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Surgery for Type B Dissection Using a Short-Stented Elephant Trunk Procedure

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ABSTRACT

Background: Stent grafting is a very important treatment for type B dissection. Some patients are unsuitable for endograft repair because of inadequate proximal and/or distal fixation zones. We reviewed our experience of proximal descending thoracic replacement combined with short-stented elephant trunk implantation for type B dissection for patients without adequate fixation zones for endografts.

Methods: Twenty-one patients with type B dissection (10 acute, 11 chronic) underwent this procedure between August 2003 and December 2007. After replacement of the proximal descending thoracic aorta, a short-stented elephant trunk was implanted into the residual descending thoracic aorta. The residual false lumen was evaluated postoperatively using computed tomography (CT) scans.

Results: There were no in-hospital deaths. One death was observed during a mean follow-up of 69 ± 15 months. One patient with preoperative shock suffered paraparesis but recovered postoperatively. One patient had paraplegia and was lost to follow-up. Cerebral hemorrhage was observed in 1 patient, but he recovered. Thrombus obliteration of the false lumen around the stented elephant trunk was observed in 19 patients (95%) and at the diaphragmatic level in 17 patients (85%) during follow-up.

Conclusion: Replacement of the proximal descending thoracic aorta combined with short-stented elephant trunk implantation was a suitable alternative for type B dissection for patients without adequate fixation zones for endografts (particularly for young subjects). This procedure allowed enlargement of the true lumen, re-establishment of the true lumen, induction of thrombosis of the false lumen, and shrinkage of the aorta. Injury to the spinal cord, however, was an intractable problem.

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INTRODUCTION

The optimal treatment strategy for patients with type B dissection is controversial. Aggressive medical therapy was the preferred method for patients who did not have complications. Open surgery was indicated for patients with complicated type B dissection. Endografting may be an alternative to open surgery because it is associated with a low prevalence of morbidity and mortality. Endografting was unsuitable for patients without suitable landing zones for stent graft therapy. Open surgery or endografting with coverage of the left subclavian artery was recommended in these patients [Riesenman 2007]. We introduced proximal descending thoracic replacement combined with short-stented elephant trunk implantation to treat type B dissection with unsuitable anatomy for endograft repair.

MATERIALS AND METHODS

Patients

Between August 2003 and December 2007, 21 patients with type B dissection (10 acute, 11 chronic) underwent proximal descending thoracic aorta replacement combined with short-stented elephant trunk implantation. Patients with acute aortic dissection were diagnosed by pain onset within 14 days. There were 18 men (86%) and 3 women (14%) whose ages ranged from 28 to 61 years (mean, 44 ± 8 years). This technique was approved by the institutional review board of Peking Union Medical College. Three patients with Marfan syndrome had previously undergone aortic surgery: ascending aorta associated with hemi-arch replacement and atrial septal defect (ASD) repair in 1 patient; the Bentall procedure in 1 patient; and the Wheat procedure in 1 patient. A history of hypertension was the most common preoperative finding (Table 1). Failure of endografting was observed in 3 patients, failure of out-of-hospital medical treatment in 7, and refractory pain irrespective of in-hospital aggressive medical treatment in 11.

Postoperative computed tomography (CT) scanning with contrast enhancement was routinely done to evaluate

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Table 1. Clinical Profiles of Patients with Type B Dissection

Characteristic	Number (%)
Number of patients	21
Age, y ± SD	44 ± 8
Number of women	3 (14)
Hypertension	15 (71.4)
Marfan syndrome	3 (14.3)
Aortic rupture	1 (4.8)
Acute mesenteric ischemia	1 (4.8)
Lower extremity ischemia	1 (4.8)
Distal aortic arch involvement	2 (9.5)
Failure of endografting	3 (14.3)
Failure of the medical treatment	7 (33.3)

the residual false lumen in all patients who survived surgery before hospital discharge, 3 or 6 months after surgery, and once each year after hospital discharge. Patients discharged from the hospital were followed up by telephone, written communication, or interview in our outpatient clinic.

Stent Graft

The stent graft (MicroPort Medical Company Limited, Shanghai, China) had a length of 4 cm or 6 cm (Figure 1). The stented graft consisted of a Gianturco-type self-expandable metallic stent and a high-porosity woven Dacron graft in a bound, compressed state. The whole length of the woven Dacron graft (elephant trunk) was sustained by the expandable stent. The proximal and distal end of the surgical stent graft had 1 cm of extra vascular graft that was used for sewing. Selection of the sizing of the stented elephant trunk was close to the diameter of the descending aorta of normal subjects matched for age, sex, and height.

Surgical Technique

Patients underwent surgery under double-lumen endotracheal anesthesia. The femoral artery and femoral vein were routinely used for cardiopulmonary bypass (CPB) after dissection of the left groin. The left thoracic incision was routinely made through the fourth intercostal space. If the patient was taller than 170 cm, a 6 cm long surgical stent was employed. Otherwise, a 4 cm long surgical stent was used. To reduce sacrifice of intercostal arteries, a 4 cm long surgical stent was recommended. The procedure was carried out with right lung ventilation and collapse of the left lung. After completion of the incisions, a femoral–femoral bypass was started after full heparinization. If patients with stable hemodynamics did not suffer comorbidities (coronary heart disease and poor renal function) or distal organ malperfusion, simple aortic cross-clamping with open distal anastomosis was employed if anticipated to take less than 30 minutes. If longer periods of cross-clamping were required, aortic cross-clamping with distal aortic perfusion using a femoral–femoral bypass was employed.

One clamp was placed between the left subclavian artery and the left common carotid artery proximally; the other clamp was between the fourth and fifth intercostal space distally (Figure 2B). Distal aortic perfusion was maintained by femoral–femoral bypass, or the preserved blood was transfused back by pump via the femoral vein. After the proximal descending thoracic aorta was transected 1 cm distal to the origin of the left subclavian artery (Figure 2B), the proximal anastomosis to the prosthetic graft was completed (Figure 2C). One clamp was placed on the distal end of the prosthetic graft, and the proximal clamp was removed (Figure 2D). The distal clamp was then removed, and the preserved blood was transfused back by pump via the femoral vein. A catheter sheath containing a 4 cm or 6 cm long surgical stent graft in a bound compressed state was inserted into the true lumen of the descending thoracic aorta (Figure 2E). The stented elephant trunk technique has been described in detail by our research group [Liu 2006; Sun 2008]. After implantation into the correct location, the surgical stent graft was distended to match the descending aorta. The proximal edge of the

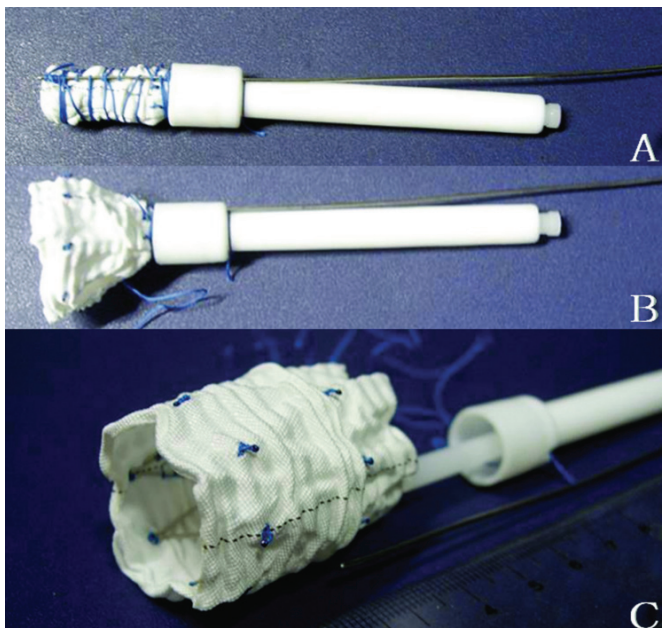

Figure 1. Stented graft. A, catheter sheath containing a short-stented graft in a bound and compressed state. B, the wire is sheared and the stent is partially sprung open. C, The stent is open and completely expanded.

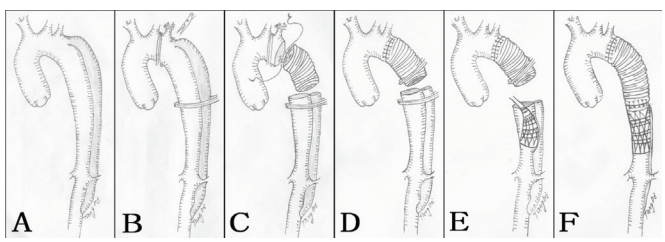

Figure 2. Technique of proximal descending aortic replacement combined with short-stented elephant trunk implantation (see main text for details).

residual descending aorta was trimmed to match the proximal end of the stent graft. The graft was fixed in the true lumen of the descending thoracic aorta by the self-expanding stent to make the true lumen expandable. The stented elephant trunk incorporating the distal aorta was firmly attached to the distal end of the prosthetic graft using the suture line (Figure 2F). Air was eliminated from the descending aorta when the anastomoses were completed. CPB gradually resumed to normal flow, and rewarming started. The procedure was completed after the origin of the corresponding intercostal artery was sutured.

RESULTS

Surgical Data

Aortic cross-clamping with distal aortic perfusion by femoral–femoral bypass was carried out in 13 patients. The femoral–femoral bypass time was 15 to 55 minutes (mean, 28.73 ± 11.63 minutes), and the distal open anastomosis time was 12.13 ± 2.28 minutes (range, 8 to 15 minutes). Simple cross-clamping with open distal anastomosis was done in 6 patients, and the preserved blood was transfused back by pump via the femoral vein (mean, 21.00 ± 2.37 minutes; range, 18 to 24 minutes). Profound hypothermic circulatory arrest (PHCA) was carried out in 2 patients with involvement of the left subclavian artery. The circulatory arrest time was 20 minutes and 22 minutes, respectively, in these patients.

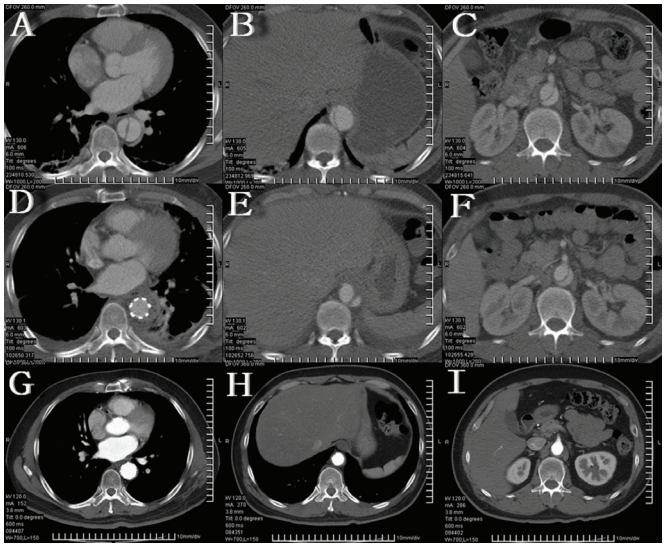

Figure 3. Computed tomography scans of a patient with type B dissection before surgery (A, B, and C), 2 weeks after surgery (D, E, and F), and 45 months after surgery (G, H, and I). At 2 weeks after surgery, a dilated true lumen and deflated thrombosed false lumen were observed (A versus D, B versus E, C versus F), and the false lumen around the stent-graft was obliterated with thrombosis (A versus D). The thrombosis in the false lumen was reabsorbed 45 months after surgery (D versus G, E versus H). The descending aorta returned to normal after remodeling of the aortic wall (G and H). No obvious change in the aortic diameter was observed at the level of the superior mesenteric artery (SMA) (C versus F and C versus I).

Morbidity and Mortality

The procedure was successful in all cases, and no patient died in hospital. Injury to the spinal cord was observed in 2 patients. One patient with acute dissection suffered postoperative paraplegia and underwent cerebrospinal fluid drainage, but the patient did not recover before hospital discharge. The distal stented graft end was located at the Th10 level, and thrombosis of the false lumen was at the diaphragmatic level 6 days after surgery as demonstrated by CT. Paraparesis was observed in 1 patient with acute dissection. A lot of blood was lost because of aortic rupture. The systolic blood pressure was 48 to 60 mmHg during the induction of anesthesia, and paraparesis occurred 2 days after surgery. Cerebral hemorrhage occurred in 1 patient who had a history of hypertension, and multiple mononeuropathy of uncertain cause was observed in 1 patient. Two patients underwent reoperation due to bleeding but recovered after surgery.

Imaging

Twenty-one patients were evaluated by CT. A thrombosed false lumen around the stented graft was observed in 19 patients (95%, 19/20) (the patient with paraplegia was lost

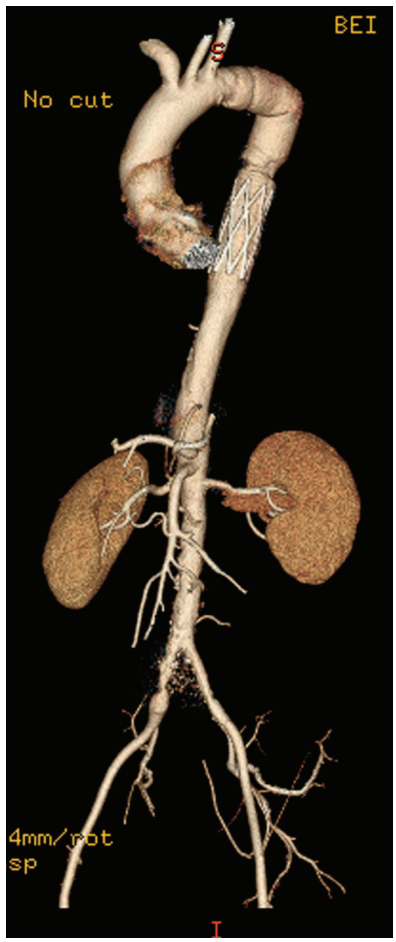

Figure 4. Three-dimensional reconstructions of the postoperative computed tomography scans of the aorta.

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to follow-up after discharge). The false lumen became obliterated with thrombus at the diaphragmatic level in 17 patients (85%). The false lumen in the abdominal aorta was obliterated with thrombosis at the level of the superior mesenteric artery (SMA) in 3 patients (15%). Disappearance (or near-complete disappearance) of the false lumen in the descending aorta was observed in 10 of 20 patients (50%). The descending aorta returned to normal size after remodeling of the aortic wall (Figure 3 and Figure 4). The preoperative false lumen of the descending aorta was 22.82 ± 4.81 mm. Compared with preoperative data, the diameter of the descending aorta decreased to 27.41 ± 2.68 mm (versus 35.34 ± 3.15 mm). No obvious change in the aortic diameter was observed at the level of the SMA.

Follow-Up

The duration of follow-up ranged from 38 months to 90 months (mean, 69 ± 15 months). Two patients were out of follow-up (including the case with paraplegia). One patient received thoracoabdominal aortic replacement during follow-up but died of multiple organ failure. The patient with paraparesis recovered 3 months after surgery. The patient with multiple mononeuropathy recovered 2 months after surgery, and the patient with cerebral hemorrhage recovered 3 months after surgery. One patient had left renal atrophy during follow-up. The true lumen of the abdominal aorta was compressed by the false lumen (as demonstrated by follow-up CT), and a stenosis was observed in the left renal artery.

DISCUSSION

Open surgery was indicated for patients with complicated type B dissection [Elefteriades 1992]. One important question was how much of the descending aorta should be resected if there was no evident aneurysm dilation distal to the proximal descending aorta [Elefteriades 1999]. The patency of the false lumen was also observed in most patients using open surgery, and it is a strong independent risk factor for dissection-related morbidity and mortality [Akutsu 2004].

Endografting may be an alternative to open surgery. In patients without suitable landing zones, the left subclavian artery must be covered to achieve an adequate proximal seal. Several aspects of endografting with coverage of the left subclavian artery must be considered. First, a greater frequency of endoleak occurred. Type-I endoleak was an independent risk factor of early mortality [Khoynezhad 2008]. A high prevalence of complications and mortality [Böckler 2006], and late failure has been reported [Alves 2009]. The long-term durability and late complications of endograft are unknown. Second, the risk of neurologic complications increased after coverage of the left subclavian artery during endografting [Cooper 2009]. Third, the long-time durability of an end-to-side anastosmosis of the left subclavian artery is uncertain. Fourth, an end-to-side anastomosis has poor hemodynamics. More importantly, endovascular failure or retrograde aortic dissection occurred in some patients. Managing stent graft failure was an intractable problem.

Encouraging preliminary results were achieved by our research group in patients with aortic dissection using the stented elephant trunk technique [Liu 2006; Li 2009; Sun 2008; Sun 2010; Sun 2011]. Further modification of the stented elephant trunk technique for surgical treatment of type B dissection was made by Sun et al: (1) shortening of the length of the stented elephant trunk; (2) replacement of the proximal descending thoracic aorta.

Because of a relevant morbidity, mortality, and reintervention rate, aortic arch hybrid repair should be limited to patients not suitable for conventional aortic arch repair [Geisbüsch 2011]. The short stented elephant trunk procedure was performed in younger patients with insufficient length of the landing zone (<10 mm) or the diameter of the fixation zone (>40 mm) in our center. Patients in this group tended to be younger (mean age, 44 ± 9 years) and would survive longer after successful surgery. The endovascular approach was palliative [Alves 2009], so we thought this approach may be justified for this group. Coverage of the left subclavian artery with or without prior surgical revascularization was performed in elderly or higher surgical risk patients in our surgical group.

Compared with patients with type B dissection with unsuitable anatomy for endografting, the short-stented elephant trunk technique had several advantages. First, the short-stented elephant trunk was fixed to the proximal prosthetic graft using the suture line. This reduced the risk of dangerous endoleaks. Second, patients with Marfan syndrome could be treated using this technique because the diameter of the short stent graft was close to the diameter of the descending aorta of normal subjects matched for age, sex, and height. Third, the short-stented elephant trunk re-establishes and enlarges the true lumen and promotes thrombosis of the false lumen in the distal descending thoracic aorta. This is demonstrated by our surgical results. Meanwhile, it was very easy to have hemostasis during the distal anastomosis due to the rigid surgical stent. If late surgery was required, it was safer and easier to carry out the anastomosis between the distal end of the stent graft and the Dacron prosthesis, or the stented elephant trunk could be used for the proximal landing zone.

In-hospital death was not observed in this group, but whether this technique could be carried out for aortic dissection was widely debated. The first problem was injury to the spinal cord due to intercostal arteries originating from the false lumen. We speculated that spinal cord injury was related to rapid thrombosis of the false lumen in a very short time. Collateral circulation did not have a compensatory role in patients with acute dissection. Spinal cord injury was also observed in patients without stented elephant trunk technique, and rapid thrombosis of the false lumen in a very short time occurred [Kawanishi 2007]. Monitoring the neurophysiologic functions using motor- and somatosensory-evoked potentials was an effective method to detect spinal cord malperfusion in patients with endograft repair [Weigang 2006], and methods of spinal cord protection could be used promptly. Drainage of cerebrospinal fluid was effective in these cases [Kawanishi 2007]. So shortening of the surgical stent graft to reduce sacrifice of intercostal arteries and routine intraoperative drainage of cerebrospinal fluid might be a choice. Another problem was organ ischemia due

to visceral arteries originating from the false lumen in patients with chronic dissection. Our recent work demonstrated that this technique can be used in patients with chronic aortic dissection [Sun 2009]. Clinical results also showed that visceral organ ischemia was not observed in this study.

CONCLUSIONS

In summary, our results demonstrated that proximal descending thoracic aorta replacement combined with short-stented elephant trunk implantation was a suitable alternative for type B dissection without adequate fixation zones for endografts (particularly in young patients). This procedure enlarges the true lumen, re-establishes the true lumen, promotes thrombosis of the false lumen in the distal descending thoracic aorta, and helps to shrink the aorta. Injury to the spinal cord remained an intractable problem in patients with acute dissection. Further follow-up is necessary to evaluate the long-time effectiveness of the short-stented elephant trunk technique.

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