

## Complicated Acute Type B Dissections—An 8-years Experience of Endovascular Stent-graft Repair in a Single Centre

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**Objective.** To analyze the experience of a single centre using stent-grafts for treatment of complicated acute aortic type B-dissections (EVR-ABD).

**Design.** Retrospective analysis of prospectively collected data from patients undergoing EVR-ABD between January 1997 and December 2004.

**Methods.** EVR-ABD was performed in 31 patients (20 males, median age 74 years (IQR: 64–79)). Indications for treatment were aortic rupture (22 patients), intractable pain and hypertension (six patients), acute bowel ischemia (two patients) and transient paraplegia, lower limb and renal ischemia in one patient. Initially home-made devices (five patients) and subsequently commercially available thoracic stent-grafts were used.

**Results.** Five patients (16%) died within 30 days of EVR-ABD. Postoperative complications occurred in 15 (48%) patients, including one paraplegia converted to paraparesis after cerebrospinal fluid drainage, five strokes, three lower limb ischemia, three myocardial infarction, two pneumonia and one colitis). Re-interventions were required in nine patients (29%). Six more deaths occurred during a median follow-up of 22 (IQR: 16–34) months, two related to the stent-graft and four due to cardiac disease.

**Conclusions.** Stent-graft repair of complicated acute type B dissections seems to provide acceptable results and, therefore, it may be considered a valuable alternative to open surgery.

**Keywords:** Acute type B dissection; Stent-graft; Aorta.

### Introduction

Usually medical treatment controlling hypertension and pain is selected as the initial approach for uncomplicated aortic type B dissections. Surgery has been reserved for complications, including aortic rupture, mal-perfusion of end-organs and/or persistent pain in spite of medical treatment.<sup>1,2</sup>

Endovascular techniques have been proposed as a less invasive alternative to open surgery. Fenestration of the intimal membrane and stenting of dissected arteries have been applied as a means to correct the haemodynamic changes causing compression of the true lumen.<sup>3</sup> However, with these techniques the false lumen continues to be pressurized, which, together

with the weakening of the false lumen wall caused by the absence of the inner layer, can prompt further degenerative changes resulting in complications.<sup>4</sup> The rationale for the use of stent-grafts for endovascular repair of complicated acute aortic type B dissections (EVR-ABD) is based on exclusion of the false lumen by coverage of intimal tears. This is expected to depressurize the false lumen and redirect the flow into the true lumen. Therefore, perfusion of the end-organs may be improved and the haemorrhage stopped.<sup>3</sup>

The initial reports of EVR-ABD have been encouraging with decreased mortality and morbidity comparing to open surgery.<sup>5,6</sup> However, there is a need for further reassessment of this new treatment technology as it is continuously evolving.

The aim of the present study is to analyze a single-centre experience with endovascular stent-graft repair of complicated acute type B-dissections (EVR-ABD).

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## Methods

### *Patients*

Thirty-one patients (20 males and 11 females) with a median age of 74 (IQR 64–79) years underwent EVR-ABD at our tertiary university referral centre between January 1997 and December 2004. The study was approved by the Lund University Ethical Committee. Patient characteristics are listed in Table 1. Indications for treatment were rupture (22 patients, 71%, Fig. 1), intractable pain and poorly controlled hypertension in spite of medical treatment (six patients, 19%), acute bowel ischemia (two patients, 6%) and transient paraplegia, lower limb and renal ischemia in one patient (3%). Dissections were considered as acute if less than 14 days had elapsed since the onset of symptoms.<sup>7</sup> Medical therapy consisted of control of hypertension and pain in intensive care.

### *Preoperative imaging*

Preoperative imaging included contrast-enhanced spiral-CT scan with slices of 3 mm or thinner. Angiography was performed intra-operatively. Angiographic studies below the diaphragm in patients with high serum creatinine were performed using carbon dioxide as contrast-medium.

### *Stent-graft procedure*

The procedures were performed initially in the operating theatre using a C-arm with digital subtraction abilities (Siremobil 2000, Siemens, Erlangen, Germany). After the last trimester of 2000 all operations were performed in an operating room fully equipped as an angiographic suite (Angiostar

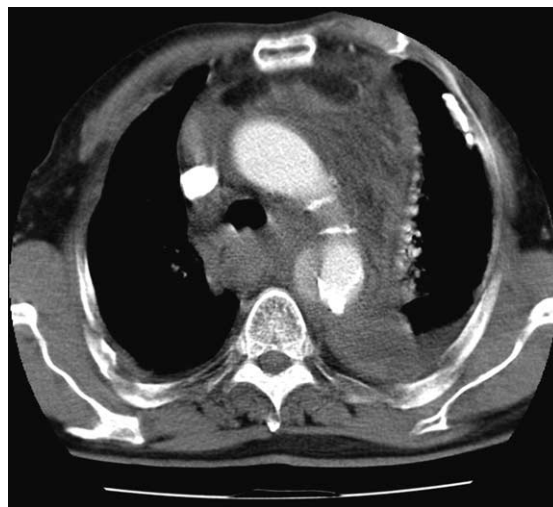


Fig. 1. Axial CT-scan from patient with ruptured acute aortic type B dissection.

Plus OR, Siemens, Erlangen, Germany). When Gore stent-grafts (Excluder and GoreTAG, Gore W.L. Gore & Associates, Inc., Flagstaff, Ariz, USA) were used, hypotension was induced at the time of stent-graft deployment using sodium nitroprusside (100 µg intravenous bolus). Percutaneous access has been routinely used since 2002, if the dissection did not extend into the femoral arteries.<sup>8</sup>

Home-made stent-grafts, based on stainless steel Z-stents sutured to Dacron grafts, were used until 2001.<sup>9</sup> Thereafter commercially available stent-grafts were employed on off-the-shelf basis. Stent-grafts were oversized by 10–15% compared to the diameter of the proximally non-dissected aorta. The stent-grafts used are listed in Table 2. The uncovered Z-stent at the distal end of the Zenith TX-1 stent-graft was removed before deployment in order to avoid unwarranted rupture of the dissection membrane by the bare struts. Balloon dilatation of the stent-graft was avoided for the same reason.

Right brachial approach was used occasionally in order to ascertain true lumen catheterization or when there was a need for through-and-through technique

Table 1. Preoperative characteristics of the patients

	<i>n</i> (%)
Age	74 (IQR: 64–79)
Sex (M/F)	20 (65%) / 11 (35%)
Cardiac disease	10 (32%)
Hypertension	23 (74%)
Diabetes	2 (6%)
COPD	5 (16%)
Cerebrovascular disease	2 (6%)
ASA	
I	1 (3%)
II	4 (13%)
III	17 (55%)
IV	8 (26%)
V	1 (3%)

COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiology classification.

Table 2. Stent-grafts used

Type of stent-graft	<i>n</i>
Homemade	7
Zenith	27
Gore excluder	1
Gore TAG	4
Endofit	3
Total	42

Zenith, William Cook, Europe A/S, Bjaeverskov, Denmark; Excluder and GoreTAG, W.L. Gore & Associates, Inc., Flagstaff, AZ, USA; Endofit, Endomed Inc., Phoenix, AZ, USA.



**Fig. 2.** Completion angiography after deployment of two stent-grafts for the treatment of a ruptured acute aortic type B dissection.

to overcome difficulties in inserting the stent-graft system due to tortuosity of the vessels.

If the main intimal tear was identified at pre- or intraoperative imaging, the stent-graft was placed at that level. When the main tear was not identified and there was no aortic rupture, the stent-graft was placed from the aortic arch and extended distally depending on the effect upon the true lumen perfusion. However, if an aortic rupture was present, there was an effort to extend the stent-graft down to the level of the diaphragm (Fig. 2). The left subclavian artery was covered liberally whenever the left internal mammary artery was not used as a coronary bypass and the contralateral vertebral artery was patent in the angiography preceding the deployment of the stent-graft. In contrast to elective procedures, no study of the intracranial circulation was routinely performed.

#### *Follow-up protocol*

Follow-up included chest X-ray and contrast-enhanced CT-scan at one and 6 months postoperatively and annually thereafter. Digital subtraction angiography was used selectively when a re-intervention was indicated. All uncertain causes of death were established by autopsy.

#### *Statistical analysis*

Data was prospectively compiled in a computer-based database and a retrospective analysis was

performed. Normal distribution was not assumed. Non-parametric tests were performed, using a significance value of  $p < 0.05$ . Values are given as median with interquartile range in-between parenthesis when not stated otherwise. Statistical analysis was done using SPSS 12.0.1 (SPSS Inc., Chicago, USA).

## **Results**

### *Intra-operative results*

More than one stent-graft was implanted in 10 patients. One patient received an extra stent-graft to reinforce and fully expand the first endoprosthesis that had collapsed in the aortic arch. In the remaining patients the second stent-graft was used to cover a longer portion of the thoracic aorta and facilitate the accurate deployment of the distal end. Median operative time was 140 (IQR108–197) min.

The left subclavian artery was intentionally covered by the stent-graft in 17 patients (55%). No symptoms of ischaemia of the left arm or subclavian steal syndrome requiring secondary revascularization were identified during the study period. A patient presenting with transient paraplegia underwent a transposition of the left subclavian artery to the left carotid the day before EVR-ABD. Another patient with a concomitant aortic arch aneurysm underwent a combined open and endovascular procedure with replacement of the aortic arch with an elephant trunk. Seven patients (23%) required 12 intraoperative adjunctive procedures (Table 3).

### *Early results*

Early postoperative complications occurred in 15 patients (48%, Table 4). One patient (3%) experienced

**Table 3.** Intraoperative adjunctive procedures (7 patients)

Procedure	Total
Stent	
SMA and celiac trunk	1
Renal	1
Iliac (with fenestration)	1
Access complications	
Femoral artery repair	5
External iliac interposition graft	1
Lower limb thrombectomy	1
Carotid stent-graft*	1
Sub-total colectomy	1

\* Stent-graft of the left carotid artery due to partial coverage of the ostium by the proximal end of the aortic stent-graft.

Table 4. Early postoperative complications

Complication type	Number of patients
Transient paraplegia	1
Stroke	5
Lower limb ischemia	3
Myocardial infarction	3
Pneumonia	2
<i>Clostridium colitis</i>	1

a transient paraplegia that was converted to paraparesis by cerebrospinal fluid drainage. Ischemic strokes occurred in five patients (16%). Left subclavian artery coverage by the stent-graft was not associated with a higher incidence of stroke (four of 17 patients versus one of 14,  $p=0.344$ ). The posterior circulation was affected in only one of the patients where the left subclavian artery had been covered (bilateral cerebellar infarct). Of the five patients with stroke, three died within the perioperative period (described below). The other two patients had non-disabling strokes with partial recovery of their neurological function after rehabilitation. Operative time was longer in patients with postoperative stroke (241 (IQR 166–355) min) than in the remainder (128 (IQR 106–165) min,  $p=0.025$ ). Further, four of the five patients suffering stroke had periods of hypotension (three due to aortic rupture and one due to an access-related iliac rupture). The indications for treatment in patient suffering strokes had been aortic rupture ( $n=3$ , two fatal), bowel ischemia ( $n=1$ ) and uncontrollable pain and hypertension ( $n=1$ , fatal).

One patient (3%) with a complicated post-operative course developed a *Clostridium* pancolitis requiring total colectomy.

Five patients (16%) died within 30 days of EVR-ABD. Indications for treatment in these patients were aortic rupture ( $n=3$ ), bowel ischemia ( $n=1$ ) and persistent pain and hypertension ( $n=1$ ). One patient presenting in haemodynamic shock due to aortic rupture died few hours after the operation due to multi-organ failure. The other two patients treated for an aortic rupture suffered strokes and multi-organ failure. One patient admitted with bowel ischaemia requiring an intraoperative subtotal colectomy, had the visceral flow successfully restored by the aortic stent-graft and stents in the superior mesenteric artery and celiac trunk. However, bowel gangrene progressed after further multi-segmental bowel resections and the patient died on the 12th postoperative day. One additional patient died due to renal insufficiency followed by multi-organ failure, stroke and sepsis.

### Late results

Six additional deaths occurred during a median follow-up of 22 (IQ: 16–34) months. Overall mortality during the study period was 35% (11 patients). Two of the late deaths were stent-graft related. One patient died 2 months after the operation. At autopsy the proximal end of the stent-graft (Zenith) was observed to have eroded through the aortic wall immediately distal to the left subclavian artery. The other graft-related death was caused by aortic rupture 2.5 years postoperatively after an otherwise uneventful CT follow-up up to 4 months before. The most likely explanation found at the autopsy was a failure of the stent-graft to provide proximal seal due to poor apposition of a stiff stent-graft to the aortic arch curvature (homemade device). The remaining four deaths were caused by cardiac disease and took place between 5 months and 4 years after the operation. No stent-graft migration was seen during the follow-up period.

### Reinterventions

Re-interventions were required in nine patients (29%). Eight of these were performed within the first 2 weeks after EVR-ABD (Table 5). One patient, already described above, underwent a simultaneous resection of the remaining colon and the proximal jejunum at the time of the second look due to bowel gangrene. A proximal extension of the stent-graft was performed after the initial prosthesis tilted in the distal arch, resulting in misalignment of the stent-graft and failure to exclude the false lumen. A re-exploratory laparotomy was performed in a patient who had suffered an intraoperative access problem requiring a right external iliac interposition graft. Another patient with recurrent deep vein thrombosis received an

Table 5. Reinterventions

Patient	FU duration	Reintervention
#1	2 days	Multisegmental bowel resection
#2	13 days	Thrombectomy and femoral patch angioplasty
#3	14 days	Femoro-popliteal bypass
	1 day	Thrombectomy and femoral patch angioplasty
#4	1 day	Thrombectomy and femoral angioplasty
#5	14 days	Total colectomy
#6	2 days	Proximal extension of the stent-graft
#7	5 days	Exploratory laparotomy
#8	7 days	Renal stent
#9	5 months	Inferior vena cava filter
	5.5 months	Renal stent-graft



inferior vena cava filter at 5 months postoperatively and a right renal artery stent 2 weeks later.

## Discussion

Endovascular stent-graft repair has been proposed as a less invasive method than open repair for the treatment of complicated acute aortic type B dissection.<sup>5</sup> Given the absence of randomised trials and the continuing development of the technique, there is a need for the continuous reevaluation of the results.

The majority of aortic type B dissections have the main entry located immediately distal to the left subclavian artery origin. The left subclavian artery was intentionally covered in more than half of the patients, in order to improve the alignment of the stent-graft in a relatively straight portion of the arch proximal to the main intimal tear. The purpose of this was to avoid the tendency of the proximal end of the stent-grafts to tilt, which can lead to aortic rupture by either erosion of the arterial wall or failure of the proximal seal provided by the stent-graft. Moreover, the misalignment of stent-grafts in angulated aortic arches, together with the high haemodynamic forces in this region, can cause structural instability of the stent-graft and its subsequent collapse.<sup>10</sup> We dealt with this problem in one patient by reinforcing the initial stent-graft with a new one. The policy of liberally covering the left subclavian artery seemed to be well tolerated in our group of patients, in accordance with previous reports in the literature.<sup>11,12</sup> Therefore, this appears to be a reasonable solution to improve the implantation site, until other technical possibilities like fenestrated or branched stent-grafts become more widely available or the adaptability of the stent-grafts is improved.

The frequent use of more than one stent-graft in a single patient was a reflection of the advantage conferred by the overlapping of multiple endoprostheses. This allowed the precise deployment of both the proximal and distal ends of the stent-grafts and coverage of a longer portion of the aorta, which sealed a higher number of intimal tears. The length of the stent-graft used has been identified as a risk factor for the development of paraplegia.<sup>13</sup> We could not confirm such a relationship, since we only had one patient who developed paraplegia.<sup>14,15</sup> The low incidence of paraplegia after EVR-ABD, both in our series and in other reports,<sup>4,16</sup> may be another potential advantage of this technique when compared to open surgical repair.<sup>17</sup>

Open surgical treatment of complicated acute aortic type B dissections is associated with an operative mortality of 36–60%.<sup>2,18–20</sup> Therefore, the peri-

operative mortality of 16% in our group of patients is considered acceptable. In contrast, the high incidence of complications, particularly ischaemic strokes, in the postoperative period might be a drawback of the technique. The coverage of the left subclavian artery does not appear to be the determining factor for stroke. Although it was associated with a higher incidence of stroke (only one in the posterior circulation) this association did not reach statistical significance. The longer operative time required by the procedures in patients suffering strokes suggests endovascular manipulation of the aortic arch as a likely cause. In addition, the high number of patients with hypotension periods suggests that hypoperfusion also could play a role in the development of postoperative strokes, particularly in the context of aortic ruptures. In these cases two potentially aggravating factors are the avoidance of complete intra-operative anticoagulation to prevent further haemorrhage and the emergency nature of the procedure. Therefore, care should be taken to avoid unnecessary manoeuvres and to adequately anticoagulate patients during the procedure.

Trans-oesophageal echocardiography has been reported to be a useful tool during stent-graft repair of dissections, especially for the repositioning of the guidewire and identification of endoleaks and new intimal tears.<sup>21,22</sup> We did not use this technique. However, we do not expect these procedures would have changed greatly if trans-oesophageal echocardiography had been used. One possible advantage might have been assessment of the atherosclerotic burden of the aortic arch. This might have permitted evaluation of any association between arch atherosclerosis and cerebrovascular events.

The high incidence of intraoperative adjunctive procedures and reinterventions, especially in the immediate postoperative period, might be a reflection of the complexity of the disease affecting multiple arterial segments.

The two late stent-graft-related deaths demonstrated the difficulties of the stent-grafts to conform to the curvature of the aortic arch, as discussed previously. Although some improvements have been seen with the more recent generations of endoprosthesis, this problem still escapes solution. Further technological developments are needed to obtain a stent-graft that aligns well in the arch, and provides good fixation without traumatizing the friable aortic wall.

In conclusion, this study shows that endovascular repair of complicated acute aortic type B dissections provides acceptable results and, therefore, can be a valuable alternative to open surgery. Although

the results of EVR-ABD are promising, the operative mortality and morbidity are not negligible. Thus, the technique should be restricted to complicated cases until long-term results and results from randomised trials become available.

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