Carotid Stenting with Flow Reversal

Marc Schermerhorn, MD
Division of Vascular and Endovascular Surgery
Beth Israel Deaconess Medical Center
Harvard Medical School
Boston, MA

Limitations of Other Embolic Protection Devices - Filters

- Must cross lesion unprotected
- Porosity of filter will allow passage of small particles
- Small particles (<100 micron) may cause infarct
  - Rapp et al. Stroke 2003
- Apposition of filter may be incomplete
- Filter may be overwhelmed by large embolic load
- Occlusion
- Embolization during attempt at recapture

Limitations of Distal Occlusion

- Must cross lesion unprotected
- Emboli may travel through ECA collaterals to intracerebral circulation
- Aspiration catheter may not allow capture of large particles
- Poor visualization of lesion during occlusion

Limitations of Current Embolic Protection

- Both Filters and Distal Occlusion
- Potential for damage to distal ICA
  - Dissection
  - Spasm
Flow Reversal System Components

- Balloon Sheath & Dilator
- Balloon Wire
- External Filter

REVERSE FLOW TECHNIQUE
Why Use Embolic Protection?

Goal in treatment of carotid stenosis is to prevent stroke (embolization)
Perioperative embolic protection logical (if it works)
**How do we know if it works?**

**CVA / Death Rates**
  - 1.8% w/ protection
  - 5.5% without
  - 2.2% w/ protection
  - 5.3% without
  - Asymptomatic: 1.8% vs 4.0%
  - Symptomatic: 2.7% vs 6.0%
- EVA 3S NEJM 2006;355:1660-71
  - 8% w/ protection
  - 25% without

**Surrogate Measures of Effectiveness**

**Diffusion Weighted MRI**
- Damaged Brain
  - Most neurologic exams may miss subtle deficits
  - Presence and # predict clinical stroke
  - Correlates with dementia and decline in cognitive function (Vermeer et al. NEJM 2003)

**DWI Detected Brain Lesions after CAS With and Without Embolic Protection**

*Kastrup et al. Stroke 2006 (n=206)*
- 49% w/ protection
- 67% w/o protection

**DWI Comparison of Distal Occlusion and Filter**

*Kim et al. Korean J Radiol 2007 (n=72)*
- 39.4% with distal occlusion balloon
- 39.5% with filter
**Distal occlusion of ICA vs Occlusion of both ICA and ECA**

*Asakura et al Neuroradiology 2006 (n=45)*

New DWI lesions
- 55% Distal occlusion of ICA alone
- 36% Distal occlusion of ICA and ECA
- p<0.01
- 11.5% Diagnostic angiography

**DWI lesions with CEA vs CAS**

<table>
<thead>
<tr>
<th></th>
<th>CEA</th>
<th>CAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poppert et al J Neurol 2004 (n=129)</td>
<td>17%</td>
<td>54%</td>
</tr>
<tr>
<td>Flach et al J Endovasc Ther 2004 (n=44)</td>
<td>9%</td>
<td>43%</td>
</tr>
<tr>
<td>Roh et al AJNR 2005 (n=44)</td>
<td>4%</td>
<td>36%</td>
</tr>
<tr>
<td>Tedesco et al JVS 2007 (n=69)</td>
<td>0%</td>
<td>70%</td>
</tr>
</tbody>
</table>

**DWI after CAS with Flow Reversal vs Diagnostic Cerebral Angio**

*Asakura et al AJNR 2006*

- CAS w/ Flow Reversal (n=11) 18%
- Diagnostic Angio (n=26) 11%
- p=.6

**TCD Detected Embolization with CAS**

*Al-Mubarak et al circ 2001 (n=76)*

<table>
<thead>
<tr>
<th></th>
<th>Filler</th>
<th>Unprotected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath placement</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Wiring</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>Predilation</td>
<td>12</td>
<td>32*</td>
</tr>
<tr>
<td>Stenting</td>
<td>17</td>
<td>75*</td>
</tr>
<tr>
<td>Postdilation</td>
<td>5</td>
<td>27*</td>
</tr>
<tr>
<td>TOTAL</td>
<td>68</td>
<td>164*</td>
</tr>
</tbody>
</table>

*p<0.01*
TCD Filter vs Proximal Occlusion w/ Flow Arrest

Schmidt et al JACC 2004 (n=42)

<table>
<thead>
<tr>
<th></th>
<th>Filter Group</th>
<th>MO.MA Group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheath placement/position</td>
<td>20 ± 15</td>
<td>18 ± 10</td>
<td>NS</td>
</tr>
<tr>
<td>device placement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing of the stent</td>
<td>25 ± 33</td>
<td>3 ± 3</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Stent deployment</td>
<td>73 ± 49</td>
<td>11 ± 19</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Balloon dilation</td>
<td>79 ± 31</td>
<td>12 ± 21</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Retrieval of the protection</td>
<td>14 ± 15</td>
<td>19 ± 15</td>
<td>NS</td>
</tr>
<tr>
<td>device</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>196 ± 84</td>
<td>57 ± 41</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Flow Arrest Trials – Stroke / Death

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>CVA/Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coppi et al J Card Surg 2005</td>
<td>416</td>
<td>4.6%</td>
</tr>
<tr>
<td>Reimers et al J Endo Ther 2005</td>
<td>157</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

Flow Reversal
Clinical Outcomes
Stroke / Death

Adami et al J Endovasc Ther 2002 (n=28) 0%
Parodi et al JVS 2005 (n=100) 3%
Rabe et al J Interven Cardiol 2006 (n=56) 1.8%
Grunwald et al Neuroradiology 2007 (n=36) 2.7%
Parodi et al J Cardiovasc Surg 2007 (n=200) 1.5%

EMPiRE
Carotid Stenting with Flow Reversal
Patient Demographics

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>245</td>
<td></td>
</tr>
<tr>
<td>Age (mean, range)</td>
<td>70</td>
<td>(46-89)</td>
</tr>
<tr>
<td>Male</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>Octogenarian</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Symptomatic</td>
<td>32%</td>
<td></td>
</tr>
</tbody>
</table>
EMPiRE - Flow Reversal System
Procedure Outcomes

(N=245)  Mean  (Min, Max)

Procedure Time (minutes)  80  (25, 345)
Flow Reversal Time (minutes)  15  (2, 56)
Fluoroscopy Time (minutes)  20  (6, 164)
Hospital Days  1  (0, 24)

EMPiRE - Flow Reversal System
Procedure Technical Results

96.3% Flow Reversal System Success  (n=236)

3.7% Flow Reversal System Technical Failure  (n=9)
  Unable to tolerate flow reversal  (n=3)
  Balloon sheath rupture  (n=2)
  Tortuous anatomy  (n=2)
  Unable to position device  (n=2)

99.2% Carotid Stent Success  (n=243)
  i.e. tech failure does not preclude success

EMPiRE—Flow Reversal Intolerance

Intolerance reported in 6 (2.4%) subjects
  Flow Reversal successfully used in 3/6
  Flow Reversal discontinued in 3/6

No permanent neurological deficits—intolerance resolved when balloons deflated
Intolerance of Flow Reversal?

Rare
Limited by avoidance of hypotension & bradycardia
- Glycopyrrolate
- Atropine
- “Seatbelt and Airbag” technique

EMPiRE Adverse Events

- Groin Hematoma: 3.7%
- Anemia: 4.1%
- Arrhythmia: 4.9%
- Hypertension: 4.9%
- Hypotension: 16.7%

% of Subjects Experiencing Event (N=245)

Avoid Isolated Hemisphere

Stroke Death MI

- Stroke / Death: 2.9%
- Stroke / Death / MI: 3.7%
- Death / Major Stroke: 0.8%
- Minor Stroke: 2.0%
30-day Stroke / Death / MI in High Risk U.S. Carotid Stent Registries

SAPPHIRE | ARCHER 2 | SECURITY | MAVERIC-2 | BEACH | CABERNET | EMPiRE | EPIC
---|---|---|---|---|---|---|---
7.8% | 8.2% | 7.5% | 5.3% | 5.4% | 3.8% | 3.7% | 3.0%

EMPiRE Major Adverse Event Rates by Subgroup
(Stroke, Death, MI)

- Octogenarians (n=38)
  - 2.6%
- Symptomatic (n=78)
  - 3.8%
- Asymptomatic (n=167)
  - 3.6%

% of Subjects in Subgroup with MAE

- Octogenarians (n=38)
- Symptomatic (n=78)
- Asymptomatic (n=167)

Trans-Cervical Carotid Stenting with Flow Reversal
### Trans-Cervical Carotid Stenting with Flow Reversal

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Sample Size</th>
<th>Stroke/Death Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang et al</td>
<td>JVS 2004</td>
<td>21</td>
<td>0%</td>
</tr>
<tr>
<td>Criado et al</td>
<td>JVS 2004</td>
<td>50</td>
<td>0%</td>
</tr>
<tr>
<td>Criado et al</td>
<td>JVS 2007</td>
<td>100</td>
<td>2%</td>
</tr>
<tr>
<td>Matas et al</td>
<td>JVS 2007</td>
<td>62</td>
<td>3.2%</td>
</tr>
<tr>
<td>Alvarez et al</td>
<td>JVS 2008</td>
<td>36</td>
<td>0%</td>
</tr>
</tbody>
</table>

### Flow Reversal the New Gold Standard

- Different approach to embolic protection
- Overcomes major flaws of prior devices
- DWI rates comparable to diagnostic angiography
- Stroke and Death rate compares favorably to other embolic protection systems and CEA
- Easy to master
- 9Fr arterial access, venous access
- Device of choice for majority of patients
- Transcervical approach for difficult access