Mid-term Results of Conservative, Conventional and Endovascular Treatment for Acute Traumatic Aortic Lesions

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Background. To analyze our results after conservative, conventional and endovascular treatment for acute traumatic aortic lesions during the last decade.

Methods. From June 1993 to September 2004, a total of 19 patients with traumatic aortic lesions were referred to our department. All patients sustained injuries from blunt deceleration trauma. In hemodynamically stable patients, initial evaluation was by multi-slice CT scan. The diagnosis of traumatic aortic injury was confirmed and an individual treatment strategy was determined. In hemodynamically unstable patients, emergency thoracotomy was performed.

Results. An emergency thoracotomy was performed in seven (37%) patients. Mortality in this group was 100%. In the remaining group of 12 (63%) patients without hemodynamic instability at time of admission, in-hospital mortality was 0%. Treatment was surgical in five patients (26%), endovascular in five (26%) and conservative in two patients (11%). Mean follow-up was 63 months (5–108 months). No patient died during follow-up. In patients treated by endovascular stent-graft placement no signs of endoleaks could be detected.

Conclusions. Hemodynamic stability and an individual treatment strategy are prerequisites for survival of acute traumatic aortic lesions. Endovascular stent-graft placement has emerged as an innovative and minimally invasive therapeutic option in this polytraumatic high-risk patient cohort.

Keywords: Traumatic aortic rupture; Conventional aortic surgery; Endovascular stent-graft.

Introduction

Aortic injury due to blunt deceleration trauma is associated with substantial morbidity and mortality. Mortality remains high, even in a minority of patients delivered to medical care centers in a hemodynamically stable condition. Despite several improvements, conventional surgical aortic repair using cardiopulmonary bypass [CPB] and full systemic heparinization still carries a substantial rate of mortality and morbidity especially in high-risk patients after polytrauma.

Endovascular stent-graft placement has developed as a safe and effective treatment modality in various diseases of the descending aorta. Recently, this technique has been applied successfully in patients after acute traumatic aortic ruptures. However, few reports are available with regard to the treatment of acute traumatic aortic lesions.

The aim of this study was to analyze our results after conservative, conventional and endovascular treatment for acute traumatic aortic lesions during the last decade.

Patients and Methods

From June 1993 to September 2004, a total of 19 patients with traumatic aortic lesions were referred to our department. All patients sustained injuries from blunt deceleration trauma.

Evaluation and therapeutical strategies

In hemodynamically stable patients, initial evaluation was by multi-slice CT scan. In hemodynamically unstable patients, the indication for emergency thoracotomy was therapy-refractory hypotension due...
to ongoing blood loss. Patients were scored by the injury severity score [ISS]. A maximum of 75 points can be achieved by summation of the three most severely injured regions (head and neck, face, chest, abdomen, extremity as well as external). A score of more than 50 points predicts a mortality rate of more than 50%, a score of more than 70 points predicts a mortality rate near to 100%. In hemodynamically stable patients, the need for surgery was decided by the consulting cardio-thoracic surgeon. Where there were signs of contained rupture, such as aggravating hypotension, pleural effusion, or marked anaemia an urgent surgical approach was chosen. In the case of local dissections without signs of contained rupture, a conservative approach was chosen.

Emergency thoracotomy
Surgical approach was by straightforward left lateral thoracotomy in the shock unit by the trauma team.

Conservative treatment
Conservative treatment consisted of continuous infusion of hypotensives such as alpha blockers, beta blockers as well as sodium nitroprusside.

Conventional surgical treatment
Procedures were performed in the cardio-thoracic operating theatre. Patients were placed in an oblique lateral decubitus position with the pelvis rotated to the left to allow access to the femoral arteries. Exposure of the aorta was achieved with a left thoracotomy through the fifth intercostal space and either cardiopulmonary bypass (CPB) or left heart bypass (LHB) were established. The diseased part of the descending aorta was resected and the proximal anastomosis to the distal arch was performed. The prosthesis was tailored and the distal anastomosis was done. Both anastomoses were performed with a 3–0 prolene running suture reinforced by a teflon felt strip. CPB or LHB were discontinued and the wound was closed in a standard fashion.

Endovascular stent-graft treatment and stent-graft systems used
Access was via the right common femoral artery in all patients. Two different stent-graft systems are available at our department. The Gore thoracic excluder endoprosthesis (W.L. Gore and Associates, Sunnyvale, CA) was used in three patients. The Talent endoluminal stent-graft system (Medtronic, Santa Rosa, CA) was used in the other two patients. The Talent stent-graft consists of a nitinol wire stent shaped in a zigzag formation, which is covered with extrathin polyester (Dacron). A straight nitinol wire passes the length of the device and avoids twisting or kinking. This self-expandable stent-graft is compressed over a placement catheter. Both the stent-graft and the catheter are loaded into polyurethane sheath for insertion. The endoluminal stent-graft system is passed over the guidewire and positioned at the desired location as determined by intraoperative angiography. After exact positioning, the stent-graft was released by removing the sheath. The GORE thoracic excluder stents are constructed differently. The system is placed into the vasculature through an introduction sheath. The stent-graft itself is mounted on a placement catheter. Deployment of the stentgraft is achieved by pulling on a string at the end of the placement catheter. GORE stent-grafts are available in standard sizes. It was not necessary to cover the entire orifice of the subclavian artery in any patient. Fig. 1

![Fig. 1. Contained rupture prior to stent-graft placement.](image-url)
depicts a patient with a contained rupture prior to stent-graft placement. Fig. 2 depicts the same patient after successful stent-graft placement without any signs of endoleaks.

Follow-up
Endpoints were defined by means of survival as well as by freedom from aortic reinterventions. All patients were seen in the outpatient clinic. Follow-up was complete in all patients.

Results
In all patients suitable for surgical treatment, the aortic injury was treated within the first 24 h after admission. Following our department’s polytrauma algorithm, the injury considered most life threatening was addressed first. Consecutive procedures were performed thereafter in an interdisciplinary approach.

Emergency thoracotomy
Seven patients with a mean age of 43 years (30–84 years) underwent a left lateral thoracotomy in the shock unit by the trauma team. Due to the severity of aortic injury as well as to concomitant injuries, all seven patients died during emergency surgery within the first 2 h after trauma.

Conservative treatment
Two patients (41 years, 76 years) with local dissections of the thoracic aorta without any signs of contained rupture were treated conservatively. Both patients were fully rehabilitated after treatment of traumatic injuries. Mean hospital stay was 66 days (32 days, 102 days). Completion CT scans revealed no signs of progression or late aneurysm formation during follow-up.

Conventional surgical treatment
Five patients with contained ruptures of the descending aorta with a mean age of 30 years (20–58 years) underwent conventional surgical treatment between 1995 and 2001. One 22-year-old female patient underwent thoracoabdominal aortic replacement as well as reimplantation of visceral and intercostals arteries due to local dissection of the entire abdominal aorta with consecutive acute renal failure due to extension of the dissection into both renal arteries after blunt abdominal trauma. All patients survived both—aortic surgery as well as trauma surgery and were discharged after a mean hospital stay of 51 days (33–68 days). Extended in-hospital stay was due to concomitant repair of other injuries.

Endovascular stent-graft treatment
An innovative less invasive approach for treatment of acute traumatic aortic injuries was applied since 2001.
Five patients with a mean age of 47 years (20–74 years) underwent endovascular stent-graft placement due to local thoracic aortic dissections with contained ruptures. The mean length of the proximal neck was 1.2 cm (0.5–1.9 cm). Partial overstenting of the left subclavian artery became necessary in two patients. However, antegrade perfusion could be maintained without any clinical signs of subclavian steal syndrome. One patient underwent overstenting of a type Ia endoleak 2 days after the initial intervention. In one patient, plication of the diaphragm was performed 2 days after stent-graft insertion due to diaphragmatic rupture. All patients survived the procedure as well as concomitant injuries and have been discharged from hospital after a mean stay of 46 days (28–90 days) without any signs of endoleaks confirmed by completion CT scans.

Postoperative course and adverse events

Postoperative course was uneventful in all patients except for postoperative bleeding requiring surgical revision in one patient undergoing conventional surgical repair. In hospital stay as well as in ICU stay was comparable within patients undergoing conventional surgical and endovascular treatment.

Injury severity score [ISS] and relation to outcome

All seven patients with an ISS greater than 70 died during emergency surgery. In the remaining patients, no in-hospital deaths were observed. Fig. 3 depicts the ISS values with regard to the individual treatment modality. A detailed overview of the concomitant injuries is given in Table 1.

Follow-up

Mean follow-up was 63 months (5–108 months). No patient died during follow-up. No patient required aortic reintervention during follow-up. Patients after endovascular stent-graft placement were readmitted for completion CT scans after three and 6 months and annually thereafter. We did not observe any signs of endoleaks in all patients after stent-graft placement.

Discussion

Despite improvements in treatment algorithms, mortality of traumatic aortic lesions has remained constantly high over the last decades. In hemodynamically unstable patients with already sustained free rupture, mortality rates are up to 100%. This is line with our observation in this high-risk subgroup of patients with traumatic aortic injuries. Additionally, concomitant major traumatic lesions aggravate diagnostic and therapeutic procedures. In our series, all deaths occurred during emergency surgery in the shock unit. The cause was ongoing blood loss due to free aortic rupture. The ability to plan a surgical approach following imaging is invaluable.

In the management of stable and non-bleeding aortic injuries postponed intervention due to treatment of additional life-threatening lesions such as free splenic rupture, seems to be an advantageous. Furthermore, uncomplicated morphological findings, such as local dissection without any signs of perforation or contained rupture, justify a conservative therapeutic approach with repeated CT scans as well as continuous hypotensive therapy. This concept was successful in two patients with free splenic rupture and multiple costal fractures.

Minor lesions of the aortic wall such as mural hematomas or limited intimal flaps have a benign course and regress spontaneously. Major lesions such as extended dissections with contained ruptures have an insidious course and require intervention. Until 2001, these patients have been treated conventionally by tubular replacement of the injured aortic segment. Systemic heparinization for CPB in already severely injured patients may have deleterious consequences in the further surgical treatment of injuries of the musculo-skeletal system. It is our policy to install left heart bypass using heparin-coated circuits with partial heparinization when feasible in order to avoiding major adverse effects of full systemic heparinization. All patients survived both, conventional aortic repair as well as...
Endovascular stent-graft placement has evolved as a safe and effective treatment modality in various diseases of the descending aorta.\textsuperscript{5–8} As initial results have been encouraging, this new treatment modality has been used more liberally and short-term as well as mid-term results are well documented.\textsuperscript{8,18,19} Especially in polytraumatized patients, who are frail and have a diminished physiologic reserve, this minimally invasive technique does not expose these patients to substantial risk. All procedures were carried out under general anesthesia to facilitate the procedure for both the patients and surgeons. One patient underwent over-stenting of a type Ia endoleak 2 days after initial stent-graft placement. During a mean follow-up 28 months, no signs of endoleaks were detected.

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age</th>
<th>Sex</th>
<th>Type of injury</th>
<th>Treatment modality</th>
<th>Outcome</th>
<th>ISS</th>
<th>Concomitant injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>84</td>
<td>m</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>75</td>
<td>Subdural and subarachnoid hematoma, basilar skull fx, Spleen rx, pelvic fx, multiple rib fx, hematotherax, femoral shaft fx, open tibial shaft</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>m</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>75</td>
<td>Liver rx, bladder rx, subdural hematoma, intracerebral bleeding, pelvic fx, multiple rib fx, lung contusions, clavicular fx</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>m</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>75</td>
<td>Liver rx, spleen rx, kidney rx, duodenal rx, humeral shaft fx, femoral shaft fracture</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>m</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>75</td>
<td>Spleen rx, multiple rib fracture, clavicular fx, hematotherax</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>f</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>54</td>
<td>Pelvic fx, femoral shaft fx, patellar fx, forearm fx, pneumothorax</td>
</tr>
<tr>
<td>6</td>
<td>52</td>
<td>f</td>
<td>Contained rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>50</td>
<td>Basilar skull fx, lefort III fx, lefort III, subdural hematoma femoral shaft fx, spleen rx, clavicular fx</td>
</tr>
<tr>
<td>7</td>
<td>37</td>
<td>m</td>
<td>Rupture</td>
<td>Em. Thoracotomy</td>
<td>Deceased</td>
<td>75</td>
<td>Spleen rx, multiple rib fx, basilar skull fx</td>
</tr>
<tr>
<td>8</td>
<td>49</td>
<td>m</td>
<td>Local dissection</td>
<td>Conservative</td>
<td>Alive</td>
<td>43</td>
<td>Liver hematoma, multiple rib fx, femoral shaft fx, clavicular fx, lung contusion</td>
</tr>
<tr>
<td>9</td>
<td>76</td>
<td>m</td>
<td>Local dissection</td>
<td>Conservative</td>
<td>Alive</td>
<td>43</td>
<td>Pelvic fx, elbow fx</td>
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<tr>
<td>10</td>
<td>28</td>
<td>f</td>
<td>Contained rupture</td>
<td>Surgery/tube graft</td>
<td>Alive</td>
<td>38</td>
<td>Spleen rx, liver rx, basilar skull fx, hematotherax</td>
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<tr>
<td>11</td>
<td>20</td>
<td>f</td>
<td>Contained rupture</td>
<td>Surgery/tube graft</td>
<td>Alive</td>
<td>43</td>
<td>Tibial fx, lefort II fx</td>
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<tr>
<td>12</td>
<td>24</td>
<td>m</td>
<td>Contained rupture</td>
<td>Surgery/tube graft</td>
<td>Alive</td>
<td>57</td>
<td>Massive lung contusion</td>
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<td>13</td>
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<td>m</td>
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<td>Surgery/tube graft</td>
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<td>47</td>
<td>Liver rx, spleen rx, ileum rx, multiple rib fx, lefort III fx</td>
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<tr>
<td>14</td>
<td>20</td>
<td>f</td>
<td>Local dissection</td>
<td>Surgery/tube graft</td>
<td>Alive</td>
<td>34</td>
<td>Diaphragm rx</td>
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<tr>
<td>15</td>
<td>46</td>
<td>m</td>
<td>Local dissection</td>
<td>Stent-graft</td>
<td>Alive</td>
<td>59</td>
<td>Pelvic fx, liver rx, spleen rx, kidney rx, ileum rx, hematopneumothorax</td>
</tr>
<tr>
<td>16</td>
<td>74</td>
<td>m</td>
<td>Local dissection</td>
<td>Stent-graft</td>
<td>Alive</td>
<td>34</td>
<td>Liver rx, pelvic fx</td>
</tr>
<tr>
<td>17</td>
<td>20</td>
<td>m</td>
<td>Local dissection</td>
<td>Stent-graft</td>
<td>Alive</td>
<td>59</td>
<td>Spleen laceration, multiple rip fx, femoral shaft fx</td>
</tr>
<tr>
<td>18</td>
<td>44</td>
<td>m</td>
<td>Local dissection</td>
<td>Stent-graft</td>
<td>Alive</td>
<td>57</td>
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<td>Stent-graft</td>
<td>Alive</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

All patients were scored by the injury severity score [ISS]. This score consists of several parameters estimating the survival probability. All seven patients with an ISS score greater than 70 died during emergency surgery. Although the majority of the remaining had an ISS of 45+, thereby predicting an in-hospital mortality rate of up to 50%, no in-hospital deaths were observed. This may be related to the good physical condition of the patients prior to trauma without any substantial cardiovascular or pulmonary comorbidities.

The main limitation of this study is its retrospective, non-randomized design and the subjective nature of the decision for intervention. In addition, the patient number is low. However, few patients with an acute traumatic aortic injury reach a level I trauma center in a stable condition.

Taking these limitations into account we conclude that hemodynamic stability as well as a
straightforward individual treatment strategy are prerequisites for survival of acute traumatic aortic lesions. Endovascular stent-graft placement has emerged as an innovative and minimally invasive therapeutic option in this polytraumatic high-risk patient cohort.

References

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