

Long-Term Changes in the Distal Aorta after Aortic Arch Replacement in Acute DeBakey Type I Aortic Dissection

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Background: We analyzed the long-term results of ascending aortic replacement and arch aortic replacement in acute DeBakey type I aortic dissections to measure the differences in the distal aortic changes with extension of the aortic replacement. **Methods:** We reviewed 142 cases of acute DeBakey type I aortic dissections (1996–2015). Seventy percent of the cases were ascending aortic replacements, and 30% of the cases underwent total arch aortic replacement, which includes the aorta from the root to the beginning of the descending aorta with the 3 arch branches. Fourteen percent (20 cases) resulted in surgical mortality and 86% of cases that survived had a mean follow-up period of 6.6±4.6 years. Among these cases, 64% of the patients were followed up with computed tomography (CT) angiograms with the duration of the final CT check period of 4.9±2.9 years. **Results:** There were 15 cases of reoperation in 13 patients. Of these 15 cases, 13 cases were in the ascending aortic replacement group and 2 cases were in the total arch aortic replacement group. Late mortality occurred in 13 cases; 10 cases were in the ascending aortic replacement group and 3 cases were in the total arch aortic replacement group. Eight patients died of a distal aortic problem in the ascending aortic replacement group, and 1 patient died of distal aortic rupture in the total arch aortic replacement group. The follow-up CT angiogram showed that 69.8% of the ascending aortic replacement group and 35.7% of the total arch aortic replacement group developed distal aortic dilatation ($p=0.0022$). **Conclusion:** The total arch aortic replacement procedure developed fewer distal remnant aortic problems from dilatation than the ascending aortic replacement procedure in acute type I aortic dissections.

Key words: 1. Aortic dissection
2. Surgery
3. Complication
4. Recurrence
5. Replacement

Introduction

Acute DeBakey type I aortic dissection is a surgical disease. When patients are fortunate to survive the surgical procedure, they should undergo frequent follow-up, because the remnant segment of the dis-

sected aorta may develop aneurysmal dilatation. Today the aortic arch replacement can be safely performed in acute aortic dissection due to the advance of surgical techniques such as the antegrade cerebral perfusion technique and the use of artificial graft materials. To determine the superiority of an arch

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Table 1. Patients demographics and operation data by procedure

| Characteristic | Ascending aortic replacement (n=100) | Arch aortic replacement (n=42) | p-value |
|---|--------------------------------------|--------------------------------|----------------------|
| Age (yr) | 56±11.4 | 53.3±10.7 | 0.1429 ^{a)} |
| Sex (male/female) | 42/58 | 26/16 | 0.0302 ^{b)} |
| Marfan syndrome | 4 | 4 | 0.2337 ^{b)} |
| Intramural hematoma | 10 | 4 | 0.9308 ^{b)} |
| Preoperative syncope | 2 | 2 | 0.5817 ^{b)} |
| Preoperative shock | 3 | 0 | 0.5550 ^{b)} |
| Limb ischemia | 2 | 0 | 1.0000 ^{b)} |
| Combined procedures | 20 (20) | 15 (35.7) | 0.0474 ^{b)} |
| Intraop thoracic endovascular aortic repair | 2 | 9 | |
| Bentall operation | 10 | 3 | |
| Aortic valve replacement | 3 | 2 | |
| Coronary artery bypass grafting | 5 | 1 | |
| Total bypass time (min) | 216.5±51.6 | 286.1±61.9 | 0.0001 ^{a)} |
| Heart ischemic time (min) | 88.9±36.1 | 146.0±48.1 | 0.0001 ^{a)} |
| Arrest time (min) | 30.0±28.4 | 45.9±41.6 | 0.0001 ^{a)} |
| Operation time (hr) | 6.86±2.69 | 8.57±3.16 | 0.0036 ^{a)} |
| Reoperation for bleeding control | 7/4 ^{c)} (6.9) | 6/3 ^{c)} (14.3) | 0.1695 ^{b)} |
| Postoperative acute renal failure | 11 | 8 | 0.1986 ^{b)} |
| Ventilation time (hr) | 121.2±39.3 | 70.7±21.5 | 0.4263 ^{a)} |
| Surgical mortality | 14 (14) | 6 (14.3) | 0.9644 ^{b)} |
| Bleeding | 6/2 ^{d)} | 3 | |
| Low cardiac output | 2 | 2 | |
| Central nerve system damage | 4 | 0 | |
| Multi-organ failure | 2 | 1 | |

Values are presented as mean±standard deviation, number, or number (%).

^{a)}By t-test. ^{b)}By χ^2 -test. ^{c)}Cases of death. ^{d)}Early anastomotic rupture.

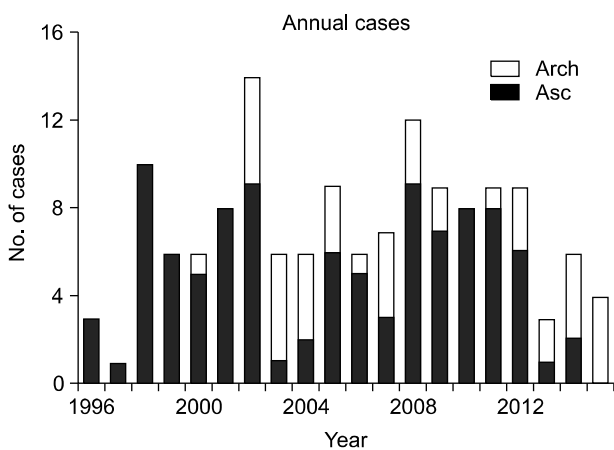


Fig. 1. Annual trends in the performance of ascending aortic replacement and arch aortic replacement. Arch, aortic arch replacement; Asc, ascending aortic replacement.

replacement in prevention of long-term postoperative distal aortic aneurysms, we researched the distal aortic status after total aortic arch replacement in

acute DeBakey type I aortic dissections and compared the results to that of the ascending aortic replacement group.

Methods

Between January 1996 and March 2015, 142 patients with acute DeBakey type I aortic dissection were treated surgically at Dong-A University Hospital. Seventy percent of the cases (100 patients) underwent ascending aortic replacements (include 13 hemi-arch replacement cases and 1 innominate artery bypass case), while the remaining 30% of the cases (42 patients) underwent total aortic arch replacements, which includes the aorta from the root to the beginning of the descending aorta with the 3 arch branches (Table 1). The arch replacement technique was changed during that period. Prior to the year 2010, 21% of the cases (30 patients) were performed with the arch-first technique under deep hypothermic cir-

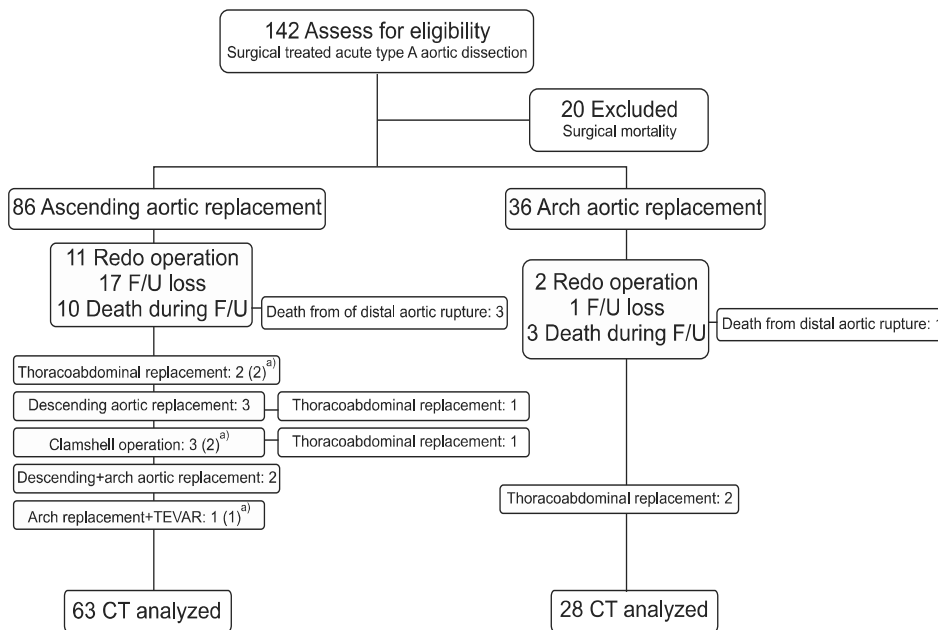


Fig. 2. Enrolled patients and F/U status. F/U, follow-up; TEVAR, thoracic endovascular aortic repair; CT, computed tomography. ^aOperative mortality.

culatory arrest [1]. After the year 2010, 9% of the cases (12 patients) were performed with selective arch replacement with a 4-vessel branched arch graft, under moderate hypothermia and antegrade cerebral perfusion. The rate of performance of each of the two procedures is described in Fig. 1. Twenty patients of the ascending aortic replacement group and 15 patients of the total arch aortic replacement group underwent concomitantly combined procedures, which included 11 intraoperative thoracic endovascular aortic repairs (TEVAR), 13 Bentall operations, 5 aortic valve replacements, and 6 coronary artery bypass grafting procedures (Table 1). Eighty-six percent of the cases (122 patients) survived these operations with a mean follow-up period of 6.9±13.3 years.

During the follow-up period, 64% of the patients (63 from the ascending aortic replacement group, 28 from the total arch aortic replacement group) were checked by serial CT scan in our out-patient clinic (Fig. 2). The follow-up CT scan allowed us to check the distal aortic pseudolumen status and diameter, the level of the largest portion of the distal remnant aorta, and the interval change between the immediate postoperative period and the late postoperative period. The mean interval between the two periods was 4.9±2.9 years. The level of the dilated aorta was defined as the proximal descending aorta above the sixth intercostal level and below was the distal de-

scending aorta [1]. We categorized the aortic change of the serial CT scan into 5 classes: class A—the distal remnant aorta was remodeled to normal size and the remnant distal aorta shrank when compared to the immediate postoperative CT; class B—the pseudolumen was totally obliterated but the size of the remnant distal aorta did not shrink; class C—the pseudolumen remained but the size of the remnant distal aorta dilatation was <40 mm in diameter; class D—the remnant distal aorta dilatation was >40 mm but <60 mm in diameter, which was generally the indicator for surgical correction; and class E—the remnant distal aorta was >60 mm in diameter or the CT was checked just before reoperation. Class D and E eventually resulted in an aneurysmal dilatated distal remnant aorta, while class A, B, and C, a normalized aorta.

We analyzed the statistical differences between the ascending aortic replacement group and the total arch aortic replacement group with a χ^2 -test and t-test. The survival rate was calculated with the Kaplan-Meier method of life test. The categorical difference between the two groups was calculated with stratified analysis using Cochran-Mantel-Haenszel statistics. The multivariate analysis was calculated with logistic regression analysis. We considered a difference statistically significant with the p-value <0.05. The statistics were calculated with the SAS ver. 9.3

Table 2. Long-term follow-up data

| Variable | Ascending aortic replacement (n=86) | Arch aortic replacement (n=36) | p-value |
|---|---------------------------------------|--------------------------------|----------------------|
| Distal aortic reoperation | 13/2 ^{a)} | 2 | 0.0001 ^{b)} |
| Thoracoabdominal aortic replacement | 4/2 ^{c)} | 2 | |
| Descending aortic replacement | 3/1 ^{a)} | | |
| Total thoracic aortic replacement | 3/1 ^{a)} , 3/2 ^{c)} | | |
| Descending + arch aortic replacement | 2 | | |
| Arch replacement + intraoperative thoracic endovascular aortic repair | 1/1 ^{c)} | | |
| Long-term mortality | 10 | 3 | 0.2809 ^{b)} |
| Non-surgical death | 5/3 ^{d)} | 3/1 ^{d)} | |
| Mean survival duration of long-term mortality cases (mo) | 76.6±47.5 | 123.3±10.4 | 0.0332 ^{e)} |

Values are presented as number or mean±standard deviation.

^{a)}Trido operation. ^{b)}By χ^2 -test. ^{c)}Death from surgery. ^{d)}Death from distal aortic rupture. ^{e)}By Student t-test.

Table 3. Characteristics of patients with late aortic events

| Sex/age (yr) | Group | Interval ^{a)} | PL ^{b)} | Redo operative procedure | Result |
|--------------------|--------------------|------------------------|------------------|---|---|
| F/33 ^{c)} | Asc ^{d)} | 38 | (+) | Type II thoracoabdominal aortic replacement | Death from redo surgery |
| F/54 | Asc | 105 | (+) | Type II thoracoabdominal aortic replacement | Death from redo surgery |
| F/40 | Asc | 5 | (+) | Descending aortic replacement | Trido type IV thoracoabdominal replacement → arch aortic dilatation |
| M/49 | Asc | 88 | (+) | Descending aortic replacement | Distal aortic dilatation |
| F/38 | Asc | 25 | (+) | Descending aortic replacement | Normal with false lumen |
| M/60 | Asc | 84 | (+) | Clamshell operation ^{e)} | Death from redo surgery |
| F/56 | Asc | 59 | (+) | Clamshell operation | Death from redo surgery |
| M/40 ^{c)} | Asc | 31 | (+) | Clamshell operation | Trido type IV thoracoabdominal replacement → normal |
| M/40 | Asc | 77 | (+) | Descending + arch aortic replacement | Normal |
| F/52 | Asc | 121 | (+) | Descending + arch aortic replacement | Distal anastomosis pseudoaneurysm |
| M/39 | Asc | 60 | (+) | Arch replacement + intraoperative thoracic endovascular aortic repair | Death from redo surgery |
| F/61 | Asc | 133 | (-) | (-) | Death from arch aortic aneurysm rupture |
| F/67 | Asc | 39 | (+) | (-) | Death from distal aortic rupture |
| F/63 | Asc | 170 | (+) | (-) | Death from distal aortic rupture |
| M/43 ^{c)} | Arch ^{f)} | 56 | (+) | Type IV thoracoabdominal aortic replacement | Normal |
| M/50 | Arch | 22 | (+) | Type IV thoracoabdominal aortic replacement | Normal |
| F/41 ^{c)} | Arch | 41 | (+) | (-) | Death from abdominal aortic aneurysm rupture |

F, female; M, male.

^{a)}Interval between initial operative day and the event day of the month. ^{b)}Pseudolumen patency. ^{c)}Marfan syndrome. ^{d)}Ascending aortic replacement group. ^{e)}Total thoracic aortic replacement with clamshell incision. ^{f)}Arch replacement group.

(SAS Institute Inc., Cary, NC, USA).

Results

The cardiopulmonary bypass time, heart ischemic time, circulatory arrest time, and operation time of the total arch aortic replacement group were longer than those of the ascending aortic replacement group.

However, postoperative renal function and ventilator support period showed no statistically significant difference between the two groups (Table 1). Fourteen percent of the cases (20 patients) resulted in surgical mortality. However, there was no statistically significant difference between the ascending aortic replacement group and the total arch aortic replacement group. The main cause of surgical death was

Table 4. Long-term follow-up data with CT scan

| Variable | Ascending aortic replacement (n=63) | Arch aortic replacement (n=28) | p-value |
|--|---|--|----------------------|
| Open distal pseudolumen | 37 (58.7) | 14 (50) | 0.4387 ^{a)} |
| Largest diameter (mm) | 47.4±13.2 (58.4±34.7 mo) ^{b)} | 36.8±12.3 (59.5±33.6 mo) ^{b)} | 0.0005 ^{c)} |
| Diameter change (mm) | 6.8889±9.5708 (45) ^{d)} (52.8±31.1 mo) ^{b)} | -1.3846±8.0104 (26) ^{d)} (60.0±34.9 mo) ^{b)} | 0.0004 ^{c)} |
| Distal aneurysm (>40 mm) | 44 (69.8) | 10 (35.7) | 0.0022 ^{a)} |
| Arch aortic aneurysm | 18/3 ^{e)} | 0 | 0.0147 ^{a)} |
| Proximal descending aorta aneurysm | 19/5 ^{e)} | 5 | |
| Distal aorta aneurysm | 7/3 ^{e)} | 5 | |
| Normal distal aorta | 19 (30.2) | 18 (64.3) | 0.0022 ^{a)} |
| Subsided pseudolumen remodeling with shrinkage | 12 | 14 | 0.3308 ^{a)} |
| | 6 | 12 | 0.0328 ^{a)} |

Values are presented as number (%) or mean±standard deviation.

CT, computed tomography.

^{a)}By χ^2 -test. ^{b)}Mean follow-up period. ^{c)}By t-test. ^{d)}No. of cases with immediately postoperative CT available. ^{e)}Cases of large aneurysm in need of surgery (diameter >60 mm).

bleeding. There were 13 reoperations for surgical bleeding and 7 of them died of bleeding complications. Two other patients in the ascending aortic replacement group developed delayed anastomotic rupture. Still there was no statistically significant difference between the two groups (Table 1). Among the other causes of death due to damage of the central nerve system (CNS) in the ascending replacement group included 2 cases of middle cerebral artery infarction, a case of severe hypoxic brain damage, and a case of intracerebral hemorrhage. However, there was no mortality due to CNS damage in the total arch aortic replacement group.

1) Distal remnant aortic events

During the follow-up period, 13 patients underwent 15 cases of late reoperations with a mean age of 45.6±8.2 years and a mean interval between initial operation and reoperation of 59.3±34.6 months. Thirteen cases were performed in the ascending aortic replacement group and 2 cases were performed in the total arch aortic replacement group ($p=0.0001$). Among the 13 cases of the ascending aortic replacement group, 4 were thoracoabdominal aortic replacements (2 of them were trido thoracoabdominal aortic replacement), 3 were descending aortic replacements, 3 were total thoracic aortic replacements with clamshell incision, 2 were descending and arch replacements, and 1 was arch replacement with intraoperative TEVAR. The 5 redo operative cases resulted in surgical mortality: 2 redo thoracoabdominal aortic re-

placements, 2 total thoracic aortic replacements with clamshell incision, and 1 arch replacement with intraoperative TEVAR (Tables 2, 3). Of the 6 patients who survived in the ascending aortic replacement group, 3 developed remnant aortic aneurysms (Table 3). All the reoperative cases in the total arch aortic replacement group survived without any distal aortic problems.

Thirteen cases of late mortality occurred; 5 redo surgical mortalities, 4 distal aortic ruptures, and 4 medical causes of death (Table 2). Ten cases were in the ascending aortic replacement group and 3 cases were in the total arch aortic replacement group. In the ascending aortic replaced group 8 cases (9.2%) resulted in late mortality due to distal aortic events but in the total arch aortic replacement group only 1 case (2.7%) developed a distal aortic event, which was an abdominal aortic aneurysm rupture; the patient had Marfan syndrome and failed to follow-up (Table 3).

We reviewed the long term CT scans and identified 11 candidates for reoperation (category E). All candidates were in the ascending aortic replacement group and the maximal aneurysm diameter was >60 mm (Table 4). When these candidates were included into the redo operations and the late mortalities due to distal aortic rupture, the total distal aortic events were statistically different between the two groups (Fig. 3). In the ascending aortic replacement group, there were 27 adverse distal aortic events (31.4%), which occurred during a mean follow-up period of

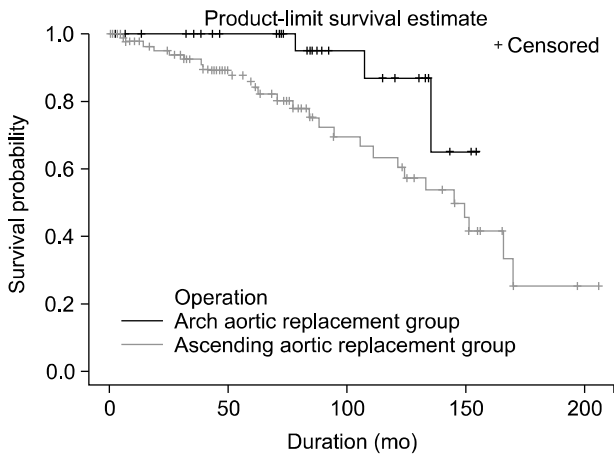


Fig. 3. Distal aortic event curves.

124.5±7.1 months, while in the total arch aortic replacement group, there were 3 adverse distal aortic events (8.3%), which occurred during a mean follow-up period of 129.8±4.3 months. The relative hazard ratio of the ascending aortic replacement group was 3.45 times higher than the total arch aortic replacement group. When we calculated the difference of the survival rate with the Log-rank method, the p-value was 0.0284, and the p-value of the likelihood ratio was 0.0094.

2) Long-term computed tomography changes

The pseudolumen remained open in 58.7% of cases in the ascending replacement group and in 50% of cases in the total arch aortic replacement group; there was no statistical difference. However, the maximal diameter and growth rate of the remnant distal aorta were significantly different between the two groups (Table 4). The mean maximal diameter of the ascending aortic replacement group was 47.4 mm with 6.8 mm growth, compared to the immediate postoperative CT scan. The mean maximal diameter of the total arch aortic replacement group was 36.8 mm, which was reduced by 1.38 mm from the immediate postoperative CT (p<0.0005).

In 69.8% of cases in the ascending replacement group and in 35.7% of cases in the total arch aortic replacement group, patients developed distal aortic aneurysm with a maximal diameter above 40 mm (p=0.0022). In the ascending aortic replacement group, 58.7% of cases were enlarged in the aortic arch or the proximal descending aorta. However, there was

Table 5. Classification of distal remnant aorta

| Class | Ascending aortic replacement | | | Arch replacement | | | |
|-------|------------------------------|------|------|------------------|------|------|-------|
| | Arch | Prox | Dist | Total | Prox | Dist | Total |
| A | | 5 | 1 | 6 | 9 | 3 | 12 |
| B | | 3 | 3 | 6 | | 2 | 2 |
| C | 1 | 1 | 5 | 7 | 2 | 2 | 4 |
| D | 10 | 9 | 2 | 21 | 3 | 4 | 7 |
| E | 8 | 10 | 5 | 23 | 2 | 1 | 3 |

p=0.003; Cochran-Mantel-Haenszel statistics.

Arch, aortic arch; Prox, proximal descending aorta; Dist, distal descending aorta.

no predominant enlargement level in the total arch aortic replacement group (Table 4). Interestingly, 22.7% (10 cases) of the ascending aortic replacement group that developed an aneurysm showed pseudolumen obliteration, but in the total arch aortic replacement group all aneurysms were combined with patent pseudolumen.

According to our classification of distal remnant aortic change categories, 36.5% of the ascending aortic replacement group were class E, and 33.3% of the ascending aortic replacement group were class D. However, 42.9% of cases in the aortic arch replacement group were class A, and the difference of normalization rate between the two groups was statistically significant (Table 4). When we considered the levels of aortic remodeling, the proximal portion was predominant. Between class E and D in the ascending aortic replacement group, 28.6% occurred in the arch level and 30.2% occurred in the proximal descending aorta. In class A of the aortic arch replacement group, 32.1% occurred in the proximal descending aorta (Table 5). We analyzed multiple variants that related to the distal aortic enlargement (age, sex, Marfan syndrome, intramural hematoma, preoperative unstable conditions, which included stroke, shock, and malperfusion, perioperative renal dysfunction, CT follow-up duration, and type of operation). Only the type of operation was a risk factor (odds ratio, 6.418; 95% confidence interval, 2.1 to 20; p=0.0014).

Discussion

Acute DeBakey type I aortic dissection surgery is a surgically challenging procedure. Most of the procedures are performed during an emergency situation

and a prolonged cardiopulmonary bypass time and multiple transfusions are generally required. Bleeding can be a major obstacle and the hemostasis depends heavily on the experience of the surgeon. The dissected aortic tissue is very fragile and requires a meticulous suture technique to accomplish hemostasis after completing the anastomosis. As a result, many surgeons prefer to reduce operative extension, that remains minimal suture lines in the acute phase of aortic dissection. Our data showed that durations of all the procedures were prolonged in the arch replacement group, and also indicated that bleeding is the most common cause of early surgical mortality (Table 1).

The primary goal of acute aortic dissection surgery has always been survival. As surgical skills have developed, the survival rate of the initial surgery has improved so that the long-term freedom from reoperation and late survival are considered important. Malvindi et al. [2] reported that the reoperation is predominantly performed at the distal dissected aorta due to aneurysmal dilatation.

Today, choosing the initial extension of aortic replacement can still be a very complicated decision. The ascending aortic replacement is still the most preferred procedure because it is less technically demanding and safer. However, the most recent data indicated that the arch aortic replacement is comparable in terms of safety, and the long-term results are better. According to the German registry for acute type A aortic dissection, the surgical mortality and neurologic complication between the ascending aortic replacement group and the total arch aortic replacement group showed no statistical difference [3]. Di Eusanio et al. [4] reported that there was no operative mortality difference between the two groups. Our analysis supports these findings. Over the past 20 years, surgical treatment of acute type I aortic dissection, our surgeons selected the extension of aortic replacement to exclude all cases of intimal tear. Prior to 2000, our surgeons performed the hemiarch replacement to exclude the intimal tear [5]. After 2002, our surgeons actively adopted the arch replacement to exclude the complex intimal tear within the aortic arch. After mastering the operation, our surgeons attempted to apply the arch replacement technique to younger patients whose life expectancy was >10 years, although the patients did not have

the intimal tear within the aortic arch [1]. To maintain this new concept and make it a policy, more data on the long-term benefits is required.

Di Eusanio et al. [4] reported the long-term reoperation rate between the total aortic arch replacement group and the ascending aortic replacement group in type A aortic dissection showed no difference, so the more extensive arch interventions were not protective for long-term survival and freedom from aortic reintervention. However, Zhang et al. [6] reported that the reintervention rate of the ascending aortic replacement group was 15.9%, and that of the extended replacement group was 4.9% ($p < 0.05$). Park et al. [7] also reported 15.6% of the ascending aortic replacement patients underwent reoperation. In our data the rate of redo operation in the ascending aortic replacement group was 15.4% and that of arch aortic replacement group was 5.5%. In our results, besides the frequency of reoperation, the extent of reoperative procedures between the two groups was diverse. In the ascending aortic replacement group, the redo operations were more extensive than the arch replacement group, such as extent I or II thoracoabdominal aortic replacement and total thoracic aortic replacement with clamshell incision. Also, surgical results were poor with a 45.5% of mortality rate; 2 cases underwent trido surgery and the other 3 cases developed new other aneurysms in the remnant aorta (Table 3). The redo operation of the arch aortic replacement group was more distal and more localized, and less commonly extended to VI or V thoracoabdominal aortic replacement. All cases survived the redo operation without remnant aortic problems. Despite redo operative mortality during the follow-up periods, 3 patients of the ascending aortic replacement group died of distal aortic rupture. Only 1 patient of the total arch aortic replacement group died of abdominal aortic aneurysm rupture, which was not related to the aortic dissection surgery. The mean survival periods of the late mortality cases were prolonged by nearly 50% in the arch aortic replacement group (Table 2). From our clinical data, after total arch aortic replacement, patients developed fewer distal aortic problems, and even when it occurred, it was possible to treat with less surgical difficulty, because the extension of late dilatation that needs redo operation is localized distally. Today's TEVAR could be a good alternative option. After arch

aortic replacement, TEVAR can be performed safely without covering the arch branches.

These late distal aortic events can be predicted with serial follow-up CT angiograms. Kimura et al. [8] reported a 62% rate of postoperative patent pseudolumen in the distal aorta after initial surgery of acute type A aortic dissection, and that a patent pseudolumen is a risk factor for late distal aortic event and reoperation. Park et al. [7] reported that 47.5% of postoperative patients developed distal aortic dilatation after ascending aortic replacement in acute type A aortic dissection and that the thoracic aorta dilated more frequently. Choi et al. [9] reported that in 42.3% cases, the pseudolumen had regressed after total arch replacement in acute type A aortic dissection. In our study, only 1 case with a late aortic event did not have a patent pseudolumen (Table 3). The follow-up CT showed that 8.6% (6 patients in the ascending aortic replacement group and 3 patients in the arch aortic replacement group) did not develop aneurysmal dilatation even though they had a patent pseudolumen. In addition, 22.2% of the cases of ascending aortic replacement with aneurysmal dilatation showed pseudolumen obliteration. In most cases, enlargement occurred in the pseudolumen of the distal remnant aorta. However, the distal remnant aortic change varied from patient to patient. The location and size of communication between the true and false lumen in the distal remnant aorta and hemodynamics of the lumens could affect the remnant aortic aneurysm. As a result, we focused on the diameter and the location of the largest dilated distal aorta and roughly classified each as arch, proximal thoracic, or the distal aorta, the last of which below the sixth intercostal level. Our researchers believe that the location of the aneurysm formation is important, especially when deciding to perform a reoperation. The location will determine the surgical approach. After the location was identified, the size of the aneurysm was measured, and the decision was made whether or not to perform the redo operation. During this process, we discovered that more patients of the ascending aortic replacement group had large aneurysms, greater than 60 mm in diameter, which is generally accepted as the indication for surgical correction. The predominant portion of the aneurysm in the ascending aortic replacement group was the aortic arch through the proximal descending

aorta above the sixth intercostal level. This particular location is relatively difficult to approach during a redo operation, primarily because of the pleural adhesion and other factors. It also a very challenging portion on which to apply TEVAR. To prevent this type of obstacle, our analysis indicates that the arch aortic replacement in acute DeBakey type I aortic dissection is a more rational approach in comparison to the ascending aortic replacement.

This study has several limitations. First, the data are retrospective and nonrandomized. There was some selection bias, as well as a sample size and character mismatch between the ascending aortic replacement group and the total arch aortic replacement group. The preoperative conditions could not be adjusted for and follow-up mismatches may have occurred. Some important operative findings, such as intimal tear and pseudolumen thrombosis, were missed and could not be analyzed. It is worth noting that before the year 2000, surgeons did not remove all intimal tears within the aortic arch, and only ascending aortic replacement was performed (Fig. 1). However, later, arch aortic replacement was performed to remove all remnant intimal tears in the aortic arch. Thus, our data does not include information about intimal tears. The degree of aortic dilatation classified as 40 and 60 mm were arbitrary decided by the authors in order to compare two groups, so these specific classifications have no clinical meaning. However, our researchers believe that the data collected from 19 years of surgical experience is very useful and will help provide a rationale for future practice.

In conclusion, after arch aortic replacement, the distal remnant aorta developed fewer aneurysmal complications in comparison to the ascending aortic replacement. After the ascending aortic replacement, the arch and proximal descending aorta dilated prominently and created major obstacles for reoperation. After arch aortic replacement, distal aortic remodeling was more favorable than after ascending aortic replacement.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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