

Off-pump coronary artery bypass surgery can be completed safely in high risk patients

Hayrettin Tekumit¹, Ali Rıza Cenal¹, Cenk Tataroglu¹, Adil Polat², Kemal Uzun¹, Esat Akinci¹

¹Avrupa Safak Hospital, Istanbul, Turkey

²John F. Kennedy Hospital, Istanbul, Turkey

Abstract

Background: Off-pump coronary artery bypass (OPCAB) grafting has the potential to reduce morbidity and mortality, compared to on-pump cardiac surgery.

Aim: We compared the early results of OPCAB lateral and posterior wall revascularisations in 'low', 'intermediate' and 'high' risk patients as defined by the EuroSCORE system.

Methods: Eighty-nine patients who underwent OPCAB with lateral and posterior wall revascularisation from January 2006 to December 2008 were included in this study. Patients were allocated to one of the three risk groups according to the EuroSCORE system: low, moderate and high risk groups. Perioperative and early postoperative results of the three groups were compared.

Results: Significantly fewer patients required prolonged ICU stay in the low risk group, compared to moderate (19.4 vs. 50%) and high risk groups (19.4 vs. 36.7%). In addition, prolonged mechanical ventilation was more common in moderate (39.3 vs. 9.7%) and high risk groups (36.7 vs. 9.7%), compared to the low risk group. However, the groups did not differ in terms of mortality or other perioperative outcomes.

Conclusions: Our results suggest that in patients who are considered high risk on the basis of the EuroSCORE model and have diseased vessels on the lateral and/or posterior walls of the heart suitable for grafting, the early outcomes with OPCAB are similar to those in medium or low EuroSCORE risk category. The EuroSCORE model may overestimate the risk for OPCAB procedures.

Key words: OPCAB, EuroSCORE, lateral wall revascularisation, posterior wall revascularisation

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Introduction

Over the last three decades, a successful and reproducible surgical approach for coronary artery revascularisation was developed. Currently, the two mainstays of coronary artery bypass grafting (CABG) surgery are cardiopulmonary bypass (CPB) and cardioplegic cardiac arrest [1]. However, CPB fails to represent normal physiological conditions with its resultant major systemic inflammatory reaction [2]. To decrease the perioperative risk, cardiovascular surgeons have recently been in search of methods that may obviate the need for CPB, such as 'off-pump' (OP) or 'beating heart' bypass surgery. After the 1980s, several cardiac surgeons began to perform myocardial revascularisation without CPB (OPCAB) in patients with lesions in the right coronary artery, left

anterior descending artery, and diagonal branches [3]. As a result of increased surgical expertise and technological advances [1], it became possible to place multiple grafts on the posterior and lateral walls or the atrioventricular groove. At present, in the US, 20-25% of surgical interventions on the coronary arteries are carried out without CPB [1].

This strategy has the potential to reduce morbidity and mortality when compared with on-pump cardiac surgery [4]. The 'high risk' category probably represents the group of patients who are most likely to benefit from OPCAB [5]. The concept of 'high risk patients' has been well defined in the literature [4]. Particularly, the EuroSCORE model has been reported to be a good risk predictor for candidates of CABG [6]. In the present study, we compared the early results of off-pump lateral and

Address for correspondence:

Adil Polat MD, PhD, John F. Kennedy Hospital, Talatpasa Bulvarı, Begonya Sokak, No: 7-9 Bahçelievler 34590 Istanbul, Turkey, tel.: +90 542 315 38 76, e-mail: adilpol@yahoo.com

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posterior wall revascularisations in 'low', 'intermediate' and 'high' risk patients as defined by the EuroSCORE system.

Methods

Patients

The study was conducted with the approval of the Institutional Ethics Committee. Eighty-nine patients who underwent OPCAB with lateral and posterior wall revascularisation in Avrupa Safak Hospital from January 2006 to December 2008 were included in this study. Preoperatively three subgroups of patients were defined on the basis of EuroSCORE: the low risk group ($n = 31$, EuroSCORE 0-2), moderate risk group ($n = 28$, EuroSCORE 3-5), and high risk group ($n = 30$, EuroSCORE ≥ 6). Sixty-six patients had one or more risk factors that precluded the use of CPB, such as renal dysfunction, severe chronic obstructive pulmonary disease (COPD), severe left ventricular dysfunction (LVD), porcelain aorta, and recent myocardial infarction (MI). There were no reoperations. None of the patients had valvular dysfunction requiring surgery. Although no risk factors for CPB were present, the remaining 23 patients were considered eligible for OPCAB due to the presence of at least one diseased coronary artery in the posterior and/or lateral wall, adequate vessel quality, or non-dilated left ventricle. The indication for OPCAB was made during the operation for patients with porcelain aorta.

Patients who were operated on electively ($n = 73$) were on anti-anginal medication (beta blockers, nitrates and acetyl salicylic acid) along with statins. Fifty-six patients were receiving antihypertensive medication (42 – ACE inhibitors, 12 – calcium channel blockers and 2 patients were using both drugs). Of the urgently or emergently operated 16 patients, 10 were on anti-anginal and statin medication, 5 had antihypertensive medication only and one was treated with acetylsalicylic acid only. Of the 50 patients with diabetes, 36 were using oral hypoglycaemic drugs and 14 were on insulin therapy.

Surgical technique

Median sternotomy was performed. Intravenous heparin (200 IU/kg) was given to maintain activated clotting time above 200 s. In patients with normal ascending aorta, initially proximal anastomosis to the ascending aorta was performed using single-side clamping. Then, in the following order left anterior descending artery, diagonal artery, right coronary artery, posterior wall arteries (right posterior descending and right posterior lateral artery), and lateral wall arteries (obtuse marginal artery) were anastomosed.

For patients with porcelain aorta, initially LITA (left internal thoracic artery) to LAD (left anterior descending branch of left coronary artery) anastomosis was performed, and following this, other lateral anastomoses were carried out. Finally, proximal anastomoses were either done to the LITA (6 patients), the innominate artery

(4 patients), or the right subclavian artery (2 patients). The following equipment was used to immobilise and stabilise the target coronary artery: (1) Genzyme stabiliser (Teleflex Medical, Research Triangle Park, NC, USA), which consists of a Straight Stabilizer Arm, an Immobilizer™ Cardiac Stabilizer, and a pair of retract-O-Tape® Vascular Loops; (2) OPVAC Synergy II Stabilizer Attachment (ESTECH, San Ramon, CA, USA); and (3) Pyramide Positioner Attachment (ESTECH, San Ramon, CA, USA).

To occlude target coronary arteries, a pair of elastic vascular loops was used on proximal and distal ends of the arteriotomy. For lateral wall exposure, the right pleural cavity was opened, and continuity of the caval return was achieved by dissecting from the lower right border of the pericardium up to a distance of 2 cm from the phrenic nerve, then by transecting from that point to the level of the superior vena cava in a direction parallel to the phrenic nerve.

Postoperative follow-up

Postoperatively, all patients were admitted to the intensive care unit and received antihypertensive, antidiabetic medications which they were using preoperatively. All patients received beta-blocker, acetyl salicylic acid and statin therapy.

Data collection

Preoperative, intraoperative and postoperative data were collected retrospectively. Risk stratification was performed according to the Standard EuroSCORE model. The standard EuroSCORE system consists of three risk groups: low risk (EuroSCORE = 0 to 2) with an expected mortality < 2%; medium risk (EuroSCORE = 3 to 5), with an expected mortality < 5%; and high risk (EuroSCORE ≥ 6), with an expected mortality > 10% [7]. Perioperative and early (in-hospital) postoperative results of the three groups were compared.

Statistical analysis

The SPSS (Statistical Package for Social Sciences) for Windows 10.0 was used for the analysis of data. Besides descriptive statistics (mean $\pm$ standard deviation, frequency), normally distributed quantitative data were compared by using one-way ANOVA. Tukey HSD test was used for post hoc comparisons. For the comparison of quantitative data without normal distribution, Kruskal Wallis test was used. Qualitative variables were compared using Chi-square test or Fisher's exact test. A p value < 0.05 was considered significant.

Results

Baseline and clinical characteristics

The mean age of the patients was 63.0 ± 11.1 years (range, 34-80 years). Twenty-nine (32.6%) patients were

female and 60 (67.4%) were male. Based on the EuroSCORE system, patients were allocated to three risk groups as follows: low risk (n = 31, 34.8%), moderate risk (n = 28, 31.5%) and high risk (n = 30, 33.7%). Baseline, clinical, and operative characteristics of each risk group are outlined in Table I. The groups differed in terms of mean age, presence of cerebrovascular disease or

preoperative renal dysfunction, and percentage of patients undergoing emergent or urgent operation. The low risk group patients were significantly younger and had higher body mass index (BMI). The incidence of cerebrovascular disease, preoperative renal dysfunction and emergency operations was significantly lower in the low risk group (none of the low risk patients had renal dysfunction or an

Table I. Baseline, clinical and operative characteristics of patients

Parameter	Risk status based on EuroSCORE system			p
	low n = 31	moderate n = 28	high n = 30	
Age [years] (mean $\pm$ SD)	56.4 $\pm$ 12.0	66.9 $\pm$ 6.2	66.3 $\pm$ 10.6	0.001
BMI [kg/m ²] (mean $\pm$ SD)	29.1 $\pm$ 4.6	25.8 $\pm$ 3.6	25.3 $\pm$ 3.8	0.001
Male gender, n (%)	22 (71.0)	17 (60.7)	21 (70.0)	0.656
CCS classification, n (%)				
class II	14 (45.2)	12 (42.9)	9 (30.0)	0.272
class III	17 (54.8)	16 (57.1)	12 (40.0)	
Unstable angina	-	-	9 (30.0)	
Functional capacity based on NYHA classification, n (%)				
NYHA class I	8 (25.8)	3 (10.7)	3 (10.0)	0.102
NYHA class II	22 (71.0)	22 (78.6)	19 (63.3)	
NYHA class III	1 (3.2)	3 (10.7)	7 (23.3)	
NYHA class IV	-	-	1 (3.3)	
Preoperative clinical characteristics, n (%)				
hypertension	17 (54.8)	20 (71.4)	24 (80.0)	0.099
diabetes	10 (32.3)	22 (78.6)	18 (60.0)	0.866
COPD	5 (16.1)	7 (25.0)	13 (43.0)	0.056
peripheral artery disease ($\geq$ 50% stenosis)	3 (9.7)	2 (7.1)	4 (13.3)	0.733
cerebrovascular disease ($\geq$ 50% stenosis)	4 (12.9)	8 (28.6)	18 (60.0)	0.001
arrhythmia	6 (19.4)	1 (3.6)	8 (26.7)	0.057
preoperative renal dysfunction (creatinine > 2.0 mg/dl)	-	6 (21.4)	8 (26.7)	0.01
previous MI	13 (41.9)	14 (50.0)	19 (63.3)	0.241
smoking	21 (67.7)	19 (67.9)	22 (73.3)	0.866
LV end-diastolic pressure (mean $\pm$ SD)	12.4 $\pm$ 2.4	13.4 $\pm$ 8.2	10.5 $\pm$ 5.4	0.533
LVEF, % (mean $\pm$ SD)	48.35 $\pm$ 22.2	46.3 $\pm$ 19.3	42.2 $\pm$ 20.4	0.086
left main coronary artery disease	-	8 (28.6)	10 (33.3)	0.002
Operative characteristics				
elective, n (%)	31 (100.0)	23 (82.1)	19 (63.3)	0.002
emergent (immediately after angiography), n (%)	-	-	4 (13.3)	0.004
urgent (within 24 h after angiography), n (%)	-	5 (17.9)	7 (23.3)	0.001
Number of grafts/patient (mean $\pm$ SD)	2.9 $\pm$ 1.1	3.0 $\pm$ 1.0	3.4 $\pm$ 0.8	0.369
Number of distal vein grafts (mean $\pm$ SD)	1.8 $\pm$ 1.0	1.9 $\pm$ 1.0	2.0 $\pm$ 0.9	0.687
Number of posterolateral distal anastomoses (mean $\pm$ SD)	1.2 $\pm$ 0.1	1.1 $\pm$ 0.13	1.3 $\pm$ 0.11	0.415
Total number of distal anastomoses (mean $\pm$ SD)	2.6 $\pm$ 0.7	2.7 $\pm$ 0.8	2.8 $\pm$ 0.9	0.647
LITA use, n (%)	25 (80.6)	24 (85.7)	23 (76.7)	0.681
Complete revascularisation, n (%)	27 (90.0)	25 (89.3)	26 (86.7)	0.913
Distal anastomoses				
LAD, n	31	28	30	
diagonal, n	9	11	8	
Cx, n	31	29	25	
PD-PL, n	6	2	14	
RCA, n	3	6	7	

Abbreviations: BMI – body mass index, CCS – Canadian Cardiac Society classification of angina, NYHA – New York Heart Association, COPD – chronic obstructive pulmonary disease, MI – myocardial infarction, LV – left ventricular, EF – ejection fraction, LITA – left internal thoracic artery, LAD – left anterior descending, Cx – circumflex, PD-PL – posterior descending-posterolateral, RCA – right coronary artery

emergency operation). In addition, left main coronary (LMC) artery disease was significantly more common among high risk patients. On the other hand, there were no significant differences in the severity of angina, functional capacity, or presence of hypertension, diabetes, COPD, peripheral artery disease (PAD), arrhythmia, previous MI or smoking. Mean values for left ventricular end-diastolic pressure and ejection fraction were also similar, as well as the type and pattern of coronary anastomoses (Table I). The mean Cleveland Clinic Foundation (CCF) scores of these groups were 1.5 ± 8.1 (range: 0-11), 4.3 ± 12.4 (range: 2-19) and 4.7 ± 15.1 (range: 1-20), respectively. The mean CCF was significantly lower in the low risk group compared with the other two groups ($p = 0.004$) whereas there was no difference in the CCF score between the moderate and high risk groups (NS).

Outcome measures

Early outcomes of the patients are shown in Table II. Duration of the operation and the amount of blood transfusions needed were similar for the three risk groups. Although the mean duration of hospitalisation was similar, groups differed in terms of the duration of the intensive care unit (ICU) stay ($p = 0.035$) (Table II). Significantly fewer

patients required prolonged ICU stay in the low risk group compared to the moderate and high risk groups. In addition, prolonged mechanical ventilation (PMV) was more common in the moderate and high risk groups, compared to the low risk group.

Two (2.2%) patients died. No significant differences were found between the groups with regard to mortality rate. Also, groups were similar in terms of other complications and perioperative parameters (Table II).

Discussion

The role of the risk scoring systems such as the EuroSCORE in the assessment of perioperative mortality risk has been well established. In a multicentre study, Al-Ruzzeh et al. found that OPCAB procedures had 1.3% in-hospital mortality and that the EuroSCORE had predictive value for in-hospital OPCAB mortality [8]. In a recent review comparing OPCAB with on-pump CABG in three risk groups, a significant reduction in the complications was found only in the high risk group undergoing OPCAB [1].

Ability to achieve superior outcomes in high risk patients clearly indicates the potential clinical benefit of this operation [9]. Moor et al. [10] compared high and low

Table II. Early outcomes of patients

Parameter	Risk status based on EuroSCORE system			p
	low n = 31	moderate n = 28	high n = 30	
Duration of operation, [min] (mean $\pm$ SD)	120 $\pm$ 29	125 $\pm$ 44	135 $\pm$ 36	0.810
Duration of ICU stay, [h] (mean $\pm$ SD)	1.2 $\pm$ 0.5	1.3 $\pm$ 0.2	1.8 $\pm$ 2.0	0.035
Duration of hospital stay, [d] (median)	4	5	5	0.716
Blood transfusion, [U] (median)	1	2	2	0.112
Prolonged mechanical ventilation (> 24 h), n (%)	3 (9.7)	11 (39.3)	11 (36.7)	0.018
Prolonged ICU stay (> 3 days), n (%)	6 (19.4)	14 (50.0)	11 (36.7)	0.046
Mortality, n (%)	-	1 (3.6)	1 (3.3)	0.578
IABP use, n (%)	1 (3.2)	1 (3.6)	1 (3.3)	0.997
Inotropic agent use (other than dopamine at renal dose), n (%)	1 (3.2)	3 (10.7)	6 (20.0)	0.116
Pulmonary complication, n (%)	7 (22.6)	12 (42.9)	12 (40.0)	0.202
Postoperative renal dysfunction (creatinine > 2.0 mg/dl), n (%)	-	1 (3.6)	2 (6.7)	0.353
Postoperative cerebrovascular accident, n (%)	-	-	1 (3.3)	0.370
Surgical revision, n (%)	1 (3.2)	1 (3.6)	2 (6.7)	0.778
Postoperative atrial fibrillation, n (%)	3 (9.7)	3 (10.7)	6 (20.0)	0.436
Postoperative ventricular arrhythmia, n (%)	2 (6.5)	4 (14.3)	7 (23.3)	0.175
Re-intubation, n (%)	-	2 (7.1)	4 (13.3)	0.115
Readmission to ICU, n (%)	-	2 (7.1)	3 (10.0)	0.217
Perioperative MI, n (%)	-	1 (3.6)	-	0.324

Unless otherwise stated, data are presented as n (%). Pulmonary complication: a need for lung physiotherapy or pulmonary medication. Postoperative cerebrovascular accident: a newly developed neurocognitive dysfunction other than delirium. Re-intubation: intubation after a successful extubation within 24 h after the operation. Incomplete revascularisation: failure to graft a coronary artery system with a 50% or greater stenosis or failure to graft both the left anterior and circumflex coronary artery systems with a 50% or greater left main coronary artery stenosis.

Abbreviations: ICF – Intensive Care Unit, IABP – intra-aortic balloon pumping, MI – myocardial infarction

risk patients undergoing OPCAB and only found a significantly prolonged duration of ICU and hospital stay as well as increased need for transfusions in the high risk group, with no significant differences in mortality and other major complications. Also in our study the occurrence of major complications was similar in all risk groups. The only difference was duration of intubation and ICU stay, which were prolonged in the high and moderate risk groups.

The overall mortality and the mortality in the high risk group were 2.2% and 3.3%, respectively (Table II). According to EuroSCORE, the expected mortality rate in high risk patients is more than 10% [6]. Although the small sample size of our study is a concern, our results suggest that the EuroSCORE may overestimate the risk level for OPCAB patients. It should be remembered that the EuroSCORE model was developed on patients undergoing mainly on-pump cardiac procedures. The use of CPB has been found to be an independent risk factor for in-hospital mortality [11]. The CCF scores differed significantly between the low risk group and the others, whereas the moderate and high risk groups were not significantly different. However, the CCF score is reported to be more accurate in predicting good outcome in high risk groups [12]. Advocates of OPCAB suggest that the greatest benefit is in high risk patients who are most likely to develop complications. Evidence supporting this possibility has been derived from 42 non-randomised trials of high risk patients. Specific patient subgroups that appear to benefit include a EuroSCORE > 5 [5].

Perioperative morbidity and mortality rates rise with increasing age in patients undergoing CABG [13]. The OPCAB approach has been shown to reduce perioperative complications and resource use in elderly patients [14]. It is also important to note that, in our study, despite significantly higher average age in the high risk group, morbidity and mortality rates did not differ significantly. Emergency CABG in patients with acute MI has poor results because the ischaemic myocardium is vulnerable to the side effects of CPB and cardiac arrest. Several authors have reported a mortality of 20% to 30% in this group of patients [15]. The OPCAB approach may be a viable alternative in these patients [16]. In our study emergency interventions were more frequent in the high risk group.

It can be seen that high risk patients had significantly prolonged intubation time and ICU stay compared to other groups (Table II). In a study by Riha et al. [17] both postoperative ventilation and ICU stay were prolonged for 3 h in high risk patients compared to the low risk group. Similar differences have been reported by Arom and coworkers [18]. In our study, preoperative incidence of cerebrovascular diseases was higher in high risk patients, with one patient experiencing a cerebrovascular accident postoperatively. This finding is in line with several studies reporting remarkably low rates of stroke following OPCAB

[3]. Calafiore et al. showed that the use of CPB increased the risk of stroke by 4.6 times in patients with EuroSCORE > 5, claiming that this was due to the avoidance of aortic manipulation in OPCAB [4].

The major drawbacks of our study are its retrospective design and small sample size. It has been reported that additive EuroSCORE is less accurate than the logistic one for risk stratification, especially in the high risk group [19]. D'Errigo et al. reported a modification to calibrate this model for more accurate risk stratification [20]. The small number of patients is a main concern for the accuracy of the statistical analysis. The lack of a control CPB group is a consequence of the low number of patients. Thus, although the mortality and morbidity rates were low in the high risk patients, our results are preliminary due to the small sample size and should be confirmed in larger studies. Another point is the limited use of LITA, which should be used in a higher proportion of patients. The use of LITA was not possible in some patients (Table I) due to their condition (COPD, age, PAD) or emergency operations.

In summary, our results suggest that in patients who are considered high risk on the basis of the EuroSCORE model for preoperative and intraoperative complications during conventional CABG and have diseased vessels on the lateral and/or posterior walls of the heart suitable for grafting, the early outcomes with OPCAB are similar to those in medium or low EuroSCORE risk category.

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Przeprowadzenie operacji pomostowania wieńcowego bez użycia krążenia pozaustrojowego może zmniejszyć ryzyko okołoperacyjne

Hayrettin Tekumit¹, Ali Rıza Cenat¹, Cenk Tataroglu¹, Adil Polat², Kemal Uzun¹, Esat Akinci¹

¹ Szpital Avrupa Safak, Istambuł, Turcja

² Szpital im. Johna F. Kennedy'ego, Istambuł, Turcja

Streszczenie

Wstęp: Przeprowadzenie operacji pomostowania wieńcowego bez użycia krążenia pozaustrojowego (OPCAB) może zmniejszyć ryzyko okołoperacyjne w porównaniu z operacjami z użyciem krążenia pozaustrojowego.

Cel: Porównanie wczesnych wyników OPCAB ściany bocznej i tylnej w grupach chorych z niskim, umiarkowanym i wysokim ryzykiem określonym na podstawie EuroSCORE.

Metody: Grupę badaną stanowiło 87 chorych poddanych OPCAB ścianach bocznej i tylnej w okresie od stycznia 2006 r. do grudnia 2008 r. Na podstawie skali EuroSCORE chorzy zostali zakwalifikowani do 3 grup: niskiego, umiarkowanego i wysokiego ryzyka operacyjnego. W wyłonionych grupach porównano przebieg operacji i wczesnego okresu pooperacyjnego.

Wyniki: W grupie niskiego ryzyka znacznie mniej chorych wymagało wydłużonego pobytu na oddziale intensywnej terapii w porównaniu z grupą umiarkowanego (19,4 vs 50%) i wysokiego ryzyka (19,4 vs 36,7%). Przedłużona mechaniczna wentylacja była stosowana częściej w grupie umiarkowanego (39,3 vs 9,7%) i wysokiego ryzyka (36,7 vs 9,7%) w porównaniu z grupą niskiego ryzyka. Nie stwierdzono różnicy w śmiertelności i pozostałych badanych parametrach przebiegu okołoperacyjnego pomiędzy grupami.

Wnioski: Wczesne wyniki OPCAB ściany bocznej i tylnej w grupie chorych wysokiego ryzyka operacyjnego określonego na podstawie EuroSCORE są podobne do wyników uzyskanych w grupie umiarkowanego i niskiego ryzyka. EuroSCORE może zawyżać ryzyko wykonania OPCAB.

Słowa kluczowe: OPCAB, EuroSCORE, rewaskularyzacja ściany bocznej i tylnej

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Adres do korespondencji:

dr n. med. Adil Polat, Szpital im. Johna F. Kennedy'ego, Talatpasa Bulvari, Begonya Sokak, No: 7-9 Bahcelievler 34590, Istambuł, Turcja, tel.: +90 542 315 38 76, e-mail: adilpol@yahoo.com

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