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Article

Perioperative Outcomes of Coronary Artery Bypass Grafting in Acute Type A Aortic Dissection

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Abstract

Background: This study aimed to evaluate the perioperative outcomes of concomitant coronary artery bypass grafting (CABG) in patients undergoing surgical repair for acute type A aortic dissection (ATAAD) and to assess the impact of CABG on mortality and complications. **Methods**: A retrospective analysis was conducted on 1198 ATAAD patients who underwent surgical treatment at our center between January 2016 and December 2022. Patients were categorized into CABG and non-CABG groups. Preoperative characteristics, surgical data, and perioperative outcomes were collected and analyzed. **Results**: A total of 1198 patients underwent surgical treatment in this study, of whom 979 (81.7%) were male. The mean age was 51.7 ± 11.5 years. Among these patients, 91 (7.6%) underwent concomitant CABG. Patients in the CABG group had significantly higher incidences of chronic coronary artery disease (58.2% vs. 22.6%, $p < 0.001$), acute myocardial infarction (59.3% vs. 9.5%, $p < 0.001$), and neurological events (28.6% vs. 18.2%, $p = 0.016$) compared to the non-CABG group before surgery. Among all patients who underwent surgical treatment, 96 (8.0%) experienced perioperative death. The perioperative mortality rate was significantly higher in the CABG group (39.6% vs. 5.4%, $p < 0.001$). Patients in the CABG group also had higher rates of postoperative complications, including heart failure, neurological events, continuous renal replacement therapy (CRRT), re-exploration for bleeding, multiple organ dysfunction syndrome (MODS), and need for extracorporeal membrane oxygenation (ECMO) support (all p-values < 0.001). Compared to patients without concomitant CABG, those undergoing CABG had a much higher rate of mortality (Odds Ratio = 2.729, 95% CI = 1.282–5.812, $p = 0.009$). **Conclusions**: Concomitant CABG in ATAAD patients was significantly associated with higher perioperative mortality and complication rates.

Keywords

coronary artery bypass grafting; acute type A aortic dissection; perioperative outcomes; surgical therapy

Introduction

Acute type A aortic dissection (ATAAD) is a life-threatening surgical emergency with a high mortality rate, presenting one of the greatest challenges for cardiac surgeons. Without timely intervention, mortality can approach nearly 100% [1]. Approximately 10%–20% of ATAAD patients have concomitant coronary artery involvement [2,3]. Despite significant advancements in the surgical management of ATAAD, the treatment of these patients remains complex, and clinical outcomes are often suboptimal [4,5]. While some studies have explored the impact of coronary artery involvement on ATAAD repair outcomes, the specific effect of concomitant coronary artery bypass grafting (CABG) on the prognosis of ATAAD patients remains underexplored. Therefore, this study aims to analyze the clinical data of ATAAD patients undergoing concomitant CABG to assess its impact on patient prognosis.

Methods

Patients

This study included ATAAD patients who underwent surgical treatment at our center from January 2016 to December 2022. Patients were categorized into the CABG and non-CABG groups based on whether they underwent concomitant CABG. Preoperative baseline characteristics, surgical data, and perioperative outcomes were collected and analyzed for all patients.

Surgical Techniques

All surgeries were performed via median sternotomy. Depending on the extent of the aortic dissection, arterial cannulation was performed through the right axillary artery, femoral artery, or directly into the aortic arch. Cold blood cardioplegia was used to achieve myocardial arrest, employing either antegrade or retrograde perfusion techniques. During aortic arch surgery, deep hypothermic circulatory arrest (23 °C–25 °C) combined with selective cerebral perfusion was employed to ensure adequate cerebral protection.

After achieving satisfactory cardiac arrest, we initially assessed the condition of the aortic root and coronary ostia. Coronary artery involvement was evaluated according to the Neri classification system [6]. Neri A is characterized by dissection involving the coronary ostium, Neri B by dissection extending into the coronary main trunk, and Neri C by circumferential detachment or complete avulsion of the coronary intima. For patients with Neri A or B, coronary ostial repair was prioritized. In cases of Neri C, the affected coronary ostium was excluded, and CABG was performed using the great saphenous vein.

For patients without intimal tears in the aortic root, our center employs the technique of reinforcing the intima at the sinotubular junction with trimmed bovine pericardial strips, followed by ascending aorta replacement. For those with irreparable aortic root, root replacement was performed using either the David or Bentall procedure. The aortic valve procedure typically involved two approaches: suspension of the commissures to repair prolapsed leaflets or aortic valve replacement. Based on the extent of the dissection, the aortic arch was treated with either partial or total arch replacement combined with the implantation of a stented elephant trunk in the descending aorta [7]. Reconstruction of the aortic arch branches was performed using a four-branch Dacron graft.

Outcomes and Definitions

The primary endpoint was perioperative mortality, defined as any death occurring before final discharge or within 30 days postoperatively, as per the Society of Thoracic Surgeons. Heart failure was characterized by substantial evidence of impaired cardiac contractility in the postoperative period, including a marked reduction in left ventricular ejection fraction (LVEF), hemodynamic instability, the requirement for high-dose vasopressor support, and overt clinical signs of heart failure. Acute myocardial infarction and chronic coronary artery disease were differentiated based on the patient's history, symptoms, electrocardiogram findings, and myocardial enzyme levels. Neurological events were defined as newly developed, significant cerebral ischemia and hypoxia after surgery, with clinical manifestations such as impaired consciousness, hemiplegia, or paraplegia.

Statistical Analysis

Statistical analysis was performed using SPSS version 24.0 (IBM Corp., Chicago, IL, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median, depending on whether they followed a normal distribution. Categorical variables were presented as numbers (percentages). Comparisons of continuous variables with a normal distribution were performed using the independent sample *t*-test, while the Mann-Whitney U test was used for non-normally distributed continuous variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. To identify risk factors for perioperative mortality, binary logistic regression analysis was employed. The dependent variable was in-hospital mortality. Independent variables were selected based on literature and clinical relevance, including age, sex, preoperative comorbidities, cardiopulmonary bypass (CPB) time, cross-clamp time, selective cerebral perfusion time, aortic root procedures, and the need for concomitant CABG. Initially, univariate logistic regression analysis was conducted. Variables with $p < 0.05$ in the univariate analysis were included in the multivariate logistic regression analysis. A p-value of <0.05 was considered statistically significant.

Results

Baseline Characteristics

A total of 1198 patients were included in this study, of whom 979 (81.7%) were male. The mean age was 51.7 $\pm$ 11.5 years. Ninety-one patients underwent concomitant CABG. Compared with patients in the non-CABG group, the incidence of chronic coronary artery disease (53/91, 58.2% vs. 250/1107, 22.6%, $p < 0.001$), preoperative acute myocardial infarction (54/91, 59.3% vs. 105/1107, 9.5%, $p < 0.001$), and neurological events (26/91, 28.6% vs. 202/1107, 18.2%, $p = 0.016$) was significantly higher in the CABG group. According to preoperative transthoracic echocardiography findings, the degree of aortic regurgitation was significantly higher in the CABG group compared to the non-CABG group ($p = 0.004$). The baseline characteristics of patients in the CABG and non-CABG groups are summarized in Table 1.

Operative Data

A total of 1198 patients underwent surgical treatment. The cardiopulmonary bypass (CPB) time was 246.3 $\pm$ 72.3 min, the aortic cross-clamp time was 132.0 $\pm$ 43.1 min, and the selective cerebral perfusion time was 18.6 $\pm$ 9.2 min. A total of 388 patients (32.4%) underwent aortic root replacement, while the remaining patients underwent aortic root repair. The majority of patients (90.3%) received total aortic arch replacement. In the CABG group, cardiopulmonary

Table 1. Baseline characteristics of ATAAD Patients.

Variable	CABG group (n = 91)	non-CABG group (n = 1107)	p value
Age, year	52.4 ± 9.9	51.4 ± 11.6	0.102
Male	77.0 (84.6%)	902.0 (81.5%)	0.457
BMI, kg/m^2	24.6 ± 3.5	24.7 ± 4.0	0.831
Hypertension	65.0 (71.4%)	722.0 (65.2%)	0.235
Diabetes mellitus	5.0 (5.5%)	50.0 (4.5%)	0.668
COPD	13.0 (14.3%)	123.0 (11.1%)	0.341
Chronic CAD	53.0 (58.2%)	250.0 (22.6%)	<0.001
Renal failure	4.0 (4.4%)	51.0 (4.6%)	0.926
Cardiac tamponade	11.0 (12.1%)	118.0 (10.7%)	0.673
Acute myocardial infarction	54.0 (59.3%)	105.0 (9.5%)	<0.001
Neurological events	26.0 (28.6%)	202.0 (18.2%)	0.016
Maximal AAo diameter, mm	50.9 ± 8.0	49.6 ± 10.0	0.253
Degree of aortic regurgitation			0.004
None	31.0 (34.0%)	608.0 (54.9%)	
Mild	43.0 (47.3%)	374.0 (33.8%)	
Moderate	7.0 (7.7%)	55.0 (5.0%)	
Severe	10.0 (11.0%)	70.0 (6.3%)	

Number of patients with percentage, mean ± SD or median.

CABG, Coronary artery bypass graft; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; AAo, ascending aorta; ATAAD, acute type A aortic dissection.

bypass time (374.2 ± 122.2 vs. 235.8 ± 54.6, $p < 0.001$), aortic cross-clamp time (189.7 ± 53.8 vs. 127.3 ± 38.4, $p < 0.001$), selective cerebral perfusion time (20.9 ± 10.3 vs. 18.4 ± 9.1, $p = 0.015$), operation time (632.0 ± 189.1 vs. 443.9 ± 89.7, $p < 0.001$), and the frequency of aortic root replacement (55/91, 60.4% vs. 333/1107, 30.1%, $p < 0.001$) were significantly higher compared to the non-CABG group. In the CABG group, 72 patients (79.1%) received a single bypass graft, while the remaining patients required multiple grafts. The most frequently grafted vessel was the right coronary artery (67.0%). The indication for CABG in 53 patients (58.2%) was coronary artery dissection, with other indications including primary coronary artery disease (19/91, 20.8%), cardiac dysfunction after CPB (13/91, 14.3%), and new-onset aortic root bleeding or hematoma following cardiac resuscitation (6/91, 6.6%). Operative data for the two groups are summarized in Table 2.

Perioperative Mortality and Complications

As shown in Table 3, a total of 96 patients (8.0%) died among all those who underwent surgery, including 36 patients (30.9%) in the CABG group and 60 patients (5.4%) in the non-CABG group ($p < 0.001$). Compared to the non-CABG group, patients in the CABG group had significantly higher rates of heart failure (44/91, 48.4% vs. 130/1107, 11.7%, $p < 0.001$), neurological events (37/91, 40.7% vs. 103/1107, 9.3%, $p < 0.001$), continuous renal replacement therapy (CRRT) (39/91, 42.9% vs. 227/1107, 20.5%, $p < 0.001$), re-exploration for bleeding (27/91, 29.7% vs. 71/1107, 6.4%, $p < 0.001$), multiple organ dysfunction syndrome (MODS) (32/91, 35.2% vs. 73/1107, 6.6%, $p < 0.001$), and extracorporeal membrane oxygenation (ECMO) support (17/91, 18.7% vs. 31/1107, 2.8%, $p < 0.001$). Patients who underwent concomitant CABG also had significantly longer ICU stay times (10.0 days vs. 7.0 days, $p = 0.003$) and mechanical ventilation times (132.0 hours vs. 89.0 hours, $p = 0.001$) compared to those who underwent aortic replacement alone.

After univariate logistic regression analysis, the need for concomitant CABG, CPB time, cross-clamp time, selective cerebral perfusion time, chronic CAD, acute myocardial infarction, and preoperative renal failure were included in the multivariate logistic regression analysis (Table 4). The results demonstrated that patients with ATAAD who underwent concomitant CABG had nearly three times the risk of mortality compared to other patients (Odds Ratio = 2.729, 95% CI = 1.282–5.812, $p = 0.009$).

Discussion

This study reviewed the data of ATAAD patients who underwent surgical treatment at our center. The results showed that concomitant CABG was associated with a higher perioperative mortality rate. In the CABG group, the perioperative mortality was 39.6%, comparable to other reports [8–10], while in the non-CABG group, this rate was only 5.4%. In most published studies, this high mortality rate is related to preoperative myocardial malperfusion. Although the incidence of preoperative acute myocardial infarction was significantly higher in the CABG group, our

Table 2. Intraoperative data of ATAAD patients.

Variable	CABG group (n = 91)	non-CABG group (n = 1107)	p value
CPB time, min	374.2 ± 122.2	235.8 ± 54.6	<0.001
Cross-clamp time, min	189.7 ± 53.8	127.3 ± 38.4	<0.001
Operation time, min	632.0 ± 189.1	443.9 ± 89.7	<0.001
Selective cerebral perfusion			0.475
Right unilateral ACP	48.0 (52.7%)	504.0 (45.5%)	
Left unilateral ACP	15.0 (16.5%)	181.0 (16.4%)	
Bilateral ACP	26.0 (28.6%)	403.0 (36.4%)	
Retrograde cerebral perfusion	2.0 (2.2%)	19.0 (1.7%)	
Cerebral perfusion time, min	20.9 ± 10.3	18.4 ± 9.1	0.015
Hypothermia, °C	23.6 ± 2.5	23.8 ± 3.1	0.626
Aortic root procedure			<0.001
Repair	36.0 (39.6%)	774.0 (69.9%)	
Replacement	55.0 (60.4%)	333.0 (30.1%)	
Total arch replacement	85.0 (93.4%)	997.0 (90.1%)	0.379
Graft number			
CABG×1	72 (79.1%)	-	
CABG×2	17 (18.7%)	-	
CABG×3	2 (2.2%)	-	
Graft location			
RCA only	61 (67.0%)	-	
LCA only	17 (18.7%)	-	
both RCA and LCA	13 (14.3%)	-	
Indications for CABG			
Coronary artery dissection	53 (58.2%)	-	
Native CAD	19 (20.8%)	-	
Heart failure	13 (14.3%)	-	
Aortic root bleeding or hematoma	6 (6.6%)	-	

Number of patients with percentage, mean ± SD or median.

CABG, Coronary artery bypass graft; CPB, cardiopulmonary bypass; ACP, antegrade cerebral perfusion; RCA, right coronary artery; LCA, left coronary artery; CAD, coronary artery disease.

regression model did not demonstrate this association. The complexity of the CABG procedure undoubtedly increases CPB time and associated risks. Our findings indicated that longer CPB time correlated with perioperative mortality. Additionally, Morjan *et al.* [11] reported that prolonged aortic cross-clamp time also influences in-hospital mortality; however, we did not observe this association in our regression analysis.

We reported an incidence of concomitant CABG of 7.6%, which is consistent with findings in the existing literature [12,13]. Most studies indicate that the primary indication for concomitant CABG is coronary artery involvement. In our study, 58.2% of patients underwent CABG due to coronary artery involvement, with the majority involving the right coronary artery, which aligns with current reports [3,6,14]. However, whether to perform CABG or attempt aortic root repair depends on the surgeon's experience and the extent of the dissection. As previously mentioned, our center currently uses the Neri classification system to describe the degree of coronary involvement. Most reports suggest that coronary ostial repair yields favorable outcomes for Neri A patients, while CABG is the preferred approach for Neri C patients in most centers. However, the optimal strategy for Neri B patients remains controversial. Zhang *et al.* [15] and Kawahito *et al.* [14] performed CABG on such patients but found that CABG was associated with higher in-hospital mortality. Given the increased complexity of surgery and the potential long-term risk of great saphenous graft failure, we prioritize CABG only for Neri C patients at our center. With approximately 300–400 ATAAD surgeries performed annually, based on our current experience, we believe that aortic root repair achieves satisfactory outcomes for most Neri B patients. However, this viewpoint requires further research for validation.

In this study, the indication for CABG in 19 patients was native coronary artery disease (CAD). However, diagnosing chronic CAD in ATAAD patients remains challenging. Although coronary angiography is considered the gold standard for diagnosing CAD, current studies do not recommend it as a routine examination in emergency cases

Table 3. Operative mortality and morbidity of ATAAD patients.

Variable	CABG group (n = 91)	non-CABG group (n = 1107)	*p* value
Mortality	36 (39.6)	60 (5.4%)	<0.001
Heart failure	44 (48.4%)	130 (11.7%)	<0.001
Neurological events	37 (40.7%)	103 (9.3%)	<0.001
CRRT	39 (42.9%)	227 (20.5%)	<0.001
Re-exploration for bleeding	27 (29.7%)	71 (6.4%)	<0.001
MODS	32 (35.2%)	73 (6.6%)	<0.001
ECMO	17 (18.7%)	31 (2.8%)	<0.001
ICU stay, day	10.0	7.0	0.003
Mechanical ventilation, hour	132.0	89.0	0.001

Number of patients with percentage, mean ± SD or median.
CABG, Coronary artery bypass graft; CRRT, continuous renal replacement therapy; MODS, multiple organ dysfunction syndrome; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit.

Table 4. Multivariate logistic regression analysis of perioperative mortality for ATAAD patients.

Variable	Odds Ratio	95% CI	*p* value
CABG	2.729	1.282–5.812	0.009
CPB time	1.010	1.003–1.016	0.002
Cross-clamp time	0.998	0.991–1.006	0.562
Selective cerebral perfusion time	1.001	0.971–1.032	0.981
Chronic CAD	1.266	0.715–2.243	0.418
Acute myocardial infarction	1.191	0.594–2.391	0.623
Preoperative renal failure	2.752	0.771–9.819	0.119

CABG, Coronary artery bypass graft; CPB, cardiopulmonary bypass; CAD, coronary artery disease.

due to the potential risk of aortic rupture, exacerbation of malperfusion, and delay in urgent surgery [16,17]. At our center, the diagnosis of chronic CAD primarily relies on a positive medical history, electrocardiogram (ECG) abnormalities, and ECG-gated coronary computed tomography angiography (CTA). Given the urgency of surgery, we do not routinely perform coronary CTA in patients without a clear history or positive symptoms of CAD. Moreover, due to the limitations of computed tomography (CT) imaging, even in patients with known CAD, accurate identification of the target vessel can be challenging. This undoubtedly increases the unpredictability of surgical decision-making. In this study, 13 patients underwent salvage CABG due to heart failure and failure to withdraw CPB. The decision was primarily based on changes in epicardial color, evaluation of ventricular wall motion via transesophageal echocardiography, and manual palpation of the coronary artery course. However, these methods do not guarantee diagnostic accuracy, and the salvage CABG further increased operative risks, resulting in postoperative death in 9 patients. Notably, 4 of these 13 patients were urgently transferred to a hybrid operating room for coronary angiography after obtaining informed consent from the family. The results confirmed CAD in 3 patients, while 1 patient had right coronary artery ostial stenosis due to compression. We believe that for ATAAD patients with severe preoperative coronary involvement or a history of CAD, performing surgery in a hybrid operating room may provide more intraoperative decision-making options for the surgeon.

Although the optimal surgical strategy for the aortic arch in ATAAD patients remains controversial, total aortic arch replacement (TAR) has become increasingly common with advances in surgical techniques. Current studies have shown no significant difference in perioperative mortality between hemiarch replacement and TAR [18]. In this study, a total of 1082 patients (90.3%) underwent TAR, with this proportion rising to 93.4% in patients who underwent concomitant CABG. Currently, there is a relative lack of studies on TAR with concomitant CABG. A study by Takashima *et al*. [19] found no statistically significant difference in mortality between patients who underwent TAR with concomitant CABG and those who underwent TAR alone. However, Okada *et al*. [20] reported that patients who underwent concomitant CABG had a significantly higher in-hospital mortality rate than those who underwent TAR alone. However, the populations of these two studies consisted only of patients without aortic dissection. In our study, regression analysis did not show an association between TAR and perioperative mortality in CABG patients. Further research is needed in the future.

Due to the high risks of concomitant CABG in ATAAD surgery, alternative surgical strategies or management protocols for ATAAD patients with coronary artery disease are needed. Uchida *et al*. [21] reported 25 ATAAD patients with coronary artery malperfusion. Emergent percutaneous coronary intervention (PCI) was performed in 14 patients before surgical treatment, and all these patients survived. Shigihara *et al*. [22] reported an old patient with ATAAD, acute myocardial infarction and cardiogenic shock. PCI and thoracic endovascular aortic repair under percutaneous cardiopulmonary support were performed in this patient. The patient was ultimately discharged after recovery. These reports suggest that PCI may be an alternative therapy for ATAAD patients with coronary artery malperfusion. However, due to the limited relevant literature and the small number of cases, its effectiveness still requires further research for confirmation.

Limitations

Our study has several limitations. First, this is a single-center retrospective study. Although this study includes the largest sample of ATAAD patients undergoing concomitant CABG compared to current reports, the proportion within the total cohort remains relatively limited. Additionally, its retrospective nature may introduce selective bias, affecting the validity of the findings. Second, multiple surgeons were involved in these operations, which may have introduced variability in the surgical strategy for coronary artery management. Third, due to incomplete surgical records and a lack of imaging data, we were unable to provide a detailed description of coronary artery anatomical abnormalities using the Neri classification in each patient. Fourth, due to insufficient follow-up data, the scope of this study is limited to perioperative outcomes. The mid-term and long-term survival rates and reoperation rates of these patients should be evaluated in future studies.

Conclusions

In ATAAD patients, the proportion of concomitant CABG is relatively low, but it is significantly associated with high perioperative mortality and complication rates. The primary indication for concomitant CABG is coronary artery dissection. The application of the Neri classification system can assist surgeons in making intraoperative decisions. For patients with chronic CAD, preoperative diagnostic methods remain insufficiently precise. Although failure to wean from CPB may indicate the need for salvage CABG, it remains unclear whether patients benefit from this approach.

Availability of Data and Materials

Data and materials are available through direct request to the corresponding authors.

Author Contributions

CH and JLW designed the study. JDZ, JY, GT, XLuo and KZ participated in data collection. CH performed the analysis and wrote the manuscript. TCS, RXF, CJY, XLi and ZRC carried out the surgical procedures and participated in the research design. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki. This study has been approved by the ethics committee of Guangdong Provincial Peoples' Hospital, Approval No. GDREC 2018322H (R1). Because this study is a retrospective study, the informed consent is waived.

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Conflict of Interest

The authors declare no conflict of interest.

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