**Original
Article**

Early Postoperative Outcome of Off-Pump Coronary Artery Bypass Grafting: A Report from the Highest-Volume Center in Japan

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Background: Off-pump coronary artery bypass grafting (OPCAB) has evolved into a standard technique in coronary artery bypass grafting. However, a detailed investigation in Japanese population undergoing OPCAB has not yet been fully elucidated.

Methods: A total of 1109 consecutive patients undergoing isolated OPCAB between 2006 and 2013 at Juntendo University were reviewed. The data was evaluated in the light of previously published OPCAB-associated reports.

Results: There were 904 male (81.5%) and a mean was 67.5 ± 9.8 years. Eight patients (0.5%) died within 30 days postoperatively or before discharge, which was equivalent to or rather better than the previously reported mortality rates, including the European System for Cardiac Operation Risk Evaluation II (2.1 ± 2.1) data. A morbidity analysis revealed that prolonged intubation (>24 h) occurred in 43 patients (3.6%), surgical site infections in 18 (1.9%), neurological complications in 13 (1.3%). A reduced preoperative left ventricular ejection fraction (less than 40%) was found to be a risk factor for early postoperative death (odds ratio 10.58, respectively, $p < 0.05$) in our cohort.

Conclusions: Early postoperative mortality and morbidity rates in Japanese population after OPCAB were rather satisfactory and similar to those reported by other countries.

Keywords: off-pump coronary artery bypass grafting, Japanese population, outcome

Introduction

Ischemic heart disease (IHD) is a major cause of death worldwide, and is responsible for about one-third or more of all deaths in individuals older than 35 years.^{1,2)}

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Coronary artery bypass grafting (CABG) is a standard treatment option for patients with coronary artery disease. The indication for CABG is considered to be dependent on multiple factors.³⁾ In particular, CABG is generally preferred for patients with relatively broad lesions at risk of ischemia, with an unprotected left main trunk or/and diffuse three-vessel disease. According to an annual report by the Japanese Association for Thoracic Surgery, more than 15000 CABG procedures have been performed over the past few years in Japan.⁴⁾ CABG is usually performed with the use of cardiopulmonary bypass (CPB), the so-called on-pump beating CABG (ONCAB). The use of CPB requires cannulation to the aorta, which may increase the risk of stroke especially in patients with calcified or atherosclerotic ascending aorta. Furthermore, CPB may cause hemodynamic alteration

Fig. 1 The changes in a proportion of OPCAB in total CABG cases in the US (above) and in Japan (below) by era. The data was obtained from reports in the Japanese Associate for Coronary Artery Surgery⁴⁾ and the Society of Thoracic Surgeons Adult Cardiac Surgery,⁹⁾ and reconstructed. The OPCAB case in 2012 in the US was about 17%, whereas it was 65% in 2013 in Japan. OPCAB: off-pump coronary artery bypass grafting; CABG: coronary artery bypass grafting

and cytokine release.⁵⁾ In contrast, off-pump (i.e., without CPB on the beating heart) coronary artery bypass (OPCAB) prevents such adverse effects associated with CPB, although it should be performed by an experienced surgeon. According to the multiple advantages of OPCAB over ONCAB in addition to the recent advances in surgical devices such as the stabilization system of targeted vessels, OPCAB has evolved into a standard technique.⁶⁾ Especially in Japan, surgeons have become proficient in OPCAB techniques in the past 10 years. Therefore, a proportion of OPCAB among total CABG cases in Japan has reached more than 60%,^{4,7,8)} which is extremely higher than that in the US (17%) (**Fig. 1**).^{4,9)} Although long-term prognosis in patients who underwent OPCAB is controversial, this technique has been reported to reduce the occurrence of perioperative complications.¹⁰⁾ However, the advantages of OPCAB over ONCAB have not been fully clarified, because the number of cases reported by each center that participated in OPCAB-related studies varies a lot to draw conclusions.¹¹⁾ Indeed, only a few studies on OPCAB performed in Japan have been reported. Of note, our institution has actively performed OPCAB in a routine manner, and tends to use CPB only in limited cases these days (**Fig. 2**). Therefore, in the present report, we reviewed the clinical characteristics

Fig. 2 The changes in a proportion of OPCAB in a total CABG cases at our institution. The OPCAB cases exceed 90% of total CABG cases since 2002. OPCAB: off-pump coronary artery bypass grafting; CABG: coronary artery bypass grafting

and early postoperative outcomes of patients who underwent OPCAB at our institution, which is one of the high-volume centers in Japan, and evaluated the results in the light of previously published OPCAB-related papers.

Material and Methods

Patients

At Juntendo University Hospital in Japan, 1203 consecutive patients who underwent elective isolated OPCAB between December 2006 and October 2013 were reviewed. Of these, 94 patients who underwent an emergency procedure, re-sternotomy operation, and conversion to extracorporeal circulation-supported surgery were excluded from the study. The remaining 1109 patients were included in the present analysis.

Study design

We summarized the preoperative and postoperative courses in our cohorts. Postoperative death was defined as death occurring within 30 days after surgery or during hospitalization. Neurological complication was defined as a focal or global neurological deficit including transient ischemic attack (TIA) that resolves within 24 h, and ischemic or hemorrhagic intracranial stroke persisting beyond 24 h accompanied by an imaging study. Renal dysfunction is defined by the presence of organic kidney damage or a persistent decrease in estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m² (Chronic kidney damage stage 3a or more severe) for three or more

months. Diabetes was defined as HbA1c $\geq 6.5\%$ [NGSP] or a status requiring antidiabetic agents/insulin. Extracardiac arteriopathy was defined as claudication, carotid occlusion or as $>50\%$ stenosis, amputation for arterial disease, or a history of intervention on the abdominal aorta, limb arteries or carotids. Respiratory complications were defined as indications for mechanical ventilation for longer than 24 h or development of pneumonia. Re-sternotomy was performed in patients who developed sudden massive bleeding or showed signs of cardiac tamponade. The data collection protocol was approved by the institutional review board of Juntendo University. Our data was evaluated in the light of previously published reports, which focused on early postoperative mortality and morbidity following OPCAB.^{7,12–14)}

Surgical techniques

All the procedures were performed through a median sternotomy. The conduits (one or both internal thoracic arteries, the right gastroepiploic artery, and the saphenous vein) were harvested and skeletonized. Arterial conduits were used whenever possible. The arterial grafts are covered with warm papaverine hydrochloride gauze, and spasms are released with olprinone injections. The left side pericardium retracted sutures and two deep pericardial sutures are placed so as to position the apex towards the ceiling. These procedures and a suction stabilizer enable us to approach any region. A suction stabilizer is used to fix in place the coronary artery site for anastomosis, and the coronary artery is exposed. In patients with a risk of hemodynamic instability, CPB usage was considered appropriate. An incision is made in the coronary artery, and the central side is snared with an elastic string to create a bloodless operative field. Internal shunt tubes are used if there is excessive coronary blood flow and if hemorrhage or myocardial ischemia is a concern. Carbon dioxide (which is water-soluble and not prone to causing embolisms) is blown onto the site with a CO₂ blower to locally disperse blood and to assist in achieving a bloodless operative field. Coronary artery anastomosis was performed by using continuous 8-0 or 7-0 propylene sutures. For proximal anastomosis with free grafts of the ascending aorta, systemic blood pressure was maintained at around 80 mmHg, and anastomosis was performed with a continuous 6-0 propylene suture on a partially clamped aorta. If clamping of the ascending aorta was not possible due to calcification or plaque, an automatic anastomotic device was used. After completion of all anastomoses, a transit time flow measurement device was used

Table 1 Patients' characteristics

Variable	n = 1109
Age, years	67.5 $\pm$ 9.8
Sex male, n (%)	904 (81%)
Body mass index, kg/m ²	23.6 (21.6–25.8)
Diabetic mellitus, n (%)	633 (57%)
Dyslipidemia, n (%)	316 (28%)
Hypertension, n (%)	859 (77%)
Chronic kidney disease, n (%)	440 (39%)
Hemodialysis, n (%)	80 (7%)
Neurological complications, n (%)	177 (16%)
Arteriopathy, n (%)	159 (14%)
COPD, n (%)	120 (11%)
Hemoglobin, g/dL	12.7 $\pm$ 1.7
Brain natriuretic peptide, pg/mL	172.2 $\pm$ 420.6
HbA1c, %	5.9 (5.4–6.7)
Total cholesterol, mg/dL	165.0 (142.0–190.8)
Triglyceride, mg/dL	115.0 (84.0–159.8)
Low density lipoprotein, mg/dL	94.0 (75.0–116.0)
High density lipoprotein, mg/dL	43.0 (36.0–52.0)
eGFR, mL/min/1.73 m ²	65.4 (49.1–79.7)
Creatinine, mg/dL	0.8 (0.7–1.1)
LVEF, %	59.0 (48.0–66.0)
Number of diseased vessels, n	3.1 $\pm$ 0.8
NYHA classification	1.2 $\pm$ 1.1
CCS classification	2.0 $\pm$ 0.5
EuroSCORE II, %	1.4 (1.0–2.3)

COPD: chronic obstructive pulmonary disease; eGFR: estimated glomerular filtration rate; LVEF: left ventricular ejection fraction measured by echocardiographic analysis; NYHA: New York Heart Association Functional Classification; CCS: Canadian Cardiovascular Society Functional Classification

to ensure sufficient blood flow in all the grafts, and the bypass was completed.¹⁵⁾ In order to prevent postoperative arrhythmia-induced cardiac emboli, left atrial appendage amputation and/or occlusion (LAA A/C) has been performed in our institution since 2012. This is because the LAA is the main source of emboli in patients with atrial fibrillation (Af), which is the most prevalent arrhythmia after cardiac surgery. The LAA procedure is performed with a purse-string suture and a continuous over and over suture.¹⁶⁾

Statistical analysis

Data were presented as mean $\pm$ SD values for continuous variables and as percentages for categorical variables. Normality was evaluated for each variable from normal

distribution plots and histograms. Where data were not normally distributed, the median value associated with the interquartile range is presented. Factors associated with postoperative outcome were evaluated by univariate and multivariate logistic regression analyses based on the available clinical data. For the purpose of including variables into uni- and multivariate logistic regression analysis, data that showed a bimodal distribution were subjected to logarithmic transformation of the variables as needed to improve normality before performing the statistical analysis. Co-variables which were found to be associated with combined morbidities by univariate analysis ($p < 0.05$) were entered into the subsequent multivariate analysis. Statistical analyses were performed using the Statistical Analysis System Software JMP 11.0 (SAS Institute Inc. Cary, NC, USA).

Results

The present observation included 1109 patients who underwent OPCAB during the study period. Their preoperative clinical characteristics are shown in **Table 1**. Of these patients, 904 were men (81.5%), 859 (77.2%) had a history of hypertension, and 633 (57.3%) had diabetes mellitus. In addition, the European system for cardiac operative risk evaluation showed that the estimated mortality within 30 days after cardiac surgery in the present cohort was 2.1 ± 2.1 . Among all patients, 186 (16.7%) underwent simultaneous LAA A/C at the time of OPCAB. The effect of the LAA procedure on their postoperative outcomes is now under investigation (data not shown).

Perioperative mortality and morbidity

Table 2 shows the perioperative mortality and morbidity. The overall mortality rate was 0.5% in this cohort. Around 30% of the patients developed postoperative arrhythmia, most of whom had Af. Forty-three patients (3.6%) had respiratory complications, 32 (3.3%) had newly developed renal failure that required renal replacement therapy of whom two (0.2% in total cohort) required permanent hemodialysis, and 13 (1.3%) had postoperative neurological complications,

The detailed information about patients who died during hospitalization is summarized in **Table 3**. Among eight deaths, there were two cardiovascular deaths and six non-cardiac deaths. Half of the patients who died were already on chronic hemodialysis prior to the surgery, and one patient required transient renal replacement therapy postoperatively. Six out of eight patients developed cardiac

Table 2 Peri- and postoperative data

Variable	n = 1109
Operation time, min	278.0 (252.0–328.0)
Number of grafts, n	3.5 ± 1.3
Mortality, n (%)	8 (0.5%)
Neurological complications, n (%)	13 (1%)
Respiratory complications, n (%)	43 (4%)
GI bleedings, n (%)	2 (0.1%)
Surgical site infection, n (%)	18 (2%)
ICU stay, days	1 (1–1)
Postoperative hospital stay, days	9 (8–11)

GI: gastrointestinal; ICU: intensive care unit

arrhythmia. The mean duration from surgery to death was 6.5 (2–35) days.

Outcome analysis of our data and those in the recent literatures

Table 4 summarizes the outcomes of OPCAB reported in the literature^{7,12–14}) as referrals for our results. Of note, our observation was based on a single-center retrospective analysis, but the number of participants was sufficient. Triple-vessel bypass grafting surgery seemed to be less frequently performed under OPCAB in general, according to the literature. In the present investigation in our institution, the mean number of grafts was 3.5 ± 1.3 . Peterson et al. performed an observational study in 267089 patients who underwent an isolated CABG procedure, not focusing on on-or off-pump procedure, and reported that the early postoperative mortality after CABG ranged from 2% to 5%.¹⁷) The mortality rates in the literature, which are shown in **Table 4**, also ranged from 1% to 6%. Therefore, the mortality rate of 0.5% at our institution seemed to be satisfactory. The incidences of adverse events in our cohort other than new-onset Af, such as stroke or respiratory failure, were compatible with those reported in previous studies.

Details of the patients who underwent ONCAB instead of OPCAB

During the same period that the patients evaluated in the present study underwent OPCAB at our institution, only 14 patients underwent elective or urgent ONCAB as a conversion from OPCAB. The detailed data are summarized in **Table 5**. The mean age of this group was 68.4 ± 12.0 years, which was similar to that of the patients who underwent OPCAB. This group of patients had relatively impaired left ventricular function as reflected by preoperative left

Table 3 Patients who died during hospitalization

	Age, years	Sex	Reason	Op time, min	Number of graft, n	Required CHDF	Stroke	Respiratory complications	SSI	Re-operation	IABP	Arrhythmia	ICU stay, days	Duration bet ope to death
1	67	F	GI bleeding	220	3	HD*	-	-	-	-	-	-	2	2
2	72	M	Pneumonia	233	3	HD*	-	+	-	-	-	Paf	3	35
3	76	M	Enteral infection	371	4	-	-	+	-	-	-	Paf	15	15
4	81	M	Drug allergy	221	3	-	-	+	-	-	+	Paf	1	7
5	83	M	Sudden cardiac death	365	3	-	-	-	-	-	-	-	1	4
6	77	M	Enteral infection	272	4	HD*	-	-	-	-	+	VT, Paf	2	17
7	43	M	NOMI	294	4	Transient	-	+	-	-	-	-	7	7
8	53	F	Vf	380	2	HD*	-	-	-	-	+	Vf	4	4

*a person receiving preoperative hemodialysis. CHDF: continuous hemodiafiltration; SSI: surgical site infection; IABP: intra-arterial balloon pumping; ICU: intensive care unit; M: male; F: female; GI: gastrointestinal; NOMI: non-occlusive mesenteric ischemia; Vf: ventricular fibrillation; HD: hemodiafiltration; Paf: paroxysmal atrial fibrillation; VT: ventricular tachycardia

Table 4 Previous literatures including OPCAB graft surgery outcome data and our results

Literatures	Study type	OPCAB/CABG	Number of patients*	Age**	EuroSCORE II**	Number of grafts**	Mortality**	Stroke**	Respiratory failure**	Postoperative stay (days)**
Our result	Retrospective observational	99%	1109	67.5 ± 9.8	2.1 ± 2.1	3.5 ± 1.3	8 (0.5%)	13 (1.3%)	43 (4.1%)	10.7 ± 12.0
Edgerton et al. (2003) ⁽²⁾	Retrospective observational	40%	1908	64.0 ± 11.3	Not shown	2.9 ± 1.1	44 (2.3%)	15 (0.8%)	Not shown	Not shown
Suzuki et al. (2008) ⁽⁷⁾	Retrospective observational	100%	477	68.5 ± 10.1	Not shown	3.5 ± 0.9	5 (1.1%)	1 (0.2%)	22 (4.9%)	15.7 ± 13.1
Reber et al. (2010) ⁽¹³⁾	Retrospective observational	61%	185	69.3 ± 1.0	5.4	1.7 ± 0.6	4 (6.2%)	Not shown	Not shown	Not shown
Tarakji et al. (2011) ⁽⁴⁾	Prospective cohort	10%	2163	Not shown	Not shown	Not shown	Not shown	17 (0.79%)	Not shown	Not shown

*Number of patients undergoing OPCAB shown in each literature. **The data derived from OPCAB patients shown in each literature. OPCAB: off-pump coronary artery bypass grafting; CABG: coronary artery bypass grafting

Table 5 Patients undergoing ONCAB during the same observational period

	Age, years	Sex	CABG type	Reason for ONCAB	Op time, min	CPB time, min	Number of graft, n	Operative death	Stroke complications	Respiratory complications	SSI	Re-operation	IABP	Arrhythmia	ICU stay, days	Hospital stay, days
1	67	F	Conversion	High PA pressure	258	57	2	-	-	-	-	-	-	-	7	21
2	72	M	Conversion	High PA pressure	307	111	3	-	-	-	-	-	-	-	1	9
3	76	M	Conversion	Venous hem-orthage	314	124	4	-	-	-	-	-	-	Paf	1	15
4	81	M	Conversion	High PA pressure	583	127	4	-	+	+	-	-	+	Paf	24	47
5	83	M	Conversion	Arrhythmia	313	200	5	-	-	-	-	-	+	-	6	37
6	77	M	Planned	Low EF	305	88	4	-	+	+	-	-	+	Paf	27	77
7	43	M	Planned	Low EF	307	96	3	-	-	-	-	-	-	-	4	11
8	53	F	Planned	Low EF	435	112	5	-	-	-	-	-	-	-	6	16
9	72	M	Planned	Multiple vessels	335	160	3	-	-	-	-	-	-	Paf	1	8
10	77	M	Planned	Low EF	374	167	6	-	-	-	-	-	-	Paf	4	35
11	73	M	Planned	Multiple vessels	600	315	4	-	-	-	-	-	-	-	1	7
12	68	M	Planned	Multiple vessels	317	127	3	-	-	-	-	-	-	-	1	9
13	66	M	Planned	Multiple vessels	415	182	3	-	+	-	-	-	-	-	1	12
14	49	M	Planned	Multiple vessels	371	159	3	-	-	-	-	-	-	-	1	8
Mean	68.4	Male 14%	Conversion 35%	High PA 21% Low EF 28%	374.0	144.6	4.0	none	N=3 21%	N=2 14%	none	none	N=3 21%	N=5 35%	6.0	22.0

CABG: coronary artery bypass grafting; ONCAB: on-pump beating CABG; CPB: cardiopulmonary bypass; SSI: surgical site infection; IABP: intra-arterial balloon pumping; ICU: intensive care unit; M: male; F: female; PA: pulmonary artery; EF: ejection fraction

ventricular ejection fraction (LVEF) and higher predicted mortality derived from the EuroSCORE II. In our institution, we electively perform ONCAB rather than OPCAB in patients with impaired left ventricular function and multiple-vessel disease because such patients are at risk of perioperative hemodynamic change, especially when anastomosis to the left circumflex coronary artery is planned. Furthermore, unexpected conversion from OPCAB to ONCAB is performed in patients whose pulmonary artery (PA) pressure has increased beyond the normal range under the procedure of apical elevation.

Factors associated with mortality and morbidity based on an available dataset

The event rates of both death ($n = 8$, 0.5%) and combined morbidity ($n = 85$, 8.7%) were not sufficient enough to perform analysis for preoperative determinants of mortality/morbidities. Furthermore, we could not obtain complete preoperative information from all patients. Therefore, although we admit that the analyses were limited to a crude conception derived from only available data, we performed univariate and multivariate logistic analyses for outcomes (**Table 6**). Among the variables we studied, reduced LVEF ($<40\%$), preoperative hemodialysis requirement, low body mass index (BMI), anemia, low high density lipoprotein (HDL), elevated creatinine concentration, severe preoperative conditions as reflected by a high CCS/EuroSCORE, and elevated brain natriuretic peptide (BNP) were found to be associated with postoperative mortality. For combined morbidities, advanced age, history of arteriopathy and stroke, reduced LVEF ($<40\%$), anemia, elevated creatinine concentration, reduced eGFR, high EuroSCORE and elevated BNP were found by univariate analysis to be risk factors. Due to the correlation between eGFR and creatinine concentration, eGFR, but not creatinine level, was entered into the multivariate analysis. The EuroSCORE consisted of several known risk factors, which were therefore not included in the multivariate analysis either. According to the multivariate analysis, previous stroke, reduced eGFR and elevated BNP levels remained as risk factors for combined morbidity.

Discussion

In the present report, we demonstrated that (i) the early postoperative mortality of the 1109 consecutive Japanese patients who underwent OPCAB at our institution was 0.5%, which was much lower than the estimated mortality

as calculated based on EuroSCORE II of 2.1; (ii) early postoperative adverse events, including stroke and respiratory failure, occurred in approximately 9% of the patients, which was equivalent to the morbidity incidences shown in previous literatures from the US or Europe; (iii) the ratio of ONCAB to OPCAB during the study period was 14:1109 (0.01) at our institution; (iv) patients with impaired left ventricular function and pulmonary hypertension tended to receive elective ONCAB; and (v) preoperative reduced LVEF may predict a poor outcome.

According to the 2013 investigation in Japan, initial elective OPCAB was performed in 5830 patients, and the mortality was 0.82%.⁴⁾ Edgerton et al. reported a mortality rate of 2.3% in 1908 patients who underwent OPCAB in their retrospective study.¹²⁾ In the largest multicenter randomized trial to date that compared OPCAB with ONCAB (2203 patients), Shroyer et al. reported that the 30-day mortality rate was 2.5%.¹⁸⁾ Considering the estimated mortality rate of our patients that was derived from EuroSCORE II and by referring to the mortality rates reported in the literatures shown in **Table 3**,^{7,12–14)} we assume that the outcome of OPCAB at our institution was satisfactory.

Several studies reported that OPCAB is a useful technique for reducing postoperative mortality and morbidity compared with ONCAB.^{19,20)} Therefore, several institutions actively perform OPCAB rather than ONCAB, especially in patients at high risk for postoperative complications, considering its beneficial effect of avoiding CPB.²¹⁾ However, the advantages of OPCAB over ONCAB remain controversial.²²⁾ The ongoing Coronary Artery Bypass Grafting Surgery Off- or On-Pump Revascularization Study trial (CORONARY trial) enrolled 4752 patients to investigate short- and long-term outcomes, including comorbidities after either OPCAB or ONCAB. This trial failed to prove the superiority of OPCAB over ONCAB, but its inferiority was not shown as well.^{20,23)} Our present report also showed acceptable incidences of adverse events during the early postoperative period. Sufficiently low mortality and morbidity rates after OPCAB, as shown in this report, have encouraged us to promote OPCAB even more actively in the recent years.

Furthermore, we have recently performed LAA A/C simultaneously with OPCAB. The reason why we have added this procedure to OPCAB is because we assume that an add-on LAA procedure may be effective for the prevention of postoperative stroke or other systemic embolisms. The LAA is the main source of emboli in patients with

Table 6 Preoperative factors associated with mortality and combined morbidity in the overall cohort (data limited)

Variables	Mortality		Combined morbidities			
	Univariate		Univariate		Multivariate	
	OR (95%CI)	p Value	OR (95%CI)	p Value	OR (95%CI)	p Value
Age years	1.04 (0.96–1.15)	0.30	1.03 (1.01–1.06)	0.02	1.01 (0.98–1.04)	0.23
Male (yes = 1, no = 0)	1.76 × 10 ⁶ (0.72–)	0.08	1.78 (0.67–2.22)	0.58		
BMI kg/m ²	0.73 (0.57–0.94)	0.01	0.95 (0.89–1.03)	0.23		
DM (yes = 1, no = 0)	1.85 (0.39–12.96)	0.45	1.30 (0.33–2.09)	0.25		
DL (yes = 1, no = 0)	0.53 (0.11–2.70)	0.42	0.67 (0.42–1.07)	0.10		
Hypertension (yes = 1, no = 0)	0.72 (0.16–5.09)	0.92	1.01 (0.61–1.76)	0.96		
Preoperative hemodialysis (yes = 1, no = 0)	2.14 (0.11–12.76)	0.03	2.04 (0.99–3.89)	0.051		
History of stroke (yes = 1, no = 0)	0.86 (0.05–5.13)	0.89	2.38 (1.42–3.88)	<0.01	1.78 (1.03–3.00)	0.03
History of arteriopathy (yes = 1, no = 0)	<0.01 (0.00–1.89)	0.14	1.83 (1.04–3.09)	0.04	1.05 (0.54–1.78)	0.87
COPD (yes = 1, no = 0)	3.36 (0.47–15.78)	0.19	0.72 (0.30–1.51)	0.42		
LVEF (%) (EF <40 = 1, ≥40 = 0)	10.58 (2.31–54.22)	<0.01	1.92 (1.04–3.35)	0.04	0.99 (0.98–1.02)	0.98
Hb g/dL	0.54 (0.34–0.81)	<0.01	0.71 (0.62–0.81)	<0.01	0.93 (0.80–1.09)	0.36
Log BNP pg/mL	23.04 (6.37–106.10)	<0.01	3.76 (2.56–5.60)	<0.01	2.12 (1.26–3.61)	<0.01
HbA1c %	0.95 (0.42–1.73)	0.87	1.04 (0.85–1.25)	0.71		
T-Chol mg/dL	0.98 (0.96–1.00)	0.10	1.00 (0.99–1.01)	0.91		
TG mg/dL	0.99 (0.97–1.00)	0.35	0.99 (0.99–1.00)	0.89		
LDL mg/dL	0.99 (0.96–1.01)	0.28	1.00 (0.99–1.01)	0.78		
HDL mg/dL	0.92 (0.83–0.99)	0.02	0.99 (0.98–1.01)	0.78		
Cre g/dL	1.28 (1.04–1.53)	0.02	1.20 (1.11–1.29)	<0.01		
eGFR mL/min/1.73 m ²	0.98 (0.56–1.01)	0.30	0.97 (0.96–0.97)	<0.01	0.98 (0.97–0.99)	<0.01
Number of graft n	0.82 (0.34–2.18)	0.67	1.14 (0.86–1.54)	0.36		
CCS	3.83 (1.38–9.25)	0.01	1.61 (1.08–2.36)	0.02		
EuroSCORE	1.26 (1.12–1.43)	<0.01	1.29 (1.18–1.41)	<0.01		

OR: odds ratio; CI: confidential interval; BMI: body mass index; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; EF: ejection fraction; LVEF: left ventricular ejection fraction; BNP: brain natriuretic peptide; TG: triglyceride; LDL: low-density lipoprotein; HDL: high-density lipoprotein; eGFR: estimated glomerular filtration rate; CCS: Canadian Cardiovascular Society Functional Classification

Af.²⁴⁾ Indeed, Af is the most prevalent arrhythmia encountered after cardiac surgery, and previous studies indicated that 20%–50% of patients develop postoperative Af.²⁵⁾ Although the incidence of postoperative Af was reported to be lower in OPCAB patients than ONCAB patients, sizable patients definitely develop transient Af regardless of the type of procedure. Therefore, LAA A/C may be useful in preventing emboli-associated devastating adverse events even in patients undergoing OPCAB. Percutaneous LAA closure devices are now widely used especially in Europe.²⁴⁾ However, such devices are not available in Japan. Hence, we initiated prophylactic LAA A/C simultaneously with OPCAB, the results of which are now under prospective observational study. In addition, use of the aorta no-touch technique, in which in situ arterial grafts are used for all grafts to avoid manipulation of the ascending aorta, has been shown to reduce the occurrence of stroke.¹⁵⁾ Our institution also chose in situ arterial grafts whenever possible. The use of LAA A/C and the aorta no-touch technique

might contribute to reducing perioperative mortality and morbidity rates.

Patients who undergo unplanned ONCAB as a result of intraoperative conversion from OPCAB have significantly higher rates of postoperative complications, operative mortality, and 30-day readmission.²⁶⁾ The mean duration of postoperative hospital stay in OPCAB patients at our institution was 11 days, whereas those of ONCAB patients (elective and urgent) and a subset of five patients with urgent conversion from OPCAB to ONCAB were 22 and 26 days, respectively. We speculate that the prolonged hospitalization of the ONCAB patients may be related to their tough postoperative courses with several complications. In our institution, we select OPCAB rather than ONCAB for as many cases as possible, except for those with extremely poor preoperative left ventricular function. Unexpected CPB requirement occurred in patients whose PA pressure was elevated during apical elevation. These findings indicate that hemodynamic stability is one of the

most important factors to accomplish OPCAB procedures in a successful manner.^{26,27)}

Although an analysis identifying factor associated with mortality and morbidity based on our data contains statistical limitations, only low EF was found to be a possible predictive factor for a poor outcome as was shown in the previous reports.²⁸⁾ Our results indicate that even under OPCAB procedures, patients with reduced systolic function may require special attention during their perioperative management in order to treat them as promptly as possible in case of adverse event occurrence.

The present paper is a preliminary report of more than 7 years of experience with OPCAB at one of the highest-volume centers in Japan. We admit that this is a cohort study; however, considering the fact that we perform OPCAB in a routine manner and CPB usage is an extreme exception at our institution, we believe our results are worth reporting. Due to the small number of ONCAB cases, we were unable to compare outcomes between OPCAB and ONCAB. However, we believe that the clinical review of the patients' characteristics and early post-operative courses of the OPCAB patients in the present paper can provide useful information for other institutions that will engage in surgical coronary revascularization.

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