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Advantages of Off-Pump Coronary Artery Bypass Grafting in Long-Term Hemodialysis Patients: Multicenter Analysis

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ABSTRACT

Objective: Long-term hemodialysis remains a major risk factor for coronary artery bypass grafting (CABG). Off-pump CABG (OPCAB) is expected to offer benefits for these high-risk patients; however, this issue has not been clarified. To elucidate the issue, we conducted a multicenter retrospective review of long-term hemodialysis patients who underwent on- or off-pump CABG.

Patients: Between January 1998 and December 2002, 53 hemodialysis patients underwent elective CABG at 14 centers. Nineteen patients underwent OPCAB, and 34 patients underwent conventional CABG (CCAB). Preoperative and perioperative variables, morbidity, and mortality were compared in the 2 groups. There were no significant differences in preoperative variables between the 2 groups.

Results: The length of intensive care unit (ICU) stay (3.7 versus 5.9 days), the amount of blood loss (668 versus 1100 mL), and the amount of red cell transfusion (4.7 versus 12.2 units) were less in the OPCAB group. The perioperative morbidity was significantly lower in the OPCAB group (0.0% versus 26.5%). The hospital mortality was not significant but was low in the OPCAB group (0% versus 14.7%, $P = .079$).

Conclusion: OPCAB significantly decreased blood loss, blood transfusion, ICU stay, and major perioperative morbidity compared with the values for CCAB. OPCAB may have advantages over CCAB in long-term hemodialysis patients.

INTRODUCTION

In recent years, the number of hemodialysis patients has been steadily increasing, and the number of patients who become candidates for coronary artery bypass grafting (CABG) also is increasing [National Institutes of Health. 2000]. Because the major cause of death among hemodialysis patients is cardiovascular disease, improvement in outcome is desired. However, the results of CABG in hemodialysis patients have been reported to be less successful than those in patients not receiving hemodialysis [Samuels 1996, Agirbasli 2000, Franga 2000, Liu 2000, Dacey 2002].

Recently, off-pump CABG (OPCAB) has been introduced as less-invasive cardiac surgery and has gained widespread popularity. Although its benefits compared with conventional CABG (CCAB) in general candidates are controversial [van Dijk 2001, Abu-Omar 2002, Angelini 2002, Reston 2003], high-risk patients such as hemodialysis patients may be more likely to benefit from this procedure.

To elucidate this issue, we conducted a multicenter retrospective review of long-term hemodialysis patients who underwent CABG. We compared short-term and long-term clinical outcomes between OPCAB and CCAB.

MATERIAL AND METHODS

A retrospective study was conducted on results of CABG in hemodialysis patients at 14 participating medical centers, the members of the Osaka University group. The population consisted of 53 consecutive hemodialysis patients who underwent elective CABG between January 1998 and December 2002. Patients with acute renal failure not undergoing long-term hemodialysis were excluded from this review. Data were collected retrospectively from the patients' medical records.

The mean age of the patients was 60.3 ± 7.3 years. There was a 3:1 ratio of male to female patients. The mean duration of preoperative hemodialysis was 5.6 ± 5.1 years. The major etiologies of renal failure were diabetes mellitus (56.6% of cases) and chronic glomerulonephritis (35.8% of cases). Twenty-six patients had triple-vessel coronary artery disease, and 5 patients had left main coronary artery disease. The mean left ventricular ejection fraction was 57% ± 14.4%, and 14 (26.4%) of the patients were in New York Heart Association (NYHA) class 3 or 4. Nineteen patients underwent OPCAB, and 34 patients underwent CCAB. Patient selection for OPCAB or CCAB was based on clinical decision by each surgeon. Patients were followed for 13 days to 4.3 years (15.2 ± 17.1 months). Preoperative and perioperative variables, morbidity, and mortality were compared in the 2 groups. Table 1 summarizes the demographic and clinical

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Table 1. Demographic and Clinical Characteristics*

	OPCAB Group	CCAB Group	*P*
Age, y	60.5 ± 8.1	60.3 ± 6.9	NS
Sex ratio, M/F	14/5	26/8	NS
Body mass index	22.4 ± 3.7	21.9 ± 2.4	NS
New York Heart Association class	2.0 ± 0.8	2.1 ± 0.9	NS
No. of diseased vessels	2.2 ± 0.9	2.4 ± 0.6	NS
Left ventricular ejection fraction, %	61.0 ± 11.8	54.8 ± 15.4	NS
Duration of hemodialysis, y	5.7 ± 4.3	5.5 ± 5.6	NS
Diabetes mellitus, %	47.4	61.8	NS

*OPCAB indicates off-pump coronary artery bypass grafting; CCAB, conventional coronary artery bypass grafting; NS, not significant.

characteristics of each group. There were no significant differences between the groups in terms of age (60.5 ± 8.1 years in the OPCAB group and 60.3 ± 6.9 years in the CCAB group), sex (14 men/5 women versus 26 men/8 women), NYHA classification (2.0 ± 0.8 versus 2.1 ± 0.9), number of diseased coronary arteries (2.2 ± 0.9 versus 2.4 ± 0.6), left ventricular ejection fraction (61.0% ± 11.8% versus 54.8% ± 15.4%), preoperative hemodialysis duration (5.7 ± 4.3 years versus 5.5 ± 5.6 years), and comorbidity of diabetes mellitus (47.4% versus 61.8%). The groups were also similar in terms of coronary risk factors such as hypertension, smoking, cerebrovascular disease, and hyperlipidemia (Table 2).

Table 3 shows perioperative variables compared between the 2 groups. Operation time was shorter in the OPCAB group (4.9 ± 1.2 versus 6.6 ± 1.5 hours, $P = .0002$). The numbers of grafted vessels per patient were similar (2.3 ± 1.2 and 2.7 ± 0.8). The patients were selected for either OPCAB or CCAB on the basis of the clinical decision of the surgeons. Therefore the OPCAB group had fewer diseased vessels and shorter duration of surgery compared with the CCAB group. Arterial graft use was higher in the OPCAB group (72% versus 44%, $P < .05$). IMA was used in 95% of OPCAB patients and in 94% of CCAB patients. Seventy-five percent of the OPCAB group underwent aortic no-touch procedures.

Statistical Analysis

Continuous variables were analyzed by means of Student *t* test. The χ^2 or Fisher exact test was used for categorical data. All values are expressed as mean ± SD. $P < .05$ was considered significant. Long-term survival and cardiac event–free rate were estimated by the Kaplan-Meier method.

Table 2. Coronary Risk Factors*

Risk Factor	OPCAB Group (n = 19)	CCAB Group (n = 34)	*P*
Hypertension	14 (73.7%)	19 (55.9%)	NS
Diabetes mellitus	9 (47.4%)	21 (61.8%)	NS
Smoking	5 (26.3%)	8 (23.5%)	NS
Cerebrovascular disease	5 (26.3%)	7 (20.6%)	NS
Hyperlipidemia	2 (10.5%)	6 (17.6%)	NS

*OPCAB indicates off-pump coronary artery bypass grafting; CCAB, conventional coronary artery bypass grafting; NS, not significant.

Table 3. Perioperative Variables*

	OPCAB Group	CCAB Group	*P*
Operation time, h	4.9 ± 1.2	6.6 ± 1.5	.0002
No. of grafted vessels	2.3 ± 1.2	2.7 ± 0.8	.103
Arterial grafts used	72%	44%	<.05

*OPCAB indicates off-pump coronary artery bypass grafting; CCAB, conventional coronary artery bypass grafting.

RESULTS

The amount of blood loss was less in the OPCAB group (668 ± 417 mL versus 1100 ± 818 mL, $P < .05$) (Figure 1). The amount of red cell transfusion was less in the OPCAB group (4.7 ± 3.5 versus 12.2 ± 5.7 units, $P < .0001$). The length of ICU stay was shorter in the OPCAB group (3.7 ± 1.4 versus 5.9 ± 2.2 days, $P < .0005$). The hospital mortality was not significant but was low in the OPCAB group (0% versus 14.7%, $P = .079$) (Figure 2).

There was a significant difference between the groups in perioperative complications (Figure 2). No serious complication occurred in the OPCAB group. In the CCAB group, however, there were 5 cases of mediastinitis, 4 of cardiac tamponade due to bleeding, 1 case of brain infarction, 1 of mesenteric infarction, and 1 of low output syndrome (Figure 3). Mediastinitis occurred in 5 patients in the CCAB group at 4 medical centers. All the cases of cardiac tamponade necessitated reoperation within 48 hours, and 3 of 4 patients developed mediastinitis after reoperation.

There was no hospital death in the OPCAB group, but there were 5 in the CCAB group. The causes of death were mediastinitis in 3 cases, mesenteric infarction in 1 case, and low-output syndrome in 1 case (Figure 3).

The overall survival rate at 6 months was 90.9% in the OPCAB group and 76.6% in the CCAB group. The rate at 1 year was 75.8% and 76.6% (Figure 4). The cardiac event–free

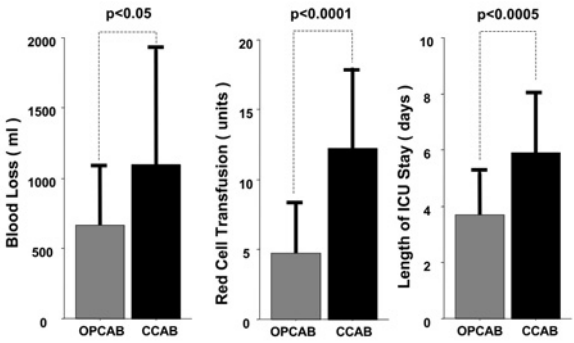

Figure 1. Amount of blood loss, amount of red cell transfusion, and length of intensive care (ICU) unit stay. OPCAB indicates off-pump coronary artery bypass grafting; CCAB, conventional coronary artery bypass grafting.

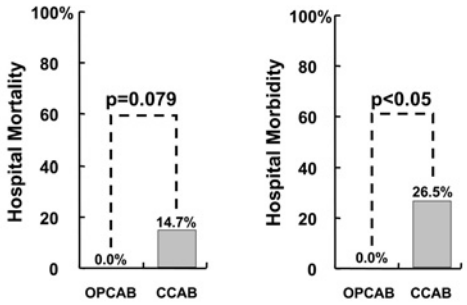

Figure 2. Hospital mortality and morbidity. OPCAB indicates off-pump coronary artery bypass grafting; CCAB, conventional coronary artery bypass grafting.

rate at 2 years was 100% in the OPCAB group and 96.6% in the CCAB group (Figure 5). The other cause of death was brain infarction: 3 patients in the OPCAB group and 1 patient in the CCAB group.

COMMENTS

Menzoin et al [1974] performed the first CABG procedure on a hemodialysis patient in 1974. Since then, a number of authors have reported early results of CABG in hemodialysis patients. However, the procedures tend to be less successful than those in patients not undergoing hemodialysis [Samuels 1996, Agirbasli 2000, Franga 2000, Liu 2000, Dacey 2002]. Gelsomino et al [2001] suggested that these unsuccessful results are attributable to the unfavorable effects of the use of cardiopulmonary bypass (CPB). CPB causes several disadvantages, such as fluid retention, inflammatory response, and coagulopathy. In addition to these shortcomings, hemodialysis patients have a number of disadvantageous conditions, such as leukocyte dysfunction, coagulation defects, and endocrine disorders [Ko 1993, Kaul 1994]. Procedures in which CPB is not used are likely to prevent these unwanted effects.

OPCAB recently has become an alternative technology for CCAB. Many reports have described the efficacy of OPCAB [van Dijk 2001, Abu-Omar 2002, Angelini 2002, Reston

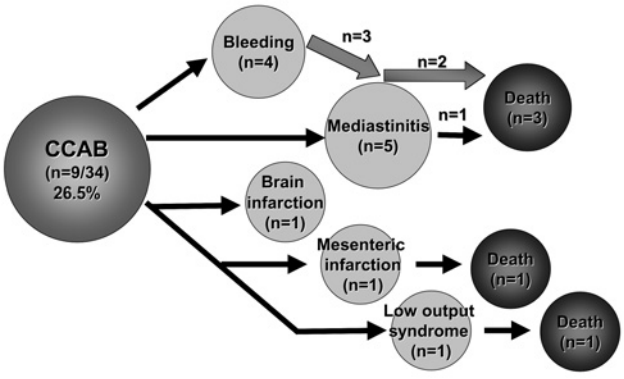

Figure 3. Postoperative complications and causes of death. CCAB indicates conventional coronary artery bypass grafting.

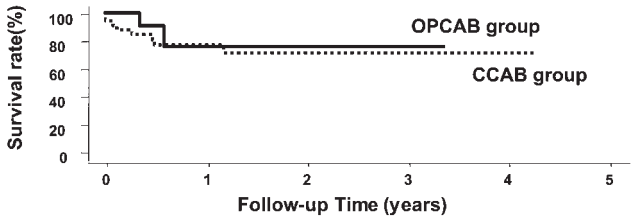

Figure 4. Overall survival rates after coronary artery bypass grafting (CABG) in the off-pump CABG (OPCAB) and conventional CABG (CCAB) groups.

2003], but it is still unclear whether operative outcome is comparable to that of CCAB. A recent multicenter randomized controlled trial (the Octopus trial [van Dijk 2001]) did not show a statistically significant difference between OPCAB and CCAB for short-term morbidity and mortality. That trial lacked the necessary statistical power to detect a difference in outcomes because of the extremely low event rates in both groups.

On the other hand, mortality and event rates are high with CCAB in hemodialysis patients [Samuels 1996, Agirbasli 2000, Franga 2000, Liu 2000, Dacey 2002]. We presumed that we could find the advantage of OPCAB over CCAB in these high-risk patients. For that reason, we conducted this study.

In our series, the amount of blood loss and the amount of red cell transfusion were less and the length of ICU stay was shorter in the OPCAB group. The perioperative morbidity was significantly lower in the OPCAB group. No serious complication and no hospital death occurred in the OPCAB group. In contrast, 9 patients in the CCAB group developed major complications, and 5 patients died. It is noteworthy that all the patients in the CCAB group who had cardiac tamponade needed a reoperation, and 75% of them finally developed mediastinitis, which was the cause of death in 2 of 3 patients. The use of CPB may increase the bleeding tendency of hemodialysis patients and predispose them to postoperative bleeding and reoperation. In addition, the decreased immunity of hemodialysis patients [Bhattacharyya 1997] may increase the occurrence of serious infection and lead to an unfavorable operative outcome. OPCAB may have potential for preventing bleeding complications and may

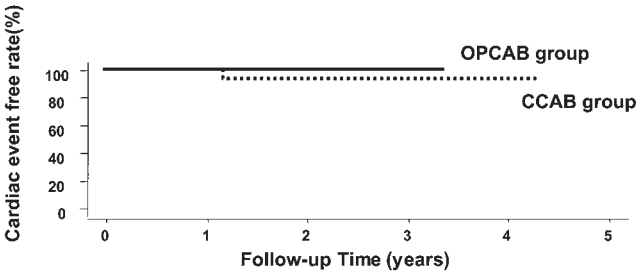

Figure 5. Cardiac event–free rates after coronary artery bypass grafting (CABG) in the off-pump CABG (OPCAB) and conventional CABG (CCAB) groups.

lead to improved operative outcome in hemodialysis patients.

The long-term survival rate and cardiac event–free rate were similar between the 2 groups. OPCAB improved hospital morbidity and mortality but did not change late mortality, which in most cases was not cardiac. This finding may be the result of limitations of our study, such as small sample size and short follow-up duration. A prospective study with a larger sample size and long-term duration is required to confirm this finding.

In conclusion, OPCAB significantly decreased blood loss, ICU stay, blood transfusion, and perioperative morbidity. OPCAB may be a safe and effective procedure for coronary revascularization in long-term hemodialysis patients.

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