Hospital and Mid-Term Outcomes in Elderly Patients Undergoing Off-Pump Coronary Artery Bypass Grafting

— Comparison With Younger Patients —

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Background Clinical outcomes and problems following off-pump coronary artery bypass grafting (OPCAB) in elderly patients have not been clarified.

Methods and Results The surgical results of elderly patients aged 75 years or older (n=50; 38 males, mean age, 78.8 years) were reviewed and compared with those of younger patients (n=95; 79 males, mean age, 63.0 years). The EuroSCORE score was 6.9 ± 3.5 in the elderly group and 3.0 ± 2.4 in the younger group ($p < 0.0001$). There were no hospital deaths in either group. There was no significant difference in the postoperative complication rate except for atrial fibrillation (40.0% elderly vs 24.2% younger, $p = 0.0479$). Postoperative intensive care unit and hospital stays did not differ. The frequency of blood transfusion was significantly higher in the elderly group (78.0% elderly vs 37.2% younger, $p < 0.0001$). During the mean follow-up of 18.6 ± 8.8 months, there was 1 sudden death in the elderly group, but no cardiac deaths in either group. The 32-month cardiac event-free and survival rates were similar for the 2 groups.

Conclusion OPCAB provides satisfactory clinical outcomes for elderly as well as younger patients. (Circ J 2004; 68: 1184–1188)

Key Words: Coronary artery bypass; Elderly; Mid-term results; Off-pump coronary artery bypass (OPCAB)

The number of elderly patients undergoing coronary artery bypass grafting (CABG) has been increasing in recent years and it has been demonstrated that advanced age is an independent predictor of mortality, morbidity, and delayed postoperative recovery for patients undergoing conventional CABG with cardiopulmonary bypass (CPB).^{1,2} During the past decade, off-pump coronary artery bypass surgery (OPCAB) has come to be used worldwide and has been proposed as a less invasive technique of myocardial revascularization associated with excellent graft patency.^{3–5} As well, OPCAB reduces the postoperative length of stay, and morbidity in elderly patients when compared with conventional CABG with CPB.^{6,7} Therefore, we hypothesized that because OPCAB is less invasive it could provide similar satisfactory results in elderly patients as is expected in younger patients and the aim of this study was to assess that hypothesis.

Methods

Between October 1, 2001, and February 28, 2004, 159 consecutive patients underwent isolated CABG at Kanto Medical Center NTT EC. CPB was used in 14 patients for: reoperation (5 patients), an intramyocardial coronary artery (1 patient) and hemodynamic instability (8 patients). The

remaining 145 patients underwent OPCAB. The patients were divided into 2 groups according to their age (elderly group: ≥ 75 years; younger group: < 75 years). Their charts were reviewed retrospectively and the following data were collected and compared between the 2 groups: preoperative data; risk factors; angiographic findings; surgical data, including graft materials; intubation time; intensive care unit (ICU) stay; hospital stay; postoperative complications; mortality; and mid-term clinical data such as cardiac events and late death.

The elderly group consisted of 50 patients (38 males; mean age: 78.8 years, range: 75–88 years) and the younger group consisted of 95 patients (79 males; mean age: 63.0 years, range: 27–74 years). Preoperative patient data are summarized in Table 1. The body surface area was significantly lower in the elderly group than in the younger group (1.5 m^2 elderly vs 1.6 m^2 younger, $p = 0.001$). The preoperative hemoglobin concentration was also lower in the elderly group than in the younger group (12.1 mg/dl elderly vs 13.2 mg/dl younger, $p = 0.0006$). There were significantly more patients with diabetes mellitus in the younger group (38.0% elderly vs 60.0% younger, $p = 0.012$). Although the use of preoperative intraaortic balloon pumping (IABP) for hemodynamically unstable patients was more common in the elderly group (18% elderly vs 1.1% younger, $p = 0.0008$), the number of emergency surgeries was not significantly different. There were no significant differences in the severity of coronary artery disease, cardiac profiles, or the frequency of preoperative comorbidity. The European System for Cardiac Operative Risk Evaluation score (EuroSCORE), which indicates the expected mortality rate, was significantly higher in the elderly group (6.9 elderly vs 3.0 younger, $p < 0.0001$).⁸

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Table 1 Preoperative Patient Data

	Elderly (n=50)		Younger (n=95)		p value
	n	%	n	%	
Age, mean $\pm$ SD (years)	78.8 $\pm$ 3.3		63.0 $\pm$ 8.5		<0.0001
Range (years)	75–88		27–74		
Male	38	76.0	79	83.2	NS
Body surface area, mean $\pm$ SD (m ²)	1.5 $\pm$ 0.2		1.6 $\pm$ 0.2		0.0005
EuroSCORE	6.9 $\pm$ 3.5		3.0 $\pm$ 2.4		<0.0001
Emergency operation	14	28.0	19	20.0	NS
Unstable angina	20	40.0	24	25.2	NS
Acute myocardial infarction	7	14.4	6	6.3	NS
Old myocardial infarction	9	18.0	25	26.3	NS
Poor ejection fraction (<30%)	3	6.0	8	8.4	NS
Preoperative IABP	7	18.0	1	1.1	0.0008
Scheduled IABP	5	10.0	11	11.6	NS
Coronary artery disease					
Left main disease	9	18.0	18	19.0	NS
1-vessel	3	6.0	8	8.4	NS
2-vessel	18	36.0	31	32.6	NS
3-vessel	27	54.0	51	53.6	NS
Coronary risk factor					
Hypertension	35	70.0	65	68.4	NS
Diabetes	19	38.0	57	60.0	0.012
Hyperlipidemia	14	28.0	33	34.7	NS
Smoking history	27	54.0	56	58.9	NS
Comorbidity					
Cerebral vascular accident	9	18.0	16	16.8	NS
Chronic renal failure (serum creatinine >1.5)	10	20.0	13	13.7	NS
Dialysis	3	6.0	2	2.1	NS
Chronic obstructive pulmonary disease	12	24.0	19	20.0	NS
Preoperative hemoglobin, mean $\pm$ SD (mg/dl)	12.1 $\pm$ 1.5		13.2 $\pm$ 1.7		<0.0001

IABP, intra-aortic balloon pump.

Table 2 Intraoperative Data

	Elderly (n=50)		Younger (n=95)		p value
	n	%	n	%	
Operation time, mean $\pm$ SD (min)	310 $\pm$ 65		324 $\pm$ 71		NS
No. of distal anastomosis, mean $\pm$ SD	2.7 $\pm$ 0.7		2.8 $\pm$ 0.9		NS
Distal anastomosis					
1	3	6.0	5	5.3	NS
2	15	30.0	32	33.7	NS
3	27	54.0	40	42.1	NS
4	5	10.0	14	14.7	NS
>5	0	0	4	4.2	NS
Grafts					
Single ITA	16	32.0	31	32.6	NS
Bilateral ITA	33	66.0	62	65.3	NS
Radial artery	14	28.0	38	40.0	NS
Gastroepiploic artery	18	36.0	41	43.2	NS
Total artery bypass	36	72.0	87	91.5	0.0018
Saphenous vein	14	28.0	8	8.4	0.0018
Composit graft	8	16.0	14	14.7	NS
New IABP	0	0	0	0	NS
Conversion to CABG with CPB	0	0	0	0	NS
Ventricular tachycardia	0	0	1	1.1	NS

IABP, intra-aortic balloon pump; ITA, internal thoracic artery; CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass.

Surgical Strategies and Techniques

Since October 1, 2001, we have performed OPCAB for patients requiring coronary artery revascularization as the standard operation, except for those patients who are being redone. It has been our strategy to use the internal thoracic arteries (ITA) as much as possible for revascularization of the left coronary artery in all patients, because they have been confirmed as a safe and effective graft. The OPCAB procedure was performed through a median sternotomy.

Four deep pericardial sutures and XPOSE 3 Access Device (Guidant, Indianapolis, IN, USA) were used for cardiac displacement and presentation. Target vessels were stabilized with the Octopus III stabilizer (Medtronic, Minneapolis, MN, USA). Coronary shunts were not routinely used unless a target coronary artery was large or did not have collateral circulation. Whenever an aortic side clamp was needed for proximal anastomoses, we carefully examined the ascending aortic wall with computed tomography and

Table 3 Postoperative Outcomes

	Elderly (n=50)		Younger (n=95)		p value
	n	%	n	%	
Hospital death	0	0	0	0	NS
Intubation time, mean $\pm$ SD (min)	13.0 $\pm$ 14.5		10.9 $\pm$ 26.1		0.0017
>24 h (patients)	5	10.0	4	4.2	NS
Tracheotomy	1	2.0	1	1.1	NS
Postoperative ICU stay, mean $\pm$ SD (days)	2.6 $\pm$ 1.36		2.3 $\pm$ 1.4		NS
>2 weeks (patients)	1	2.0	1	1.1	NS
Postoperative hospital stay, mean $\pm$ SD (days)	16.4 $\pm$ 18.4		14.5 $\pm$ 11.8		NS
>1 month (patients)	1	2.0	2	2.1	NS
Major complication (patients)	3	6.0	4	4.2	
Low output syndrome	0	0	0	0	NS
Perioperative myocardial infarction	0	0	0	0	NS
Cerebrovascular accident	1	2.0	0	0	NS
Mediastinitis	0	0	0	0	NS
Re-exploration for bleeding	0	0	0	0	NS
Pneumonia	0	0	0	0	NS
Respiratory failure	2	4.0	2	2.1	NS
Hemodialysis	1	2.0	0	0	NS
Late tamponade	0	0	1	1.1	NS
Intestinal perforation	0	0	1	1.1	NS
Atrial fibrillation	20	40.0	23	24.2	0.0479
Angina	0	0	0	0	NS
Transfusion	39	78.0	36	37.9	<0.0001
Autotransfusion	9	18.0	47	49.5	0.0002

ICU, intensive care unit.

epiaortic echography. We performed OPCAB with the so-called 'aorta-no-touch' technique utilizing a composite graft or all in-situ grafts when the ascending aorta was found to be atherosclerotic or calcified.

Statistical Analysis

Continuous data are described by mean value $\pm$ standard deviation (SD) and are compared using the Mann-Whitney U test. Categorical data were compared by chi-square tests (Fisher's exact test if $n < 5$). Time-related events were described using the Kaplan-Meier estimate. Results with a probability value of less than 0.05 were considered statistically significant. All statistical analyses were performed using Stat view version 5.0 (SAS Institute, Cary, NC, USA).

Results

The intraoperative data for each group are shown in Table 2. There were no significant differences in operation time, the number of distal anastomoses, the use of single or bilateral ITA, and the use of composite grafts. Total arterial bypass was significantly less frequent in the elderly group (72.0% elderly vs 91.5% younger, $p = 0.0026$). In other words, saphenous vein grafting was performed more frequently in the elderly group (28.0% elderly vs 8.5% younger, $p = 0.0026$). There was no intraoperative conversion to CABG with CPB and no new induction of IABP during or after surgery in either group.

The postoperative outcomes are summarized in Table 3. There were no hospital deaths in either group. Although the number of patients who required an intubation time of more than 24 h did not differ, the average intubation time was significantly longer in the elderly group (13.0 h elderly vs 10.9 h younger, $p = 0.0017$). However, there were no significant differences in postoperative ICU stay (2.6 days elderly vs 2.4 days younger) or hospital stay (16.4 days elderly vs 14.3 days younger). Tracheotomy was needed in 2 patients, 1 in each group. The elderly patient was an 81-year-old man

with a history of tuberculosis who had a severe Parkinsonian syndrome. He underwent emergency OPCAB under IABP for acute myocardial infarction. However, paralytic ileus because of Parkinsonian syndrome occurred, and subsequently renal and respiratory failure developed. The younger patient was a 69-year-old man who underwent elective 3-vessel OPCAB. He suffered from intestinal perforation and needed long-term respiratory support.

The incidence of other major complications was low (3 patients elderly vs 4 patients younger) and not significantly different between the groups. Atrial fibrillation (AF) occurred in 40.0% of the elderly group and 24.2% of the younger group ($p = 0.0479$). A cerebrovascular accident occurred in 1 elderly patient on the third postoperative day, but at that time, the patient had paroxysmal AF and was not treated with warfarin, which we suspect was the cause of the incident. The patient recovered in several days without any paralysis. We examined the exercise electrocardiogram and echocardiography of all patients at discharge, and there were none with a positive change or evidence of angina pectoris.

Blood transfusion was significantly more common in the elderly group (78.0% elderly vs 37.2% younger, $p < 0.0001$), although autotransfusion was significantly less common (18% elderly vs 50% younger, $p < 0.0001$).

During the mean follow-up period of 18.6 $\pm$ 8.8 months, we were able to follow 100% of the patients (Table 4). There were no mid-term cardiac deaths, although there was 1 case of sudden death of unknown cause in the elderly group. Non-cardiac deaths occurred in 4 patients (2 patients died of cancer and 2 patients died of cerebrovascular accident). Congestive heart failure was found more frequently in the elderly group (6.0% elderly vs 0% younger, $p = 0.016$), although it was not caused by coronary ischemic heart problems at that time. Other cardiac events and the late death rate did not differ between the groups. Using the Kaplan-Meier estimate, the 32-month survival rate and the cardiac event-free rate did not differ between the 2 groups (survival rate: 93.4% in the elderly group and 97.5% in the

Table 4 Mid-Term Outcomes

	Elderly (n=50)		Younger (n=95)		<i>p</i> value
	<i>n</i>	%	<i>n</i>	%	
<i>No. of patients followed up</i>	50	100.0	95	100.0	NS
<i>Follow-up period, mean ± SD (months)</i>	18.7±9.4		17.9±8.4		NS
<i>Cardiac events</i>					
<i>Angina</i>	0	0	1	1.1	NS
<i>Myocardial infarction</i>	1	2.0	0	0	NS
<i>Congestive heart failure</i>	3	6.0	0	0	0.016
<i>Percutaneous coronary intervention</i>	0	0	2	2.1	NS
<i>Arrhythmia</i>	0	0	1	1.1	NS
<i>Late death</i>					
<i>Cardiac death</i>	0	0	0	0	NS
<i>Noncardiac death</i>	2	4.0	2	2.1	NS
<i>Unknown sudden death</i>	1	2.0	0	0	NS

younger group, $p=0.22$; cardiac event-free rate: 90.3% in the elderly group and 94.9% in the younger group, $p=0.32$).

Discussion

Hospital mortality and morbidity after OPCAB in the present elderly group were comparable with those in the younger group. Neither group had any hospital deaths, and both had similar hospital stays and a low incidence of postoperative complications. However, the intubation time was significantly longer and the incidence of both atrial fibrillation and blood transfusion were higher in the elderly group. The 32-month cardiac event-free and survival rates did not differ between the 2 groups.

It has been reported that surgical results, including postoperative recovery, after conventional CABG with CPB in elderly patients are not sufficient.^{1,2,9} Hirose et al compared elderly patients aged over 75 years undergoing conventional CABG to younger patients aged less than 75 years and concluded that the frequency of postoperative complications was higher in elderly patients, who also required a longer postoperative recovery than younger patients, whether or not there were any major complications.² Wong et al have shown that advanced age is an independent predictor of delayed extubation and prolonged ICU stay.¹ Many institutions have recently introduced OPCAB because it has been proposed as a less invasive myocardial revascularization technique, with earlier recovery and reduced incidence of postoperative complications in elderly patients because of the elimination of CPB.^{5–7} We obtained acceptable results after OPCAB in elderly patients that substantiate those previous reports.

Basically, our surgical indication and procedures are not changed by the patients' age. In this study both elderly and younger patients had similar OPCAB procedures as judged by the number of bypasses, the use of both ITA, and the operation time. However, elderly patients have more severe atherosclerotic change and are more often hemodynamically deteriorated than younger patients. Consequently, the surgical technique must be able to address such difficulties in elderly patients. In this study, the use of saphenous vein graft was higher in elderly group (28.0% elderly vs 8.5% younger, $p=0.0026$) because it is less invasive and the vessel is not affected by atherosclerotic change. Unlike elastic arteries, muscular arteries, such as the radial or gastroepiploic artery, are more prone to atherosclerotic changes in elderly patients¹⁰ and failure of such muscular grafts may occur more frequently in elderly patients than

in younger patients. Therefore, we believe that elderly patients with limited life expectancy may benefit from a saphenous vein graft. However, when using a saphenous vein graft, a proximal anastomosis of aorto-coronary bypass is problematic because of the severe atherosclerotic change often seen in the ascending aorta of elderly patients. Nevertheless, we believe that careful selection of patients using preoperative computed tomography and intraoperative epiaortic echography makes it possible to properly use side clamping of the ascending aorta. In the present study, aortic side-clamp was not feasible because of atherosclerosis of ascending aorta in 10% of our patients and in such cases, we performed OPCAB with the aorta-no-touch technique utilizing a composite graft or all in-situ grafts. In consequence, there was no embolic complication. Recently, we have used Guidant Heartstring (Guidant, Indianapolis, IN, USA) to perform a proximal anastomosis without aortic side clamp in several cases.

When the coronary circulation is extremely jeopardized, as in unstable angina, or when a severe stenosis exists in the left main trunk or a proximal portion of the dominant circumflex artery, hemodynamic compromise can occur during cardiac displacement and presentation. In such high-risk cases, we introduce scheduled IABP in the operating theater just before the surgical procedures to maintain systemic blood pressure and coronary perfusion during cardiac displacement. In the present study we used scheduled IABP in 16 patients (11.0%) and none of them experienced hemodynamic compromise or needed CPB.

Generally, we know that advanced age is still a detrimental factor for many surgical procedures. Aging affects all the organs, so elderly patients may not have enough capacity to suffer the unphysiologic stress of operation, anesthesia, mechanical ventilation, and even staying in the ICU. Therefore, it is essential to return them to physiologic conditions as early as possible in the postoperative period by correcting acidosis, blood plasma, electrolytes or anemia as required.

Several recent studies have claimed that advanced age is an independent predictor of morbidity and mortality even in patients undergoing OPCAB, showing a relatively high operative mortality of 1.9–6.0%.^{11–13} In our study, we found that there was a statistically significant difference in 3 postoperative factors. Intubation time was significantly longer in the elderly group (13.0h elderly vs 10.9h younger, $p=0.0017$), even though the number of patients who required an intubation time >24h did not differ between the 2 groups. The elderly group included more hemodynamically unstable patients with conditions such as acute myocar-

dial infarction and unstable angina requiring preoperative IABP. In such patients, we deliberately confirmed hemodynamic stability and the peak cardiac enzyme concentration before extubation and termination of IABP, which may have directly contributed to the longer intubation times in the elderly group.

AF occurred more frequently in the elderly group (40.0% elderly vs 24.2% younger, $p=0.0479$). In cardiac surgery with CPB advanced age has been proven to be a dominant factor promoting postoperative AF^{14,15}. Our study suggested that advanced age can be a negative predictor of AF even in OPCAB. Age-related fibrosis in the atrial tissue, an increase in the atrial chamber size, sympathetic activation, inflammation, and nonuniform anisotropic conduction may account for the increased risk of AF in elderly patients. Moreover, they all may not be reduced only by the elimination of CPB. To reduce AF we do not withdraw β -blocker therapy in the immediate postoperative period and administered magnesium sulfate (4 g/day) for 2 days after surgery to patients in both groups. However, the actual incidence of AF was as common as 29.6% of all patients. Therefore, we introduce warfarin for patients with postoperative AF to prevent cerebrovascular accidents, even though almost all cases of AF discontinue in the short-term because coagulability may be accelerated after OPCAB¹⁶. Furthermore, angiotensin-converting enzyme inhibitors and antiinflammatory drugs have been reported to offer protection against postoperative AF and we have considered them as well¹⁷.

The use of postoperative blood transfusion was significantly higher in the elderly group (78.0% elderly vs 37.2% younger, $p<0.0001$). On the other hand, autologous blood transfusion was less frequent. It has been reported that the elimination of CPB reduces the amount of blood loss and the need for blood transfusion^{6,18–20}. However, there was a high rate of blood transfusion in the elderly patients in this study, which may be related to the lower preoperative hemoglobin concentration (12.1 mg/dl elderly vs 13.1 mg/dl younger, $p=0.0006$) and smaller body surface area (1.5 m² elderly vs 1.6 m² younger, $p=0.001$) of the elderly patients.

On examination of the results of mid-term follow-up at 18.6 $\pm$ 8.8 months, there were no cardiac deaths, although there was 1 case of sudden death of unknown cause. The 32-month survival rate and the cardiac event-free rate did not differ and were lower compared with previous reports^{4,21}. The total number of cardiac events did not differ between the 2 groups. Among them congestive heart failure occurred significantly more frequently in the elderly group (6.0% elderly vs 0% younger, $p=0.013$). However, it was not because of graft failure or progression of coronary ischemia, but mainly caused by poor ventricular function related to old myocardial infarction or deterioration of other organs. This reflects the fact that elderly patients have various health problems resulting from the aging process itself. Puskus et al reported that complications occurring within 30 days and at 1 year after OPCAB in patients with a mean age of 62.2 years were similar to those of patients undergoing CABG with CPB. They also reported that 12.4% of patients needed readmission for cardiac causes, with the most common complication being congestive heart failure at 3.4%²¹.

In conclusion, our study showed that OPCAB in elderly patients can provide satisfactory hospital and mid-term outcomes that are comparable to those obtained in younger patients.

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