

Coronary Arteries Bypass Grafting Surgery in Elderly Patients

Feridoun Sabzi, MD^{1*}, Hashem Kazerani, MD¹, Arash Jalali, PhD², Mojgan Samadi, MD¹, Fahime Ghasemi, MD¹

¹Imam Ali Hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran.

²Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran.

Received 16 February 2012; Accepted 07 August 2012

Abstract

Background: The incidence of coronary artery bypass grafting surgery (CABG) in elderly patients has been increasing. There are contradictory reports on the early outcome of elderly coronary artery patients as compared with their young counterparts. We designed this retrospective study to address this issue.

Methods: We retrospectively analyzed the results of 1489 on-pump CABG cases performed at our hospital during a 4.5-year period. Perioperative data such as demographic, medical, clinical, operative, and postoperative variables were collected and compared between patients 70 years old or younger (Group A, n = 1164) and patients above 70 years of age (Group B, n = 325). Statistical analysis was performed using the t-test for the continuous and the X² tests for the categorical variables. Significant variables according to the univariate analysis (X² and t-test) were further analyzed using multivariate logistic regression analysis.

Results: The variables of weight (P value < 0.001), preoperative PO₂ (P value = 0.005), ejection fraction > 30% (P value = 0.001), body surface area (P value = 0.003), and hypercholesterolemia (P value = 0.007) were higher in Group A, whereas preoperative myocardial infarction (P value < 0.001), postoperative low cardiac output syndrome (P value = 0.019), emergent surgery (P value = 0.003), inotropic drug use (P value < 0.001), preoperative heparin use (P value < 0.001), re-exploration for bleeding (P value = 0.015), hospital stay (P value < 0.001), low ejection fraction (≤ 30%) (P value = 0.001), preoperative creatinine > 1.5 mg/dl (P value < 0.001), chronic obstructive pulmonary disease (P value < 0.001), intra-aortic balloon pump use (P value < 0.001), infection (P value < 0.001), pulmonary complications (P value < 0.001), atrial fibrillation (P value < 0.001), postoperative renal complications (P value < 0.001), and death (P value = 0.012) were more frequent in Group B.

Conclusion: CABG in the elderly patients had certain surgical risks such as chronic obstructive pulmonary disease, preoperative myocardial infarction, emergent surgery, and death. Also, postoperative complications such as pulmonary complications, inotropic drug use, intra-aortic balloon pump use, and infection were more frequent in the elderly than in the younger patients.

J Teh Univ Heart Ctr 2013;8(2):76-88

This paper should be cited as: Sabzi F, Kazerani H, Jalali A, Samadi M, Ghasemi F. Coronary arteries bypass grafting in elderly patients. J Teh Univ Heart Ctr 2013;8(2):76-88.

Keywords: Coronary artery bypass • Aged • Treatment outcome

*Corresponding Author: Feridoun Sabzi, Associate Professor of Cardiac Surgery, Kermanshah University of Medical Sciences, Imam Ali Hospital, Shaheed Beheshti Ave., Kermanshah, Iran. Tel: +98 918 1311896. Fax: +98 831 8360043. E-mail: dr_Sabzi@yahoo.com.



Introduction

The development of the health care system has led to a continuous growth in the elderly population in Iran, which has been allied with a rise in the number of candidates for coronary artery bypass grafting surgery (CABG). Our data indicate a gradual rise in the mean age of patients undergoing CABG in the Iranian province of Kermanshah. The first article on the usefulness of CABG in elderly patients was published by MacDonald.¹ In that study, the CABG outcome in the elderly was placed in doubt by this question: "Is the decision to perform CABG in elderly patients supported by evidence or by faith?" This was a vitally important quandary inasmuch as many clinical studies- up to that point- had excluded octogenarian patients in the comparison between CABG outcome and that of medical therapy in the treatment of coronary artery disease (CAD). Flather, Gersh, Sen, and their colleagues²⁻⁴ in separate studies reported higher perioperative morbidity and mortality rates in elderly patients. Cohn et al.⁵ demonstrated that short-term treatment costs were higher for elderly patients than for their younger counterparts. Smith et al.⁶ evaluated the outcome of CABG in octogenarian patients and reported that the early outcome was similar between the elderly patients (> 70 years) and young patients. Nevertheless, because of the small number of the elderly patients (61 patients), the authors could not make a strong conclusion because a single individual death in the elderly population would have increased the death rate to 5.6%.

The comparison of CABG outcomes between elderly and young CAD patients is encouraging. Solano et al.⁷ evaluated this issue and reported that the rate of survival to 3 years was significantly higher in their elderly group. It is also noteworthy that several studies have shown substantial improvement in functional capacity and quality of life after CABG.⁸ Still, for all these promising observations, elderly patients continue to have poorer outcomes than younger patients.⁹ Risk factors that have an effect on CABG mortality in younger patients may affect mortality in elderly patients in a different manner. Further improvements in surgical results in this high-risk age group necessitate the investigation and identification of the risk factors affecting postoperative mortality and morbidity in addition to survival analysis.^{10, 11} In this study, we retrospectively analyzed short-term and early outcomes in patients who underwent CABG at our hospital, with a special focus on patients at a minimum age of 70 years.

Methods

During a 4.5-year period, 1489 patients underwent CABG at our center. Records of 1469 consecutive patients were retrospectively reviewed after excluding 20 patients, who

were lost due to missing records. The selection of elderly candidates for cardiac surgery at our hospital is at the discretion of the individual referring physician, cardiologist, and surgeon. Routine assessment of the cardiac function via history angiography and echocardiography is supplemented by objective measurements of comorbidities, including the pulmonary function test and carotid duplex for all patients over 70 years of age and for patients with symptoms of bruits of transient ischemic attack and cerebrovascular accident. Patients with forced expiratory volume (FEV1) less than 1100 ml after medical therapy by the internist for chronic obstructive pulmonary disease (COPD) are usually referred for off-pump CABG. The patients were divided into two groups of A and B. Group A was comprised of patients 70 years old or younger and Group B consisted of patients older than 70 years. The following variables were collected: gender, age, weight, body surface area, ejection fraction, preoperative arterial air pressure of oxygen (PO₂), preoperative air pressure of carbon dioxide (PCO₂), hypercholesterolemia, acetyl salicylic acid (ASA) use, preoperative myocardial infarction, COPD, infection, diabetes, preoperative heparin use, emergent surgery, clamp and pump time, left internal mammary artery use, number of grafts, death, re-intubation, postoperative bleeding, re-exploration for postoperative bleeding, atrial fibrillation, postoperative inotropic drug use, intra-aortic balloon pump (IABP) use, opium use, peripheral vascular disease, left main CAD, hospital length of stay, postoperative renal complications, postoperative stroke or pulmonary complications, hematocrit, creatinine higher than 1.5 mg/dl, transfusion volume, postoperative low cardiac output syndrome, and postoperative myocardial infarction.

Renal failure was defined as creatinine greater than 1.5 mg/dl; myocardial infarction was defined as a new Q wave or creatine phosphokinase myocardial band (CPK MB) or troponin rise; infection was defined as purulent discharge or culture positive or inflammation for which the surgeon ordered antibiotics; COPD was defined as positive spirometry or a 3-month history of bronchodilator use; hypercholesterolemia was defined as a blood cholesterol level above 250 mg/dl; and the patient was considered diabetic if receiving a diabetic drug or insulin to control the blood glucose level. Additionally, hypertension was defined as either a systolic arterial pressure greater than 140 mmHg or a diastolic pressure greater than 90 mmHg or use of at least one antihypertensive medication. The term "early hospital mortality" was used to refer to deaths that occurred within 30 days postoperatively. The patients were grouped according to the timing of their surgical operations as elective or emergent operations. The elective patients underwent surgery in stable condition, and the emergent patients underwent surgery within 48 hours of angiography due to conditions such as unstable angina and left main CAD. Interventional complications such as tamponade and respiratory failure were defined as mechanical ventilatory

support beyond 3 days or the occurrence of adult respiratory distress syndrome or the need for tracheostomy. The term “neurological complication” was used to refer to a new transient ischemic attack or stroke persisting for more than 24 hours. The patients who had left ventricular aneurysm, post-myocardial infarction ventricular septal defect, moderate to severe mitral insufficiency, or associated heart valve disease were excluded from the study.

After the induction and maintenance of anesthesia with Fentanyl and Propofol, a radial artery line was inserted to monitor the systemic blood pressure. Following median sternotomy, cardiopulmonary bypass was established via routine aortic and venous cannulation and the roller pump. During cardiopulmonary bypass, oxygenation was achieved using the Dideco Oxygenator, which was primed with one liter of ringer lactate. One homo filter was used in the arterial way. Antegrade and retrograde cardioplegia were administered in all the patients after aortic cross-clamping. High potassium cardioplegia was infused into the aortic root at 15 ml/kg or until diastolic arrest was achieved. Retrograde cardioplegia was infused via the coronary sinus at 5 ml/kg, and diastolic arrest was maintained by the infusion of intermittent cold cardioplegic at 20-minute intervals. Topical hypothermia with a crystalloid ice slush solution was applied in all the patients. The body temperature was

maintained between 30 and 32 °C during cardiopulmonary bypass. Complete revascularization was attempted via the left internal mammary artery and the saphenous vein in all the patients.

For the statistical analyses, the statistical software SPSS version 11.5 for Windows (SPSS Inc., Chicago, IL) was employed. The perioperative variables were compared between Group A and Group B with respect to the categorical or continuous variables using the chi square or the t-test, respectively. In addition, mortality and morbidity were analyzed using multivariable stepwise logistic regression analysis or linear regression, and the odds ratio of the significant variables was obtained. A p value less than 0.05 was considered statistically significant.

Results

Group A consisted of 1164 patients, including 603 men and 562 women at a mean age of 55 ± 8 years, and group B was comprised of 325 patients, including 172 men and 152 women at a mean age of 73 ± 3 years. The preoperative variables are described in Table 1. Variables such as sex, hypertriglyceridemia, total number of diseased vessels, ASA use, re-intubation, preoperative PCO₂, diabetes, cigarette

Table 1. Preoperative variables in the two study groups

| | Group A (≤ 70 y) (n=1164) | Group B (> 70 y) (n=325) | P value |
|---------------------------------------|------------------------------|-----------------------------|---------|
| Age (y) | 55.3±8.2 | 74.8±3.8 | < 0.001 |
| Male gender | 61.2 (712) | 60.3 (196) | 0.779 |
| Left main coronary artery disease | 10.6 (123) | 15.1 (49) | 0.025 |
| Ejection fraction ≤ 30% | 7.6 (88) | 17.3 (56) | < 0.001 |
| ASA use | 92.4 (1076) | 91.1 (296) | 0.419 |
| Preoperative myocardial infarction | 5.5 (64) | 12.6 (41) | < 0.001 |
| Smoking | 13.3 (155) | 15.4 (50) | 0.339 |
| Emergent surgery | 9.4 (109) | 15.1 (49) | 0.003 |
| Preoperative heparin use | 4.3 (50) | 14.5 (47) | < 0.001 |
| Preoperative PO ₂ (mmHg) | 100.7±20.3 | 97.4±20.0 | 0.005 |
| Diabetes | 21.8 (254) | 18.2 (59) | 0.151 |
| Hypercholesterolemia | 30.4 (354) | 22.8 (74) | 0.007 |
| Hypertriglyceridemia | 27.7 (322) | 26.2 (85) | 0.589 |
| Opium use | 15.1 (176) | 15.4 (50) | 0.907 |
| Preoperative PCO ₂ (mmHg) | 31.7±5.8 | 31.5±5.0 | 0.633 |
| Peripheral vascular disease | 0.6 (7) | 1.2 (4) | 0.241 |
| Preoperative creatinine > 1.5 mg/dl | 3.0 (35) | 7.7 (25) | < 0.001 |
| Chronic obstructive pulmonary disease | 4.3 (50) | 13.5 (44) | < 0.001 |
| Weight (kg) | 72.4±11.9 | 69.7±9.3 | < 0.001 |
| Body surface area (m ²) | 1.8±0.2 | 1.7±0.2 | 0.003 |
| Hematocrit (%) | 43.1±6.3 | 43.9±5.4 | 0.165 |

*Data are presented as mean±SD or % (n)

ASA, Acetyl salicylic acid; PO₂, Arterial pressure of oxygen; PCO₂, Arterial pressure of carbon dioxide



smoking, opium use, left internal mammary artery use, clamp time, pump time, hematocrit, and peripheral vascular disease were almost the same in both groups. However, age, weight, ejection fraction, preoperative heparin use, hypercholesterolemia, postoperative stroke or pulmonary complications, postoperative renal complications, postoperative inotropic drug use, postoperative low cardiac output syndrome, emergent surgery, postoperative myocardial infarction, body surface area, preoperative creatinine level more than 1.5 mg/dl, weight, IABP use, hospital stay, re-exploration for bleeding, death, and COPD were different between the two groups. Group B had a higher frequency of postoperative low cardiac output syndrome, COPD, preoperative heparin use, emergent surgery, postoperative myocardial infarction, stroke, infection, and preoperative creatinine higher than 1.5 mg/dl, while Group A had higher hypercholesterolemia, body surface area, ejection fraction greater than 30%, preoperative PaO₂, and weight (Tables 1 and 3) The predicting factors for postoperative stroke in the logistic regression analysis in the total study population were

COPD, opium use, postoperative myocardial infarction, and peripheral vascular disease, whereas in the elderly patients, the significant variables were clamp time and hematocrit (Table 2). The intra- and postoperative courses are also displayed in Table 3. Group B required longer hospital stays. The overall in-hospital mortality rates were 1.9% and 4.3% in Group A and Group B, respectively (P value < 0.012). Major complications such as stroke, postoperative low cardiac output syndrome, inotropic drug use, atrial fibrillation, death, IABP use, postoperative pulmonary complications, and infection were more frequent in Group B (P value < 0.05). The overall mean length of hospital stay was 14.7 ± 5.7 days. The factors that could predict the hospital length of stay according to the linear regression analysis were inotropic drug use, cerebrovascular accident, age, female gender, and infection in the total study population; in the elderly subjects, however, these factors were peripheral vascular disease, weight, emergent surgery, and clamp time (Table 4). The IABP was inserted in 11.7% of the elderly patients. The predicting factors for the IABP insertion were infection,

Table 2. Factors predicting postoperative stroke in the elderly by logistic regression analysis

| | Univariate | | | Multivariable | | |
|---------------------------------------|------------|--------------|---------|---------------|-------------|---------|
| | OR | 95% CI | P value | OR | 95% CI | P value |
| Age (y) | 1.04 | 0.91 - 1.19 | 0.583 | | | |
| Male gender | 0.76 | 0.25 - 2.31 | 0.628 | | | |
| Left main coronary artery disease | 0.46 | 0.06 - 3.61 | 0.459 | | | |
| Ejection fraction ≤ 30% | 0.87 | 0.19 - 4.03 | 0.857 | | | |
| ASA use | 1.18 | 0.15 - 9.44 | 0.874 | | | |
| Preoperative myocardial infarction | 0.24 | 0.01 - 4.15 | 0.885 | | | |
| Smoking | 0.45 | 0.06 - 3.52 | 0.445 | | | |
| Emergent surgery | 1.03 | 0.22 - 4.77 | 0.975 | | | |
| Preoperative heparin use | 0.48 | 0.06 - 3.80 | 0.488 | | | |
| Preoperative PO ₂ (mmHg) | 0.99 | 0.96 - 1.02 | 0.584 | | | |
| Diabetes | 2.08 | 0.62 - 6.99 | 0.238 | | | |
| Hypercholesterolemia | 1.02 | 0.27 - 3.80 | 0.978 | | | |
| Hypertriglyceridemia | 0.84 | 0.23 - 3.13 | 0.797 | | | |
| Opium use | 0.19 | 0.01 - 3.29 | 0.656 | | | |
| Preoperative PCO ₂ (mmHg) | 1.04 | 0.93 - 1.17 | 0.490 | | | |
| Peripheral vascular disease | 2.54 | 0.13 - 49.59 | 0.395 | | | |
| Preoperative creatinine > 1.5 mg/dl | 0.42 | 0.02 - 7.23 | 0.998 | | | |
| Chronic obstructive pulmonary disease | 1.17 | 0.25 - 5.46 | 0.843 | | | |
| Weight (kg) | 0.99 | 0.94 - 1.06 | 0.962 | | | |
| Body surface area (m ²) | 0.23 | 0.01 - 6.31 | 0.387 | | | |
| Hematocrit | 0.93 | 0.87 - 0.99 | 0.044 | 0.93 | 0.87 - 0.99 | 0.043 |
| Clamp time (min) | 0.93 | 0.89 - 0.98 | 0.005 | 0.93 | 0.89 - 0.98 | 0.005 |
| Pump time (min) | 0.970 | 0.95 - 0.99 | 0.011 | | | |

OR, Odds ratio; CI, Confidence interval; ASA, Acetyl salicylic acid; PO₂, Arterial pressure of oxygen; PCO₂, Arterial pressure of carbon dioxide

Table 3. Intraoperative and postoperative variables in the study groups*

| | Group A (≤ 70 y) (n=1164) | Group B (> 70 y) (B=325) | P value |
|---|------------------------------------|--------------------------------|---------|
| Left internal mammary artery use | 97.9 (1139) | 97.8 (318) | 0.995 |
| Length of hospital stay (d) | 12.6 \pm 3.3 | 17.0 \pm 4.8 | < 0.001 |
| Pump time (min) | 87.3 \pm 28.2 | 85.2 \pm 27.5 | 0.319 |
| Clamp time (min) | 47.1 \pm 17.7 | 46.8 \pm 17.2 | 0.949 |
| Postoperative exploration for bleeding | 9.7 (113) | 14.5 (47) | 0.015 |
| Intra-aortic balloon pump | 3.0 (35) | 11.7 (38) | < 0.001 |
| Postoperative renal complications | 3.9 (45) | 14.2 (46) | < 0.001 |
| Postoperative pulmonary complications | 2.1 (24) | 12.9 (42) | < 0.001 |
| In-hospital death | 1.9 (22) | 4.3 (14) | 0.012 |
| Atrial fibrillation | 5.5 (64) | 13.5 (44) | < 0.001 |
| Postoperative stroke | 1.4 (16) | 4.0 (13) | 0.002 |
| Inotropic drug use | 6.2 (72) | 15.7 (51) | < 0.001 |
| Infection | 4.1 (48) | 8.6 (28) | 0.001 |
| Postoperative low cardiac output syndrome | 8.3 (97) | 12.6 (41) | 0.019 |

*Data are presented as mean \pm SD or % (n)

Table 4. Factors predicting long hospital stay by linear regression method in the elderly patients

| | Univariate | | Multivariable | | |
|---------------------------------------|------------|---------|---------------|-----------------|---------|
| | r | P value | coefficient | 95% CI | P value |
| Age (y) | 0.031 | 0.593 | | | |
| Gender (female/male) | 0.121 | 0.029 | | | |
| Left main coronary artery disease | 0.056 | 0.311 | | | |
| Ejection fraction $\leq 30\%$ | 0.092 | 0.106 | | | |
| ASA use | 0.052 | 0.351 | | | |
| Preoperative myocardial infarction | 0.031 | 0.582 | | | |
| Smoking | 0.003 | 0.961 | | | |
| Emergent surgery | 0.164 | 0.003 | 2.045 | 0.651 - 3.441 | 0.004 |
| Preoperative heparin use | 0.111 | 0.045 | | | |
| Preoperative PO ₂ (mmHg) | -0.084 | 0.131 | | | |
| Diabetes | -0.021 | 0.714 | | | |
| Hypercholesterolemia | -0.032 | 0.569 | | | |
| Hypertriglyceridemia | -0.035 | 0.532 | | | |
| Opium use | -0.072 | 0.194 | | | |
| Preoperative PCO ₂ (mmHg) | 0.007 | 0.904 | | | |
| Peripheral vascular disease | 0.111 | 0.047 | 5.576 | 1.067 - 10.084 | 0.016 |
| Preoperative creatinine > 1.5 (mg/dl) | 0.051 | 0.359 | | | |
| Chronic obstructive pulmonary disease | 0.098 | 0.078 | | | |
| Weight (kg) | -0.144 | 0.009 | -0.061 | -0.115 - -0.007 | 0.026 |
| Body surface area (m ²) | 0.001 | 0.986 | | | |
| Hematocrit (%) | -0.059 | 0.293 | | | |
| Aortic clamp time (min) | 0.222 | < 0.001 | 0.061 | 0.032 - 0.091 | < 0.001 |
| Pump time (min) | 0.187 | 0.001 | | | |

ASA, Acetyl salicylic acid; PO₂, Arterial pressure of oxygen; PCO₂, Arterial pressure of carbon dioxide

respiratory complications, and inotropic drug use in the total study population and opium use (OR = 2.24), ASA use (OR = 0.22), preoperative PO₂ (OR = 0.96), COPD (OR = 0.27),

and weight (OR = 0.94) in the elderly subjects (Table 5). Renal failure occurred in 7.7% of the elderly patients, and the predicting factors for renal failure in the logistic regression



analysis were postoperative atrial fibrillation (OR = 11.4), re-intubation (OR = 2.5), death (OR = 10), IABP use (OR = 2.7), left main CAD (OR = 0.5), sex (OR = 0.2), and ejection fraction (OR = 0.9) in the total study population; nonetheless, in the elderly patients, these factors were reduced to four: preoperative myocardial infarction (OR = 4.1); left main CAD (OR = 8.8); death (OR = 5.4); and atrial fibrillation (OR = 7.4). The variables that influenced in-hospital death in the entire study population according to the logistic analysis comprised postoperative creatinine more than 1.5 mg/dl, COPD, type of surgery, cerebrovascular accident, infection, ejection fraction greater than 30%, atrial fibrillation, and gender; in the elderly subjects, however, emergent surgery (OR = 3.55), preoperative PO₂ (OR = 0.96), and preoperative PCO₂ (OR = 0.85) influenced in-hospital death (Table 6). There was a significant difference in operative mortality between the men and women, with the mortality rates in the male and female groups being 2% and 4.8%, respectively. The factors that correlated with gender according to the logistic regression analysis were comprised of weight, body surface area, diabetes, preoperative PO₂, preoperative

hematocrit, infection, re-exploration for bleeding, ejection fraction, and hypercholesterolemia in the total population and postoperative low cardiac output syndrome, hypercholesterolemia, weight, preoperative creatinine smaller than 1.5, and body surface area in the elderly subjects. Also, 7.7% of the patients who had emergency surgery expired; the mortality rate in the elective group was 2.1%. In the univariate analysis, emergency surgery correlated with weight, preoperative PCO₂, preoperative PO₂, preoperative myocardial infarction, COPD, preoperative creatinine more than 1.5 mg/dl, ejection fraction, preoperative hematocrit, left main CAD, preoperative heparin use, aortic clamp time, pump time, and hospital length of stay. In the logistic regression analysis, emergent surgery correlated with only preoperative myocardial infarction, left main CAD, preoperative creatinine more than 1.5 mg/dl, preoperative hematocrit, hospital length of stay, and pump time in the entire study population, whereas in the elderly patients, emergent surgery correlated only with preoperative myocardial infarction, left main CAD, death, and hospital length of stay. Atrial fibrillation occurred in 13% of the

Table 5. Factors predicting postoperative IABP use in the elderly patients by logistic regression analysis

| variables | Univariate | | | Multivariable | | |
|---------------------------------------|------------|--------------|---------|---------------|-------------|---------|
| | OR | 95% CI | P value | OR | 95% CI | P value |
| Age (y) | 0.99 | 0.91 - 1.09 | 0.960 | | | |
| Male gender | 0.49 | 0.25 - 0.97 | 0.040 | | | |
| Left main coronary artery disease | 1.06 | 0.42 - 2.70 | 0.896 | | | |
| Ejection fraction ≤ 30% | 2.19 | 1.02 - 4.73 | 0.046 | | | |
| ASA use | 0.37 | 0.15 - 0.93 | 0.035 | 0.22 | 0.08 - 0.61 | 0.004 |
| Preoperative myocardial infarction | 0.80 | 0.27 - 2.37 | 0.680 | | | |
| Smoking | 0.28 | 0.06 - 1.19 | 0.084 | | | |
| Emergent surgery | 1.32 | 0.55 - 3.19 | 0.541 | | | |
| Preoperative heparin use | 0.30 | 0.07 - 1.29 | 0.105 | 0.26 | 0.06 - 1.18 | 0.001 |
| Preoperative PO ₂ (mmHg) | 0.97 | 0.95 - 0.99 | 0.003 | 0.96 | 0.94 - 0.99 | 0.001 |
| Diabetes | 0.50 | 0.17 - 1.46 | 0.202 | | | |
| Hypercholesterolemia | 2.21 | 1.08 - 4.53 | 0.031 | | | |
| Hypertriglyceridemia | 1.55 | 0.76 - 3.19 | 0.232 | | | |
| Opium use | 2.21 | 1.00 - 4.89 | 0.051 | 2.24 | 0.94 - 5.30 | 0.008 |
| Preoperative PCO ₂ (mmHg) | 1.04 | 0.97 - 1.12 | 0.238 | | | |
| Peripheral vascular disease | 2.56 | 0.26 - 25.24 | 0.421 | | | |
| Preoperative creatinine > 1.5 (mg/dl) | 1.03 | 0.29 - 3.63 | 0.960 | | | |
| Chronic obstructive pulmonary disease | 0.32 | 0.08 - 1.40 | 0.131 | 0.27 | 0.06 - 1.26 | 0.005 |
| Weight (kg) | 0.96 | 0.92 - 0.99 | 0.040 | 0.94 | 0.90 - 0.98 | 0.005 |
| Body surface area (m ²) | 0.69 | 0.09 - 5.31 | 0.717 | | | |
| Hematocrit (%) | 0.97 | 0.92 - 1.03 | 0.356 | | | |
| Aortic clamp time (min) | 1.01 | 0.99 - 1.03 | 0.599 | | | |
| Pump time (min) | 1.01 | 0.99 - 1.02 | 0.311 | | | |

CI, Confidence interval; ASA, Acetyl salicylic acid; PO₂, Arterial pressure of oxygen; PCO₂, Arterial pressure of carbon dioxide

Table 6. Factors predicting in-hospital death in the elderly patients by logistic regression analysis

| variables | Univariate | | | Multivariable | | |
|---------------------------------------|------------|--------------|---------|---------------|--------------|---------|
| | OR | 95% CI | P value | OR | 95% CI | P value |
| Age (y) | 0.99 | 0.85 - 1.14 | 0.859 | | | |
| Male gender | 0.35 | 0.11 - 1.07 | 0.065 | | | |
| Left main coronary artery disease | 0.42 | 0.05 - 3.30 | 0.410 | | | |
| Ejection fraction \leq 30% | 2.83 | 0.91 - 8.80 | 0.072 | | | |
| ASA use | 1.29 | 0.16 - 10.20 | 0.812 | | | |
| Preoperative myocardial infarction | 1.16 | 0.25 - 5.39 | 0.848 | | | |
| Smoking | 0.41 | 0.05 - 3.22 | 0.397 | | | |
| Emergent surgery | 4.67 | 1.55 - 14.13 | 0.006 | 3.55 | 0.97 - 13.02 | 0.055 |
| Preoperative heparin use | 0.44 | 0.06 - 3.47 | 0.438 | | | |
| Preoperative PO ₂ (mmHg) | 0.95 | 0.92 - 0.98 | 0.002 | 0.96 | 0.93 - 0.99 | 0.021 |
| Diabetes | 0.15 | 0.01 - 2.49 | 0.404 | | | |
| Hypercholesterolemia | 1.95 | 0.63 - 6.00 | 0.245 | | | |
| Hypertriglyceridemia | 0.46 | 0.10 - 2.09 | 0.313 | | | |
| Opium use | 0.41 | 0.05 - 3.22 | 0.397 | | | |
| Preoperative PCO ₂ (mmHg) | 0.81 | 0.74 - 0.90 | < 0.001 | 0.85 | 0.78 - 0.94 | 0.001 |
| Peripheral vascular disease | 2.36 | 0.12 - 45.87 | 0.421 | | | |
| Preoperative creatinine > 1.5 (mg/dl) | 2.09 | 0.44 - 9.89 | 0.354 | | | |
| Chronic obstructive pulmonary disease | 1.07 | 0.23 - 4.94 | 0.933 | | | |
| Weight (kg) | 0.97 | 0.91 - 1.03 | 0.259 | | | |
| Body surface area (m ²) | 0.13 | 0.01 - 2.97 | 0.199 | | | |
| Hematocrit (%) | 0.98 | 0.90 - 1.08 | 0.712 | | | |
| Clamp time (min) | 1.02 | 0.99 - 1.05 | 0.123 | | | |
| Pump time (min) | 1.01 | 0.99 - 1.03 | 0.323 | | | |

ASA, Acetyl salicylic acid; PO₂, Arterial pressure of oxygen; PCO₂, Arterial pressure of carbon dioxide

elderly patients, and the predicting factors for the occurrence of atrial fibrillation in the logistic regression analysis were diabetes, re-exploration for bleeding, infection, and re-intubation.

Discussion

Atherosclerosis in the elderly is a common phenomenon. CAD, hypertension, renal artery stenosis, stroke, and peripheral vascular disease are all related to atherosclerotic vascular changes and are more prevalent in elderly patients.¹²⁻¹⁴ Limited application of catheter intervention for patients with severe CAD could be related to the increased number of emergency surgical operations in the elderly; and in this study, we observed this difference between urgent and elective patients. There were significant differences with respect to inotropic drug use, stroke, death, and left main CAD between our elective and emergent patients. Since the

global cardiac function is decreased in the elderly, a history of congestive heart failure is more frequently observed in elderly patients.¹⁵ The increased frequency of female patients among the elderly receiving CABG has been noted in previous reports.¹⁶ In the present study, gender indeed had a significant effect on the rate of CABG. Not only the longer life expectancy of women but also exacerbation and acceleration of atherosclerosis and increased body mass index after menopause, which are concomitant with lifestyle changes, lead to an increased percentage of the women who undergo CABG in higher age groups. Our study revealed that there were significant differences as regards age, body surface area, preoperative hematocrit, weight, preoperative PO₂, preoperative PCO₂, hypercholesterolemia, transfusion volume, IABP use, opium use, postoperative myocardial infarction, postoperative low cardiac output syndrome, postoperative renal complications, clamp time and pump time, and number of grafts between the elderly men and women. Our elderly male patients had a higher frequency of opium



addiction and re-exploration for postoperative bleeding than our elderly females, who had more preoperative creatinine greater than 1.5 mg, lower body surface area, lower weight, lower preoperative PO₂, higher preoperative PCO₂, higher hypercholesterolemia, higher prevalence of IABP insertion, lower opium use, lower ejection fraction, lower preoperative hematocrit, lower number of grafts, lower pump time, lower clamp time, higher mortality, and higher postoperative low cardiac output syndrome. It is worthy of note that the prevalence of COPD in the elderly female patients was higher than that of the elderly male patients (17.1 vs. 11.2%); however, the difference was not statistically significant.

CAD in women is known to have a poorer prognosis than in men.^{17,18} In our logistic regression analysis, gender did not correlate directly with mortality but it did influence mortality indirectly by age, body surface area, ejection fraction, and preoperative hematocrit. In this analysis, the elderly females were older and had lower body surface area, EF, and preoperative hematocrit than the elderly males. Curtis et al.¹⁹ found that female gender was indicated as a risk factor for in-hospital mortality in the elderly. This variable did not reach statistical significance according to the logistic regression in our study; there were significant differences in operative mortality in the univariate analysis between the men and women (3.1% vs. 10.1%, respectively) and the factors that correlated with gender according to the logistic regression analysis included body surface area, postoperative low cardiac output syndrome, hypercholesterolemia, weight, preoperative creatinine more than 1.5 mg/dl, and preoperative hematocrit. It has been previously demonstrated that female gender appears to be a risk factor for in-hospital mortality due to diabetes, older age, emergent surgery, complications of percutaneous coronary intervention, low ejection fraction, calcified CAD, COPD, and small coronary artery diameter.²⁰⁻²³ One of the important issues that has not been reported in previous studies but was observed in our study population is the existence of different mechanisms and patterns of COPD and interstitial lung disease. In the Iranian province of Kermanshah, females in rural regions tend to use biomass and wood fuel for cooking and heating in the home; repeated smoke inhalation causes non-smoking COPD and interstitial lung disease. On the other hand, the high incidence of COPD in elderly male patients has different mechanisms. The elderly males appeared to have more COPD in consequence of cigarette smoking and opium use, both of which appeared to be independent predictors of mortality. The incidence of opium use in our patients was approximately 19.3% and 9.4% of the CABG male and female patients, respectively. There are two conventional routes for opium inhalation in Iran. In the more common method, the opium user utilizes a device named "Vafour", which filters the smoke from the melting "Taryak" (opium) in the head of the device. Some of the inhalational smoke is deposited along the lengthy internal wall of the Vafour and converts into a concentrate

which has the high value of pure opium and is called "Shyreh". This opium concentrate can be consumed orally. In the second method, addicts use a simple device named the "Sikh and Sang", which has two simple components, i.e. a thermal source and a thin metal rod, in contrast to the Vafour, the smoke leaving this device enters directly into the respiratory tract and causes a destructive effect. The most important extracts of opium are morphine and codeine, but other alkaloids and inert substances such as chocolate and animal blood are in the list of opium constituents that have been consumed by patients. The resulting smoke of these inert substances can wreak havoc on the respiratory tract and beget asthma, bronchitis, and COPD. In regard to the effect of opium smoke on the respiratory tract, there is always a confounding factor: concomitant cigarette smoking, which is a known risk factor for COPD. It is worthy of note that the incidence of isolated opium addiction is low and the number of opium addicts who are also cigarette smokers is high. A low ejection fraction has not been reported to be a risk factor for mortality in univariate analysis in the elderly.²⁴⁻²⁶ Our univariate analysis revealed operative mortality rates of 12.5% and 4.5% in the patients with left ventricular dysfunction (left ventricular ejection fraction \leq 30% and $>$ 30%), respectively (P value = 0.02); this result was similar to the KO et al. study.²⁷ Factors that predict in-hospital death in our elderly patients by the logistic regression analysis comprised preoperative PO₂, preoperative PCO₂, and emergent surgery (Table 6). However, in similar previous studies, the in-hospital mortality rates in the elderly were between 2.3% and 16.2%.¹⁹ Sahar et al.²⁸ found mortality rates of 12% and 4% in patients older than 70 and younger than 70 years, respectively. In the Curtis study,¹⁹ elderly patients were further sub-grouped into various age groups, and a 14.7% mortality rate was reported in the patients older than 80 years and a 4.2% mortality rate in those 70 years or less. Between the pre-, intra-, and postoperative variables, the preoperative factors and condition of patients are reported to be the most significant predictors of mortality.¹⁹⁻²¹ Type of surgical operation has been shown to be a predictor of increased mortality in some studies.^{25,26} We divided our patients with respect to the type of surgical operation into elective and emergent operations. Our experience also indicates that there are higher mortality risks in emergent operations than in elective ones (12.2% vs. 2.9%). In our univariate analysis, emergent surgery was also correlated with preoperative myocardial infarction, left main CAD, hypertriglyceridemia, body surface area, transfusion volume, length of hospital stay, infection, smoking, preoperative creatinine more than 1.5 mg/dl, and death, while our logistic regression analysis revealed emergent surgery as a dependent variable correlating with only left main CAD, length of hospital stay, preoperative myocardial infarction, and death. Female gender did not constitute statistical significance as a predictor of the type of surgical operation. Curtis et al.¹⁹ reported that female gender

was a risk factor for in-hospital mortality in the elderly; this variable reached statistical significance in our study. There was a significant difference in terms of operative mortality in our study between the elderly men and women: the latter appeared to have more risk factors for in-hospital mortality due to a higher prevalence of postoperative bleeding, higher prevalence of postoperative low cardiac output syndrome, smaller body surface area, lower weight, lower number of grafts, lower preoperative hematocrit, higher postoperative blood transfusion, higher frequency of IABP insertion, lower ejection fraction, lower preoperative PO₂, and lower preoperative PCO₂, whereas the former group was more frequently cigarette smokers (18.4%) and opium users (18.8%) (Only 8.5% and 10.2% of the elderly women were opium users and cigarette smokers, respectively). The prevalence of COPD in the elderly women was higher than that in the men (16.1% vs. 14.1%); the difference, however, was not statistically significant. We think that this controversial finding could be related to undiagnosed non-smoking COPD amongst our elderly female patients. This phenomenon is concerned with a history of exposure to non-cigarette smoke such as biomass, wood, animal dung, and bakery. The majority of our patients denied having been exposed to cigarette smoke, yet they had been exposed to biomass and wood smoke for decades. A meticulous history taking can demonstrate such conflicting findings. If internists fail to consider this issue (low score of the spirometry profile in non-smoking COPD patients), they may consider it as lack of cooperation on the part of patients or malfunction of the spirometry device.

In the current study, the prevalence of COPD in the patients 70 years old or younger was different from that of the elderly patients, amongst whom 5.5% of the men versus 2.4% of the women had COPD. In multiple studies presented by Mohan, Tsai, and Salomon,²⁴⁻²⁷ a low ejection fraction was a risk for mortality in the elderly according to univariate analysis. We found operative mortality rates of 4.5% versus 12.5% in the patients with a left ventricular ejection fraction > 30% and ≤ 30%, respectively; nevertheless, this variable was not an independent predictor of mortality in the logistic analysis.²⁸ This result was in concordance with that of the KO et al study, in which the mortality rates of the patients with an ejection fraction > 30% and ≤ 30% were 2.4% and 4.4%, respectively.²⁹ Islamoglu et al.³⁰ showed that old age was a predictor of mortality in patients with a low ejection fraction. Cane et al.³¹ found that alongside high mortality rates in comparison to younger patients, CABG in elderly patients is associated with more complications such as postoperative low cardiac output syndrome, arrhythmia, prolonged hospital stay, and respiratory failure. The incidence of postoperative complications was between 24% and 69.5% in the studies of KO and Montague.^{29, 32} In our study, the incidence rates of such complications as postoperative low cardiac output syndrome, postoperative IABP use, re-exploration for

postoperative bleeding, postoperative stroke, postoperative renal complications, postoperative pulmonary complications, atrial fibrillation, and death in the elderly subjects were 12.6%, 11.7%, 14.5%, 4%, 14.2%, 12.9%, 13.5%, and 4.3%, respectively. The most frequent complications were re-exploration for postoperative bleeding, and postoperative renal complications have not been demonstrated by previous studies to be a common complication, as indicated by Avery and Horneffer et al.^{33, 34} Our univariate analysis of each risk factor with the perioperative variables revealed that overall morbidity was influenced by some variables such as postoperative low cardiac output syndrome and a low ejection fraction. Postoperative low cardiac output syndrome was found to be an independent risk factor for complications such as respiratory complications, renal failure, inotropic drug use, prolonged intensive care unit (ICU) stay, and length of hospital stay. Horneffer et al.³⁴ showed that the overall postoperative morbidity was influenced by prolonged pump time and cross-clamp time. In our study, prolonged cross-clamp time (> 60 minutes) was not a predictor of complications in the postoperative period and prolonged pump time was only associated with a prolonged ICU stay. The additional risk factors associated with older age like malnutrition, respiratory muscle weakness, and chronic infection combined with postoperative low cardiac output syndrome increase the risk of prolonged mechanical support and lead to tracheostomy and its undesirable consequences such as pneumonia and multi-organ failure. The in-hospital mortality rate of the elderly patients in our study was 4.3%, which is within the range of previous reports.^{35, 36} The lack of functional reserves in elderly patients and the increased presence of chronic medical diseases combined with late referral patterns may predispose elderly patients to higher morbidity and mortality rates than younger patients.³⁶ Postoperative stroke is difficult to predict preoperatively. In one study, among 13 cases of postoperative stroke in the elderly, no patient had a preoperative history of stroke. Additionally, postoperative atrial fibrillation requiring medical control occurred more often in the elderly than in the younger patients (13.5% vs. 5.5%) with a p value < 0.05. The authors also argued that atrial fibrillation would be a life-threatening complication; however, it had no effect on hospital mortality as determined by logistic analysis.¹² In our study, factors predicting atrial fibrillation were re-intubation, diabetes, infection, and postoperative re-exploration for bleeding. The most important factor in predicting postoperative atrial fibrillation was re-intubation. The etiology of atrial fibrillation following cardiac surgery may be multifactorial, and includes intraoperative handling of the right atrium,³⁷ suture of the cannulation site,³⁷ suture at the site of a retrograde cannula,³⁷ a large hematoma in the atrial wall,³⁷ venting of the right superior pulmonary vein,³⁸ traumatic laceration of the atrial tissue,³⁹ inadequate atrial tissue preservation by cardioplegia,⁴⁰ inadequate use of



iced slush/cooling of the atria,⁴¹ beta-blocker withdrawal,⁴² hypothyroidism, withdrawal of thyroid hormone replacement therapy in the preoperative period,⁴³ pericarditis, and many other factors.^{44,45} Suture line, hematoma, and other traumatic causes of atrial fibrillation lead to a lack of uniformity in the atrial refractory period, and dispersion of refractoriness is the underlying mechanism causing vulnerability of the atrial tissue to develop atrial fibrillation. Hypothyroidism reduces cardiac contractility and raises peripheral resistance as well as capillary permeability and gives rise to atrial fibrillation. On the other hand, thyroid replacement therapy improves cardiac diastolic function as well as systemic vascular resistance and may induce myocardial ischemia and cardiac arrhythmia. Therefore, experts have not reached a consensus about the need to replace thyroid hormone in patients with CAD.⁴⁶

One of the most important risk factors for postoperative atrial fibrillation in our study was re-intubation, which was also reported by Holford et al.⁴⁷ Patients with COPD, asthma, acute respiratory distress syndrome, and other risk factors for respiratory failure have a high incidence of re-intubation and atrial fibrillation. Patients with these lung diseases may have an intrapulmonary shunt, ventilation-perfusion mismatch associated with atelectasis, reduced vital capacity, and other abnormal ventilatory mechanics following cardiac surgery, which aggravate arterial hypoxia and create the hypoxia of the atrial tissue and atrial fibrillation. The atrial tissue is more vulnerable to hypoxia than the myocardium. Another risk factor for predicting atrial fibrillation in the current study was re-exploration for postoperative bleeding. In these patients, high blood transfusion caused pulmonary edema and adult respiratory distress syndrome, which through hypoxia mechanism led to atrial fibrillation. In our study, COPD was not a predictor of atrial fibrillation; this is one of the limitations of our study and was in consequence of the absence of a unanimous interpretation of the spirometry results by the internists. The odds ratio of re-intubation in our study in the logistic regression was 9.6. It is probable that hypoxia leads to atrial fibrillation, which begets low cardiac output; this vicious cycle brings about further deterioration of hypoxia and fatal events. Creswell et al.⁴⁸ showed that patients with postoperative myocardial infarction have more premature atrial contractions, which can predispose them to atrial fibrillation. Our study did not investigate premature atrial contractions as a risk factor for atrial fibrillation, which is another limitation of our study. In another retrospective study, Leitch et al.⁴⁹ confirmed the relationship between postoperative infection and atrial fibrillation. The odds ratio of infection in our study in the logistic regression was 8.6. The most important infection in the postoperative period is respiratory infection, which allied to hypoxia mechanism causes atrial fibrillation. Postoperative functional recovery in our elderly patients required a longer time period than in our younger patients, although the surgical quality with

respect to the number of grafts, left internal mammary artery use, clamp time, and cardiopulmonary bypass time was almost the same between the two groups. The incidence of death was different between the two groups by the univariate analysis (t-test); and in the logistic regression analysis, the postoperative predictors of in-hospital death in the elderly comprised preoperative PO₂, preoperative PCO₂, and need for emergent surgery. The total numbers of the grafts and the left internal mammary artery grafts were almost the same in both groups. Aortic clamp time and pump time were not significantly different between the elderly men and women. Postoperative low cardiac output requiring intra-aortic balloon pump, stroke, and respiratory failure were the major forms of morbidity in the elderly. The longer postoperative recovery period in the elderly may be the reflection of increased incidence of major complications in the elderly. On the other hand, the delayed recovery in the elderly may simply be due to the aging process affecting the lung, kidney, liver, and central nervous system. Apropos of the postoperative course, our elderly patients required longer hospital stays.

Our study was performed in a single institute with a single surgical group, which may have rendered the resulting operative data biased. The postoperative length of stay was longer than that reported in a previous investigation.³ This would be a reflection of the local cultural background and late discharge by the ICU physicians. In summary, CABG in elderly patients can be performed with acceptable risks. Successful surgical revascularization in the elderly may provide freedom from cardiac events, as is the expected case in younger patients; be that as it may, considerable controversy remains as to whether the health care system budget and government resources should be even further extended in the case of elderly patients so as to provide the most cost-effective method for preserving quality of life and independent living. In our experience, the risk of death and complications may not be the determining factors in a patient's decision to undergo surgery. Our results indicate that the presence or absence of certain preoperative and postoperative variables can be drawn upon to predict a prolonged postoperative hospital stay. Patients with preoperative risk factors such as emergent surgery or peripheral vascular disease who develop postoperative complications have the longest length of stay. Patients with preoperative risk factors such as morbid obesity or low body mass index may develop postoperative complications and will have the longest length of hospital stay. However, patients with preoperative risk factors who do not develop postoperative risk factors will still have significantly shorter lengths of stay. In the present study, the two most common reasons for a prolonged length of hospital stay were peripheral vascular disease and emergent surgery. The R² of a prolonged hospital stay was 11.4%, which exhibited a bias alongside the existence of some other unknown variables, affecting our

results. We focused on elderly patients and defined a set of liberal criteria for preoperative IABP use so that the number of patients requiring postoperative IABP insertion would be minimized because postoperative IABP is known to be associated with a high prevalence of vascular complications. The preoperative criteria for IABP insertion encompassed emergent surgery, failed percutaneous transluminal coronary angioplasty or critical left main stenosis, significant left ventricular dysfunction (left ventricular ejection fraction < 30%), and unstable angina refractory to medical therapy. The elderly patients who received the IABP represented higher-risk patients, with a greater proportion having low ejection fractions and less preoperative acute myocardial infarction than those not receiving preoperative IABP. Despite this higher predicted operative risk, there were no statistically significant differences in the operative mortality and postoperative complication rates between the patients who received preoperative IABP and those who did not. However, patients who received the IABP had a longer postoperative hospital stay than those who did not require the IABP. This difference probably reflects the increased postoperative morbidity associated with factors such as COPD and opium use. COPD and opium addiction are complex variables, which in our elderly patients were associated with a low ejection fraction and postoperative low cardiac output syndrome. Opium addiction is a risk factor for CAD, and a majority of opium addicts have a low ejection fraction. In our study, opium addiction was a risk factor for COPD and it was associated with low preoperative PO₂ as well as lower weight and preoperative heparin use. Low preoperative PO₂ causes preoperative hypoxia and further reduces the ejection fraction and increases need for IABP insertion. In very low or high body mass index values, respiratory dysfunction is allied to respiratory muscle dysfunction. Fat tissue accumulation in the thoracic and abdominal walls impairs the ventilatory function in post-CABG patients. A rise in the body mass index is typically associated with a reduction in FEV1, forced vital capacity (FVC), total lung capacity, functional residual capacity, and expiratory reserve volume. A reduction in these respiratory parameters is correlated with cardiopulmonary bypass-induced edema, postoperative respiratory dysfunction, hypoxia, low cardiac output syndrome, and need for IABP insertion.⁵⁰⁻⁵²

Conclusion

In summary, CABG can be carried out with acceptable risks in elderly patients. Successful surgical revascularization in the elderly is likely to confer freedom from cardiac events, as is the expected case in younger patients. Nonetheless, significant controversy persists as to whether the health care system budget and government resources should be even further extended in the case of elderly patients in order to

offer the most cost-effective method for the preservation of quality of life and independent living. In our experience, the risk of death and complications may not be the determining factors in a patient's decision to opt for surgery.

Acknowledgement

The authors would like to acknowledge the kind efforts made by nurses at Imam Ali Hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran. This study was approved and supported by Kermanshah University of Medical Sciences.

References

1. MacDonald P, Johnstone D, Rockwood K. Coronary artery bypass surgery for elderly patients: is our practice based on evidence or faith? *CMAJ* 2000;162:1005-1006.
2. Flather M, Rhee JW, Boothroyd DB, Boersma E, Brooks MM, Carrié D, Clayton TC, Danchin N, Hamm CW, Hueb WA, King SB, Pocock SJ, Rodriguez AE, Serruys P, Sigwart U, Stables RH, Hlatky MA. The effect of age on outcomes of coronary artery bypass surgery compared with balloon angioplasty or bare-metal stent implantation among patients with multivessel coronary disease. A collaborative analysis of individual patient data from 10 randomized trials. *J Am Coll Cardiol* 2012;60:2150-2157.
3. Gersh BJ, Kronmal RA, Schaff HV, Frye RL, Ryan TJ, Myers WO, Athearn MW, Gosselin AJ, Kaiser GC, Killip T, 3rd. Long-term (5 year) results of coronary bypass surgery in patients 65 years old or older: a report from the Coronary Artery Surgery Study. *Circulation* 1983;68:III190-199.
4. Sen B, Niemann B, Roth P, Aser R, Schönburg M, Böning A. Short- and long-term outcomes in octogenarians after coronary artery bypass surgery. *Eur J Cardiothorac Surg* 2012;42:e102-107.
5. Cohen EA. Coronary artery bypass grafting in elderly patients: the price of success. *CMAJ* 1999;160:823-825.
6. Smith KM, Lamy A, Arthur HM, Gafni A, Kent R. Outcomes and costs of coronary artery bypass grafting: comparison between octogenarians and septuagenarians at a tertiary care centre. *CMAJ* 2001;165:759-764.
7. Sollano JA, Rose EA, Williams DL, Thornton B, Quint E, Apfelbaum M, Wasserman H, Cannavale GA, Smith CR, Reemtsma K, Greene RJ. Cost-effectiveness of coronary artery bypass surgery in octogenarians. *Ann Surg* 1998;228:297-306.
8. Higgins TL, Estafanous FG, Loop FD, Beck GJ, Blum JM, Paranandi L. Stratification of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. A clinical severity score. *JAMA* 1992;267:2344-2348.
9. Williams DB, Carrillo RG, Traad EA, Wyatt CH, Grahowski R, Wittels SH, Ebra G. Determinants of operative mortality in octogenarians undergoing coronary bypass. *Ann Thorac Surg* 1995;60:1038-1043.
10. Edmunds LH, Jr, Stephenson LW, Edie RN, Ratcliffe MB. Open-heart surgery in octogenarians. *N Engl J Med* 1988;319:131-136.
11. Pivatto Júnior F, Pereira EM, Valle FH, Teixeira Filho GF, Nesralla IA, Sant'anna JR, Prates PR, Kalil RA. Does diabetes mellitus increase immediate surgical risk in octogenarian patients submitted to coronary artery bypass graft surgery? *Rev Bras Cir Cardiovasc* 2012;27:600-606.
12. Loop FD, Lytle BW, Cosgrove DM, Goormastic M, Taylor PC, Golding LA, Stewart RW, Gill CC. Coronary artery bypass graft surgery in the elderly. Indications and outcome. *Cleve Clin J Med*



- 1988;55:23-34.
13. Dalrymple-Hay MJ, Alzetani A, Aboel-Nazar S, Haw M, Livesey S, Monro J. Cardiac surgery in the elderly. *Eur J Cardiothorac Surg* 1999;15:61-66.
 14. Kaul TK, Fields BL, Wyatt DA, Jones CR, Kahn DR. Angioplasty versus coronary artery bypass in octogenarians. *Ann Thorac Surg* 1994;58:1419-1426.
 15. Tsai TP, Chaux A, Matloff JM, Kass RM, Gray RJ, DeRobertis MA, Khan SS. Ten-year experience of cardiac surgery in patients aged 80 years and over. *Ann Thorac Surg* 1994;58:445-450.
 16. Loop FD, Golding LR, MacMillan JP, Cosgrove DM, Lytle BW, Sheldon WC. Coronary artery surgery in women compared with men: analyses of risks and long-term results. *J Am Coll Cardiol* 1983;1:383-390.
 17. Eritsland J, Arnesen H, Fjeld NB, Grønseth K, Abdelnoor M. Risk factors for graft occlusion after coronary artery bypass grafting. *Scand J Thorac Cardiovasc Surg* 1995;29:63-69.
 18. Hochberg MS, Levine FH, Daggett WM, Akins CW, Austen WG, Buckley MJ. Isolated coronary artery bypass grafting in patients seventy years of age and older: early and late results. *J Thorac Cardiovasc Surg* 1982;84:219-223.
 19. Curtis JJ, Walls JT, Boley TM, Schmaltz RA, Demmy TL, Salam N. Coronary revascularization in the elderly: determinants of operative mortality. *Ann Thorac Surg* 1994;58:1069-1072.
 20. Kirsch M, Guesnier L, LeBesnerais P, Hillion ML, Debauchez M, Seguin J, Loisançe DY. Cardiac operations in octogenarians: perioperative risk factors for death and impaired autonomy. *Ann Thorac Surg* 1998;66:60-67.
 21. Mullany CJ, Darling GE, Pluth JR, Orszulak TA, Schaff HV, Ilstrup DM, Gersh BJ. Early and late results after isolated coronary artery bypass surgery in 159 patients aged 80 years and older. *Circulation* 1990;82:IV229-236.
 22. Scott BH, Seifert FC, Grimson R, Glass PS. Octogenarians undergoing coronary artery bypass graft surgery: resource utilization, postoperative mortality, and morbidity. *J Cardiothorac Vasc Anesth* 2005;19:583-588.
 23. Ennker IC, Albert A, Pietrowski D, Bauer K, Ennker J, Florath I. Impact of gender on outcome after coronary artery bypass surgery. *Asian Cardiovasc Thorac Ann* 2009;17:253-258.
 24. Mohan R, Amsel BJ, Walter PJ. Coronary artery bypass grafting in the elderly--a review of studies on patients older than 64, 69 or 74 years. *Cardiology* 1992;80:215-225.
 25. Tsai TP, Nessim S, Kass RM, Chaux A, Gray RJ, Khan SS, Blanche C, Utley C, Matloff JM. Morbidity and mortality after coronary artery bypass in octogenarians. *Ann Thorac Surg* 1991;51:983-986.
 26. Maraschini A, D'Errigo P, Casali G, Rosato S, Badoni G, Seccareccia F. Risk stratification models in elderly patients: recalibrating or remodeling? *Acta Cardiol* 2013;68:11-18.
 27. Shimizu T, Miura S, Takeuchi K, Tashiro T, Saku K. Effects of gender and aging in patients who undergo coronary artery bypass grafting: from the FU-Registry. *Cardiol J* 2012;19:618-624.
 28. Sahar G, Raanani E, Sagie A, Ad N, Vidne BA. Surgical results in cardiac patients over the age of 80 years. *Isr J Med Sci* 1996;32:1322-1325.
 29. Ko W, Krieger KH, Lazenby WD, Shin YT, Goldstein M, Lazzaro R, Isom OW. Isolated coronary artery bypass grafting in one hundred consecutive octogenarian patients. A multivariate analysis. *J Thorac Cardiovasc Surg* 1991;102:532-538.
 30. Islamoglu F, Apaydin AZ, Ozbaran M, Yuksel M, Telli A, Durmaz I. Predictors of outcome after coronary bypass surgery in patients with left ventricular dysfunction. *Anadolu Kardiyol Derg* 2002;2:26-34.
 31. Cane ME, Chen C, Bailey BM, Fernandez J, Laub GW, Anderson WA, McGrath LB. CABG in octogenarians: early and late events and actuarial survival in comparison with a matched population. *Ann Thorac Surg* 1995;60:1033-1037.
 32. Montague NT, 3rd, Kouchoukos NT, Wilson TA, Bennett AL, 3rd, Knott HW, Lochridge SK, Erath HG, Jr, Clayton OW. Morbidity and mortality of coronary bypass grafting in patients 70 years of age and older. *Ann Thorac Surg* 1985;39:552-557.
 33. Avery GJ, 2nd, Ley SJ, Hill JD, Hershon JJ, Dick SE. Cardiac surgery in the octogenarian: evaluation of risk, cost, and outcome. *Ann Thorac Surg* 2001;71:591-596.
 34. Horneffer PJ, Gardner TJ, Manolio TA, Hoff SJ, Rykiel MF, Pearson TA, Gott VL, Baumgartner WA, Borkon AM, Watkins L. The effects of age on outcome after coronary bypass surgery. *Circulation* 1987;76:V6-12.
 35. Kennedy JW, Kaiser GC, Fisher LD, Maynard C, Fritz JK, Myers W, Mudd JG, Ryan TJ, Coggin J. Multivariate discriminant analysis of the clinical and angiographic predictors of operative mortality from the Collaborative Study in Coronary Artery Surgery (CASS). *J Thorac Cardiovasc Surg* 1980;80:876-887.
 36. Horvath KA, DiSesa VJ, Peigh PS, Couper GS, Collins JJ, Jr, Cohn LH. Favorable results of coronary artery bypass grafting in patients older than 75 years. *J Thorac Cardiovasc Surg* 1990;99:92-95.
 37. Mathew JP, Fontes ML, Tudor IC, Ramsay J, Duke P, Mazer CD, Barash PG, Hsu PH, Mangano DT; Investigators of the Ischemia Research and Education Foundation; Multicenter Study of Perioperative Ischemia Research Group. A multicenter risk index for atrial fibrillation after cardiac surgery. *JAMA* 2004;291:1720-1729.
 38. Almassi GH, Schowalter T, Nicolosi AC, Aggarwal A, Moritz TE, Henderson WG, Tarazi R, Shroyer AL, Sethi GK, Grover FL, Hammermeister KE. Atrial fibrillation after cardiac surgery: a major morbid event? *Ann Surg* 1997;226:501-511.
 39. Tchervenkov CI, Wynands JE, Symes JF, Malcolm ID, Dobell AR, Morin JE. Persistent atrial activity during cardioplegic arrest: a possible factor in the etiology of postoperative supraventricular tachyarrhythmias. *Ann Thorac Surg* 1983;36:437-443.
 40. Angelini P, Feldman MI, Lufschanowski R, Leachman RD. Cardiac arrhythmias during and after heart surgery: diagnosis and management. *Prog Cardiovasc Dis* 1974;16:469-495.
 41. Roffman JA, Fieldman A. Digoxin and propranolol in the prophylaxis of supraventricular tachydysrhythmias after coronary artery bypass surgery. *Ann Thorac Surg* 1981;31:496-501.
 42. Klemperer JD, Klein IL, Ojamaa K, Helm RE, Gomez M, Isom OW, Krieger KH. Triiodothyronine therapy lowers the incidence of atrial fibrillation after cardiac operations. *Ann Thorac Surg* 1996;61:1323-1327.
 43. Lauer MS, Eagle KA, Buckley MJ, DeSanctis RW. Atrial fibrillation following coronary artery bypass surgery. *Prog Cardiovasc Dis* 1989;31:367-378.
 44. Gavaghan TP, Feneley MP, Campbell TJ, Morgan JJ. Atrial tachyarrhythmias after cardiac surgery: results of disopyramide therapy. *Aust N Z J Med* 1985;15:27-32.
 45. Weiner B, Rheinlander HF, Decker EL, Cleveland RJ. Digoxin prophylaxis following coronary artery bypass surgery. *Clin Pharm* 1986;5:55-58.
 46. Hashimoto K, Ilstrup DM, Schaff HV. Influence of clinical and hemodynamic variables on risk of supraventricular tachycardia after coronary artery bypass. *J Thorac Cardiovasc Surg* 1991;101:56-65.
 47. Holford FD, Mithoefer JC. Cardiac arrhythmias in hospitalized patients with chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1973;108:879-885.
 48. Creswell LL, Schuessler RB, Rosenbloom M, Cox JL. Hazards of postoperative atrial arrhythmias. *Ann Thorac Surg* 1993;56:539-549.
 49. Leitch JW, Thomson D, Baird DK, Harris PJ. The importance of age as a predictor of atrial fibrillation and flutter after coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 1990;100:338-342.
 50. Christenson JT, Buswell L, Velebit V, Maurice J, Simonet F, Schmuziger M. The intraaortic balloon pump for postcardiotomy heart failure. Experience with 169 intraaortic balloon pumps. *Thorac Cardiovasc Surg* 1995;43:129-133.
 51. Mackenzie DJ, Wagner WH, Kulber DA, Treiman RL, Cossman DV, Foran RF, Cohen JL, Levin PM. Vascular complications of the intra-aortic balloon pump. *Am J Surg* 1992;164:517-521.



52. Makhoul RG, Cole CW, McCann RL. Vascular complications of the intra-aortic balloon pump: an analysis of 436 patients. *Am Surg* 1993;59:564-568.