Repair of complicated type B dissection with an isolated left vertebral artery using the stented elephant trunk technique

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Abstract

OBJECTIVES: The presence of an isolated left vertebral artery (ILVA) remains a challenging issue for thoracic endovascular aortic repair (TEVAR) of type B dissection if the proximal landing zones are inadequate. We retrospectively reviewed our experience of the surgical management of complicated type B dissection with an ILVA using the stented elephant trunk technique.

METHODS: Between February 2009 and May 2013, 7 patients with complicated type B dissection (acute = 2 and chronic = 5) underwent the stented elephant trunk procedure under hypothermic cardiopulmonary bypass with selective antegrade cerebral perfusion. All the patients were males with a median age of 53 ± 6 (range 42–59) years. Preoperative lower limb ischaemia was observed in 1 patient, renal dysfunction in 1 patient and visceral ischaemia in 1 patient.

RESULTS: There were no in-hospital deaths. The median ventilator support time was 16 ± 3 (range 11–20) h. Ischaemia of the lower limb and viscera was ameliorated after surgical stent-graft implantation. Continuous renal replacement therapy was not required in patients with preoperative renal dysfunction after surgery. No neurological deficits were observed in any patients prior to hospital discharge. One patient underwent TEVAR due to distal aortic dilatation within the mean follow-up period, which was 44 ± 19 months.

CONCLUSION: Repair of complicated type B dissection with an ILVA using the stented elephant trunk technique was associated with satisfactory surgical results in patients with inadequate proximal fixation zones. This technique is an alternative to TEVAR for complicated type B dissection with inadequate proximal landing zones.

Keywords: Type B dissection • Stented elephant trunk technique • Isolated left vertebral artery

INTRODUCTION

An isolated left vertebral artery (ILVA), which arises directly from the aortic arch, is not uncommon among aortic arch vessel anomalies. The presence of an ILVA has considerable impact on the choice of aortic arch reconstruction techniques and cerebral protection methods in patients with aortic arch lesions. Improper management of the ILVA may result in ischaemia or infarction of the brain if the arterial circle of Willis is incomplete [1, 2]. In patients with type A dissection with an ILVA, total arch replacement using the separated graft technique was described in detail in our previous report [3]. In patients with an inadequate proximal landing zone, complicated type B dissection with an ILVA can be challenging for thoracic endovascular aortic repair (TEVAR). During TEVAR, coverage and revascularization of the left subclavian artery (LSCA) in patients with type B dissection with an ILVA have been reported [4]. In this study, we reviewed our experience with the surgical treatment of complicated type B dissection with an ILVA and inadequate proximal landing zones, using the stented elephant trunk technique.

METHODS

Patients

Between February 2009 and May 2013, 7 patients with complicated type B dissection and an ILVA (Fig. 1) underwent surgical treatment using a stented elephant trunk procedure under hypothermic cardiopulmonary bypass (CPB) with selective antegrade cerebral perfusion (SACP) at Beijing Aortic Disease Center, Beijing Anzhen Hospital. This technique was approved by the institutional review board of Capital Medical University. The mean age of our patient cohort was 53 ± 6 (range 42–59) years; all patients were male. The mean interval between the onset of aortic dissection and surgery was 42 ± 34 (range, 10–110) days. Two patients underwent surgery during the acute stage (within 2 weeks of symptom onset).

Aortic dissection was confirmed prior to surgery by computed tomography (CT). Six patients had a history of hypertension; a failed prior TEVAR was present in 1 patient. In this group, type B dissection was complicated by uncontrolled
hypertension in 2 patients, persistent pain in 2 patients, lower limb ischaemia in 1 patient, visceral ischaemia in 1 patient and renal dysfunction in 1 patient. Preoperative complications were common (Table 1). The primary tear was located near the origin of the LSCA in 6 patients and distal to the origin of the LSCA in the subject with the failed prior TEVAR. Involvement of the LSCA origin was present in 5 patients and involvement of the ILV A origin in 3. The dissection extended into the abdominal aorta in 3 cases and into the iliac artery in 4 cases.

Postoperative CT and echocardiography were recommended to be performed before hospital discharge, 3 or 6 months after surgery and once each year after hospital discharge.

### Table 1: Clinical profiles of patients with type B dissection with the ILVA

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>Acuity</th>
<th>Symptoms and findings</th>
<th>Location of the primary tear</th>
<th>Distal arch involvement</th>
<th>Concomitant procedure</th>
<th>Complication</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55</td>
<td>M</td>
<td>C</td>
<td>Uncontrolled HT</td>
<td>Adjacent to the LSCAO</td>
<td>LSCA</td>
<td>AA-LSCA bypass</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>M</td>
<td>C</td>
<td>Uncontrolled HT</td>
<td>Adjacent to the LSCAO</td>
<td>LSCA</td>
<td>No TEVAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>M</td>
<td>C</td>
<td>Lower limb ischaemia</td>
<td>Adjacent to the LSCAO</td>
<td>LSCA</td>
<td>LSCA-LCCA transposition</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>M</td>
<td>C</td>
<td>Failure of TEVAR/persistent pain</td>
<td>Adjacent to the LSCAO</td>
<td>LSCA</td>
<td>No TEVAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>59</td>
<td>M</td>
<td>A</td>
<td>HT/persistent pain</td>
<td>Adjacent to the LSCAO</td>
<td>LSCA</td>
<td>LSCA-LCCA/ILVA-LSCA transposition</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>6</td>
<td>53</td>
<td>M</td>
<td>A</td>
<td>HT/visceral ischaemia</td>
<td>Adjacent to the LSCAO</td>
<td>LSCAO</td>
<td>LSCA-LCCA/ILVA-LSCA transposition</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>M</td>
<td>C</td>
<td>Previous TEVAR/HT/DB/CAD/renal dysfunction</td>
<td>Distal to the LSCAO</td>
<td>LSCAO</td>
<td>LSCA-LCCA/ILVA-LCCA transposition</td>
<td>No</td>
<td>Alive</td>
</tr>
</tbody>
</table>


### Surgical technique

After anaesthesia induction, intra-arterial cannulation in the radial and femoral arteries were performed for invasive arterial blood pressure measurement. A right subclavicular incision was made and the right axillary artery (RAA) was exposed. Then, mobilization of the transverse arch and brachiocephalic arteries was performed. CPB was initiated after cannulation of the RAA and dual-stage atrio-caval cannulation of the right atrium was performed via a median sternotomy incision. Cannulation of the RAA was used for CPB and SACP. The arterial line was bifurcated for the RAA and for antegrade perfusion through one limb of a four-branched prosthetic graft.
Myocardial protection was maintained using intermittent antegrade perfusion of cold-blood cardioplegic solution. Aortic root procedures (if indicated) were performed during the cooling stage. As soon as the nasopharyngeal temperature reached 23–25°C, circulatory arrest was established and the brachiocephalic arteries were cross-clamped. In practice, blood pressure measurement of the left radial artery and/or back-bleeding through the left common carotid artery (LCCA) were performed to assess whether intraoperative left hemispheric cerebral circulation was adequate (left radial arterial pressure greater than or equal to 15–20 mmHg). Unilateral SACP was started through the RAA and the brain was perfused at \( \approx 5–10 \) ml/kg/min.

The stented elephant trunk (Cronus, Microport, Shanghai, China) technique for type B dissection has been described in detail in our previous reports [5]. It consisted of a Gianturco-type self-expandable metallic stent and a high-porosity woven Dacron graft in a bound, compressed state. The proximal and distal end of the surgical stent graft had 1 cm of extra vascular graft, which was used for sewing [5–7]. A half circumferential or a longitudinal incision was made on the distal end of the transverse arch. The extent of aortic dissection involvement, site of the intimal tear and the involved aortic branch vessel were inspected. We prefer a longitudinal incision because of better exposure and easier manipulation.

In patients with inadequate proximal fixation zones, the ILVA was anastomosed to the LCCA in the same manner (Fig. 2C).

**RESULTS**

**Surgical data**

CPB duration was 108–177 (mean 137 ± 26) min; aortic cross-clamp time was 32–89 (mean 53 ± 19) min and SACP time was 18–59 (mean 32 ± 14) min. Concomitant LSCA–LCCA transposition was performed in 4 patients, LSCA–ascending aorta bypass in 1 and ILVA–LCCA transposition in 3 (Table 1).

**Morbidity and mortality**

There were no in-hospital deaths. The median ventilator support time was 16 ± 3 (range 11–20) h. The median ICU stay was 38 ± 5 (range 31–42) h. The estimated blood loss during operation was 1333 ± 673 ml and the average red cell transfusion during hospitalization was 5.4 ± 5.0 (range, 0–13) U. After implantation of the stented elephant trunk into the distal aorta, lower limb and visceral ischaemia was ameliorated. Postoperative continuous renal replacement therapy was not required in the 1 patient with preoperative renal dysfunction. No cerebral complications were observed in this group. All patients recovered and were discharged from the hospital.

**Follow-up period**

All cases were followed up for a mean of 44 ± 19 (range 19–70) months; there were no late deaths. One patient underwent TEVAR due to a large tear in his descending aorta, distal to the stented elephant trunk. Spinal cord injury and visceral organ ischaemia were not observed during the follow-up period. Patients resumed their normal activities and antihypertensive therapy after hospital discharge.

The anastomotic sites, between the LSCA and the LCCA, and between the ILVA and the LCCA, were patency, as confirming by postoperative CT (Fig. 3). Thrombosis in the false lumen around the
surgical graft was observed in 100% of patients. Thrombus formation extending to the diaphragmatic level was found in 85.7% (6/7) of patients and at the diaphragmatic level in 42.9% (3/7) patients. The mean diameter of the descending aorta decreased from 38.4 ± 4.6 to 29.7 ± 3.7 mm during follow-up.

**DISCUSSION**

In patients without suitable proximal landing zones, TEVAR of type B dissection with an ILVA remains a challenging problem. LSCA coverage results in an adequate proximal seal in some patients undergoing TEVAR; however, this can also result in endoleak and malperfusion of the upper extremity, brain and spinal cord in others [8]. In patients with an ILVA undergoing TEVAR, LSCA revascularization is indicated [9]. However, pre-emptive LSCA revascularization offers no protection against potential neurological complications [10]. During TEVAR, overall persistent complications of LSCA revascularization have been reported in 7.5-9.4% of patients [4, 11]. More importantly, partial or even complete debranching procedures were required when the distal aortic arch was involved in the type B dissection. High mortality and morbidity rates were associated with hybrid aortic arch repair for complicated type B dissection [12-14]. Additionally, managing stent-graft failure was an intractable problem because the need to remove a failed endograft increased the complexity of the aortic reconstruction.

To attenuate mortality and morbidity of hybrid aortic arch repair, a stented elephant trunk technique was performed in our centre for complicated type B dissection with an ILVA, in patients without a suitable proximal landing zone for TEVAR. This technique was performed when the primary tear was adjacent to the origin of the LSCA (n = 2). If the distal aorta was involved by the dissection, LSCA revascularization was performed (n = 5). Although bypass of the LSCA to the ascending aorta was completed in 1 case expeditiously, we prefer LSCA-LCCA transposition (n = 4) due to the long-term patency of autologous brachiocephalic vessels. If the ILVA origin was involved by the dissection, concomitant ILVA-LCCA transposition was performed (n = 3). Total arch replacement combined with the stented elephant trunk technique was performed if the LCCA was involved by the aortic dissection or the diameter of the aortic arch was greater than 50 mm, as our previous report described [3, 15, 16]. Moderate or greater regurgitation of the aortic valve is necessary for surgical treatment of complicated type B dissection with concomitant aortic regurgitation. As for an aneurysm of the aortic root or ascending aorta, surgical intervention was indicated when the diameter of the aortic root or ascending aorta was more than 50 or 45 mm with concomitant repair of the aortic valve.

Due to extensiveness of the surgery itself, the stented elephant trunk procedure as applied to complicated type B dissection remains controversial. Patients tended to be younger in this group (mean age 53 ± 6 years) and would survive longer after successful surgery. As it consists of a woven Dacron graft, the stented elephant trunk ensures a desirable long-term result. Meanwhile, native LSCA and/or ILVA transposition also has the advantage of long-term patency. If late surgery is required, it becomes safer and easier to perform the anastomosis between the distal end of the stent graft and the Dacron prosthesis [17]; the stented elephant trunk can also be used as a proximal landing zone [18]. Thus, we thought the stented elephant trunk procedure would be justified for this select group of patients.

The primary objective of surgical treatment of type B dissection with an ILVA is to preserve the ILVA, as is done in the management of type A dissection with an ILVA [3]. A high incidence of an incomplete circle of Willis has been reported in the Chinese population [7]. In certain aortic arch anomalies, the LCCA does not supply normal blood flow and the ILVA compensates for this [19]. Ligation of the ILVA was performed only when the ILVA was thin, after confirmation of sufficient collateral pathways and a complete circle of Willis. Satisfactory results were demonstrated in this study, without postoperative neurological deficits or in-hospital mortality. We also demonstrated that unilateral SACP was safer after evaluation for adequate left hemispheric cerebral circulation. However, this study was limited by the small number of participants and lack of a control group.

**CONCLUSION**

In conclusion, satisfactory surgical results were obtained for complicated type B aortic dissection with an ILVA using the stented elephant trunk technique. This technique is an alternative to TEVAR for complicated type B dissection with an ILVA and inadequate proximal landing zones. As the follow-up period was relatively short, long-term follow-up is required to confirm the durability of this technique for complicated type B dissection with an ILVA.

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**Conflict of interest**: none declared.
Thoracic endovascular aortic repair (TEVAR) has become the preferred procedure for the treatment of complicated type B aortic dissection owing to the fact that, when compared with conventional open repair, it has dramatically improved perioperative outcome. In addition, TEVAR has recently also been recommended for uncomplicated type B aortic dissection since it is associated with improved 5-year aortic specific survival and positive aortic remodelling [1]. The rationale for endovascular treatment in aortic dissection is coverage of the most proximal dissection entry tear with covered endografts in order to prevent blood from flowing, in an antegrade direction, into the dissection false lumen in order to promote false lumen thrombosis, and avoid aortic enlargement and rupture.