Surgical outcome of elective total arch replacement with coronary artery bypass grafting

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Abstract

Purpose We aimed to compare the surgical outcome between total arch replacement with coronary bypass surgery and that without.

Methods Between 2008 and 2016, 157 consecutive patients underwent total arch replacement with antegrade cerebral perfusion and moderate hypothermic circulatory arrest using the proximal first approach. They were divided into two groups: total arch replacement with coronary bypass surgery (group 1, $n = 38$) and that without (group 2, $n = 119$).

Results Of the 38 patients in group 1, 37 (97%) were asymptomatic. The left internal thoracic artery and saphenous vein were used in one (2.6%) and 38 (100%) patients, respectively. The mean number of coronary anastomoses was 1.5 ± 1.0 . In-hospital mortality rate was 3.8%. Cardiopulmonary bypass time and operation time in group 1 were significantly longer than those in group 2 (336 ± 52 min vs. 276 ± 38 min, $P < 0.0001$ and 702 ± 122 min vs. 619 ± 94 min, $P < 0.0001$, respectively). No differences in in-hospital mortality and perioperative myocardial infarction were found between the groups (5.3% vs. 3.4%, $P = 0.633$ and 0% vs. 1.7%, $P = 1.000$, respectively). In the multivariate analysis, age (odds ratio, 1.208; 95% confidence interval, 1.041–1.497; $P = 0.008$) and cardiopulmonary bypass time (odds ratio, 1.019; 95% confidence interval, 1.001–1.041; $P = 0.041$) were significant determinants of in-hospital mortality.

Conclusions Although prolonged cardiopulmonary bypass time was a significant determinant of in-hospital mortality, total arch replacement with coronary bypass surgery could be safely performed with favorable outcomes.

Keywords Total arch replacement · CABG · Proximal first approach · In-hospital mortality · Morbidity

Introduction

Currently, the overall hospital mortality after total arch replacement (TAR) has been declining even among elderly patients because of the improvement in surgical techniques, postoperative intensive care, and sealing grafts used in aortic

arch surgery [1]. However, some subgroups may be at an increased surgical risk because of preoperative comorbidity, particularly patients with significant coronary artery disease (CAD).

Generally, the concomitant coronary artery bypass grafting (CABG) in the TAR has been considered a risk factor for adverse outcome because of prolonged myocardial ischemia and cardiopulmonary bypass (CPB) time [2]. On the other hand, some studies have reported that no significant difference in mortality and morbidity between TAR with CABG and that without [3, 4]. Nevertheless, as the reports that focused on the effect of concomitant CABG are few, whether concomitant CABG is a risk factor for an adverse TAR outcome remains unclear. The purpose of this study was to review the clinical characteristics of patients undergoing elective TAR with or without CABG, and to analyze the influence of concomitant CABG on surgical outcome.

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Materials and methods

Study population

This single-center retrospective study was approved by our institutional review board, and informed consent for surgery was obtained from all patients. Between October 2008 and December 2016, 168 consecutive patients underwent TAR with brain protection. From this cohort, we reviewed 157 patients (mean age 70.9 ± 12.0 years) who had elective TAR via median sternotomy alone or median sternotomy concomitant with left thoracotomy. Patients who underwent emergent surgery (acute aortic dissection or aortic aneurysm rupture) and TAR with other valve (aortic and/or mitral valve) surgery were excluded from this study. Conversely, patients who underwent TAR with the frozen elephant trunk technique or TAR with aortic root replacement (Bentall procedure) were included in this study. Preoperative invasive coronary angiography or multidetector-row computed tomography (CT) was performed in all patients. On the other hand, ischemic tests (scintigraphy, magnetic resonance imaging, or dobutamine stress echocardiography) were not routinely performed before surgery. In patients with significant coronary artery stenosis ($>75\%$ in major branches or $>50\%$ in the left main trunk), CABG was considered even in those who were asymptomatic.

We divided the 157 patients into two groups according to CABG status: 38 (24.2%) underwent TAR with CABG (group 1) and 119 (75.8%) underwent TAR without CABG (group 2). We evaluated the early surgical outcomes of the two groups.

Surgical procedures (Fig. 1)

All patients underwent elective TAR, which was performed by a single surgeon (Y.T.) with a significant experience in cardiovascular surgery.

The arterial perfusion sites were bilateral axillary arteries and the unilateral femoral artery in 148 patients (94.3%), the right axillary artery and unilateral femoral artery in eight (5.1%), and the left axillary artery and unilateral femoral artery in one (0.6%). The axillary or femoral artery was used for arterial inflow, and an 8-mm Hemashield Gold vascular graft (Maedox Medicals, Inc., Oakland, NJ, USA) was interposed to perform systemic perfusion from CPB. Moreover, we used multiple arterial inflow sites to reduce the likelihood of perioperative stroke due to embolic materials by decreasing the turbulent flow during CPB [5, 6].

In all patients who underwent TAR, the proximal first approach was employed to reduce myocardial ischemia during surgery. Selective antegrade cerebral perfusion (SACP) was

performed for adjunctive brain protection. For a single-stage extended aortic arch repair, the L-incision approach [7] or combined median sternotomy and left posterior thoracotomy were applied for TAR.

Details of arch replacement with hypothermic circulatory arrest (HCA) and SACP have been published previously [8]. After CPB was established with bicaval drainage, left ventricular venting and systemic cooling were initiated (Fig. 1a). The proximal anastomosis with a four-branched arch graft was performed during cardiac arrest using antegrade and retrograde cardioplegia after cross-clamping of the ascending aorta. When aortic root surgery or CABG was needed, we first performed the procedures during systemic cooling after cross-clamping of the ascending aorta. Immediately after the proximal anastomosis of the prosthetic graft, the heart was reperfused from one branch of the prosthetic graft. When the rectal temperature was approximately $25\text{--}28\text{ }^{\circ}\text{C}$, circulatory arrest of the lower body and SACP were performed (Fig. 1b). Open distal anastomosis using the elephant trunk technique was performed during moderate HCA and SACP, which was followed by systemic reperfusion through the femoral artery (Fig. 1c). In the cases of TAR with the frozen elephant trunk procedure, the J Graft Open Stent Graft or J Graft FROZENIX (Japan Lifeline, Tokyo, Japan) was implanted into the descending aorta. In most instances, cerebral perfusion, which was maintained at a perfusion rate of $10\text{--}20\text{ mL/kg/min}$ and a mean perfusion pressure at $40\text{--}70\text{ mmHg}$, was achieved by cannulation of the left common carotid artery and inflow via synthetic grafts of the bilateral axillary arteries. In patients without axillary artery inflow, cerebral perfusion was achieved by selective cannulation of the brachiocephalic, left common carotid, and left subclavian arteries. Moreover, during coronary and systemic reperfusion, anastomosis between the proximal and distal grafts was performed. Thereafter, arch vessel's reconstruction was performed during systemic rewarming (Fig. 1d). After the repair was completed, the patient was warmed to $36\text{ }^{\circ}\text{C}$ (rectal temperature) and weaned from CPB. Cardiac de-airing was carefully performed with transesophageal echocardiography before CPB termination.

Graft arrangement in CABG

Distal anastomoses of the saphenous vein (SV) graft or in situ graft using left internal thoracic artery (LITA) were performed during systemic cooling after cross-clamping of the ascending aorta. The SV was preferentially used for myocardial revascularization so that coronary reperfusion can be started immediately after completion of proximal anastomosis of the aorta, followed by proximal anastomosis of the SV graft on the prosthesis.

Fig. 1 Diagram of the perfusion strategy adopted during the surgery. AxA, axillary artery; CCA, common carotid artery; Lt., left; LV, left ventricle; RA, right atrium; Rt., right. Cross marks show the clamping site of the vessel or perfusion tube

Definition of clinical parameters

CAD was defined as > 50% stenosis of the left main trunk and > 75% stenosis of the 3 major branches. Carotid and/or intracranial artery disease was defined as > 50% stenosis in the carotid or intracranial cerebral artery. Permanent neurological deficit was defined as the presence of either focal (stroke) or global (coma) neurological deficits, including cerebral stroke, that persisted after discharge from the hospital [9]. Permanent neurological deficit due to spinal cord ischemia was classified as paraplegia or paraparesis. Moreover, transient neurological deficit was described as the occurrence of postoperative confusion, agitation, delirium, and prolonged obtundation without any new structural abnormality observed on imaging [9]. Shaggy aorta was defined as a fragile and speculated

atheroma measuring at least 4 mm based on enhanced CT or epiaortic echocardiography in the ascending aorta or the arch, excluding the aneurysm itself [10, 11]. Perioperative myocardial infarction (PMI) was defined as a positive result for new Q waves in the electrocardiogram or a peak creatine kinase myocardial band (MB) level > 10% of the total creatine kinase [3, 4].

Statistical analysis

Data were analyzed using the statistical analysis system software JMP 12.0.1 (SAS Institute Inc., Cray, NC, USA). Categorical variables are expressed as frequencies and percentages and continuous variables as means $\pm$ standard deviations. Statistical analyses were performed with Pearson's χ^2 test or Fisher's test for categorical variables

or the Mann–Whitney U test for continuous variables. Pearson's χ^2 test or Fisher's test was applied for categorical analysis using a 2×2 contingency table. We used multivariable logistic regression analysis to determine the risk factors associated with in-hospital mortality. Clinically relevant variables with P value < 0.2 on univariate analysis were entered into the multivariate analysis. The predictive accuracy of our multivariate models was assessed using the concordance index c . P values < 0.05 were considered statistically significant.

Results

Tables 1 and 2 show the preoperative patient characteristics and surgical data, respectively. Moreover, descriptive statistics for patients who underwent TAR with (group 1) and that without (group 2) CABG are shown in Tables 1 and 2. The number of men was significantly higher in group 1 than in group 2 (87% vs. 65%, $P = 0.009$). The proportion of patients with a shaggy aorta was significantly greater in group 1 than in group 2 (34% vs. 18%, $P = 0.031$). CPB time, coronary ischemic time, HCA time, SACP time, and operation time in group 1 were significantly longer than those in group 2.

Table 3 shows the details of CAD and graft distribution in CABG. The mean number of distal coronary anastomosis was 1.5 ± 0.6 . The SV was preferentially used for revascularization, including the left anterior descending coronary (LAD) artery. The LITA was used in one (3.8%) of 26 patients

undergoing revascularization to the LAD artery; the patient showed angina symptoms preoperatively. Of 38 patients undergoing TAR concomitant with CABG, 37 (97%) were asymptomatic and nine (24%) underwent sequential bypass grafting using the SV.

The early surgical outcome is shown in Table 4. Overall 30-day mortality, in-hospital mortality, and the occurrence of PMI were 3.2% ($n = 5$; group 1/group 2: 1/4), 3.8% ($n = 6$; 2/4), and 1.3% ($n = 2$; 0/2), respectively. However, no significant differences in 30-day mortality, in-hospital mortality, and the occurrence of PMI between groups 1 and 2 were found (2.6% vs. 3.4%, $P = 1.000$; 5.3% vs. 3.4%, $P = 0.633$; 0% vs. 1.7%, $P = 1.000$, respectively). The causes of in-hospital mortality were pulmonary failure in two patients (group 1/group 2: 0/2), PMI in one (0/1), non-occlusive mesenteric ischemia in one (1/0), multiple systemic embolization in one (0/1), and circulatory collapse due to kinking of the graft used for frozen elephant trunk in one (1/0). The etiology of PMI was inadequate preoperative coronary artery evaluation. Postoperative creatine kinase MB isozyme in group 1 was comparable with that in group 2 (60.3 ± 41.2 IU/L vs. 54.9 ± 60.4 IU/L, $P = 0.148$). Postoperative multidetector-row CT was performed to assess graft patency in 36 (95%) undergoing TAR with CABG. The overall graft patency was 100%. Both groups had similar postoperative neurological complications (permanent neurological deficit: 5.4% vs. 3.4%, $P = 0.628$; paraplegia or paraparesis: 2.6% vs. 2.5%, $P = 1.000$; transient neurological deficit: 13.5% vs. 12.6%, $P = 1.000$). Conversely, the patients in group 1 had a

Table 1 Comparison of patient characteristics between TAR with and TAR without CABG

Variables	Overall ($n = 157$)	With CABG ($n = 38$)	Without CABG ($n = 119$)	P With vs. without
Age (SD)	71 (12)	69 (12)	71 (12)	0.089
Male (%)	110 (70)	33 (87)	77 (65)	0.009
Obesity (body mass index > 26) (%)	24 (15)	5 (13)	19 (16)	0.799
Diabetes mellitus (%)	23 (15)	7 (18)	16 (13)	0.450
Chronic renal dysfunction (serum creatinine > 2.0 mg/dL) (%)	9 (6)	4 (11)	5 (4)	0.221
COPD ($FEV_{1.0}\%$ $< 60\%$ and/or prednisolone use) (%)	36 (23)	7 (18)	29 (24)	0.448
Previous cerebrovascular accident (%)	40 (25)	10 (26)	30 (25)	0.892
CIAD	40 (25)	12 (32)	28 (24)	0.322
Peripheral arterial disease (ankle brachial index ≤ 0.8) (%)	37 (24)	13 (34)	24 (20)	0.076
EF (SD), %	68 (7)	66 (8)	68 (7)	0.387
Shaggy aorta (%)	34 (22)	13 (34)	21 (18)	0.031
Type of aneurysm (%)				0.556
Atherosclerotic (%)	114 (73)	29 (76)	85 (71)	
Chronic aortic dissection (%)	43 (27)	9 (24)	34 (29)	

Data are presented as mean $\pm$ standard deviation or number (percentage)

CABG, coronary artery bypass grafting; CIAD, carotid and/or intracranial artery disease; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; $FEV_{1.0}\%$, forced expiratory volume 1-s percent; SD, standard deviation; TAR, total arch replacement

Table 2 Comparison of surgical data between TAR with and TAR without CABG

Variables	Overall (<i>n</i> = 157)	With CABG (<i>n</i> = 38)	Without CABG (<i>n</i> = 119)	<i>P</i> With vs. without
Previous cardiac surgery via median sternotomy (%)	6 (4)	2 (5)	4 (3)	0.633
Concomitant procedures (aortic root operation) (%)	5 (3)	1 (3)	4 (3)	1.000
Extended aortic repair through L-incision or combined median sternotomy and left posterior lateral thoracotomy (%)	16 (10)	5 (13)	11 (9)	0.540
Frozen elephant trunk technique (%)	14 (9)	4 (11)	10 (8)	0.745
CPB time (SD), min	290 (49)	336 (52)	276 (38)	<0.0001
Coronary ischemic time (SD), min	64 (28)	92 (21)	56 (24)	<0.0001
HCA time (SD), min	67 (15)	73 (14)	65 (14)	0.0009
SACP time (SD), min	161 (33)	174 (37)	157 (31)	0.016
Lowest rectal temperature (SD), °C	26.0 (4.3)	25.5 (1.4)	26.1 (4.9)	0.270
Operation time (SD), min	639 (107)	702 (122)	619 (94)	<0.0001

Data are presented as mean ± standard deviation or number (percentage)

CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; HCA, hypothermic circulatory arrest; SACP, selective antegrade cerebral perfusion; SD, standard deviation; TAR, total arch replacement

significantly more prolonged ventilation time than those in group 2 (29% vs. 14%, $P = 0.03$). Moreover, group 1 tended to include higher proportions of patients with postoperative hemodialysis than group 2 (16% vs. 7%, $P = 0.09$).

Table 5 shows the univariate and multivariate analyses for in-hospital mortality. In the multivariate analysis, age (odds ratio, 1.208; 95% confidence interval, 1.041–1.497, $P =$

0.008) and CPB time (odds ratio, 1.019; 95% confidence interval, 1.001–1.041; $P = 0.041$) were significant determinants of in-hospital mortality, whereas concomitant CABG was not a risk factor for in-hospital mortality.

Discussion

In the current study, TAR with CABG could be safely performed with favorable surgical outcomes. Moreover, the early postoperative patency rates of CABGs were excellent.

The number of patients with preoperative comorbidities, such as respiratory dysfunction, chronic kidney disease, and systemic severe atherosclerosis, undergoing TAR has increased with the aging of the society, and CABG in conjunction with TAR tends to be performed more frequently [1, 3, 4]. Ehrlich et al. described that concomitant CABG is a predictor of adverse outcome in patients undergoing elective open aortic arch surgery [2]. Nevertheless, surgical outcomes improved over the past decade because of recent advances in brain protection, surgical techniques, anesthesia, and critical care [1]. Given the discrepancies in the literature, the effect of procedures concomitant with elective TAR has not been well documented.

TAR with CABG has been considered inevitable; however, it is associated with prolonged coronary ischemia and CPB time, which may be significant risk factors for adverse outcome in open aortic arch surgery [2]. To minimize the coronary ischemic time, several techniques, such as distal coronary artery anastomosis on the perfused fibrillating heart, off-pump CABG following TAR with SACP, and coronary artery perfusion through a cardioplegic line during aortic arch repair, have been employed [12, 13]. Yokoyama et al. reported that

Table 3 Details of coronary artery disease and CABG

Variables	Number
Coronary artery disease (%)	
One-vessel disease	16 (42)
Two-vessel disease	11 (29)
Three-vessel disease	5 (13)
Left main trunk	5 (13)
Others	1 (3)
Number of distal anastomosis (SD)	1.5 (0.6)
CABG, target vessels (<i>n</i> = 57)	
LAD	26 (46)
Dx	6 (10)
Cx	12 (21)
RCA	13 (23)
Type of conduits	
LITA + SVG	1 (3)
SVG	37 (97)
Sequential anastomosis	9 (24)

Data are presented as mean ± standard deviation or number (percentage)

CABG, coronary artery bypass grafting; Cx, circumflex artery; Dx, diagonal artery; LAD, left anterior descending artery; LITA, left internal thoracic artery; RCA, right coronary artery; SD, standard deviation; SVG, saphenous vein graft

Table 4 Surgical outcomes

Variables	Total (n = 157)	With CABG (n = 38)	Without CABG (n = 119)	P With vs. without
In-hospital mortality (%)	6 (3.8)	2 (5.3)	4 (3.4)	0.633
30-day mortality (%)	5 (3.2)	1 (2.6)	4 (3.4)	1.000
Postoperative maximum CK-MB (SD), IU/L	56.2 (56.3)	60.3 (41.2)	54.9 (60.4)	0.148
PND (%)	6 (3.9)	2 (5.4)	4 (3.4)	0.628
Paraplegia or paraparesis	4 (2.6)	1 (2.6)	3 (2.5)	1.000
TND (%)	20 (12.8)	5 (13.5)	15 (12.6)	1.000
Reoperation for bleeding (%)	8 (5.1)	2 (5.3)	6 (5.0)	1.000
PMI (%)	2 (1.3)	0 (0)	2 (1.7)	1.000
PCPS	3 (1.9)	0 (0)	3 (2.5)	1.000
Required hemodialysis	14 (8.9)	6 (15.8)	8 (6.7)	0.088
Mediastinitis	1 (0.6)	1 (2.6)	0 (0)	0.242
Prolonged ventilation (> 48 h)	27 (17.2)	11 (29.0)	16 (13.5)	0.028

Data are presented as mean $\pm$ standard deviation or number (percentage)

CABG, coronary artery bypass grafting; CK-MB, creatine kinase MB; PCPS, percutaneous cardiopulmonary support; PMI, perioperative myocardial infarction; PND, permanent neurological deficit; SD, standard deviation; TND, transient neurological deficit

off-pump CABG could minimize coronary ischemic time, thereby decreasing the risk of postoperative myocardial failure [13]. However, such an approach somewhat increases the

complexity of the intervention. In our study, distal anastomosis of coronary vessels, which was followed by proximal anastomosis of the prosthetic graft, was performed during systemic

Table 5 Risk factors for in-hospital mortality in univariate and multivariate analyses

Variables	Univariate		Multivariate: c-index 0.952	
	OR (95% CI)	P	OR (95% CI)	P
Age, years	1.226 (1.062–1.490)	0.002	1.208 (1.041–1.497)	0.008
Male	1.178 (0.160–6.279)	0.854		
Chronic renal dysfunction	3.575 (0.176–26.006)	0.328		
COPD	1.509 (0.233–29.396)	0.700		
Previous cerebrovascular accident	3.081 (0.550–17.276)	0.189	1.022 (0.117–7.369)	0.983
CIAD	1.487 (0.200–7.934)	0.662		
Peripheral arterial disease	1.657 (0.223–8.864)	0.580		
EF	1.125 (0.993–1.290)	0.066	1.104 (0.974–1.286)	0.128
Shaggy aorta	1.859 (0.250–9.975)	0.501		
Atherosclerotic aneurysm	1.341 (0.181–7.144)	0.744		
Previous cardiac surgery via median sternotomy	5.840 (0.278–46.838)	0.203		
Concomitant procedure (CABG)	1.597 (0.215–8.536)	0.607		
Extended aortic repair through L-incision or combined median sternotomy and left posterior lateral thoracotomy	1.813 (0.092–12.273)	0.620		
Frozen elephant trunk technique	2.123 (0.107–14.548)	0.538		
CPB time, min	1.013 (0.998–1.027)	0.085	1.019 (1.001–1.041)	0.041
Coronary ischemic time, min	1.004 (0.971–1.025)	0.772		
HCA time, min	1.027 (0.972–1.084)	0.331		
SACP time, min	1.003 (0.979–1.026)	0.794		
Lowest rectal temperature, °C	0.721 (0.336–1.080)	0.273		
Operation time, min	1.001 (0.993–1.008)	0.855		

CABG, coronary artery bypass grafting; CI, confidence interval; CIAD, carotid and/or intracranial artery disease; COPD, chronic obstructive pulmonary disease; CPB, cardiopulmonary bypass; EF, ejection fraction; HCA, hypothermic circulatory arrest; OR, odds ratio; SACP, selective antegrade cerebral perfusion

cooling after cross-clamping of the ascending aorta. Moreover, because of the proactive use of the SV graft, coronary reperfusion could be performed from one branch of the prosthetic graft immediately after the proximal anastomosis of the bypass graft to the prosthetic graft.

The graft design in concomitant CABG is vital. The LITA–LAD artery grafting has been the gold standard in isolated CABG, and patients with the LITA–LAD artery grafting are associated with improved long-term survival compared with those who received SV graft only for aortic valve replacement [14]. In our study, we preferred free graft for the following reasons: (1) coronary reperfusion could be performed immediately after proximal reconstruction of the aortic arch and CABG; (2) the use of internal thoracic artery or gastroepiploic artery with a small caliber may result in hypoperfusion and vasospasm under the circumstances of excessive bleeding [12]; and (3) sequential bypass grafting using SV graft or radial artery could reduce coronary ischemic time and CPB time. Moreover, 37 (97%) of 38 patients undergoing TAR with CABG had asymptomatic CAD, and CAD in these patients was accidentally discovered during preoperative evaluation using coronary angiography. When patients with symptoms of angina have CAD, including the LAD artery, the internal thoracic artery should be used for revascularization of the LAD artery. Proximal first approach with CABG using free grafts may be useful to reduce myocardial ischemic time during the operative procedure. However, the long-term outcome of patients undergoing CABG using SV grafts in aortic arch surgery remains unclear. Hence, further studies evaluating the midterm- or long-term outcome of these patients are warranted.

Kazui et al. performed a multivariate analysis and reported that a CPB time > 300 min is an independent determinant of in-hospital mortality in TAR with SACP [15]. In our study, 55 (35%) of the patients had a CPB time > 300 min, and CPB time was a significant determinant of in-hospital mortality. Moreover, a CPB time > 300 min in patients undergoing TAR with CABG was observed in 27 (71%) of 38 patients (group 1 vs. group 2: 71% vs. 24%, respectively; $P < 0.001$). On the other hand, in-hospital mortality in patients who underwent TAR with CABG was comparable with those who did not undergo the procedures. The numbers of patients and adverse events were small; therefore, this study might not have had enough power to detect any increase in risk caused by the addition of CABG to TAR. Longer CPB time in patients undergoing TAR with CABG was attributed not only to prolonged coronary ischemic time but also to longer HCA and SACP times. Because patients undergoing TAR with CABG presented with shaggy aorta more often, a greater amount of time might be required for surgery to avoid dislodging the debris in such an aorta. In addition, the incidence of postoperative complications was higher in patients undergoing TAR with CABG. Elaborate surgical strategy and greater care are

needed in patients with multiple risk factors. Cardiac surgeons must determine how CPB time and coronary ischemic time can be reduced to maximize the benefits of the CABG procedure. In the present study, distal anastomosis was performed during core cooling, and coronary circulation was restarted just after proximal anastomosis of the prosthetic graft using the proximal first approach. Hence, this approach may be useful in shortening the coronary ischemic time.

A previous study on thoracic aortic disease with CAD using the Japanese national registry database reported an approximately twofold increase in operative mortality and the incidence of major complications when aortic surgery alone was performed for significant coronary stenosis [16]. The patient who died because of PMI in our study underwent preoperative multidetector-row CT alone. In multidetector-row CT, severe coronary calcification is an obstacle for an accurate assessment of the coronary arterial anatomy [17]. Since we experienced this case, invasive coronary angiography has become a routine preoperative coronary artery screening method. Before aortic arch surgery, an elaborate coronary artery evaluation is necessary.

Limitations

This study has several limitations. First, this is a retrospective study from a single center, and the study is statistically limited because of the small number of patients enrolled. Especially, because of the few adverse events in this study, it remains unclear whether the proximal first approach could reduce the operative risk. Second, because all patients with CAD underwent concomitant CABG, a comparison between patients who underwent CABG and those who did not undergo CABG could not be performed. Third, little is known regarding the difference in long-term survival between LITA–LAD bypass and SVG–LAD bypass in patients undergoing elective TAR concomitant with CABG. Hence, further studies to clarify the long-term outcome are needed.

Conclusions

TAR with or without CABG could be accomplished with an acceptable surgical outcome. Because patients undergoing TAR with CABG have more preoperative comorbidities, a carefully constructed surgical strategy is crucial.

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Data analysis/interpretation: KI

Drafting article: KI

Critical revision of article: YT, SM, AS

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Statistics: KI

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict interest.

Ethics approval This study complies with the principles of the Declaration of Helsinki and was approved by the institutional ethics committee.

Consent to participate Informed consent was obtained from all patients included in this study.

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