ORIGINAL ARTICLE

Descending thoracic aortic repair outcomes for chronic aortic dissection: a single-centre experience

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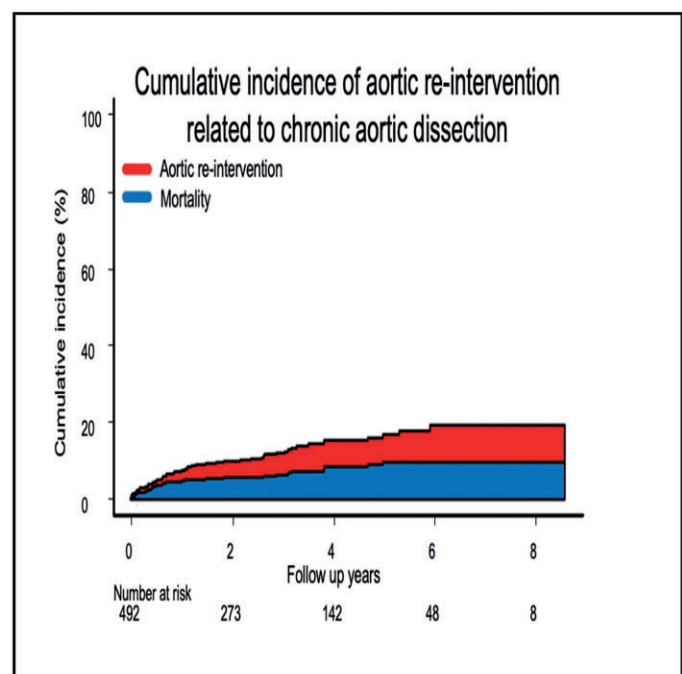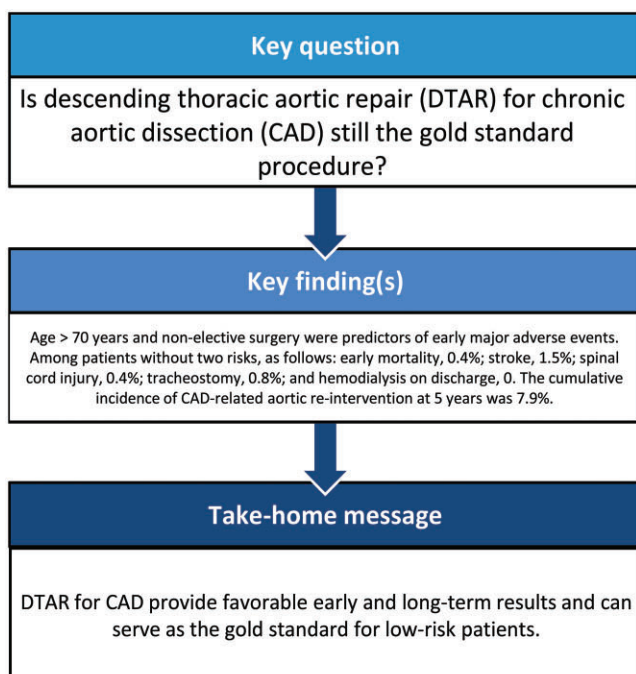
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Key question

Is descending thoracic aortic repair (DTAR) for chronic aortic dissection (CAD) still the gold standard procedure?

Key finding(s)

Age > 70 years and non-elective surgery were predictors of early major adverse events. Among patients without two risks, as follows: early mortality, 0.4%; stroke, 1.5%; spinal cord injury, 0.4%; tracheostomy, 0.8%; and hemodialysis on discharge, 0. The cumulative incidence of CAD-related aortic re-intervention at 5 years was 7.9%.

Take-home message

DTAR for CAD provide favorable early and long-term results and can serve as the gold standard for low-risk patients.

Abstract

OBJECTIVES: Thoracic endovascular aortic repair is a widely accepted treatment for chronic aortic dissection because of good early results compared to open surgical repair. We provide early and long-term results of descending thoracic aortic repair for chronic aortic dissection.

METHODS: Patients who underwent descending thoracic aortic repair for chronic aortic dissection between January 2012 and December 2020 at Kawasaki Aortic Centre were included in this analysis.

RESULTS: Four hundred ninety-two patients (median age, 64 years; interquartile range, 52–75 years) were included. The median duration of follow-up was 3.2 years (interquartile range, 1.5–5.2 years). The early mortality rate was 2.0% (n = 10); strokes occurred in 17 patients (3.5%); and spinal cord injuries occurred in 30 patients (6.1%). Early major adverse events including early death, stroke, spinal cord injury, tracheostomy and haemodialysis at the time of discharge occurred in 62 patients. Multivariable analysis indicated that age > 70 years and

non-elective surgery were predictors of early major adverse events. Among patients without both risk factors (i.e. low-risk patients), 1 early death (0.4%), 3 strokes (1.5%) and 1 spinal cord injury (0.4%) were observed, 2 tracheostomies were performed (0.8%) and no patients required haemodialysis at the time of hospital discharge. The 5-year survival rate was 87.2%. The cumulative incidence of chronic aortic dissection-related aortic reintervention at 5 years was 7.9%.

CONCLUSIONS: Descending thoracic aortic repair for chronic aortic dissection resulted in good early and long-term results, and it can serve as the gold standard for low-risk patients.

ABBREVIATIONS

CAD	Chronic aortic dissection
CI	Confidence interval
DHCA	Deep hypothermia circulatory arrest
DTAR	Descending thoracic aortic repair
eGFR	estimated glomerular filtration rate
IQR	Interquartile range
KAC	Kawasaki Aortic Center
MAEs	Major adverse events
OR	Odds ratio
OSR	Open surgical repair
SCI	Spinal cord injury
TAAR	Thoracoabdominal aortic repair
TEVAR	Thoracic endovascular aortic repair

INTRODUCTION

Open surgical repair (OSR) has long been the gold standard for chronic aortic dissection (CAD). In recent years, many studies involving thoracic endovascular aortic repair (TEVAR) for CAD have been published, and TEVAR has replaced OSR as the preferred treatment option based on early favourable results [1–5]. The goal of TEVAR is to cover the entry tear, stabilize the true lumen and facilitate false lumen thrombosis; however, a previous study revealed that false lumen thrombosis is achieved in approximately 40% of patients [2], and positive aortic remodelling after TEVAR occurs in 41% of patients within 2 years [3]. Furthermore, reintervention, including additional TEVAR, false lumen occlusion or OSR, is required in 15%–39% of patients [3–5]. For these reasons, OSR is the first choice for CAD in our centre. OSR is a radical treatment, although the early results are considered inferior to those achieved with TEVAR [6–8]. Even though several studies involving OSR for CAD have been published [7–11], these studies often include thoraco-abdominal aortic repair (TAAR), which could explain the higher mortality and morbidity rates in the OSR cohort. Thus, descending thoracic aortic repair (DTAR) and TAAR must be considered separately. In addition, because TEVAR is a simple procedure that only involves the descending thoracic aorta, we suggest that the OSR cohort results involving DTAR should be summarized and that a properly conceived comparison study between DTAR and TEVAR should be conducted.

Thus, in the current study, we examined the early and long-term results of DTAR for CAD performed at the Kawasaki Aortic Center (KAC) in Japan, where approximately 500 open surgical procedures for thoracic aortic disease are performed annually.

MATERIALS AND METHODS

Ethical statement

This study complied with the standards of the Declaration of Helsinki and current ethical guidelines. The study was approved by the Kawasaki Saiwai Hospital institutional review board (approval number R3-7). Informed consent was waived.

Methods

We retrospectively analysed the clinical and imaging data of the patients diagnosed with a CAD between January 2012 and December 2020 at KAC. We performed DTAR rather than TAAR when the diameter of the distal descending thoracic aorta or distal anastomosis site was < 40 mm. The indications for surgical intervention included an aortic diameter > 50 mm, rapid growth of the aorta (5 mm within 6 months) and rupture or impending rupture of the dissection. The preoperative demographic data, surgical strategies, operative details and postoperative outcomes were reviewed. According to Japanese guidelines [12], an aortic dissection is defined as chronic when 3 months have elapsed after the onset of symptoms. The aortic diameter was based on measurements of all segments of the descending thoracic aorta; the largest diameter was used as the maximum diameter.

Surgical strategies and techniques

Cerebrospinal fluid drainage was not routinely performed in patients who had DTAR. The surgical technique for the DTAR is described in our previous report [13]. We established cardiopulmonary bypass and performed an open proximal anastomosis with deep hypothermia circulatory arrest (DHCA) when proximal aortic clamping was not feasible. Among patients in whom DHCA was applied, left subclavian artery reconstruction was performed as required. We established left heart bypass under mild permissive hypothermia (32–34°C) if proximal aortic control was obtained with cross-clamping. We did not routinely perform intercostal artery reconstruction. Intraoperative neurological measurements, such as motor evoked potentials, were not used. A standard posterolateral incision was made along the fifth or sixth intercostal space. Patients in whom DHCA was applied underwent cardiopulmonary bypass with the left pulmonary artery, left femoral vein drainage and arterial return via the left femoral artery. Antegrade selective cerebral perfusion at 10 ml/kg/min was performed during open proximal anastomosis. These patients were cooled to a core body temperature of 18–22°C, which was measured using a urinary catheter in all cases. Patients in whom

DHCA was not applied underwent left heart bypass with left pulmonary vein drainage and arterial return via the left femoral artery [13].

We used a Dacron graft (Triplex graft; Terumo, Tokyo, Japan) in the majority of patients. The proximal site of the aorta was opened, and the end anastomosis was performed with continuous suture (3–0 or 4–0 polyvinylidene difluoride, Asflex; Kono Seisakusho, Chiba, Japan) and full circumference multiple double-pledgeted sutures. The distal anastomosis was performed with fenestration of the intimal flap when the dissection extended to the thoraco-abdominal aorta.

Definition of clinical outcomes

Early death was defined as death 30 days postoperatively or at the time of hospital discharge. Urgent surgery was defined as an operation performed within 48 h after hospital admission. Non-elective surgery was defined as an emergency or urgent operation due to rupture or impending rupture of the aortic dissection. Spinal cord injury (SCI) was defined as any spinal cord deficit after the operation. A permanent SCI was defined as an SCI that did not resolve by the time of hospital discharge. Transient SCI was defined as an SCI that resolved by the time of hospital discharge. Early major adverse events (MAEs) were calculated and included early death or the occurrence of a cerebrovascular stroke, an SCI, the need for a tracheostomy or haemodialysis required at the time of discharge. The clinical frailty scale ranges from 1 to 9, and higher values indicate greater frailty (1 = very fit, 2 = well, 3 = managing well, 4 = very mildly frail, 5 = mildly frail, 6 = moderately frail, 7 = severely frail, 8 = very severely frail and 9 = terminally ill) [14]. Frail was defined as a clinical frailty scale score ≥4. Prolonged ventilator use was defined as an intubation time > 72 h. Aortic reintervention was defined as a reintervention performed for any aortic pathology. Reintervention for a treated segment was defined as a reintervention for an anastomotic false aneurysm, graft infection and graft injury. CAD-related reintervention was defined as a reintervention for the treated segment or expansion or rupture of the residual dissected aorta. Proximal or distal reintervention was defined as reintervention performed for other aortic pathologies, including aneurysmal degeneration, type A aortic dissection and anastomotic pseudoaneurysm related to previous surgery for acute type A aortic dissection.

Follow-up

After hospital discharge, patients were evaluated 1 and 6 months postoperatively and subsequently at 12-month intervals. Computed tomography or magnetic resonance imaging studies were obtained before hospital discharge, 6 months postoperatively and yearly thereafter.

Statistical analyses

Values are presented as the median [interquartile range (IQR), 25th - 75th percentiles] for continuous variables and n (%) for categorical variables. Calculated *P*-values <0.05 were considered significant. Multivariable risk assessment of early results was performed using logistic regression analysis. Multivariable risk assessments for long-term mortality were performed using Cox proportional-hazards regression analysis. Multivariable

analyses were performed in which each variable with a *P*-value < 0.10 on univariable analysis was entered into the model. The univariable analysis model included the following variables: age; gender; clinical frailty scale score; dyslipidaemia; hypertension; COPD; estimated glomerular filtration rate (eGFR); diabetes mellitus; atrial fibrillation; non-elective surgery; Marfan syndrome; maximum diameter of the aorta; DHCA use; open distal anastomosis; minimum bladder temperature; site of distal anastomosis; and intercostal artery reconstruction. Long-term mortality was calculated among the patients who were discharged alive. The overall survival was estimated using the Kaplan–Meier method. Aortic reintervention was analysed with death as a competing risk using the cumulative incidence method [15]. Receiver operating characteristic curve analysis was used to determine the diagnostic value of age in patients with MAEs. The cut-off for age was estimated with the highest Youden index [(sensitivity + specificity) - 1]. All statistical analyses were performed with EZR, a modified version of R commander that was designed to add statistical functions frequently used in biostatistics (https://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmedEN.html).

RESULTS

Patient characteristics

Between January 2012 and December 2020, a total of 1494 patients underwent thoracic and thoraco-abdominal aortic surgery via a left thoracotomy at the KAC. Of the 1494 patients, 675 and 492 had CAD and DTAR, respectively. The preoperative characteristics of the patients are shown in Table 1. The median age was 64 years (IQR, 52–75 years) and 385 patients (78.3%) were males. The median duration of follow-up was 3.2 years (IQR, 1.5–5.2 years) and the follow-up index was 0.89 (IQR, 0.72–0.98). Forty-eight patients (9.8%) had a clinical frailty scale > 4. One hundred seven patients (21.7%) underwent emergency or urgent surgery. Twenty-two patients (4.5%) had Marfan syndrome. One hundred forty-eight patients (30.1%) had a history of surgery for acute type A aortic dissection. The median maximum diameter of the aorta was 54.0 mm (IQR, 51.0–59.0 mm).

Operative details

The median operative time was 318.0 min (IQR, 271.0–375.0 min), and the median extracorporeal circulation time was 118.0 min (IQR, 89.0–161.25 min). DHCA was applied in 141 patients (28.7%). An open distal anastomosis was performed in 249 patients (50.6%). Left subclavian artery reconstruction was performed on 85 patients (18.1%), of whom 60.3% had DHCA applied.

Early results

The early results are shown in Table 2. The overall early mortality rate was 2.0%. Strokes occurred in 17 patients, and SCIs occurred in 30 patients. The neurological status improved during the in-hospital stay in the majority of patients (23/30); only 7 patients (1.4%) had a permanent SCI. Based on the univariable analysis results, multivariable logistic analysis identified non-elective surgery [odds ratio (OR) 25.1, 95% confidence interval (CI), 2.87–219.0; *P* = 0.004] as a

Table 1: Preoperative and operative details

Variable	n = 492
Preoperative details	
Age, years, n (%)	64.0 (52.0 - 75.0)
Age >70 years, n (%)	176 (35.8)
Male, n (%)	385 (78.3)
Clinical Frailty Scale, n (%)	2.0 (1-3)
Clinical Frailty Scale ≥4, n (%)	48 (9.8)
Dyslipidaemia, n (%)	132 (26.8)
Hypertension, n (%)	427 (87.0)
Smoking history, n (%)	240 (48.8)
COPD, n (%)	44 (8.9)
eGFR, mL/min/1.73 m^2, n (%)	58.3 (46.4–68.9)
Chronic kidney disease staging, n (%)	
Stage 1 (eGFR ≥90), n (%)	30 (6.1)
Stage 2 (eGFR 60-89), n (%)	187 (38.0)
Stage 3a (eGFR 45-59), n (%)	155 (31.5)
Stage 3b (eGFR 30-44), n (%)	72 (14.6)
Stage 4 (eGFR 15-29), n (%)	25 (5.1)
Stage 5 (eGFR < 15), n (%)	13 (2.6)
Diabetes mellitus (%), n (%)	36 (7.3)
Coronary artery disease, n (%)	44 (8.9)
Peripheral vascular disease, n (%)	15 (3.1)
Atrial fibrillation, n (%)	20 (4.1)
Non-elective surgery, n (%)	107 (21.7)
Marfan syndrome, n (%)	22 (4.5)
CSFD, n (%)	4 (2.1)
History of ATAAD surgery, n (%)	148 (30.1)
Extent of distal aortic dissection, n (%)	
Residual DeBakey I, n (%)	148 (30.1)
DeBakey IIIa, n (%)	89 (18.1)
DeBakey IIIb, n (%)	261 (53.0)
Maximum diameter of aorta (mm)	54.0 (51.0 - 59.0)
Operative details	
Operative time	318.0 (271.5 - 375.0)
CPB time	118.0 (89.0 - 161.25)
Aortic clamp time	97.0 (75.0 - 120.0)
DHCA, n (%)	141 (28.7)
Open distal anastomosis, n (%)	249 (50.6)
Minimum bladder temperature, °C, n (%)	28.0 (20.8 - 32.0)
Site of distal anastomosis, n (%)	T 8.8
T6, n (%)	21 (4.3)
T7, n (%)	77 (15.7)
T8, n (%)	85 (17.3)
T9, n (%)	129 (26.2)
T10, n (%)	155 (31.5)
T11, n (%)	25 (5.1)
ICA reconstruction, n (%)	48 (9.8)
LSCA reconstruction, n (%)	89 (18.1)

ATAAD: acute type A aortic dissection; COPD: chronic obstructive pulmonary disease; CPB: cardiopulmonary bypass; CSFD: cerebrospinal fluid drainage; DHCA: deep hypothermia cardiac arrest; eGFR: estimated glomerular filtration rate; ICA: intercostal artery; LSCA, left subclavian artery.

Table 2: Postoperative early results

Variable	n = 492
Early death, n (%)	10 (2.0)
Stroke, n (%)	17 (3.5)
SCI, n (%)	30 (6.1)
Transient SCI, n (%)	23 (4.7)
Permanent SCI, n (%)	7 (1.4)
Re-exploration for bleeding , n (%)	13 (2.6)
Prolonged ventilation , n (%)	24 (4.9)
Tracheotomy, n (%)	15 (4.1)
Pneumonia , n (%)	13 (2.6)
Lymphorrhea, n (%)	34 (6.9)
Delirium , n (%)	15 (3.0)
Temporary use of HD, n (%)	27 (5.5)
Newly HD on discharge , n (%)	6 (2.6)
Early MAEs, n (%)	62 (12.6)

HD: haemodialysis; MAEs: major adverse events; SCI: spinal cord injury.

Table 3: Multivariable logistic regression analysis of predictors for early results

	Variable	OR (95% CI)	*P*-value
Early death	Age, per year	1.04 (0.98–1.10)	0.16
	Non-elective surgery	25.10 (2.87 - 219.00)	0.004
	DHCA	1.17 (0.24 - 4.24)	0.83
Early MAEs	Age, per year	1.05 (1.02-1.08)	0.004
	COPD	2.16 (0.89-5.26)	0.06
	eGFR	0.99 (0.98-1.01)	0.39
	Non-elective surgery	4.6 (2.61-10.9)	0.001
	Clinical Frailty Scale ≥4	1.81 (0.81-4.1)	0.14
	DHCA	1.17 (0.58-2.39)	0.66
	Operative time, per min	1.00 (0.99-1.01)	0.19

The regression model included the following variables: age; gender; Clinical Frailty Scale; dyslipidaemia; hypertension; COPD; eGFR; diabetes mellitus; atrial fibrillation; non-elective surgery; Marfan syndrome; maximum diameter of the aorta; operative time; DHCA use; open distal anastomosis; minimum bladder temperature; site of distal anastomosis; and intercostal artery reconstruction.

CI: confidence interval; COPD: chronic obstructive pulmonary disease; DHCA: deep hypothermia cardiac arrest; MAEs: major adverse events; OR: odds ratio; SCI: spinal cord injury.

predictor of early death (Table 3). Sixty-two patients had early MAEs, and independent predictors of early MAEs were age (OR 1.05, 95% CI, 1.02–1.08; P=0.005) and non-elective surgery (OR 4.6, 95% CI, 2.61–10.9; P = 0.001). The receiver operating characteristic curve for age was calculated to predict MAEs. The cut-off value for age was 70 years, which was calculated from the point of maximal specificity (74.2%) and sensitivity (69.8%), and the area under the curve was 0.742 (95% CI, 0.67–0.81). Among patients < 70 years of age and patients who had elective surgery [i.e. low-risk patients (*n* = 266); mean age, 62.0 years], there was 1 early death (0.4%; 95% CI, 0.01–2.3), 3 strokes (1.5%; 95% CI, 0.22–3.4), 1 transient SCI (0.4%; 95% CI, 0.15–2.3%), 2 patients who required tracheostomies

(0.8%; 95% CI, 0.02–2.9%), and no patients who were discharged from the hospital on haemodialysis.

Long-term results

During the follow-up period (median duration of follow-up = 3.2 years), 34 patients died after discharge from the hospital. The 5-year survival rate was 87.2% (Fig. 1). Cox regression analysis showed that the eGFR (hazard ratio, 0.98; 95% CI, 0.96–0.99; P = 0.03) and non-elective (hazard ratio, 2.91; 95% CI, 1.53–5.51; P = 0.001) surgery were pre- and intraoperative predictors of long-term mortality among all patients (Table 4). Table 5 shows the details of all aortic reinterventions. Fifty-four patients (11.0%) required subsequent aortic procedures, and 13 patients (2.6%) required reintervention of the treated segment. Non-elective surgery was performed in 11 patients (2.2%), including 6 patients with aortic ruptures. Approximately one-half of all reinterventions were related
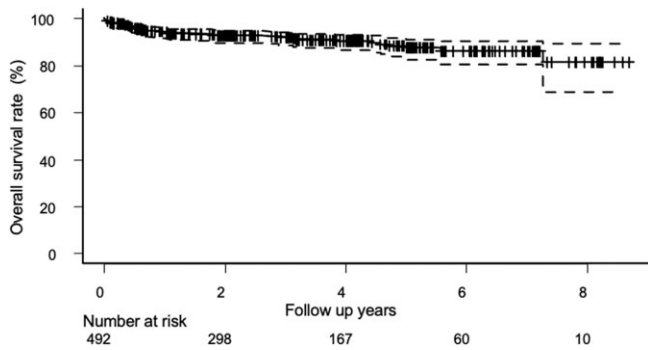
Figure 1: Kaplan–Meier curve demonstrating survival after descending thoracic aortic replacement for chronic type B aortic dissection: 87.2% at 5 years.

Table 4: Final model of the Cox regression analysis for predictors of long-term death with or without early results

Variable	With early death, n = 492		Without early death, n = 482	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Age, per year	1.02 (0.99-1.04)	0.16	1.02 (0.99-1.04)	0.21
Hypertension	0.65 (0.32-1.34)	0.25	0.63 (0.31-1.28)	0.23
Clinical Frailty Scale ≥4	1.86 (0.81-4.36)	0.15	1.64 (0.57-4.53)	0.37
COPD			1.15 (0.41-3.26)	0.78
eGFR	0.98 (0.96-0.99)	0.03	0.98 (0.96-0.99)	0.01
Non-elective surgery	2.91 (1.53-5.51)	0.001	1.94 (0.94-3.90)	0.07

CI: confidence interval; COPD; chronic obstructive pulmonary disease; eGFR; estimated glomerular filtration rate; HR: hazard ratio.

Table 5: Details of all aortic reinterventions

Variable	n = 54
Follow-up, months, n (%)	18.9 (6.3-29.6)
CAD-related, n (%)	28 (51.9)
Non-elective surgery, n (%)	11 (16.7)
Rupture , n (%)	6 (11.1)
Segment, n (%)	
Treated	12 (22.2)
Proximal	13 (24.1)
Distal	29 (53.7)
Reintervention contiguous to the graft, n (%)	25 (46.3)
Surgical procedure, n (%)	
ARR	8 (14.8)
HAR	1 (1.9)
TAR	6 (11.1)
TAAR	10 (18.5)
AAAR	14 (25.9)
TEVAR	9 (16.7)
EVAR	6 (11.1)

AAAR: abdominal aortic aneurysm repair; ARR: aortic root replacement; CAD: chronic aortic dissection; EVAR: endovascular aortic repair; HAR: hemiarch replacement; TAAR: thoraco-abdominal aortic repair; TAR: total arch replacement; TEVAR: thoracic endovascular aortic repair.

to CAD. Endovascular aortic repair and TAAR were performed in 15 and 10 patients, respectively. The cumulative incidence of any aortic reintervention at 5 years (Fig. 2A) was 15.3% (95% CI, 11.3–19.9%),
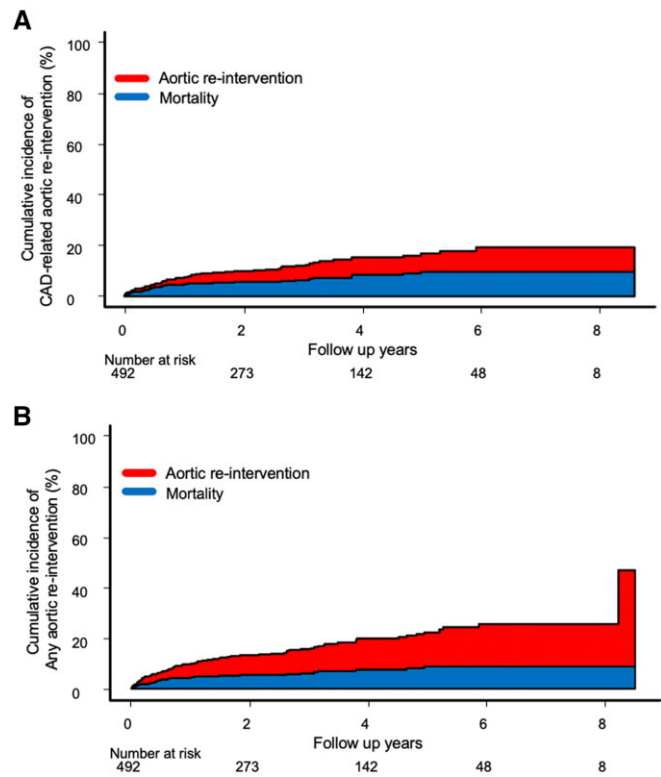

Figure 2: Stacked cumulative incidence of both events (red area: aortic reintervention; blue area: deaths) visualizing the competing risk analysis. Cumulative incidence of any aortic reintervention (**A**): 15.3% at 5 years. Cumulative incidence of aortic reintervention related to chronic aortic dissection; 7.9% at 5 years (**B**).

and the cumulative incidence of CAD-related aortic reintervention at 5 years (Fig. 2B) was 7.9% (95% CI, 5.2–11.3%). This study did not detect any factor associated with aortic reintervention after DTAR (data not shown)

DISCUSSION

High mortality and morbidity rates have been reported with OSR for CAD. Specifically, the early mortality rate ranges from 0–13% [2, 4, 10]. Based on the greatest number of patients to date, Tanaka et al. [7] reported that among 427 patients who underwent OSR for CAD, the 30-day mortality rate was 8.4%, the SCI rate was 5.2% and the stroke rate was 4.0%. Moreover, Tanaka et al. [7] reported that among low-risk patients, the 30-day mortality rate was 2.6%, and the procedure achieved excellent long-term durability for OSR.

Most of the patients in the OSR group had TAAR as well as DTAR [6–11, 13], whereas the TEVAR group only underwent intervention involving the descending thoracic aorta. This difference could account for the higher mortality and morbidity rates in the OSR cohort. Thus, we speculate that these results do not reflect the results of a comparison between OSR and TEVAR. Indeed, our previous report [9] showed that the 30-day mortality rate was higher in patients who had TAAR than in patients with CAD who had DTAR (10.3% vs 3.9%, *P* = 0.06), even though the 30-day mortality rate for patients who underwent elective surgery was 6.9% [16]. In addition, the mortality rate in patients who had TEVAR for CAD performed proximal to landing zone 2

ranged from 20.8% to 34.3% [17–19]. TEVAR with a zone 2 landing corresponds to DTAR with DHCA, and 28.7% of the cohort was in the DHCA group in our study. For these 2 reasons, we believe that the present study serves as a clinically meaningful reference between OSR and TEVAR for CAD.

Reported issues with OSR include higher early mortality and severe complication rates (neurological complications, a tracheostomy and haemodialysis at the time of hospital discharge), making patients unable to return to normal life. Several reports have suggested that increased age, low eGFR, a history of DTAA/TAAA repair and COPD are predictors of the OSR 30-day mortality rate for CAD [7, 11, 20]; however, few reports refer to the risks of OSR, such as early mortality combined with severe complications (early MAEs). We speculate that it is important to reveal the risks of early MAEs as a risk of OSR. In the current study, the early mortality rate was only 2.0%; however, the incidence of strokes and SCIs was slightly higher than in previous studies [7, 8, 11, 20]. Low rates of intercostal artery reconstruction and cerebrospinal fluid drainage might contribute to the incidence of SCIs. Early MAEs occurred in 62 patients (12.6%), and age and non-elective surgery were independent predictors; the cut-off value for age was 70 years. Variables with a P-value < 0.10 on univariable analysis were plausible and reasonable from both a clinical and a biological point of view. Among patients < 70 years and patients who underwent elective surgery (i.e. low-risk patients), the early mortality rate was 0.4%, the incidence of stroke was 1.5%, the incidence of SCIs was 0.4%, 0.8% of patients required a tracheostomy and no patients were discharged from the hospital on haemodialysis. Thus, we recommend OSR as the gold standard procedure for low-risk patients.

A previous report revealed that midterm survival for patients treated with TEVAR for CAD was unacceptable, especially in patients with a lack of aortic remodelling [5]. Midterm survival was also poor in patients with a stable aortic diameter, which made it difficult to determine the timing of reintervention. Thus, how residual aortic dissection changes after DTAR or TEVAR is an important issue. Recent reports have demonstrated that nearly 70% of patients who underwent TEVAR for CAD did not show regression of the aortic diameter [18].

In a recent study, Arnaoutakis et al. [3] reported findings of early aortic remodelling and events after TEVAR for CAD. Arnaoutakis et al. [3] showed that stabilization of aortic diameters occurs in >50% of patients; however, 38.9% (37/95) of all patients require reintervention, and 81% of reinterventions were performed within the first 2 years postoperatively. Even among patients with reverse aortic remodelling, 25.6% (10/39) required reintervention. Most reinterventions were localized within the intended treatment zone (70%), secondary to persistent false lumen perfusion. Moreover, 13.7% (13/95) of all patients underwent OSR, 8 of whom had TAAR. In addition, approximately 30% of reintervention procedures are OSR , and the benefits of TEVAR are offset by higher reintervention rates in surgical conversions.

Our study revealed that the cumulative incidence of any aortic reintervention at 5 years was 15.3% (95% CI, 11.3–19.9%), and the cumulative incidence of CAD-related aortic reintervention at 5 years was 7.9% (95% CI, 5.2–11.3%). With respect to the distal segment, reintervention was performed in 29 patients (5.9%), and open TAAR involved only 10 patients (2.0%) after DTAR.

In our opinion, TEVAR has a serious problem in need of resolution. Specifically, the false lumen status or aortic remodelling before the first intervention cannot be predicted, and good aortic remodelling does not occur. Thus, OSR should be performed in patients to achieve good long-term results.

This study revealed that low-risk patients (i.e. age < 70 years and elective cases) achieved excellent early outcomes, and good long-term durability was expected with DTAR for CAD. Thus, low-risk CAD patients, especially young patients in whom good long-term results were required, should undergo OSR if the replacement can be confined to the descending thoracic aorta.

LIMITATIONS

The present study had several limitations. First, the study was retrospective and limited to patients who underwent open surgery in our institution. The authors seldom considered TEVAR for CAD; the basic strategy for these patients was open surgery. Second, this was a single-centre study, and no firm conclusions can be drawn from the findings. Third, the median follow-up duration was relatively short (3.2 years). Fourth, this study might be affected by type II errors, which preclude detection of relevant factors associated with early and long-term outcomes. Finally, we excluded patients with CAD in whom TAAR was performed; thus additional studies are warranted.

CONCLUSION

DTAR for CAD at the KAC provided a satisfactory low early mortality rate and good long-term results. Age > 70 years and non-elective surgery were independent predictors of the occurrence of early MAEs, and we expect good early results among low-risk patients,. Thus, OSR can serve as the gold standard for low-risk patients, especially if the replacement can be confined to the descending thoracic aorta.

Funding

Conflict of interest: None declared.

Data availability

The article's data will be shared on reasonable request to the corresponding author.

Author contributions

Yoshitaka Yamane: Data curation; Formal analysis; Project administration; Supervision; Writing—original draft; Writing—review & editing; **Susumu Oshima:** Data curation; Investigation; Methodology; Writing—review & editing; **Kazumasa Ishiko**: Writing—review & editing; **Takaaki Itohara**: Writing—review & editing; **Makoto Okiyama:** Writing—review & editing; **Tomohiro Hirokami:** Investigation; Conceptualization; Writing—review & editing; **Yuki Hirai:** Investigation; Writing—review & editing; **Sigeru Sakurai:** Conceptualization; Writing—review & editing; **Kensuke Ozaki:** Writing—original draft; Writing—review & editing; **Kenichi Yoshimura**: Supervision; Writing—review & editing; **Shinya Takahashi:** Methodology; Supervision; Writing—review & editing; and **Shin Yamamoto:** Writing—review & editing.

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