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%

DISTRIBUTION OF THORACIC INJURIES SECONDARY TO BLUNT TRAUMA

• Consequences of Chest Wall Injury:
  – Rib Fractures (most common chest wall injury in blunt trauma)
  – Hemothorax (70-80% of penetrating and major blunt injuries)
  – Flail Chest (Incidence 1.2% -- 20-40% mortality)
  – Sternal Fracture (5-8% in blunt trauma; 25-30% mortality)

• Consequences of Chest Wall Injury and Lung Injury
  – Pulmonary Contusion (30-75% of blunt trauma; mortality 14-20%)
  – Pneumothorax (10-30% in blunt injury; 95% in penetrating injury)
    • Simple
    • Open
    • Tension

• Consequences of Cardiac Injury
  – Pericardial Tamponade (usually associate with penetrating trauma)
  – Myocardial Contusion (most common blunt injury to heart)
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 INJURY

- 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

A Measuring pulsus paradoxus
- Sphygmomanometer cuff deflated
- Korotkoff sounds
  - First
  - Intermittent
  - Continuous
  - None
- Sphygmomanometer pressure, mm Hg
  - 120
  - 110
  - 100
  - 90
  - 80
  - 70
  - 60
- Presence of Korotkoff sounds
- Arterial blood pressure tracing
- Intrathoracic pressure

B Ventricular interdependence
- Cardiac tamponade
  - Inspiration
  - Expiration
- Normal
  - Inspiration
  - Expiration
- Effusion
  - Right ventricle
  - Left ventricle
CARDICAC TAMPONADE

- Treatment
  - Drainage
    - Surgical
      - L thoracotomy
      - Laparotomy (with pericardial window)
      - Median Sternotomy
    - Pericardiocentesis

![Graph showing pressure over time with critical tamponade phases]
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
Incision Choice for Tracheal Injury

Maximum resection of upper trachea (Grillo, 1969)

Maximum resection of lower trachea (Grillo, 1969)
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%

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

[Diagram showing distribution of aortic injuries with percentages for Arch, Isthmus, Ascending aorta, and Descending aorta.]
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</th>
<th>Percentage</th>
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<td>Wide mediastinum</td>
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<td>(85)</td>
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<tr>
<td>Indistinct aortic knob</td>
<td>63</td>
<td>(24)</td>
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<tr>
<td>Left pleural effusion</td>
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<td>(19)</td>
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<tr>
<td>Apical cap</td>
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<tr>
<td>First and/or second rib fracture</td>
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<td>(13)</td>
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<td>Tracheal deviation</td>
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<td>(12)</td>
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<tr>
<td>Depressed left bronchus</td>
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<td>(5)</td>
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<tr>
<td>NG tube deviation</td>
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<td>(11)</td>
</tr>
<tr>
<td><strong>Negative x-ray</strong></td>
<td>19</td>
<td>(7)</td>
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</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

CT Scan
with contrast

normal

abnormal or
equivocal

stop

stop

Angiography
BAI: DEFINITIVE DIAGNOSIS

• Thoracic CT

• Angiography

• TEE (operator dependent)
### BAI: DEFINITIVE DIAGNOSIS

**Helical CT vs. Angiography**

**Conclusion:** CT comparable to Aortography

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<th>HCTT</th>
<th>Aortography</th>
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<td>True positive</td>
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<td>False positive</td>
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<td>Indeterminate</td>
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<td>&quot;Aortic injury&quot;</td>
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<td>Sensitivity</td>
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</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

Minard, Gage MD, Schuur, Michael J. MD, Croce, Martin A. MD, Goyant, Morris L. MD, Kudsk, Kenneth A. MD, Taylor, Martha J. RN, Pichard, F. Elizabeth MD, Fabian, Timothy C. MD

From the Department of Surgery (K.A., M.J.C., M.A.C., K.K.P., T.C.F.) and Department of Radiology (M.L.G.), The University of Tennessee, Memphis, Memphis, Tennessee.

Presented at the Eight Annual Scientific Session of the Eastern Association for the Surgery of Trauma, January 11-14, 1995, Seattle, WA.

Address for reprints: Gage Minard, MD, The University of Tennessee, Memphis, Department of Surgery, 650 Court Avenue, Suite 622B, Memphis, TN 38163.

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 practicability of TEE in the diagnosis of TDA.

Design: Prospective clinical trial.

Materials and Methods: Patients with blunt trauma admitted with a suspected diagnosis of TDA were evaluated with TEE and angiography. Patients were evaluated within four and twenty-four hours in 20 TEE results were performed in 2 patients, and two injuries were missed (two were proceed to the left subclavian artery, and one was a localized aortic disruption). Sensitivity and specificity of TEE were 97% and 91%, respectively, compared with 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

- 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
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.D.R., L.W.), Louisville, Kentucky; The Pennsylvania State University (J.S.S.), Hershey, Pennsylvania; Methodist Hospital of Indiana, Inc. (S.P.H.), Indianapolis, Indiana; University of Kentucky Chandler Medical Center (A.A.), Lexington, Kentucky; Erie County Medical Center (G.H.), Buffalo, New York; Harrison County Medical Center (A.L.N.), Harrison, Ohio; University of Arkansas (B.E.), Little Rock, Arkansas; University of Cincinnati Medical Center (F.A.L.), Cincinnati, Ohio; University of California at Davis (D.H.), Sacramento, California; Bittner Regional Trauma Center (D.L.), Graphi, Wayland, Michigan; Ohio State University (S.B.L.), Columbus, Ohio; Massachusetts General Hospital (J.A.C.), Boston, Massachusetts; St. John's Regional Health Care (P.C.), Springfield, Massachusetts; University of California at Berkeley (G.D.), San Diego, California; Wake Forest University (J.T.), Martinsville, Tennessee; Washington Hospital Center (J.G.), Washington, DC; University Medical Center (R.G.), Pittsburgh, Pennsylvania; Drexel College of Medicine (S.R.B.), Houston, Texas; Brigham and Women's Hospital (L.G.H.), Boston, Massachusetts; University of Southern California (W.M.), Los Angeles, California; Wright State University (M.S.R.), Dayton, Ohio; St. Jude's Hospital (D.F.L.), Lexington, Kentucky; University of Alabama at Birmingham (S.E.M.), Birmingham, Alabama; University of Southern California (J.W.), Los Angeles, California; Appalachian Regional Medical Center (R.H.), Johnson City, Tennessee; University of South Carolina (C.L.M.), Columbia, Missouri; University of Texas Memorial Hospital of Central Texas (D.A.C.), Austin, Texas; University of North Carolina (B.H.), Chapel Hill, North Carolina; New York University (S.O.C.), New York; University of Kentucky (R.G.M.), Lexington, Kentucky; University of Alabama at Birmingham (J.J.), Birmingham, Alabama; University of Texas Southwestern Medical Center (R.B.), Dallas, Texas; University of California (B.L.), San Francisco, California; University of South Alabama (R.R.), Mobile, Alabama; and University of Tennessee (B.L.), Knoxville, Tennessee.

Presented at the 50th Annual Meeting of the American Association for the Surgery of Trauma, September 18–21, 1996, Houston, Texas.

Address for reprints: Timothy C. Fabian, MD, 666 Court Avenue, Room 2219, Memphis, TN 38103.

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 60 trauma centers in North America under the direction of the Multinstitutional Trial 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 transesophageal echocardiography were applied in 98 and 30 cases, respectively, and were 75 and 90% diagnostic, respectively. Two hundred seven stable patients underwent planned thoracotomy and repair. Clamping and repair technique was scored in 23 (95%) and bypass techniques in 133 (90%). Overall mortality was 31%, with 63% of deaths being attributable to aortic occlusion or rupture; mortality was not affected by method of repair. Paraplegia occurred postoperatively in 8.7%. Logistic regression analysis demonstrated a clamp and sew time of > 103 minutes (odds ratio 1.7) to be associated with development of postoperative paraplegia.

Article Outline

- Abstract
  - METHODS
  - RESULTS
  - Diagnostics
    - Operative Repair and Outcome
  - DISCUSSION
  - Acknowledgements
  - PAPER DISCUSSION
  - REFERENCES
  - Citing Articles

Figures/Tables


## USE OF CENTRIFUGAL PUMP FOR BAI

Multicenter Trial: 207 patients; 1997

<table>
<thead>
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<th>Operative Technique</th>
<th>n</th>
<th>Paraplegia (%)</th>
<th>Mortality (%)</th>
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<tr>
<td>Bypass</td>
<td>134</td>
<td>6 (4.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20 (14.9)</td>
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<tr>
<td>Gott shunt</td>
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<td>0</td>
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<td>Full bypass</td>
<td>22</td>
<td>1 (4.5)</td>
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<td>Partial bypass</td>
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<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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<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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<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 $\rightarrow$ Standard of Care.
SURGICAL REPAIR OF BAI
ENDOVASCULAR THERAPIES
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY

Where do we stand?
ENDOVASCULAR STENT GRAFTS FOR ACUTE BLUNT AORTIC INJURY

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 TRAUMA Injury, Infection, and Critical Care

Endovascular Stent Grafts for Acute Blunt Aortic Injury

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<tr>
<th>Center</th>
<th>Patient</th>
<th>Age (yr)</th>
<th>Sex</th>
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<th>Total LOS (days)</th>
<th>ICU LOS (days)</th>
<th>Mortality</th>
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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.

Despite a yield in 99% to 100% of cases, about 10% of patients who initially survive the injury die before operative intervention. Typically, these patients are young, with severe comorbid head, chest, abdominal, and orthopedic injuries. The surgical standard of care has been early operative repair with thoracotomy and graft interposition, with a mortality rate of 5% to 28%4-7 and a cardia infarction-related paraplegia risk of 9% to 19%.3,5,6 Recent data suggest that delaying the repair to treat comorbidities in stable patients decreases morbidity and mortality without a concurrent increase in rupture risk.9-11

The objective of this study was to determine the outcome of EVSG for acute BAI at two tertiary (Level I) trauma centers, the Calgary Health Region (CHR), in Calgary, Alberta, Canada, and Harborview Medical Center (HMC) in Seattle, Washington.

PATIENTS AND METHODS

A retrospective review from the CHR and HMC was...
Management of Blunt Thoracic Aortic Injuries: Endovascular Stents versus Open Repair

Michael C. Ott, MD, Tanya Charyk Stewart, MSc, 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 repair versus open repair over an 11-year period.

Methods: A retrospective review of all patients younger than 60 years with blunt aortic injury treated at the University of Western Ontario from January 1997 to December 2007 was performed. The outcomes were compared between the EV and open repair groups.

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, or crack statistics between groups. The mean age was similar between the EV and open groups, and the EV group had a shorter mean hospital stay and ICU stay.

Conclusion: The EV group showed a trend toward improved outcomes after adjusting for confounding factors.

Table 5: Transfusion Requirements

<table>
<thead>
<tr>
<th>Variable</th>
<th>EV (n = 6)</th>
<th>Open (n = 12)</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Mean total PRBCs</td>
<td>2.33</td>
<td>7.33</td>
<td>0.16</td>
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<td>Mean total PLT</td>
<td>0.50</td>
<td>5.60</td>
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<td>Mean total FFP</td>
<td>1.00</td>
<td>6.75</td>
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Table 6: Mortality and Morbidity

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<tr>
<th>Variable</th>
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<th>Open (n = 12)</th>
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<td>Deaths</td>
<td>0 0.00%</td>
<td>2 16.67%</td>
<td>0.53</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0 0.00%</td>
<td>1 8.33%</td>
<td>0.52</td>
</tr>
<tr>
<td>Recurrent laryngeal nerve injury</td>
<td>0 0.00%</td>
<td>1 8.33%</td>
<td>0.52</td>
</tr>
<tr>
<td>Major adverse outcomes (death, paraplegia, recurrent laryngeal nerve)</td>
<td>0 0.00%</td>
<td>5 41.67%</td>
<td>0.16</td>
</tr>
<tr>
<td>Perioperative complications</td>
<td>ARDS</td>
<td>0 0.00%</td>
<td>1 8.33%</td>
</tr>
<tr>
<td></td>
<td>Sepsis</td>
<td>0 0.00%</td>
<td>1 8.33%</td>
</tr>
<tr>
<td></td>
<td>MI</td>
<td>0 0.00%</td>
<td>2 16.67%</td>
</tr>
<tr>
<td></td>
<td>Tracheostomy postoperatively</td>
<td>1 16.67%</td>
<td>4 33.33%</td>
</tr>
<tr>
<td></td>
<td>Arrhythmia</td>
<td>2 33.33%</td>
<td>2 16.67%</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>1 16.67%</td>
<td>1 8.33%</td>
</tr>
</tbody>
</table>

Table 7: Hospital Stay

<table>
<thead>
<tr>
<th>Variable</th>
<th>EV (n = 6)</th>
<th>Open (n = 12)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU days Median</td>
<td>6.5</td>
<td>6.5</td>
<td>0.63</td>
</tr>
<tr>
<td>Range</td>
<td>3-28</td>
<td>3-28</td>
<td></td>
</tr>
<tr>
<td>Ventilator days Median</td>
<td>0-16</td>
<td>0-16</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0-85</td>
<td>0-85</td>
<td></td>
</tr>
</tbody>
</table>

ARDS, acute respiratory distress syndrome; MI, myocardial infarction; PE, pulmonary embolism.
Association for Academic Surgery, 2006

The Midterm Results of Stent Graft Treatment of Thoracic Aortic Injuries

James T. McPhee, M.D., Emaad H. Asham, M.D., Michael J. Rohrer, M.D., Michael J. Singh, M.D., Geoffrey Wong, M.D., Robert W. Vorhies, M.D., Peter R. Nelson, M.D., and Bruce S. Cutter, M.D.

Division of Vascular Surgery, University of Massachusetts Medical Center, Worcester, Massachusetts

Submitted for publication January 9, 2006

Introduction and objectives. Several publications document the technical feasibility of stent graft repair of aortic transection. We report our mid-term results of endovascular 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 midterm 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 = 8), repairs were performed with stacked AneuRx stent grafts (Medtronic, Inc., Minneapolis, MN) (n = 6), a Gore thoracic aortic stent graft (Thoratec 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 = 5), iliac artery (n = 4), or distal abdominal aorta (n = 2). Completion aortic arch arteriography 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 thrombosis in one patient as well as an external iliac artery dissection and acute renal failure in a second patient for a complication rate of 28.6%. 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.

Keywords: 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>8</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>36</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>22</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>Paralysis (%)</td>
<td>n/a</td>
<td>n/a</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>16.6</td>
<td>32.2</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

ISS = injury severity score; LOS = length of stay.
Improved Outcomes with Endovascular Stent Grafts for Thoracic Aorta Transsections

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b Westmead Hospital, Hawkesbury Road, Wentworthville, Sydney, NSW, Australia

Submitted 29 August 2007; accepted 28 March 2008

Abstract  Objective: To retrospectively assess the outcome of endovascular stent-graft implantation for thoracic aortic transections (ETAT). Design: Retrospective review. Methods: 16 patients median age 30 years, treated between May 2000 and April 2007. Median injury severity score was 33 (range 29 to 66) in 14 acute patients; 2 patients had thoracic pseudoaneurysms. The Cook Zenith endograft was used in eight patients, Medtronic Talent (6) and Gore-Excluder (2). Average procedure time was 90 minutes, blood loss 100 (range 40 to 3000) mL, screening time 10.8 (range 5.9 to 22.6) minutes, and contrast dose was 195 (range 60 to 400) mLs. Results: Graft deployment was successful in all cases. There was one death within 30 days. The left subclavian artery was completely covered in one case, and partially in three. Two patients had Type I endoleak, and one delayed Type II endoleak. One patient had intortotic right coronary artery dissection. Two patients developed difficult to treat hypertension, and one acute renal failure. Conclusion: Endovascular intervention is a safe and effective treatment for aortic transection in multiple trauma patients. ETAT reduces the major morbidity and mortality associated with open repair in multiple trauma patients. The majority of these patients are young and long-term follow up is necessary to assess graft durability.

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

<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>

* Corresponding author. Dr I.V. Mohan, MBBS, MD, FRCS, FRACS, P.O. Box 653, Westmead, Sydney, NSW 2145, Australia. Tel.: +61 2 9845 6831; fax: +61 2 9843 7440. E-mail address: irvin.mohan@doctors.org.au (I.V. Mohan).

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META-ANALYSIS

REVIEW ARTICLE

From the Southern Association for Vascular Surgery

Meta-analysis of endovascular vs open repair for traumatic descending thoracic aortic rupture

Eleftherios S. Xenos, MD, PhD, Nicholas N. Abedi, MD, Daniel L. Davie, PhD, David J. Minion, MD, Omar Hamdallah, MD, Ehab E. Sorial, MD, and Eric D. Endean, MD, Lexington, Ky.

Objectives: Traumatic thoracic aortic injuries are associated with high mortality and morbidity. These patients often have multiple injuries, and delayed repair is frequently used. Endovascular grafts offer an alternative to open surgical repair. We performed a meta-analysis of comparative studies evaluating endovascular vs open repair of these injuries.

Methods: A systematic review of studies reporting treatment of traumatic aortic injury was performed using the following databases: Medline, PubMed, CINAHL. Proquest, Up to Date, Database of Abstracts of Reviews of Effects (DARE), Clinical Trials.gov, the Cochrane Central Register of Controlled Trials, and the Cochrane Database of Systematic Reviews. Search terms were thoracic aortic trauma, traumatic thoracic aortic injury, traumatic aortic rupture, stern graft repair, and endovascular repair. Outcomes analyzed were procedure-related mortality, overall 30-day mortality, and paraplegia/paraparesis rate using odds ratio (OR) and 95% confidence intervals (CI). Publication bias was investigated using funnel plots. Assessment of homogeneity was performed using the Q test; statistical heterogeneity was considered present at $P<.15$. Weighted averages of age, interval to repair, and injury severity were compared with the Welch test; $P<.10$ was considered statistically significant.

Results: Seventeen retrospective cohort studies from 2003 to 2007 were included. All were nonrandomized; no prospective randomized trials were found. These studies reported on 889 patients; 869 were treated with open repair, and 220 underwent thoracic endograft placement. There was no significant difference in age (mean 38.8 years for both) or interval to repair (mean 1.5 days for endoluminal repair; 1 day for open repair). Injury severity score was higher for patients undergoing endoluminal repair (mean, 42.4 vs 37.4; for open repair, $P=.001$). Procedure-related mortality was significantly lower with endoluminal repair (OR, 0.31; 95% CI, 0.15-0.66; $P=.002$), Overall 30-day mortality was also lower after endoluminal repair (OR, 0.44; 95% CI, 0.25-0.78; $P=.005$). Sixteen studies reported data for postoperative paraplegia: 218 patients were treated with endograft placement and 333 with open repair. The risk of postoperative paraplegia was significantly lower with endoluminal repair (OR, 0.32; 95% CI, 0.1-0.69; $P=.037$). The Q test did not indicate significant heterogeneity for the outcomes of interest; publication bias was limited.

Conclusions: Meta-analysis of retrospective cohort studies indicates that endovascular treatment of descending thoracic aortic trauma is an alternative to open repair and is associated with lower postoperative mortality and spinal cord injury complication rates. (J Vasc Surg 2008;48:1343-51.)

Blunt rupture of the thoracic aorta is devastating, and most patients die at the time of injury. In order of frequency, rupture occurs as the aortic arch, the distal descending aorta, and the abdominal aorta. The force from rapid deceleration necessary to tear the aorta often leads to other organ injuries. Pace et al found that associated injuries were present in >90% of patients with aortic transection, and 24% of them required a major operation before aortic repair. More than 85% of motor vehicle occupants who sustain a thoracic aortic laceration extrinsically is the scene.3-7

From the Department of Surgery, University of Kentucky.

Cooperation of all authors.


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Traditional treatment of blunt traumatic aortic rupture has been early open surgical repair with graft reconstruction. Stannard et al found that thoracic aortic transection is associated with significant mortality ranging from 24% to 41%. Because of these considerations, tension less invasive, less traumatic methods of repair have developed. Dake et al in 1994 reported preliminary results indicating that endovascular stent graft repair is safe in highly selected patients with descending thoracic aortic aneurysms, and Semba et al in 1997 demonstrated that stent graft repair is technically feasible in acute rupture of the descending thoracic aorta. Results of several other clinical studies have shown successful emergency repair of acute thoracic aortic disease by endovascular means.8-10

- Tx
- LOS
- Paraplegia
- Mortality

1348
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
- Standard of Care
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
Penetrating Cardiac Injuries: A Prospective Study of Variables Predicting Outcomes

Juan A. Asemanio, MD, FACS, James Murray, MD, Demetros Demetriades, MD, PhD, FACS, John Berne, MD, Edward Conwell, MD, FACS, George Velmahos, MD, PhD, Hugo Gomez, MD, Thomas V. Berne, 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 (MST-OIS) 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 28) 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-OIS 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
Thoracic Trauma

• Recognition
  – Diagnosis
  – Severity/Lethality
• Early Treatment
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