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Postoperative Outcomes after Off-Pump Coronary Artery Bypass Grafting in EuroSCORE Low- and High-Risk Women

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ABSTRACT

Background. Many previous studies have reported that women who undergo coronary artery bypass grafting have higher perioperative morbidity and mortality rates than men. The use of off-pump coronary artery bypass grafting (OPCAB) has been suggested to decrease morbidity and mortality because the deleterious effects of cardiopulmonary bypass, particularly in high-risk patients, are avoided. The reduction in unwanted postoperative complications in women undergoing OPCAB surgery has not been extensively investigated. The aim of this retrospective study was to compare perioperative rates of morbidity and mortality and follow-up events after OPCAB in female patients assessed as high- or low-risk according to the European System for Cardiac Operative Risk Evaluation (EuroSCORE).

Methods. The study included 377 adult female patients who underwent elective primary isolated OPCAB. The study patients were divided into 2 groups based on the Additive EuroSCORE: low-risk patients (group I, n = 301, EuroSCORE <6) and high-risk patients (group II, n = 76, EuroSCORE ≥6).

Results. Patient ages were 60.1 ± 7.77 years in group I and 69.3 ± 5.51 years in group II ($P < .001$). Compared to group I patients, group II patients had significantly higher Additive EuroSCORE ($P < .001$), predicted mortality rate (Logistic EuroSCORE) ($P < .001$), and Canada angina classification ($P < .001$) and higher rates of preoperative myocardial infarction ($P < .001$), peripheral vascular disease ($P < .001$), carotid artery disease ($P < .005$), and hypertension ($P < .05$). Occurrence of postoperative arrhythmia and mortality were significantly higher ($P < .05$) in group II. The observed mortality rate in group I was 1%, which was 41% of the predicted mortality rate (Logistic EuroSCORE) of 2.42 ± 0.76. The observed mortality rate in group II was 5.3%, which was 79% of the predicted rate (6.74 ± 2.89), but the difference was not significant ($P = .2$). Intensive care unit length of stay ($P < .01$) and ventilation times ($P < .05$) were longer for group II than group I, and the incidence of conversion to cardiopulmonary bypass was 1.6% versus 5.3%, respectively, in groups I and II ($P = .08$).

Conclusion. These results indicate that OPCAB surgery is safe and seems to be an effective surgical technique for lowering rates of morbidity and mortality in high- and low-risk female patients.

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INTRODUCTION

Many previous studies have found that women who undergo coronary artery bypass grafting (CABG) with cardiopulmonary bypass (CPB) have higher perioperative morbidity and mortality rates than men [Edwards 1998; Shroyer 2003; Woods 2003]. Possible explanations for this disparity in mortality include anatomical differences, such as women having a smaller body surface area and coronary artery diameters than men. In addition, women are usually older than men at the time of disease presentation; have a greater number of diseased vessels; are more likely to be suffering from diabetes mellitus, hypertension, and peripheral and cerebral vascular disease; and are in a worse functional status at the time of surgery [Christakis 1995; Aldea 1999]. A major recent development in cardiac surgery is reduced dependence on CPB assistance in CABG. The use of off-pump coronary artery bypass (OPCAB) grafting has been suggested to decrease morbidity and mortality because the deleterious effects of CPB, particularly in high-risk patients, are avoided. Patients undergoing OPCAB grafting have reduced mortality and complication rates, reduced lengths of hospital stay, and reduced costs at selected centers in selected subgroups [King 1997]. The potential benefits of OPCAB grafting with regard to the prevalence of adverse perioperative outcome in women undergoing CABG has not yet been fully investigated. Therefore, it is essential that the short-term and long-term safety, benefits, and efficacy of the off-pump approach be evaluated. Previous similar studies focused on OPCAB surgery in low- and high-risk patients, but none focused specifically on female patients. Therefore, we conducted a retrospective study to compare perioperative morbidity and mortality rates and the follow-up events in high- and low-risk female patients undergoing OPCAB surgery.

MATERIALS AND METHODS

Clinical Data

The records of 377 adult female patients who underwent elective primary isolated OPCAB surgery between January 2001 and May 2006 were reviewed retrospectively after this study was approved by the institutional research board. We used both additive and logistic methods of the European System for Cardiac Operative Risk Evaluation (EuroSCORE) system in this study. The patients were divided into 2 groups, according to their Additive EuroSCORE, and predictive mortality rates were calculated by use of their Logistic EuroSCORE. The method incorporates the risk factors of each patient. Group I patients were low risk (Additive EuroSCORE <6; n = 301), and group II patients were high risk (Additive EuroSCORE ≥6; n = 76). Demographic characteristics and comorbidities of the 2 groups of patients are listed in Table 1. Other preoperative variables are defined in Table 2. The ejection fraction (EF) was defined as a categorical variable (good EF, >50%; moderate EF, 30%-49%; poor EF, <30%). Perfusionist standby was available for all patients. Conversion was defined strictly as the use of CPB at any stage during the treatment episode. For example, CPB used as resuscitative measure for a patient who suffered cardiac arrest during anesthesia induction or while in the intensive care unit (ICU) would be classified as a conversion. The use of CPB at any stage during CABG surgery (including prior to the onset of grafting) was also considered conversion. Criteria for intraoperative conversion to CPB were persistent hypotension (mean arterial blood pressure <50 mmHg) nonresponsive to pharmacological and surgical maneuvers and worsening arrhythmias related to ischemia. CPB conversion occurred in patients in both groups. Mortality was defined as in-hospital death and death within the 30-day postoperative period.

Table 1. Patient Characteristics and Results*

	Group I	Group II	*P*
Patients, n	301	76	
Age, y	60.1 ± 7.77	69.3 ± 5.51	<.001
Body mass index, kg/m^2	29.1 ± 4.35	28.3 ± 4.69	NS
Additive EuroSCORE	3.12 ± 1.37	6.68 ± 1.11	<.001
Logistic EuroSCORE (predicted mortality), %	2.42 ± 0.96	6.74 ± 2.89	<.001
Canada angina classification	3.26 ± 0.70	3.78 ± 0.47	<.001
Ejection fraction			
<30	5 (1.7%)	1 (1.3%)	NS
30-49	88 (29.2%)	40 (52.6%)	<.001
>50	208 (69.1%)	35 (46.1%)	<.001
Preoperative myocardial infarction	94 (31.2%)	47 (61.8%)	<.001
Age >70	32 (10.6%)	35 (46.1%)	<.001
Overweight	121 (40.2%)	21 (27.6%)	<.05
Peripheral vascular disease	15 (5.0%)	16 (21.1%)	<.001
Coronary artery disease	12 (4.0%)	10 (13.2%)	<.01
Chronic obstructive pulmonary disease	15 (5.0%)	5 (6.6%)	NS
Chronic renal failure	3 (1.0%)	0 (0.0%)	NS
Positive family history	101 (33.6%)	22 (28.9%)	NS
History of smoking	90 (29.9%)	10 (13.2%)	<.01
Diabetes mellitus	128 (42.5%)	30 (39.5%)	NS
Hypertension	207 (68.8%)	61 (80.3%)	<.05
Hyperlipidemia	77 (25.6%)	24 (31.6%)	NS
Left main coronary artery stenosis	10 (3.3%)	4 (5.3%)	NS
Preoperative atrial fibrillation	6 (2.0%)	1 (1.3%)	NS
Previous PTCA	13 (4.3%)	5 (6.6%)	NS

*Results are mean ± SD or n (%). NS indicates not significant; PTCA, percutaneous transluminal coronary angioplasty.

Table 2. Preoperative Variables

Mortality	Death within 30 days postoperatively
Overweight	Body mass index >30 kg/m^2
Hypertension	Need of medical treatment for hypertension
History of Smoking	>10 Cigarettes/d for ≥10 y
Hypercholesterolemia	Past or cholesterol >200 mg/dL
Chronic renal failure	Creatinine value >200 µmol/L
Chronic obstructive pulmonary disease	1-s Forced expiratory volume <75% predicted value, pO_2 <60 mmHg, or chronic medical treatment (eg, long-term use of bronchodilatators or steroids for lung disease)
Preoperative intraaortic balloon pump (IABP)	Use of IABP for cardiogenic shock or to stabilize unstable angina
Diabetes mellitus	Medical treatment for hyperglycemia at rest, insulin treatment, or oral treatment
Peripheral vascular disease	Symptoms or angiographic or echographic evidence of dilation or flow reduction (stenosis or occlusion) of any artery except carotid arteries
Coronary artery disease	Fibrocalcific plaque with a stenosis >50% or soft plaque with any degree of stenosis
Myocardial infarction (MI)	Electrocardiogram sign of previous MI or documented non-Q MI within 3 months
Left main coronary artery	Left main coronary artery stenosis ≥50%
Arrhythmia	Any type, including atrial fibrillation

Surgical Technique

All procedures were performed via a median sternotomy while the patient was under general anesthesia. Systemic heparinization was achieved with an initial dose of 1 mg/kg, and supplementary boluses were administered as required to maintain activated clotting time (ACT) at >300 seconds during the OPCAB surgery. Cardiac lifting and rotation were achieved using a single-snared suture placed in the posterior pericardium. The target mean blood pressure was a >100 mmHg systolic and >70 mmHg mean and was achieved via volume preload, a dopamine infusion (2-3 µg/kg per minute), and Trendelenburg position. A temperature of 35°C to 36°C was maintained by ambient operating room temperature (23°C). Intravenous vasodilator or inotropic agents were administered via infusion when necessary.

Stabilization of the patient's anastomotic region during revascularization procedures was accomplished with the assistance of the Octopus tissue stabilizer (Medtronic, Minneapolis, MN, USA). Proximal occlusion of the target coronary artery was obtained with a microvessel occluder, and a filtrated medical air blower (5 L/min) was used to clear the surgical field. We routinely kept the distal artery open. The left anterior descending coronary artery (LAD) was the first in the revascularization sequence, except for the occluded right coronary artery when collateralized by a stenotic LAD. However, the sequence of grafting was individualized for each patient, depending on the severity of the lesions in different coronary arteries and the patient's hemodynamics. Neither ischemic preconditioning nor shunts were used except in a few patients in whom an intracoronary shunt (Baxter AnastaFLO, Irvine, CA, USA) was used to prevent regional ischemia and/or atrioventricular block due to low-grade stenosis.

In the presence of proximal left main coronary artery stenosis, the circumflex system was also revascularized, even if the LAD did not have a significant stenosis. Thus a side-biting clamp was applied to the ascending aorta in all patients. In both groups all proximal anastomoses were completed in the usual manner during a single partial clamping of the ascending aorta. On completion of all anastomoses, protamine (at one half the dose of heparin) was given to reverse the effect of heparin.

Statistical Analysis

Continuous variables were compared using the Student *t* test for data that were normally distributed or the Mann-Whitney test for data that were not normally distributed. Categorical variables were compared using the Pearson χ^2 test or Fischer exact test. A *P* value <.05 was considered statistically significant. Logistic regression models were used for quantifying the association between risk factors and the predicted rates of mortality and morbidities. Variables were included in the multivariate model if the *P* value was ≥.05 in the univariate analysis. All statistical analysis was done using statistical software SPSS version 10.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Clinical characteristics for the 301 patients in group I and the 76 patients in group II are shown in Table 1. No statistically significant differences were observed between the groups for body mass index and the incidences of chronic obstructive pulmonary disease, chronic renal failure, diabetes mellitus, hyperlipidemia, left main coronary artery disease, EF <30%, positive family history, preoperative atrial fibrillation (AF), or previous percutaneous transluminal coronary angioplasty. Compared to the patients in group I, the patients in group II were older (*P* < .001); had significantly higher Additive EuroSCOREs (*P* < .001), predicted mortality rates (Logistic EuroSCORE) (*P* < .001), and Canadian Cardiovascular Society classification of stable angina pectoris scores (*P* < .001); had higher rates of preoperative EF 30% to 49% (*P* < .001), preoperative myocardial infarction (*P* < .001), peripheral vascular disease (*P* < .001), carotid artery disease (*P* < .005), and hypertension (*P* < .05); and were more likely to be >70 years old (*P* < .001). Although no difference was observed between the groups in the number of patients with preoperative EF <30%, the number of patients with preoperative EF >50% was significantly higher in group I (*P* < .001). Interestingly, group I patients were significantly more likely to be smokers (*P* < .005) and overweight (*P* < .05).

The operative variables are presented in Table 3. Group II spent longer times in the ICU (*P* < .01) and on mechanical ventilation (*P* < .05) than group I. The amount of drainage in the first 24 hours was significantly higher in group II. Frequency distributions of diseased coronary vessels and number of distal grafts were similar in both groups. Although there was no significant difference between groups in the use of right internal thoracic artery and radial artery conduits, the left internal thoracic artery was used in the vast majority of cases (97% and 94.7%, respectively, in both groups; non-significant). There was no significant difference between the groups in the lengths of time required for surgery or hospitalization. The use of perioperative intraaortic balloon pump and inotropic support was similar in both groups. The incidence of CPB conversion was 1.6% versus 5.3%, respectively, in groups I and II (*P* = .08), and all these patients survived to hospital discharge. In addition, the 2 groups showed no significant differences in time spent on CPB, and all patients in both groups underwent surgery with an empty beating heart (without using an aortic cross clamp) technique.

Table 3. Operative Variables and Results*

	Group I (n = 301)	Group II (n = 76)	*P*
Diseased coronary vessels	2.42 ± 0.76	2.56 ± 0.67	NS
Distal graft number	2.32 ± 0.92	2.47 ± 1.01	NS
Operation time, h	3.34 ± 0.86	3.46 ± 0.87	NS
Ventilation time, h	6.50 ± 3.76	11.8 ± 36.0	<.05
Intensive care unit time, h	33.3 ± 22.7	45.1 ± 53.8	<.01
Hospital stay, d	8.30 ± 3.09	8.90 ± 3.79	NS
24-h Drainage volume, mL	313 ± 142	356 ± 182	<.05
Cardiopulmonary bypass time, min	91.6 ± 50.1	84.0 ± 39.8	NS
Conversion to cardiopulmonary bypass	5 (1.6%)	4 (5.3%)	NS
Left internal thoracic artery graft	292 (97.0%)	72 (94.7%)	NS
Right internal thoracic artery graft	1 (0.3%)	0 (0.0%)	NS
Radial artery graft	6 (2.0%)	1 (1.3%)	NS
Perioperative intraaortic balloon pump	3 (1.0%)	2 (2.6%)	NS
Perioperative inotropic support	17 (5.7%)	7 (9.2%)	NS

*Results are mean ± SD or n (%). NS indicates not significant.

Further postoperative differences between the groups are listed in Table 4. The occurrences of postoperative arrhythmia and mortality were significantly higher ($P < .05$) in group II. In group I the observed mortality rate was 1%, 41% of the predicted mortality rate (Logistic EuroSCORE) of 2.42 ± 0.76. In group II the observed mortality rate was 5.3%, which was 79% of the predicted rate (Logistic EuroSCORE) of 6.74 ± 2.89, but the difference was not significant. No significant differences between the 2 groups were observed for the other postoperative variables.

DISCUSSION

CABG surgery leads to an improvement in the long-term survival in specific subsets of patients with coronary artery disease. OPCAB is a recently developed surgical technique that avoids the deleterious consequences of CPB. Used initially in the early 1990s, OPCAB was mainly used in highly selected and relatively low-risk groups of patients [Benetti 1991]. Patient selection is related to the experience of the center and to the extent of reengineering that has taken place, but at present OPCAB is possible without prior patient selection [Puskas 2003]. In our institution, we have been performing OPCAB since 1996, and >90% of the coronary surgeries are now done without using CPB.

Methods to classify risk in cardiac patients are not consistent [Calafiore 1999; Nashef 1999; Roques 2000]. The EuroSCORE is a risk stratification system developed to assess quality of cardiac surgical care [Nashef 1999], and the use of a score of 6 as cutoff point to identify high-risk patients is artificial. Because the mean EuroSCORE 30-day mortality in coronary surgery is 3.4% [Roques 1999], an expected risk of 6 or higher seemed to us as a reasonable criterion for selecting patients with an objectively increased mortality risk.

Although an appreciable body of evidence supports the advantages of OPCAB over on-pump CAB, which groups of patients would benefit from OPCAB has not been established [Bittner 2001]. It has been suggested that high-risk patients are the most likely to benefit from OPCAB, because these patients are the most likely to develop complications related to the use of CPB [Brown 2002]. Only small amounts of data exist regarding the outcomes of low- and high-risk patients undergoing OPCAB [Nashef 1999; Arom 2000; Sergeant 2001]. The applicability and safety of OPCAB surgery were investigated a group of high-risk female patients [Petro 2000], but no published reports compare the outcomes of low- and high-risk female patients undergoing OPCAB surgery. In our study we found that in both low- and high-risk groups of female patients, the actual mortality rate was not significantly lower than the predicted rate. This result is in agreement with that found by Riha et al [2002], who did not detect any significant decreases in actual mortality rates compared to mortality rates predicted by the EuroSCORE in high-risk patients undergoing OPCAB.

Table 4. Postoperative Variables and Results*

	Group I (n = 301)	Group II (n = 76)	*P*
Arrhythmia	43 (14.3%)	18 (23.7%)	<.05
Inotrope requirement	33 (11.0%)	12 (15.8%)	NS
Neurological complications transient (delirium, ischemic attack, stroke)	6 (2.0%)	2 (2.6%)	NS
Atrial fibrillation	30 (10.0%)	10 (13.2%)	NS
Electrocardiographic changes	33 (11%)	13 (17.1%)	NS
Intraaortic balloon pump	8 (2.7%)	2 (2.6%)	NS
Myocardial infarction	14 (4.7%)	7 (9.2%)	NS
Mortality	3 (1.0%)	4 (5.3%)	<.05
Conversion	4 (1.3%)	1 (1.3%)	NS

*Results are n (%).

Several studies of cardiac surgery without CPB in subgroups of high-risk patients have reported reductions of morbidity, including lower transfusion rates [Allen 1997; Boyd 1999; Stamou 2000; Yokoyama 2000; Ascione 2001; Chamberlain 2002; Ascione 2002], shorter ICU stays [Allen 1997; Chamberlain 2002], shorter postoperative hospital stays [Allen 1997; Boyd 1999; Stamou 2000; Chamberlain 2002], fewer inotropic requirements [Ascione 2001], lower incidence of postoperative stroke [Ascione 2001; Bergsland 1998], less need for prolonged ventilatory support [Boyd 1999; Stamou 2000], and less need for postoperative intraaortic balloon pump [Bergsland 1998]. In our study, we found that the length of ICU stay and the time needed for ventilation were significantly longer in the high-risk than in the low-risk patients. Similar results have been reported [Arom 2000; Riha 2002].

In addition, we found that the incidence of postoperative arrhythmias and volume of fluid collected in the immediate 24 hours postoperatively were significantly higher in the high-risk than in the low-risk group. The incidence of postoperative AF after OPCAB surgery has been reported to vary between 1.7% and 33% [Collard 1997; Tasdemir 1998]. There is speculation that OPCAB may reduce the incidence of AF, but current data do not prove this hypothesis. The overall incidence of AF in our study population was 11.6%. Because older age, structural changes in the heart, and low EF are known risk factors for AF after CABG [Stamou 2000], this problem appeared, as expected, more often in our high-risk patients.

We did not observe significant differences between the low- and high-risk groups for other postoperative variables and morbidities. The rates of these complications were comparable with those of previous studies, and similar results were reported by Riha et al, suggesting that after OPCAB surgery in patients classified as high- or low-risk according to the EuroSCORE, high-risk patients have slightly higher postoperative morbidity than low-risk patients [Riha 2002].

Increased use of internal thoracic artery conduits in female patients undergoing CABG might improve outcomes. A prospective cohort study [O'Connor 1993] found that use of the internal thoracic artery was associated significantly with lower rates of mortality in both women and men. Results of another study [Tan 1999] in which graft patency was angiographically assessed 1 year after CABG (although this assessment was likely underpowered) showed a nonsignificant trend toward more occlusion in the grafted veins of women (16.7%) than in those of men (12.4%), whereas internal thoracic artery occlusion was lower in women (3.4% versus 5.7%). In our 2 groups of patients undergoing OPCAB, it was obvious that the extensive use of the left internal thoracic artery in female patients was not associated with significant increases in operative mortality and morbidity.

In conclusion, we found that OPCAB is a safe surgical technique for myocardial revascularization, even in female patients. Within the limitations of a retrospective study conducted in a single institution, our results demonstrate that OPCAB can be performed with lower rates of morbidity and mortality and postoperative complications in both high- and low-risk female patients.

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