Determinants of operative mortality following primary coronary artery bypass surgery

Navid Sadeghi*, Sarmad Sadeghi, Zhoobin Abbasi Mood, Abbasali Karimi

Department of Cardiac Surgery, Dr. Shariati Hospital, Tehran University of Medical Sciences (TUMS), Tehran, Iran

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Abstract

Background: The purpose of this study was to determine the factors which can help to predict operative mortality before performing the operation, and afterwards. Methods: The study population consisted of 504 patients (91 women and 413 men) who underwent primary isolated coronary artery bypass surgery from December 1997 to September 1999 by the same surgeon in a referral center in Tehran, Iran. Perioperative data were gathered and analyzed both in a univariate and multivariate model. Results: After the operation patients spent 7.3 ± 4.0 days in hospital. The total operative morbidity was 20.5%. Arrhythmias were the most common complication, with atrial fibrillation as the predominant feature. Major complications of the operation were: low cardiac output (4.2%); prolonged ventilatory support (2.4%); hemorrhage and exploratory reoperation (2.0%); postoperative myocardial infarction (1.4%); postoperative renal failure in (1.4%); and postoperative cerebrovascular accident (0.8%). Operative mortality rate in this study was 2.98%. Factors associated with high operative mortality in univariate analysis were: recent myocardial infarction, low ejection fraction, non-elective operation, left main coronary artery disease and prolonged cardiopulmonary bypass time. Conclusion: Our data suggest that prior to operation, operative mortality can be best predicted by urgency of operation and left ventricle ejection fraction. After performing the operation, prognostic factors include preoperative LVEF ≤ 35%, non-elective operation, and prolonged cardiopulmonary bypass time. Further study is required to assess the generalization of our findings to Iranian patients.

Keywords: Coronary artery bypass; Operative mortality; Risk factors

1. Introduction

Since the early 1960s, Coronary Artery Bypass Grafting (CABG) has evolved from being a rarely performed high-risk operation into a common treatment procedure, owing to improvements in surgical techniques, medications and patient care. Like any other medical procedure the prediction of outcome based on preoperative data is very valuable.

During the past few decades, the mortality risk of CABG operations has been the focus of numerous studies [1], which differed with respect to the time period examined, the data elements compared, and inclusion of the patients with concomitant procedures or reoperations [2]. Inclusion and exclusion of certain variables, variations in definitions of same variables and institutional and regional differences in practice style, have made it difficult to compare the results across datasets [1]. Results that are controversial in certain aspects are best exemplified by the uncertainty about the impact of gender on mortality and morbidity following CABG [1,3]. There have also been tremendous efforts to develop risk stratification models to provide a more accurate risk prediction for mortality of patients facing CABG; however, general application of these risk models must be done with caution and after careful study and calibration for any specific population. Additionally, the changing profile of patients undergoing cardiac surgery operations necessitates continuous updating and revision of risk models [4].

To these, we must add the variations in demographics, patient mix and distribution of risk factors among populations between different ethnic groups, races and geographical locations.

The goal of this study was to identify preoperative and postoperative determinants of operative mortality in Iranian patients who underwent primary isolated CABG in a referral center in Tehran, Iran.

2. Materials and methods

The study population consisted of 504 patients (91 women and 413 men) who underwent isolated primary CABG by the same surgeon (AK) between December...
1997 and September 1999 in Dr. Shariati Hospital. Those who underwent CABG combined with any other surgical procedure were excluded from the study. All medical records of the aforementioned patients were reviewed and data were collected on a set of variables, which can be grouped into pre-, intra- and postoperative subsets:

The preoperative variables were: patient’s age and gender, height, weight, body surface area, hyperlipidaemia, hypertension, diabetes mellitus, smoking habits, left ventricular hypertrophy, prior cerebrovascular accident (CVA), peripheral vascular disease, congestive heart failure, chronic obstructive pulmonary disease (COPD), recent myocardial infarction (<1 week), history of arrhythmia, presence of unstable angina, functional class, ejection fraction, previous percutaneous transluminal coronary angioplasty (PTCA), priority of surgery, number and type of diseased vessels, serum creatinine and urea, and hematocrit.

Number and type of diseased vessels were determined based on the angiography report(s) of the patient. The left anterior descending (LAD), left circumflex, right coronary artery (RCA) or posterior descending artery were considered to be diseased only if the stenosis was equal to or greater than 70 percent of the luminal diameter. The left main coronary artery was classified as diseased if any stenosis equal to or greater than 50% of luminal diameter was reported. If the coronary circulation of the patient was left dominant, the left main coronary artery disease was considered equivalent to three-vessel disease.

Priority of surgery was defined as elective, and non-elective; the latter included both urgent and emergent operations. The most recent measurement of left ventricular ejection fraction by contrast ventriculography, radionuclide ventriculography or echocardiography was considered as the preoperative LVEF.

The intraoperative variables consisted of aortic cross-clamp time, cardiopulmonary bypass time, number and type of grafts, and minimum level of hematocrit.

The postoperative variables and complications of the operation were: postoperative myocardial infarction, determined by persistent CPK-MB enzyme elevations, new Q waves or ST depression on electrocardiograms; arrhythmias, which were considered to be a complication only if they were life-threatening or needed medical treatment; low cardiac output (LCO), which is cardiac index <2 l/min/m² requiring pharmacological inotropic support and/or insertion of intra-aortic balloon pump; postoperative renal failure requiring dialysis; postoperative CVA – cerebrovascular accidents confirmed by computed tomography (CT); respiratory failure – defined as the need for mechanical ventilator support for more than 48 h; hemorrhage, only if it needed reoperation; early graft occlusion, as determined by coronary angiography; surgical site infection, if they had supportive drainage; sternal dehiscence; and finally operative mortality which is death during the same hospitalization or in the first 30 days after the operation. All other complications such as urinary tract infection, pneumothorax and other CNS complications, were also recorded.

2.1. Statistical analysis

Univariate analysis of continuous variables was carried out by Student’s t-test. Univariate analysis of categorical variables was carried out through χ² analysis or the Fisher exact test. Variables with a P-value of less than 0.2, or those with known clinical importance that failed to meet the mentioned α level were included in logistic regression analysis, using stepwise selection. Multivariate analysis was performed in two settings; first with proper preoperative variables and then with proper perioperative variables. A P-value of less than 0.05 was considered significant. The analysis was performed with the SPSS V9.05 package.

3. Results

Patients (91 women and 413 men) were 30–81 years old; the mean age was 54.79 ± 9.25 years. The mean body surface area of patients was 1.81 ± 0.16 with a mean preoperative ejection fraction of 47.93 ± 10.08 (median of 50%). Seventy-three patients (14.3%) had a low preoperative EF, ranging from 20 to 35%. In this group of patients, the mean and median preoperative ejection fraction was 31.44 ± 4.12 and 30%, respectively. The mean number of diseased vessels was 2.64 ± 0.58 with left main coronary artery disease in 7.9% of the patients. The most common diseased vessel was LAD artery (88.7% of cases). About 69.2% of patients had three-vessel disease, 25.4% had two-vessel disease and the remaining 5.4% had single-vessel disease. Hyperlipidaemia was the most common comorbidity (47.0% of patients) followed by positive history of myocardial infarction (44.2%), smoking (38.3%), hypertension (31.2%), and diabetes (23.6%). Alcohol consumption was rather rare (0.8%) considering Islamic religious rulings. About 17.1% patients presented unstable angina at the time of admission. Patients spent 4.06 ± 4.01 days in hospital prior to their operation. Descriptive measures of the patients are listed in Tables 1 and 2.

Non-elective operation was performed in 11.5% of cases. The mean aortic cross-clamp time was 56.17 ± 16.75 min, ranging from 16 to 112 min, while mean cardiopulmonary bypass time was 96.60 ± 27.74 min, ranging from 30 to 233. Mean number of grafts per patient was 3.11 ± .84. Grafts were mostly mixed arterial and venous (86.7% LIMA and SVG).

3.1. Main outcomes

After the operation, patients spent 1.8 ± 2.7 days in the ICU and were discharged from the hospital after 7.3 ± 4.0 days. All patients had a minimum follow-up of 30 days. The operative mortality rate was 2.98% in our study with 95% confidence interval of 1.50–4.46%. During the same time
Table 1
Perioperative characteristics of patients, major quantitative variables

<table>
<thead>
<tr>
<th></th>
<th>Female mean ± SD</th>
<th>Male mean ± SD</th>
<th>Total mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>56.22 ± 7.97</td>
<td>54.47 ± 9.49</td>
<td>54.79 ± 9.25</td>
</tr>
<tr>
<td>Preop EF</td>
<td>50.98 ± 10.23</td>
<td>47.26 ± 9.94</td>
<td>47.93 ± 10.08</td>
</tr>
<tr>
<td>BSA</td>
<td>1.65 ± 0.13</td>
<td>1.84 ± 0.15</td>
<td>1.81 ± 0.16</td>
</tr>
<tr>
<td>Preop serum Cr</td>
<td>1.03 ± 0.24</td>
<td>1.10 ± 0.33</td>
<td>1.09 ± 0.31</td>
</tr>
<tr>
<td>ACC time</td>
<td>92.94 ± 52.9</td>
<td>56.88 ± 16.88</td>
<td>56.17 ± 16.75</td>
</tr>
<tr>
<td>CPB time</td>
<td>92.94 ± 52.9</td>
<td>97.41 ± 27.93</td>
<td>96.60 ± 27.74</td>
</tr>
<tr>
<td>ICU stay</td>
<td>1.58 ± 0.96</td>
<td>1.86 ± 2.97</td>
<td>1.81 ± 2.72</td>
</tr>
<tr>
<td>Postoperative Hospital stay</td>
<td>7.63 ± 3.74</td>
<td>4.22 ± 4.00</td>
<td>7.29 ± 3.96</td>
</tr>
</tbody>
</table>

* SD, standard deviation; BSA, body surface area; EF, ejection fraction; Cr, creatinine; ACC, aortic cross-clamp; CPB, cardiopulmonary bypass.

In univariate analysis, the following variables were found to be associated with high operative mortality: EF ≤ 35%, recent myocardial infarction, left main coronary artery disease, non-elective operation and, longer cardiopulmonary bypass time (Table 4).

When only preoperative variables were taken into account in stepwise analysis, preoperative EF ≤ 35% (P = 0.0023) and non-elective operation (P = 0.0000) were identified to be associated with high operative mortality. Adding intraoperative variables to the model, the following were found to be predictive of operative mortality after performing the surgery: preoperative EF ≤ 35% (P = 0.0013), non-elective operation (P = 0.0000) and prolonged cardiopulmonary bypass time (P = 0.0043).

4. Discussion

Jones et al. in a review of seven datasets, reports that seven core variables (urgency of operation, age, prior heart surgery, gender, LVEF, percentage of stenosis of the left main coronary artery, and number of major coronary arteries with >70% stenosis) were found to be predictive of mortality following CABG [5]. The predictive power of these factors was greatest for urgency of the operation, age, and prior CABG and least for variables describing coronary anatomy [5]. The ACC/AHA guidelines for CABG Surgery [1] summarizes that early mortality after CABG is associated particularly with advancing age, poor LV function, and the urgency of operation. We will further discuss the effect of these variables, with respect to the results of our own study (Tables 5 and 6).

Table 3
Complications of the operation

<table>
<thead>
<tr>
<th></th>
<th>Female n (%)</th>
<th>Male n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrhythmia</td>
<td>4 (4.4%)</td>
<td>32 (7.8%)</td>
<td>36 (7.1%)</td>
</tr>
<tr>
<td>LCO</td>
<td>4 (4.4%)</td>
<td>17 (4.1%)</td>
<td>21 (4.2%)</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>2 (2.2%)</td>
<td>10 (2.4%)</td>
<td>12 (2.4%)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>3 (3.3%)</td>
<td>6 (1.5%)</td>
<td>9 (1.7%)</td>
</tr>
<tr>
<td>IABP</td>
<td>1 (1.1%)</td>
<td>7 (1.7%)</td>
<td>8 (1.6%)</td>
</tr>
<tr>
<td>MI</td>
<td>1 (1.1%)</td>
<td>6 (1.5%)</td>
<td>7 (1.4%)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0 (0%)</td>
<td>7 (1.7%)</td>
<td>7 (1.4%)</td>
</tr>
<tr>
<td>Dehiscence</td>
<td>1 (1.1%)</td>
<td>4 (1.0%)</td>
<td>5 (0.99%)</td>
</tr>
<tr>
<td>CVA</td>
<td>1 (1.1%)</td>
<td>3 (0.7%)</td>
<td>4 (0.8%)</td>
</tr>
<tr>
<td>Surgical site infection</td>
<td>0 (0%)</td>
<td>4 (1.0%)</td>
<td>4 (0.79%)</td>
</tr>
<tr>
<td>Early graft occlusion</td>
<td>1 (1.1%)</td>
<td>0 (0%)</td>
<td>1 (0.2%)</td>
</tr>
<tr>
<td>CNS damage</td>
<td>1 (1.1%)</td>
<td>9 (2.18%)</td>
<td>10 (1.98%)</td>
</tr>
<tr>
<td>GIB</td>
<td>0 (0%)</td>
<td>5 (1.21%)</td>
<td>5 (0.99%)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0 (0%)</td>
<td>3 (0.73%)</td>
<td>3 (0.60%)</td>
</tr>
</tbody>
</table>

* LCO, low cardiac output; CVA, cerebrovascular accident; IABP, intra-aortic balloon pump; MI, myocardial infarction; CNS, central nervous system; GIB, gastrointestinal bleeding.
4.1. Age

Tu et al. found that the relative risk in short-term after CABG, increases to 2.07 for patients between 65 and 74 years of age and to 3.84 for those older than 75 years [6]. So is the finding of other studies; advanced age consistently predicts mortality after CABG [3–10].

During the past few decades, the percentage of patients aging more than 70 years has increased [2,11], while the operative mortality has decreased owing to evolution of surgical techniques and medical care. Ivanov and colleagues reported a significant decline in operative mortality of elderly patients (1982–1996), despite an increase in the prevalence and severity of their risk profile [12].

Likewise, Hartz et al. reported that 25% of CABG patients in their center were older that 70 in 1984–1994 in contrast to 1% in 1968–1971 [2]. Clearly, the definition of ‘elderly’ has gradually changed, as most of the studies in the past 10 years have defined ‘elderly’ in the context of coronary surgery as an age of 70 years or older [1]. It is noteworthy that some authors believe that a careful weighing of risk, rather than advanced age alone, should determine who could be offered the surgical revascularization procedure [1,12].

In our study, the mean age of patients at operation was 54 ± 9.25 years (ranging from 30 to 81 years, median 55 years), which is about 7–10 years less than those of similar studies. Twenty-one patients (4.17%) were older than 70 years with the mean age of 72.38 ± 2.85 years and median of 71 years, which means that on average they are not far from 70 years. As it was expected, age was not significantly associated with hospital mortality following CABG ($P = 0.3643$ in univariate analysis), which can be explained by the younger patient mix in our center.

4.2. Gender

The impact of gender on the mortality and morbidity of coronary surgery is still a matter of uncertainty. Some studies have shown that female gender is an independent risk factor for hospital mortality and morbidity of CABG.

Table 6
Comparison of major qualitative variables in survivors vs. non-survivors

<table>
<thead>
<tr>
<th></th>
<th>Non-survivors n (%)</th>
<th>Survivors n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF ≤ 35%</td>
<td>7 (46.7%)</td>
<td>66 (13.5%)</td>
</tr>
<tr>
<td>LMCA disease</td>
<td>3 (20%)</td>
<td>37 (7.6%)</td>
</tr>
<tr>
<td>Three-vessel disease</td>
<td>12 (80.0%)</td>
<td>337 (68.9%)</td>
</tr>
<tr>
<td>Recent MI</td>
<td>3 (20.0%)</td>
<td>36 (7.4%)</td>
</tr>
<tr>
<td>HLP</td>
<td>8 (53.34%)</td>
<td>229 (45.44%)</td>
</tr>
<tr>
<td>Non-elective operation</td>
<td>9 (60.0%)</td>
<td>49 (10.0%)</td>
</tr>
<tr>
<td>Postoperative MI*</td>
<td>5 (33.3%)</td>
<td>2 (0.4%)</td>
</tr>
<tr>
<td>Low cardiac output*</td>
<td>10 (66.7%)</td>
<td>11 (2.2%)</td>
</tr>
<tr>
<td>Insertion of an IABP*</td>
<td>5 (33.3%)</td>
<td>3 (0.6%)</td>
</tr>
<tr>
<td>Postoperative CVA*</td>
<td>1 (6.7%)</td>
<td>3 (0.6%)</td>
</tr>
<tr>
<td>Respiratory failure*</td>
<td>3 (20.0%)</td>
<td>9 (1.8%)</td>
</tr>
<tr>
<td>Postoperative renal failure*</td>
<td>2 (13.3%)</td>
<td>5 (1.0%)</td>
</tr>
</tbody>
</table>

* EF, ejection fraction; MI, myocardial infarction; HLP, hyperlipidemia; LMCA, left main coronary artery; IABP, intra-aortic balloon pump; CVA, cerebrovascular accident.

* Postoperative complications were not included in analysis.
operation [5,8–10,13–15]. But recent studies have suggested that the observed difference in mortality and morbidity between the two genders is due to unfavorable preoperative clinical profile of the women [3,7,16–20]. In other words, men and women run similar risks of early and late mortality after CABG when the patients’ characteristics are taken into account [16]. In our study, the mortality rate for women was 2.2% compared to 3.15% for men. Women in our study had smaller body surface area and lower preoperative hematocrit, and were more likely to have hypertension, hyperlipidemia and diabetes in contrast to men. On the other hand men were more likely to have a history of recent MI, COPD, low ejection fraction prior to operation, higher level of preoperative serum creatinine, longer cross-clamp and cardiopulmonary bypass time, and to undergo a non-elective operation. It should also be noted the mean age of women in our study was more than those of men (56.22 ± 7.97 to 54.47 ± 9.49), though the difference was not statistically significant. We, like other authors [1,3,7,16–20], believe that it is the clinical profile and not the gender, which affects the outcome of CABG in the short-term setting.

4.3. Ejection fraction

Like advanced age, improvements in surgical techniques and medical care have made CABG an acceptable treatment option for patients with severely depressed left ventricular function, although the risk is still high. Low ejection fraction is associated with increased early and late mortality and also morbidity following CABG [1,3,5,6,8–11]. Stahle et al. reported a 6.6% operative mortality in patients with an EF < 35% in contrast to 2.6% in those with an EF > 50% [21]. Other studies have shown, more or less, the same.

In our study an EF < 35%, which was seen in 14.5% of the cases, was associated with a five-fold increase in mortality rate (9.59 vs. 1.93%), which was statistically significant both in univariate (P = 0.0016) and multivariate analysis (P = 0.0023). Odds ratio for EF ≤ 35% was 5.38 with 95% CI = 1.89–15.34. EF ≤ 35% is a predictor of operative mortality before performing the operation and afterwards.

4.4. Number of diseased vessels/LMCA disease

Three-vessel disease, irrespective of left main coronary artery disease, has been reported to be associated with higher 30-day mortality [5,9]. In some studies, LMCA disease itself was associated with high operative mortality [3,5,6,8]. Jones and colleagues considered number of diseased vessels and also stenosis of left main coronary artery as two core variables in their risk model [5], while Tu et al. included only the latter as a core variable [6]. In our study, LMCA disease had significant association with operative mortality (P = 0.0424) in univariate analysis, but our data failed to show statistically significant association between LMCA disease and operative mortality in multivariate analysis (P = 0.2428).

4.5. Recent myocardial infarction

Recent (<1 week) myocardial infarction has been shown to be associated with increased operative mortality. It has been considered as a level 1 variable in the risk model developed by the Working Group Panel on the Collaborative CABG Database Project [5,6]. Tu et al. reported that recent MI along with emergency operation, redo surgery and grade 4 LVF, were associated with the highest operative mortality rate [6]. In our study, recent myocardial infarction had a significant association with operative mortality in univariate analysis (P = 0.0304), but the observed association was not statistically significant in multivariate analysis (P = 0.2435).

4.6. Priority of operation

Priority of operation has been reported to be an independent risk factor and predictor of operative mortality [5–10]. In the present study, 11.51% of operations have been performed in a non-elective context, which includes both urgent and emergent operations. In this group of patients mortality rate was more than 11 times higher than the rest of patients (15.52 vs. 1.35%). Consistent with other studies, we concluded that non-elective CABG is significantly associated with hospital mortality (P = 0.0000 both in univariate and multivariate analyses). Odds ratio for non-elective operation was 13.47 with 95% CI 4.60–39.44.

4.7. Cardiopulmonary bypass time

Previous studies reported higher CPB time to be a risk factor of exploratory reoperation for bleeding [22,23], postoperative stroke [24] and late mortality [25]. In our study, there was a significant association between longer CPB time and operative mortality both in univariate and multivariate analysis (P-value = 0.0089 and 0.0043, respectively). The odds ratio for bypass time longer than 100 min was 3.25 with 95% CI 1.13–9.37.

4.8. Study limitations

The major limitations of the present study are: (a) low number of patients which resulted in small number of outcome events, the reason is we selected patients who underwent CABG by a single surgeon to exclude the effect of surgeon on the outcome; (b) we did not have data on variables that reflect the function and condition of the right ventricle.

5. Conclusions

As mentioned earlier, the study objective was to identify variables which can help to predict operative mortality before performing the surgery and afterwards. Our data suggests that prior to operation, operative mortality can be best predicted by urgency of operation and left ventricular ejection fraction. After performing the operation, prognostic
factors include non-elective operation, prolonged cardiopulmonary bypass time, preoperative LVEF ≤ 35%.

It should be emphasized that different demographics of Iranian patients and case mix in our center, play a key role in arriving at different results from those of similar studies. This difference is of special importance when trying to apply a risk model to a population other than the one on which the model is based. The authors believe that further studies, especially in prospective multicenter settings, are required to assess generalizability of our findings and to determine the optimal set of risk factors of operative mortality of CABG in Iranian patients.

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References


