Effect of Multiple Prior Percutaneous Coronary Interventions on Outcomes After Coronary Artery Bypass Grafting

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Background: The effect of multiple prior percutaneous coronary interventions (PCIs) before subsequent coronary artery bypass grafting (CABG) on long-term outcomes has not been well elucidated.

Methods and Results: Between 2007 and 2016, 1,154 patients undergoing primary isolated CABG in our institution had no prior PCI (Group N), 225 had a single prior PCI (Group S), and 272 had multiple prior PCIs (Group M). Cumulative incidences of all-cause death, cardiac death and myocardial infarction (MI) at 10 years post-CABG were highest in Group M. After adjusting for confounders, the risk of all-cause death was higher in Group M than in Group N (hazard ratio [HR] 1.45; 95% confidence interval [CI], 1.10–1.91; $P < 0.01$). Between Groups N and S, however, the risk of all-cause death was not different. The risks of cardiac death and MI were likewise higher in Group M than in Group N (HR, 2.39; 95% CI, 1.55–3.71; $P < 0.01$ and HR, 3.65; 95% CI, 1.16–11.5; $P = 0.03$, respectively), but not different between Groups N and S. The risk of repeat revascularization was not different among any of the groups.

Conclusions: Multiple prior PCIs was associated with higher risks of long-term death and cardiovascular events. The incidence of repeat revascularization after CABG was low regardless of the history of single/multiple PCIs.

Key Words: Coronary artery bypass grafting; Coronary artery disease; Percutaneous coronary intervention

Since the introduction of drug-eluting stents (DES), the worldwide incidence of percutaneous coronary intervention (PCI) with initial and repeated therapy for coronary artery disease (CAD) has rapidly increased. As the frequency of PCI has increased, the numbers of patients who are referred for coronary artery bypass grafting (CABG) after multiple prior PCIs have also increased. According to the Society of Thoracic Surgeons 2018 Adult Cardiac Surgery Database, 28.9% of patients who underwent isolated CABG had prior histories of PCIs.¹ This figure is larger than that reported a decade previously, and the numbers of patients with multiple prior PCIs are likely to continue to increase in future. A possible adverse effect of prior PCI on early and mid-term outcomes after subsequent CABG has been reported,^{2–4} but the question of whether multiple prior PCIs might also influence long-term outcomes after subsequent CABG has not been thoroughly explored. As investigators in most previous reports have divided patients into 2 groups, those with and those without prior PCI, the effect of multiple prior PCIs has not been clearly distinguished from that of a single prior PCI. Thus, the aim of our study was to investigate the effect of

multiple prior PCIs on long-term outcomes after subsequent CABG.

Methods

Study Population

This study was a retrospective single-center cohort study. This study was approved by the institutional review board of Kokura Memorial Hospital. A total of 1,708 patients underwent primary CABG at our institution between January 2007 and December 2016. Patients with a history of prior CABG (7 patients), cardiogenic shock complicating acute myocardial infarction (MI) or PCI failure (20 patients), and concomitant mitral valve surgery for ischemic mitral regurgitation (30 patients) were excluded. Overall, 1,651 patients were included in this study. Patients were divided into 3 groups according to whether they had no prior PCI procedures (Group N, $n = 1,154$ [69.9%]), a successful single prior PCI procedure (Group S, $n = 225$ [13.6%]) or multiple prior PCI procedures (Group M, $n = 272$ [16.5%]) before CABG (among the 30 patients excluded due to concomitant mitral valve surgery for ischemic mitral

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Table 1. Patient Clinical Characteristics

Variables	Group N (n=1,154)	Group S (n=225)	Group M (n=272)	P value
Age, years	69±9.3	69±9.7	68±8.9	0.17
Gender				
Male	861 (74.6)	177 (78.7)	215 (79.0)	0.18
Female	293 (25.4)	48 (21.3)	57 (21.0)	0.18
Body mass index (kg/m ²)	24±3.5	24±2.9	24±3.4	0.33
BMI >25	403 (34.9)	83 (36.9)	112 (41.2)	0.15
BMI <18.5	50 (4.3)	5 (2.2)	8 (2.9)	0.23
Hypertension	919 (79.6)	181 (80.4)	229 (84.2)	0.23
Dyslipidemia	781 (67.7)	159 (70.7)	201 (73.9)	0.12
Diabetes mellitus	606 (52.5)	101 (44.9)	153 (56.3)	0.04
Diabetes with insulin	179 (15.5)	30 (13.3)	41 (15.1)	0.71
Renal disease				
Serum creatinine (mg/dL)	1.5±2.0	1.5±2.0	2.3±3.0	<0.01
Estimated GFR (mL/min/1.73 m ²)	59±24	57±23	51±27	<0.01
Chronic kidney disease	545 (47.2)	114 (50.7)	163 (59.9)	<0.01
Hemodialysis	86 (7.5)	17 (7.6)	43 (15.8)	<0.01
Prior stroke	201 (17.4)	35 (15.6)	46 (16.9)	0.79
Prior myocardial infarction	254 (22.0)	91 (40.4)	87 (32.0)	<0.01
Congestive heart failure	180 (15.6)	29 (12.9)	37 (13.6)	0.47
Unstable angina	333 (28.9)	59 (26.2)	74 (27.2)	0.67
Preoperative IABP	144 (12.5)	18 (8.0)	23 (8.5)	0.04
Urgency of procedure				
Elective	945 (81.9)	193 (85.8)	233 (85.7)	0.16
Urgent	64 (5.5)	13 (5.8)	16 (5.9)	0.97
Emergency	145 (12.6)	19 (8.4)	23 (8.5)	0.05
Smoking status				
Ex-smoker	620 (53.7)	135 (60.0)	149 (54.8)	0.22
Current smoker	231 (20.0)	45 (20.0)	34 (12.5)	0.02
Chronic lung disease	55 (4.8)	9 (4.0)	12 (4.4)	0.87
Peripheral artery disease	125 (10.8)	30 (13.3)	40 (14.7)	0.15
Atrial fibrillation	29 (2.5)	8 (3.6)	8 (2.9)	0.66
Ejection fraction (%)	57±14	57±14	54±14	<0.01
Left ventricular systolic dysfunction	193 (16.7)	32 (14.2)	53 (19.5)	0.29
CCS angina status				
I	311 (26.9)	75 (33.3)	59 (21.7)	0.01
II	536 (46.4)	105 (46.7)	145 (53.3)	0.12
III	177 (15.3)	32 (14.2)	42 (15.4)	0.91
IV	130 (11.3)	13 (5.8)	26 (9.6)	0.04
NYHA functional class				
I	656 (56.8)	140 (62.2)	155 (57.0)	0.32
II	341 (29.5)	68 (30.2)	89 (32.7)	0.59
III	91 (7.9)	9 (4.0)	12 (4.4)	0.03
IV	66 (5.7)	8 (3.6)	16 (5.9)	0.40

Data are presented as number (%) or mean ± standard deviation. Group N, no prior percutaneous coronary intervention (PCI); Group S, single prior PCI; Group M, multiple prior PCIs. CCS, Canadian Cardiovascular Society; GFR, glomerular filtration rate; IABP, intra-aortic balloon pumping; NYHA, New York Heart Association.

regurgitation, 15 patients had no prior PCI, 6 patients had a single PCI, and 9 patients had multiple prior PCIs before CABG). There was no patient undergoing CABG with left ventricular reconstruction. Before the operation, each patient granted permission for the use of his/her medical records for research purposes and written informed consent was obtained.

Data Collection and Definitions

Demographic, angiographic and procedural data were collected from hospital charts and databases. Follow-up data were obtained through either review of hospital records or a scripted telephone interview with referring physicians and patients.

Baseline patient characteristics such as hypertension, dyslipidemia, diabetes mellitus, smoking status, prior MI, congestive heart failure, atrial fibrillation, and chronic lung

Variables	Group N (n=1,154)	Group S (n=225)	Group M (n=272)	P value
Number of PCIs	0	1	3.6±2.1	<0.01
Extent of CAD				
Left main disease	488 (42.3)	104 (46.2)	135 (49.6)	0.07
3 vessel disease	799 (69.2)	122 (54.2)	143 (52.6)	<0.01
2 vessel disease	259 (22.4)	80 (35.6)	96 (35.3)	<0.01
1 vessel disease	63 (5.5)	17 (7.6)	22 (8.1)	0.18
Stent type				<0.01
BMS	0	132 (58.7)	176 (64.7)	
DES	0	70 (31.1)	162 (59.6)	
Both BMS+DES	0	0	71 (26.1)	
Unreported	0	23 (10.2)	6 (2.2)	
Target vessels of prior PCI				<0.01
Left descending artery	0	77 (34.2)	208 (76.5)	
Left circumflex artery	0	33 (14.7)	153 (56.3)	
Right coronary artery	0	110 (48.9)	193 (71.0)	
Left main trunk	0	5 (2.2)	11 (4.0)	
Indication for CABG				<0.01
In-stent restenosis	0	41 (18.2)	138 (50.7)	
De novo stenosis	0	205 (91.1)	214 (78.7)	
Combined	0	21 (9.3)	70 (25.7)	
Interval from initial PCI to CABG	—	4.1±5.6	8.0±6.9	<0.01

Data are presented as number (%) or mean±standard deviation. Group N, no prior PCI; Group S, single prior PCI; Group M, multiple prior PCIs. BMS, bare metal stent; CABG, coronary artery bypass grafting; CAD, coronary artery disease; DES, drug-eluting stent; PCI, percutaneous coronary intervention.

disease were regarded as present when these diagnoses were recorded in the hospital charts or databases. Prior stroke was regarded as present when the diagnosis was made by a consultant neurologist. Peripheral artery disease was regarded as present even if it had already been treated by surgical or endovascular interventions. Chronic kidney disease was regarded as present when creatinine clearance, estimated according to the Cockcroft-Gault formula, was <60 mL/min. Left ventricular ejection fraction (LVEF) was measured by echocardiography. The experienced operators in our institution performed M-mode and/or 2-dimensional echocardiography; M-mode LVEF was calculated using the Teichholz correction and 2-dimensional echocardiographic LVEF was measured by using the Simpson biplane method. Patients with LVEF <40% were considered to have LV systolic dysfunction.

Cardiac death was defined as any cardiac-related or sudden death. MI was defined according to the Fourth Universal Definition of Myocardial Infarction (2018). Stroke was defined as hemorrhagic or ischemic stroke requiring hospitalization. Traumatic stroke was excluded. Repeat revascularization was defined as revascularization including PCI or re-CABG because of ischemic symptoms or electrocardiographic changes.

Study Endpoints

Early Outcomes We investigated operative mortality and major morbidity. Operative mortality was defined as death occurring within 30 days after the operation or any death during the index hospitalization. Major morbidity was defined as stroke within 30 days after the operation, reoperation for bleeding and deep sternal infection.

Long-Term Outcomes The primary endpoint was all-cause

death. The secondary endpoints were cardiac death, MI, and repeat coronary revascularization.

Statistical Analyses

Data are presented as values, percentages and mean±standard deviation (SD). Regarding the baseline characteristics, categorical variables among the 3 groups were compared using a chi-squared test. Also, continuous variables among the 3 groups were compared using an ANOVA test.

After the descriptive statistics, cumulative incidence was estimated by using the Kaplan-Meier method, and differences were assessed with the log-rank test. Data on patients who were lost to follow up were censored. We used multivariate Cox proportional hazards models to assess the effects of multiple prior PCIs on death and cardiovascular events. Cox proportional hazards models were adjusted for the following confounders: age, gender, body mass index, hypertension, dyslipidemia, diabetes mellitus, chronic kidney disease, hemodialysis, prior stroke, prior MI, congestive heart failure, unstable angina, preoperative intra-aortic balloon pumping, urgency of procedure, smoking status, chronic lung disease, peripheral artery disease, atrial fibrillation, left ventricular systolic dysfunction, left main disease, 3-vessel disease, 2-vessel disease, 1-vessel disease, CCS 3–4, and NYHA 3–4. We calculated the hazard ratios (HRs) of Group M and Group S for Group N, considering the clinical importance and bias of baseline characteristics comprehensively.

Statistical analyses were performed using SPSS software version 24.0 (IBM Corporation, NY, USA). The authors had full access to the data and take responsibility for its integrity.

Table 3. Intraoperative Characteristics

Variables	Group N (n=1,154)	Group S (n=225)	Group M (n=272)	P value
Operation				
Off-pump CABG	1,121 (97.1)	216 (96.0)	269 (98.9)	0.13
On-pump beating CABG	32 (2.8)	8 (3.6)	3 (1.1)	0.19
On-pump CABG	1 (0.1)	1 (0.4)	0 (0)	0.30
Use of intrathoracic artery				
Bilateral	396 (34.3)	91 (40.4)	102 (37.5)	0.17
Single	714 (61.9)	128 (56.9)	164 (60.3)	0.36
None	44 (3.8)	6 (2.7)	7 (2.6)	0.43
Use of right gastroepiploic artery	114 (9.9)	30 (13.3)	17 (6.3)	0.03
Distal anastomoses (n)	3.2±1.0	3.0±1.0	2.8±0.9	<0.01

Data are presented as number (%) or mean ± standard deviation. Group N, no prior percutaneous coronary intervention (PCI); Group S, single prior PCI; Group M, multiple prior PCIs. CABG, coronary artery bypass grafting.

Table 4. Postoperative Outcomes

Outcomes	Group N (n=1,154)	Group S (n=225)	Group M (n=272)	P value
Operative mortality	11 (1.0)	2 (0.9)	5 (1.8)	0.43
Reoperation for bleeding	5 (0.4)	2 (0.9)	2 (0.7)	0.63
Postoperative stroke	5 (0.4)	4 (1.8)	3 (1.1)	0.12
Deep sternal infection	14 (1.2)	2 (0.9)	7 (2.6)	0.18

Data are presented as number (%). Group N, no prior percutaneous coronary intervention (PCI); Group S, single prior PCI; Group M, multiple prior PCIs.

Results

Baseline Patient Characteristics

Preoperative patient clinical characteristics in each of the 3 groups are shown in **Table 1**. Chronic kidney disease and hemodialysis were more often found in Group M (Group N: 47.2%, Group S: 50.7%, and Group M: 59.9% for chronic kidney disease [$P<0.01$] and Group N: 7.5%, Group S: 7.6%, and Group M: 15.8% for hemodialysis [$P<0.01$]). The proportion of patients with prior MI was highest in Group S (Group N: 22.0%, Group S: 40.4%, and Group M: 32.0%, $P<0.01$). Sixty patients (26.7%) in Group S had received an emergency single PCI due to acute coronary syndrome (ACS). After treatment for ACS, they were referred for CABG due to the revascularization of the remaining coronary lesions. Ejection fraction was lowest in Group M (Group N: $57\pm 14\%$, Group S: $57\pm 14\%$, and Group M: $54\pm 14\%$, $P<0.01$).

Angiographic and operative characteristics are shown in **Table 2** and **Table 3**, respectively. The mean number of sessions of PCI before CABG in Group M was 3.6 ± 2.1 (range: 2–13). Regarding the indication for CABG, patients in Group M were more likely to have in-stent restenosis or a combination of de novo stenosis and in-stent restenosis ($P<0.01$). Patients in Group M were less likely to have bypass grafts than those in Group N or Group S (Group N: 3.2 ± 1.0 , Group S: 3.0 ± 1.0 , Group M: 2.8 ± 0.9 , $P<0.01$).

Early Outcome

Postoperative outcomes are shown in **Table 4**. Unadjusted operative mortality was comparable among the 3 groups (Group N: 1.0%, Group S: 0.9%, Group M: 1.8%, $P=0.43$). Similarly, the incidences of reoperation for bleeding, post-

operative stroke and deep sternal infection were comparable among the 3 groups (Group N: 0.4%, Group S: 0.9% and Group M: 0.7% for reoperation for bleeding ($P=0.63$), 0.4%, 1.8% and 1.1% for stroke ($P=0.12$), and 1.2%, 0.9% and 2.6% for deep sternal infection ($P=0.18$), respectively.

Long-Term Outcome

Clinical follow up was completed in 98%. Overall, 22 patients (1.9%) in Group N, 6 patients (2.6%) in Group S and 3 patients (1.1%) of group M were lost to follow up. The median follow-up duration was 8.0 years. Kaplan-Meier analysis showed that the cumulative incidence of all-cause death at 10 years post-CABG was highest in Group M (16.9%, 15.6%, and 26.1% for Groups N, S, and M, respectively, $P<0.01$) (**Figure**). Similarly, the cumulative incidences of cardiac death and MI at 10 years were highest in Group M (4.9%, 4.9%, and 12.9% for cardiac death, respectively, $P<0.01$; and 0.5%, 0.4%, and 2.6% for MI, respectively, $P<0.01$). In contrast, the incidence of repeat revascularization was similar among the groups (8.9%, 7.1%, and 11.4%, respectively, $P=0.09$).

Multivariate Analysis by Cox Proportional Hazards Models

The likelihood of all-cause death was higher in Group M than in Group N (HR 1.45; 95% confidence interval [CI], 1.10–1.91; $P<0.01$) (**Table 5**). Between Group N and Group S, in contrast, the likelihood of all-cause death was not different (HR, 0.87; 95% CI, 0.61–1.26; $P=0.47$). In addition, the likelihood of cardiac death and MI were higher in Group M than in Group N (HR, 2.39; 95% CI, 1.55–3.71; $P<0.01$ for cardiac death and HR, 3.65; 95% CI, 1.15–11.5; $P=0.03$ for MI). Between Groups N and S, however, the likelihood of cardiac death and MI were not

Figure. Kaplan-Meier analysis for cumulative incidences of: (A) all-cause death; (B) cardiac death; (C) myocardial infarction; and (D) repeat revascularization.

Table 5. Multivariate Analysis by Cox Proportional Hazard Models

Outcome	HR	P value	95% CI
All-cause death			
Group N	Ref.	Ref.	Ref.
Group S	0.87	0.47	0.61–1.26
Group M	1.45	<0.01	1.10–1.91
Cardiac death			
Group N	Ref.	Ref.	Ref.
Group S	0.85	0.63	0.44–1.65
Group M	2.39	<0.01	1.55–3.71
MI			
Group N	Ref.	Ref.	Ref.
Group S	0.74	0.78	0.09–6.40
Group M	3.65	0.03	1.15–11.5
Repeat revascularization			
Group N	Ref.	Ref.	Ref.
Group S	1.12	0.47	0.73–1.96
Group M	1.47	0.08	0.96–2.23

CI, confidence interval; HR, hazard ratio; MI, myocardial infarction. Group N, no prior percutaneous coronary intervention (PCI); Group S, single prior PCI; Group M, multiple prior PCIs. Adjusted for the following confounders: age, gender, body mass index, hypertension, dyslipidemia, diabetes mellitus, chronic kidney disease, hemodialysis, prior stroke, prior MI, congestive heart failure, unstable angina, preoperative intra-aortic balloon pumping, urgency of procedure, smoking status, chronic lung disease, peripheral artery disease, atrial fibrillation, left ventricular systolic dysfunction, left main disease, 3-vessel disease, 2-vessel disease, 1-vessel disease, Canadian Cardiovascular Society (CCS) 3–4, New York Heart Association (NYHA) 3–4.

Table 6. Causes of Death After CABG

Causes of death	Group N	Group S	Group M
Hospital death (total)			
Infection	6 (3.0)	0 (0)	4 (5.6)
Sudden death	3 (1.5)	0 (0)	0 (0)
Aorta related	1 (0.5)	1 (2.7)	0 (0)
Heart failure	1 (0.5)	1 (2.7)	1 (1.4)
Cardiac death (total)			
Sudden death	25 (12)	5 (14)	13 (18)
Heart failure	10 (5.0)	2 (5.6)	10 (14)
Myocardial infarction	5 (2.5)	1 (2.7)	7 (9.7)
Ventricular arrhythmia	3 (1.5)	1 (2.7)	2 (2.8)
Non-cardiac death (total)			
Malignancy	40 (20)	3 (8.3)	10 (14)
Respiratory failure	6 (5.0)	6 (17)	5 (6.9)
Infection	30 (15)	7 (19)	7 (9.7)
Cerebrovascular	14 (6.9)	0 (0)	2 (2.8)
Trauma	5 (2.5)	0 (0)	0 (0)
Renal failure	4 (2.0)	2 (5.6)	0 (0)
Liver failure	2 (1.0)	0 (0)	0 (0)
Aortic aneurysm/dissection	4 (2.0)	0 (0)	0 (0)
Gastrointestinal	6 (3.0)	1 (2.7)	1 (1.4)
Others	13 (6.4)	1 (2.7)	3 (4.2)
Unknown	24 (12)	5 (14)	7 (9.7)

Data are presented as n (%). Group N, no prior percutaneous coronary intervention (PCI); Group S, single prior PCI; Group M, multiple prior PCIs.

different (HR, 0.85; 95% CI, 0.44–1.65; $P=0.63$ and HR, 0.74; 95% CI, 0.09–6.40; $P=0.78$). The risk of repeat revascularization was not different among the groups (HR, 1.12; 95% CI, 0.73–1.96, $P=0.47$ for Groups N and S, and HR, 1.47; 95% CI, 0.96–2.23, $P=0.08$ for Groups N and M).

Cause of Death

During follow up, 310 patients died; the causes of death are shown according to group in **Table 6**. The specific causes for non-cardiac death included cerebrovascular disease, respiratory failure and renal failure.

Discussion

We showed a significantly increased long-term risk of death and cardiovascular events in patients with multiple prior PCIs who subsequently underwent primary isolated CABG.

PCI is considered the standard first-line treatment for ischemic heart disease. As new PCI techniques and devices such as drug-coated balloons (DCB) are still being developed, the average number of rounds of PCI that each patient has undergone continues to increase; in many cases, each PCI was performed with a different device.^{5,6} The number of patients with multiple prior PCI before CABG will probably increase in future.

Previous studies have reported an adverse effect of prior PCI before CABG on early and mid-term clinical outcomes. Kinoshita et al, for example, have reported higher rates of surgical mortality in patients who had previous PCI (7.6% vs. 1.0%, $P=0.008$).² Thielmann et al has reported that patients with multiple prior PCIs undergoing CABG have a significantly increased risk for in-hospital mortality (adjusted OR, 3.01; 95% CI, 1.51–5.98; $P<0.0017$) and major adverse cardiac events (adjusted OR, 2.31; 95% CI, 1.45–3.67; $P<0.0004$).³ Similarly, Massoudy et al have shown in a multicenter analysis that a history of multiple previous PCIs increased in-hospital mortality (adjusted OR, 1.9; CI, 1.3–2.7; $P=0.0016$) and the incidence of major adverse cardiac events after subsequent CABG (adjusted OR, 1.5; CI, 1.2–1.9; $P=0.0019$).⁴

Regarding long-term outcomes, Mannacio et al have demonstrated that a history of PCI before CABG decreased survival at 5 years' follow up. They reported that survival at 3 and 5 years was lower in patients with previous PCI than in no-PCI patients ($97.4\pm0.01\%$ vs. $96.5\pm0.02\%$ and $94.2\pm0.03\%$ vs. $92.1\pm0.05\%$; $P=0.03$).⁷

In contrast, several other studies have found no differences in early and mid-term mortality or cardiovascular events between patients undergoing CABG with and without prior PCI. More recently, Biancari et al reported that a history of multiple prior PCIs was not associated with an increased risk of early adverse events in patients undergoing isolated CABG.⁸ Regarding long-term outcomes, Fukui et al found that the survival rate at 7 years post-CABG was not different between the stent and no-stent groups ($87.2\pm3.2\%$ vs. $84.8\pm2.9\%$, $P=0.47$), and that the 2 groups had similar rates of freedom from major adverse cardiac and cerebrovascular events at 7 years post-CABG ($78.9\pm3.8\%$ vs. $77.6\pm3.3\%$, $P=0.81$).⁹ In these studies, it should be noted that investigators divided patients into 2 groups, a group who had received and a group who had not received prior PCI. In our study, in contrast, we divided patients into 3 groups: a no prior PCI group, a single prior PCI group and a multiple prior PCIs group. We found

comparable risks of all-cause death and cardiovascular events between the no prior PCI group and the single prior PCI group. Taken together with previous findings, our results may suggest that multiple prior PCIs is associated with higher risks of long-term death and cardiovascular events, whereas a single prior PCI is not.

The reasons for the adverse effects of multiple prior PCIs on outcomes have not been clarified, but several possible influences of PCI have been considered. First, multiple coronary stents might cause coronary endothelial injury with intimal hyperplasia and stimulation of platelet and neutrophil adhesion, leading to decreased graft patency.^{10,11} In addition, the use of cardiopulmonary bypass might amplify inflammatory reactions locally and/or systemically.^{10,11} Second, multiple coronary stents may cause more distant anastomosis of target vessels. In cases of in-situ arterial grafting, we have no choice but to use a more distal site for the arterial graft. This might affect coronary run-off and the patency rate of the bypass grafts.³

In our study, preoperative LVEF was lowest in Group N. One possible reason for this is that multiple prior PCI can cause side-branch obstruction, leading to compromised collateral blood flow and myocardial injury. However, a subset of patients in the Group M had high operative risk, and in such 'high-risk' patients, PCI is sometimes inevitable even if CABG would be preferable. In the 2018 European Society of Cardiology/European Association for Cardio-Thoracic Surgery Guidelines on myocardial revascularization, repeat PCI is recommended as the first-line treatment for recurrent ischemia after PCI; In contrast, in patients with recurrent episodes of diffuse in-stent restenosis in large vessels – and in those with associated multivessel disease, especially in the presence of other complex lesions such as chronic total occlusions – CABG should be considered before a new PCI attempt.¹² In every case, the operating institution's Heart Team should carefully evaluate the choice between CABG and PCI.

Study Limitations

Our study has several limitations. First, this study was a retrospective and observational study at a single center. Therefore, selection bias might exist. Second, some potentially relevant data such as SYNTAX score and graft patency were not collected from all patients and so were not included in this study. These data might have had some influence on the outcomes. Third, patients with LV systolic dysfunction sometimes have concurrent ischemic mitral regurgitations. Patients who underwent concomitant mitral valve surgeries were not enrolled in the present study. In future, we must consider a study design including patients with ischemic mitral regurgitations.

Conclusions

Postoperative mortality after CABG was not different among patients with no prior PCI, single prior PCI and multiple prior PCIs. Long-term, however, multiple prior PCIs were associated with higher risks of death and cardiovascular events after the perioperative period. The incidence of repeat revascularization after CABG was low regardless of the history of single/multiple PCI.

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The authors did not receive any funding for this study.

Disclosures

The authors have no conflicts of interest to declare.

IRB Information

This study was approved by the institutional review board of Kokura Memorial Hospital (reference number: 20031201).

Data Availability

Due to the nature of this research, participants in this study did not agree for their data to be shared publicly, so supporting data is not available.

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