Off-pump coronary surgery improves in-hospital and early outcomes in octogenarians

Alessandro D'Alfonso, Massimo A. Mariani, Andrea Amerini, Riccardo Codecasa, Luca Bellieni, Agnese Proietti, Jan G. Grandjean

Department of Cardio-Thoracic Surgery, University Hospital of Pisa, Pisa, Italy

Key words:
Aging;
Cardiopulmonary bypass;
Coronary artery disease;
Coronary artery surgery;
Nervous system.

Background. **A retrospective study on octogenarians who underwent off-pump (OPCAB) or conventional (CCAB) coronary artery bypass surgery undertaken to evaluate the in-hospital and early outcomes in terms of survival and cardiac and neurological events.**

Methods. **The design of the study was single-institutional, retrospective and comparative. Between January 1997 and May 2003, 114 patients were included and 73 underwent OPCAB, while 41 underwent CCAB. Uni- and multivariate analyses were used to determine the correlation between the pre- and intraoperative data and hospital death or complications. The overall survival and freedom from cardiac events were determined using Kaplan-Meier analysis. The linearized rates of follow-up complications were compared between the two groups.**

Results. **Overall, comparison of CCAB to OPCAB revealed differences in the operative mortality (6 deaths for CCAB, 14.6% vs 5 deaths for OPCAB, 6.8%; p = 0.05). Postoperative complication variables showed that there was no significant difference in the number of patients who suffered from cardiac events and stroke (2.4% CCAB vs 1.4% OPCAB, p = NS) whereas there was a significant difference for minor neurological events (12.2% CCAB vs 2.8% OPCAB, p = 0.04). The mean follow-up was 2.1 ± 1.8 years, for a total follow-up of 234 patient-years. There were 12 late deaths, 6 in the CCAB group and 6 in the OPCAB group. The linearized rate of overall death was 9.5 ± 2.6%/year in the CCAB group and 13.3 ± 3.9%/year in the OPCAB group (p = NS). The actuarial survival at 24 months was 84 ± 7% for OPCAB and 81 ± 12% for CCAB (p = NS). The actuarial freedom from cardiac events at 24 months was 89 ± 4% for OPCAB and 90 ± 6% for CCAB (p = NS). The linearized rate of neurological events was 0.7 ± 0.7%/year for the CCAB group and 1.1 ± 1.1%/year for the OPCAB group (p = NS).**

Conclusions. **Our analysis shows that OPCAB improves the early outcome and that octogenarians can lead event-free lives after cardiac surgery.**

(Ital Heart J 2004; 5 (3): 197-204)

Received October 28, 2003; revision received December 15, 2003; accepted January 20, 2004.

Address:

Dr. Massimo A. Mariani

Dipartimento
Cardio Toracico
Ospedale Cisanello
Via Paradisa, 2
56124 Pisa
E-mail:
massimo_mariani@hotmail.com

Introduction

Refinements and advances in anesthesia, surgical techniques, and myocardial preservation, as well as in postoperative monitoring and management, have led to a decline in morbidity and mortality for cardiac surgical patients. These advances have made it possible to extend the benefits of cardiac operations to older patients[1,2].

However, the incidence of cerebrovascular accidents (CVA) after conventional coronary artery bypass (CCAB) has remained unchanged, such events occurring in up to more than 5% of all patients[3-10]. CVA are the most devastating complications of cardiac surgery. In particular, for patients > 80 years, the incidence of CVA may be as high as 10%[11,12]. The incidence of cognitive and neuropsychological complications is much higher and may exceed 60% at discharge[13,14] declining to 20-40% at 6 weeks, and to 10-30% at 6 months[15,16].

The cumulative effects of aging on the cardiovascular system and the progressive nature of stroke risk factors over a prolonged period of time substantially increase the risk of CVA, both at surgery and at follow-up.

Recent advances in cardiac surgical techniques, in particular the development of off-pump coronary artery bypass (OPCAB) through a median sternotomy or through a left lateral minithoracotomy (minimally invasive direct coronary artery bypass), may reduce the incidence of CVA. While more patients are undergoing OPCAB surgery, the patient risk profiles are also increasing owing to a higher proportion of advanced age individuals and other comorbidities[17].

An up-to-date risk factor analysis is therefore necessary to determine the predictors of CVA in elderly patients in the era of modern cardiac surgery. Previous studies have attempted to identify the predictors of

CVA after coronary artery bypass grafting (CABG) as well as during other cardiac surgical procedures. Although these studies have yielded important data, most were derived from small study populations or were focused on a single surgical procedure. Furthermore, recent studies examining the impact of "minimally invasive" techniques including OPCAB surgery on stroke have yielded inconsistent and sometimes controversial results[18,19].

Therefore the aim of the present study was to investigate the incidence of in-hospital mortality and morbidity and in particular the predictors of perioperative CVA as well as their association with two different revascularization procedures (OPCAB vs CCAB) and to report the early outcomes in terms of survival, cardiac and neurological events in preoperative neurologically asymptomatic octogenarians.

Methods

Study design. The design of the study was single-institutional, retrospective and comparative. The patients enrolled had been consecutively submitted to one of the two procedures. All patient data were collected using our custom-made database (Microsoft Access, 1997) that is used daily for clinical data management.

Study population, data collection and follow-up. A total of 2713 consecutive adult patients underwent CABG between January 1997 and May 2003 in our Department. Starting from June 2000 we began a comprehensive institutional policy for off-pump revascularization. At present (2002 data) 97% of coronary surgery procedures are performed off-pump at our institution. One hundred and fourteen patients (4.2%) were > 80 years. With regard to this octogenarian population, CCAB was performed in 41 patients (36%) and OPCAB in 73 (64%).

The logistic EuroSCORE was 15 ± 11 (median 12; 95% confidence limit 11.9-19.1) for CCAB and 12 ± 7 (median 12; 95% confidence limit 10.8-14.1) for OPCAB (p = NS).

The patient characteristics are shown in table I.

The preoperative and operative data were obtained by retrospective review of the clinical and pathology reports contained in the database which were cross checked with all medical charts. Follow-up information on hospital survivors was collected, by telephone interview, during a 1-month interval ending in July 2003. Unsuccessful attempts to trace patients were followed by contacting a family member or the referring physician.

Data regarding the in-hospital mortality and major postoperative complications were obtained from our database which is updated daily.

Table I. Preoperative data.

Variable	CCAB (n=41)	OPCAB (n=73)	p
Age (years)	82.1 ± 1.9	81.8 ± 1.9	NS
Female sex	17 (41.5%)	24 (32.9%)	NS
Body mass index (kg/m^2)	24 ± 2	25 ± 3	NS
Hypertension	17 (41.5%)	41 (56.2%)	NS
Diabetes	10 (24.4%)	19 (26.0%)	NS
COPD	1 (2.4%)	7 (9.6%)	NS
Renal disease	–	3 (4.1%)	NS
Extracardiac arteriopathy	7 (17.1%)	13 (17.8%)	NS
Peripheral arteriopathy	2 (4.9%)	4 (5.5%)	NS
Abdominal aortic aneurysm	1 (2.4%)	2 (2.7%)	NS
Asymptomatic carotid disease	4 (9.8%)	7 (9.6%)	NS
Left main stenosis > 50%	9 (21.9%)	14 (19.2%)	NS
No. diseased vessels	2.6 ± 0.6	2.5 ± 0.7	NS
Three-vessel disease	25 (60.9%)	44 (60.3%)	NS
Unstable angina	14 (34.1%)	23 (32.5%)	NS
NYHA class			
II	17 (41.5%)	27 (37.0%)	NS
III	12 (29.3%)	13 (17.8%)	NS
IV	4 (9.8%)	6 (8.2%)	NS
Ejection fraction	47 ± 7	47 ± 10	NS
Ejection fraction < 0.35	–	7 (10%)	0.05
Log EuroSCORE	15 ± 11	12 ± 7	NS
Log EuroSCORE ≥ 15	14 (34.1%)	20 (27.4%)	NS
EuroSCORE medium risk (3-5)	4 (9.8%)	8 (11.0%)	NS
EuroSCORE high risk (> 5)	37 (90.2%)	65 (89%)	NS

CCAB = conventional coronary artery bypass; COPD = chronic obstructive pulmonary disease; OPCAB = off-pump coronary artery bypass.

Cardiac events were defined as new episodes of angina, myocardial infarction, congestive heart failure, graft occlusion and re-CABG requiring hospitalization or leading to death.

CVA after CABG were classified into two groups. Type I injuries include stroke, transient ischemic attack, coma, and stupor. These injuries are caused by specific and identifiable focal insults to the cerebral parenchyma. As a result, the diagnosis of type I injuries was achieved through standard clinical and computed tomography scan assessment. Type II neurological injuries include a new deterioration in intellectual function, such as confusion, agitation, disorientation, memory deficit, or seizures and neurocognitive dysfunction. The diagnosis of type II injuries was achieved through tests assessing a number of different cognitive domains, including memory, mood, attention, and constructive ability. A cognitive deficit was defined as a postoperative 20% decrease in performance (as compared to the preoperative performance) in at least 20% of the tests administered. We used the recommended core neuropsychological battery according to the 1994 Conference on CNS Dysfunction After Cardiac Surgery[20] with some additional assessment instruments.

All CVA were diagnosed during clinical assessment by physicians involved in the daily care of patients, and were confirmed by computed tomography or magnetic resonance imaging whenever possible. The diagnosis of a CVA was also confirmed and documented by a staff neurologist.

Operative technique. Ninety-six percent of the procedures were performed through a median sternotomy. The internal thoracic arteries were harvested as a pedicle, both for free and *in situ* grafting. The harvesting was performed by means of electrocautery. The radial artery was harvested as a pedicle through a skin incision in the left forearm starting 2 cm distal to the elbow and ending 3 cm proximal to the wrist. In all patients an Allen test was performed prior to surgery and the pressure of the radial artery stump was measured intraoperatively and recorded before dividing the artery. The saphenous vein grafts were harvested through small incisions using the tunneling technique.

All arterial conduits were distally divided after heparinization of the patient and irrigated with a 1% saline solution of papaverin. During off-pump procedures, heparinization was achieved by administering 150 IU/kg heparin in order to obtain a target activated clotting time > 300 s. Protamine sulfate was generally used to neutralize 50% of the heparin dose at completion of the procedure[21]. In order to obtain a better visualization of the target coronary arteries during the distal anastomoses, a single 0-silk suture was placed on the posterior pericardium between the inferior vena cava and the left inferior pulmonary vein. A suction stabilizer (Guidant Axius™ Vacuum 2 Stabilizer System, Santa Clara, CA, USA, or alternatively Octopus 3, Medtronic, Minneapolis, MN, USA) was used to stabilize the target coronary artery.

On-pump procedures were performed under moderately hypothermic cardiopulmonary bypass (33 to 36°C). Ringer's acetate and mannitol were used to prime the extracorporeal circuit. Myocardial protection was achieved by injection of cold blood cardioplegia (modified St. Thomas' cold crystalloid cardioplegic solution) into the aortic root and into the coronary sinus. The mean cardiopulmonary bypass and aortic cross-clamping times were 125 ± 33 and 49 ± 10 min respectively.

Postoperatively, all patients received low-molecular weight heparin (5000 IU twice daily) until fully mobilized.

The intraoperative data are shown in table II.

Statistical analysis. Data are presented as mean ± SD and as simple percentages. The Student's t-test or Wilcoxon test was used for continuous data and the χ^2 or Fisher's exact test was used for discrete variables, as appropriate. All variables with a p value < 0.10 at univariate analysis were entered into the multivariate analysis (forward stepwise logistic regression for hospital mortality

Table II. Intraoperative data.

Variable	CCAB (n=41)	OPCAB (n=73)	p
Urgent or emergent procedures	18 (43.9%)	41 (56.1%)	NS
Use of 1 ITA graft	36 (87.8%)	69 (94.5%)	NS
Use of 2 ITA grafts	–	2 (2.8%)	NS
Use of radial artery graft	1 (2.4%)	3 (4.1%)	NS
Use of only arterial grafts	4 (9.8%)	14 (19.2%)	NS
Use of arterial Y-graft	–	3 (4.1%)	NS
No. peripheral anastomoses/patient	2.5 ± 0.8	2.7 ± 1.0	NS
No. arterial anastomoses/patient	0.9 ± 0.4	1.4 ± 0.7	< 0.001
Endarterectomy	–	4 (5.5%)	NS
Minithoracotomy	–	4 (5.5%)	NS
Intra-aortic balloon pump	2 (4.9%)	4 (5.5%)	NS

CCAB = conventional coronary artery bypass; ITA = internal thoracic artery; OPCAB = off-pump coronary artery bypass.

and Cox's proportional hazards regression for events during follow-up). The linearized rates of the two groups were compared using a likelihood ratio test. The overall survival and freedom from myocardial infarction were determined by Kaplan-Meier actuarial analysis and expressed as the percentages of patients who were event free ± SE. The differences in actuarial freedom between the CCAB group and OPCAB patients were determined using the Cox-Mantel test. The linearized rate of postoperative complications was expressed as percent per year ± SE. Statistical analyses were performed using the NCSS 2000 software (Statistical Solutions Ltd, Cork, Ireland).

Results

In-hospital data. Overall, comparison of CCAB and OPCAB showed no significant differences in the preoperative and intraoperative data except for the number of patients with an ejection fraction < 0.35 (0% CCAB vs 10% OPCAB, p = 0.05) and for the number of arterial anastomoses per patient (0.9 ± 0.4 CCAB vs 1.4 ± 0.7 OPCAB, p < 0.001). There were more distal anastomoses and more use of only arterial grafts in OPCAB (2.7 ± 1.0 grafts per patient vs 2.5 ± 0.8 grafts per patient and 14 [19%] vs 4 [10%] completely arterial grafts, respectively).

The surgical intervention was undertaken on an urgent or emergent basis in 59 patients (52%). At our institution, urgent operations are those performed during the same hospital admission for anatomical reasons or because of the patient's clinical signs or symptoms. Emergent operations are those performed within 6 hours of catheterization.

The overall 30-day mortality was 9.6%. The difference in operative mortality between the two groups (6 deaths for CCAB, 14.6% vs 5 deaths for OPCAB, 6.8%, p = 0.05) was significant. The causes of in-hospital mortality included myocardial infarction (2 for OPCAB and 2 for CCAB), respiratory distress (2 for OPCAB and 1 for CCAB), low output syndrome (1 for OPCAB and 2 for CCAB), and sepsis (1 for CCAB). Postoperative complication variables showed that there was no significant difference in the number of patients who suffered from type I CVA (2.4% CCAB vs 1.4% OPCAB, p = NS) whereas there was a significant difference for type II CVA (12.2% CCAB vs 2.8% OPCAB, p = 0.04). Within the OPCAB group, no significant difference was found between patients in whom the aorta was not manipulated and those in whom the proximal anastomoses were performed with a side-clamp. New renal failure, which was censored for preoperative renal failure and defined as a postoperative increase in the serum creatinine levels > 2 mg/dl, showed no significant difference (12.2% CCAB vs 6.8% OPCAB, p = NS). Severe wound infection (mediastinitis) requiring open treatment was recorded in 1 (1.4%) patient. In 3 (4.1%) patients minor soft-tissue wound infections were treated by means of surgical debridement and vacuum-assisted closure. The operation-to-discharge length of stay was 1 day longer for OPCAB group (10 ± 9 days) than for CCAB (9 ± 4 days) but this difference was not statistically significant.

At multivariate analysis, no predictors of hospital mortality and neurological complications were identified.

The postoperative outcomes are summarized in table III.

Follow-up data. The follow-up of hospital survivors (103 patients) was 100% complete at a mean of 2.1 ± 1.8 years (range 32 days to 79 months), for a total follow-up of 234 patient-years. For CCAB patients, the total follow-up was 147 patient-years (mean 3.3 ± 2.1 years), while that of OPCAB patients was 90 patient-years (mean 1.3 ± 1.0 years). There were 29 current survivors in the CCAB group and 61 in the OPCAB group. The mean follow-up of the 90 current survivors was 2.3 ± 1.7 years.

Table III. Postoperative outcome.

Variable	CCAB (n=41)	OPCAB (n=73)	p
30-day mortality	6 (14.6%)	5 (6.8%)	0.05
Perioperative myocardial infarction	4 (9.8%)	7 (9.6%)	NS
Low output syndrome	4 (9.8%)	6 (8.2%)	NS
Postoperative renal failure	5 (12.2%)	5 (6.8%)	NS
Type I neurological complications	1 (2.4%)	1 (1.4%)	NS
Type II neurological complications	5 (12.2%)	2 (2.8%)	0.04
Atrial fibrillation	11 (26.8%)	23 (31.5%)	NS
Ventricular fibrillation or tachycardia	1 (2.4%)	3 (4.1%)	NS
Adult respiratory distress syndrome	2 (4.9%)	4 (5.5%)	NS
Redo operation for bleeding	2 (4.9%)	4 (5.5%)	NS
Minor wound infections	–	3 (4.1%)	NS
Major wound infections	–	1 (1.4%)	NS
Hospital stay (days)	9 ± 4	10 ± 9	NS

CCAB = conventional coronary artery bypass; OPCAB = off-pump coronary artery bypass.

Ninety-three of the 103 patients (90%) available for follow-up were free from recurrent angina at the time of telephone survey and 73% were free from readmission for cardiac-related causes. There were 12 late deaths, 6 in the CCAB group and 6 in the OPCAB group. The causes of late death were: congestive heart failure in 2 patients (both in the OPCAB group); myocardial infarction in 1 patient (CCAB group); other causes in 9 patients (5 in the CCAB group and 4 in the OPCAB group). The linearized rate of overall death, including hospital deaths, was 9.5 ± 2.6%/year in the CCAB group and 13.3 ± 3.9%/year in the OPCAB group (p = NS; Table IV). The differences in actuarial survival at 24 months between the two groups were not significant, being 84 ± 7% for OPCAB and 81 ± 12% for CCAB (Fig. 1).

Cardiac events. Five patients in the CCAB group presented with cardiac events during follow-up (3.4 ± 1.5%/year), while 7 cardiac events were observed in the OPCAB group (7.8 ± 2.9%/year, p = NS). The actuarial freedom from cardiac events at 24 months was 89 ± 4% for OPCAB and 90 ± 6% for CCAB (p = NS).

Cardiac events included mainly episodes of congestive heart failure requiring hospitalization and myocardial infarction, graft occlusion and re-CABG. At multivariate analysis no predictors of late mortality and cardiac events were identified.

Neurological events. Follow-up showed that there was no significant difference in the linearized rate of neurological events (both type I and type II) (0.7 ± 0.7%/year for the CCAB group vs 1.1 ± 1.1%/year for the OPCAB group, p = NS).

Discussion

OPCAB is continuously gaining its worldwide acceptance because of its cost-effectiveness and the pres-

Table IV. Linearized rate of cardiac events, cerebrovascular accidents and death due to different causes during follow-up.

	CCAB		OPCAB		p	Total	
	No.	%/year	No.	%/year		No.	%/year
Myocardial infarction	2	1.4 ± 1.0	3	3.3 ± 1.9	NS	5	2.1 ± 0.9
Fatal	1	0.7 ± 0.7	–	–	NS	1	0.4 ± 0.4
Congestive heart failure	1	0.7 ± 0.7	1	1.1 ± 1.1	NS	2	0.8 ± 0.6
Cerebrovascular accident	1	0.7 ± 0.7	1	1.1 ± 1.1	NS	2	0.8 ± 0.6
Graft occlusion	2	1.4 ± 1.0	2	2.2 ± 1.5	NS	4	1.7 ± 0.9
Re-CABG	–	–	1	1.1 ± 1.1	NS	1	0.4 ± 0.4
Cardiac events	5	3.4 ± 1.5	7	7.8 ± 2.9	NS	12	5.1 ± 1.5
Fatal	1	0.7 ± 0.7	2	2.2 ± 1.5	NS	3	1.3 ± 0.7
Late mortality	6	4.1 ± 1.7	6	6.7 ± 2.7	NS	12	5.1 ± 1.5
Overall mortality	14	9.5 ± 2.6	12	13.3 ± 3.9	NS	26	11.0 ± 2.2

CABG = coronary artery bypass grafting; CCAB = conventional coronary artery bypass; OPCAB = off-pump coronary artery bypass.

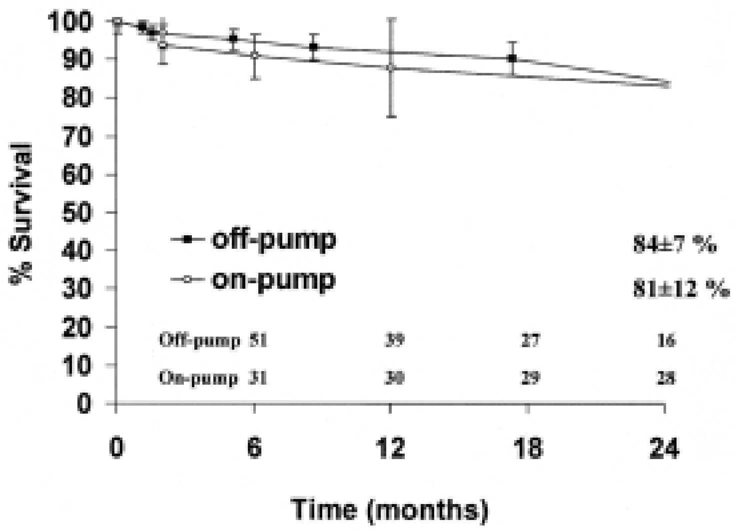

Figure 1. *Actuarial survival at 24 months of follow-up.*

ence of commercially available stabilizing devices. This explosive growth of OPCAB parallels the growth of the referral of elderly patients for revascularization. Even though some of the literature addresses the use of OPCAB in patients with lower risk profiles, many investigators believe that the greatest benefits derived from the avoidance of cardiopulmonary bypass will be realized not in low-risk individuals but in patients who fall into a higher risk profile including those with multiple co-morbid conditions and the elderly. To date, the largest study documenting the experience with conventional CABG in octogenarians was conducted by Peterson et al.[22] and included 24 461 octogenarians who had undergone cardiac revascularization. It is noteworthy that there were statistically significant escalations in the length of hospital stay and costs and in the in-hospital and short-term (3-year) mortality compared with younger patients (aged 65 to 70 years). The long-term mortality for patients in this population was similar to that of the general octogenarian population. Morris et al.[23] investigated the results of conventional CABG in 474 octogenarians. The mortality rate was 7.8%, and major morbidity included postoperative myocardial infarction (4.1%) and neurological complications (5.8%). Williams et al.[24] specifically examined the determinants of mortality in octogenarians undergoing CABG. These included preoperative renal dysfunction, intraoperative intra-aortic balloon pump use, and postoperative pulmonary insufficiency, renal dysfunction, and sternal wound infection. The overall mortality rate was 11%. The authors of these studies collectively suggested that CABG in octogenarians is a safe procedure with an acceptable mortality. Pfister et al.[25] reported their experience with 440 patients who underwent CABG with and without cardiopulmonary bypass. Their series also included 43 elderly patients (≥ 75 years), 24 of whom were operated without cardiopulmonary bypass and 19 with cardiopulmonary bypass. Their investigation revealed that the elderly patients in the off-pump cohort were at a lower risk for the development of postoperative low output syndrome compared with their on-pump counterparts (16 vs 31%). Moreover, their length of hospital stay was shorter (13.3 vs 18.4 days), and they were less likely to experience mental confusion postoperatively (4.2 vs 15.8%). On the basis of these results, the authors hypothesized that elderly patients as well as patients with a poor left ventricular function and those requiring redo operations may benefit most from OPCAB.

In analyzing the results of our study, it must be considered that 34.1% of the patients in the CCAB group and 27.4% of those in the OPCAB group had a logistic EuroSCORE ≥ 15. Although there was a significant difference in the 30-day mortality (6.8% in OPCAB vs 14.6% in CCAB, $p = 0.05$) and in the development of type II neurological complications between the two groups (2.8% in OPCAB vs 12.2% in CCAB, $p = 0.04$), the considerable proportion of patients with a high EuroSCORE may have been partly responsible for the higher mortality rates noted in the CCAB group.

Our rates of OPCAB mortality, however, do compare favorably with those reported by others, both for on-pump or off-pump surgery (Table V)[26-29]. Ricci et al.[26] indicated that the risk of CVA was reduced by the use of OPCAB, as there were no postoperative neurological events in their group of 97 octogenarian patients. Nevertheless, their study noted that there was a trend toward a higher mortality (10.3%) in the OPCAB cohort. Similarly, Stamou et al.[27] reported that among 71 octogenarians, the CVA rate was 3.0% compared with 1.0% in patients 70 through 79 years old and the mortality rate was 6.0% compared with 3.0% in the 70-79 years old; however, in both studies, the patients were submitted to minimally invasive direct CABG and their mean number of grafts was < 2. Yokoyama et al.[28] referred in their study that among 28 octogenarians, the rate of neurological events was 7.1% and the mortality rate was 0%. The authors concluded that OPCAB reduced the overall incidence of postoperative complications. The study of Beauford et al.[29] including 113 octogenarian patients undergoing OPCAB, which is to our knowledge the largest series published in the literature, reported a mortality rate of 0.9%, as compared to the expected 6.0%, and a CVA rate of 3.5%.

The higher percentage of intra-aortic balloon pump in the OPCAB group (5.5%) in our study is due to our protocol which requires the use of this device prior to the beginning of surgery in those patients with a hemodynamically unstable status.

Table V. Published series of rates of mortality and cerebrovascular accidents (CVA) in octogenarians submitted to conventional coronary artery bypass (CCAB) or off-pump coronary artery bypass (OPCAB).

	CCAB				OPCAB			
	No. patients	Mortality expected	Mortality rate	CVA rate	No. patients	Mortality expected	Mortality rate	CVA rate
Ricci et al.[26], 2000	172	7.1	5.2	9.3	97	8.9	10.3	0
Stamou et al.[27], 2000	–	–	–	–	71	?	6.0	3.0
Yokoyama et al.[28], 2000	58	?	5.2	13.8	28	?	0	7.1
Beauford et al.[29], 2003	–	–	–	–	113	6.0	0.9	3.5
D'Alfonso et al. (present study)	41	15	14.6	2.4	73	12	6.8	1.4

Overall wound infections reported in this study include major and minor infections requiring surgical treatment. Recent studies report deep sternal wound infections in 0.2-2.9% of patients[30,31], while others refer a prevalence of total wound infections after cardiac surgery, including both sternal wound and donor site infections, ranging from 1.3 to 12.8%[32,33]. Postoperative wound infections after cardiac surgery do cause extramorbidity and mortality, long hospitalization, high costs, and discomfort for the patient[34].

Despite our satisfactory results, the study has several limitations. The major limitation is that it is a non-randomized retrospective review comparing the preoperative and postoperative courses of multivessel coronary patients operated off-pump to those of patients operated with conventional cardiopulmonary bypass under cardioplegic arrest. Another limitation of this study is the difference in the length of follow-up between the two groups (3.3 ± 2.1 years for the CCAB group and 1.3 ± 1.0 years for OPCAB) being the great number of OPCAB procedures performed after 2000; at present, this does not allow us to lengthen the actuarial survival period more than 24 months. When reviewing the in-hospital incidence of CVA in the OPCAB group, no significant difference was found between patients in whom proximal anastomoses were performed with a partial occluding clamp and patients in whom the aorta was not manipulated. Unfortunately, the latter group included only a small number of patients. Therefore, although not conclusively, it appears that side-clamping of the aorta might not constitute an incremental risk factor for CVA.

The general consensus is that there is a significant reduction in the stroke rate after OPCAB compared with conventional revascularization with cardiopulmonary bypass. Our results further support these findings.

In conclusion, the results of univariate analysis of our retrospective, single-institutional data suggest that OPCAB in octogenarians improves the in-hospital mortality and reduces the incidence of type II neurological events. In addition, our data suggest that octogenarians may lead event-free lives after cardiac surgery and that the late mortality is mainly due not to cardiac events but to the cumulative effects of aging.

References

1. Katz NM, Hannan RL, Hopkins RA, Wallace RB. Cardiac operations in patients aged 70 years and over. Ann Thorac Surg 1995; 60: 96-101.
2. Kirsch M, Guesnier L, LeBesnerais P, et al. Cardiac operations in octogenarians. Ann Thorac Surg 1998; 66: 60-7.
3. Reich DL, Bodian CA, Krol M, Kuroda M, Osinski T, Thys DM. Intraoperative hemodynamic predictors of mortality, stroke, and myocardial infarction after coronary artery bypass surgery. Anesth Analg 1999; 89: 814-22.
4. Hogue CW, Murphy SF, Schechtman KB, Davila-Roman VG. Risk factors for early or delayed stroke after cardiac surgery. Circulation 1999; 100: 642-7.
5. Almassi GH, Sommers T, Moritz TE, et al. Stroke in cardiac surgical patients: determinants and outcome. Ann Thorac Surg 1999; 68: 391-8.
6. McKhann GM, Goldsborough MA, Borowicz LM, et al. Predictors of stroke risk in coronary artery bypass patients. Ann Thorac Surg 1997; 63: 516-21.
7. Roach GW, Kanchuger M, Mangano CM, et al. Adverse cerebral outcomes after coronary bypass surgery. Multicenter study of Perioperative Ischemia Research Group and the Ischemia Research and Education Foundation Investigators. N Engl J Med 1996; 335: 1857-63.
8. Redmond JM, Greene PS, Goldsborough MA, et al. Neurologic injury in cardiac surgical patients with a history of stroke. Ann Thorac Surg 1996; 61: 42-7.
9. Gardner TJ, Horneffer PJ, Manolio TA, et al. Stroke following coronary artery bypass grafting. Ann Thorac Surg 1985; 40: 574-81.
10. Hartman GS, Yao FF, Bruefach M 3rd, et al. Severity of aortic atheromatous disease diagnosed by transesophageal echocardiography predicts stroke and other outcomes associated with coronary artery surgery. Anesth Analg 1996; 83: 701-8.
11. Tuman KJ, McCarthy RJ, Najafi H, et al. Differential effects of advanced age on neurologic and cardiac risks of coronary artery operations. J Thorac Cardiovasc Surg 1992; 104: 1510-7.
12. Stamou SC, Hill PC, Dangas G, et al. Stroke after coronary artery bypass: incidence, predictors, and clinical outcome. Stroke 2001; 32: 1508-13.
13. Shaw PJ, Bates D, Cartlidge NE, et al. Early intellectual dysfunction following coronary bypass surgery. QJM 1986; 58: 59-68.
14. Mahanna EP, Blumenthal JA, White WD, et al. Defining neuropsychological dysfunction after coronary artery bypass grafting. Ann Thorac Surg 1996; 61: 1342-7.
15. Murkin JM, Martzke JS, Buchan AM, et al. A randomized study of the influence of perfusion technique and pH management strategy in 316 patients undergoing coronary artery bypass surgery: neurological and cognitive outcomes. J Thorac Cardiovasc Surg 1995; 110: 349-62.
16. Newman MF, Schell RM, Croughwell N, et al. Pattern and time course of cognitive dysfunction following cardiopulmonary bypass. (abstr) Anesth Analg 1993; 76: S294.
17. Zykla-Menhorn V, Clade H. Herzchirurgen stellen Leistungszahlen 1993 vor-Der Anteil älterer Patienten steigt stetig an. Deutschs Ärzteblatt 1994; 91: 23-6.
18. Diegeler A, Hirsch R, Schneider F, et al. Neuromonitoring and neurocognitive outcome in off-pump versus conventional coronary bypass operations. Ann Thorac Surg 2000; 69: 1162-6.
19. Stump DA, Rorie KD, Jones TJ. Does off-pump coronary artery bypass surgery reduce the risk of brain injury? Heart Surg Forum 2001; 4 (Suppl 1): S14-S18.
20. Murkin JM, Newman SP, Stump DA, Blumenthal JA. Statement of consensus on assessment of neurobehavioral outcomes after cardiac surgery. Ann Thorac Surg 1995; 59: 1289-95.
21. Mariani MA, Gu YJ, Boonstra PW, Grandjean JG, van Oeveren W, Ebels T. Procoagulant activity after off-pump coronary operation: is the current anticoagulation adequate? Ann Thorac Surg 1999; 67: 1370-5.
22. Peterson ED, Cowper PA, Jollis JG, et al. Outcomes of coronary artery bypass graft surgery in 24 461 patients aged 80 years or older. Circulation 1995; 92 (Suppl): II85-II91.
23. Morris RJ, Strong MD, Grunewald KE, et al. Internal thoracic artery for coronary artery grafting in octogenarians. Ann Thorac Surg 1996; 62: 16-22.
24. Williams DB, Carrillo RG, Traad EA, et al. Determinants of

operative mortality in octogenarians undergoing coronary bypass. Ann Thorac Surg 1995; 60: 1038-43.
25. Pfister AJ, Zaki MS, Garcia JM, et al. Coronary artery bypass without cardiopulmonary bypass. Ann Thorac Surg 1992; 54: 1085-92.
26. Ricci M, Karamanoukian HL, Abraham R, et al. Stroke in octogenarians undergoing coronary artery surgery with and without cardiopulmonary bypass. Ann Thorac Surg 2000; 69: 1471-5.
27. Stamou SC, Dangas G, Dullum MK, et al. Beating heart surgery in octogenarians: perioperative outcome and comparison with younger age groups. Ann Thorac Surg 2000; 69: 1140-5.
28. Yokoyama T, Baumgartner FJ, Gheissari A, Capouya ER, Panagiotides GP, Declusin RJ. Off-pump versus on-pump coronary bypass in high-risk subgroups. Ann Thorac Surg 2000; 70: 1546-50.
29. Beauford RB, Goldstein DJ, Sardari FF, et al. Multivessel off-pump revascularization in octogenarians: early and midterm outcomes. Ann Thorac Surg 2003; 76: 12-7.
30. Brown JW, Moor GF, Hummel BW, Marshall WG, Collins JP. Toward further reducing wound infections in cardiac operations. Ann Thorac Surg 1996; 62: 1783-9.
31. El Oakley R, Paul E, Wong PS, et al. Mediastinitis in patients undergoing cardiopulmonary bypass: risk analyses and midterm results. J Cardiovasc Surg 1997; 38: 595-600.
32. Roberts AJ, Wilcox K, Devineni R, Harris RB, Osevala MA. Skin preparations in CABG surgery: a prospective randomized trial. Complications in Surgery 1995; 14: 741-5.
33. Kollef MH, Sharpless L, Vasnik J, Pasque C, Murphy D, Fraser VJ. The impact of nosocomial infections on patient outcomes following cardiac surgery. Chest 1997; 112: 666-75.
34. King RC, Reece B, Hurst JL, et al. Minimally invasive coronary artery bypass grafting decreases hospital stay and cost. Ann Surg 1997; 225: 805-11.