Emergency Off-Pump Coronary Artery Bypass Graft Surgery for Patients on Preoperative Intraaortic Balloon Pump

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Background. **The aim of this study was to investigate early and long-term outcomes of patients with acute coronary syndrome preoperatively requiring intraaortic balloon pump support who underwent emergency off-pump coronary artery bypass graft surgery.**

Methods. **One hundred and fifteen patients on preoperative intraaortic balloon pump receiving emergency off-pump coronary artery bypass graft surgery over an 11-year period were evaluated. The median age was 71 years (range, 33 to 87). Acute myocardial infarction and unstable angina were present in 54 patients (47.0%) and 61 patients (53.0%), respectively. Left main disease and triple-vessel disease without left main involvement were present in 74 patients (64.3%) and 33 patients (28.7%), respectively.**

Results. **There were 3 perioperative deaths. Complete surgical revascularization was accomplished in 82 patients (71.3%), and in situ internal thoracic artery graft was used in 96 (83.5%). Late survival, freedom from major adverse cardiac and cerebrovascular events, and freedom from repeat revascularization rates at 5 years were 83.3%, 73.5%, and 84.2%, respectively. The Cox multivariate prognostic predictors of total mortality were preoperative renal impairment (hazard ratio [HR] 7.90; 95% confidence interval [CI]: 3.06 to 20.4) and low ejection fraction (HR 0.94, 95% CI: 0.88 to 0.99). The multivariate risk predictors of major adverse cardiac and cerebrovascular events were preoperative renal impairment (HR 2.68, 95% CI: 1.00 to 7.19) and peripheral vascular disease (HR 2.81, 95% CI: 1.05 to 7.51), and complete revascularization was protective (HR 0.39, 95% CI: 0.19 to 0.81). The multivariate risk factor of repeat revascularization was previous percutaneous coronary intervention (HR 3.26, 95% CI: 1.14 to 9.33), and complete surgical revascularization was also protective (HR 0.30, 95% CI: 0.11 to 0.85).**

Conclusions. **Off-pump coronary artery bypass graft surgery is a feasible option for patients requiring preoperative intraaortic balloon pump support.**

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Surgical revascularization plays an essential role in the treatment of the patients with acute coronary syndrome (ACS) exhibiting complex coronary anatomies and hemodynamic instability even in the era of widely prevalent percutaneous coronary intervention (PCI). According to the Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) trial, coronary artery bypass graft surgery (CABG) demonstrated a good survival benefit for patients with ACS excluding ST-segment elevation myocardial infarction, with approximate operative mortality of 3.3% [1]. Biancari and colleagues [2] reported 10.1% inhospital mortality for emergency CABG in ACS patients including ST-segment elevation myocardial infarction [2].

It has been discussed whether off-pump coronary artery bypass graft surgery (OPCABG) has a better survival benefit than on-pump coronary artery bypass graft surgery (ONCABG), or vice versa for this subset of patients, and the optimal surgical approach still remains a matter for debate [2–7]. Immediate postoperative mortality benefit for OPCABG has been advocated since it could avoid inflammatory burden caused by cardiopulmonary bypass on those who is already in proinflammatory state with acute myocardial damage. Concerns exist, however, over the possibility of fewer grafts and incomplete revascularization due to technical difficulties, especially during anastomosis of the circumflex branches, with hemodynamic instability on upward positioning of the acutely ischemic heart. Conflicting results have been reported about whether fewer grafts or incomplete revascularization have a negative impact on long-term outcomes, including repeat revascularization. According to the literature, long-term survival after emergency OPCABG varied from 24.6 to 85.4% [4, 5].

A limited number of analyses have been reported in the literature on the feasibility of OPCABG and its long-term effect on ACS patients, and few studies have been

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Abbreviations and Acronyms

ACS = acute coronary syndrome
AMI = acute myocardial infarction
CABG = coronary artery bypass grafting
CI = confidence interval
HR = hazard ratio
IABP = intraaortic balloon pump
ITA = internal thoracic artery
LAD = left anterior descending coronary artery
MACCE = major adverse cardiac and cerebrovascular events
ONCABG = on-pump coronary artery bypass graft surgery
OPCABG = off-pump coronary artery bypass graft surgery
PCI = percutaneous coronary intervention

published on the long-term results of OPCABG for the ACS patients requiring preoperative intraaortic balloon pump (IABP) support. The aim of this study was to analyze the early and long-term outcomes of OPCABG for high-risk ACS patients preoperatively on IABP and to identify the prognostic factors for late outcomes, including the need for repeat revascularization.

Patients and Methods

From January 2004 to December 2014, 747 patients underwent isolated CABG in our facility. Among them, 115 patients (15.4%) with ACS requiring preoperative IABP support underwent emergency or urgent OPCABG, and constituted the study cohort. The patients with ACS who did not require IABP support preoperatively or those for whom ONCABG was intended before surgery were excluded from the study. The IABP support was begun for all patients in the cardiac catheterization laboratory on the cardiologists' decision. The indications for IABP insertion were hemodynamic instability or ongoing ischemia with persistent chest pain and ST-segment change on electrocardiogram with left main disease or multivessel disease with involvement of critical lesions of the proximal left anterior descending artery (LAD). Thirty patients (26.1%) received IABP owing to hemodynamic instability, and 85 patients (73.9%) received IABP owing to hemodynamically stable ongoing ischemia with intractable chest pain and ST-segment change on electrocardiogram. No patient received IABP merely for the reason of critical coronary anatomy. OPCABG was the first choice for patients who were relatively stable on IABP support, whereas ONCABG was limited to patients who had cardiac arrest, including ventricular arrhythmia requiring defibrillation, patients with hemodynamic deterioration even with IABP, patients who were on percutaneous mechanical circulatory support device, or patients who required concomitant procedures such as valve repair or replacement.

The median follow-up was 40 months (range, 0 to 126). Preoperative patient characteristics are shown in Table 1. Nine patients (7.8%) were in cardiogenic shock, of whom 4 (3.5%) required intubation before surgery and 6 (5.2%) required catecholamine support. Three patients (2.6%) required temporary pacing owing to bradycardia. One patient (0.87%) had cardiac tamponade requiring pericardiocentesis before surgery. The ACS caused by PCI problems was seen in 4 patients (3.5%). All the operations were performed through median sternotomy. The arterial grafts were harvested in fully skeletonized fashion using the Harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, OH). The internal thoracic artery (ITA) to LAD anastomosis was performed first, and intracoronary shunts were routinely used only for that anastomosis. Silicone coronary artery snares (Quest Medical, Allen, TX) were used to occlude the vessels of other territories. Ischemic preconditioning was not used. The Starfish heart positioner (Medtronic, Minneapolis, MN) was used for an appropriate heart positioning for distal anastomoses of the circumflex and the right coronary arteries. Proximal anastomoses of the vein grafts were usually performed with

Table 1. Preoperative Patient Characteristics

Preoperative Characteristics	Values (n = 115)
Age, years	71 (33–87)
Female	24 (20.9)
Hypertension	91 (79.1)
Dyslipidemia	82 (71.3)
Diabetes mellitus	61 (53.0)
Insulin dependent	11 (9.57)
Oral antiglycemic agents	40 (34.8)
Smoker	46 (40.0)
History of cerebrovascular accident	14 (12.2)
Previous myocardial infarction	12 (10.4)
History of PCI	34 (29.6)
Peripheral artery disease	16 (13.9)
Serum creatinine, mg/dL	0.79 (0.43–12.61)
Hemodialysis	9 (7.83)
LVEF, %	50.0 (25.0–71.9)
Acute myocardial infarction	54 (47.0)
STEMI	42 (36.5)
Non-STEMI	12 (10.4)
Unstable angina	61 (53.0)
Three-vessel disease	69 (60.0)
Left main disease	74 (64.3)
LMD plus three-vessel disease	36 (31.3)
Two-vessel disease without LMD	7 (6.09)
One-vessel disease	1 (0.87)
EuroSCORE II	10.2 (3.70–60.5)

Values are n (%) or median (range).

EuroSCORE = European System for Cardiac Operative Risk Evaluation; LMD = left main disease; LVEF = left ventricular ejection fraction; PCI = percutaneous coronary intervention; STEMI = ST-segment elevation myocardial infarction.

partial clamping of the ascending aorta after completion of all the distal anastomoses; however, the proximal anastomoses were done before the distal anastomoses to perfuse the corresponding coronary arteries immediately after the distal anastomoses in case of little hemodynamic improvement even with the ITA-LAD graft. The graft flow was routinely measured by the transit time-flow measurement method (Medi-Stim AS, Oslo, Norway).

By definition, completeness of revascularization was defined as at least one bypass graft per territory. Major adverse cardiac and cerebrovascular events (MACCE) were defined as the occurrence of cardiac-related death, recurrent angina, acute myocardial infarction (AMI), the need for repeat revascularization, and hospitalization for congestive heart failure, stroke, or other vascular complications. This retrospective observational study has been approved by the Institutional Review Board, and the need for written consent was waived.

Statistical Analysis

Continuous variables are presented as mean and standard deviation or as median and range, and dichotomous data are presented as number and percentage. Baseline and perioperative patient characteristics were compared by Student's t test or the Mann-Whitney U test for continuous variables, and the χ^2 test or Fisher's exact test for categoric variables, as appropriate. Unless the variables were in normal distribution proven by Shapiro-Wilk's test, the U test was applied. For immediate postoperative results, logistic regression analysis was used to identify independent risk factors for perioperative mortality and morbidity. The regression models were calibrated by the Hosmer-Lemeshow goodness-of-fit test. For late survival, Kaplan-Meier curves were constructed, and the study groups were compared using the log rank test. Cox proportional hazards regression analysis was used to identify independent risk predictors of late outcome. Perioperative clinically relevant variables that were statistically significant in the univariate analyses ($p < 0.05$) were entered into the multivariate models. Results are presented as odds ratio or hazard ratio (HR) with the 95% confidence interval (CI). A value of p less than 0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS software, version 19.0 (IBM Corp, Armonk, NY).

Results

Operative Outcome

Table 2 shows the operative data. The patients operated on more than 24 hours after IABP placement were those who received IABP at outside hospitals and were transferred to our facility, or those who were stabilized immediately after IABP insertion but became unstable again while waiting for surgery. Redo surgery was performed in 1 patient with prior CABG. The OPCABG was completed in 112 patients (97.4%), and 3 patients (2.6%) were converted to ONCABG. On-pump beating-heart CABG was performed in 2 patients owing to hemodynamic instability during the circumflex artery being anastomosed or intractable ventricular tachycardia. Another patient had an intraoperative aortic dissection on partial clamping of the ascending aorta, requiring cardiopulmonary bypass and ascending aortic replacement. None of the patients was in cardiogenic shock preoperatively.

Table 2. Operative Data

Operative Data	Values
Time to operation after IABP, hours	
<6	91 (79.1)
<12	5 (4.3)
<24	8 (7.0)
<48	10 (8.7)
<96	1 (0.90)
Operation time, minutes	262 (216–309)
OPCABG completion	112 (97.4)
On-pump conversion	3 (2.6)
On-pump beating heart	2 (1.7)
On-pump arrest	1 (0.90)
Number of grafts	2.6 ± 0.96
≥4	18 (15.7)
3	34 (29.6)
2	53 (46.1)
1	10 (8.7)
Complete revascularization	82 (71.3)
Bypass grafts	
Saphenous vein graft	100 (87.0)
In-situ ITA	96 (83.5)
Left ITA	90 (78.3)
Right ITA	14 (12.2)
Bilateral ITA	8 (7.0)
Radial artery	8 (7.0)
Gastroepiploic artery	1 (0.87)

Values are n (%), median (interquartile range), or mean ± SD.

IABP = intraaortic balloon pump; ITA = internal thoracic artery; OPCABG = off-pump coronary artery bypass graft surgery.

The mean number of grafts per patient was 2.6 ± 0.96. Complete revascularization was accomplished in 82 patients (71.3%). The main reasons for incomplete revascularization were target issues in 21 patients; conduit issues in 4 (great saphenous veins used in the previous operations, 2; unusable due to multiple branching, 2); hemodynamic issues in 6; and other issues in 2 patients (severe gastrointestinal bleeding, 1; and request from cardiology aiming at hybrid revascularization, 1). Among the 21 patients with the target issues, 10 patients were deemed not to be candidates for complete revascularization preoperatively (diffusely diseased or diminutive targets, 7; no myocardial viability, 2; and ostial left main disease without stenosis between the LAD and the circumflex artery, 1); and complete revascularization was abandoned in 11 patients during surgery (intramuscular course of the circumflex artery, 6; diminutive circumflex artery, 3; and severely calcified right coronary artery, 2). Two of 6 patients with intramuscular circumflex artery

underwent repeat PCI without interprocedural complications during the same hospitalization. The vessels were not considered the most important culprit lesion in the other 4 patients, and they had had no MACCE, including repeat revascularization.

Either the left or the right in-situ ITA was anastomosed to the LAD in 96 patients (83.5%). The ITAs were a diminutive and weakly pulsatile artery deemed unusable in 4 patients, were injured in 4, and were decided not to be used preoperatively because of the left subclavian artery occlusion in 1 patients. The other reasons were hemodynamic instability in 5 patients and advanced age (more than 80 years) of 5 patients, in which cases the decision to not use the ITAs was made before surgery. The patient who had preoperative cardiac tamponade presented with oozing rupture of the posterolateral wall, which was repaired conservatively with hemostatic collagen sponges to seal the rupture site.

Early Results

Table 3 shows the immediate postoperative data. The inhospital mortality was 2.6% (3 of 115). One patient was an 85-year-old woman who had intraoperative aortic dissection; another patient was a 74-year-old hemodialysis-dependent man with previous complex peripheral artery bypass surgery who had myonephropathic metabolic syndrome due to leg ischemia on postoperative day 2; and the third patient was a 64-year-old woman who had rapid hemodynamic deterioration immediately after arriving in the intensive care unit and required percutaneous mechanical circulation. Regarding major postoperative complications, 3 patients had cerebral infarction. These events occurred on postoperative day 6 immediately after hemodialysis, on postoperative day 8 during routine postoperative coronary angiography, and on postoperative day 16 during cardiopulmonary resuscitation due to ventricular tachycardia. They all eventually became ambulatory and were discharged home. One patient with peripheral arterial disease had acute thromboembolism of the ipsilateral leg immediately after IABP removal, requiring thromboembolectomy. Postoperative AMI requiring PCI to the culprit lesion occurred in 1 patient (0.87%).

Multiple logistic regression analysis disclosed that preoperative high serum creatinine was an independent risk factor for early mortality and morbidity (OR 1.31, 95% CI: 1.06 to 1.63, $p = 0.015$) and in-situ ITA use was protective (OR 0.17, 95% CI: 0.045 to 0.67, $p = 0.011$). Although preoperative low ejection fraction and conversion to ONCABG were statistically significant on univariate analyses, they were not risk predictors in the multivariate analysis. The logistic regression analysis was overfitted with four variables over 19 early adverse events however, this model showed a good calibration by Hosmer-Lemeshow test (Table 4). Cardiogenic shock or AMI were not adverse prognostic factors, even in the univariate analysis; however, the patients presenting with cardiogenic shock had a significantly lower rate of in-situ ITA use (4 of 9, versus 92 of 106 stable patients, $p = 0.006$).

Late Results

The long-term overall survival was 83.3% at 5 years and 73.5% at 10 years (Fig 1A). Preoperative renal impairment (creatinine ≥1.3 mg/dL; HR 7.90, 95% CI: 3.06 to 20.4, $p < 0.001$) and low ejection fraction (HR 0.94, 95% CI: 0.88 to 0.99, $p = 0.019$) were found to be the adverse prognostic factors in Cox regression analysis (Table 5). Survival free of MACCE was 73.5% at 5 years and 61.2% at 10 years (Fig 1B). Cox proportional hazards test (Table 5) revealed preoperative mild or greater renal impairment (creatinine ≥1.3mg/dL; HR 2.68, 95% CI: 1.00 to 7.19, $p = 0.049$; Fig 2A), and peripheral arterial disease (HR 2.81, 95% CI: 1.05 to 7.51, $p = 0.039$; Fig 2B) were the significant risk predictors of late MACCE. Complete revascularization was protective (HR 0.39, 95% CI: 0.19 to 0.81, $p = 0.012$; Fig 2C). Of note, preoperative cardiogenic shock or AMI were not statistically significant risk factors for incompleteness of revascularization. Reintervention-free survival was 84.2% at 5 years and 79.5% at 10 years (Fig 1C). Fifteen patients (13.0%) underwent repeat PCI during the late follow-up, 9 of whom had undergone complete surgical revascularization. The reasons for PCI after complete surgical revascularization were development of a new lesion in 4 patients, bypass graft occlusion in 4, and both in 1 patient. Five of 6 patients with incomplete surgical revascularization received PCI within 6 months after

Table 3. Postoperative Data

Postoperative Data	Values
Hospital stay, days	13 (11–16.5)
Mortality	3 (2.6)
Morbidity	
Cerebral infarction	3 (2.6)
AKI requiring hemodialysis	2 (1.7)
Prolonged intubation/reintubation	6 (5.2)
Pulmonary embolism	1 (0.87)
Leg thromboembolism	1 (0.87)
Chest wound infection	2 (1.7)
Arrhythmia	
Atrial fibrillation	11 (9.6)
Supraventricular tachycardia	1 (0.87)
Ventricular tachycardia	1 (0.87)

Values are median (interquartile range) and n (%).

AKI = acute kidney injury.

Table 4. Logistic Regression Analysis for Perioperative Mortality and Morbidity

Variable	OR (95% CI)	*p* Value
Preoperative creatinine	1.31 (1.06–1.63)	0.015
In-situ ITA use	0.17 (0.045–0.67)	0.011

CI = confidence interval; ITA = internal thoracic artery; OR = odds ratio.

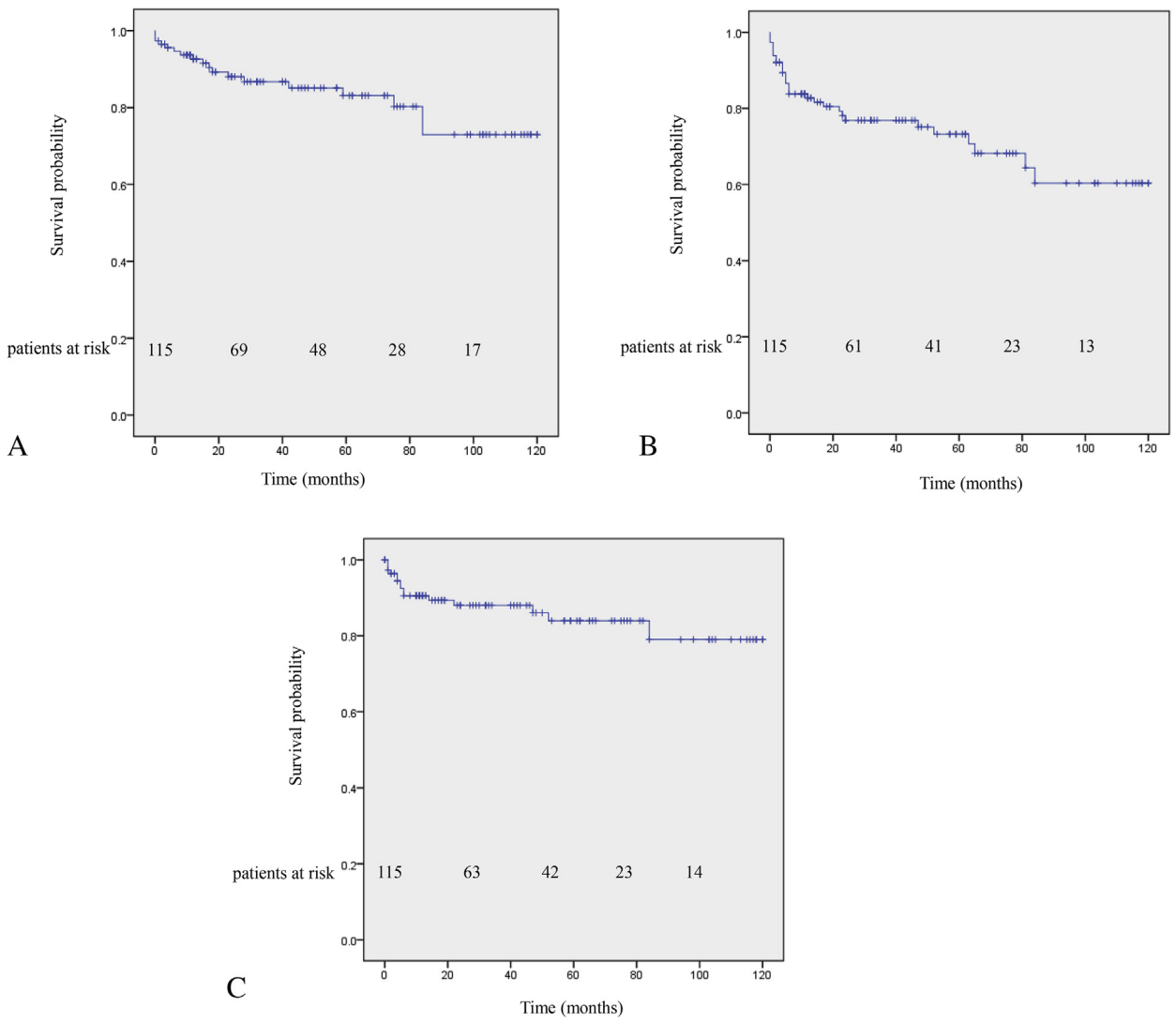

Fig 1. (A) Kaplan-Meier estimates of overall survival. (B) Major adverse cardiac and cerebrovascular events–free survival. (C) Reintervention-free survival.

surgery. Cox regression analysis (Table 5) disclosed preoperative history of PCI (HR 3.26, 95% CI: 1.14 to 9.33, $p = 0.027$) was a significant risk factor for repeat revascularization, and complete revascularization was also a protective factor (HR 0.30, 95% CI: 0.11 to 0.85, $p = 0.023$; Fig 2D).

Comment

The present study is a retrospective study that analyzed immediate and long-term outcomes of patients with ACS who required preoperative IABP support to stabilize hemodynamics followed by emergency OPCABG in a dedicated OPCABG facility. Harling and colleagues [3] reported in their metaanalysis that OPCABG conferred mortality comparable to ONCABG at both 30 days and midterm follow-up predominantly in stable ACS patients. Fukui and colleagues [4] reported an excellent early (operative mortality, 2.6%) and long-term

Table 5. Cox Proportional Hazard Analyses for Late Survival, Repeat Revascularization, and Major Adverse Cardiac And Cerebrovascular Events

Variable	HR (95% CI)	*p* Value
Total mortality		
Renal impairment[a]	7.90 (3.06–20.4)	<0.001
Left ventricular ejection fraction	0.94 (0.88–0.99)	0.019
Repeat revascularization		
Previous PCI	3.26 (1.14–9.33)	0.027
Complete revascularization	0.30 (0.11–0.85)	0.023
MACCE		
Renal impairment[a]	2.68 (1.00–7.19)	0.049
Peripheral arterial disease	2.81 (1.05–7.51)	0.039
Complete revascularization	0.39 (0.19–0.81)	0.012

[a] Serum creatinine greater than 1.3 mg/dL.

CI = confidence interval; HR = hazard ratio; MACCE = major adverse cardiac and cerebrovascular events; PCI, percutaneous coronary intervention.

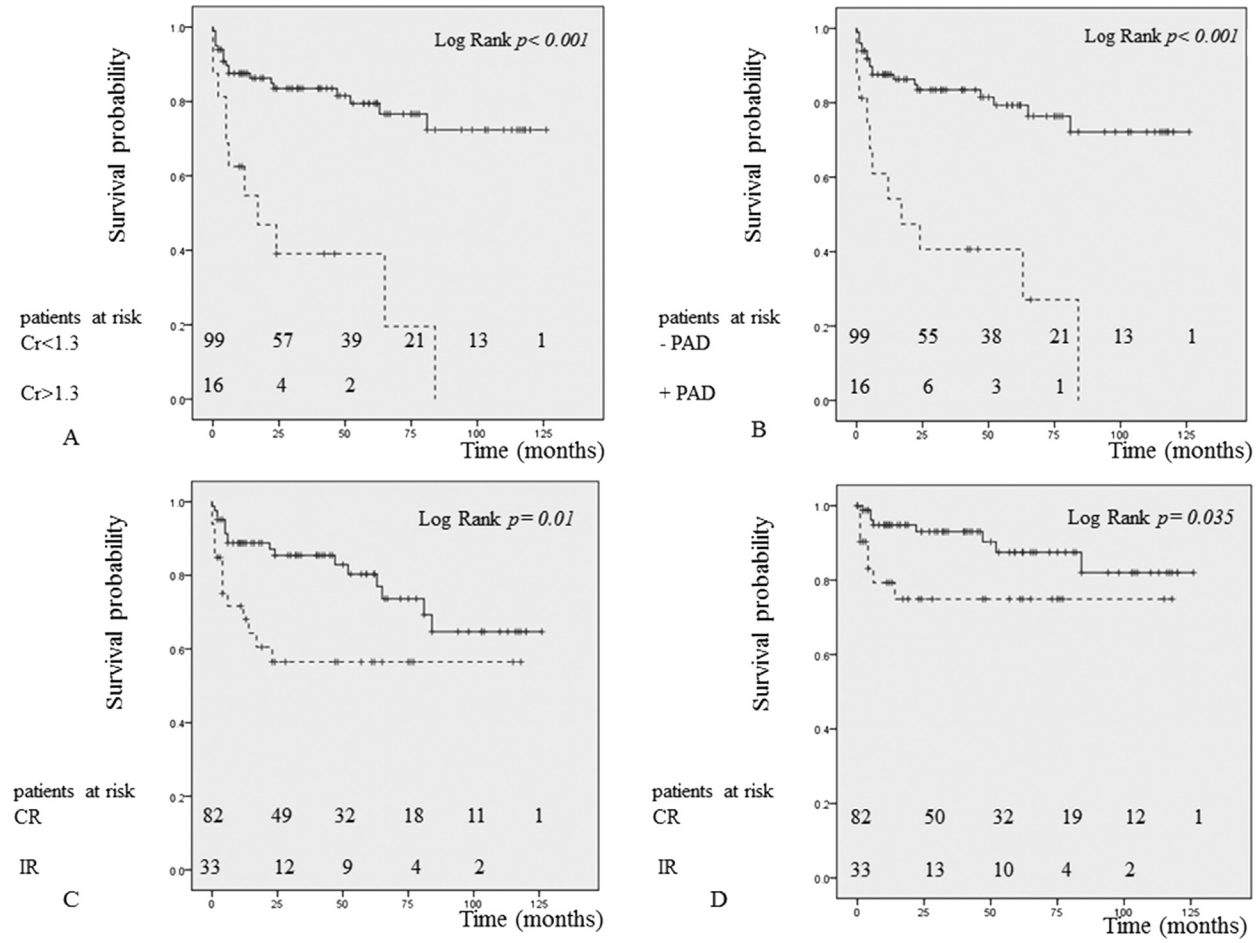

Fig 2. (A) Major adverse cardiac and cerebrovascular events (MACCE)-free survival curves (Kaplan-Meier) of the patients with (dashed line) versus patients without (solid line) preoperative renal impairment. (B) MACCE-free survival curves of the patients with (dashed line) versus patients without (solid line) peripheral arterial disease (PAD). (C) MACCE-free survival curves of the patients with (solid line) versus patients without (dashed line) complete surgical revascularization (CR). (D) Reintervention-free survival curves of the patients with (solid line) versus patients without (dashed line) complete surgical revascularization. (Cr = creatinine; IR = incomplete revascularization.)

mortality (survival, 85.4% at 7 years) benefit for OPCABG in unstable angina and non–ST-segment elevation myocardial infarction patients with unknown incident rate of preoperative IABP support. Conversely, Hemo and colleagues [5] reported a study with conflicting results of emergency CABG (OPCABG, 24.6%) in ACS patients preoperatively on IABP support (cardiogenic shock, 8.4%); they observed significantly decreased operative and late survival with OPCABG (early mortality, 18.9%; actuarial 10-year survival 23.6%, versus 67.4% for ONCABG) [5].

In Japan, with evolving techniques and accumulated experience, OPCABG was performed in 60.2% of all CABG cases according to the 2012 nationwide survey [8]; and correspondingly, we have had a default policy of OPCABG even in emergent situations, provided patients' hemodynamic stability allows for avoidance of cardiopulmonary bypass. For reference, we performed emergency or urgent attempted OPCABG for 52 ACS patients who did not need preoperative IABP support during the study period (median age 67.5 years; median European System for Cardiac Operative Risk [EuroSCORE] II, 2.63). There were 2 redo cases with previous CABG and 2 cases with intraoperative conversion to ONCABG. There was no perioperative mortality, and the rates of complete revascularization and of ITA use were 82.7% (43 of 52) and 86.5% (45 of 52), respectively. The Kaplan-Meier 5-year survival was 86.4%. During the same period, 22 ACS patients (median age 70 years; cardiogenic shock, 27.3% [6 of 22]; preoperative IABP or mechanical circulatory support, 68.2% [15 of 22]; median EuroSCORE II, 25.6) underwent preoperatively decided ONCABG, among whom 7 patients underwent concomitant procedures including valve surgery. The rates of complete revascularization and of ITA use were 72.7% (16 of 22) and 45.5% (10 of 22), respectively. Inhospital mortality was 22.7% (5 of 22), and 8 patients died of cardiopulmonary cause within 1 year. The Kaplan-Meier 5-year survival was 49.0%.

Immediate Outcome

The immediate postoperative outcome was acceptable, with 3 inhospital deaths. Preoperative renal impairment had a negative impact on perioperative mortality and morbidity, which is in line with the literature [9]. Conversely, the ITA to LAD grafting had a positive effect on preventing perioperative death and complications, for which a possible reason could be that the patients relatively stable enough on IABP to allow for sufficient time for harvesting the ITA tended to have a favorable postoperative course, considering that nearly half of the cardiogenic shock patients had no ITA to LAD grafting.

Late Outcome

The long-term outcome was also encouraging, with a survival rate of 83.3% at 5 years and 73.5% at 10 years, demonstrating OPCABG had not only immediate but also late survival benefit for patients with ACS necessitating IABP compared with the studies in previous literature [2, 5, 10, 11]. Cox regression analysis disclosed preoperative renal impairment and low ejection fraction were the adverse prognostic factors for late survival, a finding in concordance with a previously published study [2]. Preoperative renal dysfunction was also a significant risk predictor of late MACCE. The association of preoperative renal dysfunction and early and late adverse outcomes in cardiac surgery has been discussed in numerous studies in the literature. Even mild renal dysfunction (serum creatinine 1.2 to 2.2 mg/dL, estimated glomerular filtration rate less than 60 mL $\cdot$ min^{-1} $\cdot$ 1.73 m^{-2}) could lead to poor outcomes after cardiac surgery [9, 12]. Moreover, the negative impact of chronic kidney disease on long-term survival was reported to be prominent in ACS patients undergoing either emergent PCI or CABG [13]. OPCABG could mitigate renal damage by avoiding the unfavorable effects of cardiopulmonary bypass on kidney function; however, preoperative renal impairment adversely affected the late outcome even in OPCABG patients [14], which is in agreement with our results. In addition, peripheral arterial disease was also identified as an independent risk predictor of late MACCE in the present study. It is well known that peripheral arterial disease could represent global vasculopathy, which has an adverse effect not only on operative survival but also on late survival [15].

Regarding repeat reintervention, few reports are available on late repeat revascularization after emergency OPCABG in ACS patients preoperatively on IABP support [3, 11, 16]. In the present study, reintervention-free survival (84.2% at 5 years and 79.5% at 10 years) was comparable with the OPCABG analyses in the earlier literature [11, 17]; and preoperative history of PCI emerged as the multivariate risk factor for repeat revascularization after OPCABG during follow-up. Approximately 30% of the patients had a history of single or multiple PCIs, which seemed to be a higher prevalent rate compared with the studies from Western countries [1, 2, 5, 18]. Biancari and colleagues [18] reported prior history of PCI was associated with an increased risk of immediate postoperative morbidity and mortality in their metaanalysis; however, our result showed prior PCI had no statistically significant adverse effect on early outcomes. Instead, it was one of the independent risk factors for late repeat revascularization, which could translate into more diffuse and complex coronary artery disease in the study population. In our study, incomplete revascularization also increased the risk of repeat revascularization. The completeness of revascularization was 71.3%, which seemed less than desirable; however, 9 patients (7.8%) had diminutive targets or the targets were in nonviable territories, which were considered ungraftable or not worth grafting before surgery.

Numerous previous studies have documented higher rates of incomplete revascularization and subsequent reintervention in elective OPCABG compared with ONCABG, and the concern seems to be raised all the more in acute settings. OPCABG in ACS patients was reportedly associated with fewer grafts and less complete revascularization than ONCABG; however, there was no documented difference in late reintervention rate [3, 16]. Conversely, fewer grafts resulted in higher late reintervention rates and worse late survival in other reports; however, the investigators did not clearly describe the relationship between the graft number and completeness of revascularization [5, 17]. In our analysis, completeness of revascularization was found to be a favorable prognostic factor for preventing late MACCE, including repeat revascularization. We, therefore, speculate that complete revascularization is a matter of importance for the long-term outcomes rather than the number of bypass grafts. In our experience, the majority of repeat PCI was performed within the initial 6 months after surgery to compensate for the incompleteness of surgical revascularization. We think the complete revascularization consequent to an immediate postoperative complementary PCI might be acceptable for patients with incomplete surgical revascularization in this emergent situation.

The main limitation of the present study is its retrospective, observational nature of a single center's experience with a small number of cases. Moreover, various selection biases could have been involved. Even the use of multivariate models would not have been able to exclude the possibility of other confounders that were not considered in the analyses. Furthermore, our report is a descriptive study and does not include detailed comparison of OPCABG results with those of ONCABG. In addition, angiographic data were not available; therefore, we could not determine the relationship between true graft patency and the late outcomes. Our data must be interpreted cautiously because the generalizability of the outcomes is limited as it is from a single center with more than average experience in OPCABG.

In conclusion, OPCABG is a feasible option for high-risk ACS patients, considering its immediate postoperative survival benefit even when potentially fewer grafts and lower rate of complete revascularization are taken into account. Complete revascularization is

indisputably a major goal in CABG; however, the tradeoff of reasonable incomplete revascularization followed by complementary PCI might be justified for the operative mortality benefit in ACS patients requiring preoperative IABP support. Moreover, the importance of an ITA graft is emphasized, considering not only its proven favorable effect on long-term results, but also its negative impact on early postoperative outcome by not using this graft, as shown in the present analysis. Therefore, even in case of reasonable incomplete revascularization, ITA use is crucial to improve operative results of emergency OPCABG.

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