Repair of complicated type B dissection with an aberrant right subclavian artery

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Abstract

OBJECTIVES: An aberrant right subclavian artery (ARSA) is one of the most common congenital anomalies, but the coexistence of type B dissection and an ARSA is extremely rare. Repair of type B dissection poses a technical challenge due to an ARSA. We retrospectively reviewed our experience of surgical treatment of a complicated type B dissection with an ARSA.

METHODS: From August 2010 to March 2014, 7 patients with chronic type B dissection with an ARSA underwent the stented elephant trunk procedure under hypothermic cardiopulmonary bypass in our center. The mean age was 45 ± 7 (range, 32–54) years. Total arch replacement was performed in 2 patients. Revascularization of the ARSA was done in 5 of 7 patients.

RESULTS: There were no in-hospital deaths. The mean time of mechanical ventilation and stay in the intensive care unit was 22 ± 11 and 53 ± 11 hours, respectively. Neurological deficit, visceral ischemia or injury to the spinal cord was not observed. Right upper-limb ischemia was not observed in patients without ARSA revascularization during follow-up.

CONCLUSIONS: In patients not undergoing descending aortic replacement, the stented elephant trunk method is our preferred procedure for this anomaly via a median sternotomy. Repair of type B dissection and revascularization of the ARSA were achieved in a single stage using this technique. Satisfactory surgical results and follow-up outcomes were obtained. There was no right upper-limb ischemia or neurological deficit in patients without ARSA revascularization, but revascularization of the ARSA is recommended for this vessel anomaly.

Keywords: Complicated type B dissection • Aberrant right subclavian artery • Stented elephant trunk procedure

INTRODUCTION

An aberrant right subclavian artery (ARSA) is a common congenital anomaly of the aortic arch. The prevalence of this anomaly is between 0.4 and 2.0% [1]. Most patients with an ARSA often remain asymptomatic, and the ARSA is often discovered incidentally. In as many as 60% of cases, the ARSA may undergo aneurysmal dilatation (Kommerell’s diverticulum) [2]. Surgical intervention is indicated if the ARSA becomes symptomatic or related to aneurysmal dilatation of the ARSA. Even without symptoms, it carries a risk of rupture or dissection [3, 4] and aggressive surgical therapy is recommended.

The coexistence of type B dissection and ARSA is extremely rare; only a few case reports of type B dissection with ARSA have been published [5–10]. The cause of this anomaly is not clear but some authors have speculated that the acute angle of the ARSA weakens the aortic wall, which induces aortic dissection [8]. Several surgical methods, such as thoracic endovascular aortic repair (TEVAR) [9], TEVAR with the chimney method [11], hybrid method [10], frozen elephant trunk [12] and open surgery [8], have been undertaken to manage this lesion. In the present study, we retrospectively report 7 patients with complicated type B dissection and an ARSA, who underwent a stented elephant trunk procedure in our center.

MATERIALS AND METHODS

The study protocol was approved by the institutional review board of Capital Medical University (Beijing, China).

Patients

Between August 2010 and March 2014, 7 patients with complicated type B dissection and an ARSA (Fig. 1) underwent the stented elephant trunk procedure under hypothermic cardiopulmonary bypass (CPB) in our center. Surgery was done >2 weeks after pain onset in all cases and was classified as ‘chronic aortic dissection’. The mean age of the study cohort was 45 ± 7 (range, 32–54) years. Two cases had suffered aortic insufficiency and one subject had coronary artery disease. A previous cerebral infarction was observed in 1 patient. Preoperative characteristics are listed in Table 1.
Patients with type B dissection with an ARSA were confirmed preoperatively using computed tomography (CT). The primary tear was located at the transverse arch in 1 case and at the proximal descending thoracic aorta in 6 patients. The left subclavian artery (LSCA) was involved by aortic dissection in 1 patient. Aortic dissection involved the thoracoabdominal aorta in all cases, and extended to the iliac artery in 5 patients.

**Surgical methods**

Patients underwent the surgical procedure via a median sternotomy. Brachiocephalic vessels and the transverse arch were dissected and exposed as much as possible. Cannulation of the ascending aorta or femoral artery, and venous cannulation of the right atrium. During the cooling stage, a proximal aortic procedure was done if necessary; aortic valve replacement (AVR) was carried out in 1 case, Bentall procedure in 1 patient and coronary artery bypass grafting (CABG) in one subject. Cannulation of the common carotid artery was used for selective antegrade cerebral perfusion (SACP). After the nasopharyngeal temperature reached 25°C, the brachiocephalic vessels were clamped. Circulatory arrest was instituted and the brain perfused at $\approx 5-10$ ml kg$^{-1}$ min$^{-1}$ using SACP. In patients with type B dissection, only the stented elephant trunk (Cronus, Microport, Shanghai, China) method [13, 14] or the stented elephant trunk method with total arch replacement [14–16] has been described in detail by us previously. 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 aortic dissection was sealed with an endograft system, and the stented elephant trunk was terminated in the origin of the common iliac artery.

**Table 1:** Clinical profiles of subjects with complicated type B dissection with an aberrant right subclavian artery (all patients were alive at follow-up)

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Symptoms and findings</th>
<th>Location of primary tear</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>M</td>
<td>Previous cerebral infarction</td>
<td>Descending aorta</td>
<td>SET</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>M</td>
<td>Hypertension/renal ischaemia</td>
<td>Descending aorta</td>
<td>SET</td>
</tr>
<tr>
<td>3</td>
<td>43</td>
<td>M</td>
<td>Hypertension</td>
<td>Descending aorta</td>
<td>SET/AA-LSCA bypass/AA-RSCA bypass</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>M</td>
<td>Aortic incompetence</td>
<td>Distal aortic arch</td>
<td>SET/LSCA-LCCA transposition/RCCA-RCA transposition/AVR</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
<td>M</td>
<td>Hypertension</td>
<td>Descending aorta</td>
<td>SET/TAR–RSCA bypass</td>
</tr>
<tr>
<td>6</td>
<td>54</td>
<td>M</td>
<td>Hypertension/AI/Aortic root aneurysm</td>
<td>Descending aorta</td>
<td>SET/TAR/Bentall/TA–RSCA bypass</td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>M</td>
<td>Hypertension/CAD</td>
<td>Descending aorta</td>
<td>CABG/TAR/ TA–RSCA bypass</td>
</tr>
</tbody>
</table>


**Figure 1:** Preoperative CT of type B dissection with an aberrant right subclavian artery. Posterior view of the aortic arch (A) and the aortic arch from an anterior view (B). 1: Left axillary artery; 2: Left vertebral artery; 3: left subclavian artery; 4: left common carotid artery; 5: right common carotid artery; 6: common brachiocephalic trunk; 7: aberrant right subclavian artery; 8: superior vena cava; CT: computed tomography.
surgical stent graft had 1 cm of extra vascular graft, which was used for sewing.

In patients using only stented elephant trunk, the surgical graft was implanted into the distal aorta after the anterior wall of the aortic arch was incised. The origin of the ARSA was excluded by the stented elephant trunk. The distal aorta containing the surgical graft was anastomosed firmly to the proximal normal aortic segment distally using a suture. Then, transposition or bypass of the ARSA was done.

Total arch replacement was performed according to our previous report [14–16]. In brief, the origin of the ARSA was closed after the stented elephant trunk was implanted into the distal aorta. The distal aorta incorporating the stent graft was anastomosed to the distal end of the four-branched prosthetic graft using an ‘open’ aortic procedure and antegrade blood perfusion of the lower body was started. After anastomosis to the left common carotid artery (LCCA) was accomplished, bilateral selective antegrade cerebral perfusion (SACP) was started. CPB was gradually resumed to normal flow and rewarming was then started. The proximal aortic stump, the LSCA and the innominate artery were anastomosed to the prothetic graft in an end-to-end manner in succession. Then, revascularization of the ARSA was achieved. After the anastomosis, air was eliminated and the procedure was completed.

RESULTS

Surgical data

The mean operative time, CPB time, aortic cross-clamp time, SACP time and lower body circulatory arrest time was 367 ± 76, 180 ± 31, 91 ± 19, 35 ± 12 and 25 ± 5 min, respectively. Revascularization of the ARSA was not undertaken in 2 patients. The RSCA was manipulated in 5 patients: bypass of the RSCA and LSCA was undertaken in 1 patient, transposition of the RSCA to the right common carotid artery (RCCA) and LSCA to the LCCA in 1 patient, and bypass of the RSCA in 3 patients. The ligation of the ARSA was done proximal to the site of the ARSA revascularization in 5 patients. The Bentall procedure and total arch replacement was carried out in 1 case, AVR in one subject, and replacement of the ascending aorta and aortic arch with CABG in one individual.

Morbidity and mortality

There were no in-hospital deaths in the present study. Six patients required mechanical ventilation for <24 h and 1 case required mechanical ventilation for <48 h. The mean duration of mechanical ventilation and duration of stay in the intensive care unit was 22 ± 11 (range, 13–44) h and 53 ± 11 (range, 41–66) h, respectively. Neurological deficit, visceral ischaemia or injury to the spinal cord was not observed. All patients were discharged from hospital.

Follow-up

There was no death during a mean follow-up of 31 ± 19 (range, 12–56) months. Right upper-limb ischaemia was not observed in 2 patients who did not undergo ARSA revascularization. Patients had a normal life after hospital discharge. Compared with preoperative data, the mean diameter of the distal arch, the descending aorta and the false lumen in the descending aorta decreased from 46 ± 4 to 35 ± 8 mm, 41 ± 2 to 32 ± 9 mm and 25 ± 4 to 11 ± 12 mm, respectively. Obvious enlargement of the descending aorta was observed in 1 case with partial thrombosis of the false lumen in contrast to the preoperative imaging.

Figure 2: CT of a patient with type B dissection with an aberrant right subclavian artery using total arch replacement with stented elephant trunk implantation after surgery. The neonatal right subclavian artery (prosthetic graft, red arrow) (A, B) originated from the ascending aorta (B). Thrombosis of the false lumen was reabsorbed gradually after remodelling of the aortic wall around the surgical stent graft (B) and at the diaphragmatic level (C), and the false lumen was obliterated with thrombosis at the level of the superior mesenteric artery (D). CT: computed tomography.
Thrombosis of the false lumen at the end of the stented elephant trunk was observed in 6 patients (85.7%) by postoperative CT (Fig. 2) and partial thrombosis of the false lumen in 1 case (14.3%). Thrombus formation extending to the diaphragm was observed in 5 patients (71.4%) and at the diaphragm in 3 patients (42.9%).

**DISCUSSION**

Coexistence of type B dissection and an ARSA is extremely rare. Due to a limited number of reported case studies [5–10], there is no standard surgical procedure for the treatment of this anomaly. An ARSA increases the surgical difficulty and adds risks to the surgical treatment of type B dissection. Conventional open surgery for this anomaly involves replacement of the affected aorta proximal to the origin of the ARSA with preservation of the ARSA [17] and repair of the diseased aortic lesion after revascularization of the ARSA [18].

After introduction of TEVAR, deployment of an endograft began to be carried out to exclude the ARSA and promote thrombus formation in the false lumen [9]. Posterior cerebral circulation is dependent upon the left and right subclavian artery, so the endograft should be deployed precisely to avoid exclusion of the origin of the LSCA. Otherwise, pre-emptive transposition or bypass of the subclavian artery should be carried out to prevent cerebral complications: the hybrid method [5–7, 10]. In patients with inadequate landing zones, debouching of the supra-aortic arch vessels is done to create an adequate proximal landing zone for TEVAR. However, unsatisfactory surgical results and follow-up outcomes have been reported in patients with complicated type B dissection using hybrid repair of the aortic arch [19–21].

In manipulation of type B dissection with an ARSA, the stented elephant trunk method is our preferred procedure for this anomaly via a median sternotomy because: (i) it provides direct access to transposition or bypass of the ARSA; (ii) closure of the origin of the ARSA and thrombosis of the distal aorta can be achieved after implantation of the stented elephant trunk; (iii) concomitant lesions of the heart, proximal aorta and aortic arch can be repaired in a one-staged procedure.

Measurement of blood pressure (BP) in the right radial artery was adopted to ascertain if blood flow in the right subclavian artery was adequate after exclusion of the ARSA. BP ≥40 mmHg in the right radial artery was considered to be sufficient. In 2 patients using this method, the BP in the right radial artery was >40 mmHg and revascularization of the ARSA was not carried out. Right upper-limb ischaemia or brain injury was not observed in these patients during follow-up, but ARSA revascularization was recommended in our centre. Moreover, it was also easy to carry out the ARSA revascularization via a median sternotomy.

Detection of an ARSA before surgery is crucial so that appropriate methods of cerebral protection during reconstruction of type B dissection with the ARSA can be adopted. It makes supply of blood to the RCCA via cannulation of the axillary artery impossible. A catastrophe occurs if unilateral SACP is done via cannulation of the axillary artery. Three-dimensional reconstruction by imaging has enabled detailed analyses of the complex anatomy of aortic-arch anomalies to guide preoperative planning [12]. Cannulation of the ascending aorta or femoral artery can be chosen. In our patient cohort, cannulation of the ascending aorta was done in 3 patients and the femoral artery in 4 cases, and satisfactory outcomes obtained. No in-hospital death or cerebral complications were observed in our group, which we attribute to our stented elephant trunk method.

**CONCLUSION**

Simultaneous repair of proximal aortic lesions, revascularization of the ARSA, closure of the origin of the ARSA and thrombosis of the false lumen in the distal aorta can be obtained using the stented elephant trunk procedure. Coexistence of type B dissection and an ARSA can be managed using a one-staged procedure to obtain satisfactory surgical results. However, long-term follow-up is required.

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**Conflict of interest**: none declared.

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