Blunt Thoracic and Abdominal Aortic Injury

4th International Meeting on Aortic Diseases
New insights into an old problem CHU Liège, APF
September 11-13, 2014 - Crowne Plaza Liège, Belgium
www.chuliege-imaa.be

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Disclosures

Endologix- Ventana Medical Advisory Board

Co-Founder: AORTICA Corporation

Intellectual Property: Cook Inc
Blunt Thoracic Aortic Injury (BTAI)

2nd leading cause of trauma-related death: 8,000 deaths/year

85% die before reaching the hospital

Fabian et al, J Trauma 1997
Intra-abdominal hemorrhage requiring celiotomy
Open abdomen
Suspected colon injury
Conclusions: “Most surgeons select stent grafts for traumatic thoracic aortic ruptures, irrespective of associated injuries, injury severity, and age. Stent Grafts are associated with significantly lower mortality and fewer blood transfusions, but there is a considerable risk of serious device-related complications. *There is a major and urgent need for improvement of the available endovascular devices.*”

Demetriades et al, J Trauma. 2008 Mar;64(3):561-70
Harborview - 10 years, 140 patients

<table>
<thead>
<tr>
<th>Year</th>
<th>Open</th>
<th>TEVAR</th>
<th>Medical</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>14</td>
<td>12</td>
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<td>2000</td>
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<td>12</td>
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<tr>
<td>2001</td>
<td>9</td>
<td>11</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>2002</td>
<td>17</td>
<td>9</td>
<td>9</td>
<td>35</td>
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<tr>
<td>2003</td>
<td>9</td>
<td>15</td>
<td>15</td>
<td>39</td>
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<tr>
<td>2004</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>60</td>
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<tr>
<td>2005</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>54</td>
</tr>
</tbody>
</table>

Legend:
- Open
- TEVAR
- Medical

Total patients over 10 years: 140
0.5% of all trauma patients who survive to ED presentation

BAI N = 140
• Mean age: 40 years old (range 10-89)

Endovascular repair n = 49
• Patients with multiple injuries

The Harborview Experience 1999-2008

BAI presented at the 64th Society for Vascular Surgery annual meeting
## UW BAAI Classification

### Absent External Contour Abnormality

<table>
<thead>
<tr>
<th>Type of Aortic Injury</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intimal Tear</td>
<td>No aortic external contour abnormality: tear and/or associated thrombus is &lt;10mm</td>
<td></td>
</tr>
<tr>
<td>Large Intimal Flap</td>
<td>No aortic external contour abnormality: tear and/or associated thrombus is &gt;10mm</td>
<td></td>
</tr>
</tbody>
</table>

### Present External Contour Abnormality

<table>
<thead>
<tr>
<th>Type of Aortic Injury</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudoaneurysm</td>
<td>Aortic external contour abnormality: contained</td>
<td></td>
</tr>
<tr>
<td>Rupture</td>
<td>Aortic external contour abnormality: not contained. free rupture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Open Repair</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>Intimal tear</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Large Intimal Flap</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>100</td>
<td>43</td>
</tr>
<tr>
<td>Rupture</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>55</td>
</tr>
</tbody>
</table>
Endovascular Repair for Blunt Thoracic Aortic Injury using the Zenith TX2 Low Profile Device

• Benjamin Starnes, MD
• on behalf of TRANSFIX investigators

• The TRANSFIX study was sponsored by Cook Medical, Inc. Dr. Starnes has NO relevant disclosures as it relates to this presentation.
## Zenith TX2 Low Profile Endovascular Graft
(Zenith Alpha Thoracic Endovascular Graft)

<table>
<thead>
<tr>
<th>Zenith TX2</th>
<th>Zenith TX2-LP (Zenith Alpha Thoracic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-24 Fr introduction system</td>
<td>16-20 Fr introduction system</td>
</tr>
<tr>
<td>22-42 mm diameter devices</td>
<td>18-46 mm diameter devices</td>
</tr>
<tr>
<td>Aortic arch radius &gt; 35 mm</td>
<td>Aortic arch radius ≥ 20 mm</td>
</tr>
<tr>
<td>Stainless steel Z-stents</td>
<td>Nitinol Z-stents</td>
</tr>
<tr>
<td>Standard Dacron</td>
<td>Thinner, more tightly woven Dacron</td>
</tr>
<tr>
<td>Covered proximal stent</td>
<td>Bare rounded proximal stent</td>
</tr>
<tr>
<td>-</td>
<td>MR compatible</td>
</tr>
</tbody>
</table>

Investigational Device in the United States
Smallest Diameter Delivery System -16 Fr
Study Design

- Prospective, non-randomized study
  - Study enrollment complete - 50 patients treated between Jan 2013 and May 2014.
  - All patients beyond 30 days from index procedure.
- Primary safety endpoint:
  30-day mortality
- Primary effectiveness endpoint:
  30-day device success
- Patients will be followed through 5 years
Procedural Results

- Technical success in 100% (48/48) of patients
- No intraoperative mortality

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure time (min)</td>
<td>85 ± 45 (34 - 278); N=48</td>
</tr>
<tr>
<td>Estimated blood loss (cc)</td>
<td>107 ± 148 (0 - 1000); N=48</td>
</tr>
<tr>
<td>Duration of ICU stay (days)</td>
<td>14 ± 12 (1 - 51); N=45</td>
</tr>
<tr>
<td>Duration of hospital stay (days)</td>
<td>23 ± 21 (2 - 120); N=46</td>
</tr>
</tbody>
</table>
Image Example

Complete aortic healing at 6 months

Pre-procedure  1 month  6 months

Spontaneous resolution of an endoleak (type II per site; type unknown per corelab)
Conclusions

- Short-term results indicate that TX2 Low Profile device appears safe and effective for the treatment of BTAI
- Completely Percutaneous access in 40% of patients
- Technical success in 100% of patients
- No aortic injury-related mortality within 30 days
- Smallest delivery profile
- MR-compatible
Conclusions- BAI

• The use of TEVAR for BAI has become standard in most modern aortic centers
• More BAI is being diagnosed with modern imaging techniques
• Minimal Aortic Injury (-EACA) requires observation only
• Newer devices show promise for treating BAI with less device-related complications
5% of all blunt aortic injuries
- Protected position of abdominal aorta

24% fatality

Mechanisms
• Rapid deceleration
• Direct anterior posterior crushing
• Direct laceration

Drawing by J. Heuser.
BAAI contemporary literature

- Seat belt syndrome: Garret & Braunstein (1962)
- Seat belt aorta: Dajee (1967)
- Riesman: 46 cases (1979)
- Lock: 33 cases (1987)
- Roth: 62 cases (1990)
- American J of Roentgenol (2005)
Blunt Abdominal Aortic Injury (BAAI)

Presentation

- Acute arterial insufficiency (81%)
- Acute abdomen (55%)
- Weakness/paralysis (47%)
- Abdominal wall contusion (24%)

AIM

• Review our experience at a major US Level I Trauma Center with blunt abdominal aortic injury

• Retrospective
• 1996 to 2010
• Blunt Trauma only
• Injuries to aorta from diaphragmatic hiatus to aortic bifurcation
UW BAAI Classification

Aortic contour abnormality

No

Yes

Intimal defect (dissection &/or thrombus)

< 10 mm

≥ 10 mm

Intimal Tear

Large intimal flap (LIF)

Contained rupture

Yes

No

Pseudoaneurysm (PSA)

Rupture/branch vessel avulsion

BAI presented at the 64th Society for Vascular Surgery annual meeting
Abdominal Aorta Zones of Blunt Injury

Zone I
- diaphragmatic hiatus to SMA
- includes celiac artery

Zone II
- includes SMA to renal arteries

Zone III
- inferior to renal arteries to aortic bifurcation
Results

- 37,922 blunt trauma admissions
- 220 Blunt aortic injury
- 28 BAAI
- Incidence: 0.07% of those surviving to the hospital
- 13% of blunt aortic injuries
### Patient Demographics

<table>
<thead>
<tr>
<th>Male</th>
<th>19 (68%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (range)</td>
<td>28.5 (6-61)</td>
</tr>
</tbody>
</table>

#### Mechanism of Injury

- Motor vehicle crash: 57%
- Motor cycle crash: 11%
- Car vs. pedestrian: 11%
- Car vs. bicycle: 3.6%
- Fall: 7%
- Crush injury: 7%
- All terrain vehicle crash: 3.6%
<table>
<thead>
<tr>
<th>Associated Injuries</th>
<th>All N = 28</th>
<th>Intimal Tear n = 6</th>
<th>LIF n = 11</th>
<th>PSA n = 3</th>
<th>Rupture n = 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic Brain Injury</td>
<td>21</td>
<td>33</td>
<td>0</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>“seat belt sign”</td>
<td>36</td>
<td>17</td>
<td>55</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>Solid organ injury</td>
<td>29</td>
<td>33</td>
<td>18</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>Mesenteric injury</td>
<td>36</td>
<td>0</td>
<td>55</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>Small bowel injury</td>
<td>39</td>
<td>0</td>
<td>55</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>Colon Injury</td>
<td>39</td>
<td>0</td>
<td>64</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>Spine Fracture</td>
<td>50</td>
<td>33</td>
<td>46</td>
<td>0</td>
<td>63</td>
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<tr>
<td>Pelvic Fracture</td>
<td>32</td>
<td>0</td>
<td>36</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>IVC injury</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75</td>
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</table>
BAAI Location

Zone III: 71%
Zone I: 18%
Zone II: 11%
<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>LIF</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Rupture</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>N = 6</td>
<td></td>
</tr>
<tr>
<td>Traumatic brain injury</td>
<td>N = 2</td>
<td></td>
</tr>
<tr>
<td>Zone I</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Zone II</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Zone III</td>
<td>15%</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

BAAI is a spectrum of injury

Management

- Depends on the patient's hemodynamics & injuries
- Varies by type & location
- Intimal tears & some LIF can be managed non operatively
- Zone I & III amenable to endovascular repair
- Zone II requires open repair

Successful repair correlates with a favorable prognosis