Original Article

Total Arch Replacement for Distal Enlargement after Ascending Aortic Replacement for Acute Type A Aortic Dissection

Satoshi Yamashiro, MD, PhD, Yukio Kuniyoshi, MD, PhD, Katsuya Arakaki, MD, Hitoshi Inafuku, MD, Yuji Morishima, MD, and Yuya Kise, MD

Objective: Distal reoperations for aortic dissection are associated with high morbidity rates. We describe distal aortic enlargement that was treated using our surgical strategy.
Patients and Methods: From January 1997 to April 2008, 63 patients underwent ascending aortic replacement for acute type A aortic dissection. Four patients (7.4%; 3 males, 1 female; mean age, 67.8 ± 4.6 years) required reoperation for distal enlargement after long-term follow-up. Individual 5- and 10-year rates of those remaining free of reoperation after the initial procedure were 94.9% and 83.0%, respectively. At reoperation, a median sternotomy with left anterolateral thoracotomy provided a good visual field, and bilateral axillary arteries were preferentially used for systemic as well as selective cerebral perfusion.
Results: Mechanical ventilation was required after surgery for 3.0 ± 1.4 days. No new phrenic or left recurrent laryngeal nerve palsy or permanent neurological dysfunction occurred in this series. Although the surgical duration and relative mechanical circulation time were significantly elongated, all patients recovered uneventfully.
Conclusion: We postulate that the surgical principle involved in treating aortic dissection is a resection of the aortic segment containing the initial intimal tear and graft replacement, especially in acute dissection. Our results showed that total arch replacement through a median sternotomy and left anterolateral thoracotomy seem to be helpful for extended replacement of the thoracic aorta, as well as in the distal reoperation for dissecting type A. Moreover, our results suggested that perfusion from bilateral axillary arteries is useful to prevent cerebral damage. (Ann Thorac Cardiovasc Surg 2009; 15: 318–323)

Key words: aortic dissection, reoperation, hypothermic circulatory arrest, selective cerebral perfusion, axillary artery

Introduction

A more aggressive approach with replacement of the dissected aortic arch might reduce the incidence of late reoperations.[1–3] However, the current general consensus is that a distal repair should be sufficiently extended to excise the aortic segment containing the intimal tear.[4–8] Late dilation of the remnant false lumen after ascending aortic replacement is indispensable for patients with extensive arch dissection, but distal reoperations are still associated with high morbidity rates.[1–8] We describe 4 patients who had undergone initial ascending aortic replacement because of intimal tears located in the ascending aorta and distal

From Division of Thoracic and Cardiovascular Surgery, Department of Bioregulatory Medicine, Faculty of Medicine, University of the Ryukyus, Okinawa, Japan

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Address reprint requests to Satoshi Yamashiro, MD, PhD: Division of Thoracic and Cardiovascular Surgery, Department of Bioregulatory Medicine, Faculty of Medicine, University of the Ryukyus, 207 Uehara, Nishihara, Okinawa 903–0215, Japan.
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Table 1. **Characteristics of patients after emergency surgery for acute type A aortic dissection from January 1997 to April 2008 at our institution**

Total number of dissecting type A patients	90
Asc. Ao. replacement	63 (70.0%)
Concomitant procedure	
Root replacement	13
Visceral artery bypass	2
F-F crossover bypass	1
Early mortality	9 (14.3%)
Multiple organ failure	3
Low output cardiac syndrome	3
Cerebral infarction	3
Late mortality	2
Cerebral infarction, renal failure	2
Reoperation related to dissection	4 (4/54 7.4%)
Total arch replacement	27 (30.0%)
Concomitant procedure	
Root replacement	2
Aortic valve replacement	1
Coronary artery bypass grafting	1
Early mortality	5 (18.5%)
Multiple organ failure	2
Low-output cardiac syndrome	1
Cerebral infarction	2
Late mortality	0
Reoperation related to dissection	0

Asc. Ao., ascending aorta.

aortic enlargement (chronic type A dissection), including arch aorta, that were treated using our current protocol.

Patients and Methods

From January 1997 to April 2008, 90 consecutive patients underwent emergency surgery to treat acute type A aortic dissection at our institution. Distal repair was extended sufficiently to excise the aortic segment containing an intimal tear that was located within the ascending aorta at the initial operation. Sixty-three of those patients underwent ascending aortic replacement, including root replacement (Table 1). Among them, 9 patients (14.3%) died of perioperative complications: multiple organ failure (n = 3), low output cardiac syndrome (n = 3), and cerebral infarction (n = 3) during the early postoperative period. One patient in each group died of cerebral infarction and renal failure during follow-up. Actuarial survival rates at 10 years after surgery were 82.1% (Fig. 1). Four patients (4/54, 7.4%; 3 males; 1 female; mean age, 67.8 ± 4.6 years; range, 62–72 years) required reoperation for distal enlargement during long-term follow-up. The individual reoperation-free rates at 5 and 10 years after the initial operation were 94.9% and 83.0% (Fig. 2). The mean interval between the initial operation and reoperation was 6.4 ± 4.3 years (range, 1–11 years) (Table 2).

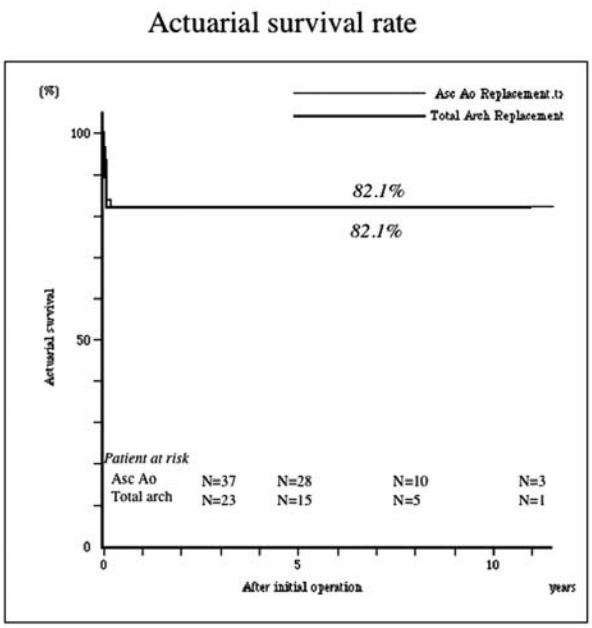

Fig. 1. Actuarial survival rates after replacing either the ascending aorta or the total arch.

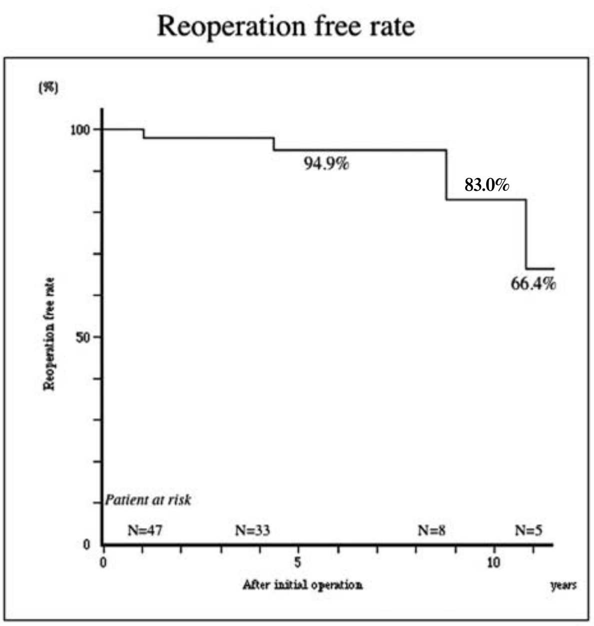

Fig. 2. Actuarial freedom from reoperation among 54 patients who were discharged after initial replacement of ascending aorta.

Table 2. Summary of patients requiring reoperation

	1	2	3	4	Mean
Gender	M	F	M	M	
Age	72	66	71	62	67.8 ± 4.6
Initial operation	Asc. Ao. replacement	Asc. Ao. replacement	Bentall procedure	Asc. Ao. replacement	
Pseudo lumen	Thrombus	Thrombus	Not closed	Thrombus	
Interval (month)	60	105	12	130	76.8 ± 52.0
Operation time (min)	680	629	738	1,020	766.8 ± 174.6
CPB time (min)	263	201	191	264	229.8 ± 39.2
Cardiac arrest time (min)	191	134	150	173	162.0 ± 25.1
SCP time (min)	118	127	156	130	132.8 ± 16.3
HCA time (min)	0	0	82	0	
Lowest rectal temperature (°C)	20	22	19	22	20.8 ± 1.5
Mechanical ventilation time (days)	1	4	4	3	3.0 ± 1.4
Hospital stay (days)	45	33	33	30	35.3 ± 6.7
Outcome	Alive	Alive	Alive	Alive	

M, male; F, female; CPB, cardiopulmonary bypass; SCP, selective cerebral perfusion; HCA, hypothermic circulatory arrest; Asc. Ao., ascending aorta.

Reoperation Technique

Patients were endotracheally intubated with a double-lumen tube to deflate the lung, then placed on an operating table with the chest rotated 60° from the supine toward the right. The bilateral axillary and right femoral arteries were exposed, and the heart, ascending aorta, aortic arch, and arch vessels were then exposed through a median sternotomy and a sternum transection plus left thoracotomy at the fourth intercostal space (the “door open” method). At reoperation, the combined approach (median sternotomy with left anterolateral thoracotomy) was used because the predicted distal anastomosis level was below the sixth vertebra, providing a good visual field. This approach provided a good view of the whole heart as well as of the entire aorta, and it enabled distal anastomosis under cross-clamping with distal perfusion to prevent visceral ischemia. After systemic heparinization, an 8-mm-diameter graft was anastomosed to the bilateral axillary arteries for systemic arterial cannulation, and these grafts were used for selective cerebral perfusion (SCP). When the patient’s rectal temperature reached 20°C, systemic circulation was arrested and the aorta was opened. Antegrade SCP was established through vascular grafts anastomosed to the bilateral axillary arteries and a perfusion catheter placed directly into the left carotid artery. Moreover, the left common carotid artery was directly cannulated, in the same manner reported previously,[9] to prevent cerebral thromboembolization in two patients. The temperature of antegrade SCP was maintained at 15°C, and cerebral perfusion was established at a flow rate of 10–15 ml/kg/min, using a double roller pump separate from the systemic circulation. And bilateral radial arteries and left carotid artery stump pressure were monitored, which were controlled from 40 to 50 mmHg by regulating SCP flow. Preoperative blood flow through the middle cerebral arteries was monitored continuously with bilateral transcranial Doppler (Viasys Inc., Conshocken, PA, USA). Moreover, cerebral oxygen saturation was monitored with the Somanetics Invos® Cerebral Oximeter (CO, Troy, MI, USA). Meanwhile, the left phrenic and left recurrent laryngeal nerves were identified, mobilized with the aneurysmal wall and protected. Distal anastomosis proceeded, with the distal descending aorta cross-clamped after distal fenestration had been recognized in 3 patients and with distal perfusion to prevent visceral ischemia. The temperature of distal perfusion from femoral artery was maintained at 20°C. The root of the left subclavian artery was ligated and reconstructed by graft-graft anastomosis, a graft at the limb of the arch, and by an 8-mm-diameter graft anastomosed to the left axillary artery.

Results

None of the patients died in a hospital. Table 2 shows that the surgical duration, total cardiopulmonary bypass (CPB) time, cardiac ischemic time, and SCP time in minutes were 766.8 ± 174.6, 229.8 ± 39.2, 162.0 ± 25.1, and 132.8 ± 16.3, respectively. Hypothermic circulatory arrest (HCA) was applied to only one patient for 82 minutes. Rectal temperature in this patient had remained at 20°C during HCA. There were no significant differences between patients who underwent total arch replacement through a median sternotomy in the same period and between those who also had a left anterolateral thoracotomy, though surgical duration was relatively extended (data not shown). Distal anastomosis proceeded under cross-clamping with distal perfusion for the other 3 patients. Permanent neurological dysfunction, defined as permanent neurological deficits with localized neurological signs and corresponding new defects on CT images, did not occur in this series. Early morbidity in 2 patients comprised pulmonary failure, defined as requiring respiratory support for > 48 hours. Mechanical ventilation was required after surgery for 3.0 ± 1.4 days. No new phrenic or left recurrent laryngeal nerve palsies occurred as a result of surgery. The length of the hospital stay after surgery was 35.3 ± 6.7 days, and the patients were followed up after reoperation for 12.0 ± 5.4 months.

Discussion

The indications for arch replacement in patients with arch dissection when an intimal tear is located in ascending aorta remain controversial because the surgical results after arch replacement are suboptimal. Actually, none of the patients in the present study who underwent initial replacement of the total arch required reoperation during the follow-up period. We have adopted an aggressive approach toward intimal tears when they are located in the transverse arch, which occurs in 10%–30% of patients, and many surgeons apparently agree that the aortic arch should be replaced whenever necessary. The incidence of late reoperations after repair of acute type A aortic dissection ranges from 7 to 20%.[1,4–7] We found here that 4 patients (7.4%) required reoperations on the distal aorta at a mean of 6.4 ± 4.3 years after the initial operation. Individual reoperation-free rates at 5 and 10 years after the initial procedure were 94.9% and 83.0%, respectively. Moreover, the actuarial survival rates at 10 years after replacing either the ascending aorta or the total arch were 82.1% (Fig. 1). Kirsch et al.[6] described that the risk of total aortic resection for the initial surgical management largely outweighs the relatively low incidence of reoperation and the associated operative risk. In our results, early mortality rate in arch replacement and ascending replacement at initial surgery were 18.5% (5/27) and 14.3% (9/63), respectively (Table 1). Moreover, the actuarial survival rates at 10 years after replacing either the ascending aorta or the total arch were 82.1% (Fig. 1). Some controversies existed, however, regarding indications for arch replacement in patients with arch dissection when intimal tear is located in ascending aorta because of suboptimal surgical results after arch replacement. In such cases, should we perform to extensive aortic arch replacement? There is now a general agreement that the distal repair should be extended sufficiently to excise the segment of aorta containing the intimal tear.[4–8] We also believe that the surgical principle in treating aortic dissection is resection of the aortic segment that contains the initial intimal tear and graft replacement, especially in acute dissection. These procedures do not remove the entire diseased portion of the aorta, so they are usually palliative. Therefore close observation to anticipate late dilation of the remnant false lumen after ascending aortic replacement is indispensable for patients with extensive arch dissection. We have followed up all of our residual dissections with serial imaging at least annually and have offered surgery if annual growth exceeds 0.5 cm/year or when the absolute maximal diameter exceeds 6.0 cm.

We performed total arch replacement through a median sternotomy with left anterolateral thoracotomy in these 4 patients. Some controversies existed regarding indications for approaches in patients with arch aneurysm, because of suboptimal surgical results after extended arch replacement. This combined surgical approach to treating thoracic aortic aneurysms has been considered too invasive.[10] However, Ohata et al.[11] found no significant differences in respiratory function or in the inflammatory response between patients who underwent total arch replacement through a median sternotomy and those who also had a left anterolateral thoracotomy. Especially in the distal reoperative situation for dissecting type A, the retrosternal space can be easily excised from a left thoracotomy, although adhesion resulting from previous surgeries can be moderate or severe. The cannulae are conveniently situated anteriorly away from the main operative field, and access to the aortic arch and descending thoracic aorta is improved. Moreover, the ability to visualize and protect the phrenic and recurrent laryngeal nerves contributes to extending the recovery of patients with impaired respiratory function. We believe that extensive reinmplantation of thoracic aorta accompanied by adequate distal aortic perfusion under distal clamping through a median sternotomy with left anterolateral thoracotomy to avoid HCA is effective for organ protection.

The prevention of cerebral embolism is an important consideration during repair of an aortic arch aneurysm and is a major goal of cerebral protection techniques. Toward this end, a selection of the arterial cannulation site for CPB is critical. Cannulation of the femoral artery with retrograde aortic perfusion and profound HCA is the standard surgical approach to the aortic arch.[1–8] However, retrograde perfusion of the brain can be caused by an atheroma or by disrupted flow distribution. Westaby et al.[10] described that retrograde embolism from an atheroma or thrombus in the descending thoracic or abdominal aorta can occur upon perfusion through the femoral artery. In 1995, Svensson et al.[12] began to use subclavian or axillary artery cannulation strategy with HCA and antegrade brain perfusion and found it to be a safe approach for aortic arch operation; it resulted in a stroke risk of less than 2%. Recently, the theoretical advantages of using the subculavian or axillary artery site for inflow for complex cardiac and cardioaortic operations have become apparent.[12,13] These possible advantages include less likelihood of stroke from embolic material, less possibility of malperfusion with aortic dissection, less disruption of atheroma or calcified plaques, and the ability to administer antegrade brain perfusion. Since 2000 we have preferentially used biaxillary arteries for perfusion with total arch replacement, and none of these patients has developed neurological injury.

We have used only SCP in aortic arch repair because of this longer cerebral safety time and low incidence of temporary neurological dysfunction. In SCP, however, atheromatous emboli to the brain, which are considered to be a main cause of permanent neurological dysfunction, remain as a serious major concern. Svensson et al.[12] described that when using the subclavian or axillary artery for inflow, it become clear to early adopters that the direct cannulation was associated with a great risk of local complications, including dissection of the artery, inadequate flow, abutment of the cannula tip against the carotid artery wall, and tears that were difficult to repair because of fragile and often traumatized arterial tissue. Arterial inflow was then switched to a side graft sewn to the vessels, and at the end of the operation a delicate and sometimes difficult repair of the artery was not required; instead, the side graft could simply be oversewn and tied off clipped. We doubt that whole brain perfusion is sufficient with only right axillary artery perfusion. The best approach for cerebral protection during these operations is still a matter of controversy. Although refinements continue to be made and results are getting better, brain injury is known to occur in association with all the cerebral protection techniques suitable for these operations. So left-side brain perfusion was added. Moreover, vertebral perfusioin via the left axillary artery is important for spinal protection and also for cerebral protection. We used a blood-flow monitor (bilateral transcranial Doppler) and a cerebral oxygen saturation monitor (Somanetics Invos® Cerebral Oximeter) for cerebral protection during SCP. Cerebral perfusion was established at a flow rate of 10–15 ml/kg/min, using a double-roller pump, and the pressure of the bilateral radial arteries and the left carotid artery were controlled from 40 to 50 mmHg by regulating SCP flow. It had been described that cerebral oximeter is a satisfactory and possibly superior device for monitoring the adequacy of cerebral perfusion and oxygenation.[14] Furthermore, cerebral oximeter monitoring is simple to use and does not require pre- and intraoperative technical support. Regional oxygen saturation did not decline during SCP in this series. Therefore we supposed that perfusion from the bilateral axillary arteries is useful to prevent cerebral damage. Sewing a graft to a bilateral axillary artery takes about 20 to 30 minutes simultaneously. The axillary artery has less atherosclerotic change than the ascending aorta or the femoral artery and can easily be exposed.[15] When reconstruction of left subclavian artery, branch of arc graft could simply be sewn to the graft which previously anastomosed to left axillary artery.

Geirsson et al.[2] reported that highly morbid distal reoperations are dependent on the extent of the repair. However, our experience suggests that total arch replacement through a median sternotomy together with a left anterolateral thoracotomy can help extended replacement of the thoracic aorta, including the distal reoperation to treat dissecting type A, without increasing postoperative respiratory complications. Moreover, our results suggest that perfusion from the bilateral axillary arteries is useful to prevent cerebral damage.

Conclusion

We believe that the surgical principle in treating aortic dissection is a resection of the aortic segment that contains the initial intimal tear and graft replacement, especially in acute dissection. Because the risk of total aortic resection for the initial surgical management largely outweighs the relatively low incidence of reoperation after ascending aortic replacement for acute dissection. If reoperation was required at a late period, we supposed that median sternotomy plus a left anterolateral thoracotomy approach and perfusion from the bilateral axillary arteries illustrate the safety of the method.

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