Original Article

Early Outcome of Coronary Artery Bypass Grafting in Patients with Severe Left Ventricular Dysfunction

Saeed Davoodi, MD*, Abbasali Karimi, MD, Seyed Hossein Ahmadi, MD
Mehrab Marzban, MD, Namvar Movahhedi, MD, Kyomars Abbasi, MD
Abbas Salehi Omran, MD, Mahmood Shirzad, MD, Mehrdad Sheikhvatan, MD
Seyed Hesameddin Abbasi, MD

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

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Abstract

Background: *Left ventricular dysfunction is one of the most powerful predictors of early and late outcomes in patients who undergo coronary artery bypass grafting (CABG). The aim of this study was to assess the early results of CABG that predict 30-day mortality and prolonged length of hospital stay (LOS) after CABG in patients with an ejection fraction (EF) of 30% or less.*

Methods: *Seven hundred seven patients who underwent CABG with EF≤30% in Tehran Heart Center between January 2002 and January 2006 were entered and compared with 9467 patients with EF>30% as the control group. Demographic and clinical characteristics and postoperative complications were considered.*

Results: *The thirty-day mortality rate (2.3% vs. 0.8%, P<0.0001), the mean of LOS (P<0.0001), and the mean of the length of ICU stay (P<0.0001) were higher in the severe left ventricular dysfunction group than in the control group. In patients with severe left ventricular dysfunction, the mean of NYHA score (P=0.0081), prolonged ventilation (P=0.0051), and renal failure (P=0.0606) were related to the 30-day mortality rate. Also, the prolonged LOS in these patients was correlated with the female gender (P=0.0018) and atrial fibrillation (P=0.0164).*

Conclusion: *Although left ventricular dysfunction is itself an important strong risk factor in patients undergoing CABG, the early outcome of CABG in patients with left ventricular dysfunction is acceptable and the management of this factor will help to reduce the mortality and total length of stay in hospital.*

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Keywords: *Left ventricular dysfunction • Coronary artery bypass grafting • Mortality*

Introduction

Risk factors for operative mortality after CABG have been defined by several investigators and include urgency of operation, left ventricular ejection fraction (LVEF), reoperation, age, sex, and presence of left main coronary

*Corresponding Author: ***Saeed Davoodi,*** *Cardiac Surgeon, Tehran Heart Center, North Kargar Street, Tehran, Iran. 1411713138. Tel: +98 21 88029256. Fax: +98 21 88029256. E-mail: davoodi@tehranheartcenter.org.*

artery disease.[1,2] Left ventricular dysfunction is one of the most powerful predictors of perioperative and late mortality. In the CABG patch trial confined to patients with an ejection fraction (EF) of 35% or less, perioperative mortality was 3.5% for patients without clinical signs of heart failure versus 7.7% for those with severe heart failure.1 Also, in the CASS registry, operative mortality was 1.97% for patients with nearly normal left ventricular function, 4.2% for those with EF=35-49%, and 6.2% for the ones with EF<35%.[3] Management of patients with poor left ventricular dysfunction caused by coronary artery disease (CAD) remains a challenge. According to the National Adult Cardiac Surgical Database (NACSD) report in 2000, over the years the distribution of patients with good, fair/moderate, and poorly functioning hearts has remained relatively constant. However, there is a considerable variation between the reported ejection fractions from different centers, which may be real or may relate to varying methods of estimating the ejection fraction. The importance of this difference is that a low ejection fraction is associated with a higher operative mortality.[4]

Any survival benefit after CABG in the face of severely depressed LV function is relatively unknown. Furthermore, any increase in the functional status or the degree of quantitative improvement in LV function has yet to be defined. We aimed to develop multivariable models of preoperative, operative, and postoperative risk factors that predict 30-day mortality and prolonged length of stay in hospital after CABG in patients with an ejection fraction of 30% or less.

Methods

Demographic and clinical characteristics of 10174 patients undergoing CABG (707 patients with LVEF≤30% as the study group and 9467 patients with EF>30% as the control group) from 1 January 2002 to 1 January 2006 were collected and entered into a computerized database.

Final determination of ejection fraction was based on angiographic reports. In this study, CAD was considered significant if there was a 75% or greater stenosis in the cross-sectional diameter and 50% or greater stenosis in the luminal view.5 The following data were included for analysis: The preoperative variables: 1) general characteristics: age, gender, and body mass index; 2) preoperative risk factors: current smoking history (patient regularly smokes a tobacco product/products one or more times per day or has smoked in the 30 days prior to admission),6 hypercholesterolemia (total cholesterol≥5.0 mmol/l, HDL-cholesterol≤1.0 mmol/l in men, or≤1.1 mmol/l in women, triglycerides≥2.0 mmol/l),7 family history of CAD (first-degree relatives before the age of 55 in men and 65 years in women),8 hypertension (systolic blood pressure≥140 mmHg and/or diastolic≥90 mmHg and/or on anti-hypertensive treatment),9 diabetes mellitus (symptoms of diabetes plus plasma glucose concentration≥11.1 mmol/l) or fasting plasma glucose≥7.0mmol/l or 2-hp≥11.1 mmol/l);10 renal failure (creatinine>355 μmol/l with a rise of >44 units or urine output below 0.3 ml/kg for 24 h), cerebrovascular disease, peripheral vascular disease, and chronic lung disease; 3) preoperative cardiac status: previous myocardial infarction (an acute event with abnormal creatine phosphokinase and troponin levels), New York Heart Association (NYHA) score, arrhythmia, and previous CABG and PCI; and 4) preoperative homodynamic status: number of defected coronary vessels, left main disease≥50%, and LVEF. The operative data included type of surgery (elective or emergency), the number of distal anastomoses with vein grafts, and the use of internal mammary artery (IMA) as grafts.

We considered four criteria to a complicated postoperative short-term outcome: 1) In-hospital postoperative complications (existence of at least one of these complications): cardiac complications (heart block, cardiac arrest, tamponade, and atrial fibrillation) and non-cardiac complications (brain stroke, transient ischemic attack, renal failure, urinary tract infection, pulmonary emboli, pneumonia, acute limb ischemia, multi-system failure, continuous coma≥24 hours, and prolonged ventilation≥10 hours); 2) prolonged length of stay in ICU before and after surgery; 3) prolonged hospital stay before and after operation; and 4) 30-day mortality rate (sometimes termed operative mortality) defined as death within 30 days of operation.[11]

Results were reported as mean±standard deviation (SD) for quantitative variables and percentages for categorical variables. The groups were compared using the Student's t-test for continuous variables and the chi-square test (or Fisher's exact test if required) or Mantel-Haenszel chi-square test for trend for categorical variables. The predictors exhibiting a statistically significant relationship with the outcome in the univariate analyses were taken for a multivariate logistic regression analysis to investigate their independence. Odds ratios (OR) and 95% confidence intervals (CI) for OR were calculated. Model discrimination was measured using the c statistics, which is equal to the area under the ROC (Receiver Operating Characteristic) curve. Model calibration was estimated using the Hosmer-Lemeshow (HL) goodness-of-fit statistics (higher P values imply that the model fits the observed data better). Data analyzer was anonymous, and data collection and processing were approved by the institutional review board of our heart center. P values of 0.05 or less were considered statistically significant. All the statistical analyses were performed using SPSS version 13 (SPSS Inc, Chicago, IL, USA) and SAS version 9.1 for Windows (SAS Institute Inc, Cary, NC, USA).

Results

The two groups were similar with respect to mean age

(P=0.081) (Table 1).

There was no significant difference between the two groups in terms of history of diabetes mellitus and hypertension. Among other risk factors, hypercholesterolemia (P<0.0010) and obesity (P=0.0008) were more prevalent in the patients with EF>30, whereas cigarette smoking (P<0.0001), renal failure (P=0.0010), cerebrovascular disease (P=0.0020), peripheral vascular disease (P=0.0330), the mean of NYHA score (P<0.0001), and arrhythmia (P<0.0001) were more frequent in the patients with severe left ventricular dysfunction. There was a significant difference in the number of defected vessels between the two groups, so that three-vessel disease was found more common in patients with severe left ventricular dysfunction (P=0.0005). Both arterial and venous grafts were similar in the two groups (Table 2). Also, emergency CABG was more frequent in patients with severe left ventricular dysfunction (P=0.0290).

Table 1. Preoperative characteristics in patients with FE≤30 and EF>30 undergoing CABG*

Characteristics	Group with EF≤30 (n=707)	Group with EF>30 (n=9467)	P value
Male gender	85.1	73.7	<0.0001
Age (yr)	58.02±9.40	58.68±9.74	0.0810
BMI	26.47±3.72	27.09±4.01	0.0001
Obesity	16.0	21.3	0.0008
Current cigarette smoking	20.4	15.5	0.0006
Family history of CAD	32.2	33.7	0.4153
Diabetes mellitus	36.6	34.2	0.1950
Hypercholesterolemia	55.1	64.4	<0.0001
Last creatinine (mg/dl)	1.24±0.32	1.17±0.41	<0.0001
Renal failure	3.5	1.8	0.0015
Hypertension	53.0	51.9	0.5722
Cerebrovascular disease	25.7	20.9	0.0026
Peripheral vascular disease	2.4	1.4	0.0330
Previous MI	67.1	35.6	<0.0001
NYHA score	2.37±1.09	1.92±0.90	<0.0001
Arrhythmia	4.6	1.9	<0.0001
Ejection fraction (%)	27.32±4.35	50.93±8.66	<0.0001
Previous CABG	0.1	0.2	0.5590
Previous PTCA	2.0	3.6	0.0255
Left main disease (>50%)	10.2	9.5	0.5414
Single-vessel disease	2.7	5.0	0.0060
Two-vessel disease	17.9	21.6	0.0209
Three-vessel disease	79.4	73.4	0.0005

* Data are presented as percentage or mean±SD
EF, Ejection fraction; CABG, Coronary artery bypass grafting; BMI, Body mass index; CAD, Coronary artery disease; MI, Myocardial infarction; NYHA, New York heart association; PTCA, Percutaneous transluminal coronary angioplasty

Table 2. Operative characteristics in patients with FE≤30 and EF>30 undergoing CABG*

Characteristics	Group with EF≤30 (n=707)	Group with EF>30 (n=9467)	P value
Emergency CABG	13.9	11.2	0.0291
Anastomoses with arterial conduits	97.0	97.5	0.4140
Anastomoses with venous grafts	98.2	98.1	0.8500
IMA used as graft	96.0	97.0	0.1377

*Data are presented as percentage or mean±SD
EF, Ejection fraction; CABG, Coronary artery bypass grafting; IMA, Internal mammary artery

Clinical outcomes and postoperative complications are detailed in Table 3.

Cardiac arrest (P<0.0001) and heart block (P=0.0007) were more prevalent in the severe left ventricular dysfunction group, and there were no significant differences between the two groups in terms of other postoperative complications. The thirty-day mortality rate (P<0.0001) and length of stay in ICU (P<0.0001) and hospital before and after surgery (P<0.0001) were also higher in the re ventricular dysfunction group.

Table 3. Early postoperative outcome in patients with FE≤30 and EF>30 undergoing CABG*

Characteristics	Group with EF≤30 (n=707)	Group with EF>30 (n=9467)	P value
Re-intubation	1.8	1.1	0.0920
Continuous coma	0.1	0.2	0.0620
Prolonged ventilation	1.6	1.0	0.1290
Cardiac arrest	3.0	0.6	0.0001>
Heart block	1.3	0.4	0.0007
Atrial fibrillation	5.8	6.0	0.8280
Tamponade	0.1	0.0	0.1950
Urinary tract infection	0.1	0.0	0.3030
Renal failure	1.0	0.5	0.0870
Dialysis	0.1	0.1	0.5140
Transient ischemic attack	0.1	0.2	0.9999
Brain stroke	0.6	0.3	0.1521
Pneumonia	0.3	0.1	0.2013
Pulmonary emboli	0.0	0.1	0.9999
Acute limb ischemia	0.1	0.1	0.4387
Multi-system failure	0.3	0.1	0.1023
days mortality 30	2.3	0.8	0.0001>
(LOS (day	18.34±8.06	15.76±6.65	0.0001>
(ICU stay (hour	49.24±41.20	39.70±33.60	0.0001>
LOS>12 days	76.5	65.7	0.0001>
ICU stay>72 hours	18.2	9.5	0.0001>

* Data are presented as percentage or mean±SD
EF, Ejection Fraction; CABG, Coronary artery bypass grafting; LOS, Length of stay in hospital; ICU, Intensive care unit

Multivariate logistic regression analysis showed that in patients with left ventricular dysfunction, the NYHA score (P=0.0081), postoperative prolonged ventilation (P=0.0051), prolonged ICU stay (P=0.0010), and slightly postoperative renal failure (P=0.0606) were related to the 30-day mortality rate (Table 4). In addition, prolonged length of stay in hospital in these patients was related to the female gender (P=0.0018) and postoperative atrial fibrillation (P=0.0164) (Table 5).

Table 4. Factors influencing 30-day mortality in patients with EF≤30 undergoing CABG

Variables	Univariate analysis				Multivariate analysis			
	Odds ratio	95% confidence interval		P value	Odds ratio	95% confidence interval		P value
		Lower	Upper			Lower	Upper	
Peripheral vascular disease	6.438	1.343	30.867	0.054	4.349	0.589	32.083	0.1494
NYHA score	9.791	2.761	34.716	<0.001	6.251	1.610	24.274	0.0081
Arrhythmia	5.268	1.422	19.510	0.032-	3.353	0.569	19.762	0.1813
Left main disease	3.054	0.958	9.731	0.070	3.011	0.746	12.157	0.1217
IMA used as graft	0.163	0.044	0.607	0.022	0.165	0.035	0.775	0.0224
Postoperative brain stroke	49.214	6.463	374.77	0.003	11.149	0.557	223.103	0.1147
Postoperative prolonged ventilation	32.571	8.405	126.21	<0.001	14.139	2.218	90.141	0.0051
Postoperative renal failure	19.600	3.499	109.79	0.009	11.205	0.898	139.755	0.0606
Postoperative atrial fibrillation	3.966	1.084	14.512	0.060	1.654	0.242	11.283	0.6077
Prolonged ICU stay	13.556	3.479	98.353	<0.001	9.405	1.214	86.860	0.0010

EF, Ejection fraction; CABG, Coronary artery bypass grafting; NYHA, New York heart association; IMA, Internal mammary artery; ICU, Intensive care unit.
Hosmer and Lemeshow goodness of fit test, P=0.8050
Area under the ROC curve, c=0.84976

Table 5. Factors influencing the prolonged length of stay in hospital in patients with EF≤30 undergoing CABG

Variables	Univariate analysis				Multivariate analysis			
	Odds ratio	95% confidence interval		P value	Odds ratio	95% confidence interval		P value
		Lower	Upper			Lower	Upper	
Gender (male / female)	0.389	0.237	0.639	<0.001	0.442	0.265	0.739	0.0018
Age>40 years old	1.986	0.904	4.361	0.082	1.685	0.761	3.731	0.1986
Diabetes mellitus	1.338	0.971	1.844	0.074	1.086	0.775	1.523	0.6312
Hypercholesterolemia	1.405	1.035	1.907	0.029	1.299	0.945	1.785	0.1072
Hypertension	1.415	1.042	1.920	0.026	1.248	0.906	1.718	0.1751
Vein used as graft	2.704	0.875	8.353	0.072	2.860	0.880	9.298	0.0806
Atrial fibrillation	2.608	1.186	5.736	0.014	2.690	1.199	6.034	0.0164

EF, Ejection fraction; CABG, Coronary artery bypass grafting
Hosmer and Lemeshow goodness of fit test, P=0.9855
Area under the ROC curve, c=0.61391

Discussion

Left ventricular function remains one of the most important predictors of postoperative outcomes 4, and the ejection fraction is an excellent predictor of short-term and long-term survival following CABG.12 In previous studies, perioperative mortality in patients with severe left ventricular dysfunction who underwent CABG ranged from 3% to 30%.13-15 In our study, however, perioperative mortality was 2.3% in patients with EF≤30%, which was significantly higher than that in patients with greater EF. Similarly, in the Argenziano study, no relation was found between 30-day mortality and female gender,1 whereas in the Topkara and Wang studies, the female gender was a main predictor of mortality.4,16 It is still controversial whether the female gender represents a risk factor.16 Some of the suggested contributing factors in women are advanced age, advanced disease, comorbidities, and smaller body surface area.[17] Also, in our and Argenziano studies, advanced age was not a risk factor for mortality, but this relation was seen in other studies.[3,15,18]

In our study, congestive heart failure was a strong risk factor for 30-day mortality in patients with left ventricular dysfunction. In the Argenziano et al. study, mortality was significantly higher in patients with preoperative symptomatic heart failure.1 This relation was also found in other studies.3,15 Patients with this degree of congestive heart failure have been previously shown to have four times the mortality rate after bypass compared to patients with better ventricular performance.19 Improvements in the ejection fraction may have a beneficial effect on survival, and this is likely to be greatest in patients with severe left ventricular dysfunction.[20,21]

Another strong predictor for 30-day mortality was prolonged intensive care unit stay. In the Ghotkar study, mortality was significantly higher in patients with a prolonged ICU stay following coronary bypass.22 Also, the Hein study showed a significantly increased mortality in the patients with an ICU stay of greater than 3 days in comparison with the patients with an ICU stay of 3 days or less.23 In addition, the impact of a prolonged ICU stay on mortality of patients with left ventricular dysfunction was reported in other recent study.24 In the evaluation of survival after cardiac surgery, up to 36% of patients have a longer intensive care unit (ICU) stay, which is associated with multi-organ failure, higher mortality rates of 11% to 94%, and high resource consumption.25-29 Independent risk factors for an ICU stay of greater than 3 days are related to perioperative risk factors such as age, catecholamine therapy, IABP, ARF-D, respiratory failure, and re-exploration. The risk factors with the highest adjustable odds ratio for the study end point in ICU stays greater than 3 days are respiratory failure.[23]

In our study, the female gender was an important predictor for prolonged lengths of stay in hospital, which chimes in with the results of the Lazar and Borzak studies.[30,31] It seems that the most common causes of prolonged lengths of stay in hospital in women are a higher incidence of preoperative risk factors and postoperative complications of CABG in women compared to men and the necessity of control and improvement of these risk factors in hospital before admission.[32] However, hospital discharge is an incomplete measure of outcome for patients with severe left ventricular dysfunction and longer follow-up is more appropriate.

Conclusion

Both thirty-day mortality and prolonged LOS and ICU stay are more frequent in patients with left ventricular dysfunction who undergo CABG. The most important predictors of the 30-day mortality rate in these patients are congestive heart failure, prolonged ventilation, postoperative renal failure, and ICU stay prolongation, whereas the female gender and atrial fibrillation influence the time of hospital stay. Although left ventricular dysfunction is itself an important strong risk factor in patients undergoing CABG, the early outcome of CABG in patients with left ventricular dysfunction is acceptable and the management of this factor will help to reduce the mortality and total length of stay in hospital with the help of a regular follow-up.

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