Early and long-term outcomes in the elderly: Comparison between off-pump and on-pump techniques in 1191 patients undergoing coronary artery bypass grafting

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Objective: The aim of the present study was to investigate the influence of off-pump coronary artery bypass grafting on early and long-term mortality and morbidity in a consecutive series of elderly patients (aged > 65 years) compared with conventional coronary artery bypass grafting.

Methods: From January of 1999 to December of 2003, data were extracted for 1191 patients aged more than 65 years: a conventional coronary artery bypass grafting group (n = 744) and an off-pump coronary artery bypass grafting group (n = 447). Age-related early outcomes of interest were in-hospital mortality and postoperative morbidities. Long-term outcomes, including total mortality, repeated revascularization, Q-wave myocardial infarction, stroke, readmission, and the combination of death, Q-wave myocardial infarction, stroke, and repeated revascularization, were evaluated with Cox regression analysis.

Results: Univariate analysis for early outcomes showed significant benefits from off-pump coronary artery bypass grafting. After adjustment for baseline characteristics, there was still a benefit of off-pump coronary artery bypass grafting. Kaplan–Meier survival analyses (propensity matched cases) showed that stroke, major adverse cardiac and cerebrovascular events, and readmission occurred more frequently in the off-pump coronary artery bypass grafting group ($P < .001$). There was a nonsignificant trend to higher total mortality ($P = .193$) and higher repeated revascularization rates ($P = .067$) in the off-pump coronary artery bypass grafting group. Cox regression for long-term outcomes showed that patients in the off-pump coronary artery bypass grafting group had a higher incidence of stroke (hazard ratio 2.611, 95% confidence interval 2.152–3.070), readmission (hazard ratio 2.000, 95% confidence interval 1.747–2.253), and major adverse cardiac and cerebrovascular events (hazard ratio 1.764, 95% confidence interval 1.456–2.072).

Conclusion: Our analysis shows that off-pump coronary artery bypass grafting compared with conventional coronary artery bypass grafting was associated with favorable early outcomes in the elderly population. However, the early benefits of off-pump coronary artery bypass grafting were not maintained in the long term, and off-pump coronary artery bypass grafting showed trends toward worse long-term results.

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Most countries have accepted the chronologic age of 65 years as a definition of “elderly,” and the expansion of the elderly population worldwide has led to a dramatic increase in the number of patients aged more than 65 years. Because of a higher incidence of coronary artery disease in the developing world, surgical revascularization in the elderly is increasing. Although coronary revascularization in these patients is associated with an increased risk of mortality and postoperative morbidities, the improvements in surgical, anesthetic, and perfusion

Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
CCABG	= conventional coronary artery bypass grafting
CPB	= cardiopulmonary bypass
OPCAB	= off-pump coronary artery bypass
MACCE	= major adverse cardiac and cerebrovascular event
PVD	= peripheral vascular disease

procedures led to coronary artery bypass grafting (CABG) being regarded as a safe option for treatment of this high risk group.¹

The past decade heralded the development of off-pump coronary artery bypass (OPCAB) grafting, which does not require hypothermia, cardiopulmonary bypass (CPB), aortic cannulation, or crossclamping of the ascending aorta and allows surgeons to perform coronary revascularization by avoiding the adverse effect of CPB. Some previous work suggests that OPCAB in the elderly may be superior for early outcome compared with conventional CABG (CCABG).²⁻⁵ However, the long-term prognosis of OPCAB in elderly patients remains unclear. Therefore, this study aimed to answer the following questions. 1) In elderly patients undergoing CABG surgery, is OPCAB associated with a lower incidence of mortality and postoperative morbidity in the short term? 2) How do the differences between the 2 surgical procedures respond in relation to long-term follow-up?

Materials and Methods**Patients**

From January of 1999 to December of 2003, data of 3371 patients undergoing isolated CABG at Fuwai Hospital, Beijing, China, were prospectively entered into a database after institutional review board approval. Data were extracted for 1191 patients aged more than 65 years: CCABG group (n = 744) and OPCAB group (n = 447). All the procedures were performed by cardiac surgeons who completed their learning curve. The operating surgeons decided whether to proceed with OPCAB or CCABG according to the anatomic and clinical findings. The follow-up was achieved by telephone, mail, or medical records. The median follow-up achieved in 95.7% of the patients was 46.9 ± 17.7 months. Preoperative, intraoperative, and postoperative variables and follow-up data were recorded according to prespecified data entry forms. To minimize selection bias in our study, long-term survival analysis involved a comparison of pairs of patients matched with regard to significant predictors of the type of procedures used.

Definition

Chronic obstructive pulmonary disease was defined by the long-term use of bronchodilators or steroids. Peripheral vascular disease (PVD) was defined by any one or more of the following: claudication, carotid occlusion or greater than 50% stenosis, and previous or planned intervention on the abdominal aorta, limb arteries, or ca-

rotids. Cerebrovascular disease was defined by a history of any one of the following: unresponsive coma more than 24 hours, cerebrovascular accident (symptoms > 72 hours after onset), reversible ischemic neurologic deficit (recovery within 72 hours), and transient ischemic attack (recovery within 24 hours). Previous stroke was defined as a history of central neurologic deficit persisting more than 72 hours. Hyperlipidemia was defined as a history of hyperlipidemia diagnosed or treated by a physician. Renal failure was defined as a documented history of renal failure or a history of a serum creatinine greater than 200 $\mu\text{mol/L}$. Unstable angina was defined as rest angina requiring intravenous nitrates until arrival in the operating room. Critical preoperative state was defined by any one or more of the following: ventricular tachycardia or fibrillation or rescued sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the operating room, preoperative inotropic support, and intraaortic balloon pump or preoperative acute renal failure (anuria or oliguria < 10 mL/h). Incomplete revascularization was identified by comparing the number of distal anastomoses with the number of diseased vessels observed on the preoperative coronary angiogram. During the early postoperative period, postoperative low cardiac output syndrome was defined as a cardiac index less than 2.0 L/min/m² and the postoperative need for left ventricular assist device, intraaortic balloon pump, and inotropic support. Stroke was defined as new acute focal neurologic deficit with signs and symptoms lasting greater than 24 hours, and neurologic events included transient ischemic attack and stroke. New renal failure was defined as prolonged oliguria or anuria requiring dialysis or hemofiltration. Pulmonary complication included prolonged mechanical ventilation (>24 hours), reintubation, and pneumonia, which was diagnosed by sputum culture and radiographic findings. Infective complications included sepsis, deep sternal infection, mediastinitis, and leg wounds infection as defined by positive culture and requiring antibiotic therapy. During the follow-up period, total mortality was defined as all causes of mortality. Q-wave myocardial infarction was defined as new significant Q waves in continuous leads documented in medical record. Repeated revascularization was defined as new CABG procedure or percutaneous coronary intervention with documented graft failure or new culprit lesion. Stroke was defined as new acute focal neurologic deficit with signs and symptoms lasting greater than 24 hours documented in a medical record. Major adverse cardiac and cerebrovascular events (MACCEs) were the combination of death, Q-wave myocardial infarction, stroke, and repeated revascularization. Readmission was defined as any cardiovascular hospital readmissions for acute myocardial infarction, congestive heart failure, and unstable angina.

Statistical Analysis

Age-related early outcomes of interest were in-hospital mortality and postoperative morbidities. Long-term outcomes of interest were total mortality, repeated revascularization, stroke, Q-wave myocardial infarction, readmission, and MACCEs during the entire follow-up. Continuous variables were presented as mean $\pm$ standard deviation. Comparisons between means were performed using the Student *t* test, whereas differences in categorical variables were assessed using the Fisher's exact test or chi-square test. Early outcomes were compared with or without risk adjusting, using logistic regression.

A propensity-matched analysis was used to adjust for selection bias between OPCAB versus CCABG. The propensity score was

calculated for each patient on the basis of a logistic regression analysis of the predicted probability of OPCAB. All of the preoperative patient risk factors available were used as candidate variables in this propensity model. The significant predictors of surgery type were used to match each patient in the OPCAB group to a patient in the CCABG group with the same set of predictors. A total of 610 of 1191 patients were matched. Survival curves of the propensity score matched cases were generated using the Kaplan–Meier method, and group differences were assessed by the log-rank test.

Multivariable stepwise Cox proportional hazards models were created with the use of preoperative, intraoperative, and postoperative variables to identify independent predictors of total mortality and other long-term outcomes. The candidate variables include age, gender, chronic obstructive pulmonary disease, PVD, cerebrovascular disease, history of stroke, hypertension, hyperlipidemia, diabetes, previous cardiac operation, renal failure, serum creatinine, unstable angina, depressed left ventricular ejection fraction (<50%), recent myocardial infarction, critical operative state, emergency operation, EuroSCORE, left main disease, triple-vessel disease, off-pump technique, absence of internal thoracic artery graft, incomplete revascularization, postoperative neurologic event, low cardiac output syndrome, new-onset atrial fibrillation, new renal failure, pulmonary complication, infective complication, and gastrointestinal complication. Only variables with a *P* value less than .05 at univariate analysis were included in the regression model. All statistical tests were 2 tailed. Statistical analyses were performed using SPSS version 13.0 (SPSS Inc, Chicago, Ill).

Results

Patients

A total of 1191 patients aged 65 years or more underwent coronary artery bypass surgery. Of these patients, 744 (62.5%) were in the CCABG group and 447 (37.5%) were in the OPCAB group. Baseline preoperative and intraoperative characteristics are listed in Table 1. Patients in OPCAB group were significantly older (70.0 ± 3.9 years vs 69.1 ± 3.4 years, $P < .001$), had a higher incidence of PVD (15.4% vs 6.6%, $P < .001$), had a higher EuroSCORE (4.01 ± 1.68 vs 3.59 ± 1.51 , $P < .001$), had a higher rate of use of internal thoracic artery graft (94.9% vs 91.7%, $P = .039$), had a higher rate of incomplete revascularization (16.3% vs 3.2%, $P < .001$), and had more arterial distal anastomoses (1.00 ± 0.35 vs 0.94 ± 0.37 , $P = .006$). However, patients in the CCABG group had a higher prevalence of triple vessel disease (88.4% vs 83.9%, $P < .001$), a higher ratio of grafts/diseased vessels (1.342 ± 0.32 vs 1.10 ± 0.31 , $P < .001$), and more venous distal anastomoses (2.89 ± 0.96 vs 2.03 ± 0.92 , $P < .001$).

Early Outcome

The in-hospital mortality rate for overall patients in our study was low ($n = 26$, 2.18%). The early clinical outcome and risk-adjusted analysis are shown in Table 2. Univariate analysis showed significant benefits from OPCAB for pulmonary complications (14.5% vs 6.3%, $P < .001$), infective complications (3.8% vs 1.1%, $P = .007$), and length of intensive

TABLE 1. Baseline preoperative and intraoperative characteristics

	CCABG (n = 744)	OPCAB (n = 447)	P value
	n (%)	n (%)	
Age	69.10 ± 3.38	70.04 ± 3.94	<.001
Female	140 (18.8)	77 (17.2)	NS
COPD	184 (24.7)	117 (26.2)	NS
PVD	49 (6.6)	69 (15.4)	<.001
CVD	70 (9.4)	59 (13.2)	NS
Previous stroke	63 (8.5)	43 (9.6)	NS
Hypertension	464 (62.4)	289 (64.7)	NS
Hyperlipidemia	240 (32.3)	145 (32.4)	NS
Diabetes	225 (30.2)	130 (29.1)	NS
Prior cardiac operation	1 (0.1)	3 (0.7)	NS
Renal failure	8 (1.1)	10 (2.2)	NS
Serum creatinine	93.70 ± 20.91	94.09 ± 21.71	NS
Unstable angina	60 (8.1)	39 (8.7)	NS
LVEF			
LVEF < 30%	5 (0.7)	2 (0.4)	NS
LVEF 30%–50%	159 (21.4)	75 (16.8)	NS
Recent MI < 21 d	13 (1.7)	12 (2.7)	NS
Critical preoperative state	7 (0.9)	9 (2.0)	NS
Left main disease	275 (37.0)	140 (31.3)	NS
Triple-vessel disease	658 (88.4)	375 (83.9)	<.001
Emergency operation	44 (5.9)	28 (6.3)	NS
EuroSCORE	3.59 ± 1.51	4.01 ± 1.68	<.001
No. of arterial distal anastomoses	0.94 ± 0.37	1.00 ± 0.35	.006
No. of venous distal anastomoses	2.89 ± 0.96	2.03 ± 0.92	<.001
ITA graft	682 (91.7)	424 (94.9)	.039
Incomplete revascularization	24 (3.2)	73 (16.3)	<.001
Grafts/diseased vessel	1.34 ± 0.32	1.10 ± 0.31	<.001

COPD, Chronic obstructive pulmonary disease; PVD, peripheral vascular disease; CVD, cerebrovascular disease; LVEF, left ventricular ejection fraction; MI, myocardial infarction; ITA, internal thoracic artery. Continuous variables are reported as mean $\pm$ standard deviation.

care unit stay (99.6 ± 124.7 vs 83.1 ± 138.9 , $P = .004$). It also showed a benefit of OPCAB for stroke, new renal failure, intraaortic balloon pump use, inotrope use, and low cardiac output syndrome. After adjustment for age, gender, PVD, EuroSCORE, triple vessel disease, and grafts/diseased vessels, there was still a benefit of OPCAB. Table 2 shows that the adjusted odds ratios favoring the OPCAB group were 2.627 for pulmonary complication, 1.575 for low cardiac output syndrome, 2.334 for reoperation, and 3.354 for infection-related complication. Table 2 also shows that there were no significant differences in in-hospital mortality and postoperative hospital stay between the 2 groups.

TABLE 2. Early clinical outcomes^a

	CCABG (n = 744)	OPCAB (n = 447)	P value	OR ^b (adjusted)	95% CI	P value
	n (%)	n (%)				
In-hospital mortality	20 (2.7)	6 (1.3)	NS	2.352	0.848–6.527	NS
Postoperative hospital stay (d)	15.30 ± 79.72	10.99 ± 29.39	NS			
ICU stay (h)	99.64 ± 124.68	83.10 ± 138.85	.004			
Postoperative morbidities	298 (40.1)	150 (33.6)	.025	1.329	1.007–1.755	.045
Neurologic event	24 (3.2)	6 (1.3)	.045	2.386	0.862–6.605	NS
Stroke	8 (1.1)	0 (0.0)	.028			
Low cardiac output syndrome	190 (25.5)	90 (20.1)	.033	1.575	1.138–2.180	.006
IABP support	23 (3.1)	4 (0.9)	.015	3.995	1.224–13.036	.022
LVAD support	5 (0.7)	0 (0.0)	NS			
Significant inotrope support	125 (16.8)	51 (11.4)	.011	1.811	1.217–2.695	.003
New-onset atrial fibrillation	111 (14.9)	73 (16.3)	NS	0.868	0.602–1.252	NS
New renal failure	9 (1.2)	0 (0.0)	.017			
Dialysis	2 (0.3)	0 (0.0)	NS			
Pulmonary complications	108 (14.5)	28 (6.3)	.000	2.627	1.607–4.295	.000
Infective complications	28 (3.8)	5 (1.1)	.007	3.354	1.189–9.466	.022
Gastrointestinal complication	9 (1.2)	6 (1.3)	NS	1.060	0.340–3.309	NS
Reexploration for bleeding	17 (2.3)	7 (1.6)	NS	1.233	0.451–3.371	NS
Reexploration for graft occlusion	3 (0.4)	0 (0.0)	NS			

OR, odds ratio; CI, confidence interval; ICU, intensive care unit; IABP, intraaortic balloon pump; LVAD, left ventricular assist device; NS, not significant. ^aVariables are reported as frequencies (%) or means ± standard deviation. ^bOdds ratio adjusted by variables significantly related to CCABG and OPCAB in Table 1.

Long-term Outcome

Figure 1 shows the Kaplan–Meier event-free survival analyses (propensity score matched cases) for long-term outcomes. The log-rank test was used to describe the differences between OPCAB and CCABG surgery using the matched data. Stroke, MACCEs, and readmission occurred more frequently in the OPCAB group ($P < .001$). There was a nonsignificant trend to higher total mortality ($P = .193$) and higher repeated revascularization rates ($P = .067$) in the OPCAB group. There were no significant differences in Q-wave myocardial infarction ($P = .817$).

Table 3 summarizes the results of univariate and multivariate analyses (Cox regression model) in identifying the preoperative, intraoperative, and postoperative risk factors associated with the long-term outcomes. The candidate independent variables used in stepwise Cox proportional hazards models are listed in Table 3. Intraoperatively, the off-pump technique was shown to be a significant predictor of stroke (hazard ratio = 2.611; $P < .001$), readmission (hazard ratio = 2.000; $P < .001$), and MACCEs (hazard ratio = 1.764; $P < .001$).

Discussion

The analysis carried out in the present study focused on the influence of the off-pump surgical technique on early and long-term clinical outcome in the elderly population. The most important result of our study is that despite more favorable early outcomes, the benefits of OPCAB cannot be maintained in the long term.

CCABG is performed with the help of cardiopulmonary bypass, which allows the surgeon to perform the delicate anastomoses on an arrested heart under optimal visualization. However, previous studies have demonstrated that the use of CPB during CABG is associated with substantial complications,^{6–11} which are largely attributed to the CPB itself and the aortic cannulation and crossclamping. OPCAB does not require hypothermia, CPB, aortic cannulation, or crossclamping. In reviewing meta-analyses comparing early outcomes after OPCAB and CCABG, we found that it has been accepted that OPCAB is associated with a lower incidence of postoperative morbidities in the short term.^{12–16} Table 2 shows that the early outcome in our study also favored the OPCAB group. These findings are in accordance with the aforementioned meta-analyses suggesting that OPCAB may reduce in-hospital morbidity in elderly surgical patients.

However, the exposure of the vessels at the back of the heart (circumflex artery) is sometimes difficult during OPCAB, and the motion of the heart may impede the anastomotic process. Many trials have reported fewer grafts being performed with OPCAB so that the degree of revascularization is less. Khan and colleagues¹⁷ reported a significant reduction in the patency rate associated with OPCAB compared with CCABG,¹⁷ and a registry from New York State demonstrated a lower survival and freedom from revascularization with OPCAB compared with CCABG.¹⁸ In our study, patients in the OPCAB group had more internal thoracic artery grafts and arterial distal anastomoses but a lower ratio of grafts/diseased vessels and a higher rate of

Figure 1. Kaplan-Meier curves for event-free survival analyses in total mortality, Q-wave myocardial infarction, repeated revascularization, stroke, MACCEs, and readmission (propensity score matched cases). CCABG, Conventional coronary artery bypass grafting; OPCAB, off-pump coronary artery bypass; MACCE, major adverse cardiac and cerebrovascular event.

TABLE 3. Preoperative, intraoperative, and postoperative risk factors of long-term outcomes for operative survivors according to univariate and multivariate analysis*

	Total Mortality				Repeated revascularization			
	Univariate Analysis	Multivariate Analysis			Univariate Analysis	Multivariate Analysis		
	<i>p</i>	<i>p</i>	<i>HR</i>	<i>95%CI</i>	<i>p</i>	<i>p</i>	<i>HR</i>	<i>95%CI</i>
Preoperative								
Age	n.s.				0.035	0.010	1.110	1.026-1.201
Female	n.s.				0.025	0.005	2.882	1.368-6.074
COPD	n.s.				n.s.			
PVD	n.s.				n.s.			
CVD	n.s.				0.009	0.004	3.209	1.459-7.060
Stroke	n.s.				n.s.			
Hypertension	n.s.				n.s.			
Hyperlipidemia	n.s.				n.s.			
Diabetes	n.s.				n.s.			
Prior cardiac operation	n.s.				0.011	0.002	23.806	3.122-181.504
Renal failure	0.026				0.021	0.012	6.375	1.507-26.966
Serum creatinine	0.003	0.028	1.011	1.001-1.022	n.s.			
Unstable angina	n.s.				n.s.			
LVEF<50%	0.001	0.006	2.083	1.554-2.612	n.s.			
Recent MI <21 days	n.s.				n.s.			
Critical preoperative state	n.s.				n.s.			
Left main disease	n.s.				n.s.			
Triple-vessel disease	n.s.				n.s.			
Emergency operation	n.s.				n.s.			
EuroSCORE	n.s.				0.012			
Intraoperative								
Off-pump	n.s.				n.s.			
Absence of IMA graft	n.s.				n.s.			
Incomplete revascularization	n.s.				n.s.			
Postoperative								
Neurological event	n.s.				n.s.			
Low cardiac output syndrome	<0.001	0.001	2.403	1.444-3.999	n.s.			
New onset AF	0.005				n.s.			
New renal failure	0.052				n.s.			
Pulmonary complications	0.003				n.s.			
Infective complications	n.s.				n.s.			
Gastrointestinal complications	0.001	0.003	6.200	1.885-20.396	n.s.			

*Abbreviations are as shown in Tables 1 and 2.

incomplete revascularization, all of which are related to prognosis.

With respect to long-term outcomes, we found a nonsignificant trend to higher rates of total mortality and repeated revascularization. Less information is available from other studies on comparative long-term outcomes after CABG, but evidence exists of higher rates of long-term mortality and repeated revascularization. Raczy and colleagues¹⁸ found that patients undergoing OPCAB had higher rates of mortality and subsequent revascularization. Wijeyesundera and colleagues¹⁹ also found higher long-term (1 to 2 years) repeated revascularization in a meta-analysis of randomized and observational studies.

Stroke is a serious complication after coronary surgery and influences the long-term prognosis of elderly patients. Previous studies have shown that advanced age, hypertension, PVD, previous stroke, diabetes mellitus, depressed left ventricular ejection fraction, and chronic renal failure are all identified as independent determinants for stroke after cardiac surgery.^{20,21} Our study patients in the OPCAB group were significantly older and had a higher incidence of PVD. With multivariable Cox regression, the off-pump technique was shown to be a significant predictor of stroke. We also attempted propensity score matching to balance all the preoperative variables available. In these propensity score-matched cases, stroke still occurred more frequently in the OPCAB group.

TABLE 3. (Continued)

Stroke				Readmission				MACCEs			
Univariate Analysis	Multivariate Analysis			Univariate Analysis	Multivariate Analysis			Univariate Analysis	Multivariate Analysis		
<i>p</i>	<i>p</i>	<i>HR</i>	<i>95%CI</i>	<i>p</i>	<i>p</i>	<i>HR</i>	<i>95%CI</i>	<i>p</i>	<i>p</i>	<i>HR</i>	<i>95%CI</i>
<0.001	0.001	1.093	1.037-1.153	<0.001	0.017	1.042	1.007-1.078	<0.001			
n.s.				<0.001	0.001	1.644	1.222-2.211	n.s.			
n.s.				n.s.				n.s.			
0.018				<0.001	0.006	1.787	1.181-2.703	n.s.			
0.008	0.006	2.237	1.254-3.992	0.004	0.017	1.527	1.078-2.163	0.002	0.004	1.799	1.206-2.684
0.020				0.034				0.005			
n.s.				0.013				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				0.011	0.041	2.347	1.034-5.330
n.s.				n.s.				n.s.			
0.040				<0.001				0.035			
0.033				n.s.				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				n.s.			
n.s.				n.s.				n.s.			
0.011	0.019	2.573	1.165-5.681	0.006				n.s.			
<0.001				<0.001	0.000	1.172	1.0730-1.280	<0.001	0.001	1.166	1.066-1.276
<0.001	0.000	2.611	2.152-3.070	<0.001	0.000	2.000	1.747-2.253	<0.001	0.000	1.764	1.456-2.072
n.s.				n.s.				n.s.			
n.s.				0.005				0.035			
n.s.				n.s.				n.s.			
n.s.				0.028				0.004	0.140	1.539	1.090-2.174
n.s.				n.s.				0.029			
n.s.				n.s.				n.s.			
n.s.				0.025	0.034	1.498	1.031-2.176	0.027			
n.s.				n.s.				n.s.			
n.s.				n.s.				0.026	0.051	2.711	0.994-7.393

Readmission in our present study was defined as any cardiovascular hospital readmissions for acute myocardial infarction, congestive heart failure, and unstable angina. Patients in the OPCAB group were more likely than patients in the CCABG group to be readmitted during follow-up. With multivariable Cox regression, the off-pump technique was also shown to be a significant predictor of readmission. MACCEs were the combination of death, Q-wave myocardial infarction, stroke, and repeated revascularization; therefore, MACCEs occurred more frequently in the OPCAB group.

Patients in the OPCAB group were significantly older and had a higher EuroSCORE, higher prevalence of PVD, and higher rate of incomplete revascularization, which may explain

their worse long-term results. However, we were unable to determine the extent to which the higher rates of these long-term adverse outcomes in the OPCAB group were related to choice of procedure or incomplete revascularization versus other risk factors. We believe this will be important because choice of procedure or incomplete revascularization may be easily remedied by changing practice pattern. A large, randomized clinical trial is warranted to confirm the influence of the off-pump technique on the long-term outcomes in elderly patients.

Potential Clinical Implications of Data

Because OPCAB showed trends toward early benefit but worse long-term result, it is possible that a larger sample

size and longer-term follow-up might revealed other statistically significant outcome variables. A randomized trial is indicated because randomization, as with all trials comparing OPCAB with CCABG, eliminates clinical judgment in patient selection and carries a potential for being misleading as a predictor of outcomes in actual daily life.

Study Limitations

The nonrandomized nature of the study limits any direct comparisons of the 2 surgical procedures of coronary revascularization. We included all patients aged more than 65 years undergoing isolated CABG, resulting in a heterogeneous population of elderly patients with some baseline clinical differences between the study groups. This study was observational, uncontrolled, and without specific protocols, therefore limiting any direct comparisons of the 2 procedures. Perioperative myocardial infarction was not evaluated in our study because cardiac enzymes were not routinely obtained after revascularization. Patients were subject to treatment bias because the decision to proceed with OPCAB versus CCABG was made solely at the discretion of the operating surgeon on the basis of anatomic and clinical findings. We attempted to minimize this bias by matching patients exactly on the basis of patient-related factors in our database that were significant predictors of the type of procedure in multivariable analyses. However, the selection bias may still be present because of some undefined factors related to the choice of procedure and adverse outcomes that were not present in our database, for example, an extensively calcified ascending aorta, the target vessel size, and the extent of disease in the target vessel.

Conclusions

OPCAB compared with CCABG reduced early morbidities in elderly patients. However, the early benefits of OPCAB could not be maintained in the long term, and OPCAB showed trends toward worse long-term results. A large, randomized clinical trial is warranted to confirm the influence of the off-pump technique in elderly patients.

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