Endovascular Repair of Traumatic Aortic Disruptions

James W. Dennis MD, FACS

Department of Surgery, Division of Vascular Surgery and Endovascular Therapy
University of Florida College of Medicine-Jacksonville
Jacksonville, Florida

No disclosures
Case study

• What should be a high priority phone call to make when viewing this image?
  a. The OR
  b. Blood bank
  c. Device rep
  d. SICU
  e. Chaplain
Case study

• What should be a high priority phone call to make when viewing this image?
  a. The OR
  b. Blood bank
  c. Device rep
  d. SICU
  e. Chaplain ←
Scope of problem

- Blunt thoracic aortic trauma is a life threatening emergency
  - Cause of death in fatal blunt injuries 15-20% of cases
  - Second only to head injury as cause of death
  - >80% result from high speed MVC

- Usually occur at the proximal descending aorta is relatively mobile against a fixed ligamentum arteriosum

- 7500 -8000 traumatic aortic disruptions/year

- As many as 85% of victims who sustain traumatic aortic disruption die at the scene
Results – 92 Patients

Mechanism of Injury

- 77% MVC
- 20% MCC
- 3% Peds vs Auto
Age of Presentation

Results Cont.
Real case study

Chief Complaint

- Patient presents with
  - MCC
  - Hip Pain

History of present illness

- 35 yo F hx HTN and depression presents to ED s/p motorcycle accident. Pt c/o hip and foot pain. Pt was on passenger on a motorcycle that was hit, driver was pronounced dead on scene. Pt was not wearing helmet. Complaining of bilateral hip pain. The incident occurred just prior to arrival. The incident occurred in the street. She came to the ER via EMS.

- CXR shows widened mediastinum. Other injuries include a grade 2 liver laceration w/o active extravasation, bilateral pubic rami fractures, possible bladder injury and right foot distal phalanx fracture.
Name CXR findings other than widened mediastinum that indicate blunt aortic injury
Name CXR findings other than widened mediastinum that indicate blunt aortic injury

<table>
<thead>
<tr>
<th>Finding</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide mediastinum</td>
<td>221 (85)</td>
</tr>
<tr>
<td>Indistinct aortic knob</td>
<td>63 (24)</td>
</tr>
<tr>
<td>Left pleural effusion</td>
<td>49 (19)</td>
</tr>
<tr>
<td>Apical cap</td>
<td>49 (19)</td>
</tr>
<tr>
<td>First and/or second rib fracture</td>
<td>33 (13)</td>
</tr>
<tr>
<td>Tracheal deviation</td>
<td>32 (12)</td>
</tr>
<tr>
<td>Depressed left bronchus</td>
<td>12 (5)</td>
</tr>
<tr>
<td>NG tube deviation</td>
<td>29 (11)</td>
</tr>
<tr>
<td>Negative x-ray</td>
<td>19 (7)</td>
</tr>
</tbody>
</table>

*a Numbers in parentheses are percentage of x-ray films with the particular finding.
Initial CTA on arrival
What grade of aortic injury is it?

- A. Grade 1
- B. Grade 2
- C. Grade 3
- D. Grade 4
Aortic injury grading system

- Grade 1 16%
  - Intimal tear +/- thrombus (<10mm)
- Grade 2 5%
  - Intramural hematoma
  - Intimal flap >10mm
- Grade 3 71%
  - Pseudoaneurysm
- Grade 4 6%
  - Rupture
What benefits does endovascular repair have over open?

• A. Less mortality
• B. Less paralysis
• C. Less blood transfusion
• D. Less procedure time
• E. All of the above
Treatment Options

- Answer → E
- Several meta-analyses in 2007-2009 have shown the superiority of endovascular repair

<table>
<thead>
<tr>
<th></th>
<th>Endovascular</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>7.6%</td>
<td>15.2%</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0-3%</td>
<td>5.5-15%</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.81%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Tech Success</td>
<td>96.5%</td>
<td>98.5%</td>
</tr>
<tr>
<td>Blood Trans</td>
<td>2.3 Units</td>
<td>7.3 Units</td>
</tr>
<tr>
<td>OR Time</td>
<td>2.7hrs</td>
<td>4.4hrs</td>
</tr>
</tbody>
</table>
What is the timing recommended for the repair?

• A. Immediately, top priority
• B. Emergently
• C. 2-3 days
• D. Depends…….
Timing of repair

• Answer → D (Depends on grade and other associated injuries)

• Grade 1 injuries can be observed with serial imaging (usually 2-3 days later)

• All others within 24 hours

• Higher grades emergently
Timing of Injury to Endovascular Repair

Results Cont.
BP & HR of patient after admission

• How was the medical management?
• What should be instituted and with what goals in mind?

- 0200  100/72  93
- 0145  127/71  90
- 0130  103/84  94
- 0115  116/77  94
- 0100  122/78  94
- 0045  130/90  99
- 0030  (!) 131/102  99
- 0015  (!) 184/104  123
- 0006  (!) 173/96  122
- 03/17/19

- 2345  153/81  104
- 2330  132/77  104
- 2315  141/85  113
- 2312  (!) 158/102  111
- 03/16/19

• Actual record – read up ↑
BP & HR of patient after admission

- How was the medical management?
- What should be instituted and with what goals in mind?
  - → If associated injuries delay treatment, place on esmolol drip to keep HR<100 and sBP<100 or MAP 50-70

<table>
<thead>
<tr>
<th>Time</th>
<th>BP</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0200</td>
<td>100/72</td>
<td>93</td>
</tr>
<tr>
<td>0145</td>
<td>127/71</td>
<td>90</td>
</tr>
<tr>
<td>0130</td>
<td>103/84</td>
<td>94</td>
</tr>
<tr>
<td>0115</td>
<td>116/77</td>
<td>94</td>
</tr>
<tr>
<td>0100</td>
<td>122/78</td>
<td>94</td>
</tr>
<tr>
<td>0045</td>
<td>130/90</td>
<td>99</td>
</tr>
<tr>
<td>0030</td>
<td>(I) 131/102</td>
<td>99</td>
</tr>
<tr>
<td>0015</td>
<td>(I) 184/104</td>
<td>123</td>
</tr>
<tr>
<td>0006</td>
<td>(I) 173/96</td>
<td>122</td>
</tr>
<tr>
<td>03/17/19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2345</td>
<td>153/81</td>
<td>104</td>
</tr>
<tr>
<td>2330</td>
<td>132/77</td>
<td>104</td>
</tr>
<tr>
<td>2315</td>
<td>141/85</td>
<td>113</td>
</tr>
<tr>
<td>2312</td>
<td>(I) 158/102</td>
<td>111</td>
</tr>
<tr>
<td>03/16/19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Actual record – read up ↑
What percentage of acute thoracic aortic disruptions occur just past the fixed ligament arteriosum or next to the left subclavian artery?

- A. 99%
- B. 85-90%
- C. 60-65%
- D. < 50%
Aortic Disruptions at Unusual locations

Answer → B (85-90%)
At total of 74 patients with thoracic BTAI met the study criteria
Fourteen patients out of 74 (19%) had injuries at an unusual location
How are aortic disruptions at unusual sites different?

• A. Tend to be higher grade
• B. More often need intervention
• C. More common in men
• D. No statistical relationship with any other associated injury
• E. Carry a lower overall mortality
• F. All of the above
• G. None of the above
Aortic disruptions at unusual locations

Answer → G (none of the above)

Injuries at the distal (unusual) zone have the following unique characteristics:

1. They tend to be of lower grade compared to injuries at the usual location
2. They are less likely to require intervention
3. The prognosis is worse and the mortality is higher due to other traumatic injuries
4. They are associated with thoracic spine fractures (50%)
5. They are more common in females (66% vs 25%)
Back to the case
How many components are needed and how long of length typically?

• A. Usually multiple 30cm
• B. Usually one 10cm
• C. Usually two 20cm
Stent Grafts Components Used in 92 Patients

- Answer → B
- 79 Patients required only 1 stent graft component
- 11 patients required 2 components
- 2 patient required 3 components
- Mean stent graft diameter = 25mm
- Range = 24mm-31mm
- 95% = 10cm lengths
Length of proximal neck

- How much proximal neck is needed distal to the left subclavian to land the device?
  - A. 25mm
  - B. 20mm
  - C. 15mm
  - D. 10mm
  - E. None
Technical Considerations

• Answer D (10mm or less) Normal artery

• Length from LSC artery to Injury
  – Mean = 19mm
  – Range = 7.5mm – 40mm

• Length from LSC artery to Proximal end of endograft
  – Mean = 0.71mm
  – Range = 0-10mm
See any potential problems in this post-op CTA?
What is the result of covering the left subclavian artery?

- Never a problem
- Left UE ischemia 10-15% of time
- Left UE ischemia 25% of time
- Majority of patients will have an ischemic left UE
What is the result of covering the left subclavian artery?

• Never a problem
• Left UE ischemia 10-15% of time ← Answer
• Left UE ischemia 25% of time
• Majority of patients will have an ischemic left UE
Other considerations vs elective TAA repair?

- A. Same sizing
- B. Need to do routine spinal fluid drainage
- C. Contraindicated in teenagers
- D. Never give heparin
- E. None of the above
- F. All of the above
Other considerations vs elective TAA repair?

- Answer → E (None of the above)
- Must recognize the aortic diameter may be reduced due to shock +/- luminal narrowing distal to the injury or thrombus
- Some amount disagreement over the degree of oversizing (Most 10%)
- Systemic heparin but at decreased dose
- Do not routinely use spinal fluid drainage
- General anesthesia
- Endovascular repair regardless of age
Patient Follow-Up

- Pt discharged 9 days post-injury
- Repeat CTA with no leaks
- Asymptomatic left UE
- No evidence of a stroke or weakness
- Ambulating with a walker
- Normal cognition
Thank you
Single institutional study
Jacksonville, FL

- Retrospective review of the Trauma and Vascular Registry of last 100 endovascular repairs for traumatic thoracic aortic injuries prior to June 2015.
- Level 1 trauma center with over 4000 resuscitations/year
- Treat approximately 15-20 acute thoracic aortic disruptions/year
- Represents “real world” experience
- 92 patients with complete data
### Results Cont.

<table>
<thead>
<tr>
<th></th>
<th>Number of Patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Complications</td>
<td>2</td>
<td>2.1%*</td>
</tr>
<tr>
<td>Mortality Rate</td>
<td>9</td>
<td>9.8%</td>
</tr>
<tr>
<td>Re-Intervention, stroke, paralysis</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean follow-up 2.7 years

* Iliac injury; Delayed diagnosis 3 weeks post-injury, presented 3 months later with chest pain, fever and enlarging pseudoaneurysm
Summary

• Endovascular repair of acute thoracic aortic disruptions well established as the gold-standard treatment
• Technical considerations differ from aneurysms & dissections
• Acceptable landing zones can be lengths <10mm with good results
• In most cases only 1 stent graft required
• Seldom needs early re-intervention
• Long-term durability remains a concern
Identification of Unique Characteristics Associated with Blunt Traumatic Aortic Injuries Occurring at Unusual Locations and Implications for Patient Management

Michel J Sabra, MD1, James W Dennis, MD, FACS1, Jon Christian Allmon, MD, FACS1, Shiva Gautam, Ph.D2, Joseph Habib, MD, FACS1

1 Department of Surgery
Division of Vascular surgery
University of Florida, College of Medicine – Jacksonville

2 Department of Medicine
University of Florida, College of Medicine-Jacksonville
Background:

The usual location of blunt traumatic aortic injury (BTAI) is just distal to the left subclavian artery; however, injuries can also be found in other locations.

The purpose of this study is to identify specific characteristics associated with thoracic BTAIs that are found at unusual locations.
Methods:

We queried the trauma registry at our level 1 trauma center at the University of Florida-Jacksonville for BTAI between January 2010, and July 2017

Inclusion criteria were:

- Blunt trauma as the mechanism of injury (MVC, MCC, pedestrians, and falls)
- Confirmed aortic injury on computed tomography angiography (CTA) obtained on admission to the trauma center
- Adult patients (age 18 years old and above)
We divided the patients into 2 groups based on the location of thoracic BTAI.

We defined the “usual” location of the BTAI as those within 5 cm of the origin of the left subclavian artery. Any injury distal to this area in the descending thoracic aorta were considered to be “unusual”

We measured the distance from the left subclavian artery to the site of intimal disruption using the candy cane (modified sagittal) view of the CTA of the chest obtained on admission to the trauma center.
We chose 5 cm as the distal extension of the usual BTAI location based on radiographic observations.

Rajani et al, (35 CTA of patient with BTAI): the average length from the left subclavian artery to the proximal end of injury was 16.2 mm (range 2-31 mm). The average length of injured aortic segment was 27mm.

Borsa et al, (50 CTA of patients BTAI): The mean distance from the left subclavian artery to the superior aspect of the injury measured 14.9 mm along the greater curve. The mean length of the injury was 26.0 mm along the greater curve.
An example of a thoracic BTAI at an unusual location that is associated with thoracic spine fracture at T9-T10 level.
Patients’ demographics at presentation:

<table>
<thead>
<tr>
<th></th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age Mean (SD)</strong></td>
<td>42.05 (16.52)</td>
<td>49.86 (15.69)</td>
<td>0.131</td>
</tr>
<tr>
<td><strong>Gender No (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>44 (73.33)</td>
<td>5 (35.71)</td>
<td>0.012</td>
</tr>
<tr>
<td>Female</td>
<td>16 (26.67)</td>
<td>9 (64.29)</td>
<td></td>
</tr>
<tr>
<td><strong>Race No (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>42 (70.00)</td>
<td>12 (85.71)</td>
<td>0.458</td>
</tr>
<tr>
<td>African American</td>
<td>17 (28.33)</td>
<td>2 (14.29)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1 (1.67)</td>
<td>0 (0.00)</td>
<td></td>
</tr>
</tbody>
</table>
The mechanism of injury (P values = NS)

<table>
<thead>
<tr>
<th></th>
<th>Usual location</th>
<th>Unusual location</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVC No (%)</td>
<td>42 (70.00)</td>
<td>9 (64.29)</td>
</tr>
<tr>
<td>MCC No (%)</td>
<td>10 (16.67)</td>
<td>1 (7.14)</td>
</tr>
<tr>
<td>Pedestrian vs auto No (%)</td>
<td>7 (11.67)</td>
<td>2 (14.29)</td>
</tr>
<tr>
<td>Fall No (%)</td>
<td>1 (1.67)</td>
<td>2 (14.29)</td>
</tr>
</tbody>
</table>
## Past medical history:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension No (%)</td>
<td>14 (23.33)</td>
<td>2 (14.29)</td>
<td>0.720</td>
</tr>
<tr>
<td>Diabetes No (%)</td>
<td>10 (16.67)</td>
<td>0 (0.00)</td>
<td>0.192</td>
</tr>
<tr>
<td>Coronary Artery Disease No (%)</td>
<td>9 (15.00)</td>
<td>0 (0.00)</td>
<td>0.193</td>
</tr>
</tbody>
</table>
### Basic physiologic characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heart rate</strong> Mean (SD)</td>
<td>100.55 (17.52)</td>
<td>104.21 (22.14)</td>
<td>0.562</td>
</tr>
<tr>
<td><strong>Respiratory rate</strong> Mean (SD)</td>
<td>21.30 (7.06)</td>
<td>22.14 (5.01)</td>
<td>0.653</td>
</tr>
<tr>
<td><strong>Systolic blood pressure</strong> Mean (SD)</td>
<td>124.07 (35.25)</td>
<td>120.93 (37.61)</td>
<td>0.877</td>
</tr>
<tr>
<td><strong>Body Mass Index (BMI)</strong> Mean (SD)</td>
<td>29.39 (7.83)</td>
<td>27.43 (6.82)</td>
<td>0.504</td>
</tr>
<tr>
<td><strong>Hematocrit</strong> Mean (SD)</td>
<td>36.97 (6.19)</td>
<td>37.03 (4.44)</td>
<td>0.885</td>
</tr>
<tr>
<td><strong>Creatinine</strong> Mean (SD)</td>
<td>1.28 (0.63)</td>
<td>1.00 (0.37)</td>
<td>0.081</td>
</tr>
<tr>
<td><strong>INR</strong> Mean (SD)</td>
<td>1.28 (0.36)</td>
<td>1.17 (0.12)</td>
<td>0.435</td>
</tr>
</tbody>
</table>
## Associated bony injuries on CT scan on presentation:

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cervical Spine Fracture</strong></td>
<td>12 (20.00)</td>
<td>1 (7.14)</td>
<td>0.440</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thoracic Spine Fracture</strong></td>
<td>12 (20.00)</td>
<td>7 (50.00)</td>
<td>0.038</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lumbar Spine Fracture</strong></td>
<td>15 (25.00)</td>
<td>5 (35.71)</td>
<td>0.506</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ribs Fracture</strong></td>
<td>38 (63.33)</td>
<td>6 (42.86)</td>
<td>0.228</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scapula Fracture</strong></td>
<td>7 (11.67)</td>
<td>0 (0.00)</td>
<td>0.334</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sternal Fracture</strong></td>
<td>3 (5.00)</td>
<td>0 (0.00)</td>
<td>1.000</td>
</tr>
<tr>
<td>No (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Basic injury severity scales (GCS and ISS):

<table>
<thead>
<tr>
<th></th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glasgow Coma Scale (GCS) Mean (SD)</td>
<td>13.14 (3.49)</td>
<td>13.14 (3.32)</td>
<td>0.539</td>
</tr>
<tr>
<td>Injury Severity Scale (ISS) Mean (SD)</td>
<td>32.93 (10.86)</td>
<td>28.71 (11.21)</td>
<td>0.351</td>
</tr>
</tbody>
</table>
### Associated solid organs injuries on CT scan:

<table>
<thead>
<tr>
<th>Injury</th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary Contusion No (%)</td>
<td>25 (41.67)</td>
<td>5 (35.71)</td>
<td>0.770</td>
</tr>
<tr>
<td>Blunt Cardiac Injury No (%)</td>
<td>2 (3.33)</td>
<td>0 (0.00)</td>
<td>1.000</td>
</tr>
<tr>
<td>Spleen Injury No (%)</td>
<td>10 (16.67)</td>
<td>4 (28.57)</td>
<td>0.447</td>
</tr>
<tr>
<td>Liver Injury No (%)</td>
<td>12 (20.00)</td>
<td>6 (42.86)</td>
<td>0.090</td>
</tr>
</tbody>
</table>
## Grade of injury by location (P value = 0.016)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Usual location No (%)</th>
<th>Unusual location No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>15 (25.00)</td>
<td>7 (50.00)</td>
</tr>
<tr>
<td>Grade 2</td>
<td>7 (11.67)</td>
<td>4 (28.57)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>34 (56.67)</td>
<td>2 (14.29)</td>
</tr>
<tr>
<td>Grade 4</td>
<td>4 (6.67)</td>
<td>1 (7.14)</td>
</tr>
</tbody>
</table>
Management

Only 14% of patients with BTAI at unusual locations were treated with an endovascular stent graft, whereas 66% of patients with BTAI at the usual location were treated (p= 0.0006)

None of the grade II injuries at the unusual locations was treated with an endovascular stent graft, while 3 of the 7 grade II injuries at the usual location were treated
Length of Stay, and Mortality:

<table>
<thead>
<tr>
<th></th>
<th>Usual location</th>
<th>Unusual location</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality No (%)</strong></td>
<td>5 (8.33)</td>
<td>5 (35.71)</td>
<td>0.017</td>
</tr>
<tr>
<td><strong>Length of Stay Mean (SD)</strong></td>
<td>20.37 (17.36)</td>
<td>8.57 (6.88)</td>
<td>0.004</td>
</tr>
</tbody>
</table>
Causes of mortality (none related to aortic injury):

Of the 5 mortalities in the unusual location group:
• 3 patients with traumatic brain injury (TBI)
• 1 patient with adult respiratory distress syndrome (ARDS)
• 1 patient with multisystem organ failure (MSOF)

Of the 5 mortalities in the usual location group:
• 2 patients died of cardiac arrest
• 1 patient died of TBI
• 1 patient died of ARDS
• 1 patient died of MSOF
References


