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# On-pump Coronary Artery Bypass Surgery in High-risk Patients Aged Over 65 Years (EuroSCORE 6 or More): Impact on Early Outcomes

N Erdil[1], V Nisanoglu[1], M Kaynak[1], I Fansa[2], T Eroglu[1], HB Cihan[1] and B Battaloglu[1]

[1]Department of Cardiovascular Surgery, Turgut Ozal Medical Centre, Inonu University, Malatya, Turkey; [2]Department of Cardiovascular Surgery, Medical Faculty, Mustafa Kemal University, Hatay, Turkey

**The results of on-pump coronary artery bypass graft (CABG) surgery in 166 high-risk elderly patients (EuroSCORE 6 or more; over age 65 years [mean 71.8 years]) were compared with 176 low-risk elderly patients (EuroSCORE below 6; over age 65 years [mean 68.8 years]). There was no significant difference in hospital mortality or number of grafts between the two groups. Rates of inotropic agent use, intra-aortic balloon pump insertion and atrial fibrillation, and the duration of intensive care unit and hospital stay were significantly higher in high-risk than low-risk patients. There were no significant differences in the incidence of major complications between the two groups. The results suggest that, in selected patients, on-pump CABG can be safely performed in high-risk patients over 65 years old with no effect on mortality.**

KEY WORDS: Coronary artery disease; Cardiopulmonary bypass; Elderly patients; Myocardial revascularization; Risk

## Introduction

The incidence of symptomatic coronary artery disease (CAD) requiring coronary artery bypass grafting (CABG) in elderly patients has been dramatically increasing over the past decade.[1 – 4] Successive improvements in cardiopulmonary bypass (CPB) grafting operations have led to an increasing number of elderly patients being considered as candidates for this operation.[5,6] The elderly population is a challenging group of patients when undergoing surgical procedures[7] and they are considered to have a higher rate of morbid outcomes after CABG.[5] Elderly patients are often referred for surgery with advanced disease and this can be problematic as their functional capacity is diminished compared with younger patients.[5] The increased operative risk is likely to correlate in these patients with a poor life expectancy.[8] CPB has long been claimed to be responsible for systemic inflammation and multiple organ dysfunction after CABG.[9] It has been thought, therefore, that the mortality and

morbidity of high-risk patients could be reduced if surgery is performed without CPB.[10] Studies have indicated the advantages of off-pump coronary artery bypass (OPCAB) particularly in elderly patients.[5]

Accordingly, we evaluated our results of on-pump CABG surgery in high-risk patients aged > 65 years old and compared them with our results in low-risk patients.

# Patients and methods

## PATIENT POPULATION

The computerized clinical database records of consecutive patients aged > 65 years who underwent CABG surgery at the Department of Cardiovascular Surgery, Turgut Ozal Medical Centre (Inonu University, Malatya, Turkey) between January 2004 and March 2007 were retrospectively reviewed. They were classified into two subgroups according to the European System for Cardiac Operative Risk Evaluation (EuroSCORE): high risk (EuroSCORE ≥ 6) and low risk (EuroSCORE < 6).[11] The records of patients who underwent off-pump CABG and re-operation were excluded.

## SURGICAL MANAGEMENT

In each case, the patient was placed under general anaesthesia and conventional median sternotomy was performed. CPB was established by cannulating the ascending aorta and right atrium. Anti-coagulation was achieved with heparin (3 mg/kg) and this maintained the activated clotting time at > 450 s; a roller pump and non-pulsatile flow (2.4 l/m$^2$ per min) were used. The body was cooled to a core temperature of 32 – 34 °C when distal anastomosis was being performed and was warmed to 36 °C before weaning from CPB. Cold blood cardioplegia was delivered via antegrade and retrograde routes intermittently throughout the procedure. A final dose of 'hot-shot' cardioplegia was administered just before the aorta was unclamped.

The choice of graft type(s) used was left to the surgeon, but certain standard restrictions were applied. Radial artery (RA) grafts were only used to bypass target vessels that exhibited > 70% stenosis. The RA and venous grafts were harvested while internal thoracic artery (ITA) material was being prepared. In each case where an RA was used, adequacy of collateral circulation to the hand was assessed pre-operatively with the Allen test and then again during surgery using digital plethysmography. Each arterial graft (ITA or RA) was harvested using the 'no-touch' technique, and was removed as a pedicle with its associated adjacent veins and surrounding tissue. In most of the cases, the left ITA was used for revascularization of the left anterior descending artery. Distal and proximal anastomoses, and left ventricle aneurysm repair were completed during a single period of aortic cross-clamping.

## DATA COLLECTION AND DEFINITIONS

The following pre- and intra-operative data were recorded for each case: patient age and sex; history of hypertension, diabetes, smoking, body mass index (BMI) and obesity (BMI > 30 kg/m$^2$), hyperlipidaemia (total cholesterol level > 200 mg/dl) or chronic obstructive pulmonary disease (COPD) (forced expiratory volume in 1 s [$FEV_1$]/forced vital capacity [FVC] < 70%); family history of coronary artery disease; previous cerebrovascular accident or myocardial infarction (MI); prior percutaneous transluminal coronary angioplasty; presence of carotid artery disease or renal insufficiency (serum creatinine ≥ 1.5 mg/dl); left ventricular ejection fraction; presence of left main coronary artery disease; extent of coronary

disease (one-, two-, or three-vessel disease); number of grafts per operation and graft types used (i.e. left internal mammary artery, radial artery or saphenous vein grafts); CPB time; aortic cross-clamp time; and any other additional procedures performed. The recorded post-operative data were: mechanical ventilation time; need for an inotropic agent or intra-aortic balloon pump support; peri-operative MI (immediate post-operative period); infective, pulmonary, neurological or gastrointestinal complications; re-exploration for bleeding or cardiac tamponade; length of stay in the intensive care unit (ICU); overall hospital stay; and hospital mortality (death in the first 30 days after CABG). The EuroSCORE risk stratification model, which is widely used in cardiac surgery, was also applied.[11] Each individual's EuroSCORE was calculated based on demographic and clinical characteristics.

A patient was considered to have peri-operative MI if new Q waves appeared or if there was significant loss of R-wave amplitude (> 25% loss) in at least two leads on electrocardiography (ECG).

### STATISTICAL ANALYSIS

The data were statistically analysed using SPSS® version 10.0 (SPSS Inc., Chicago, IL, USA) for Windows®. Data for patient characteristics and outcomes were expressed either as a percentage of the total or as mean ± SD. Comparison between the groups regarding categorical data was performed with the $\chi^2$ test or Fisher's exact test. Results for continuous variables were compared using an independent *t*-test. A *P*-value < 0.05 was considered statistically significant.

## Results

The records of 342 consecutive patients were divided into those at high risk (EuroSCORE ≥ 6; $n = 166$) and those at low risk (EuroSCORE < 6; $n = 176$) and their pre-operative variables are listed in Table 1. The mean age (± SD) of the patients at operation was 71.8 ± 4.9 years in the high-risk group and 68.8 ± 4.0 years in the low-risk group ($P < 0.001$). Unstable angina rates were significantly higher in the high-risk than in the low-risk group ($P < 0.0001$). The high-risk group also had a significantly higher incidence of prior MI, carotid artery disease and COPD ($P < 0.0001$, $P = 0.021$, $P < 0.0001$, respectively), and a lower mean pre-operative left ventricular ejection fraction and mean BMI than the low-risk group ($P < 0.0001$, $P = 0.016$, respectively).

The intra-operative variables in both groups are listed in Table 2. Cross-clamp time and CPB time were significantly higher in the high-risk patients ($P = 0.018$, $P = 0.003$, respectively). In our patient group, 42 (25.3%) high-risk patients underwent 49 additional surgical procedures and eight (4.5%) low-risk patients underwent nine additional procedures ($P < 0.0001$) (Table 2). Carotid endarterectomy was performed in seven (4.2%) high-risk patients and in none in the low-risk group ($P = 0.006$). Left ventricular aneurysm repair rates were significantly higher in high-risk than low-risk patients ($P < 0.0001$). There was no significant difference in the number of grafts per operation between the two groups. There were no significant differences in the other intra-operative variables between the two groups, apart from a more frequent use of RA grafts in low-risk patients to bypass target vessels that exhibited > 70% stenosis ($P = 0.029$).

Post-operative data are listed in Table 3. There was no significant difference in hospital mortality rate, which was 1.8% in high-risk patients and 1.1% in low-risk patients. High-risk patients had a significantly higher incidence of inotropic agent requirement ($P < 0.0001$), intra-aortic

**TABLE 1:**
**Pre-operative variables in patients aged > 65 years classified as 'high-risk' or 'low-risk' who underwent coronary artery bypass grafting (CABG) surgery**

| Pre-operative variable | High risk (EuroSCORE ≥ 6) *n* = 166 | Low risk (EuroSCORE < 6) *n* = 176 | *P*-value |
|---|---|---|---|
| Age (years) | 71.8 ± 4.9 | 68.8 ± 4.0 | < 0.001 |
| Age ≥ 75 years | 50 (30.1%) | 20 (11.4%) | < 0.0001 |
| Women | 59 (35.5%) | 47 (26.7%) | 0.077 |
| Diabetes mellitus | 30 (18.1%) | 36 (20.5%) | NS |
| Hypertension | 84 (50.6%) | 87 (49.4%) | NS |
| Obesity (BMI > 30 kg/m$^2$) | 28 (16.9%) | 25 (14.2%) | NS |
| Body surface area (m$^2$) | 1.69 ± 0.24 | 1.73 ± 0.16 | 0.073 |
| BMI (kg/m$^2$) | 24.9 ± 4.1 | 25.9 ± 3.7 | 0.016 |
| Smoking | 83 (50.0%) | 89 (50.6%) | NS |
| Family history of CAD | 42 (25.3%) | 52 (29.5%) | NS |
| COPD ($FEV_1$/FVC < 70%) | 67 (40.4%) | 26 (14.8%) | < 0.0001 |
| Prior stroke | 4 (2.4%) | 6 (3.4%) | NS |
| Hyperlipidaemia (total cholesterol > 200 mg/dl) | 52 (31.3%) | 44 (25.0%) | NS |
| Unstable angina | 57 (34.3%) | 15 (8.5%) | < 0.0001 |
| Peripheral vascular disease | 6 (3.6%) | 7 (4.0%) | NS |
| Carotid artery disease | 57 (34.3%) | 40 (22.7%) | 0.021 |
| Prior MI | 147 (88.6%) | 84 (47.7%) | < 0.0001 |
| Prior PTCA | 8 (4.8%) | 9 (5.1%) | NS |
| Renal insufficiency | 5 (3.0%) | 5 (2.8%) | NS |
| One-vessel disease | 16 (9.6%) | 12 (6.8%) | NS |
| Two-vessel disease | 52 (31.3%) | 71 (40.3%) | NS |
| Three-vessel disease | 98 (59.0%) | 93 (52.8%) | NS |
| LMCA | 14 (8.4%) | 7 (4.0%) | NS |
| LV ejection fraction (%) | 0.45 ± 0.10 | 0.54 ± 0.8 | < 0.0001 |
| EuroSCORE | 7.67 ± 2.03 | 3.98 ± 1.1 | |

Data are mean ± SD or *n* (%).
BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; $FEV_1$, forced expiratory volume in 1 s; FVC, forced vital capacity; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; LMCA, left main coronary artery; LV, left ventricle; NS, not statistically significant ($P > 0.05$).

balloon pump insertion ($P = 0.006$) and atrial fibrillation ($P = 0.013$) compared with the low-risk patients. The ICU and hospital stays were also significantly longer in the high-risk group ($P = 0.003$, $P < 0.0001$, respectively) with significantly more high-risk patients staying ≥ 6 days in the ICU ($P = 0.009$). The incidence of prolonged ventilation time (≥ 24 h) and the mean mechanical ventilation time were also significantly higher in high-risk patients compared with low-risk patients ($P = 0.008$, $P = 0.013$, respectively). The incidences of major complications, such as post-operative renal failure, neurological complications, gastrointestinal complications and respiratory failure, were small and no statistically significant between-group differences could be detected. Likewise, infection rates, deep venous thrombosis and

**TABLE 2:**
**Intra-operative variables in patients aged > 65 years classified as 'high-risk' or 'low-risk' who underwent coronary artery bypass grafting (CABG) surgery**

| Intra-operative variable | High risk (EuroSCORE ≥ 6) *n* = 166 | Low risk (EuroSCORE < 6) *n* = 176 | *P*-value |
|---|---|---|---|
| LIMA used | 162 (97.6%) | 176 (100%) | NS |
| Radial artery used | 15 (9.0%) | 30 (17.0%) | 0.029 |
| Number of grafts per operation | 2.93 ± 0.95 | 2.95 ± 0.75 | NS |
| Cross-clamp time (min) | 79.9 ± 22.7 | 74.5 ± 10.01 | 0.018 |
| CPB time (min) | 95.9 ± 27.7 | 87.9 ± 21.2 | 0.003 |
| Additional procedures | 42 (25.3%)[a] | 8 (4.6%)[b] | < 0.0001 |
| Coronary endarterectomy | 6 (3.6%) | 2 (1.1%) | NS |
| Carotid endarterectomy | 7 (4.2%) | 0 | 0.006 |
| LV aneurysm repair | 30 (18.1%) | 6 (3.4%) | < 0.0001 |
| Post-MI VSD | 2 (1.2%) | 0 | NS |
| Mitral anuloplasty | 2 (1.2%) | 0 | NS |
| Mechanical valve replacement | 2 (1.2%) | 1 (0.6%) | NS |
| Total arterial revascularization | 12 (7.2%) | 23 (13.1%) | NS |

[a]A total of 42 (25.3%) patients had 49 additional procedures.
[b]A total of eight (4.6%) patients had nine additional procedures.
Data are mean ± SD or *n* (%).
LIMA, left internal mammary artery; CPB, cardiopulmonary bypass; LV, left ventricle; MI, myocardial infarction; VSD, ventricular septal defect; NS, not statistically significant ($P > 0.05$).

sternal dehiscence rates were low and no significant between-group differences could be detected.

## Discussion

The EuroSCORE system was introduced as a way to measure the predicted 30-day mortality rate after cardiac surgery.[11,12] In another report, Biancari *et al.*[8] also introduced it as a relevant measure of both early and late outcomes after cardiac surgery. Based on these findings, it seemed reasonable for us to define patients at 'high risk' as those who had a EuroSCORE ≥ 6.[12] The present study compared peri-operative mortality and morbidity in elderly patients undergoing on-pump CABG who were categorized as either high- or low-risk according to their EuroSCORE.[11]

Coronary artery disease is one of the most frequent ailments in the elderly.[7] With an increase in life expectancy, the number of elderly patients with symptomatic CAD is growing.[13] Elderly patients undergoing CABG surgery often have significant comorbid illnesses, including prior stroke, renal insufficiency and pulmonary disease, which may increase the risk of post-operative morbidity and mortality. In high-risk patients, the standard concepts, criteria and techniques for surgical myocardial revascularization often produce poor results and lead to significant rates of mortality and morbidity.[1,3,7] Advances in cardiopulmonary bypass techniques, myocardial protection and improved peri-operative care, however, have allowed CABG operations to be safely offered to patients > 80 years of age.[7,14,15]

In some studies it has been reported that CPB is an independent predictor of the raised likelihood of mortality and morbidity in patients with a EuroSCORE ≥ 6.[12]

**TABLE 3:**
**Post-operative variables in patients aged > 65 years classified as 'high-risk' or 'low-risk' who underwent coronary artery bypass grafting (CABG) surgery**

| Post-operative variable | High risk (EuroSCORE ≥ 6) *n* = 166 | Low risk (EuroSCORE < 6) *n* = 176 | *P*-value |
|---|---|---|---|
| Inotropic therapy required | 26 (15.7%) | 3 (1.7%) | < 0.0001 |
| IABP required | 7 (4.2%) | 0 | 0.006 |
| Mechanical ventilation time (h) | 10.98 ± 8.21 | 9.2 ± 3.5 | 0.013 |
| Prolonged ventilation time (≥ 24 h) | 9 (5.4%) | 1 (0.6%) | 0.008 |
| ICU stay (days) | 3.29 ± 2.68 | 2.43 ± 1.09 | 0.003 |
| Prolonged ICU stay (≥ 6 days) | 16 (9.6%) | 5 (2.8%) | 0.009 |
| Hospital stay (days) | 7.63 ± 3.63 | 6.6 ± 1.1 | < 0.0001 |
| Hospital mortality (first 30 days) | 3 (1.8%) | 2 (1.1%) | NS |
| Re-exploration for bleeding or tamponade | 4 (2.4%) | 1 (0.6%) | NS |
| Atrial fibrillation | 40 (24.1%) | 24 (13.6%) | 0.013 |
| Significant pleural effusion | 8 (4.8%) | 4 (2.3%) | NS |
| Pneumonia | 1 (0.6%) | 0 | NS |
| Peri-operative MI | 1 (0.6%) | 0 | NS |
| Post-operative TIA or stroke | 4 (2.4%) | 2 (1.1%) | NS |
| GIS complications | 1 (0.6%) | 2 (1.1%) | NS |
| Superficial wound infection | 2 (1.2%) | 0 | NS |
| Deep wound infection | 1 (0.6%) | 0 | NS |
| Saphenous vein incision infection | 9 (5.4%) | 6 (3.4%) | NS |
| Radial artery incision infection | 0 | 0 | – |
| Stenal dehiscence | 2 (1.2%) | 1 (0.6%) | NS |
| Renal dysfunction | 1 (0.6%) | 0 | NS |
| Deep venous thrombosis | 1 (0.6%) | 3 (1.7%) | NS |

Data are mean ± SD or *n* (%).
IABP, intra-aortic balloon pump; ICU, intensive care unit; MI, myocardial infarction; TIA, transient ischaemic attack; GIS, gastrointestinal system; NS, not statistically significant ($P > 0.05$).

Measurement of the likelihood of morbidity and mortality, however, provides only a small amount of information about the post-operative physical, functional, emotional and mental well-being of patients.[16] Post-operative patient disposition and discharge status should also be considered as an important component of overall CABG success.

Studies have shown that mortality and morbidity in patients with high operative risk can be reduced by using an off-pump CABG technique,[10,17] however complete revascularization of all diseased vessels is not feasible with this operative technique.[2,12] Incomplete revascularization affects the long-term outcomes of surgery,[13] so the concept of complete surgical revascularization of all diseased vessels is still the gold standard for the majority of patients.[10] Additionally, life expectancy has been increasing amongst elderly patients.[3,4,6] The present study evaluated data from on-pump coronary artery bypass operations carried out at the Turgut Ozal Medical Centre, Malatya, Turkey, in high-risk patients aged > 65 years and compared them with the results from low-risk patients. No significant difference in hospital mortality rate was seen between the two groups (1.8%

in high-risk versus 1.1% in low-risk patients). High-risk patients showed significantly higher rates of inotropic agent requirement, intra-aortic balloon pump insertion and atrial fibrillation compared with low-risk patients, and ICU and hospital stays were also significantly longer. The incidences of major complications, such as post-operative renal failure, neurological complications, gastrointestinal complications and respiratory failure were small, and no statistically significant between-group differences could be detected.

Given the pre-operative low ejection fraction, high prevalence of unstable angina and additional surgical procedures associated with the high-risk patients, it would be reasonable to expect these patients to have long cross-clamp and CPB durations, high rates of inotropic agent requirements and intra-aortic balloon pump application rates. Despite these factors, however, the hospital mortality rate did not differ between the high- and low-risk elderly patients in the present study. We believe, therefore, that for appropriate cases, such as patients whose coronary arteries are suitable for beating heart CABG and where complete revascularization is possible, off-pump CABG may be appropriate for some elderly high-risk patients. Nevertheless, the CPB technique is routinely used in most cases, such as in patients who require additional surgical procedures like ventricular aneurysm and post-MI ventricular septal defect repair, or when there is serious mitral insufficiency.[18,19]

The present study suggests that, when compared with low-risk (EuroSCORE < 6) patients, on-pump CABG surgery is as safe, with similar low rates of major complications and mortality, when used in elderly high-risk patients (EuroSCORE ≥ 6) who require additional surgical procedures or whose coronary arteries are not suitable for off-pump surgery.

## Conflicts of interest

The authors had no conflicts of interest to declare in relation to this article.

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Author's address for correspondence
**Dr Nevzat Erdil**
Department of Cardiovascular Surgery, Turgut Ozal Medical Centre, Inonu University, 44315 Malatya, Turkey.
E-mail: nerdil@inonu.edu.tr