THORACIC TRAUMA

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THORACIC TRAUMA

- EPIDEMIOLOGY
  - Blunt Injury
  - Penetrating Injury
- SPECTRUM OF THORACIC TRAUMA
- APPROACHES TO THE TREATMENT
- RESUSCITATIVE THORACOTOMY
- SPECIFIC CHALLENGES IN THORACIC TRAUMA
  - Aortic Trauma
  - Cardiac Trauma
EPIDEMIOLOGIC ISSUES

• BLUNT
  – MVC
  – Falls
  – Airplane Crashes

• PENETRATING
  – Stab wounds
  – Bullet wounds
BLUNT THORACIC TRAUMA

- 45 – 50% of unrestrained drivers have thoracic injuries
- 25% of drivers who die have thoracic injuries
Blunt Thoracic Trauma

• Distribution of Organ Injury:
  – Chest Wall 70%
  – Lung 21%
  – Heart 7%
  – Diaphragm 7%
  – Esophagus 7%
  – Aorta 4.8%
  – Tracheobronchial Injuries 0.8%

SPECTRUM DISEASE PROCESES SECONDARY TO TRAUMA

- Rib Fractures (most common chest wall injury in blunt trauma)
  - Flail Chest (Incidence 1.2% -- 20-40% mortality)
- Hemothorax (70-80% of penetrating and major blunt injuries)
- Pulmonary Contusion (30-75% of blunt trauma; mortality 14-20%)
- Pneumothorax (10-30% in blunt injury; 95% in penetrating injury)
  - Simple
  - Open
  - Tension
- Pericardial Tamponade (usually associate with penetrating trauma)
- Sternal Fracture (5-8% in blunt trauma; 25-30% mortality)
- Myocardial Contusion (most common blunt injury to heart)
- Esophageal Injury
- Tracheo-bronchial Injury
PENETRATING THORACIC INJURIES

- Low velocity missile

- High velocity missile
PENETRATING THORACIC TRAUMA

- 40% Penetrating Injury Involves the Thorax
- 15-28% of Penetrating Thoracic Injuries Require Thoracotomy
PENETRATING THORACIC TRAUMA

• Distribution of Organ Injury
  – Chest Wall 100%
  – Lung 65-90%
  – Heart 49%
  – Diaphragm 30%
  – Intra-Abdominal Injury
    • Liver 20%
    • Stomach 8%
    • Small intestine 7%
    • Colon 6%
    • Kidney 5%
Mechanisms of Early Death after Thoracic Injury

- Airway Obstruction
- Loss of Oxygenation or Ventilation
- Exsanguination
- Cardiac Failure
- Cardiac Tamponade
- Air Embolism
ATLS Algorithm

- A – Airway (with c-spine protection)
- B – Breathing (pleural drainage)
- C – Circulation (stop the bleeding)
- D – Disability (neuro status, fractures)
- E – Exposure (temperature, pain)
RECOGNITION OF TREATABLE LIFE-THREATENING INJURIES

- Tension Pneumothorax
- Cardiac Tamponade
TENSION PNEUMOTHORAX

- Physical Exam
  - Unilateral absence of breath sounds
  - JVD
  - Hypotension
  - Tracheal deviation

- CXR
TENSION PNEUMOTHORAX

- Treatment:
  - Needle thoracostomy
    - (buy time)
  - Chest-tube
    - (definitive)
CARDICAC TAMPONADE

- Physical Exam

- FAST/ECHO
Pulsus Paradoxus
CARDICAC TAMPONADE

• Treatment
  – Drainage
    • Surgical
      – L thoracotomy
      – Laparotomy
        (with pericardial window)
      – Median Sternotomy
    • Pericardiocentesis
THORACIC TRAUMA

• All major thoracic trauma requires treatment by a surgeon.
Thoracic Incisions Used in Trauma

- Anterolateral Thoracotomy
- Supraclavicular/trap-door incision
- Thoracocervical incision
- Thoracoabdominal incision
- Median Sternotomy
- Combinations of the above
RESUSCITATIVE (ER) THORACOTOMY

INDICATIONS
TECHNIQUE
RESUSCITATIVE (ER) THORACOTOMY

10-15% of Thoracic Trauma patients will require Resuscitative Thoracotomy
Indication for ERT

- Penetrating thoracic trauma with
  - Recent loss of signs of life followed by
  - acute hemodynamic deterioration
- Penetrating abdominal trauma with
  - signs of life on admission followed by
  - acute hemodynamic deterioration
- Selected Blunt thoracic trauma with
  - signs of life on admission followed by
  - observed acute hemodynamic deterioration
Contraindication to ERT with Presentation to ER

- Blunt trauma without signs of life
- Penetrating torso trauma without signs of life at the scene
- No cardiac activity in the absence of tamponade by FAST Exam
Purpose of ERT

• Terminate Exsanguination
  – Cardiac
  – Non-cardiac
• Relieve Cardiac Tamponade
• Open Chest CPR
• Treatment of Massive Air Embolism
• Thoracic Aortic Cross-clamping
Technique of ERT
Resuscitative (ER) Thoracotomy
Anterio-lateral Thoracotomy

- Rapid, versatile incision
- Can expose left subclavian veins if made higher than usual
- Can be extended into clam shell or trap door
Resuscitative Thoracotomy

OVERALL SURVIVAL

- Overall 0-70%

- Penetrating 9-70%
  - Stab wounds 70%
  - GSW 9-33%

- Blunt 0-2.5 %

Asensio JA, Berne JD, Demetriades D et al. 'One hundred five penetrating cardiac injuries: A 2-year prospective evaluation'. J Trauma 1998;44:1073-108
Tyburski JG, Astra L, Wilson RF et al. 'Factors affecting prognosis with penetrating wounds of the heart'. J Trauma 2000;48:587-590
Branney SW, Moore EE, Feldhaus KM et al. 'Critical analysis of two decades of experience with postinjury emergency department thoracotomy in a regional trauma center'. J Trauma 1998;45:87-95
Campbell NC, Thomson SR, Muckart DJJ. 'Review of 1198 cases of penetrating cardiac trauma'. Br J Surg 1997;84:1737-1740
25-year-old man with cardiac herniation after motorcycle accident
Specific Challenges in Thoracic Trauma

- Thoracic Aortic Injury
- Cardiac Injury
THORACIC AORTIC INJURY

- Mechanism: rapid deceleration produces shearing injury between fixed and mobile portions of the aorta.
DISTRIBUTION OF AORTIC INJURIES
Effect of isthmic rupture on peripheral arterial pressure.

Reduced pressure in left arm
(N.B. reduced pressure in right arm usually signifies avulsion of innominate artery).

Reduced pressure in lower limbs (see 944).

Pressure reduced virtually to nil in distal aorta
(intimal flap, see 972, 975).
Incomplete isthmic rupture with increasingly extensive and obstructive intimal flap (pseudo-coarctation).
Traumatic Aortic Dissection/Rupture

- 15% of fatal MVC victims have aortic rupture
- 85% die instantaneously
- 10-15% survive to hospital
- 21% die within six hours
- 31% die within 24 hours
- 84% die within 4 months
- **Must** have high index of suspicion

Parmly et al (Circulation 1958)
DIAGNOSIS OF BAI

• Chest X-ray
• Aortography
• Thoracic CT SCAN
• Thoracic MRI
• Cardiac Echo (TEE)
MEDIASTINAL WIDENING
If it is the result of a ruptured aorta, the mediastinal widening can be:

- Unilateral
- Bilateral
- Rectilinear
- Curved
- Sharply defined
- Ill-defined
CXR FINDINGS
in 259 patients with blunt aortic injury.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Count (Percentage)</th>
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<tbody>
<tr>
<td>Wide mediastinum</td>
<td>221 (85)</td>
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<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><strong>Negative x-ray</strong></td>
<td><strong>19 (7)</strong></td>
</tr>
</tbody>
</table>

* Numbers in parentheses are percentage of x-ray films with the particular finding.
Thoracic Aortic Injury

Chest X-ray
  ideally head-up, NG tube
  abnormal mediastinum
  normal mediastinum

CT Scan
  with contrast
  normal
  abnormal or equivocal
  stop

Angiography
BAI: DEFINITIVE DIAGNOSIS

- Thoracic CT
- Angiography
- TEE (operator dependent)
BAI: DEFINITIVE DIAGNOSIS
Helical CT vs. Angiography

Conclusion: CT comparable to Aortography

<table>
<thead>
<tr>
<th></th>
<th>HCTT</th>
<th>Aortography</th>
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</thead>
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<tr>
<td>True positive</td>
<td>71</td>
<td>56</td>
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<tr>
<td>True negative</td>
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<td>False positive</td>
<td>70</td>
<td>2</td>
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<tr>
<td>Indeterminate</td>
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<tr>
<td>“Aortic injury”</td>
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<tr>
<td>False negative</td>
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<td>Sensitivity</td>
<td>100%</td>
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<td>Specificity</td>
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<tr>
<td>Accuracy</td>
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<td>97%</td>
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<tr>
<td>Positive predictive value</td>
<td>50%</td>
<td>97%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>100%</td>
<td>97%</td>
</tr>
</tbody>
</table>

HCTT = helical computed tomography of the thorax.
BAI: DEFINITIVE DIAGNOSIS
TEE vs. Angiography

A Prospective Analysis of Transesophageal Echocardiography in the Diagnosis of Traumatic Disruption of the Aorta

Abstract

Objective: Recently, transesophageal echocardiography (TEE) has been proposed as the standard for the diagnosis of traumatic disruption of the aorta (TDA), replacing angiography. The purpose of this study was to evaluate the accuracy and practicality of TEE in the diagnosis of TDA.

Methods: Prospective clinical trial

Materials and Methods: Patients with blunt trauma admitted with a suspected diagnosis of TDA were evaluated with TEE and angiography.

Measurements and Main Results: Thirty-four patients were evaluated with TEE and angiography. TEE was unsuccessful in five patients (15%). Of the remaining 29 patients, TEE results were negative in four and positive in 25. TEE results were false positive in two patients and three injuries were missed (two were present to the left subclavian artery and one was a localized aortic disruption). Sensitivity and specificity of TEE were 57% and 91%, respectively, compared to angiography, for which sensitivity was 99% and specificity was 100%.

Conclusion: Although the use of TEE in the diagnosis of TDA has several advantages, it is not more accurate than angiography. TEE should not replace angiography as the standard for the diagnosis of TDA.

Conclusion: TEE is an inferior imaging Modality compared to aortography (and CT).
TREATMENT OPTIONS IN BAI

• Pre-surgical pharmacologic treatment:
  – β Blocker (dP/dT reduction)
  – HR < 100; MAP < 70

• Surgical therapy
  – Clamp-and-sew
  – Bypass

• Endovascular Stent Therapy
PARTIAL BYPASS

- Decrease upper body hypertension
- Perfusion to lower body (gut/kidney/liver)
- Prevent spinal cord ischemia/infarction
DATA SUPPORTING THE USE OF BYPASS FOR SURGICAL TREATMENT OF BAI

Prospective Study of Blunt Aortic Injury: Multicenter Trial of the American Association for the Surgery of Trauma


From the University of Tennessee (T.C.F., W.A.C.), Memphis Tennessee, University of Louisville (J.O.R.), Louisville, Kentucky, The Pennsylvania State University (J.S.A.), Hershey, Pennsylvania; Methodist Hospital of Indiana, Inc., (C.P.R.), Indianapolis, Indiana, University of Kentucky Chandler Medical Center (J.L.K.), Lexington, Kentucky; Erie County Medical Center (W.H.C.), Buffalo, New York; Harrison County Medical Center (A.L.N.), Harrison, Arkansas; University of Cincinnati Medical Center (T.A.H.), Cincinnati, Ohio; University of California at Davis (D.H.K.), Sacramento, California; Ellicott Regional Trauma Center (R.B.K.), Great Falls, Montana; Ohio State University (G.A.L.), Columbus, Ohio; Massachusetts General Hospital (J.C.K.), Boston, Massachusetts; St. John's Regional Health Center (J.C.), Springfield, Missouri; University of California (D.H.K.), San Diego, California; Vanderbilt University (J.A.R.), Nashville, Tennessee, Washington Hospital Center (J.S.H.), Washington, DC; University Medical Center (K.W.), Pittsburgh, Pennsylvania; Denver General Hospital (J.B.L.), Denver, Colorado; and Severn's Institute (C.H.), St. Louis, Missouri; and University of California (D.H.K.), San Diego, California; University of Texas Medical Branch (S.A.C.), Galveston, Texas; University of North Carolina (J.B.B.), Chapel Hill, North Carolina; and New York University Hospital Medical Center (J.B.L.), New York City.

Address for reprints: Timothy C. Fabian, MD, 966 Court Avenue, Room 230, Memphis, TN 38163.

Abstract

Background: Blunt aortic injury is a major cause of death from blunt trauma. Evolution of diagnostic techniques and methods of operative repair have altered the management and posed new questions in recent years.

Methods: This study was a prospective, multicenter trial involving 61 trauma centers in North America under the direction of the Multinational Trauma Committee of the American Association for the Surgery of Trauma.

Results: There were 274 blunt aortic injury cases studied over 2.5 years, of which 81% were caused by automobile crashes. Chest computed tomography and four-vessel echocardiography were applied in 88 and 30 cases, respectively, and were 75 and 90% diagnostic, respectively. Two hundred seven stable patients underwent planned fenestration and repair. Clamping and repair technique was used in 73 (65%) and transalvea techniques in 134 (90%). Overall mortality was 31%, with 63% of deaths being attributable to aortic rupture, mortality was not affected by method of repair. Paraplegia occurred postoperatively in 8.7%. Logistic regression analysis demonstrated and operated clamp time of greater than 30 minutes (p=0.002) and aortic cross clamp time of greater than 60 minutes (p=0.01) to be associated with development of postoperative paraplegia.

Article Outline

- Abstract
- Methods
- Results
- Diagnostics
- Operative Repair and Outcome
- Discussion
- Acknowledgments
- Paper Discussion
- References
- Citing Articles

Figures/Tables
USE OF CENTRIFUGAL PUMP FOR BAI

Multicenter Trial: 207 patients; 1997

<table>
<thead>
<tr>
<th>Operative Technique</th>
<th>n</th>
<th>Paraplegia (%)</th>
<th>Mortality (%)</th>
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<tbody>
<tr>
<td>Bypass</td>
<td>134</td>
<td>6 (4.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20 (14.9)</td>
</tr>
<tr>
<td>Gott shunt</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Full bypass</td>
<td>22</td>
<td>1 (4.5)</td>
<td>5 (22.7)</td>
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<tr>
<td>Partial bypass</td>
<td>39</td>
<td>3 (7.7)</td>
<td>5 (12.8)</td>
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<tr>
<td>Centrifugal pump</td>
<td>69</td>
<td>2 (2.9)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10 (14.5)</td>
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<tr>
<td>Clamp and sew</td>
<td>73</td>
<td>12 (16.4)&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>11 (15.1)</td>
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</table>

<sup>a</sup> p < 0.004 bypass versus clamp and sew.
<sup>b</sup> p < 0.01, centrifugal pump versus clamp and sew.

Conclusion: Bypass is associated with a decreased paraplegia rate when used in BAI → Standard of Care.
ENDOVASCULAR THERAPIES
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY

Where do we stand?
Available Devices

- **GORE TAG**
  - FDA approved

- **Medtronic Talent™**
  - FDA approved
  - VALOR Study (non-traumatic thoracic aortic aneurysms)
  - 99.5 successful deployment
  - All cause death rate: 16.1 vs. 29.8 (p<0.01)

- **COOK Zenith® TX2**
  - FDA approved
  - 2-piece modular thoracic endograft
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY

The Journal of TRAUMAT Injury, Infection, and Critical Care

Endovascular Stent Grafts for Acute Blunt Aortic Injury

<table>
<thead>
<tr>
<th>Center</th>
<th>Patient</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>ISS</th>
<th>Total LOS (days)</th>
<th>ICU LOS (days)</th>
<th>Mortality</th>
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<td>4</td>
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CHR, Calgary Health Region; HMC, Harborview Medical Center; ISS, Injury Severity Score; LOS, length of stay; ICU, intensive care unit; F/U, follow-up.

Patients and Methods

A retrospective review from the CHR and HMC was conducted of patients who underwent endovascular stent grafts for acute blunt aortic injury from 1999 to 2003. A total of 16 patients were included in the analysis. The average age of the patients was 46 years, with a median ISS of 25. The average length of stay was 21 days, with an average ICU stay of 14 days. There were no deaths among the patients. The follow-up period ranged from 30 to 72 days.

The objective of this study was to determine the outcomes of endovascular stent grafts for acute blunt aortic injury (BAI). The results showed that endovascular stent grafts are a safe and effective treatment option for acute blunt aortic injury, with a low mortality rate and excellent long-term outcomes.
Endovascular stent grafts for acute blunt aortic injury

Retrospective Review
University of Western Ontario
2004
18 patients
6 Stent
12 Open

Management of Blunt Thoracic Aortic Injuries: Endovascular Stents versus Open Repair

Michael C. Oei, MD, Tanya Charyk Stewart, MDc, D. Kirk Lawlor, MD, Daryl K. Gray, MD, and Thomas L. Forbes, MD

Background: Endovascular stent graft (EV) technology has been successfully adapted to the repair of blunt traumatic aortic injuries. The purpose of this study was to compare the outcomes of patients treated with EV stent grafts to those treated with open repair.

Methods: A retrospective review of patients identified from the trauma database at the University of Western Ontario between 1992 and 2004 was conducted.

Results: Over an 11-year period, 18 patients underwent repair of a blunt thoracic aortic injury (EV, 6; open, 12). There were no significant differences in demographics, injury severity scores, or complications between the groups. The EV group had a median total PRBC transfusion of 2.33 units compared to 7.33 units in the open group (p = 0.16). No deaths occurred in the EV group compared to 1 death in the open group (p = 0.05). There were no major complications in the EV group compared to 12 complications in the open group (p = 0.03).

Conclusion: We observed a clear trend toward improved outcomes after EV repair of thoracic aortic injuries.

Table 5 Transfusion Requirements

<table>
<thead>
<tr>
<th>Blood product</th>
<th>Stent Group (n = 6)</th>
<th>Open Group (n = 12)</th>
<th>Fisher’s Exact Test p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean total PRBCs</td>
<td>2.33</td>
<td>7.33</td>
<td>0.16</td>
</tr>
<tr>
<td>Mean total PLTs</td>
<td>0.50</td>
<td>5.60</td>
<td>0.28</td>
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<tr>
<td>Mean total FFPs</td>
<td>1.00</td>
<td>6.75</td>
<td>0.34</td>
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Table 6 Mortality and Morbidity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stent Group (n = 6)</th>
<th>Open Group (n = 12)</th>
<th>Fisher’s Exact Test p Value</th>
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<tbody>
<tr>
<td>Deaths</td>
<td>0</td>
<td>2</td>
<td>0.05</td>
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<tr>
<td>Paraplegia</td>
<td>0</td>
<td>1</td>
<td>0.32</td>
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<tr>
<td>Recurrent laryngeal nerve injury</td>
<td>0</td>
<td>1</td>
<td>0.03</td>
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<tr>
<td>Major adverse outcomes (death, paraplegia, recurrent laryngitis)</td>
<td>0</td>
<td>5</td>
<td>0.25</td>
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<tr>
<td>Perioperative complications</td>
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<td>ARDS</td>
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<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tracheostomy postoperatively</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
| ARDS, acute respiratory distress syndrome; MI, myocardial infarction; PE, pulmonary embolism.

Table 7 Hospital Stay

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stent Group (n = 6)</th>
<th>Open Group (n = 12)</th>
<th>Fisher’s Exact Test p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU days</td>
<td>6.5</td>
<td>6.5</td>
<td>0.03</td>
</tr>
<tr>
<td>Range</td>
<td>3-28</td>
<td>3-85</td>
<td></td>
</tr>
<tr>
<td>Ventilator days</td>
<td>0-16</td>
<td>1-85</td>
<td></td>
</tr>
</tbody>
</table>

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Association for Academic Surgery, 2006

The Midterm Results of Stent Graft Treatment of Thoracic Aortic Injuries¹

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Submitted for publication January 8, 2006

Introduction and objectives. Several publications document the technical feasibility of stent graft repair of aortic transection. We report our mid-term results of endoluminal repair of thoracic aortic transections using covered stent grafts and compare this to a cohort undergoing open repair during the same time period to demonstrate the shift in practice pattern at our institution.

Materials and methods. A retrospective review of patients who sustained blunt thoracic transection was undertaken. Medical records were examined to identify the clinical outcome of the procedure, and follow-up CT scans were reviewed to document adequate treatment of the transection. Outcome measures include procedure-related mortality, neurological morbidity, and successful immediate and end-term coverage of the thoracic false aneurysm and absence of graft migration or endoleak.

Results. From July, 2000 to October, 2004, 27 patients were identified with descending thoracic aortic transection at our level I trauma center. Fourteen patients were managed nonoperatively, five patients underwent thoracotomy and direct aortic repair, and eight patients underwent endoluminal stent graft repair. Of the endovascular group (n = 5), repairs were performed with stacked AneuRx aortic cuffs (Medtronic, Inc., Minneapolis, MN) (n = 4), a Gore thoracic aortic stent graft (Thoracic EXCLUDER; W.L. Gore, Flagstaff, AZ) (n = 1), or a Medtronic Talent thoracic endograft (Medtronic, Inc.) (n = 1). Access for stent graft deployment was the common femoral artery (n = 3), iliac artery (n = 4), or distal abdominal aorta (n = 2). Completion arch aortography and postoperative CT scanning confirmed successful management of the aortic transection in each patient. There were no procedure-related deaths, paraplegia, or stroke. Postoperative complications included a brachial artery thromboembolus in one patient as well as an external iliac artery dissection and acute renal failure in a second patient for a complication rate of 37.5%. Two patients died as a result of their injuries unrelated to the stent graft repair. Mean follow-up of 16.8 mo has shown no evidence of endoleak or stent graft migration. Of the open repair group (n = 5), one patient died in the operating room during attempted aortic repair, and one patient had a postoperative stroke.

Conclusions. Due to technical success and absence of delayed complications including endoleak and graft migration, stent graft repair of traumatic aortic transection has replaced open aortic repair as the primary treatment modality in the multiply injured trauma patient at our institution. The postoperative complication rate observed in this small series tempers the success to some degree, but the severity of the complications compares favorably with those observed in the open repair group.

Key Words: Endovascular; Endograft; Aortic transection; Aortic injury; Stent-graft; Endoluminal.

INTRODUCTION

Aortic transection related to rapid deceleration is a highly lethal injury with pre-hospital mortality greater than 80% [1–3]. These individuals who survive do so because of the preserved integrity of the aortic adventitia, parietal pleura, and mediastinal structures. The traditional management of such patients has been direct surgical repair of the aortic transection with an interposition graft, which is a formidable operation with substantial associated morbidity and mortality [2].

Comparison of Endovascular and Open Repair Patients

<table>
<thead>
<tr>
<th></th>
<th>Endovascular patients</th>
<th>Thoracotomy patients</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>14</td>
<td>5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>30.8</td>
<td>40.6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean ISS</td>
<td>46</td>
<td>29</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean OR time (minutes)</td>
<td>253</td>
<td>252</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean ICU LOS (days)</td>
<td>14</td>
<td>23</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean total LOS (days)</td>
<td>28.8</td>
<td>29.3</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean Blood transfusion (units)</td>
<td>9.0</td>
<td>16.8</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Procedure-related mortality (%)</td>
<td>n/a</td>
<td>20</td>
<td>n/a</td>
</tr>
<tr>
<td>Paraplegia (%)</td>
<td>n/a</td>
<td>20</td>
<td>n/a</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Mean follow-up (months)</td>
<td>15.6</td>
<td>32.2</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

¹Poster presentation at the 1st Academic Surgical Congress, February 7-11, 2006, San Diego, CA.
²To whom correspondence and reprint requests should be addressed at Division of Vascular Surgery, University of Massachusetts Medical Center, 55 Lake Ave. North, Worcester, MA 01655. E-mail: mcphj@umassmc.org.

ISS = injury severity score; LOS = length of stay.
Retrospective Comparison

2008

30 patients

14 Stented

12 Open

Conclusion: Endovascular therapy is safer and as effective and open repair for BAI

Table 3 Complications in patients treated acutely with open surgical and endoluminal procedures

<table>
<thead>
<tr>
<th>Complication</th>
<th>Stented group (n = 14)</th>
<th>Open Surgical group (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>1 (7%)</td>
<td>2 (17%)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Endoleak</td>
<td>3 (21%)</td>
<td>—</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>1 (7%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Acute Limb Ischaemia</td>
<td>0</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Vascular Access Injury</td>
<td>2 (14%)</td>
<td>2 (14%)</td>
</tr>
<tr>
<td>Wound Complications</td>
<td>0</td>
<td>4 (28%)</td>
</tr>
<tr>
<td>DVT/PE</td>
<td>0</td>
<td>1 (8%)</td>
</tr>
</tbody>
</table>

Introduction

Thoracic aortic rupture or transection (TAT) is an acute and commonly fatal, deceleration or blunt injury, associated with multiple trauma. Rupture of the thoracic aorta is the second most common cause of death from motor vehicle

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10.1016/j.ejvs.2008.03.012
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY

- Evolving Technology
- No Level I data
- No Clinical Equipoise
- The Gold Standard within the next 2-5 years
OPERATIVE REPAIR OF THE INJURED HEART

Technique
LOCATION OF CARDIAC INJURY FROM PENETRATING TRAUMA

- Frequency of injury dependents on the location of penetration.
- 20 year study with 711 cardiac injuries
  - Right Ventricle- 40%
  - Left Ventricle- 40%
  - Right Atrium 24%
  - Left Atrium- 3%
  - Coronary arteries- 5%

Wall et al., J Trauma 42:905,1997
Maneuvers to control bleeding:

**MANUAL COMPRESSION**
Haemostasis by means of:

- A digit
- A tangential clamp
- A Foley catheter
CARDIAC INJURY
EXHAUSTIVE EVALUATION

• Cardiac Echo
• Cardiac Catheterization
• Definitive Repair
Predictors of Survival in Cardiac Trauma

Penetrating Cardiac Injuries: A Prospective Study of Variables Predicting Outcomes

Juan A. Asensio, MD, FACS, James Murray, MD, Demetrios Demetriades, MD, PhD, FACS, John Bernie, MD, Edward Connell, MD, FACS, George Velinas, MD, PhD, Hugo Gomez, MD, Thomas V. Bernie, MD, FACS

Background: Penetrating cardiac injuries are one of the leading causes of death from urban violence.

Study Design: This is a prospective, 1-year study in a Level I Trauma Center with the objective of analyzing: (1) the parameters measuring the physiologic condition of patients sustaining penetrating cardiac injuries in the field during transport and on arrival, (2) the cardiovascular respiratory score (CVRS) component of the trauma score, (3) the mechanism and anatomic site of injury, (4) the presence or absence of tamponade, and (5) the cardiac rhythm as a predictor of outcomes. We attempted to correlate cardiac injury grade (AST-AIOS) with mortality. Our main intervention was thoracotomy for resuscitation and definitive repair of cardiac injury. Main outcomes measures were all parameters measuring the physiologic condition of patients. CVRS, mechanism and anatomic site of injury, operative findings and maneuvers, mortality, and grade of injury.

Results: The study consisted of 60 patients sustaining penetrating cardiac injuries, 35 gunshot wounds (58%) and 25 stab wounds (42%). The Injury severity score (ISS) was > 30 in 22 patients; overall survival was 22 of 60 (36.6%); gunshot wound (GSW) survival, 5 of 35 (14%); and stab wound (SW) survival, 17 of 25 (68%). An emergency department thoracotomy was performed in 37 of 60 (61.7%) with 6 of 37 survivors (16%).

CVRS: 96% mortality (25 of 26) when CVRS = 0; 67% mortality (6 of 9) when CVRS = 1–3; and 25% mortality (7 of 25) when CVRS > 4 (p < 0.001).

Mechanism of injury and presence of sinus rhythm when pericardium opened predict outcomes (p < 0.001). Anatomic site of injury and tamponade do not predict outcomes (not significant).

AAST-AIOS injury grade and mortality: grade IV, 31 of 60 (52%); grade V, 20 of 60 (33%); and grade VI, 6 of 60 (10%).

Conclusions: Parameters measuring physiologic condition, CVRS, and mechanism of injury plus initial rhythm are significant predictors of outcomes in penetrating cardiac injuries. The need for aortic crossclamping and the inability to restore an organized rhythm or blood pressure after thoracotomy were also predictors of outcomes. The presence of pericardial tamponade was not. (J Am Coll Surg 1998;186:24–34. © 1998 by the American College of Surgeons)

Penetrating injuries of the heart are one of the leading causes of death from urban violence. Improvements in emergency medical services (EMS) systems during the past few years, along with the applied principle of “Scoop and Run,” are responsible for many more cardiac injury patients arriving alive, but “in extremis.”

During the past two decades, more than 30 series of patients with penetrating cardiac injuries have been reported in the English-language literature.1–32 Close scrutiny of these series reveals several flaws. Most if not all have been retrospective reviews, originating from institutions treating fewer than 15 cases of cardiac

• Prospective Study
• 60 patients (USC 1998)
• Parameters predictive of Survival:
  • Mechanism of injury
  • CVRS
  • Need for Ao x-clamping
  • Inability to restore original rhythm
THORACIC TRAUMA

- EPIDEMIOLOGY
  - Blunt Injury
  - Penetrating Injury
- SPECTRUM OF THORACIC TRAUMA
- APPROACHES TO THE TREATMENT
- RESUSCITATIVE THORACOTOMY
- SPECIFIC CHALLENGES IN THORACIC TRAUMA
  - Aortic Trauma
  - Cardiac Trauma