Original Article

Perioperative and Mid-Term Results of Coronary Bypass Surgery in Patients Undergoing Chronic Dialysis

Tsuneo Ariyoshi, MD, Kiyoyuki Eishi, MD, Shiro Yamachika, MD, Shiro Hazama, MD, Hideaki Takai, MD, Tomohiro Odate, MD, and Seiji Matsukuma, MD

Purpose: The goal of this study was to evaluate perioperative and mid-term results of coronary artery bypass grafting (CABG) in patients with end-stage renal disease (ESRD).
Methods: Thirty-five consecutive dialysis patients who required CABG over a 5-year period were investigated retrospectively.
Results: Mean patient age was 62.5±11.5 years. The mean number of diseased vessels was 2.3±0.8. Off-pump CABG (OPCAB) was performed in 12 patients. The mean number of anastomoses per patient was 2.5±1.1. The perioperative mortality was 5.7%, and the average duration of hospitalization was 25.3±13.4 days. Overall 5-year survival rates were 63.7%. The cardiac-related 5-year survival rate was 89.3%, and the cardiac event-free rate was 51.7%. Multivariate analysis failed to identify any significant prognosticators for perioperative or long-term outcomes. The morbidity rate was significantly lower in patients undergoing OPCAB than in patients undergoing conventional CABG (8.3 vs. 47.8%; p=0.03). Perioperative mortality in the OPCAB group was 0%, and the average duration of hospitalization was shorter in the OPCAB group than in the conventional CABG group (19.7 days vs. 28.5 days; p=0.1).
Conclusion: In the context of coronary artery bypass surgery, OPCAB produced better outcomes than conventional CABG procedure in patients undergoing chronic dialysis. Furthermore, OPCAB procedure seems to offer a greater benefit to dialysis patients than non-dialysis patients. (Ann Thorac Cardiovasc Surg 2006; 12: 257–64)

Key words: kidney, mortality, morbidity, bypass

Introduction

Patients with end-stage renal disease (ESRD) are at high risk of cardiovascular disease and cardiac complications, resulting in higher rates of mortality than in the general population.[1] Advancements in dialysis treatments have resulted in a progressive increase in the prevalence of people living with ESRD. For example, the Japanese Society for Dialysis Therapy[2] recently reported that the number of patients with ESRD increased by approximately 10,000 cases every year. The 5-year survival rate for patients with ESRD has increased to 59.3% while the mean age of ESRD patients has increased to 62 years.

Although there has been tremendous advancement in the use of percutaneous transluminal coronary angioplasty (PTCA) for the treatment of coronary artery disease, coronary artery bypass grafting (CABG) remains the gold standard for revascularization.[3] Several groups have investigated outcomes following CABG with cardiopulmonary bypass (CPB) in patients with ESRD.[4–7] However, outcomes following CABG with off-pump CABG (OPCAB) in patients with ESRD remain unclear. Therefore, the goal of this study was to evaluate perioperative and mid-term results of CABG in patients with ESRD and to identify any prognostic factors that may be associated with favorable outcomes.

From Department of Cardiovascular Surgery, Nagasaki University School of Medicine, Nagasaki, Japan

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Address reprint requests to Tsuneo Ariyoshi, MD: Department of Cardiovascular Surgery, Nagasaki University School of Medicine, 1–7–1 Sakamoto, Nagasaki 852–8501, Japan.

Methods

Thirty-five patients (26 males and 9 females) with ESRD who were undergoing chronic dialysis and who underwent a CABG procedure at our institution between August 1, 1999 and September 30, 2004 were retrospectively analyzed. Patients undergoing elective procedures underwent hemodialysis 2 days prior to the day of surgery. Twenty-three patients underwent conventional CABG, and 12 patients underwent OPCAB procedures.

In patients undergoing revascularization under CPB assistance, CPB was initiated at a perfusion index of 2.4 L/min/m^2. An adequate perfusion pressure (40–60 mmHg) and moderate controlled systemic hypothermia (28–32˚C) were maintained, and hematocrit was kept above 20%. Dialysis was performed intraoperatively, concomitant with CPB. For myocardial protection, antegrade hypothermic (4˚C) crystalloid cardioplegia was applied. In patients undergoing revascularization with OPCAB, blood pressure was maintained greater than 80 mmHg, and a stabilizer was used for coronary artery anastomosis. Postoperatively, patients were routinely observed in the intensive care unit for 2 days, and hemodialysis was resumed on the second postoperative day in most patients. Patient profiles, operative and postoperative data, and remote outcomes were recorded. Operative mortality included deaths occurring during hospitalization, and remote cardiac events were defined as recurrent angina; history of postoperative PTCA or repeat CABG, postoperative congestive heart failure, fatal arrhythmia, or arrhythmia requiring hospitalization. Remote data were collected by telephone questionnaires administered to the patients or from reports by private physicians. All patients were followed for at least 1 year postoperatively, with a mean follow-up period of 28.8 months.

Statistical analysis

All data are represented as the mean ± standard deviation (SD), and independent continuous scale data were analyzed using the Mann-Whitney's U test for nonparametric data. A p value ≤0.05 was considered statistically significant. The χ^2 or Fisher's exact test was used for categorical data. Potential risk factors for operative mortality and morbidity were assessed by univariate analysis, and factors with p values ≤0.3 were included in a stepwise logistic regression analysis model. Overall survival rate, cardiac-related survival rate and cardiac-event-free rate were computed by Kaplan-Meier methods followed by log-rank test, and the Cox regression analysis was used to evaluate the influence of variables on time to all death or cardiac death.

Results

Patient profiles

Mean patient age was 62.5±11.5 years (range, 21–81 years). Of these patients, 25 (71.4%) were less than 70 years of age, and 10 (28.6%) were 70 years of age or older. Primary causes of renal insufficiency are summarized in Table 1. Mean preoperative duration of dialysis was 8.4±7.4 years (1 month–33.4 years), and preoperative creatinine level was 8.1±2.4 mg/dL (range, 3.6–12.4 mg/dL). The mean preoperative hemoglobin level was 9.9±1.7 g/dL (range, 7.4–15.2 g/dL). Preoperative comorbidities included cerebrovascular disease (n=8; 22.9%), peripheral vascular disease (n=11; 31.4%), chronic obstructive pulmonary disease (n=6; 17.1%), diabetes mellitus (n=18; 51.4%), and hypertension (n=11; 31.4%). Preoperative patient profiles are summarized in Table 1.

Cardiac profile

Preoperative cardiac data are summarized in Table 1. Incidence of cardiac disease included unstable angina (n=17; 48.6%), mitral valve disease (n=7, 20.0%), and concomitant mitral and aortic valve disease (n=2; 5.7%). Twenty-eight patients (80.0%) were designated as New York Heart Association (NYHA) classification III (n=23) or IV (n=5), and 24 patients (68.6%) were designated as Canadian Cardiovascular Society (CCS) anginal classification III (n=19) or IV (n=5). Mean ejection fraction (EF) was 53.7±14.1%, and 4 patients (11.4%) were diagnosed with moderate or severe left ventricular (LV) dysfunction (LVEF≤40%). Mean number of diseased vessel was 2.3±0.8; 17 patients (48.6%) had 3-vessel disease, and 14 patients (40.0%) had left main trunk stenosis (≥50%). Thirteen patients (37.1%) had moderate or severe LV dilatation (LVDd≥60 mm), and 15 patients (42.9%) had moderate or severe calcification of the ascending aorta.

Surgical procedure

Seven patients (20.0%) required emergent operation case. Twelve patients (34.3%) underwent revascularization with OPCAB. The mean number of anastomoses per patient was 2.5±1.1. Twenty-four patients (68.6%) underwent complete revascularization, of which 15 (42.9%) was bypassed with arterial grafts alone. Six patients (17.1%) underwent concomitant valvular repair or replacement. The mean duration of the surgical procedure was 297±50

Table 1. Preoperative status of patients with end-stage renal disease

Patient profile			
	Total patient	35	
	Sex (M/F)	26/9	
	Age (y)	62.5±11.5	
	Age≥70	10	28.6%
	Creatinine (mg/dL)	8.1±2.4	
	Hemoglobin (g/dL)	9.9±1.7	
	Preoperative dialysis		
	Duration (y)	8.4±7.4	
	Range	0.1–33.4	
Causes of chronic renal failure			
	Diabetes mellitus	16	45.7%
	Chronic glomerulonephritis	7	20.0%
	Nephrosclerosis	2	5.7%
	Polycystic kidney	0	0.0%
	Unknown	7	20.0%
	Systemic lupus erythematosus	1	2.9%
	Nephric urinary stone	2	5.7%
Associated disease			
	Hypertension	11	31.4%
	Diabetes mellitus	18	51.4%
	Chronic obstructive pulmonary disease	6	17.1%
	Peripheral vascular disease	11	31.4%
	Cerebrovascular disease	8	22.9%
Cardiac profile			
	Unstable angina	17	48.6%
	NYHA classification ≥III	28	80.0%
	Anginal CCS classification ≥III	24	68.6%
	Old myocardial infarction	7	20.0%
	No. of diseased vessels	2.3±0.8	
	Three vessel disease	17	48.6%
	Left main coronary artery stenosis ≥50%	14	40.0%
	EF (%)	53.7±14.1	
	EF≤40%	4	11.4%
	LVDd≥60 mm	13	37.1%
	Asc Ao calcification	15	42.9%

M, male; F, female; y, years; NYHA, New York Heart Association; CCS, Canadian Cardiovascular Society; EF, ejection fraction; LVDd, left ventricular end-diastolic dimension; Asc Ao, ascending aorta.

min (range, 139–565 min), mean CPB time was 133±74 min (range, 139–565 min), and mean aortic cross-clamp time was 75±50 min (range, 51–215 min). Operative data are summarized in Table 2.

Early mortality

There were 2 hospital deaths, and perioperative mortality was 5.7% (Table 3). Of these 2 deaths, 1 was an 80-year-old male who underwent CABG with CPB and died 11 days postoperatively of multiple organ failure caused by hepatic infarction. This was due to diffuse spasm in the hepatic artery, as diagnosed by angiography. The other death was a 74-year-old male who underwent concomitant mitral valve replacement and revascularization. He died 18 days postoperatively of multiple organ failure secondary to sepsis. Statistical analysis failed to identify any factor that was significantly associated with early mortality.

Table 2. Surgical procedures

Urgency of operation		
Elective	28	80.0%
Emergent	7	20.0%
Preoperative IABP support	2	5.7%
CPB time (min)	133±74	
Aortic cross-clamp time (min)	75±50	
No. of anastomoses per patient	2.5±1.1	
OPCAB	12	34.3%
Complete revascularization	24	68.6%
Complete revascularization bypassed with arterial grafts alone	15	42.9%
Valve surgery	6	17.1%
CABG isolated	29	82.9%
CABG+MVR	2	5.7%
CABG+MP	2	5.7%
CABG+DVR	1	2.9%
CABG+AVR+MP	1	2.9%

IABP, intraaortic balloon pumping; CPB, cardiopulmonary bypass; OPCAB, off-pump coronary artery bypass; CABG, coronary artery bypass grafting; MVR, mitral valve replacement; MP, mitral valve plasty; DVR, double valve replacement; AVR, aortic valve replacement.

Table 3. Perioperative result

Mortality	2 (5.7%)
Morbidity rate	34.3%
Cardiac failure	2
Prolonged mechanical ventilation (>48 hrs)	6
Arrhythmia	2
Consciousness decline	2
Gastric ulcer bleeding	1
Liver infarction	1
Sepsis	1
Hospitalization (days)	25.3±13.4

Morbidity

Perioperative and postoperative complications in all CABG patients with ESRD are summarized in Table 3. Excluding operative deaths, 10 patients had severe complications postoperatively, including mechanical ventilation >48 hrs (n=4; 11.4%), heart failure (n=1; 2.9%), bradycardia (n=1; 2.9%), prolonged atrial fibrillation (n=1; 2.9%), gastric ulcer bleeding (n=1; 2.9%), and postoperative decline in level of consciousness without major cerebrovascular accident (n=2; 5.7%). In addition, minor complications, such as wound dehiscence and wound infection, were seen in 7 cases (20.0%). Serious complications and problems with wound healing were associated with prolonged hospitalization (average hospitalization, 25.3±13.4 days).

Conventional CABG vs. OPCAB

There was no significant difference in preoperative patient profile or cardiac profiles when comparing patients that underwent conventional CABG with CPB and those that underwent OPCAB. However, there was a significant difference in the number of anastomoses per patient (2.7±1.1 in the conventional CABG group vs. 1.9±0.8 in the OPCAB group; p=0.03) when comparing the 2 groups, and the conventional CABG group had a slightly higher rate of complete revascularization than the OPCAB group (p=0.2).

In the group of patients that underwent revascularization with OPCAB, there were no perioperative deaths, and the perioperative mortality rate was 0.0%. In the group of patients that underwent revascularization with conventional CABG group, there were 2 perioperative deaths, and the operative mortality rate was 8.7%. The morbidity rate was 8.3% in the OPCAB group and 47.8% in the conventional CABG group. The average duration of hospitalization of patients in the conventional CABG and OPCAB groups was 28.5±15.8 days and 19.7±3.8 days, respectively. However, there was a significant statistical difference only in the morbidity rate (43.5% in the con-

Table 4. Comparison of perioperative results between conventional CABG and OPCAB groups

	Conventional CABG (n=23)	OPCAB (n=12)	p value
Sex (M/F)	18/5	8/4	0.5
Age (y)	65.7±9.5	60.9±12.3	0.2
Creatinine (mg/dL)	8.0±2.5	8.2±2.2	0.8
Hemoglobin (g/dL)	10.3±1.9	9.0±0.9	0.1
NYHA classification ≥III	18 (78.3%)	10 (83.3%)	0.7
Anginal CCS classification ≥III	15 (65.2%)	10 (83.3%)	0.3
Old myocardial infarction	4 (17.4%)	2 (16.7%)	0.9
Number of diseased vessels	2.4±0.7	2.1±0.9	0.4
EF (%)	52.4±14.9	56.0±12.8	0.3
EF≤40%	3 (13.0%)	1 (8.3%)	0.7
LVDd≥60 mm	9 (39.1%)	4 (33.3%)	0.7
Asc Ao calcification	11 (47.8%)	4 (33.3%)	0.4
No. of anastomoses per patient	2.7±1.1	1.9±1.8	0.03
Complete revascularization	18 (78.3%)	7 (58.3%)	0.2
Mortality	2 (8.7%)	0 (0.0%)	0.3
Morbidity rate	47.8%	8.3%	0.03
Cardiac failure	2	0	
Prolonged mechanical ventilation (>48 hrs)	5	1	
Arrhythmia	2	0	
Consciousness decline	2	0	
Gastric ulcer bleeding	1	0	
Liver infarction	1	0	
Sepsis	1	0	
Hospitalization (days)	28.5±15.8	19.7±3.8	0.11

CABG, coronary artery bypass grafting; OPCAB, off-pump coronary artery bypass; y, years; M, male; F, female; NYHA, New York Heart Association; CCS, Canadian Cardiovascular Society; EF, ejection fraction; LVDd, left ventricular end-diastolic dimension; Asc Ao, ascending aorta.

ventional CABG group vs. 8.3% in the OPCAB group; p=0.03) when comparing the 2 groups (Table 4).

Long-term follow-up

The mean follow-up period was 28.8 months. There were 10 (30.3%) late deaths, and 23 patients (69.7%) remain alive. The causes of late death were cardiac events in 2 patients, sepsis in 4, cerebral infarction in 2, pneumonia in 1, and unknown in 1. Overall 1- and 5-year survival rates were 84.7% and 63.7%, respectively (Fig. 1). The cardiac-related 5-year survival rate was 89.3% (Fig. 2), and the cardiac-event-free rate of the 33 hospital survivors was 51.7% (Fig. 3). Multivariate analysis failed to identify any factor that was significantly associated with late death or cardiac events. For example, there were no significant differences between the conventional CABG group and the OPCAB group in survival rates, cardiac-related survival rate and cardiac-event free rates.

Discussion

Studies investigating outcomes in patients with ESRD following cardiac surgery have reported variable results,[4–14] and comparison between studies has been hampered by differences in patient populations and surgical variables. The increasing use of OPCAB during revascularization has introduced yet another variable for patient outcomes. Further, the increasing rate of survival of patients with ESRD has made long-term outcomes following revascularization more relevant.

In our series, there were 2 perioperative deaths that were attributed to hepatic infarction and sepsis, respec-

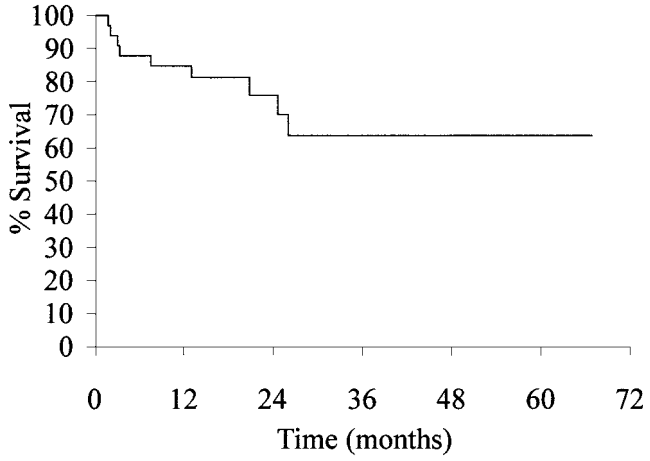

Fig. 1. Actuarial survival rate including all death.

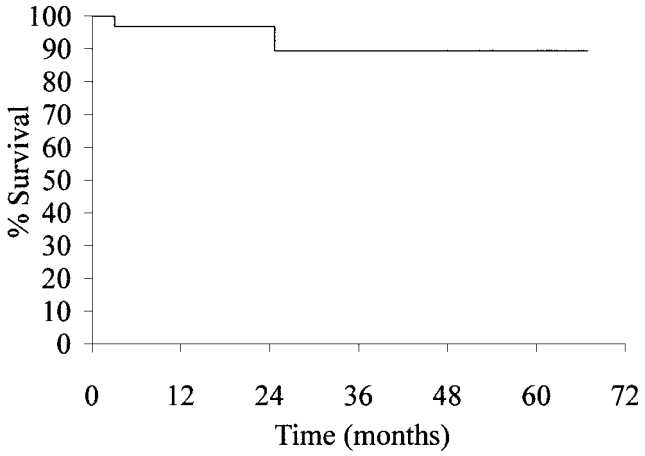

Fig. 2. Actuarial cardiac-related survival rate.

tively. Review of the literature suggests that sepsis and intra-abdominal complications occur at a high rate in patients with ESRD undergoing cardiac surgery.[4–6,8–11,15)]

Mack and associates[15)] retrospectively analyzed 17,401 patients undergoing CABG (OPCAB, n=7,283; conventional CABG, n=10,118) and reported that the use of CPB was an independent risk factor for sepsis and gastrointestinal complications.

A previous study[16)] reported that there was a statistically significant association between abdominal complications, age, total cardiopulmonary bypass time, and advanced systemic atherosclerosis in elderly patients that may result in an increased risk of visceral ischemia secondary to visceral hypoper-fusion. In addition, because of the association between severe vascular calcification and ESRD,[17)] the risk of visceral ischemic may be even higher in patients undergoing chronic hemodialysis than the general population.

Severe infections are also a major cause of death in patients with ESRD undergoing cardiac surgery[4–6,8,10,11,18)] and may be related to underlying diabetes mellitus or immunosuppression, associated with impaired leukocytic chemotaxis ability in patients undergoing chronic dialysis.[18–20)]

For these reasons, use of CPB may result in even worse outcomes in patients with ESRD than in patients without ESRD.

In the present study, perioperative mortality rate of 5.7% is relatively low when compared to the 7.8–14.3% mortality rate reported by other investigators.[4–7)] The improved outcomes in the present study may result from improved operative procedure and perioperative care. For example, both patients who died in the present study underwent CABG with CPB, while all of the patients that underwent OPCAB procedure survived. However, statistical analysis failed to identify any parameter in the present study that was associated with operative death, including the use of OPCAB.

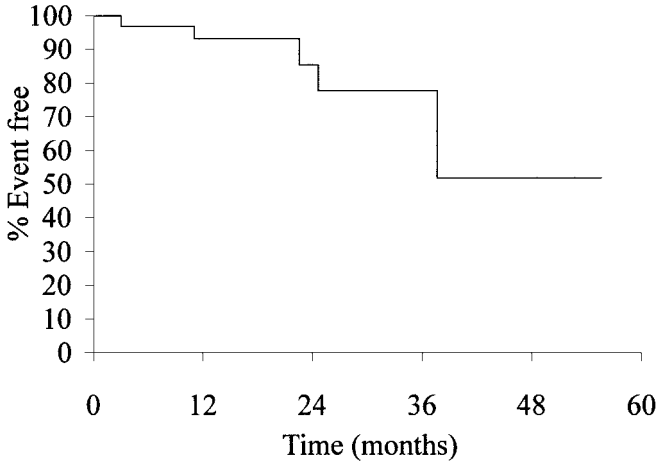

Fig. 3. Cardiac-event-free rate of the 33 hospital survivors.

On the other hand, the morbidity rate was significantly lower and the mean hospitalization was shorter in the OPCAB group than in conventional CABG group, partially because of the lower incidence of complications in the OPCAB group. Previous reports suggest that OPCAB is less invasive than conventional CABG procedure in several populations.[21–23)] In addition, our data suggests that OPCAB is particularly beneficial for patients with ESRD, which is consistent with several studies[12–14)] that have demonstrated that outcomes of dialysis patients were better

after OPCAB than after conventional CABG.

In the present study, the 5-year survival rate was 63.7%. Cardiac-related deaths comprised 20% of all deaths (2 of 10 deaths), and the cardiac-related 5-year survival rate was 89.3%. It was reported that the 5-year survival rate of all Japanese dialysis patients older than 60 years old was 49.6% and that approximately 35.6% of all ESRD died of heart failure and myocardial infarction.[2] Compared with these data, our outcome could be interpreted as correct. However, the 5-year cardiac-event free rate was lower than we expected.

The present study was unable to identify any parameter that was significantly associated with long-term outcomes in ESRD undergoing operative revascularization. Both cases that died of cardiac causes (arrhythmia and heart failure, respectively) in the follow-up period had undergone complete revascularization using only arterial grafts. Four (50%) of 8 non-cardiac deaths in the follow-up period were attributed to sepsis, and the mean postoperative survival of these 4 cases was 181 days. While these infections may be associated with ESRD, as discussed above, it is also possible that patients were in poor health in the postoperative period or that there is another factor associated with ESRD that predisposes towards negative outcomes.

Cardiac surgery in patients undergoing chronic dialysis is presumed to carry a greater risk of complications, and patients with ESRD often have minimal anginal systems in the presence of substantial coronary artery disease, which may result from diabetic or uremic polyneuropathy.[24] These factors could lead to a delay in operative revascularization and contribute to poor outcomes in patients undergoing chronic dialysis.[8]

Although the present study was unable to identify any parameter that was significantly associated with perioperative and long-term outcomes in ESRD undergoing operative revascularization, it is likely that ESRD itself is an important risk factor for poor outcomes[7] in patients undergoing operative revascularization.

Conclusion

Outcomes of the CABG procedure in patients with ESRD were acceptable. Further, use of OPCAB resulted in better outcomes than the use of CABG with CPB in patients undergoing chronic dialysis. Further refinements of surgical techniques and timely institution of operative revascularization may result in even better outcomes in patients with ESRD.

Study limitations

The patient population in the present study was relatively small, which may reduce our ability to detect statistically significant differences or associations. Further investigation in larger populations is required.

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