Annals of Surgery: International
Received: May 01, 2016, Accepted: Jun 20, 2016, Published: Jun 25, 2016
Ann Surg Int, Volume 2, Issue 5
http://crescopublications.org/pdf/asi/ASI-2-028.pdf
Article Number: ASI-2-028

Research Article Open Access

Risk Factors for in-hospital Mortality after Coronary Artery Bypass Grafting in Patients 80 Years Old or Older: A Retrospective Cohort Study

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Citation: Jacek Piątek, Anna Kędziora, Janusz Konstanty-Kalandyk, Grzegorz Kiełbasa, Marta Olszewska, Bryan HyoChan Song, Karol Wierzbicki, Irena Milaniak, Tomasz Darocha andBogusławKapelak (2016) Risk Factors for in-hospital Mortality after Coronary Artery Bypass Grafting in Patients 80 Years Old or Older: A Retrospective Cohort Study. Ann Surg Int 2: 028.

Abstract

Background: Age remains a significant and unmodifiable risk factor for cardiovascular diseases, and an increasing number of patients older than 80 yo (years old) undergo Coronary Artery Bypass Grafting (CABG). Older age is also an independent risk factor for postoperative complications

Methods: A retrospective cohort study analyzing 388 consecutive patients aged 80 yo or older who underwent isolated CABG procedure between 2010 and 2014 in the Department of Cardiovascular Surgery and Transplantology, John Paul II Hospital, Krakow.

Results: In-hospital mortality stood at 7%, compared to 3.4% for all isolated CABG procedures at our Institution. In an univariate logistic regression analysis, risk factors for in-hospital mortality were as follows: NYHA class ($p=0.005$, OR 1.05, 95% CI [1.23-3.1]), prolonged mechanical ventilation ($p<0.001$, OR 7.08, 95% CI [2.47-20.3]), rethoracotomy ($p=0.04$, OR 3.31, 95% CI [1.04-10.6]), duration of the procedure and ECC (for every 10 minutes $p=0.01$, OR 1.01, 95% CI [1.0-1.01]; $p=0.03$, OR 1.01, 95% CI [1.0-1.02], respectively), PRBC, FFP, andPLT transfusion (for every unit transfused $p=0.004$, OR 1.42, 95% CI [1.12-1.8]; $p=0.002$, OR 1.55, 95% CI [1.18-2.04]; $p=0.009$, OR 1.93, 95% CI [1.18-3.14], respectively). Higher LVEF ($p=0.02$, OR 0.97, 95% CI [0.94-0.99]) and LIMA graft implantation ($p=0.04$, OR 0.36, 95% CI [0.13-0.98) decreased the in-hospital mortality. Death before discharge was more often observed in patients with multiple risk factors for cardiovascular diseases (0-2 – 5.7%; 3-7.4%, 4 – 26.6%; $p=0.03$).

Discussion & Conclusions: Older age is associated with higher in-hospital mortality after isolated CABG. Risk stratification scores and individualized risk evaluation, centered on comorbidities, NYHA class and left ventricular function, should be assessed in all cases. Whenever suitable, LIMA grafts should be used. Prolonged procedure and ECC time worsen the short-term outcome. Elderly individuals should be closely monitored postoperatively and the care should be focused on excessive blood loss and respiratory failure.

Keywords: Coronary Artery Bypass Grafting; In-hospital mortality; Elderly patients; Risk factors.

Introduction

Civilization development has prolonged longevity in developed countries, and statistics show that 6.2% of the American society has reached the age of 80 years old (yo). The expected life time for this population reached 8.1 years [1]. Age remains a significant and unmodifiable risk factor for cardiovascular diseases and nowadays, more than 20% and 30% of octogenarians and nonagenarians have vascular disease in at least 1 arterial territory [2].Therefore, an increasing number of patients older than 80 yo undergo Coronary Artery Bypass Grafting (CABG), reaching 7.3% of all CABG procedures at our Institution. Older age is also an independent risk factor for postoperative complications [3].

Currently, mortality rates for patients over 80 yo are higher than those observed for younger groups. Studies show that the 30-day mortality and the incidence of postoperative complications increase significantly with age. In the analysis of 6057 patients who underwent isolated CABG between 1996 and 2002, the 30-day mortality rate and the incidence of postoperative complications were found to largely escalate with age [4]. In-hospital cost and outcomes were examined among 2272 elderly patients (≥75 yo) and 9745 younger patients (<75 yo) who underwent CABG between 1997 and 2001 in another study with similar results [5].

The risk stratification scores which are the most commonly used, Euroscore II and STS risk calculator, include age as a part of preoperative risk, but there is a gap in knowledge regarding risk factors for poor outcomes in the age group of 80 yo and older patients. As the risk of surgery is usually high in elderly, studies focused on defining geriatric-specific risk are warrantable.

The aim of this study is to describe the population of patients 80 yo or older who underwent CABG procedure and to assess the mortality rate and risk factors for in-hospital mortality.

Methods

In a retrospective cohort study, we analyzed 388 consecutive patients aged 80 yo or older who underwent isolated CABG procedure between 2010 and 2014 in the Department of Cardiovascular Surgery and Transplantology, John Paul II Hospital, Krakow. All patients in the analysis were qualified for surgical revascularization according to European Society of Cardiology (ESC) guidelines [6].

CABG On-Pump procedures were performed with placement of arterial grafts (left internal mammary artery (LIMA), right internal mammary artery (RIMA), and radial artery (RA)), venous grafts (saphenous vein graft (SVG)), or both. Arterial and venous grafts were used based on indications covered by our institution’s protocol and surgeon’s preferences.General anesthesia was carried out using propofol as a hypnotic, sufentanyl as an analgesic,and non-depolarizing muscle relaxant. Heparinization was achieved before startinga Cardiopulmonary Bypass (CPB) and subsequently reversed with protamine. Our institution’s standard protocol includes heparin 3mg/kg and protamine 1:1.Blood or crystalloid cardioplegia wasused for all cases. Distal and proximal anastomoses were attached with continuous running sutures, using non-absorbable Prolene®.

When suitable, Off-Pump surgery was performed. Preoperative care and anesthesia were carried out following same protocols.Distal anastomoses were performed as during On-Pumpprocedure with or without tissue stabilizers. All surgeries were performed via median sternotomy.

Statistical Analysis

Statistical analysis was performed using STATISTICA software, version 10.0. In order to confirm a normal distribution of continuous variables, the Shapiro–Wilk test was used. Results were presented based on the parameters of descriptive statistics, including mean values and its standard deviations, or median values and its quartiles, as appropriate. Categorical variables were presented as percentages. Continuous variables were compared via Student’s t-test and categorical variables via Chi-square test. Univariate and multivariate stepwise logistic regression wereused to determine risk factors for in-hospital mortality. P value less than 0.05 was considered significant.

Results

Analyzed population comprised mostly of overweight (68%) males (68%) with a mean age of 82.4 ± 2.3 yo. 85.8% of individuals had accompanying hypertension, 32.7% diabetes, and 13.9% hyperlipidemia. Most patients had history of myocardial infarction (MI) (63.4%), but minority of the study cohort had been previously treated with Percutaneous Coronary Intervention (PCI) (18.8%). 13.9% of the individuals suffered from atrial fibrillation, 5.9% from Chronic Obstructive Pulmonary Disease (COPD), and 19.6% had Chronic Kidney Disease (CKD).Most of the patients had three-vessel disease (62.6%) with affected left main (LM) (46.1%). Mean Left Ventricle Ejection Fraction (LVEF) was 48 ± 13%[Table 1].

Table 1: Baseline characteristics

Variable	
Age, years	82.4 (±2.3)
Male sex, n (%)	264 (68)
BMI, kg/m^2	27.12 (±3.8)
Normal weight, n (%)	119 (30.7)
Underweight, n (%)	5 (1.3)
Overweight, n (%)	179 (46.1)
Obese, n (%)	85 (21.9)
Diabetes, n (%)	127 (32.7)
Hypertension, n (%)	333 (85.8)
Hyperlipidemia, n (%)	54 (13.9)
0 risk factors for CAD, n (%)	22 (5.7)
1 risk factor for CAD, n (%)	92 (23.7)
2 risk factors for CAD, n (%)	151 (38.9)
3 risk factors for CAD, n (%)	108 (27.8)
4 risk factors for CAD, n (%)	15 (3.9)
Atrial fibrillation, n (%)	54 (13.9)
COPD, n (%)	23 (5.7)
CKD, n (%)	76 (19.6)

CCS class 0, n (%)	5 (1.3)
CCS class I. n (%)	39 (10.1)
CCS class II, n (%)	98 (25.26)
CCS class III, n (%)	172 (44.3)
CCS class IV, n (%)	74 (19.1)
Single-vessel disease, n (%)	72 (18.6)
Two-vessel disease, n (%)	69 (17.8)
Three-vessel disease, n (%)	243 (62.6)
LM disease, n (%)	179(62.6)
LVEF, %	48 (±13)
Previous MI, n (%)	246 (63.4)
Previous PCI, n (%)	73 (18.8)

Data shown as mean ± SD or as median (IQR), or number (percentage). Abbreviations: BMI: Body Mass Index; CAD: Coronary Artery Disease; COPD: Chronic Obstructive Pulmonary Disease; CKD: Chronic Kidney Disease; CCS: Canadian Cardiovascular Society; LM: Left Main; LVEF: Left Ventricle Ejection Fraction; MI: Myocardial Infarction; PCI: Percutaneous Coronary Intervention.

Most of the patients required two or more bypass grafts. Asides from LIMA, arterial grafts were not commonly used. Median procedure time, Aortic Cross-Clamp time, and Extracorporeal Circulation (ECC) time were 220, 40, and 82 minutes respectively. Emergent surgery was performed in 31.2 % cases [Table 2].

In-hospital mortality stood at 7 % (27 cases) and was higher than that of the overall population undergoing isolated CABG at our Institution (3.4%).

From the preoperative parameters, only NYHA class (p=0.005, OR 1.05, 95% CI [1.23-3.1]) was a significant risk factors for in-hospital mortality. The prevalence of CKD showed a statistical trend towards higher mortality (p=0.07, OR 2.19, 95% CI [0.94-5.1]).Higher LVEF had a protective influence (p=0.02, OR 0.97, 95% CI [0.94-0.99]). None of the baseline risk factors for Coronary Artery Disease (CAD), including BMI > 25 kg/m^2, hypertension, diabetes, and hyperlipidemia, influenced the risk of in-hospital mortality separately. However, death before discharge was more often observed in patients with multiple risk factors (0-2 – 5.7%; 3- 7.4%, 4 – 26.6%; p=0.03)**.**

In an univariate logistic regression analysis, other risk factors for in-hospital mortality were as follows: prolonged mechanical ventilation (p<0.001, OR 7.08, 95% CI [2.47-20.3]), rethoracotomy (p=0.04, OR 3.31, 95% CI [1.04-10.6]), duration of the procedure and ECC (for every 10 minutes p=0.01, OR 1.01, 95% CI [1.0-1.01]; p=0.03, OR 1.01, 95% CI [1.0-1.02], respectively), PRBC, FFP, and PLT transfusion (for every unit transfused p=0.004, OR 1.42, 95% CI [1.12-1.8]; p=0.002, OR 1.55, 95% CI [1.18-2.04]; p=0.009, OR 1.93, 95% CI [1.18-3.14], respectively). LIMA graft implantation was observed to decrease the in-hospital mortality (p=0.04, OR 0.36, 95% CI [0.13-0.98]).

Lastly, multivariate stepwise analysis showed that only NYHA class and PRBC transfusion were significant risk factors. However, the predictive value of this model was low.

Table 2: Intraoperative data

Variable	
Elective surgery, n (%)	267 (68.8)
Emergent surgery, n (%)	121 (31.2)
On-Pump surgery, n (%)	368 (94.85)
Off-Pump surgery, n (%)	20 (5.15)
Surgery time, minutes	220 (160-245)
Aortic Cross-Clamp time, minutes	40 (30-60)
Extracorporeal Circulation time, minutes	82 (65-100)
1 bypasses graft, n (%)	70 (18)
2 bypass grafts, n (%)	203 (52.3)
3 bypass grafts, n (%)	104 (24.8)
4 bypass grafts, n (%)	11 (2.8)
LIMA graft, n (%)	144 (37.1)
SVG graft, n (%)	345 (88.9)
RIMA graft, n (%)	3 (0.8)
RA graft, n (%)	1 (0.3)

Data shown as mean ± SD or as median (IQR), or number (percentage). Abbreviations: LIMA: Left Internal Mammary Artery; SVG: Saphenous Vein Graft; RIMA: Right Internal Mammary Artery; RA: Radial Artery.

Discussion

Age is asignificantrisk factor for poor outcome after cardiac procedures and is included in all risk stratification scores. Similar high in-hospital mortality was observed in the study cohort (7% vs 3.4% for all isolated CABG at our institution). Furthermore, comorbidities in elderly patients aredescribed to be associated withnegative outcomes[3, 7]. In the presented study, the presence of multiple comorbidities significantly increased the risk of in-hospital mortality, reaching 26.7% for patients withall 4 out of overweight (BMI >25 kg/m^2), hypertension, hyperlipidemia, and diabetes.This mortality rate was higher than it was expected after assessing Euroscore II and STS score. Thus, thepresented results suggest that the current standard risk stratifications may not suffice for older patients as it is for the younger age groups.

Moreover, higher NYHA class was associated with increased in-hospital mortality and the aggravation of heart failure symptoms should be carefully evaluated while assessing the procedure risk for elderly patients. On the other hand, individuals with preserved left ventricular function, defined by the preoperative LVEF, had better survival rates.

The study cohort required emergent CABG more often than that ofyounger age groups. 31.2% of the cases were performed in the presence ofAcute Coronary Syndrome (ACS), compared to 18.9% observed for all age groups at our Institution. Emergency of the procedure is described in the literature as a significant risk factor for poor outcome after cardiac surgeries [8, 9]. However, emergent surgery was not associated with higher rates of in-hospital mortality in the study group. This maybe due to the fact that ACS in elderly patients may be less damaging, because of the collateralblood flow that had developedover time. Moreover, acute plaque ruptures and complex lesions, that are associated with worse outcome after ACS, are observed less frequently in older age groups [10, 11]. Therefore, in spite of the presence of critical stenosis in the coronary artery that requires emergent revascularization, the outcome of the procedure may not be influenced by the high surgery priority. To our best knowledge, the influence of performing an emergent CABG procedure on the in-hospital mortality has not been previously analyzed between different age groups. Results from the study cohort suggest that there is no need in delaying the procedure in patients' ≥80 yo.

Although theLIMA graft is a gold-standard option for LAD occlusions, it was used in less than half of the cases.However, implanting a LIMA graft was associated with lower in-hospital mortality. Similar observations are made by other researchers. LIMA use was found to be one of thehighest predictive factors for 30-day and 180-day survival in septuagenarians, and have been reported similarly for other age groups(OR 0.480 for 30-day and OR 0.529 for 180-day mortality) [12, 13]. When LIMA grafts were first introduced in 1985, the mortality rate for elderly patients stood at 9.3% and has fallen since then to 5.5%. Major surgical complications have been either reduced or unchanged in patients receiving LIMA grafts [14].However, LIMA grafts have not yet become the standard protocol for elderly patients in our study cohort presumably due to relative contraindications, which include left ventricular hypertrophy, severe left ventricular dysfunction, emergency operations, COPD with enlarged lungs, advanced age, and an obstructed left subclavian artery [13, 14].Another reason may be thatmore of the coronary angiograms are nowadays performed via radial access and this result in the difficulty of obtaining the LIMA angiogram. Some surgeons may then withdraw from harvesting LIMA.However, the benefits of LIMA graft implantations outweigh the contraindicationsand should have been performed in more cases. Lastly, early results from our Institution show that there is no difference in postoperative sternal dehiscence occurrence, when a single or both internal mammary arteries were harvested in the elderly, compared to venous grafts.

Duration of the procedure and ECC were determined to be significant risk factors for in-hospital mortality in the study cohort, with the increase for every 10 minutes.Similar results for surgical procedures, other than cardiac, have been previously described and a 30-minute increasein procedure duration resulted in 17% higher odds of mortality in patients older than 80 yo [15].As the risk increased significantly for every 10 minutes of the procedure and ECC, the range of the procedure and the number of necessary bypass grafts should be closely discussed with a Heart Team preoperatively. Moreover, prolonged ECC time may contribute to hemolysis, blood loss, and need for blood products transfusions, that were also associated with higher in-hospital mortality in the study cohort.Therefore the impact of these complications on the short-term outcome may be synergic. Similar results, concerning the influence of excessive blood loss have been previously described for general population of patients undergoing cardiac surgeries [16, 17]. Moreover, re-exploration for bleeding is commonly concerned as an independent risk factor for prolonged hospitalization and mortality in cardiac surgery and more deaths before discharge were also observed in patients, who required this procedure [18].

Furthermore, prolonged mechanical ventilation resulted in the increased mortality rate. This association is observed after cardiac procedures for all age groups, but the high OR value suggests relatively strong dependence in elderlypatients. The risk of postoperative respiratory insufficiency has been observed to increase with age and have been associated with worse outcome for all groups [19, 20]. It negatively influences postoperative pulmonary rehabilitation, and increase the risk of infection. The association is most likely higher in elderly patientsdue to the lower lung compliance.Normal aging of the pulmonary system decreases overall pulmonary reserve. As a result, older adults are more susceptible to respiratory compromise in the postoperative period and during monitored anesthesia care [21]. Moreover, in a systematic review prepared for the American College of Physicians, in patients aged ≥80 yoOR ofpostoperative pulmonary complications stood at 5.63 (95% CI 4.63-6.85) compared to patients <50 years old [22].

Lastly, in-hospital mortality observed in the study cohort was higher than that of thegeneralpopulation.Theresultsindicate that one of the factors contributing might result from rare implantation of LIMA graft, which provides better blood supply to the anterior heart wall, compared to venous grafts. Moreover, multiple comorbidities were associated with high risk of death before discharge. Although the risk score stratifications were high in the subgroup of 4 or more comorbidities, the actual mortality was higher than expected, with longer duration of the procedure and ECC contributing.Because of this high rate of mortality, elderly patients with multiple comorbidities should be considered as candidates for percutaneous or hybrid procedures and their cases should be closely discussed with the Heart Team.It is further significant to note that thebenefit of CABG in the elderly observed at 6 months did not persist at 12 months observation [23].Lastly, incase of a CABG procedure, LIMA grafts should be implanted, whenever possible.

A subset of patients with suitable anatomy may benefit from a minimally-invasive off-pump CABG or MIDCAB of LIMA to LADcombined with percutaneous coronary intervention to other significantly diseased vessels. This approach may be particularly beneficial in patients with contraindications for CPB (atherosclerotic aorta, chronic obstructive pulmonary disease, renal dysfunction). However, a large randomized control trial comparing hybrid revascularization and conventional CABG, with mid-term follow-up,is required to establish the clinical effectiveness [24].

The greatest study limitation is a retrospective design that does not allow drawing any definite conclusions concerning managing revascularization in patients' ≥80 yo. However, the univariate logistic regression analysis identified risk factors for in-hospital mortality in the study cohort. The stepwise analysis excluded most of the variables, but the predictive value of this model was low, presumably due to the high clinical association between tested variables.

Conclusions

Older age is associated with higher in-hospital mortality after isolated CABG. Elderly patients should be carefully discussed with the Heart Team to ensure the best treatment option. Risk stratification scores and individualized risk assessment, centered on comorbidities, NYHA class and left ventricular function, should be evaluated in all cases while qualifying patients for revascularization. Whenever suitable, LIMA graft should be used, as it is associated with better survival to hospital discharge and show good long-term graft patency. Hybrid procedures should be considered for patients' ≥80 yo, as prolonged procedure and ECC time worsen the short-term outcome. Elderly individuals should be closely monitored postoperatively. Patients with excessive blood loss that require massive blood products transfusions or rethoracotomy, and need for prolonged mechanical ventilation should be considered at higher risk for death before discharge.

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