



# Surgical Outcomes of Type A Aortic Dissection at a Small-Volume Medical Center: Analysis according to the Extent of Surgery

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**Background:** Despite progress in treatment, Stanford type A aortic dissection is still a life-threatening disease. In this study, we analyzed surgical outcomes in patients with Stanford type A aortic dissection according to the extent of surgery at Daegu Catholic University Medical Center.

**Methods:** We retrospectively analyzed 98 patients with Stanford type A aortic dissection who underwent surgery at our institution between January 2008 and June 2018. Of these patients, 82 underwent limited replacement (hemi-arch or ascending aortic replacement), while 16 patients underwent total arch replacement (TAR). We analyzed in-hospital mortality, postoperative complications, the overall 5-year survival rate, and the 5-year aortic event-free survival rate.

**Results:** The median follow-up time was 48 months (range, 1–128 months), with a completion rate of 85.7% (n=84). The overall in-hospital mortality rate was 8.2%: 6.1% in the limited replacement group and 18.8% in the TAR group (p=0.120). The overall 5-year survival rate was 78.8% in the limited replacement group and 81.3% in the TAR group (p=0.78). The overall 5-year aortic event-free survival rate was 85.3% in the limited replacement group and 88.9% in the TAR group (p=0.46).

**Conclusion:** The extent of surgery was not related to the rates of in-hospital mortality, complications, aortic events, or survival. Although this study was conducted at a small-volume center, the in-hospital mortality and 5-year survival rates were satisfactory.

**Keywords:** Type A aortic dissection, Postoperative complications, Survival rate

## Introduction

Despite the progress of medical and surgical care, type A aortic dissection (TAAD) is still a challenging and dangerous disease. In patients with this condition, the mortality rate increases by 1% per hour, necessitating emergency treatment [1]. Emergency surgery should be performed to prevent death caused by aortic rupture or malperfusion. De Bakey et al. [2] introduced the modern concept of graft replacement for TAAD, with the key therapy being the removal of the intimal tear site. Generally, the intimal tear site determines whether hemi-arch replacement or total arch replacement (TAR) should be performed; however, at some centers, TAR has been performed prophylactically even when no tear was found in the arch region during

surgery [3-5].

In the United States and Europe, large-volume heart surgery centers have generally exhibited good results of aortic dissection surgery, while there are many reports of poor results at small-volume heart surgery centers [6-8]. In Korea, there is a tendency for surgical patients to be attracted to large-volume centers. However, in reality, TAAD surgery is often performed at local small-volume centers because they have shorter wait times. In contrast to data obtained from other parts of the world, limited data exist regarding the results of TAAD surgery in Korea. Therefore, in this study, we analyzed the surgical outcomes in patients with TAAD who were treated at a small-volume center in Korea according to the extent of surgery.



## Methods

### Patients

Between January 2008 and June 2018, we retrospectively analyzed 107 patients diagnosed with TAAD at Daegu Catholic University Medical Center. Nine of these patients were excluded from this study: 2 were transferred, and 7 refused surgery. The 98 remaining patients either underwent TAR or ascending or hemi-arch replacement (limited replacement).

Diagnoses were made using computed tomography (CT) of the chest or aortic CT with contrast media at or outside of our hospital. After anesthesia, valve status was assessed using transesophageal echocardiography.

### Surgical procedures

Our hospital's protocol requires an emergency procedure to be conducted regardless of the time elapsed after CT diagnosis. Hypothermic total circulatory arrest (TCA) and bilateral antegrade cerebral perfusion (ACP) were used as basic surgical strategies, and the extent of the operation was determined according to the presence of an aortic aneurysm or the location of the intimal tear.

With regard to the surgical protocol, after a full median sternotomy, the femoral artery or the axillary artery was used for the arterial line, and the right atrium was used for the venous line. The ascending aorta was opened; the intimal tear was explored under TCA when the required systemic temperature was reached, and a blood cardioplegic solution was administered either directly into the coronary ostia or in a retrograde fashion via the coronary sinus. If an arch tear or arch aneurysm was present after the aortotomy, a TAR was performed according to the accepted method. If no tear or aneurysm was present, an ascending or hemi-arch replacement was performed. After bilateral ACP insertion, the graft was anastomosed with the distal aorta, and a lower body perfusion was begun through the graft side branch and then sutured in the following order: the graft, then the arch vessels (in the patients who underwent TAR), and then the proximal aorta.

### Postoperative management and follow-up

In the absence of unexpected problems, patients were managed in the intensive care unit postoperatively with ventilator support. After weaning from the ventilator, blood pressure control was begun, mainly with oral be-

ta-blockers, calcium channel blockers, angiotensin-related antihypertensives, and diuretics. Follow-up evaluations were performed at 1 month, 3 months, and 6 months after discharge. Aortic CT was performed annually or when necessary. For patients who were lost to follow-up, the time of death was estimated by conducting telephone calls or investigating whether they had lost their qualification for medical insurance.

### Statistical analysis

All statistical analyses were performed using IBM SPSS ver. 25.0 software (IBM Corp., Armonk, NY, USA). The Student t-test was used for the continuous variables, and the categorical variables were analyzed using the chi-square test or the Fisher exact test. Survival curves were generated using the Kaplan-Meier method, and the differences between groups were assessed using the log-rank test. The multivariate analysis of factors influencing survival was performed through a Cox proportional hazards model, including variables that had p-values less than 0.3 in the univariate analysis of survival. A p-value of less than 0.05 was considered to indicate statistical significance.

This study was reviewed and approved by the Institutional Review Board of Daegu Catholic University Medical Center and informed consent was waived (IRB approval no., CR-19-157-L). Informed consent was waived due to the retrospective nature of this study.

## Results

The basic characteristics of the study group are shown in Table 1. In total, 82 patients underwent limited replacement and 16 patients underwent TAR. The mean age of the patients was approximately 60 years. The male-to-female sex ratio was similar between the groups. There were 5 patients with Marfan syndrome: 4 patients in the limited replacement group and 1 in the TAR group. Across both groups, the most common type of dissection was DeBakey type I. Dissection was the main pathology, while aortic intramural hematomas were relatively less frequent. Approximately half of the patients exhibited hypertension, while the majority of the patients did not have diabetes. No statistically significant difference was found between the 2 groups across any of these criteria.

Operative data and postoperative complications are shown in Table 2. The Bentall procedure was the most common concomitant procedure (n=13 cases), all instances of which were performed in the limited replacement group.

**Table 1.** Demographics and clinical characteristics

Characteristic	Limited replacement (n=82)	Total arch replacement (n=16)	p-value
Age (yr)	60.1±14.2	60.7±14.3	0.877
Height (cm)	165±12.0	162±10.6	0.514
Weight (kg)	65.8±13.6	64.1±10.9	0.640
Body mass index (kg/m <sup>2</sup> )	24±3.3	24±3.4	0.886
Body surface area (m <sup>2</sup> )	1.72±0.2	1.68±0.2	0.548
Marfan syndrome	4 (4.9)	1 (6.3)	1.000
Sex			0.789
Male	38 (46.3)	8 (50)	
Female	44 (53.7)	8 (50)	
DeBakey type			0.695
I	71 (86.6)	13 (81.3)	
II	11 (13.4)	3 (18.8)	
Aorta pathology			1.000
Dissection	63 (76.8)	12 (75)	
Intramural hematoma	19 (23.2)	4 (25)	
Cause			0.516
Spontaneous	79 (96.3)	15 (93.8)	
Traumatic	3 (3.7)	1 (6.3)	
Hypertension			0.920
Present	45 (54.9)	9 (56.3)	
Diabetes mellitus			0.585
Present	6 (7.3)	0	
Absent	76 (92.7)	16 (100)	
History of cerebrovascular accidents			1.000
Present	4 (4.9)	0	
Absent	78 (95.1)	16 (100)	
Current smoking			0.823
Yes	28 (34.1)	5 (31.3)	
No	54 (65.9)	11 (68.8)	

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

Arterial cannulation was performed in the femoral artery according to the surgeon's preference. The operation time was different between the 2 groups; in particular, the total pump time and TCA time were longer in the TAR group. No significant difference was found in the degree of hypothermia between the 2 groups.

The early mortality rate was 6.1% in the limited replacement group and 18.8% in the TAR group. New-onset cerebrovascular accidents (CVA), spinal cord ischemia, acute kidney injury (AKI) requiring continuous renal replacement therapy (CRRT), and reoperations due to bleeding were more common in the TAR group, but not to a statistically significant extent. Late aortic events requiring intervention and pneumonia were more common in the limited replacement group than in the TAR group. Since 2012, when we started applying moderate hypothermia instead

**Table 2.** Operative results and complications

Variable	Limited replacement (n=82)	Total arch replacement (n=16)	p-value
Concomitant procedure			0.174
Bentall	13	0	
Aortic valve replacement	2	1	
Atrioventricular commissural suture	3	0	
Coronary artery bypass grafting	2	1	
Arterial cannulation site			0.665
Axillary	8 (9.8)	1 (6.3)	
Femoral	72 (87.8)	14 (87.5)	
Aorta	2 (2.4)	1 (6.3)	
Operating time (min)	510.3	553.8	0.226
Total pump time (min)	215.9	283.6	<0.001
Total circulatory arrest time (min)	61.4	96.4	<0.001
Cerebral perfusion during circulatory arrest (min)	45.0	92.3	<0.001
Hypothermia management			0.863
Profound (≤14°C)	3	1	
Deep (14.1°C–20°C)	27	6	
Moderate (20.1°C–28°C)	50	9	
Mild (28.1°C–34°C)	2	0	
Early mortality	5 (6.1)	3 (18.8)	0.120
New-onset cerebrovascular accidents	2 (2.4)	2 (12.5)	0.124
Spinal cord ischemia	1 (1.2)	1 (6.3)	0.301
Acute renal failure (needing continuous renal replacement therapy)	10 (12.2)	2 (12.5)	1.000
Bleeding requiring reoperation	2 (2.4)	1 (6.3)	0.418
Pneumonia	6 (7.3)	0	0.585
Late aortic event	11 (13.4)	1 (6.3)	0.684

Values are presented as number or number (%), unless otherwise stated.

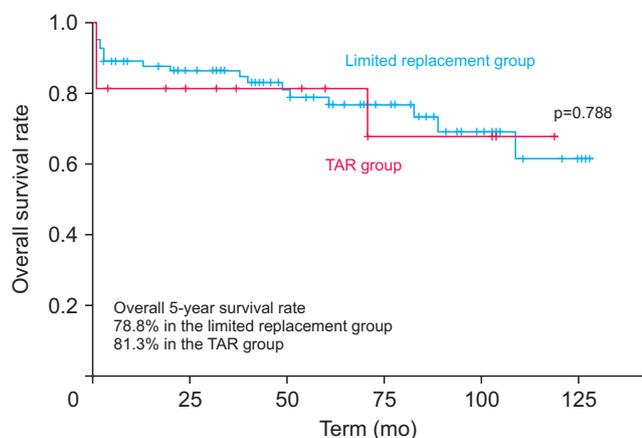
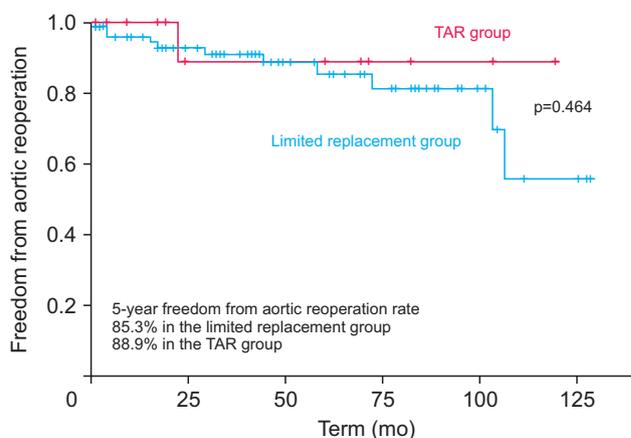
of deep hypothermia as a criterion for TAR, the early mortality rate decreased from 28.6% to 11.1%. However, no statistically significant difference was detected.

The multivariate analysis of survival showed significant results for most variables related to medication use (Table 3). In particular, the risk of death was significantly higher in patients who did not use beta-blockers after surgery.

The results of a survival analysis using the Kaplan-Meier method are shown in Figs. 1 and 2. The overall 5-year survival rate was 78.8% in the limited replacement group and 81.3% in the TAR group. The rate of freedom from aortic reoperation was 85.3% in the limited replacement group and 88.9% in the TAR group at 5 years, with no statistically significant difference between the 2 groups.

**Table 3.** Multivariate analysis of risk factors for survival

Variable	Hazard ratio (confidence interval)	p-value
Non-use of postoperative beta blocker	5.362 (1.789–16.074)	0.003
Non-use of postoperative calcium channel blocker	3.436 (0.736–16.040)	0.116
Non-use of postoperative angiotensin receptor blocker or angiotensin-converting enzyme inhibitors	4.306 (0.547–33.909)	0.166
Known hypertension	2.678 (0.879–8.163)	0.083

**Fig. 1.** Overall survival. TAR, total arch replacement.**Fig. 2.** Freedom from aortic reoperation. TAR, total arch replacement.

## Discussion

The definition of a high-volume center varies, with some researchers using a threshold of 14 cases per year and others using more than 11 cases per year [6,7]. The situation in Western countries is different from that in Korea. The entire volume of aortic surgery performed in Korea has not been investigated, so it is difficult to draw comparisons. In Korea, major hospitals are concentrated in the Seoul and Gyeonggi areas. Therefore, indirect comparisons of the number of aortic operations have been made. A total of 2,176 aortic operations were performed at 73 hospitals across the country in 2018, 72% in the metropolitan area and 28% in the provinces. The hospitals known to be Korea's leading aortic surgery centers have 40 to 50 cases of aortic dissection surgery per year. The annual case volume of our center is 8.9 cases per year.

In our study, the 30-day mortality rate was 8.2%, which was determined to be acceptable when compared to previous studies [9-11]. There was no statistically significant difference between the limited replacement group and the TAR group (6.1% and 18.8%, respectively), but the TAR group had a higher 30-day mortality rate. Since the number of cases in the TAR group was very small, this may have limited the ability to detect any statistical signifi-

cance, a limitation that may also apply to the relatively high early mortality rate in the TAR group.

No statistically significant differences were found between the 2 groups with regard to the rates of certain complications, such as new-onset CVAs, spinal cord ischemia, AKIs (requiring CRRT), reoperations due to bleeding, or pneumonia. In addition, except for pneumonia, the TAR group had a higher rate of complications. The total operation time, cardiopulmonary bypass time, and TCA time were longer in the TAR group, which appear to have affected the overall outcome of the procedure. The rate of late aortic events was higher in the limited replacement group, which was the most unexpected finding of our study, but no statistically significant difference was found with regard to the initial surgical extent and the occurrence of late aortic events (Fig. 2). In the risk factor analysis of late aortic events, the incidence of intramural hematoma (odds ratio [OR], 0.02; 95% confidence interval [CI], 0.02 to 1.87;  $p=0.016$ ) and Marfan syndrome (OR, 7.05; 95% CI, 0.88 to 56.59;  $p=0.066$ ) showed a negative effect on aortic complications during the follow up period. Although there were no statistically significant differences in complication rate between the 2 groups, it is thought that a larger number of patients and a longer follow-up period would be beneficial in further studies. In addition, the early mortality rate in

the TAR group may have affected the outcomes observed.

A number of studies have explored the extent to which the aortic annulus or arch should be included in surgical treatment [12-14]. The TAR ratio was 16.3% in our study, which is similar to that in previous studies [9-11]. The protocol in our center has not changed over the past decade, and we only performed TAR in cases of arch aneurysms or arch tears. TAR operations in patients with acute type I aortic dissection resulted in fewer late-developing aortic problems [15]. In patients with Marfan syndrome in particular, a large number of aortic problems can occur later, so there are many factors to consider in determining the extent of the initial operation [16,17]. Some believe that TAR should be performed during the first operation to reduce the risk of reoperation [18]. However, at our center, TAR was performed in only 1 patient (out of 5) with Marfan syndrome. During the follow-up period, 1 patient died, and 4 patients were kept under observation. Since this number of patients is very small, it is difficult to determine the clinical significance of these observations.

Recent surgical trends vary according to the preference of each center and surgeon. However, results have been published warning of the risks of a wide range of surgical procedures, including arch replacement [9,11]. Our center expects to reduce the operation time and the frequency of complications by making the surgical extent as small as possible.

The results graphed using Kaplan-Meier curves showed no difference in survival rates between the TAR and limited replacement groups. However, the observed trends suggest that longer follow-up periods may yield more meaningful differences.

A multivariate analysis of the survival rate according to medication use showed that beta-blockers play an important role in these procedures. In this study, the risk of death increased by more than 5-fold if beta-blockers were not used after surgery. The importance of beta-blockers in the long-term treatment of dissection has been demonstrated in many previous studies. Genoni et al. [19] reported that beta-blockers lowered aortic wall stress and improved survival, and Melby et al. [20] reported that blood pressure control, especially via the use of beta-blockers, reduced the reoperation rate after TAAD repair.

Several limitations of this study exist. First, the number of cases was small. Second, there was a procedural change in treatment during the study period. Starting in 2012, our center changed from a deep to a moderate hypothermia management strategy. In future studies, we will be able to analyze whether the degree of hypothermia affects clinical

outcomes.

In conclusion, in this study, no significant difference in clinical outcomes was found according to the surgical extent in TAAD, and small-volume medical centers may see acceptable results if patients are managed with a suitable protocol. In addition, the use of beta-blockers during long-term treatment can improve patients' prognosis, indicating that strict medication use is necessary.

## Conflict of interest

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

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