Ann Thorac Cardiovasc Surg 2020; 26: 55–59
Online September 26, 2019
doi: 10.5761/atcs.nm.19-00187

New Method

Simple Redo Proximal Thoracic Aortic Surgery with Peripheral Cardiopulmonary Bypass and Minimal Dissection

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Reoperations on the proximal thoracic aorta are increasingly observed after previous aortic or cardiac operations. Redo proximal aortic surgery remains challenging with an increased mortality compared to first-time operations. For a successful redo proximal aortic surgery in a patient with complex pathological conditions, the surgical procedure and cardiopulmonary bypass (CPB) should be simplified as much as possible. Herein, we report our experience of proximal aortic reoperations in which the strategy consisted of an axillo-axillary (jugular) and a femoro-femoral CPB in combination with minimal dissection of surgical adhesions. Satisfactory full-flow CPB was achieved with peripheral cannulations and the aid of vacuum-assisted venous drainage. A suitable surgical view of the proximal aorta was obtained without dissection of the heart. There was no operative mortality and the peripheral CPB was well managed without technical problems. We consider that the proposed strategy makes proximal aortic reoperations safe and simple.

Keywords: aortic aneurysm, thoracic, redo aortic operation

Introduction

Persistent or recurrent aortic disease in the proximal thoracic aorta after previous aortic or cardiac operation is increasingly observed.[1,2] After a successful initial surgery, several patients may develop late complications, such as aneurysmal expansion, aortic dissection, pseudoaneurysm or infection that can lead to dehiscence of the distal or proximal anastomosis. First-time operations on the ascending aorta and aortic root are performed with low mortality; however, redo proximal aortic surgery continues to be challenging for cardiovascular surgeons with increased mortality compared to first-time operations.[3] For a successful redo proximal aortic surgery, safe reentry into the chest and careful dissection of surgical adhesion should be the first step. Occasionally, extensive surgical adhesions complicate access to the heart and great vessels for venous drainage. Complete dissection of dense adhesions during redo surgery tends to be time-consuming and makes this difficult operation more complex. To simplify proximal aortic reoperation, we present our surgical strategy comprising minimal dissection of surgical adhesions, with the aid of an axillo-axillary (jugular) cardiopulmonary bypass (CPB) and a femoro-femoral CPB.

Patients

We reviewed the records of five patients who underwent proximal aortic redo surgery between June 2014

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Received: July 7, 2019; Accepted: September 2, 2019
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Table 1 Patient characteristics

Case	Age/gender	Diagnosis	Initial surgery	Infection	Reoperative procedure	Interval from initial surgery (month)	Survival
1	60/F	Pseudoaneurysm of aortic root	Hemi-arch replacement	Yes	VSRR + TAR omentopexy	2	Yes
2	74/M	Pseudoaneurysm of aortic root	TAR	No	Primary closure	44	Yes
3	82/F	Chronic DAA (arch)	Hemi-arch replacement	No	TAR	90	Yes
4	49/F	Pseudoaneurysm of aortic root	VSRR + TAR	No	Bentall	4	Yes
5	67/F	Pseudoaneurysm of ascending aorta	CABG	No	Patch closure	240	Yes

CABG: coronary artery bypass grafting; DAA: dissecting aortic aneurysm; TAR: total arch replacement; VSRR: valve-sparing root replacement

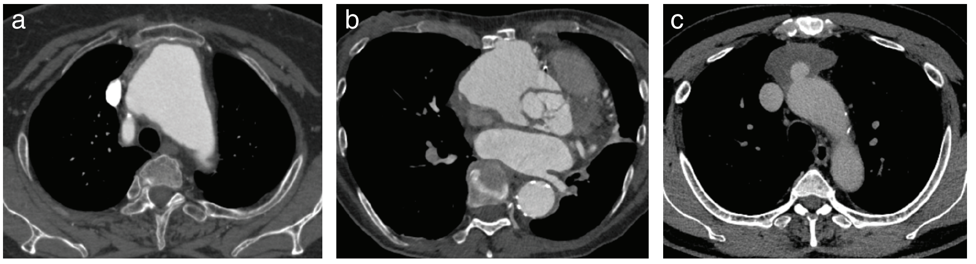

Fig. 1 Preoperative computed tomography. (**a**) Case 3. Retro-sternal adhesion of the ascending aortic aneurysm is shown. (**b**) Case 4. Severe retro-sternal adhesion to the pseudoaneurysm is demonstrated. (**c**) Case 5. Close contact between the pseudoaneurysm and sternum is shown.

and November 2018 using the strategy of minimum dissection of surgical adhesions in combination with peripheral CPB. The patients were aged between 49 and 82 years; four were females and one was male. The indications for reoperation were pseudoaneurysm of the aortic root in three patients (**Table 1**; Cases 1, 2, and 4), pseudoaneurysm of the cannulation site on the ascending aorta in one patient (Case 5), and development of a dissecting aneurysm in the arch following the repair of an acute aortic dissection in one patient (Case 3). The initial diagnoses included: Stanford type A acute aortic dissection in four patients and coronary artery disease in one patient. Four patients diagnosed with acute aortic dissection underwent either hemi-arch or total arch replacement (TAR) and one patient with stable angina pectoris underwent coronary artery bypass grafting, as an initial surgery. The interval between the initial surgery and reoperation ranged from 2 to 240 months. Retro-sternal adhesion or close contact to a pseudoaneurysm and an aneurysmal ascending aorta were suspected by computed tomography (CT) in all patients. Representative CT images of three patients (Cases 3, 4, and 5) are demonstrated (**Fig. 1**). One patient had a mediastinal infection, and two patients underwent emergency redo surgery (Cases 1 and 4). The types of reoperation procedures included: repair of a pseudoaneurysm in two patients; valve-sparing root replacement with TAR and omental transfer to the mediastinum in one patient; TAR in one patient, and Bentall operation in one patient. Written informed consent was obtained from the patients for the publication of this article.

Surgical Strategy

After induction of general anesthesia, defibrillation pads are placed on the chest, over the cardiac apex, and on the back, in the right infrascapular region. Peripheral CPB was established prior to sternal reentry because of retro-sternal adhesion or close contact (**Fig. 2**). Arterial cannulation was conducted on both the axillary and femoral arteries in all cases (**Table 2**). Purse-string suturing was performed on the arteries using a 5-0 polypropylene suture. Following arterial puncture, a guidewire was inserted and arterial cannulas were placed in both arteries. In our proposed surgical and CPB strategy, the heart

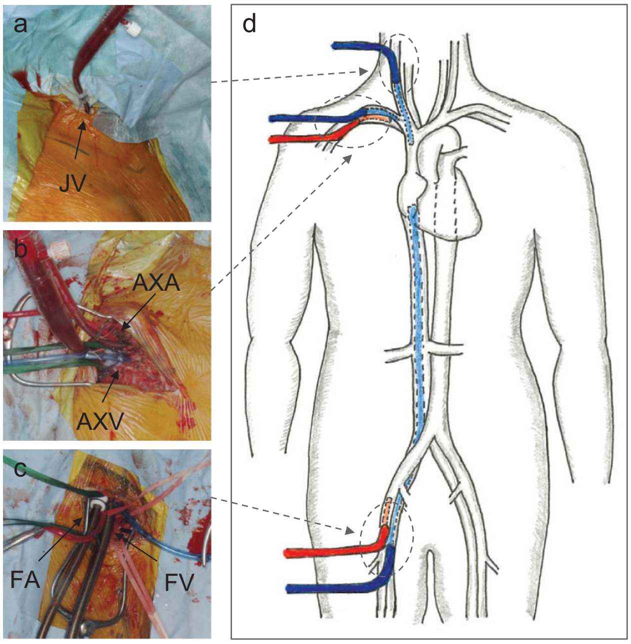

Fig. 2 Establishment of CPB. (**a**) The jugular venous cannula was inserted percutaneously. (**b**) Axillo-axillary CPB was established. Both arterial and venous cannulas were inserted surgically. (**c**) Femoro-femoral bypass was established. (**d**). Schematic drawing of the peripheral CPB. The jugular vein or the axillary vein was chosen as an adjunctive drainage site of the femoral vein. AXA: axillary artery; AXV: axillary vein; CPB: cardiopulmonary bypass; FA: femoral artery; FV: femoral vein; JV: jugular vein

was left undissected. Therefore, femoral venous cannulation in combination with jugular or axillary vein cannulation was performed (**Fig. 2**).[4] No venous cannula was placed on the surface of the right atrium. The femoral vein was cannulated using a guidewire technique and the tip of the cannula was placed in the right atrium. The jugular vein or axillary vein was cannulated using the same guidewire technique. The jugular venous cannula was inserted percutaneously. The tips of the jugular and axillary venous cannulas were positioned within the superior vena cava. Transesophageal echocardiographic monitoring was used to confirm the safe introduction of the guidewire and venous cannulas. The surgical adhesion around the right superior pulmonary vein was not dissected, and the left heart was not vented through it. Vacuum-assisted venous drainage (−30 mmHg) was performed in all patients. Because patients with a low left ventricular function may develop significant ventricular distension, a small left anterior thoracotomy is made over the ventricular apex for the placement of a venting catheter.

After establishment of hypothermic CPB, the sternum was carefully opened with an oscillating saw. The adhesions around the native ascending aorta or the prosthetic graft were minimally dissected for cross-clamping. Cardiac arrest was induced via antegrade infusion or direct infusion of a cardioplegic solution into the coronary ostium. No retrograde cardioplegia was used. In patients requiring additional aortic arch operations, antegrade selective cerebral perfusion was conducted with moderate hypothermic circulatory arrest. After the completion of each surgical procedure on the ascending aorta and aortic root with or without aortic arch procedures, the aortic cross-clamp was released and the patients were rewarmed and weaned from CPB.

Results

All five patients successfully underwent redo proximal thoracic aortic surgery with peripheral CPB and minimal dissection (**Table 2**). Venous cannulation was performed through both the femoral and jugular veins in four patients. The axillary vein, rather than the jugular vein, was used in one patient. Satisfactory full-flow CPB was obtained with vacuum-assisted drainage. Particularly, in one patient with a left ventricular ejection fraction of 11% (Case 5), the left heart was vented from the left ventricular apex through a small left anterior thoracotomy to avoid ventricular distension.

Excellent decompression of the heart was achieved without left heart venting through the right superior pulmonary vein. The sternum was opened with an oscillating saw under adequate cardiac decompression. Catastrophic rupture of a pseudoaneurysm during sternal reentry did not occur in any patient. The cooling and rewarming phases were well managed without technical problems. Although severe postoperative adhesions were not dissected, except for those around the ascending aorta and aortic root, suitable surgical exposure could be obtained with our CPB strategy (**Fig. 3**). The mean operative time was 488 minutes (**Table 3**). The mean CPB time was 279 minutes. Hemostasis tended to be time-consuming because of the prolonged CPB, which was started prior to sternal reentry. However, no patient required re-exploration for postoperative bleeding. There was no cannula or only one small cannula for antegrade infusion of the cardioplegic solution and aortic root venting was present in the surgical field throughout the procedure.

There was no operative mortality in the five patients who underwent proximal thoracic aortic redo surgery

Table 2 Manner of cardiopulmonary bypass and adjunctive procedures

Case	Arterial cannulation	Venous cannulation	Venting	VAVD	SCP	CA
1	Rt. AXA Rt. FA	Rt. FV Rt. JV	No	Yes	No	Yes
2	Rt. AXA Rt. FA	Rt. FV Rt. JV	No	Yes	No	No
3	Rt. AXA Rt. FA	Rt. FV Rt. JV	No	Yes	Yes	Yes
4	Rt. AXA Rt. FA	Rt. FV Rt. AXV	No	Yes	No	No
5	Rt. AXA Rt. FA	Rt. FV Rt. JV	Yes (LV venting)	Yes	No	Yes

AXA: axillary artery; AXV: axillary vein; CA: circulatory arrest; FA: femoral artery; FV: femoral vein; JV: jugular vein; LV: left ventricle; SCP: selective cerebral perfusion; VAVD: vacuum-assisted venous drainage

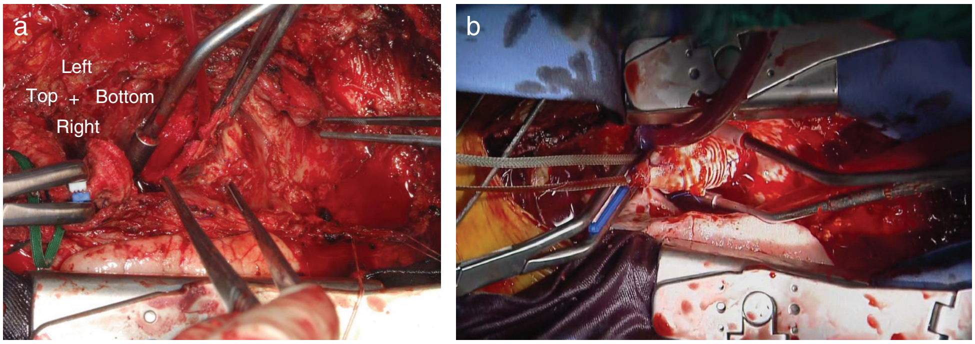

Fig. 3 Suitable surgical exposure of the proximal aorta. (**a**) Intraoperative photograph of Case 1. After cross-clamping of the ascending aortic graft subsequent to minimal dissection of the aortic root. Surgical exposure was good and there was no cannula in the operative field. (**b**) Intraoperative photograph of Case 4. The heart was left undissected. There was no cannula in the surgical field.

Table 3 Results of cardiopulmonary bypass

Case	Operation time (min)	CPB time (min)	Cross-clamp time (min)	SCP time (min)	CA time (min)
1	584	333	215	98	56
2	424	204	102	–	–
3	582	355	168	177	122
4	435	278	164	–	–
5	415	225	–	–	17

CA: circulatory arrest; CPB: cardiopulmonary bypass; SCP: selective cerebral perfusion

with peripheral CPB and minimal dissection. We also did not note any serious complication related to our strategy. One patient required permanent pacemaker implantation owing to postoperative complete atrioventricular block. All patients experienced good postoperative recovery. Follow-up CT showed no evidence of pseudoaneurysm recurrence in four patients (Cases 1, 2, 4, and 5). The patient with an infectious pseudoaneurysm (Case 1) is currently doing well, 72 months after the redo operation, with no sign of infection.

Discussion

Patients undergoing proximal aortic reoperations have a higher operative risk than those undergoing first-time procedures because of the complex nature of new-onset or recurrent aortic pathology and the life-threatening risk of sternal reentry.[3] It is mandatory to improve surgical outcomes in this kind of patients; however, the optimal surgical and CPB strategy remain controversial.

Extensive adhesions developing after the initial surgery make access to venous drainage sites, such as the right atrium, superior vena cava, and inferior vena cava, difficult. Complete dissection of the heart and great vessels was considered ideal for performing the following surgical procedure, but the time required for dissection is unpredictable and occasionally extensive. The time for dissection depends on the severity of the postoperative adhesions. However, it is not necessary to dissect surgical adhesions around the heart in patients undergoing redo proximal aortic surgery. Furthermore, direct placement of venous drainage cannulas on the heart was not necessary with our proposed strategy, which consisted of an axillo-axillary (jugular) CPB combined with a femoro-femoral CPB. Proximal aortic reoperation could be performed with the minimal dissection strategy with the aid of peripheral CPB. Despite the minimal dissection of adhesions around the heart, a suitable surgical view could be obtained. Additionally, the axillary arterial and venous cannulation allows for both antegrade and retrograde cerebral perfusion when an additional aortic arch procedure with circulatory arrest is necessary.[4,5]

However, inadequate venous drainage and cardiac distension during the cooling phase are major concerns with the peripheral CPB strategy. Modern femoral venous cannulas with multiple holes usually provide sufficient drainage for full-flow CPB in minimally invasive cardiac surgery.[6] In our series, with the additional jugular or axillary venous cannula and the vacuum device, satisfactory full-flow CPB could be achieved without left heart venting. Particularly, in the patient with ascending aortic pseudoaneurysm associated with severe ischemic cardiomyopathy, prophylactic left ventricular venting via a small left anterior thoracotomy was performed to avoid ventricular distension prior to systemic cooling via CPB. Cardiac recovery after CPB and cardioplegic arrest was good even in the patient with low cardiac function.

Although a hemorrhagic tendency during surgery was noted due to prolonged CPB time, we believe that our strategy comprising minimal dissection with the aid of peripheral CPB makes complex proximal thoracic aortic reoperations safe and simplified.

Conclusion

We performed proximal aortic reoperation using our new strategy comprising minimal dissection of surgical adhesions, with the aid of an axillo-axillary (jugular) CPB and a femoro-femoral CPB.

Acknowledgment

We thank Editage (www.editage.jp) for English language editing.

Disclosure Statement

The authors have no conflicts of interest to declare.

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