bladder
Closing 35.7C
CPB = 104 min.
XC = 43 min.
CA = 9 min.
Pre-EEG

Post-EEG
Arch Surgery – concluding thoughts

• DHCA induces extreme physiology that must be anticipated and monitored.

• NIRS represents great monitor for focal oxygenation

• Pharmacologic therapy is a useful adjunct. However this pales in comparison to the utility of adequate cooling via CPB machine, and provision of ante-grade cerebral blood flow.

• Unique approaches combine new technology for surgeons, perfusion and anesthesia to improve outcomes.