Serious complications following endovascular thoracic aortic stent-graft repair for type B dissection

Beate Neuhauser a,*, Andreas Greiner a, Werner Jaschke b, Andreas Chemelli b, Gustav Fraedrich a

a Department of Vascular Surgery, University Hospital Innsbruck, Austria
b Department of Radiology, University Hospital Innsbruck, Austria

Received 10 August 2007; received in revised form 27 September 2007; accepted 15 October 2007; Available online 19 November 2007

Abstract

Objective: To describe our experience with endovascular stent-graft repairs in type B aortic dissection focusing on serious secondary complications resulting in immediate or late conversion to open repair. Methods: From November 1997 to May 2007, 28 patients underwent a thoracic endovascular stent-graft procedure for acute symptomatic type B dissection at our institution. Indication for endovascular repair at our department is a complicated course of type B dissection, including thoracic aortic rupture, suspicion of impending rupture, visceral and/or peripheral ischemia, uncontrollable hypertension, and severe therapy-resistant pain. Median follow-up time was 48.3 months (range 2—97 months). Results: Secondary complications with indication for a secondary intervention occurred in 5/28 patients, resulting in additional procedures in 4 patients. One patient declined any further therapy. Conversion to an open procedure was performed in four patients, one due to type I endoleak followed by retrograde type A dissection, and three due to retrograde type A dissection. One of these patients had an additional stent-graft procedure performed due to a type III endoleak 20 months post stent grafting. Retrograde type A dissection occurred 39 months later, finally leading to conversion to an open procedure. Open surgery was performed in four patients after 3, 26, 29, and 1170 days post stent-graft placement and was successful in three patients. The fourth patient died 3 months post-surgically due to multi-organ failure. The procedure-related mortality rate following secondary complications was (1/5) 20%. Conclusions: Endovascular stent-graft repair of the thoracic aorta is an alternative to surgical repair, however not without significant morbidity and mortality. Potentially lethal complications, acute or delayed, may occur.

#2007 European Association for Cardio-Thoracic Surgery. Published by Elsevier B.V. All rights reserved.

Keywords: Endovascular thoracic aortic repair; Severe complication; Type B dissection

1. Introduction

Aortic dissection is a life-threatening condition associated with a mortality rate up to 80% if left untreated [1—5]. The preferred treatment in uncomplicated Stanford type B dissection involving the descending aorta is conservative with meticulous control of blood pressure [2—4]. Acute surgical treatment in type B dissection is reserved for patients with a complicated course such as dissection progression bearing the risk of aortic rupture, branch vessel occlusion resulting in visceral and/or leg ischemia, refractory hypertension, or pain. Aortic replacement for acute aortic dissection showed significant mortality (29—50%) and paraplegia rate (30—36%) [5—7]. There was and is a clear need for less invasive techniques. Endovascular repair of a complicated Stanford type B dissection has several benefits compared to open surgery. Thoracotomy, extracorporal circulation, or aortic cross-clamping and single lung ventilation can be avoided. Minimal anticoagulation is sufficient. Minimal invasiveness decreased ischemic events to the spinal cord, viscera, and kidneys. Minimal blood loss is an additional advantage. The 30-day mortality rate following endovascular type B dissection repair is acceptably low at 8.4% [1]. Several study groups have documented the feasibility of endovascular stent-graft repair in acute or elective type B dissection, however not without significant morbidity [1—14]. Acute or delayed retrograde type A dissection (6, 8%) [15—18], stroke (3%) [1], paraplegia (2%) [1], access-related complications (27%) [10], endoleaks (4%) [1], bowel infarction, limb ischemia, or wound infection have been described [1—10].

The aim of this report was to describe our experience with endovascular stent-graft repairs in type B aortic dissection focusing on serious secondary complications resulting in immediate or late conversion to open repair.
2. Materials and methods

2.1. Patient population

From November 1997 to May 2007, 28 patients underwent a thoracic endovascular stent-graft procedure for acute symptomatic or progressive type B dissection at our institution. Indication for endovascular repair at our department is a complicated course of type B dissection including thoracic aortic rupture, suspicion of impending rupture, visceral and/or peripheral ischemia, uncontrollable hypertension, and severe therapy-resistant pain.

2.2. Pre-procedural imaging studies

In all patients, CT angiography of the entire aorta with three-dimensional vascular reconstruction was performed preoperatively to determine the anatomical feasibility for the stent-graft procedure, the level of entry and re-entry sites, location, extension, and relationship between the dissection membrane and significant aortic branches such as the left subclavian artery and visceral vessels. Dimensions of stent grafts used were determined on the basis of contrast-enhanced spiral CT images (HiSpeed Advantage and Light Speed QX/I; General Electric Medical Systems, Milwaukee, WI) and angiographic images.

2.3. Stent-graft device

Two types of stent grafts were used in this series: the GORE Thoracic Excluder Endoprothesis (W.L. Gore and Associates, Inc., Flagstaff, AZ), a modular system manufactured with an expanded polytetrafluoroethylene prosthesis supported by a self-expanding nitinol stent exoskeleton; and the Talent endoluminal stent graft system (Medtronic AVE, Sunrise, FL), a self-expanding endograft consisting of a polyester (Dacron) graft fabric and self-expanding nitinol exoskeleton with bare springs at the proximal site of the covered portion. The stent-graft procedure was described in detail previously [19].

In patients with a short proximal landing zone, the origin of the left subclavian artery was crossed with the uncovered or covered portion of the stent graft to extend the landing zone. A four-vessel cerebral angiography was obtained prior to overstenting to document the collateral blood supply to the left subclavian artery in these patients. A carotid-to-carotid and subclavian-to-carotid bypass procedure was performed in one patient prior to the stent-graft procedure to extend the proximal landing zone to the left carotid artery. A completion angiography was performed to ensure complete sealing and adequate device placement and to assess the adequacy of the repair. A completion CT scan was performed within 2 days post-procedure in all patients to confirm complete sealing of the entry tear and the lack of endoleaks.

2.4. Follow-up investigation

Median follow-up time was 48.3 months (range 2—97 months). Clinical examinations and contrast-enhanced spiral CT post stent grafting was performed after 3, 6, and 12 months and annually thereafter. Follow-up CTs were repeated more frequently for the investigation of suspected complications such as changes in the morphologic characteristics or progress of the dissection, or new-onset endoleaks. Intra-arterial digital subtraction angiography (DSA) was done in cases of suspected complications. The presence and source of endoleaks are classified at all time intervals according to the standard classification [20].

2.5. Data collection

A patient database was used to record clinical variables, including information on patient history, clinical presentation, medical and surgical/endovascular treatment, and outcomes including mortality and morbidity prospectively. Yearly follow-up data were obtained including clinical and imaging data, as well as information about mortality and morbidity.

2.6. Statistical evaluation

Statistical analysis was performed by using the Statistical Package for Social Sciences (SPSS) for Windows 10.1.3. Patient survival rates were calculated according to the Kaplan–Meier life table method (Fig. 1).

3. Results

Secondary complications with indication for a secondary intervention occurred in 5/28 patients. Patient characteristics are listed in Table 1. The cumulative survival rate was 78%, 73%, and 58% after 1, 3, and 6 years, respectively (Kaplan–Meier method Fig. 1).

Five patients, four males and one female (median age 65 years, range 43—87), experienced complications after thoracic aortic endovascular stent-graft repair within a median time of 306 days (range 3—1170 days) resulting in conversion to open surgery in four patients. All besides one aortic stent graft were correctly positioned; the entry tear was completely excluded following endovascular stent

![Cumulative Survival Rate (%)](image_url)

Fig. 1. Statistical analysis was performed by using the Statistical Package for Social Sciences (SPSS) for Windows 10.1.3. Patient survival rates were calculated according to the Kaplan–Meier life table method. Six years cumulative survival (Kaplan–Meier). Years after intervention; n, number of patients at risk; CS, cumulative survival rate calculated for 6 years.
grafting in four patients suffering from type B dissection. However, the fifth patient, an 87-year-old female, showed a type I endoleak without further possibility for an additional stent-graft deployment due to anatomical conditions. Retrograde type A dissection was observed on the follow-up CT scan 3 days later. Although any kind of therapy was declined, the patient survived 50 more months and finally deceased due to respiratory failure. In a 65-year-old male completion angiography and follow-up CT scan 2 days post-procedure (Fig. 2) was unremarkable, although emergency open surgery was performed 29 days post stent-graft placement due to a retrograde type A dissection (Fig. 3) and consisted of successful graft replacement of the ascending aorta. In the intraoperative findings, there was an intimal injury next to the proximal struts of the stent graft. It is most likely that the aortic wall was injured by handling the endovascular devices. Unfortunately, the patient developed a permanent tetraplegia following the replacement of the ascending aorta and partial replacement of the aortic arch.

In a 64-year-old male the distal entry side continued to show significant blood flow at the completion of angiography during the initial procedure, therefore a third Talent stent graft was inserted and balloon dilatation was used after deployment in order to compress the additional stent graft to the dissected aortic wall. While using the inflatable balloon, disconnection between the second and third stent graft occurred resulting in a type III endoleak. Additional stent-graft deployment between the second and third stent graft was not possible because no further appropriate stent graft was on hand. The stent graft was ordered; however, the patient developed the retrograde type A dissection before we were able to do the additional stent-graft procedure. The patient complained of new-onset chest pain on post-interventional day 3. CT scan showed a retrograde type A dissection. Emergent extended aortic arch and descending aortic replacement was performed, and the Talent stent grafts were removed. Intraoperative findings revealed an aortic tear next to the proximal end of the stent graft. The patient died 3 months post-surgically due to multi-organ failure.

A 63-year-old male developed a type III endoleak 619 days post stent grafting due to migration between the originally perfectly placed two stent grafts. A further stent graft was inserted.

---

### Table 1

<table>
<thead>
<tr>
<th>Patients (age)</th>
<th>Pathology</th>
<th>Dissection extension</th>
<th>Deployed stents</th>
<th>Additional stent-graft procedure</th>
<th>48-h endoleaks</th>
<th>Type A dissection (days)</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH (87) (F)</td>
<td>Type B (a)</td>
<td>SA</td>
<td>T (3)</td>
<td>No</td>
<td>Ia</td>
<td>3</td>
<td>50 months*</td>
</tr>
<tr>
<td>OE (64) (M)</td>
<td>Type B (e)</td>
<td>SA</td>
<td>T (4)</td>
<td>No</td>
<td>III</td>
<td>3</td>
<td>Day 128*</td>
</tr>
<tr>
<td>PD (42) (M)</td>
<td>Type B (a)</td>
<td>CIA</td>
<td>T (1)</td>
<td>No</td>
<td>0</td>
<td>26</td>
<td>51 months*</td>
</tr>
<tr>
<td>SE (65) (M)</td>
<td>Type B (e)</td>
<td>CIA</td>
<td>G (2)</td>
<td>No</td>
<td>0</td>
<td>29</td>
<td>Alive</td>
</tr>
<tr>
<td>PE (63) (M)</td>
<td>Type B (a)</td>
<td>CIA</td>
<td>T (2)</td>
<td>Yes</td>
<td>III 614</td>
<td>0</td>
<td>1170 Alive</td>
</tr>
</tbody>
</table>

M, male; F, female; a, acute; e, elective; CIA, common iliac artery; SA, suprarenal aorta; T, Talent; G, Gore Tag (used number of deployed stent grafts); Ia, proximal type I endoleak; III, endoleak.

* Deceased.

---

**Fig. 2.** Post-interventional contrast-enhanced spiral CT image performed 2 days post endovascular therapy is showing the stent graft in place, the false lumen thrombosed, and the ascending aorta appears unremarkable (arrow).

**Fig. 3.** Post-interventional contrast-enhanced spiral CT image performed 29 days post endovascular therapy due to new-onset chest pain shows a dissection of the ascending aorta (arrow). The intima is nearly completely detached from the ascending aortic wall. The stent graft is seen in the descending aorta.
successfully deployed; however, 39 months later the patient developed a retrograde type A dissection. Significant descending aortic enlargement at the distal end of the stent graft following the second endovascular stent-graft procedure was observed from 60 mm up to 84 mm within 24 months. The patient and his relatives declined thoracoabdominal aortic replacement. Thirty-nine months after the second stent-graft procedure a retrograde type A dissection occurred unrelated to the additional endovascular procedure, resulting in emergency graft replacement of the ascending aorta. In a 43-year-old male completion angiography and follow-up CT scan 2 days post-procedure was unremarkable. However, 26 days after the initial procedure, the patient developed a retrograde type A dissection resulting in emergency graft replacement of the ascending aorta. The stent grafts themselves were intact and well positioned within the descending aorta. The new entry tear was located in the ascending aorta, clearly unrelated to the stent-graft procedure. The patient had an uneventful postoperative course. Follow-up investigations were done at an outside hospital. Proximal descending aortic enlargement from 50 mm to 70 mm was detected after 50 months. Graft replacement of the aortic arch and the descending aorta was performed. The patient had serious respiratory complications and finally deceased due to sepsis 51 months after the initial symptoms and endovascular stent-graft therapy for type B dissection. Autopsy was declined. In hospital mortality rate was 14% (4/28) including one stroke, two multi-organ failures, and one respiratory failure (4/27). Total mortality rate was 32% including one retrograde type A dissection, one myocardial infarction, one pulmonary failure, and one cerebral hemorrhage (8/28). The mortality was aortic disease-related in 14% (4/28). The procedure-related mortality rate following acute retrograde type A dissection was 20% (1/5). Mean follow-up was 43 months (range 2—97 months). 4. Discussion The first results on stent-graft repair in type B aortic dissection were published in 1999 by Dake et al. and Nienaber et al. [10,14]. Since then numerous reported data confirm the technical feasibility and relative low rate of complications compared to surgical repair [1—6,8—14,21]. However, with growing experience in endovascular stent-graft repair more and more serious complications are reported. Aneurysm development, aortic rupture, stroke, paraplegia, bowel infarction, limb ischemia, access-related complications, and endoleaks have been described [1—14]. Retrograde type A dissection was recognized by several study groups; however, it is still an unexpected complication following endovascular stent-graft repair [15—18]. The primary goal of endovascular stent-graft repair in type B aortic dissection is to provide false lumen thrombosis and aortic remodeling with false lumen reduction. Closure of the proximal entry tear is essential to achieve these primary goals [10,14]. After endovascular treatment, a strict imaging follow-up is essential to detect endoleaks, antegrade or retrograde dissection progression, development of proximal or distal aortic enlargement, all signs that might increase the risk of aortic rupture [11,15,22]. Extension of the dissection is a known event in type B dissection. It is important to note that patients with successful initial treatment of acute or chronic aortic dissection have a systemic illness that predisposes their entire aorta to dissection in an ante- or retrograde manner, the first possibility for retrograde type A dissection development following stent-graft repair. Medical therapy alone does not stop the blood flow to and within the false lumen. Expansion of the false lumen, aneurysm formation, or aortic rupture may occur. It has been estimated that nearly a third of patients surviving initial treatment for acute dissection will experience dissection extension or aortic rupture within 5 years of presentation [7,11]. The incidence of retrograde type A dissection with an entry in the descending aorta ranges from 4% to 20% among Stanford type A dissections [6,23]. Our results are similar to the Stanford group. Acute retrograde type A dissection after endovascular stent-graft repair is a rare complication that has been described in conjunction with the procedure [16,17]. However, as seen in five of our patients, one must be aware that this complication can occur not only during the procedure but even days, weeks, or months following stent-graft implantation, a fact that seems to be under-reported. Dissections that originate in the descending aorta and extend in a retrograde direction into the ascending aorta may lead to aortic valve regurgitation, cerebrovascular ischemia, peri-cardial tamponade, and obstruction of the coronary artery. Open surgery is the treatment of choice in an effort to avert these life-threatening complications. The retrograde dissection was clearly related to the initial stent-graft procedure in three of our patients; the entry tear was not completely excluded by a Talent stent graft in the 87-year-old lady and showed a type I endoleak at the end of the procedure. By scrutinizing all images of that patient, who was initially treated for an acute type B dissection, the pre-interventional diagnosis of peri-aortic effusion was questioned. Retrospectively, the hypodense fringe encasing the ascending aorta was interpreted as an intramural hematoma. We suspect that the fragility of the aortic wall caused by this pathology finally resulted in a type A dissection, which was triggered by the stent-graft procedure. The 64-year-old male in whom a type III endoleak occurred due to disconnection between the second and third Talent stent graft while balloon dilatation was performed was in a high risk to develop a complication while waiting for an additional suitable stent graft. Not having the appropriate material available needs to be added on the list of risk factors for developing serious complications. The 65-year-old male, in whom two Gore Tag devices were used for type B dissection repair, showed the new entry tear next to the proximal part of the stent graft during emergency surgery. Balloon dilatation during the stent-graft procedure might have triggered the intimal damage resulting in retrograde type A dissection in that case. The poor quality of the aortic wall may be another cofactor leading to this severe complication. We suspect that repeated balloon dilatation provoked the retrograde type A dissection at least in one of our patients. Two out of five patients with type B dissection showed persistent blood flow into the false lumen at the end of the procedure. The small
number of cases impaired the ability to draw final conclusions, however persistent blood flow might be a positive predictor for type A dissection due to the still existing pressure against the aortic wall within the false lumen.

Retrospectively, acute dissection may have been initiated during the endovascular procedure, and then extended in a retrograde manner during the following days or weeks. Wire and sheath handling or balloon dilatation during the endovascular procedure may have caused localized intimal minimal tears in the extremely fragile and easily injured intimal flap and aortic wall that progressed and resulted in a new-onset dissection. The device itself may have also contributed to the new-onset dissection. It is well known that the Gore Excluder prosthesis has a better longitudinal flexibility that adapts better to the aortic curve of the distal arch than the Talent device, which has a semi-rigid design. However, both types of stent grafts may require repeated balloon dilatation to accommodate the curved geometry of the aortic arch and to form a tight seal. Intimal injuries directed by local forces against the intima may have occurred. In addition, routinely performed stent-graft oversizing may have contributed to the intimal injuries despite exact measurements and the use of stent-graft oversizes recommended by the manufactures was used. Our inserted stent grafts are usually 10% larger than the diameter of the non-effected segment of the aorta proximal to the entry tear to achieve secure proximal sealing.

The new type A dissection had no relation to the stent graft in two patients. One patient initially admitted for acute type B dissection showed an entry tear located in the ascending aorta unrelated to the stent graft during emergent surgery 26 days later. The second patient developed a significant distal expansion of the descending thoracic aorta 39 months after an additional stent-graft procedure due to type III endoleak followed by retrograde type A dissection. No relation to the primary or secondary endovascular stent-graft procedure was found; the entry tear was located in the ascending aorta. The possible explanation for the new-onset type A dissection might be caused by disease progression.

5. Conclusion

The number of patients treated for acute or chronic type B dissection at our institution is small. Final conclusions regarding precursors for developing a potentially lethal retrograde type A dissection are not feasible; however, the poor quality of the aortic wall in patients with type B dissection seems to be related to this severe complication. The influence of the different stent grafts in connection with intimal injuries is questionable, although forced and repeated balloon dilatation is an important factor which contributed to intimal injuries. Avoiding of balloon dilatation is recommended whenever possible since self-expanding forces of the stent grafts also result in continuous expansion of the true lumen over time.

Endovascular stent-graft repair of the thoracic aorta is an alternative to surgical repair, however not without significant morbidity and mortality. Potentially lethal complications, acute or delayed, may occur. Life-long surveillance is mandatory.

References


