Thoracic EndoVascular Aortic Repair (TEVAR and Hybrids): Critical Care Special Considerations

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Disclosures

Conflicts

- **Medtronic**: Consultant; Primary Investigator Talent Trial; Primary Investigator Valiant Trial

- **W.L. Gore**: Consultant; Primary Investigator TAG Trial; FDA PMA submission; Primary Investigator High Risk Trial

- **Cook Medical**: Consultant; Primary Investigator TX2 Thoracic Aorta Trial
Classic Surgical Open Procedure
Stent Graft Revolution
Original Trials: 1998-2003
UPENN Thoracic Stent Grafting
Initial Experience: Trial Cases Only (n=93)

• Results:
  - Peri-op mortality: 3.3%
  - Spinal cord ischemia: 5.4%
    » Fully Reversible: 3/5
    » Partially Reversible: 1/5
    » Permanent: 1/5 1.1%
  - Vascular complications: 14.1%
  - Endoleak 12%

Appoo, Bavaria et al. Western Thoracic Meeting – Victoria, June 2005
(JTCVS 2006)
Insertion and Positioning
Proximal Deployment and Completion

New Delivery System
Key Aortic Arch Anatomic Issues which are Important for Successful DTA Endograft Outcomes: Pitfalls and Nuances
Length of Seal Sites
Ideal: 3-4 stent overlap

Visualize location of proximal & distal seal sites
Aortic Arch
Inner Radius
must be
> 35 mm

Outer Radius
Should be
70 mm or
Greater

Radius = 35 mm
Arch LZ: Not Optimal
Arch Neck Shape: Not Optimal (except Supra-Subclavian)
Neck Shape: Optimal

Note: Left Subclavian trans brachial wire

Parallel
Lateral: Need good Distal LZ

celiac

Distal stent

SMA
Adequate Access

Access vessel inner diameter... must accommodate introducer OD.

20F = 6.9 mm
22F = 7.5 mm

Investigational device, limited by federal (U.S.A.) law to investigational use.
The Arch Branches:
The Left Subclavian
The Left Carotid
Coverage of the Left Subclavian Artery

- Extension of the proximal landing zone
  - Proximal aneurysm extent
  - Angulated arch
  - Traumatic aortic injuries
  - Type B dissection
Transposition/Angulated Arch
How Easy Access to Left Subclavian and Left Carotid helps in the “Conduct of Operation”
Coil Embolization of Intrathoracic Subclavian artery via left Brachial after bypass 1 week earlier
Critical Care Implications: Pre-op (Special Considerations and Nuances)

- **Stop PO Long Acting Anti-Hypertensives**
  - Use short acting IV agents

- **Careful with Left Radial Artery lines in ICU**

- **Scan for Abnormal Left Vert Anatomy**
Chest CT Aortic Atheroma Grade

Grade II
Grade III
Grade IV

Analyzed from Aortic Valve to 2 cm distal to L subclavian
### Combining Prior Stroke and Extent Coverage


<table>
<thead>
<tr>
<th>Prior Stroke + intra-op stroke</th>
<th>Extent A</th>
<th>Extent B</th>
<th>Extent C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Stroke + no intra-op stroke</td>
<td>2</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total (n=24)</strong></td>
<td>5</td>
<td>6</td>
<td>13</td>
</tr>
</tbody>
</table>

**Extent A or C coverage + prior stroke = Perioperative stroke incidence 27.7% (5/18)**
What About Aortic Dissection?
Aortic Dissection and Stent Grafting

- Acute Type A
- Chronic Type A (Residual)
- Chronic Type B
- Acute Type B
  - Uncomplicated
  - Complicated (Malperfusion, Rupture)
Natural History: Survival


Note: All comers: 9% 1 month

IRAD Data very Similar;
2-3% Uncomplicated Type B
Estrera, et al 2-3% Uncomplicated

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Acute Type B: Malperfusion involving left renal, LSCA, LCFA

Wire / pigtail in right SCA (True lumen)  Malperfusion Left Renal Artery
Restoration of True Lumen Perfusion

Obliteration of false lumen  Perfusion of Left Renal Artery
Acute Type B Dissection with Contained Rupture (frequent imaging)

75-year-old woman with acute back pain while gardening

4:11 PM

7:35 PM

Courtesy of Mike Dake, MD, Stanford Univ.
Pre & Post TAG Device Implantation

Pre-Implant

Post-Implant

Department of Surgery, University of Pennsylvania Health System

Courtesy of Mike Dake, MD. Stanford Univ.
Pre-op ICU TEVAR Dissection Considerations

- Malperfusion: if Yes, Where
  - Direct Malperfusion Management (delayed definitive management) vs Primary proximal Treatment
- Anti-Hypertensive Control
- IMH issues
- As earlier, Left Subclavian Coverage issues
TEVAR Post –op ICU Management
Special Considerations

- Anti-Hypertensive Management (different than TAAA)
- Post op delayed Paraplegia (and CVA)
- CSF Drain management
- Re-evaluation of Access site/vessels
- Disaster Recognition!!
  - Retro Type A Dissection
  - Endoleak (Back Pain)
  - Graft Collapse
- Frequent imaging
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## Spinal Cord Ischemia After Endovascular Stent Repair Of Descending Thoracic Aortic Aneurysm

<table>
<thead>
<tr>
<th>Report</th>
<th>N</th>
<th>Spinal Cord Ischemia</th>
<th>Recovery</th>
<th>Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravereaux EC</td>
<td>53</td>
<td>3 (5.7%)</td>
<td>1/3</td>
<td>AAA repair, Long graft</td>
</tr>
<tr>
<td><em>J Vasc Surg 2001</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitchell RS</td>
<td>108</td>
<td>4 (3.7%)</td>
<td>0/4</td>
<td>AAA repair, Aortic occlusion</td>
</tr>
<tr>
<td><em>Sem Vasc Surg 1997</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moon MR</td>
<td>18</td>
<td>1 (5.6%)</td>
<td>0/1</td>
<td>AAA repair</td>
</tr>
<tr>
<td><em>J Vasc Surg 1997</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ellozy SH</td>
<td>84</td>
<td>3 (3.6%)</td>
<td>1/3</td>
<td>Not described</td>
</tr>
<tr>
<td><em>J Vasc Surg 2003</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenberg R</td>
<td>25</td>
<td>3 (12.0%)</td>
<td>2/3</td>
<td>Long graft</td>
</tr>
<tr>
<td><em>J Vasc Surg 2000</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheung AT</td>
<td>75</td>
<td>5 (6.5%)</td>
<td>3/5</td>
<td>AAA repair, Mobile atheroma, Vascular injury, Hemorrhage Hypotension</td>
</tr>
<tr>
<td><em>STS 2005</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>363</td>
<td><strong>19 (5.2%)</strong></td>
<td><strong>7/19 (37%)</strong></td>
<td></td>
</tr>
</tbody>
</table>
Gore Tag Pivotal FDA Study: Paraplegia

- Endograft cohort, 140 pts, vs. Non randomized but matched concurrent cohort of 94 pts. at 17 North American Centers
- Identical inclusion & exclusion criteria
- Paraplegia Rate: 2.9% vs. 12.8% (P=.003)
- Note: 4.9% with prior AAA
ONSET TIME OF POSTOPERATIVE PARAPLEGIA

Concept: Delayed Paraplegia

- Mean: 36.8 ± 38.9 hrs (1st Episode)
- Median: 21.6 hrs (1st Episode)
- 7.3 Days or 176 hrs (2nd episode)

Patients:
- Patient 1: Days (0) 0
- Patient 2: Days (0) 0
- Patient 3: Days (0) 4
- Patient 4: Days (0) 0
- Patient 5: Days (0) 0
- Patient 6: Days (0) 0
- Patient 7: Days (0) 4
- Patient 8: Days (0) 0
- Patient 9: Days (0) 0
- Patient 10: Days (0) 0
- Patient 11: Days (0) 0

Emergence:
- Patient 3
- Patient 7

2nd Episode:
- Patient 4
- Patient 2

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Pathophysiology of Delayed-Onset Paraplegia

Spinal Cord at Risk

- Spinal Cord Ischemia
  (paraplegia/paraparesis)
- Neurogenic Shock
  (autonomic dysfunction)
- Hypotension
- Spinal Cord Infarction
  (permanent paraplegia)

Hypoperfusion

Spinal Cord Infarction

T2-weighted MRI
Thoracolumbar Spine.
Intraoperative Spinal Cord Ischemia During Endovascular Stent Repair: Case 4

Lower Extremity SEP
At Time of Event (MAP=77 mm Hg)

Lower Extremity SEP
Recovery (MAP=115 mm Hg)
TEVAR Post –op ICU Management
Special Considerations

• Anti-Hypertensive Management (different than TAAA)
• Post op delayed Paraplegia (and CVA)
• CSF Drain management

• **Re-evaluation of Access site/vessels**

• Disaster Recognition!!
  – Retro Type A Dissection
  – Endoleak (Back Pain)
  – Graft Collapse

• Frequent imaging
Vascular Access Complications: Completely Avulsed External Iliac (Iliac on-a-stick)
Avulsed external iliac artery after deployment of endovascular stent graft (Case 5).

Other Reports:
Bhama JK. J Vasc Surg 2003;37:690
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Dissection Procedure – Conversion of Type B to Type A
Intraop Angiogram: Type I Leak Endoleak

“Bird-beak”: Poor Arch landing
Migration: Importance of Sufficient LZ and Endoleak

Initial distal fixation

Stable proximal fixation

Follow-up distal position

Investigational device, limited by federal (U.S.A.) law to investigational use.
TAA Endoleak Type II
TAA Endoleak Type III
TAA Endoleak Type III
TEVAR Endoleaks: Sac Behavior

Carpenter, Bavaria; Journal of Vascular Surgery 2006
Overall Sac Expansion of 2mm

• Type I
  – Diameter **increase** 6mm (0-10)

• Type II
  – Diameter **decreased** mean of 5mm (0-9)
  – No sac expansion

  Type I vs. Type II, P=0.003

• Type III
  – Diameter **decreased** 4mm
Examples of Thoracic Stent Graft Collapse

Cook TX2 collapse & fracture

Gore TAG collapses

Fig. 4. Radiograph of collapsed thoracic aortic stent-graft and thoracic aorta explanted en bloc from deceased patient. Note multiple collapsed stents and migration of the stent-graft.

Hinchliffe & al, EJVES 2007
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DTA Stent Graft Follow-up CT Scan: Frequent Imaging if suspicion
The Hybrid Arch Procedure

- Extension of the proximal landing zone to “zone 0”
- Debranching of great vessels
- Placement of endovascular stent graft antegrade through graft
- Variations on procedure depends on pathology

Saccular Distal/Mid Arch Aneurysm Repair
“Classic Debranching Procedure”
Type I

Zone 0 landing: On or Off Pump
The Hybrid Procedure: Classic Type I (off pump LZ 0)
Arch Hybrid with Antegrade TEVAR Delivery: On CPB with all purpose Hybrid Arch Graft

e.g. Type I (b) on CPB
Completed (Flouro) 2 Component Repair: Antegrade Delivery: Often have Prox and Distal LZ Diameter Discepancies
Arch Aneurysm most cases Giant Saccular Arch Aneurysm
# Postoperative Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Hybrid N=31</th>
<th>Open Total Arch N=45</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In hospital Mortality</td>
<td>3 9.6%</td>
<td>7 16%</td>
<td>.739</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 3%</td>
<td>4 9%</td>
<td>.644</td>
</tr>
<tr>
<td>Transient Neurological Deficit</td>
<td>0 0%</td>
<td>5 11%</td>
<td>.150</td>
</tr>
<tr>
<td>Permanent Paraplegia</td>
<td>2 6%</td>
<td>0</td>
<td>.137</td>
</tr>
<tr>
<td>Reversal Spinal Cord Ischemia</td>
<td>3 9.7%</td>
<td>0</td>
<td>.049</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>5 16%</td>
<td>5 11%</td>
<td>.486</td>
</tr>
<tr>
<td>Renal failure requiring new hemodialysis</td>
<td>3 9.7%</td>
<td>3 7%</td>
<td>.665</td>
</tr>
<tr>
<td>Reop for bleeding</td>
<td>0 0%</td>
<td>1 2%</td>
<td>1.00</td>
</tr>
<tr>
<td>Afib</td>
<td>9 29%</td>
<td>13 29%</td>
<td>.793</td>
</tr>
<tr>
<td>Mean hospital stay</td>
<td>19.1 15.9</td>
<td>17.5 16.2</td>
<td>.235</td>
</tr>
</tbody>
</table>

Paraplegia in EARLY (2006) part of series (all data thru 10/09)
### Mortality Stratification

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>In-Hospital Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;75 years old</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>&gt;75 years old</td>
<td>1 (7%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Arch</th>
<th>In Hospital Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;75 years old</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>&gt;75 years old</td>
<td>4 (36%)</td>
</tr>
</tbody>
</table>

Total arch replacements see a significant increase in mortality for patients age >75 \((p<.050)\) despite the fact that the Hybrid cohort has a higher atherosclerotic burden.
Hybrid ICU Considerations

- Ascending Aorta Endoleak (Type Ia)
- Retro Type A Dissection
- Brachiocephalic Debranching Patency and Inflow
- Paraplegia (if below T 7-8)
- Advanced/Future Hybrid Solutions
The Future of Ascending TEVAR?: Repair of Ascending Aortic Aneurysm Trans-Apically with Stent Graft
Acute Type A Dissection: Pre-Rupture

Type A Dissection is a Catastrophic Presentation!!
Type A (Debakey Type I) Dissection: Pre and Post Proximal Repair with E-Vita (type) Distal Graft (Very Compelling !!)

Beijing, China

90% Thoracic Aortic Obliteration: N=20, 2 yr. mean follow up

And update NY Aortic Surgery 2010; (Essen, Germany)
“The Treatment is best provided by specialists who are great open surgeons **AND** great endovascular surgeons”

Juan Parodi, MD; STS 2006
Thomas Eakins: Gross Clinic (1878@JEFF) and Agnew Clinic (1888@PENN)

Great Progress in 10 years!

Thank You