Endovascular Repair of Stanford Type B Aortic Dissection: Early and Mid-term Outcomes of 121 Cases

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Objective: To analyse the early and mid-term outcomes of endovascular repair of Stanford type B aortic dissection (B-AD) and to compare the outcomes between acute type B aortic dissection (AAD) and chronic type B aortic dissection (CAD).

Methods: The cohort included 121 consecutive patients undergoing endovascular repair for AAD (group A, n = 72) and CAD (group B, n = 49) between January 2001 and December 2006. Follow-up with clinical examinations and computed tomography (CT) was performed post-intervention at 1, 6 and 12 months, and then yearly thereafter.

Results: In groups A and B, respectively, the procedure success rates were 88.9% and 77.6%; the rates of postoperative endoleak were 11.1% and 22.4%; the 30-day mortality rates were 1.4% and 8.2%; and the 30-day stroke rates were 4.2% and 2.0%. No postoperative spinal cord ischaemia (SCI) was observed. The mean follow-up periods for groups A and B were 14.4 ± 11.0 months and 22.1 ± 20.8 months, respectively. Late mortality was 1.5% in group A and 4.8% in group B. In group A, the rates of complete false lumen (FL) thrombosis at 1 month, 1 year and 2 years postoperatively were 32.3%, 51.4% and 53.8%, respectively, and in group B, 26.2%, 44.8%, and 50.0%, respectively.

Conclusion: Endovascular repair is feasible for both AAD and CAD, with favourable short- and mid-term outcomes.

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for cases complicated with rupture, uncontrollable hypertension, persistent back or chest pain and end-organ ischaemia.\textsuperscript{1,2} However, traditional open surgery for AAD is associated with high mortality and morbidity. The IRAD study\textsuperscript{3} enrolled 83 patients who required open surgery for AAD and showed that the in-hospital mortality was 29.3\%, and the rate of neurological deficits was 23.2\%. The endovascular repair of AAD and CAD introduced in 1999\textsuperscript{4,5} has been proven to be an effective and less-invasive therapy, associated with relatively low mortality and low rates of complications.\textsuperscript{6,7} In this study, we present the results of 121 patients with B-AD who received endovascular repair at our centre, and compared the outcomes between AAD and CAD.

Methods

Indications for endovascular treatment of AAD were as follows: (1) persistent back or chest pain, (2) uncontrollable hypertension, (3) malperfusion syndrome, (4) rupture and (5) a maximal aortic diameter ≥5 cm. The indications for CAD were: (1) pseudo-aneurysm with diameter ≥5 cm or rapid enlargement >5 mm per year and (2) acute symptoms.

Procedure

Details of the procedure have been described previously.\textsuperscript{4} In our patient cohort, trans-oesophageal echocardiography (TEE) was not used to guide the stent positioning. When the length of proximal landing zone (PLZ) was shorter than 2 cm, computed tomography angiography (CTA), magnetic resonance angiography (MRA) or digital subtraction angiography (DSA) was performed to study the contralateral vertebral artery, the vertebrobasilar system and the Willis circle to assess the risk of left subclavian artery (LSA) coverage. If the exclusion of the left vertebral artery could be compensated sufficiently, the LSA was intentionally covered without reconstruction; otherwise, reconstruction of LSA prior to intervention was performed.

Definitions

B-AD was considered as acute when presenting within 14 days of the beginning of the symptoms and chronic after 14 days. Procedure success was defined as complete coverage of the primary entry tear without a type I or III endoleak at the end of the procedure. Type I endoleak was defined as blood flow into the false lumen (FL) due to incomplete seal or ineffective seal at one extremity of the stent graft. Complete FL thrombosis was defined as presence of thrombus without blood flow identified in the FL. Partial FL thrombosis was defined as the concurrent presence of both blood flow and thrombus in the FL.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation, while categorical data are presented as percentages. A comparison between continuous variables was performed by Student’s t-test. Categorical variables were analysed by chi-square and Fisher’s exact tests. Cumulative survival rates were calculated using Kaplan–Meier analysis and compared by the log-rank test. A P-value <0.05 was considered statistically significant. Statistical software SPSS 11.5 (Chicago, IL, USA) was used for all the statistical analyses.

Results

Patients

Among 149 patients with aortic dissection (including 28 type A aortic dissections and 121 B-ADs) treated at our centre between January 2001 and December 2006, a total of 121 patients who underwent the endovascular repair for B-AD was included in this study. In this cohort, 72 patients were treated during the acute phase (AAD; group A) while 49 patients were treated during the chronic phase (CAD; group B). The demographics of both groups are presented in Table 1. The two groups had comparable co-morbid conditions, except that the incidence of malperfusion syndrome was significantly higher in group A than in group B (20.8\% vs. \%, \( p = 0.002 \)). No transient dialysis was required for the five patients who presented with mild renal insufficiency. No significant differences were observed between the two groups related to age, male gender, hypertension, chronic renal failure, chronic heart failure, aortic rupture, pneumonia, cardiac arrhythmia, Marfan syndrome, tumour or the number of tears.

Procedural outcome

In this cohort, 130 stents were used: 103 Talent grafts (Medtronic Inc., Santa Rosa, California, USA), 12 Zenith grafts (COOK Inc., Bloomington, Indiana, USA), 11 Ankura grafts (Lifetech, Shenzhen, P. R. China) and four Aegis grafts (MicroPort, Shanghai, P. R. China). The overall procedure success rate was 84.3\%.

In group A, 77 stent grafts were used, with a mean of 1.07 ± 0.26 per patient. The procedure was successful in 88.9\% of patients. There were 25 patients (34.7\%) who underwent stent-graft placement with LSA occluded intentionally without re-vascularisation. Eight cases (11.1\%) of type endoleak were identified at the end of these procedures.

In group B, 53 stent grafts were used, with a mean of 1.08 ± 0.34 per patient. The procedure was successful in 77.6\% of patients. Intentional coverage of LSA without reconstruction was performed in 11 patients (22.4\%). Reconstruction of LSA (left common carotid artery—LSA bypass) prior to over-stenting was performed in one patient successfully. Type I endoleaks were observed in 11 patients (22.4\%) at the end of the procedure. Access complications (iliac artery rupture) occurred in three patients (6.1\%), and were treated by a bypass or direct repair for the iliac artery.

Based on the variables described above, no significant differences were found between groups A and B (Table 2). No emergent surgical conversion was required in either group.

In-hospital and 30-day outcomes

In group A, the 30-day mortality was 1.4\%. One patient with an emergent condition of shock and aortic rupture died of...
a new rupture of the aorta (Table 3). There were three strokes (4.2%), all of which were minor without severe sequelae. One patient presented with acute heart failure with a complete recovery 5 days later. All the acute patients were free from spinal cord ischaemia (SCI), renal failure, respiratory failure, pneumonia and access complication. Six endoleaks disappeared spontaneously within 30 days, two endoleaks remained, yielding a 1-month endoleak rate of 3.1%. Complete FL thrombosis was documented in 32.3% of patients.

In group B, the 30-day mortality was 8.2%. Four patients died within 30 days. The first patient with co-morbid pneumonia and cardiac arrhythmia died of multiple organ failure on the fourth postoperative day. The second patient with a history of chronic obstructive pulmonary disease and Marfan syndrome died of myocardial infarction. The third patient with previous aortic rupture and upper gastrointestinal bleeding died of a new rupture of the aorta. The fourth patient with aortic rupture before intervention died of pulmonary embolism. There was one stroke (2.0%), which resulted in a persistent vegetative state of the patient. The incidences of heart failure, respiratory failure, pneumonia and access complication were 6.1%, 2.0%, 6.1%, and 4.1%, respectively. Renal failure was not observed. The rate of complete FL thrombosis was 26.2%. Based on mortality and complications, no significant differences were found between groups A and B.

Intentional over-stenting of LSA without previous revascularisation was performed in 36 patients (29.8%). Two strokes (5.6%) occurred among these patients. The first patient had an infarction in the frontal lobe with complete rehabilitation 2 weeks later. The second patient had a cerebellar infarction and remained in a persistent neurological vegetative state during follow-up. However, all the other patients tolerated the occlusion of LSA well, without cerebral infarction, left subclavian steal syndrome or left upper extremity ischaemia. Among the other 84 patients in whom blockage of LSA was not necessary during the procedure, two strokes (2.4%) occurred. The incidence of stroke between these two groups was not significantly different.

**Follow-up data**

In group A, the mean follow-up period was 14.4 ± 11.0 months. Five patients were lost to follow-up. One patient died of aortic rupture during follow-up. The survival rates at 1 month, 1, 2 and 3 years postoperatively were 98.6%, 94.7%, 87.5% and 75.0%, respectively. The rates of complete FL thrombosis at 1 and 2 years postoperatively were 51.4% and 53.8%, respectively. The rates of partial FL thrombosis at 1 and 2 years postoperatively were 48.6% and 46.2%, respectively.

In group B, the mean follow-up was 22.1 ± 20.8 months, significantly longer than that of group A (p = 0.021). Three

### Table 2  Procedure data

<table>
<thead>
<tr>
<th>Procedure data</th>
<th>AAD (group A, n = 72)</th>
<th>CAD (group B, n = 49)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stent graft</td>
<td>77 1.07 ± 0.26</td>
<td>53 1.08 ± 0.34</td>
<td>0.824</td>
</tr>
<tr>
<td>Procedure success</td>
<td>64 88.9%</td>
<td>38 77.6%</td>
<td>0.153</td>
</tr>
<tr>
<td>Coverage of LSA</td>
<td>25 34.7%</td>
<td>11 22.4%</td>
<td>0.212</td>
</tr>
<tr>
<td>Access complication</td>
<td>0 0%</td>
<td>3 6.1%</td>
<td>0.126</td>
</tr>
<tr>
<td>Postoperative endoleak</td>
<td>8 11.1%</td>
<td>11 22.4%</td>
<td>0.153</td>
</tr>
</tbody>
</table>

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### Table 3  30-Day mortality and morbidity

<table>
<thead>
<tr>
<th>30-Day mortality and morbidity</th>
<th>AAD (group A, n = 72)</th>
<th>CAD (group B, n = 49)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-Day mortality</td>
<td>1 1.4%</td>
<td>4 8.2%</td>
<td>0.170</td>
</tr>
<tr>
<td>Stroke</td>
<td>3 4.2%</td>
<td>1 2.0%</td>
<td>0.901</td>
</tr>
<tr>
<td>Spinal cord ischaemia</td>
<td>0 0%</td>
<td>0 0%</td>
<td>—</td>
</tr>
<tr>
<td>Heart failure</td>
<td>1 1.4%</td>
<td>3 6.1%</td>
<td>0.362</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>0 0%</td>
<td>1 2.0%</td>
<td>0.846</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0 0%</td>
<td>3 6.1%</td>
<td>0.126</td>
</tr>
<tr>
<td>Access complication</td>
<td>0 0%</td>
<td>2 4.1%</td>
<td>0.316</td>
</tr>
<tr>
<td>1-Month endoleak</td>
<td>2 3.1%</td>
<td>5 12.5%</td>
<td>0.140</td>
</tr>
</tbody>
</table>

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*a* Serum creatinine: 1.2–1.9 mg/dL.
patients were lost to follow-up and two patients died during the follow-up. The first patient with co-morbid conditions of chronic renal and heart failure, polycystic liver and kidney disease pre-interventionally died of massive post-operative bleeding following a combined liver–kidney transplantation performed 42 days after the endovascular repair. The second patient died of pulmonary infection 3 months after endovascular repair. The survival rates at 1 month, 1, 2 and 3 years postoperatively were 91.8, 82.9, 75.0% and 64.7%, respectively. There were no significant differences related to survival rates between the two groups (Fig. 1). The rates of complete FL thrombosis at 1 and 2 years postoperatively were 44.8% and 50.0%, respectively. The rates of partial FL thrombosis at 1 and 2 years postoperatively were 55.2% and 50.0%, respectively.

Discussion

Currently, a consensus has been reached on the management of B-AD. Intensive medical therapy including anti-hypertensive treatment and the use of beta-blockers is the first choice, with surgery reserved for patients complicated with rupture or impending rupture, malperfusion syndrome and rapid aortic expansion. Endovascular repair for patients with B-AD has achieved favourable short- and mid-term outcomes, compared to the traditional open surgery that is still associated with relatively high mortality and morbidity.3

A meta-analysis done by Eggebrecht et al. found decreased mortality in treating the patients at chronic phase compared to acute phase.6 However, this was not observed in the study by Sayer et al., which reported a mortality of 7.5% in chronic dissections compared to 2.6% in acute dissections.10 We observed similar outcomes in these two groups. It was reported that the more stable clinical status of the patients in the chronic phase was probably the most important determinant of better survival following endovascular repair.11 In our cohort, the co-morbid conditions and clinical status (with the exception of malperfusion syndrome) are comparable in the acute and chronic groups, which is a possible reason for similar outcomes in these two groups. The patients complicated with aortic rupture or shock have been shown to be associated with increased early mortality.12,13 In group A, one patient with an emergent condition of shock and aortic rupture died of a new rupture 2 days postoperatively. In group B, both patients with rupture died even after the stent graft was successfully deployed. The postoperative mortality was as high as 60% for the patients with aortic rupture. Differences in clinical status appear to have a greater impact on outcome than the phase during which treatment was implemented. Thus, when deciding on the optimal time for stenting, clinical status should deserve more attention than the phase.

Open repair of B-AD is associated with a relatively high incidence of neurological deficits. IRAD investigators1 reported neurological deficits in 23.2% of patients treated by traditional surgery, with stroke in 9.0% and SCI in 4.5%, respectively. However, the EUROSTAR trial reported much lower rates of stroke (1.6%) and SCI (0.8%) for endovascular treatment of aortic dissections.14 In our cohort, the rate of stroke and SCI was 3.3% and 0%, respectively. It is commonly believed that stroke is associated with the manipulation of guidewire or stent-graft delivery system within the aortic arch. Amabile et al.15 found that the number of stent grafts deployed and the extensive coverage of aortic segments were predictive factors for SCI. Buth et al.16 reported that independent correlation with SCI was observed for three or more stent grafts used and LSA covering without re-vascularisation. In our study, three stent grafts were used in only one case, while one or two stent grafts were used in all other cases. The mean number of stents used per patient was 1.1. The low number of stents used per patient may explain the absence of SCI in our cohort. However, with absence of paraplegia or paraparesis, our results did not support that LSA covering without re-vascularisation is a contributing factor for causing SCI.

The relatively low rates of complete FL thrombosis in our study may be attributed to the high rates of multiple tears and small number of stents used. Previous studies found that complete FL thrombosis was a predictor of reduced aortic enlargement and dissection-related mortality.17,18 Patients with CAD demonstrate relatively poor ability to remodel the aorta, and the rates of FL thrombosis distal to the stent graft are particularly poor, indicating that a long length of aortic coverage is required to gain better FL thrombosis and aortic remodelling.10 However, when extensive coverage of aorta is indicated for CAD, the benefit of reducing aortic rupture and aneurysm expansion should be balanced against the risk of SCI. Our policy with chronic dissecting aneurysms was initially to cover the primary entry tear with one longer stent, and only consider further intervention if the FL was still patent several months later. Although this procedure has reduced the rate of SCI, it also caused a low rate of complete FL thrombosis. Though increased dissection-related mortality has not been observed, more careful imaging surveillance is necessary to detect possible aortic enlargement and rupture for the
chronic patients in our cohort. More recently, we use more than one stent to cover more extensively the primary entry tear and the dissecting aneurysm.

Sufficient PLZ is of great importance to ensure complete coverage of the proximal entry tear and to reduce the risk of a type I endoleak. There is still a controversy on the safety of coverage of the proximal entry tear and to reduce the risk of durability.

Investigations are warranted to demonstrate its long-term outcomes appear to be encouraging. Nevertheless, further investigations are warranted to demonstrate its long-term durability.

Conflict of Interest

None declared.

Acknowledgements

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References