Original Article

The Influence of Previous Percutaneous Coronary Intervention in Patients Undergoing Off-Pump Coronary Artery Bypass Grafting

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Background: The aim of the present study was to compare the early outcomes of patients undergoing off-pump coronary artery bypass grafting (OPCAB) with and without previous percutaneous coronary intervention (PCI).
Patients and Methods: We retrospectively reviewed the records of 545 patients who underwent first-time isolated OPCAB from September 2004 to June 2007. Overall, 154 had previous PCIs, including 99 with stents. The number of diseased vessels was higher in patients without a PCI than in those with a PCI (2.8 vs. 2.7; p = 0.0311). Postoperative angiography was performed to assess the graft patency in 430 patients (78.9%).
Results: The number of anastomoses per patient was lower in PCI patients than in non-PCI patients (3.8 vs. 4.2; p = 0.0066). The operative mortality rates did not differ between these groups (0% vs. 1.8%; p = 0.1995); neither did the major morbidity rates. Similar results were obtained for the comparison of patients with stents and patients without PCIs. There was no significant difference in the graft patency rates between PCI patients and non-PCI patients (97.1% vs. 97.9%; p = 0.4976).
Conclusions: A previous PCI is not a predictor of early morbidity or mortality in patients undergoing OPCAB. Furthermore, the graft patency is not affected by a previous PCI.
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Key words: coronary artery bypass grafting, off-pump, stent

Introduction

Recently, the use of percutaneous coronary intervention (PCI) for the treatment of coronary artery disease has progressively increased. Therefore the number of patients undergoing coronary artery bypass grafting (CABG) in whom previous PCI procedures have been performed is also increasing. However, local and systemic inflammatory responses have been demonstrated after PCI, and these reactions may adversely affect the outcome after CABG.[1] Furthermore, because acute and chronic inflammatory reactions with involvement of the distal coronary artery and surrounding myocardium can be induced by the presence of an intracoronary stent,[2] the quality of the anastomosis between the coronary artery and the graft may be threatened. Although some investigators have demonstrated that previous PCIs did not result in higher postoperative mortality or morbidity rates after CABG,[3,4] other authors have reported that the perioperative risks for in-hospital

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Table 1. Preoperative characteristics of patients with and without previous percutaneous coronary intervention

	PCI	Non-PCI	p value
Number	154 (28.3%)	391 (71.7%)	
Age	68.6 ± 8.9	68.8 ± 9.1	0.7917
Sex, female	20 (13.0%)	90 (23.0%)	0.0121
Unstable angina	56 (36.4%)	134 (34.3%)	0.7174
Old myocardial infarction	97 (63.0%)	163 (41.7%)	<0.0001
CCS class	2.2 ± 1.0	2.3 ± 0.9	0.5159
Ejection fraction (%)	55.8 ± 11.8	56.4 ± 12.7	0.5874
Diseased vessel	2.7 ± 0.5	2.8 ± 0.5	0.0311
Left main	52 (33.8%)	140 (35.8%)	0.7268
Creatinine (mg/dl)	1.2 ± 1.6	1.2 ± 1.4	0.7350
CHF	25 (16.2%)	52 (13.3%)	0.4537
Hypertension	94 (61.0%)	269 (68.8%)	0.1034
Diabetes mellitus	79 (51.3%)	180 (46.0%)	0.3112
Insulin	20 (13.0%)	38 (9.7%)	0.3370
Hyperlipidemia	81 (52.6%)	244 (62.4%)	0.0451
Smoking	90 (58.4%)	222 (56.8%)	0.7967
Previous stroke	17 (11.0%)	50 (12.8%)	0.6780
Chronic renal failure	6 (3.9%)	15 (3.8%)	>0.9999
COPD	5 (3.3%)	21 (5.4%)	0.3754
Nonelective	19 (12.3%)	64 (16.4%)	0.3754

PCI, percutaneous coronary intervention; CCS, Canadian Cardiovascular Society; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

morbidity and mortality during CABG were increased in patients with a history of PCI.[5,6] However, none of the CABG procedures in these previous studies included a contemporary off-pump CABG (OPCAB) technique. Cardiopulmonary bypass also induces inflammatory responses.[7]

The aim of the present study was to compare the outcomes after CABG with a contemporary off-pump strategy in patients with and without previous PCIs. We also assessed whether the early graft patency was affected by previous PCIs with stents.

Patients and Methods

Patient population

From September 2004 to June 2007, a total of 554 patients underwent isolated OPCAB at the Sakakibara Heart Institute. After exclusion of 9 patients with a history of CABG, the study population comprised 545 patients. Among these patients, 154 (28.3%; PCI group) had had at least one previous PCI procedure, and 391 (71.7%; no PCI group) had undergone OPCAB as a first-time intervention for the treatment of coronary artery disease. The mean number of PCI procedures per patient was 1.5 ± 0.7. The median interval from the last PCI procedure to the CABG operation was 47 months (range, 1 day to 288 months).

All data were collected prospectively and reviewed retrospectively. The baseline characteristics of both groups are shown in Table 1. The PCI group had higher proportions of females ($p = 0.0121$) and old myocardial infarction ($p < 0.0001$). The mean number of diseased vessels was higher in the non-PCI group than in the PCI group ($p = 0.0311$).

The previous PCI procedures included balloon angioplasty, atherectomy, and stent implantation. Patients with bare-metal stents (BMSs) and drug-eluting stents (DESs) were included in this study. To evaluate the influence of implanted stents on clinical outcomes after CABG, we further divided the PCI patients into two subgroups, namely, patients with (stent group) and without (nonstent group) a stent. Data for the stent group were compared with those of the non-PCI group to investigate the pure influence of the stent itself (Table 2). The mean number of implanted stents was 1.6 ± 0.9 per patient, and the mean number of stent implantation procedures was 1.6 ± 0.8 per patient. The median interval from the last stent implantation to the CABG operation was 9 months (range, 1 day to 150 months).

The stent group had a higher proportion of old myocardial infarction ($p = 0.0003$). The mean number of diseased vessels was higher in the non-PCI group than in the stent

Table 2. Preoperative characteristics of patients with stents and patients without percutaneous coronary intervention

	Stent	Non-PCI	p value
Number	99	391	
Age	69.0 ± 9.1	68.8 ± 9.1	0.8356
Sex, female	19 (19.2%)	90 (23.0%)	0.4950
Unstable angina	36 (36.4%)	134 (34.3%)	0.7852
Old myocardial infarction	62 (62.6%)	163 (41.7%)	0.0003
CCS class	2.3 ± 1.0	2.3 ± 0.9	0.7624
Ejection fraction (%)	56.6 ± 11.6	56.4 ± 12.7	0.8837
Diseased vessel	2.6 ± 0.6	2.8 ± 0.5	0.0024
Left main	33 (33.3%)	140 (35.8%)	0.7323
Creatinine (mg/dl)	1.2 ± 1.7	1.2 ± 1.4	0.8949
CHF	18 (18.2%)	52 (13.3%)	0.2804
Hypertension	61 (61.6%)	269 (68.8%)	0.2145
Diabetes mellitus	49 (49.5%)	180 (46.0%)	0.6146
Insulin	14 (14.1%)	38 (9.7%)	0.2741
Hyperlipidemia	51 (51.5%)	244 (62.4%)	0.0626
Smoking	58 (58.6%)	222 (56.8%)	0.8328
Previous stroke	9 (9.1%)	50 (12.8%)	0.4027
Chronic renal failure	3 (3.0%)	15 (3.8%)	>0.9999
COPD	3 (3.0%)	21 (5.4%)	0.4819
Nonelective	10 (10.1%)	64 (16.4%)	0.1619

PCI, percutaneous coronary intervention; CCS, Canadian Cardiovascular Society; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

group ($p = 0.0024$). Other preoperative variables did not differ significantly.

Nonelective operations included both emergency and urgent statuses. Perioperative myocardial infarction was defined as a positive result for new Q waves in an electrocardiogram or a peak creatine kinase MB level of greater than 10% of the total creatine kinase. Low-output syndrome was defined as the need for adrenaline or greater than 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ of dopamine or dobutamine. Postoperative stroke was defined as a central neurological deficit persisting for more than 72 hours and was confirmed by computed tomography. In patients with preoperative stroke, postoperative stroke was defined as a worsening of the neurological deficit with new radiological findings. Postoperative renal insufficiency was defined as a new requirement for dialysis postoperatively. Patients who required a blood transfusion in the present study included those who received not only red blood cells, but also platelets and fresh-frozen plasma.

The study protocol was approved by our Institutional Review Committee, and informed consent was obtained from each patient with respect to the surgical method and postoperative angiography.

Operative method

Our strategy for isolated CABG was directed toward obtaining complete myocardial revascularization with an off-pump technique whenever feasible. The techniques were described previously.[8] All arterial grafts (left internal thoracic artery, right internal thoracic artery, radial artery, and gastroepiploic artery) were harvested in a skeletonized fashion using an ultrasonic scalpel (Harmonic Scalpel; Ethicon Endosurgery, Cincinnati, OH). Saphenous vein grafts were harvested with open methods. We bypassed all significantly diseased coronary vessels larger than 1 mm in diameter. If necessary, concomitant long segmental reconstruction of the left anterior descending artery with or without endarterectomy was performed in patients with a diffusely diseased left anterior descending artery.[8] Median sternotomy was performed in most patients. A minimally invasive direct coronary bypass procedure via a small left lateral thoracotomy was used in 3 patients with one-vessel disease. Deep pericardial stay sutures were not used, and a commercially available heart positioner and stabilizer were applied in all cases.

Angiographic study

Postoperative angiography was performed to assess graft patency in patients who gave informed consent and before

Table 3. Intraoperative and postoperative data of patients with and without previous percutaneous coronary intervention

	PCI	Non-PCI	p value
Anastomoses/patient	3.8 ± 1.3	4.2 ± 1.3	0.0066
Operation time (min)	264.9 ± 57.6	271.9 ± 60.1	0.2394
Transfusion	59 (38.3%)	152 (8.9%)	0.9808
In-hospital stay (days)	16.6 ± 9.4	16.3 ± 10.7	0.7435
Postoperative ejection fraction (%)	54.7 ± 11.4	56.0 ± 11.9	0.2713
Operative deaths	0	7 (1.8%)	0.1995
Reexploration due to bleeding	1 (0.6%)	5 (1.3%)	>0.9999
Low output syndrome	1 (0.6%)	11 (2.8%)	0.1936
POMI	3 (1.9%)	6 (1.5%)	0.7171
Atrial fibrillation	45 (29.2%)	116 (29.7%)	>0.9999
Respiratory failure	5 (3.2%)	12 (3.1%)	>0.9999
Requiring hemodialysis	4 (2.6%)	10 (2.6%)	>0.9999
Stroke	3 (1.9%)	6 (1.5%)	>0.9999
Mediastinitis	1 (0.6%)	4 (1.0%)	>0.9999

PCI, percutaneous coronary intervention; POMI, perioperative myocardial infarction.

discharge after a mean hospital stay of 9.9 ± 3.1 days after surgery. The angiographic studies were reviewed and evaluated by two cardiologists.

Statistical analysis

Continuous variables are reported as the mean ± standard deviation. Continuous variables were compared by Student's *t*-test and discrete variables by the χ^2 test or Fischer's exact test. Differences were considered significant at $p < 0.05$. Statistical analyses were performed using the StatView 5.0 software package (SAS Institute Inc., Cary, NC).

Results

Patient outcomes

There were 154 patients (28.3%) in the PCI group and 391 (71.7%) in the non-PCI group. The intraoperative and postoperative results are listed in Table 3. There was a significant difference in the number of anastomoses per patient between the PCI and the non-PCI groups (p = 0.0066). However, the operation times (p = 0.2394) and in-hospital stays (p = 0.7435) did not differ between the two groups. Furthermore, the operative mortality rates did not differ between these groups (0 in the PCI group vs. 1.8% in the non-PCI group; p = 0.1995); neither did the morbidity rates, including bleeding complications.

There were 99 patients (64.3%) with previous stent implantation in the PCI group. BMS alone was used in 77 patients and DES in 22. The intraoperative and postoperative results of the stent group are listed in Table 4. There was a significant difference in the number of anastomoses per patient between the stent and the non-PCI groups (p = 0.0010). There were no significant differences between these groups regarding postoperative complications.

When the variables of the patients with BMS and DES implants were compared, only the number of diseased vessels differed significantly (2.7 ± 0.5 vs. 2.4 ± 0.7; p = 0.0405) among the preoperative data. However, the difference in the numbers of anastomoses per patient did not reach statistical significance (3.8 ± 1.3 vs. 3.4 ± 1.4; p = 0.2246). Moreover, the rate of major postoperative complications did not differ significantly between the groups (11.7% vs. 4.5%; p = 0.4503).

Angiographic outcomes

Postoperative angiography was performed in 430 patients (78.9%). A total of 1,362 grafts (3.2 per patient) with 1,788 distal anastomoses (4.2 per patient) were evaluated. The overall patency rates for all grafts and all anastomoses were 97.7% and 97.6%. There was no significant difference in the graft patency rates between the PCI and non-PCI groups (97.3% vs. 97.9%; p = 0.6666). Furthermore, no significant difference was found in the patency rates for anastomoses between the PCI and the non-PCI groups (97.2% vs. 97.7%; p = 0.6875).

We evaluated the influence of previous stents on the patency of grafts anastomosed distal to the stented coronary artery. A total of 67 patients with previous stents received postoperative angiography for 258 distal anastomoses. Among them, 113 (43.8%) were performed distal to stents in the same vessels. The patency of these anastomoses was 96.5% and did not differ significantly from the patency of 145 anastomoses without a proximal stent (97.2%; p = 0.7327).

Table 4. Intraoperative and postoperative data of patients with stent and patients without percutaneous coronary intervention

	Stent	No PCI	p value
Anastomoses/patient	3.7 ± 1.3	4.2 ± 1.3	0.0010
Operation time (min)	263.9 ± 60.3	271.9 ± 60.1	0.2574
Transfusion	42 (42.4%)	152 (38.9%)	0.5961
In-hospital stay (days)	15.9 ± 8.9	16.3 ± 10.7	0.7271
Postoperative ejection fraction (%)	55.2 ± 10.8	56.0 ± 11.9	0.5600
Operative deaths	0	7 (1.8%)	0.3539
Reexploration due to bleeding	1 (1.0%)	5 (1.3%)	>0.9999
Low output syndrome	1 (1.0%)	11 (2.8%)	0.4743
POMI	2 (2.0%)	6 (1.5%)	0.6659
Atrial fibrillation	27 (27.3%)	116 (29.7%)	0.7305
Respiratory failure	3 (3.0%)	12 (3.1%)	>0.9999
Requiring hemodialysis	1 (1.0%)	10 (2.6%)	0.7025
Stroke	2 (2.0%)	6 (1.5%)	0.6659
Mediastinitis	0	4 (1.0%)	0.5875

PCI, percutaneous coronary intervention; POMI, perioperative myocardial infarction.

Discussion

Many randomized controlled trials and retrospective studies comparing PCI and CABG have demonstrated superior long-term survival and event-free rates in patients who underwent CABG.[9–13] However, the utilization of PCI has been increasing not only in one- or two-vessel disease, but also in three-vessel disease because the progress of stent devices has been growing extensively. Therefore the proportion of patients with previous PCI procedures who ultimately need to undergo CABG has also been increasing while the number of patients undergoing CABG has been decreasing. We believe it is important to clarify whether the outcomes of CABG patients with or without prior PCI are different. However, insufficient information still remains available in this regard. In the present study, we observed similar outcomes in patients with and without previous PCIs using an off-pump strategy. Furthermore, the graft patencies were similar in patients with and without previous stent implantations.

In the present study, patients who had previous PCIs had a significantly higher incidence of old myocardial infarction. This finding is easily explained because these patients had undergone the previous PCI procedures, including stent implantations, for the treatment of initial myocardial infarction. However, there were no differences regarding cardiac function and symptom severity at the time of CABG between the PCI and non-PCI groups. Patients with previous PCIs had significantly fewer diseased vessels than non-PCI patients. This would be the reason for a lower number of anastomoses per patient in the PCI group than in the non-PCI group. This tendency was in agreement with other reports.[3,4,6]

Several authors have demonstrated that there were no differences in mortality or morbidity between patients undergoing CABGs with or without a previous PCI.[3,4] Barakate et al. reported similar postoperative myocardial infarction and 30-day mortality rates for patients undergoing CABGs with or without a previous PCI.[4] However, they concluded that PCI procedures often need to be repeated over time and may serve only to delay CABG, even though PCI may provide successful myocardial revascularization. Van den Brule et al. also described that there were no significant differences in the rates of myocardial infarction, arrhythmia, reinterventions, neurological complications, renal complications, pulmonary complications, or in-hospital mortality for patients undergoing CABG with or without previous PCI.[3] Furthermore, they reported that a 1-year follow-up revealed no significant differences in the rates of cardiac-related mortality or recurrent ischemic events between their groups. Consistent with these reports, we found that the in-hospital mortality and morbidity rates did not differ between our PCI and non-PCI groups or between the stent and non-PCI groups.

Johnson et al. reported that patients with previous PCIs and CABGs exhibited poorer long-term survival than patients with successful PCIs alone.[14] They also observed that patients with PCIs and CABGs had a greater number of total lesions and a higher incidence of diabetes. They concluded that the method of initial revascularization should be carefully considered because markers of a more severe disease may indicate primary CABG and avoidance of an initial PCI. Since their study, several authors have reported inferior outcomes after CABGs in patients with PCIs compared to non-PCI patients. Hassan et al.[6] reported that the in-hospital mortality rates after CABG were higher in patients with prior PCIs than in non-PCI patients. Furthermore, a prior PCI emerged as an independent predictor of postoperative in-hospital mortality. However, the proportions of patients with unstable angina and urgent status were relatively higher in their study than in the present study. Similarly, Thielmann et al.[5] described that multiple previous PCI procedures were strongly associated with in-hospital mortality and major adverse cardiac events after propensity matching. However, the proportion of diabetes patients and the number of distal anastomoses were lower in that study than in the present study. These differences may have led to the discrepancy between the two studies.

In the present study, we observed no difference in the graft patency rates between patients with and without previous PCIs. However, Kamiya et al. reported that the patency rates of left internal thoracic artery bypasses to the left anterior descending artery were lower in patients with previous PCIs than in non-PCI patients.[15] They estimated that inflammation triggered by stent implantation and in-stent restenosis itself may be the cause of lower patency rates in patients with previous PCIs.

In our study, an off-pump CABG was performed in all patients. That may have contributed to the improved outcomes in both groups of patients with and without PCIs.

The limitations of this clinical study are as follows: (1) the number of patients was small; (2) postoperative angiographic data could not be obtained for all patients; and (3) it was a retrospective observational study and not randomized.

In conclusion, previous PCIs and stent implantations were not predictors of early morbidity or mortality in patients undergoing isolated OPCAB. The stent type did not affect the surgical outcome. The early angiographic patency rate of patients with previous PCIs was similar to that of non-PCI patients.

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