Repair of Acute Type A Aortic Dissections Using Open Replacement With Triple-Branched Stent Grafts

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Background. Total arch replacement to treat type A aortic dissection is a complex procedure. To simplify the procedure, we used a triple-branched stent graft for total aortic arch reconstruction.

Methods. Between February 2010 and June 2011, 27 patients (mean age, 52.7 ± 11.5 years), with acute type A aortic dissection underwent open surgical placement of a triple-branched stent graft for total arch reconstruction.

Results. All patients were discharged from the hospital. Mean cardiopulmonary bypass time was 160.5 ± 25.2 minutes, aortic cross-clamp time was 85.5 ± 18.4 minutes, and lower body arrest time was 30.2 ± 11.8 minutes. The mean drainage after the operation was 560 ± 120 mL, and the mean blood transfusion was 500 ± 150 mL. The mean length of stay after surgery was 13.5 ± 3.2 days. The mean follow-up time was 19.3 ± 7.6 months (range, 18 to 33 months). Follow-up was 100%. Endoleaks occurred in 3 patients after the operation, and 1 of them died 9 months after the operation. Follow-up computed tomography scans at 3 months showed the elimination of a false lumen in 24 patients.

Conclusions. Using triple-branched stent grafts for total arch reconstruction in acute type A aortic dissections may be an effective technique to eliminate flow in the false lumen.

(Top Thorac Surg 2013;96:559–63) © 2013 by The Society of Thoracic Surgeons

The conventional treatment for acute type A aortic dissection is replacement of the ascending aorta. But the presence of a residual false lumen in the distal aorta is a risk factor for subsequent reoperation [1–3]. Kato and colleagues [4] developed a hybrid technique in which the ascending aorta and aortic arch were replaced with a branched graft and a stented graft was implanted into the descending aorta.

From Kato and colleagues’ technique, Sun and colleagues [5] proposed a skeletonized elephant trunk implantation combined with total arch replacement to treat acute and chronic type A aortic dissection. This resulted in a hospital mortality of 3.09%, and obliteration of the false lumen around the stented elephant trunk occurred in 94.2% of patients with acute dissection and in 92% of patients with chronic dissection. However, this procedure is a far more complex technique than the conventional techniques for ascending replacement. The distal anastomosis in the descending aorta is difficult to expose, and the anastomotic bleeding is difficult to control.

Chen and colleagues [6] used a triple-branched stent graft instead of arch replacement to reconstruct the aortic arch in acute type A aortic dissection with excellent results. In this report, we describe our results using this technique in 27 patients with an acute type A dissection.

Material and Methods

The open triple-branched stent graft technique and the retrospective review of the records for publication were approved by our hospital Institutional Review Board.

Patients

From February 2010 to June 2011, 27 patients with acute type A aortic dissection underwent the triple-branched stent graft technique in our hospital. Informed consent was obtained from all 27 patients. Patients were a mean age of 52.7 ± 11.5 years (range, 33 to 77 years), and their preoperative comorbidities are listed in Table 1.

The selection criteria for triple-branched stent graft were acute type A aortic dissection with the intimal tear located in transverse arch or proximal descending aorta that could not be resected by hemiarch replacement. Patients were excluded if the origin of the vertebral artery was in the aortic arch. The diameters of the native aortic arch and arch vessels were 10% to 20% smaller than the diameters of the corresponding stent grafts, and the distances between 2 neighboring arch vessels were equal to the distances between the 2 corresponding sidearm stent grafts.

The sizes of the aortic arch vessels were measured by preoperative 3-dimensional computed tomography. The triple-branched stent graft was a branched 1-piece...
graft consisting of a self-expandable nitinol stent and polyester vascular graft fabric (Yuhengjia Sci Tech Corp Ltd, Beijing, China). It comprised a main graft and 3 sidearm grafts. The main graft was tapered and flexible enough to conform to the curved aortic arch. The tapered main graft was 145 mm in length, 30 or 32 mm in proximal diameter, and 26 or 28 mm in distal diameter. At its proximal end, there was a 10-mm-long stent-free sewing Dacron (DuPont, Wilmington, DE) tube. The first sidearm graft was 30 mm long and 14 or 16 mm in diameter. The second and third sidearm grafts were 25 mm long and 12 or 14 mm in diameter. The distance between 2 neighboring sidearm grafts was 3 mm.

Surgical Technique

After induction of general anesthesia, the patient was placed supine. The arterial blood pressures of the upper and lower limbs were monitored. A right subclavian incision was made, and the right axillary artery was exposed. A standard median sternotomy was performed. An arterial cannula (Ningbo Fly Medical Healthcare Corp Ltd, Ningbo, China) was inserted into the right axillary artery, and a dual-stage atriocaval cannula (Ningbo Fly Medical Healthcare Corp Ltd) was placed at the right atrium. Right axillary artery cannulation was routinely used for cardiopulmonary bypass (CPB). The CPB flow was maintained between 2.2 and 2.4 L/min/m², and patients were cooled to a rectal temperature of 20°C. Cold blood cardioplegia was routinely administered for myocardial protection. Antegrade and retrograde cardioplegia were used. During core cooling, the innominate and left common carotid arteries were dissociated and exposed as long as possible.

The ascending aorta was clamped at the base of the innominate artery and transected just above the sinotubular junction. Proximal manipulations, such as aortic valve repair, sinus of Valsalva reconstruction, coronary artery bypass grafting, and composite valved graft replacement, were performed. The transected proximal stump of the ascending aorta was reconstructed by inner and outer Teflon (DuPont) felts, and subsequently, a continuous anastomosis was made to the 1-branched Dacron tube graft.

CPB was discontinued when the rectal temperature was 20°C, while the brain continued to be perfused at a rate of 10 mL/kg/min through the axillary artery cannula. After we cross-clamped the left common carotid artery (4 cm above the arch) and the innominate artery (4 cm above the arch), we transected the ascending aorta at the base of the innominate artery. Through the transverse incision of the ascending aorta, the main graft of the triple-branched stent graft was inserted into the true lumen of the arch and proximal descending aorta, and then each sidearm graft was positioned one by one into the aortic branch. Once the main graft and sidearm grafts were properly positioned, the restraining strings were withdrawn and the main graft and sidearm grafts were deployed (Fig 1A, 1B). The transected distal stump of the ascending aorta was reconstructed by the inner proximal stent-free Dacron tube of the main graft and the outer Teflon felt, and subsequently, continuous anastomosis to the 1-branched Dacron tube graft was made in an end-to-end fashion. The air was carefully flushed from the triple-branched stent graft with right axillary blood return.

Follow-Up

All patients were contacted by telephone or were interviewed directly in our department. All patients were followed up by means of contrast-enhanced computed tomography scan and echocardiographic examination before discharge, at 3 and 6 months after the operation, and then annually thereafter.

Table 1. Preoperative Patient Profiles

<table>
<thead>
<tr>
<th>Variables</th>
<th>No. (%) or Mean ± SD (range)</th>
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<tbody>
<tr>
<td>Demographics</td>
<td></td>
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<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22 (81)</td>
</tr>
<tr>
<td>Female</td>
<td>5 (19)</td>
</tr>
<tr>
<td>Age, y</td>
<td>52.7 ± 11.5 (33–77)</td>
</tr>
<tr>
<td>Comorbidities</td>
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</tr>
<tr>
<td>Marfan syndrome</td>
<td>1 (3.7)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>23 (85)</td>
</tr>
<tr>
<td>Aortic valve regurgitation</td>
<td>10 (37)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 (3.7)</td>
</tr>
<tr>
<td>Cardiac tamponade</td>
<td>1 (3.7)</td>
</tr>
<tr>
<td>Previous acute MI</td>
<td>1 (3.7)</td>
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MI = myocardial infarction; SD = standard deviation.

Fig 1. (A) The triple-branched stent graft is a branched 1-piece graft consisting of a self-expandable nitinol stent and polyester vascular graft fabric. The main graft and 3 sidearm grafts were individually mounted on 4 catheters and restrained by 4 silk strings. (B) Volume reconstructed postoperative computed tomography scans show the main graft and sidearm grafts were well deployed.
Results

Surgical Data

All patients with acute type A dissection successfully underwent ascending aorta replacement and placement of the triple-branched stent graft into the true lumen of the proximal descending aorta, arch, and 3 arch vessels. In 4 patients (14.8%), femoral cannulation was used to augment CPB flow from the axillary cannulation. The mean CPB time was 160.5 ± 25.2 minutes, aortic cross-clamp time was 85.5 ± 18.4 minutes, and the mean deep hypothermic circulatory arrest time was 30.2 ± 11.8 minutes. Concomitant procedures are summarized in Table 2. The mean postoperative drainage was 560 ± 120 mL, and the mean blood transfusion was 500 ± 150 mL. The mean postoperative length of stay was 13.5 ± 3.2 days.

Morbidity and Mortality

No patient died during hospitalization. A postoperative cerebral infarction occurred in 1 patient, but he recovered before hospital discharge. Transient neurologic dysfunction was observed in 4 patients. Ventilator support for more than 5 days was required in 5 patients. Reoperation was indicated for 1 patient with bleeding.

Imaging

CT examinations were performed according to schedule in all patients after discharge. Postoperative CT examinations at 3 months (Fig 2) showed that the false lumens had disappeared in 24 patients.

Follow-Up

All patients were discharged from the hospital and monitored to the end date of this study (January 2013). The mean follow-up time was 19.3 ± 7.6 months (range, 18 to 33 months). Proximal anastomosis endoleaks were discovered in 3 patients at 3 months after the operation.

One patient died 9 months after the operation. The patient was a 77-year-old man with 9 hours of chest pain before the operation. The deep hypothermic circulatory arrest time was 28 minutes, and the aortic cross-clamp time was 78 minutes. He was discharged from the hospital 15 days later, The CT scan 3 months later revealed an asymptomatic type I endoleak. At 9 months, the patient began to have symptoms of dyspnea and hemoptysis, and a CT scan showed that the diameter of the descending thoracic aorta was 8 cm. We planned to replace the aortic arch and thoracic descending aorta; however, the patient died of a serious hemoptysis just before the operation.

The remaining 2 patients with endoleak had no symptoms and have been under observation for more than 12 months. If diameter expansion of the arch is observed, we will perform the operation again and will have to replace the aortic arch and the descending thoracic aorta.

For the rest of the patients, the thrombus obliteration of the false lumen, reabsorption of false-channel thrombosis, enlargement of the true lumen, and shrinkage in the diameter of the entire aorta developed in a continuous dynamic process until the aorta returned to normal. No patients reported any symptoms during the follow-up time.

Comment

The surgical repair of acute type A aortic dissection is still one of the most challenging procedures for the cardiothoracic surgeon. The best surgical strategy for dealing with the distal flap is debated [7]. The elephant trunk technique introduced by Borst and colleagues [8] and techniques used by Kato and colleagues [4] and Sun and colleagues [5] have been developed to deal with residual aortic disease. However, these techniques are still complex and require careful manipulation of the arch and elaborate anastomoses to the distal arch and 3 arch vessels.

Table 2. Concomitant Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
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<tr>
<td>Bentall procedure</td>
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<tr>
<td>Sinus of Valsalva reconstruction</td>
<td>1</td>
</tr>
<tr>
<td>Aortic valve plasty</td>
<td>4</td>
</tr>
<tr>
<td>Replacement of the aortic valve</td>
<td>2</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig 2. The false lumen was obliterated 3 months after the operation: (A) the level above the aortic arch, showing the 3 branches; (B) the level of the aortic arch, and (C) the level of the pulmonary artery bifurcation showing the descending thoracic aorta.
Shimamura and colleagues [9] repaired the aortic arch with the open stent grafting technique using a branched endoprosthesis to reconstruct simultaneously the arch branches and the descending aorta, with satisfactory early results. Chen and colleagues [6] reported the success of the treatment of type A dissection in 30 patients using the 3-branch stent graft. Using similar technology, we only needed to implant the stent graft and complete one clearly exposed vascular anastomosis during the deep hypothermic circulatory arrest time. This procedure not only avoided the difficulty of performing the distal anastomosis in the descending aorta but also prevented injury to the recurrent laryngeal nerve.

We think the cause of the 1 death might have been the rupture of the bronchial artery, which was caused by the endoleak. The exact cause of the endoleak was not discovered. One reason we think may be that the proximal stent-free sewing Dacron tube of the main graft did not have a tight fit with the aortic wall during the reconstruction of the transected distal stump of the ascending aorta.

The primary limitation of this study was that comparisons between the total arch replacement group and the triple-branched stent graft group were not made. The number of patients was small, and the data preliminary. Our long-term follow-up results and the experience of this technique for Marfan patients were limited. To elucidate the precise advantage of this technique, a prospective case-control study would be required.

INVITED COMMENTARY

Total arch replacement in acute aortic dissection is a challenging procedure because of tissue fragility of the aorta and supraaortic trunks. The paper by Pan and colleagues [1] suggests a possible “hybrid solution” to increase the safety of the operation, which, however, remains complex and raises some concerns. The possible presence of distal reentries in dissected supraaortic trunks and reperfusion of the false channel around the stented true lumen may sustain endovascular leaks and bleeding. The distal landing zone in the dissected descending thoracic aorta are additional concerns. Reconstruction of the proximal arch wall and anastomosis to a hybrid graft placed inside may be cumbersome and may lead to development of endovascular leaks. Finally, the need to respect precise dimensional relationships between vessel diameter and the size of the implanted stent graft to achieve effective endovascular sealing raises concern. Because the aortic and each supraaortic trunk diameters are virtually infinite (and may require customization of the prosthesis), the chance to achieve a “perfect fitting, using a one-piece aorta three-branched graft” in an emergent situation is not likely. Nevertheless the results reported by the authors suggest that these are not particularly crucial issues.

Endovascular grafting of the aortic arch remains a pioneer procedure of unknown effectiveness until proved by long-term follow-up studies. Arch anatomy together with unique torsion forces and stresses are not ideal for safe and effective endovascular procedures, which so far are not reserved for patients ineligible for conventional surgical repair. Such considerations are obviously exacerbated by aortic dissection.

Nonetheless, development of prostheses based on endovascular technology implanted during open surgical repair (sutureless valves, Evita and Thoraflex hybrid grafts) is an interesting new field. This phenomenon clearly takes into account the great need for adaptability and creativity required by aortic surgery. New and better solutions, which take advantage of advances offered by our “sister” specialties (eg, radiology, interventional cardiology) are needed. In their practice, cardiac surgeons “see” the disease and know details, pitfalls, and potential sources of catastrophes. Having direct

References