Extended replacement of aortic arch aneurysms through left posterolateral thoracotomy

Kenji Okadaa,*, Akiko Tanaka a, Hiroshi Munakata a, Masamichi Matsumori a, Yoshihisa Morimoto a, Yoshiaki Tanakab, Tadaaki Maeharac, Yutaka Okitaa

a Department of Surgery, Division of Cardiovascular Surgery, Kobe University Graduate School of Medicine, Kobe, Japan
b Department of Thoracic and Cardiovascular Surgery, Japan Self-Defence Force Central Hospital, Japan
c Department of Surgery II, National Defense Medical College, Japan

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Abstract

Objective: To present our experience of total aortic arch replacement through a left posterolateral thoracotomy. Methods: Sixteen patients (13 males; mean age 62.1 ± 11.3 years) with extended thoracic aortic aneurysms, including those in the thoracoabdominal aorta, underwent replacement through a left posterolateral thoracotomy. The pathology of the diseased aorta was non-dissecting aneurysm due to aortitis in 1 patient and aortic dissection in 15 patients (acute type A: 1, chronic type A: 12, chronic type B: 2). In a prior operation, the patient with aortitis had undergone the Bentall procedure with endovascular stenting of the brachiocephalic artery, and among the other 15 patients, one previously had endovascular stenting for the aortic arch and 12 had hemi-arch replacement for acute type A dissection. Extension of arch replacement was the aortic arch and descending aorta in eight patients, the ascending arch and descending aorta in five patients and the descending arch, and thoracoabdominal aorta in three patients. Additional retroperitoneal dissection was required for the repair of a thoracoabdominal aortic aneurysm. Results: One patient died of traumatic cerebral hemorrhage on day 145 (hospital mortality 6.3%). Average duration of ventilation support was 19.4 ± 17.0 h and length of ICU stay was 3.6 ± 1.6 days. Actuarial survival at 2 years after the operations was 67.7%. However, no aortic-related mortality was observed during follow-up. Conclusions: Early results of extended aortic arch replacement through a left posterolateral thoracotomy were satisfactory in selected patients.

Keywords: Extended thoracic aneurysm; Left side thoracotomy

1. Introduction

Repair of an extended thoracic aneurysm is challenging. A staged operation is often preferred with safety as the priority [1,2]; however, this strategy may result in greater than expected mortality when considering the combined mortality from the first and second procedures as well as death in the interval between procedures [3].

A one-stage operation is highly effective in terms of both long-term survival and quality of life. However, careful patient selection based on preoperative comorbidity is of vital importance. Simple incision and good aortic exposure is mandatory in the one-stage treatment for extensive thoracic aneurysms. Brain protection during the arch replacement is another important issue in obtaining a satisfactory outcome [4].

Median sternotomy is the gold standard to access the aortic arch, however, exposure of the distal descending aorta is limited even if additional left anterolateral thoracotomy is applied. Residual dissection from the aortic arch down to the descending or thoracoabdominal aorta after ascending aortic replacement for acute type A dissection is often encountered, which requires an extended replacement of the aortic arch. Kouchoukos et al. reported excellent results of a one-stage operation for extended thoracic aneurysms through a clam-shell incision using the arch-first technique [5]. Left posterolateral thoracotomy is another beneficial option to access the ascending, arch and entire descending aorta, which allows for performance of even a thoracoabdominal procedure by entering the retroperitoneal space.

This report describes the surgical experience in repair of thoracic aneurysms through the left posterolateral thoracotomy.
2. Methods and patients profile

From 2002 to 2007, 16 patients underwent one-stage repair of extended thoracic aneurysms (all including the aortic arch and descending aorta of varying lengths) through a left posterolateral thoracotomy. Profiles of the patients were retrospectively reviewed and are shown in Table 1. The average age was 62.1 ± 11.3 years (range: 44—80) and 13 of the 16 patients were male. Chronic type A dissection (n = 12) was the major aortic pathology among these patients and all 12 patients (cases 5—16) underwent ascending aortic replacement and had progressive enlargement of residual dissection of the aortic arch and the descending aorta. One patient (case 1), who had undergone a Bentall operation and stenting in the brachiocephalic artery aneurysm due to aortitis, had a non-dissected aneurysm from the ascending, aortic arch to the descending aorta. Another patient (case 2) had dilated chronic type B 3-channel dissection associated with the arch aneurysm. Two patients (cases 2 and 3) had chronic type B dissection. Cases 3 and 13 had undergone endovascular thoracic aortic repair (TEVAR) from the aortic arch to the descending aorta, followed by progressive aortic dilatation due to type I endoleak. One patient (case 4) had an abdominal aortic aneurysm (AAA) and previously had undergone the replacement of an AAA.

Two patients (cases 2 and 13) were diagnosed to have DIC with a decreased platelet count and increased FDP level. The average standard EuroSCORE was 9.7 ± 2.5, ranging from 6 to 15. Case 4, who had acute type A aortic dissection with left leg malperfusion and a rupture in the left pleural cavity, underwent surgery on emergency basis (Table 2).

3. Preoperative risk evaluation (Table 1)

With regard to preoperative brain complications, one patient (case 8) had an epidural hematoma, which required external decompression of the brain before the aortic repair and another (case 13) had experienced a stroke after the previous TEVAR. Case 14 had stenosis of the right middle cerebral artery accompanied by an old cerebral infarction. Three patients had preoperative chronic renal failure (cases 3, 9 and 14). Case 5 had an abdominal aortic aneurysm (AAA) and previously had undergone the replacement of an AAA.

4. Surgical procedure

With the patient in the right recumbent position, the entire thoracic aorta was exposed through the 4th intercostal spaces with or without left rib-cross thoracotomy [7]. The 5th rib was transected anteriorly or posteriorly, which provided sufficient aortic exposure (Fig. 1A). The 6th rib was

![Fig. 1. Schema of thoracotomy. (A) Left side thoracotomy through the left 4th intercostal space. The 5th rib was transected anteriorly or posteriorly. (B) Left side rib-cross thoracotomy. The 4th and 7th intercostal spaces were opened. The 5th, 6th, and 7th ribs were transected at the midaxillary line, afterward the 8th costal cartilage was transected.](https://academic.oup.com/ejcts/article-abstract/35/2/270/475811)
transected particularly for thoracoabdominal procedure. With regard to the rib-cross thoracotomy (case 4), a skin incision was made from the midpoint between the spinal process and the scapula, around the lower end point of the scapula, down to the left subchondral lesion. The 4th and 7th intercostal spaces were opened, after which the 5th, 6th, and 7th ribs were transected at the midaxillar line. The 8th costal cartilage was transected along the incision through the 7th intercostal space (Fig. 1B). The sternum was not transected and the left internal thoracic artery was preserved in all cases. Cardiopulmonary bypass was established using the femoral artery for arterial return and the left femoral vein \( (n = 7) \), the pulmonary artery \( (n = 8) \) or both \( (n = 1) \) for venous drainage. Patients were cooled down to at 22.8 ± 3.8 °C (range: 16–28 °C) as measured by a tympanic thermometer. An aortic cross-clamp was placed on the mid-part of the descending aorta, maintaining lower body perfusion. The aorta was opened from the proximal descending aorta to the ascending aorta mainly up to the previous prosthetic graft for the ascending aortic replacement. Cardioplegic solution was given from inside the ascending aorta with a balloon-tipped catheter, and selective cerebral perfusion was established using balloon-tipped catheters from inside the aortic arch. A Dacron graft was anastomosed to the previous graft or the ascending aorta first in the majority of cases (Fig. 2). Afterward, arch vessels were reconstructed as an island cuff in 14 cases. Brain protection was provided by antegrade selective cerebral perfusion under deep hypothermia in 13 patients or deep hypothermic circulatory arrest with complementary retrograde cerebral perfusion in 3 patients (Table 2). Systemic rewarminng was initiated after the reconstruction of the arch vessels. Perfusion of the heart and brain was re-established through the side branch of the prosthetic graft. The distal descending aorta was transected at a normal caliber, and the graft was anastomosed to both the true and false lumen to maintain patency distally and to prevent malperfusion of the visceral organs or legs. Three patients (cases 14, 15 and 16) with a dilated thoracoabdominal aorta underwent additional replacement down to the previous abdominal Y graft or the terminal aortic bifurcation under the selective perfusion of visceral organs (Fig. 3). Five intercostal arteries were reattached in each case.

5. Extent of the repair

The extent of the thoracic aortic replacement is shown in Table 2, which was from the ascending aorta, arch to the mid-descending aorta in five patients (cases 1–5), aortic arch to the mid-descending aorta in eight patients (cases 6–13) and from the arch down to the thoracoabdominal aorta in three patients (cases 14–16), respectively.

5.1. Statistical analysis

Data were expressed as mean ± SD. Actuarial survival was assessed by the Kaplan—Meier method using the SPSS package for Windows (SPSS Inc., Chicago, IL).

6. Results

6.1. Early results

One patient (case 2), who had the comorbidity of DIC, died during hospitalization from traumatic brain bleeding on day 145 (hospital mortality 6.3%). Cardiopulmonary bypass time was 209.1 ± 58.8 min, myocardial ischemic time was 82.9 ± 29.8 min, SCP time was 84.4 ± 29.7 min and CA with RCP time was 37.7 ± 6.8 min (Table 2). Postoperative ICU stay was 3.6 ± 1.6 days. The postoperative profiles of the patient group are shown in Table 3. A reversible ischemic neurological deficit manifested by right forearm paralysis was observed in case 11, but no other brain complications were noted. Case 14, who underwent extended replacement down to the thoracoabdominal aorta, had temporary paraparesis and ischemic colitis, but had recovered com-
Fig. 2. Exposure of the ascending aorta and aortic arch through left side thoracotomy (case 11). (A) Surgeon’s view through the left side thoracotomy through the left 4th intercostal space. Aortic arch aneurysm was opened, through which antegrade selective cerebral perfusion (SCP) cannulae was inserted into neck vessels. Previous graft was grasped by Kelly clamp. (B) Schema of (A). (C) New graft was anastomosed to the previous graft. Ascending aorta was accessible through this thoracotomy. (D) Schema of (C).

Table 3
Postoperative patient profile.

<table>
<thead>
<tr>
<th>Number</th>
<th>Respiratory support (h)</th>
<th>ICU stay (days)</th>
<th>Complications</th>
<th>Outcome</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>4</td>
<td>Nil</td>
<td>Alive</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>3</td>
<td>Traumatic intracranial bleeding, GI bleeding</td>
<td>Dead</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>3</td>
<td>Hoarseness, pleural effusion</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
<td>6</td>
<td>Phrenic nerve palsy, prolonged respiratory assistance</td>
<td>Alive</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>4</td>
<td>Mediastinal bleeding</td>
<td>Alive</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>3</td>
<td>AF</td>
<td>Alive</td>
</tr>
<tr>
<td>7</td>
<td>33</td>
<td>3</td>
<td>Pleural effusion, prolonged respiratory support</td>
<td>Alive</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>5</td>
<td>Nil</td>
<td>Alive</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>2</td>
<td>Nil</td>
<td>Alive</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>2</td>
<td>Nil</td>
<td>Alive</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>3</td>
<td>RIND</td>
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</tr>
<tr>
<td>12</td>
<td>7</td>
<td>3</td>
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</tr>
<tr>
<td>13</td>
<td>10</td>
<td>2</td>
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<td>Alive</td>
</tr>
<tr>
<td>14</td>
<td>19</td>
<td>3</td>
<td>Paraparesis, ischemic colitis</td>
<td>Alive</td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>8</td>
<td>Hoarseness</td>
<td>Alive</td>
</tr>
<tr>
<td>16</td>
<td>62</td>
<td>4</td>
<td>Pleural effusion, prolonged respiratory support</td>
<td>Alive</td>
</tr>
</tbody>
</table>

pletely by discharge. Respiratory failure, defined as the necessity of more than 48 h support by mechanical ventilation, was observed in three patients (cases 4, 7 and 16). Average duration of respiratory support was 19.4 ± 17.0 h (range: 4—62 h). Intractable pulmonary bleeding was not observed.

6.2. Mid-term results

Follow-up was 100% completed. Average follow-up was 16.4 ± 12.6 months (range: 1.4—45.5 months). During follow-up, cases 1 and 7 died due to pneumonia and the rupture of a pre-existing middle cerebral artery aneurysm, respectively. Actuarial survival at 2 years after surgery was 67.7% (95% CI: 0.13—1.23) (Fig. 4). However, no aortic-related mortality was observed.

7. Discussions

Patients who underwent ascending aorta or hemi-arch replacement for acute type A dissection sometimes had extensive thoracic aortic aneurysms due to residual flow in the distal false lumen [8]. When patients are carefully selected based on the evaluation of preoperative comorbidity, a single stage operation can be expected to be highly effective in terms of long-term survival and quality of life. Svensson et al. [9], Massimo et al. [10] and Hu et al. [11] had reported the superior outcome of one-stage surgery for extended thoracic aortic aneurysms.

Wide exposure with a simple incision is mandatory and of primary importance in one-stage treatment for extensive thoracic aneurysms. Median sternotomy is the gold standard to access the aortic arch; however, exposure to the distal descending aorta is limited even if additional left anterolateral thoracotomy is applied. Kouchoukos et al. [5] reported the clam-shell approach as an excellent procedure for one-stage extended aortic arch replacement. We entirely agree that the clam-shell approach is highly useful if aortic root replacement is required.

In the current series, we could approach the ascending aorta, aortic arch and entire descending aorta through a left posterolateral thoracotomy alone. In case 5, who had undergone hemi-arch replacement, there was an unexpected disruption of the proximal anastomosis of the previous hemi-arch graft at the sino-tubular junction (STJ) level during the operation that required access to that level and that resulted in successful repair. A sternum transverse division might be an additional option to obtain better working space for the aortic root. However, we believe that avoiding division of the sternum while preserving the internal thoracic artery is important in terms of wound healing and possible future
coronary artery bypass grafting. A left posterolateral thoracotomy without sternum division eventually provided working space for the extended replacement of the aortic arch up to the STJ. Massimo et al. [10] and Hu et al. [11] reported the efficacy of multiple independent incisions for the exposure of thoracic and thoracoabdominal aneurysms. In addition, a left posterolateral thoracotomy through the 4th intercostal space with a single skin incision is a beneficial and flexible alternative for access to the ascending, aortic arch and entire descending aorta, which enables reconstruction of the intercostal artery (case 13) and repair of even the thoracoabdominal aorta with the intercostal artery reconstruction (cases 14, 15 and 16) through the retroperitoneal space approached by the extension of the left side thoracotomy. As we reported earlier [7], left side rib-cross thoracotomy is another and better option to expose both the thoracic and thoracoabdominal aorta although meticulous reconstruction of the ribs is required. We applied this approach for case 4 (retrograde type A dissection with rupture of the descending aorta) to obtain better exposure quickly, because it was hard to predict the extent of the replacement preoperatively in this complicated case. An aneurysm that included the area from the ascending aorta, aortic arch, descending aorta and thoracoabdominal aorta was the most challenging paradigm because multiple organs such as the myocardium, brain, spinal cord and visceral organs must be well protected during the procedure. Extracorporeal circulation was basically established with femoral artery return and right atrial drainage through the right femoral vein. In the right decubitus position, femoral vein cannulation was sometimes difficult and additional main pulmonary artery drainage was applied through maintaining negative drainage pressure. Myocardial protection was reliably obtained by cardioplegic solution delivered through a balloon-tipped catheter placed in the ascending aorta. Since the myocardial ischemic time averaged 83 min, myocardial recovery was sufficient enough in all cases without any drawbacks.

Brain protection during the procedure involving aortic arch replacement is another crucial issue in obtaining a satisfactory outcome since the duration of circulatory arrest has been demonstrated to be a predictor of early death [4]. We used the arch-first technique under deep hypothermia for total arch replacement in the earlier period and have shifted to a more reliable protection method of selective cerebral perfusion under deep hypothermia. Efficacy of this procedure was proved by the absence of permanent neurological deficits with the exception of temporary right hand paralysis in case 11. There was no operative mortality (30-day mortality) but one patient died of accidental traumatic cerebral hemorrhage on day 145 (case 2). Our early results were comparable to those in other reports regarding mortality [5,10,11]. A major concern with this left posterolateral thoracotomy is the complication of intraoperative endobronchial hemorrhage under a fully heparinized condition. In the majority of cases, mild endobronchial hemorrhage was observed, but resolved without respiratory failure. Duration of intubation was a mean of 19.4 ± 17.0 h, and prolonged respiratory assistance over 48 h was required in three cases (cases 4, 7 and 16), one of which was due to phrenic nerve palsy. Pulmonary complications were observed in six patients (37.5%) but those were not lethal. We believe that this is an acceptable rate of pulmonary complications.

In conclusion, satisfactory exposure for extensive thoracic aneurysms can be achieved through a left posterolateral thoracotomy, which was possible even for the reconstruction of intercostal and visceral arteries for a thoracoabdominal aneurysm by its extension to retroperitoneal space.

References