Current strategies to prevent spinal cord ischemia in TAAA repair

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Disclosures

- Proctor for COOK Medical
Blood supply spinal cord

Arteries of Spinal Cord (continued)

- Posterior spinal aa.
- Anterior spinal a.
- Anterior radicular a.
- Posterior radicular aa.
- Branch to vertebral body and dura mater
- Spinal branch
- Dorsal ramus of posterior intercostal a.
- Posterior intercostal aa.
- Paravertebral anastomosis
- Prevertebral anastomosis
- Aorta

Section through thoracic spine

Adamkiewicz artery

\[ \varnothing \ 0.5 - 1.2 \text{ mm} \]

- T5 - T8  \ 25%  
- T9 - L2  \ 75%  
- Left side  \ 75%
Collateral Network Theory
Strategies to prevent SCI

• Selection of Patients
  – Aneurysm
  – Spinal cord circulation

• Operative Strategies

• Postoperative Strategies
# Cleveland Clinic Experience

<table>
<thead>
<tr>
<th>Extent</th>
<th>Repair Technique</th>
<th>n</th>
<th>n</th>
<th>%*</th>
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<th>%</th>
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<tbody>
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<td>ER</td>
<td>163</td>
<td>8</td>
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<tr>
<td>III</td>
<td>ER</td>
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<td>SR</td>
<td>62</td>
<td>8</td>
<td>12</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>IV</td>
<td>ER</td>
<td>69</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<td>SR</td>
<td>64</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>All</td>
<td>ER</td>
<td>352</td>
<td>20</td>
<td>6</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>372</td>
<td>31</td>
<td>7</td>
<td>28</td>
<td>8</td>
</tr>
</tbody>
</table>

ER: sicker, older, more prior Ao repair
Post-dissection vs Degenerative TAAA

No collaterals (n=24)
SCI in 12%

Collaterals (n=31)
SCI in 0%

Strategies to prevent SCI

- Selection of Patients
  - Aneurysm
  - Spinal cord circulation

- Operative Strategies

- Postoperative Strategies
Comparison of magnetic resonance with computed tomography angiography for preoperative localization of the Adamkiewicz artery in thoracoabdominal aortic aneurysm patients

Robbert J. Nijenhuis, MD, a,b Michael J. Jacobs, MD, PhD, b Karolien Jaspers, MSc, a Marieke Reijnders, MSc, a Jos M. A. van Engelshoven, MD, PhD, a Tim Leiner, MD, PhD, a and Walter H. Backes, PhD, a Maastricht, The Netherlands
# Results

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>X-clamping SA-AKA</th>
<th>Decline of MEPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 patients (100%)</td>
<td>44 patients (73%)</td>
<td>14 patients (32%) YES</td>
</tr>
<tr>
<td>NO</td>
<td>16 patients (27%)</td>
<td>30 patients (68%) NO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 patients (0%) YES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 patients (100%) NO</td>
</tr>
</tbody>
</table>

Decline of MEPs:
- 14 patients (32%) YES
- 30 patients (68%) NO
- 0 patients (0%) YES
- 16 patients (100%) NO
Strategies to prevent SCI

- Selection of Patients
- **Operative Strategies**
  - CSF drainage
  - Cooling
  - SA artery reattachment/distal aortic perfusion
  - Spinal cord function monitoring
  - Staged repair
- Postoperative Strategies
Strategies to prevent SCI

- **Selection of Patients**

- **Operative Strategies**
  - CSF drainage
  - Cooling
  - SA artery reattachment/distal aortic perfusion
  - Spinal cord function monitoring
  - Staged repair

- **Postoperative Strategies**
Strategies to prevent SCI

- **Selection of Patients**
- **Operative Strategies**
  - CSF drainage
  - Cooling
  - SA artery reattachment/distal aortic perfusion
  - Spinal cord function monitoring
  - Staged repair
- **Postoperative Strategies**
cross-clamping entire aorta

MEP amplitudes [mV]

right ant.tib.m.
left ant.tib.m.
right abd.poll.br.
left abd.poll.br.
cross-clamping entire aorta
Perfusion of reimplantated segmental arteries

Maastricht UMC+
Strategies to prevent SCI

• Selection of Patients

• Operative Strategies
  – CSF drainage
  – Cooling
  – SA artery reattachment/distal aortic perfusion
  – Spinal cord function monitoring
  – Staged repair

• Postoperative Strategies
### Staged repair in Open TAAA

Comparison of single-stage and 2-stage repair in terms of hospital mortality and spinal cord injury:

<table>
<thead>
<tr>
<th></th>
<th>Single-stage procedure</th>
<th>2-stage procedure</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital mortality</td>
<td>10 (11%)</td>
<td>6 (11%)</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>8 (9%)</td>
<td>8 (15%)</td>
<td>0</td>
</tr>
</tbody>
</table>

*At 5 years*
Staged repair in EndoTAAA

- Staging TEVAR implantation
- Creating type III endoleak
  - Sac perfusion branch
  - Leaving branch open
  - Stent between SG components
  - Don’t connect iliac limb
# Staged repair in EndoTAAA

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total (N = 87), No. (%)</th>
<th>Single-stage repair (n = 32), No. (%)</th>
<th>Two-stage repair (n = 27), No. (%)</th>
<th>Unintentionally staged repair (n = 28), No. (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCI</td>
<td>19 (21.8)</td>
<td>12 (37.5)</td>
<td>3 (11.1)</td>
<td>4 (14.3)</td>
<td>.025&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time to development of SCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>None</td>
<td>68 (78.2)</td>
<td>20 (62.5)</td>
<td>24 (88.9)</td>
<td>24 (85.7)</td>
<td>.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Immediate</td>
<td>9 (10.3)</td>
<td>5 (15.6)</td>
<td>2 (7.4)</td>
<td>2 (7.1)</td>
<td></td>
</tr>
<tr>
<td>Delayed</td>
<td>10 (11.5)</td>
<td>7 (21.9)</td>
<td>1 (3.7)</td>
<td>2 (7.1)</td>
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<tr>
<td>Duration of SCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.033&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>None</td>
<td>68 (78.2)</td>
<td>20 (62.5)</td>
<td>24 (88.9)</td>
<td>24 (85.7)</td>
<td>.033&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Improved</td>
<td>11 (12.6)</td>
<td>7 (21.9)</td>
<td>3 (11.1)</td>
<td>1 (3.6)</td>
<td></td>
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<tr>
<td>Permanent</td>
<td>8 (9.2)</td>
<td>5 (15.6)</td>
<td>0 (0.0)</td>
<td>3 (10.7)</td>
<td></td>
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<tr>
<td>SCI severity score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.025&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>None</td>
<td>68 (78.2)</td>
<td>20 (62.5)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24 (88.9)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>24 (85.7)</td>
<td>.025&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weakness</td>
<td>8 (9.2)</td>
<td>5 (15.6)</td>
<td>2 (7.4)</td>
<td>1 (3.6)</td>
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<tr>
<td>No antigravity</td>
<td>2 (2.3)</td>
<td>0 (0.0)</td>
<td>1 (3.7)</td>
<td>1 (3.6)</td>
<td></td>
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<tr>
<td>Complete paralysis</td>
<td>9 (10.3)</td>
<td>7 (21.9)</td>
<td>0 (0.0)</td>
<td>2 (7.1)</td>
<td></td>
</tr>
</tbody>
</table>

two-stage, and unintentionally staged repairs was 18.8%, 0.8, and 18.8%, respectively.  

**Conclusions:** Staged repair appears both to protect against SCI and to enhance overall survival in extensive aortic repair. (J Vasc Surg 2015;61:347-54.)
Staged repair in EndoTAAA

- Staging TEVAR implantation

- Creating type III endoleak
  - Sac perfusion branch
  - Leaving branch open
  - Stent between SG components
  - Don’t connect iliac limb
Staged repair in EndoTAAA

Editor’s Choice — Temporary Aneurysm Sac Perfusion as an Adjunct for Prevention of Spinal Cord Ischemia After Branched Endovascular Repair of Thoracoabdominal Aneurysms

P.M. Kasprzak *, K. Gallis, B. Cucuruz, K. Pfister, M. Janotta, R. Kopp

Department of Surgery, Vascular and Endovascular Surgery, University Hospital, University of Regensburg, Franz-Josef-Strauss-Allee 11, 93053 Regensburg, Germany

<table>
<thead>
<tr>
<th>Sac perfusion (n=40)</th>
<th>No Sac Perfusion (n=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. paraparesis</td>
<td>13%</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>5%</td>
</tr>
</tbody>
</table>

Staged repair in EndoTAAA

- General:
  - CSF drainage
  - BP management
  - Preserve LSA and HA perfusion

- Since June 2012
  - Staging by only TEVAR first (type II TAAA)

B/FEVAR:

- Spinal cord function monitoring (MEP)
- Last branch: 15 min balloon occlusion
- Decision to leave branch open (MEP >50%)

Can we identify patients at risk?
electrical stimulation
500 V; ~1.2 A, 5 serial stimuli

SCI ischemia

Peripheral ischemia

MEP response
abd. poll. brevis muscle

MEP response
tibialis anterior muscle
MEPS @ Crawford extent 2 endo
TAAA repair with multivessel BEVAR

Peripheral ischemia Right Leg

Spinal Cord Ischemia

Peripheral ischemia Right Leg
Spinal Cord Ischemia

MEP amplitude [mV]

Time

Maastricht UMC+
Pitfall

- MEPs 100% @ branch test
- 4 branches connected
- Completion angio: endoleak
- Delayed paraparesis
- Cta: thrombosis endoleak
Staged repair in EndoTAAA

• General:
  – CSF drainage
  – BP management
  – Preserve LSA and HA perfusion

• Since June 2012
  – Staging by only TEVAR first (type II TAAA)
  – B/FEVAR:
    • Spinal cord function monitoring (MEP)
    • Last branch: 15 min balloon occlusion
    • Decision to leave branch open
      – MEP >50%
      – Endoleak on angiography
      – Aneurysms Sac Pressure
Revised Protocol

Results

• 28 patients
• 30-day mort: 3.5%
• SCI: 7% (partial; reversible): both walking again

64% (18 pts) NO “open branch” staging:
  * 5% (1 pt) SCI

36% (10 pts) “open branch” staging:
  * 10% (1 pt) SCI
Strategies to prevent SCI

• Selection of Patients

• Operative Strategies

• Postoperative Strategies
  – Hemodynamic situation (BP; Hb; CVP)
  – CSF drainage
Conclusions

- Paraplegia is still the most disabling complication in treatment of TAAA
- Several pre-intra–postoperative strategies are available to decrease SCI
  - Staging is the most promising both in open and endo repair
  - MEPs are important for decision making in open repair
  - MEPs in combination with sac pressurements and angiography help to select patients how need staging in endo repair.