Endovascular treatment of traumatic rupture of the thoracic aorta

Pavel Hoffmann

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Traumatic aortic rupture

Traumatic aortic rupture is the cause of death in ~20% of all road accident fatalities.
The majority (70-90%) die at the scene of the accident.
In those who reach hospital alive rapid diagnosis and treatment may be life saving.

**Location of injury**

Most common (80-90%): isthmus, just distal to the left subclavian artery – among those who reach hospital alive.


Few patients: descending thoracic aorta, hiatus diaphragmaticus, aortic arch.


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**Natural course**

- 70-90% die at the scene of the accident.
- 10-30% initial survival. In these patients, the rupture is contained by the the adventitia and surrounding mediastinal structures (pseudoaneurysm).
- Without treatment:
  - 10-15% of the initial survivors die the first hour
  - 20-30% die within 6 hours
  - 30-50% within one day
  - 60-70% within eight days
  - Many of these can be treated!

Coexisting injuries

90% have other organ injuries.
51% cerebral injury
62% other thoracic injury
22% intraabdominal injury
34% pelvic or extremity fractures


Radiology

Because the clinical manifestations often are meager and because the anamnestic information and clinical findings only can make us suspect aortic injury, radiologic examination is essential for the diagnosis of traumatic aortic injury.
Chest X-ray:

- Left pleural effusion
- Indistinct aortic arch
- Right paratracheal stripe thickening
- Left mainstem bronchus displaced

CT thorax

- Sensitivity: ~100%
- Specificity: ~99%  
Diagnostic CT findings

- Pseudoaneurysm
- Intraluminal wall flaps
- Thrombus
- Irregular aortic wall
- Intramural hematoma
- Dissection
- Pseudocoarctation
- Active contrast extravasation

Angiography

- Sensitivity / specificity: ~ CT
- Invasive with more complications compared to CT
- Less available than CT
- May be used when CT is equivocal
- Often combined with treatment

Mirvis SE et al 2007
The imaging end-points of reconstructed CT and conventional angiography are essentially similar.
Aortic injury?
Normal ductus diverticulum:
- smooth walls
- no intimal flap
- no delayed washout

From: Patel et al 1998

Aortic injury?
Normal broncho intercostal artery in the anteromedial istmus.

From: Patel et al 1998
Management of thoracic aortic injury

- Medical, non-operative treatment
  - Blood pressure control (SBP < 120 mmHg)
  - Most aortic injuries will need to be repaired
  - Some minor injuries may be managed non-operatively. Natural history unknown.
- Operative repair
- Endovascular repair

Endovascular treatment
MT with aortic injury

Technique – endovascular repair

- Vascular access / introducer outer diameter:
  - 20F ~ OD 7.6 mm
  - 22F ~ OD 8.3 mm
  - 24F ~ OD 9.2 mm
- Proximal neck > 10 mm
- Stent graft oversized by ~ 10-20 %
- Graft diameter 22 – 46 mm
- Stent graft 4 - 5 cm longer than lesion
Technique – endovascular repair

- Heparin 5000 IE
- Cefalotin (Keflin®) 2g x 4 iv
- Superstiff guide wire placed at the aortic root (.035", 260-300 cm, Meier Backup, Amplatz superstiff, Lunderquist)
- During graft release SBP is kept at 80 mmHg
- If satisfactory result: no balloon

Follow up - radiology

- If indicated, early, in-hospital CT
- 3 months: first control – CT
- 6 & 12 months, than once/year
- If possible, MRI after the first control
Follow up – CT (3 months)

M 15 years, skiing accident

Follow up – MRI (15 months)

M 19 years, car accident
**Ullevål university hospital surgical repair**

- Open repair 1993-2006
  - Mortality 8/25 = 32%
  - Technical difficulties 3/25 = 12%
  - Concomitant injuries 5/25 = 20%
  - Paraplegia 8/17 = 47%, permanent 2/17 = 12%  

**UUH – endovascular repair**

- 1st patient treated in 2003
- 18 patients
- Age: 35 years (15 - 61)
- 14 M, 4 F
- 12 motor, 4 fall, 2 sports
- Delay trauma – stent graft: 1,2 d (0 – 12)
- Delay after arrival UUH: 7 h (1 pat d 3 and 1 d 7)
UUH – associated injuries

- **Fractures**: 13 extremity, 6 vertebral, 7 pelvic, 10 costae, sternum, clavicula fractures …
- 5 cerebral hemorrhage
- 8 liver / spleen injury
- 4 pneumo thorax
- GCS 13 (3 – 15)
- ISS 34 (16 – 59)

UUH – Results

- Technical success 100 %
- Mortality 1/18 (6%), due to injury
- No paraplegia
- 3 patients had coiling of other bleedings
- 12 days at ICU (1-43), 17 days at UUH (1-54)
- Subclavian artery covered in 4 patients
- 1 arterial injury during insertion
- 1 malapposition → another graft
TAI: patient 1 (07 - 2003)
M 36 years, fall from a roof 5 m, paraparesis

Gore Excluder 34-150

TAI: patient 2 (08 – 2003)
M 61 years, fall at work, MT, known AAA

Talent 34-130
# Studies comparing open vs endovascular repair of traumatic aortic injury (TAI)

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Author, year</th>
<th>Total no of patients</th>
<th>Stentgraft</th>
<th>Open repair</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>McPhee 2007</td>
<td>13</td>
<td>8</td>
<td>5</td>
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<tr>
<td>2</td>
<td>Stampfl 2006</td>
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<td>Cook 2006</td>
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<td>5</td>
<td>Lebl 2006</td>
<td>17</td>
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<td>10</td>
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<td>6</td>
<td>Rouseau 2005</td>
<td>64</td>
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<td>7</td>
<td>Pacini 2005</td>
<td>66</td>
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<td>8</td>
<td>Amabile 2004</td>
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<td>11</td>
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<td>9</td>
<td>Ott 2004</td>
<td>18</td>
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<td>12</td>
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<td>10</td>
<td>Doss 2003</td>
<td>16</td>
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<td>12</td>
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<tr>
<td>11</td>
<td>Kasirajan 2003</td>
<td>15</td>
<td>5</td>
<td>10</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>314</strong></td>
<td><strong>123</strong></td>
<td><strong>191</strong></td>
</tr>
</tbody>
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All studies non-randomized

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### 30 days mortality

- **EVAR** – 11/123 (8.9%)
- **Open repair** – 32/191 (16.8%)

**Meta-analysis**

- **EVAR better**
- **Surgery better**

**Odds ratio**

0.001 0.01 0.1 1 10 100

**Reference:**
TAI – EVAR complications

- Paraplegia: 0%
- Hemiparesis: 1%
- Artery injury at insertion (access): 3%
- Endoleak: 4%
- Left arm ischemia / transposition: 2%
- Graft collapse – coarctation
- Graft migration
- Erosion
- Children – late coarctation
- Total ~ 12 %, including renal failure

Tang et al, 2008

Conclusion

- UUH: EVAR treatment of choice for TAI
- Good short and mid-term results
- Limitations:
  - Vascular access; size
  - Small aortic diameter in young patients (<19 mm)
  - Sharp aortic arch angulation
  - Short proximal landing zone
Acknowledgements:

• Morten Hestnes, Ullevål university hospital Trauma Registry
• Jack Andersen, Radiology Dept, Ullevål university hospital
Aortic injury - CT

Anatomic location of injury site among patients who reach hospital alive

<table>
<thead>
<tr>
<th>Location</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isthmus</td>
<td>80-93%</td>
</tr>
<tr>
<td>Aorta ascendens</td>
<td>3-9%</td>
</tr>
<tr>
<td>Distal aorta descendens</td>
<td>1-5%</td>
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<tr>
<td>Aortic arch</td>
<td>3-4%</td>
</tr>
<tr>
<td>Multiple sites</td>
<td>6-20%</td>
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<tr>
<td>Additional injury to major side branches</td>
<td>4-10%</td>
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Clinical evaluation

Clinical manifestations are often deceptively meager.
Most common symptoms are interscapular pain and retrosternal pain
(dyspnoe, cough, hemoptysis, dysphagia…). Present in ~25% of
patients, masked by a clinical picture of polytraumatism.
Findings: unexplained hypotension, thoracic wall injuries, unstable thorax,
palpable costae fractures, claviculae, sternum or vertebrae,
pneumothorax and subcutaneous emphysema. Hemathothorax >
750ml.
Evaluation of the trauma situation. High level of suspicion.

Technique - thoracic aortography

Premedication: diazepam 5 mg (atropine 0,5 mg)
Local anesthesia
ECG monitoring
Contrast medium: 240 (300-350) mg l/ml
Injection volume & rate: 50 ml, 25 ml/s
DSA, frame rate 7,5 / s
Technique - thoracic aortography

Puncture site: a. radialis or a. femoralis communis

Projections: depend on reason and on anatomy (CT?)

5F pigtail catheter (1200 PSI)

Side holes of catheter proximal to the area of interest

Angiography

False – negative:
- subtle injury
- injury out of imaging plane

False – positive:
- motion and flow artifacts
- atherosclerosis
- normal variants
  * smooth fusiform widening of isthmus
  * ductus diverticulum
  * broncho – intercostal artery

No other signs of thoracic aortic injury should be present if a normal variant is to be safely diagnosed
**Associated injuries in ref 1-11**

- Head injury:
- Intraabdominal injury:
- Other intrathoracic injury:
- Fractures:
- Thoracic fractures:
- Cardiac injury:
- Pulmonary injury:
- Diaphragma rupture:
- Traumatic paraplegia:

**Mortality during intervention**

- Peroperative mortality:
  - EVAR - 1/123 (0.8%)
  - Open repair – 15/191 (9.6%)

**Reference:**

1
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11

**Meta-analyse**
Technique – endovascular repair

- Feasibility of EVAR is evaluated by CT angiography
  - vascular access
  - aortic diameter
  - proximal neck
  - angulation of aortic arch

Technique – endovascular repair

- General anaesthesia & mechanical ventilation
- Left radial access for angiography and to mark left subclavian ostium
- Surgical cut down for femoral artery
- Optimal C–arm angle chosen in accordance with angle seen at CT
UUH – Endovascular repair

- Location: 17 istmus, 1 ao descendens
- 12 psa, 5 dissections, 2 intimal laceration, 2 rupture, 1 thrombus, 1 occlusion
- Ao diameter 24 mm, graft d. 27,5 mm
- Graft length 125 mm, (90 – 200)
- 2 Gore Excluder, 8 Gore TAG, 3 Medtronic Talent, 3 Medtronic Valiant, 2 Bolton Relay

Endoleak classification

- **Type I**: Perigraft leak (incomplete seal) at either the proximal or distal attachment site
- **Type II**: Retrograde in-flow from side- or collateral branches
- **Type III**: Fabric tear, modular disconnection
- **Type IV**: Graft fabric porosity
Natural course

• 70-90% die at the scene of the accident.
• 10-30% initial survival. In those who initially survive, the rupture is contained by the integrity of the adventitia and surrounding mediastinal structures (pseudoaneurysm).
  – 85-90% survive the first hour – many of these can be treated.
  – Without treatment 20-30% die within 6 hours
  – 30-50% within one day
  – 60-70% within eight days

Three categories:
  die at the scene of the accident
  reach hospital, but hemodynamically unstable (90% mortality)
  reach hospital, hemodynamically stable (15-25% mortality)


A carotis communis