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Original Article

Early Outcomes of Coronary Artery Bypass Grafting in Patients with Low Ejection Fraction

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Abstract

Background: Patients with low ejection fraction (EF) are at a higher risk for postoperative complications and mortality. Our objective was to assess the effect of low EF (<40%) on early clinical outcomes after coronary artery bypass grafting (CABG) and to determine the predictors of mortality.

Methods: From June 2017 to February 2019, 170 consecutive patients underwent CABG. There were 120 patients with low EF (<40%; 37.49 ± 2.89%); 94 were men (78.3%), and the mean age was 55.83 ± 8.04 years. Fifty patients had normal EF (> 40; 57.90 ± 2.27 %), 41 were men (82.0%), and the mean age was 54.30 ± 7.01 years and used as a control group.

Results: Overall 30-day mortality was 10/120 patients (8.3%). Factors associated with higher mortality were females (70.0% vs. 17.3%, P<0.001); older age (61.40 ± 7.01 vs. 55.32 ± 7.97 years, P=0.025); diabetes mellitus (100% vs. 51.8%; P=0.003); longer cardiopulmonary bypass time (148.70 ± 40.12 vs. 108.49 ± 36.89 min; P=0.012); longer cross clamp time (88.19 ± 31.94 vs.64.77 ± 22.67 min; P=0.049), longer total operative time (6.82 ± 1.03 vs 5.38 ± 0.95 hours; P=0.001); intra-aortic balloon pump (IABP) insertion (90.0% vs. 10.9%; P<0.001); intra-operative complications (60% vs. 1.8%, P<0.001); ventricular tachycardia and ventricular fibrillation (30% and 50% vs. 4.5% and 5.5% respectively; P=0.002 for both); myocardial infarction (70% vs 11.8%, P<0.001), and lower postoperative ejection fraction (21.46 ± 1.93 vs 40.30 ± 8.19 %, P<0.001). In patients with low EF, postoperative NYHA and CCS angina class have improved compared to the preoperative levels (1.50 ± 0.61 vs. 3.31 ± 0.56; p< 0.001 and 1.38 ± 0.52 vs. 3.11 ± 0.55; p< 0.001 respectively)

Conclusion: Patients with low EF have a higher risk of morbidity and mortality; however, the clinical and echocardiographic parameters improve over time. Therefore, CABG remains a viable option in selected patients with low EF. Factors affecting our 30-days mortality were related to the severity of the disease.

KEYWORDS
Coronary artery bypass grafting; Ejection Fraction; Mortality

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Introduction

Ischemic heart disease is one of the major causes of death, disability and healthcare resource utilization worldwide. Recent advances in operative techniques and perioperative care resulted in an increased number of elderly patients undergoing coronary artery bypass grafting (CABG) with significant improvement in the quality of life [1]. Cardiovascular disease remains the leading cause of mortality worldwide, accounting for 40% of the total number of deaths, with 20% related to coronary artery disease. Cardiovascular disease causes the premature death of 1.5 million people per year [2].

Coronary artery bypass grafting effectively relieves angina and improves survival [3], In patients with coronary artery disease and low EF, the effect of CABG on improving the left ventricular function and the quality of life are the subjects of ongoing research [4,5]. These patients are at higher risk of postoperative complications; however, improved long-term outcomes were reported [6]. The current study aimed to assess the early effect of low EF (<40%) on clinical outcomes after coronary artery bypass grafting and to determine the predictors of mortality.

Patients and Methods:

Study setting:

This is a prospective cohort study performed between June 2017 and February 2019 on 170 patients with ischemic heart disease who had elective CABG at the National Heart Institute and Ain Shams University Hospital. We exclude Patients who needed concomitant cardiac surgery with coronary artery bypass grafting surgery, redo cardiac surgery, very low EF (<20%) and emergency patients.

All patients had a complete history taken, followed by comprehensive physical and local cardiac examinations. Pre-operative Dobutamine stress echocardiography was done for all patients with low EF (<40%) and revealed significant improvement in EF. The study was approved by the Ethical Committee of the participating institutions, and all patients provided written informed consents for the use of their de-identified data for research purposes. Patients demographics are summarized in Table 1.

Operative techniques:

A standard median sternotomy was used in all patients. Left Internal Mammary artery (LIMA) and saphenous vein grafts were harvested. Cardiopulmonary bypass (CPB) was established via cannulation of the ascending aorta, and the right atrium was cannulated via single venous cannula. The distal anastomoses were done at first then all proximal anastomoses were done after removal of aortic cross-clamp. Surgery was performed under normothermia. Myocardial protection was achieved with an intermittent warm blood cardioplegia after every graft anastomosis or every 20 minutes according to surgeon preference.

The indications for IABP were: a) failure of weaning from CPB despite maximum inotropic support, b) patients with low cardiac output after a "difficult" weaning from CPB, supported by high-doses of inotropes, c) patients with "difficult" weaning from CPB and arrhythmia (premature ventricular beats or ventricular tachycardia (VT) d) post-cardiotomy low cardiac output syndrome. The IABP was inserted percutaneously through the common femoral artery.

After surgery, patients were transferred to the ICU. Weaning from mechanical ventilation was started, in the absence of hemodynamic instability and significant bleeding, as soon as normothermia and an adequate level of consciousness were achieved. Conventional therapy included antibiotics, hydration, antacids, and diuretics, as well as inotropic drugs and mechanical circulatory support devices when required by the hemodynamic conditions. Myocardial infarction was defined according to the Consensus Conference for the Universal Definition of Myocardial Infarction [7]. Low cardiac output syndrome was defined as arterial hypotension (systolic blood pressure <100 mmHg) with signs of organ hypoperfusion (decreased urine output, lactic acidosis) and the cardiac index below 2 l/min/m2 despite adequate fluid replacement.

We followed all patients clinically and echocardiography at the outpatient clinic or contacted by phone periodically one and three months postoperatively.

*Table 1: Patients' demographics. Values are presented as numbers (%) or mean + SD. * indicate significant difference between the groups (p<0.05)*

		Low EF group (n=120)	Control group (n=50)	P value
Female		26 (21.6%)	9 (18.0%)	0.286
Age (years)		55.83 ± 8.04	54.30 ± 7.01	0.242
BMI (Kg/m^2)		29.89 ± 4.55	29.27 ± 4.35	0.413
Smoking		57 (47.5%)	26 (52.0%)	0.592
Dyslipidemia		58 (48.3%)	23 (46.0%)	0.781
Hypertension		65 (54.1%)	22 (44.0%)	0.226
Diabetics		67 (55.8%)	21 (42.0%)	0.100
Preoperative LVEDD (cm)		5.79 ± 0.53	5.44 ± 0.56	< 0.001*
Preoperative LVESD (cm)		4.58 ± 0.70	3.53 ± 0.60	< 0.001*
Preoperative EF (%)		37.49 ± 2.89	57.90 ± 2.27	< 0.001*
Preoperative NYHA class	II	6 (5.0%)	6 (12.0%)	0.113
	III	70 (58.3%)	32 (64.0%)	
	IV	44 (36.7%)	12 (24.0%)	
Preoperative CCS grade	II	12 (10.0%)	9 (18.0%)	0.165
	III	82 (68.3%)	35 (70.0%)	
	IV	26 (21.7%)	6 (12.0%)	
Number of diseased vessels	Single	3 (2.5%)	3 (6.0%)	0.193
	2-vessels	11 (9.1%)	8 (16.0%)	
	3-vessels	38 (31.6%)	17 (34.0%)	
	4-vessels	51 (42.5%)	20 (40.0%)	
	5-vessels	17(14.1%)	2 (4.0%)	

BMI= body mass index, EF= ejection fraction, LVEDD = left ventricular end diastolic diameter, LVESD= left ventricular end systolic diameter, NYHA= New York Heart Association, CCS= Canadian cardiovascular society.

Statistical analysis

Data were collected, revised, coded and entered the Statistical Package for Social Science (IBM SPSS) version 20 (IBM Corporation, Chicago, IL, USA). Qualitative data were presented as number and percentages while quantitative data with parametric distribution were presented as mean, standard deviations and ranges. The comparison between two groups with qualitative data was done by using the Chi-squared test or Fisher exact test when the expected count in any cell was found less than 5. Comparison between two independent groups regarding quantitative data with parametric distribution was done by using the independent t-test. Paired t-test was used to compare pre and postoperative changes in the low EF group. Comparison between more than two independent groups regarding quantitative data with parametric distribution was made by using One Way ANOVA.

Results

Preoperatively; dobutamine stress echo-cardiography was done for all patients. The EF at rest was 37.63 ± 2.66 % and improved to 46.98 ± 3.29 % after the test. There was total viable myocardium in 94 patients (78.33%), partial non-viable myocardium in left anterior descending (LAD) artery territory in 8 patients (6.67%), partial or total non-viable myocardium in the right

*Table 2: Operative and postoperative outcomes. Values are presented as numbers (%) or mean + SD. * indicate significant difference between the groups (p<0.05)*

		Low EF group (n= 120)	Control group (n= 50)	P value
Number of grafts		3.12 ± 1.00	2.68 ± 0.89	0.007*
Type of grafts	LIMA	116 (96.6%)	48 (96.0%)	0.830
	RIMA	7 (5.8%)	2 (4.0%)	0.626
	Radial	6 (5%)	7 (14.0%)	0.044*
	SV	117 (97.5%)	47 (94.0%)	0.259
CBP time (min)		111.95 ± 41.27	103.40 ± 54.98	0.267
ACC time (min)		66.72 ± 24.90	62.54 ± 40.82	0.415
Total operative time (hours)		5.53 ± 0.81	5.12 ± 1.03	0.006*
DC Shock application		49 (40.8%)	16 (32.0%)	0.280
Surgical technique problems		9 (7.5%)	2 (4.0%)	0.398
Intra-operative complications		8 (6.6%)	2 (4.0%)	0.500
Re exploration		7 (5.8%)	3 (6.0%)	0.964
Mediastinal drainage (ml)		749.35 ± 377.99	694.34 ± 390.94	0.393
Duration of Mechanical ventilation (hrs)		17.99 ± 24.58	16.98 ± 26.16	0.811
ICU stay (days)		3.75 ± 1.93	3.39 ± 1.69	0.252
Total hospital stays (days)		8.85 ± 3.33	7.93 ± 4.10	0.127
Postoperative cardiac support	Adrenaline	93 (77.5%)	26 (52.0%)	< 0.001*
	Dobutamine	6 (5.0%)	1 (2.0%)	0.369
	Levosimendan	14 (11.6%)	2 (4.0%)	0.118
IABP insertion		21 (17.5%)	3 (6.0%)	0.049*
Superficial wound infection		11 (9.1%)	4 (8.0%)	0.806
Cerebrovascular events		6 (5.0%)	1 (2.0%)	0.369
MI		20 (16.6%)	5 (10.0%)	0.263
Non-fatal MI		13 (10.8%)	4 (8.0%)	0.574
Non-fatal cerebrovascular events		5 (4.1%)	1 (2.0%)	0.015*
Readmission for HF		5 (4.1%)	1 (2.0%)	0.015*
30-days mortality		10 (8.3%)	1 (2.0%)	0.126
Post-operative NYHA class	I	61 (55.4%)	29 (59.2%)	0.813
	II	42 (38.2%)	18 (36.7%)	
	III	7 (6.4%)	2 (4.1%)	
Postoperative CCS grade	I	70 (63.6%)	31 (63.3%)	0.995
	II	38 (34.6%)	17 (34.7%)	
	III	2 (1.8%)	1 (2.0%)	

Table 2: Continued			
Postoperative LVEDD (cm)	5.67 ± 0.49	5.40 ± 0.54	0.007*
Postoperative LVESD (cm)	4.43 ± 0.68	3.44 ± 0.57	0.002*
Postoperative EF (cm)	38.98 ± 8.50	59.44 ± 6.88	< 0.001*
30-days mortality	10 (8.3%)	1 (2.0%)	0.126

LIMA= left internal mammary artery, RIMA= right internal mammary artery, SV= Saphenous vein, CPB= cardiopulmonary bypass, ACC= aortic cross-clamp, DC= defibrillating cardiac, ICU= intensive care unit, IABP= intra-aortic balloon pump, MI= Myocardial infection, HF= Heart failure, NYHA= New York Heart Association, CCS= Canadian cardiovascular society, EF= ejection fraction, LVEDD = left ventricular end diastolic diameter, LVESD= left ventricular end systolic diameter.

coronary artery (RCA) territory in 12 patients (10.0%) and partial or total non-viable myocardium in circumflex (LCX) artery territory in 6 patients (5.0%).

Table 2 shows the study outcomes. Nine patients (7.5 %) had surgical technique problems; 4 of them had dissected LIMA which was used as a free graft in one patient. In 2 patients, LAD could not be determined, and there was kinking of vein grafts to OM in one patient and the one patient required re-anastomosis of LIMA to LAD.

There were highly significant improvements in NYHA classification, CCS grade and ejection fraction postoperatively in comparison to the preoperative value as shown in Table 3.

Cerebrovascular events occurred in 6 patients (5.0%). A patient had deep coma, and brain stem massive bilateral infarction and the patient died the second day postoperatively. The second patient had right side hemiparesis, and left parietal infarction; preoperative carotid duplex was not indicated. The third patient had right side hemiparesis and ataxia, caused by left parietal and cerebellar infarction; preoperative carotid duplex showed bilateral atherosclerotic arteries with left side carotid lesion 50%. The fourth patient had Left side hemiparesis, and right parieto-occipital infarction; preoperative carotid duplex showed bilateral atherosclerotic arteries without significant lesion. The fifth patient had right side hemiparesis and left focal infarction in parietal and temporal lobes; preoperative carotid duplex revealed left side carotid lesion 65%. The last patient had left lower limb hemiparesis, and CT brain revealed right parietal infarction, preoperative carotid duplex revealed atherosclerotic carotid on both sides without significant lesions.

The 30-days mortality occurred in ten cases; two patients were due to failure of weaning from CPB and seven patients died due to myocardial infarction (one intraoperatively, four before discharge and two patients were readmitted to CCU). The last patient died from a non-cardiac cause.

*Table 3: Preoperative and postoperative outcomes comparison in low EF group. Values are presented as numbers (%) or mean + SD. * indicate significant difference between the groups (p<0.05)*

	Preoperative (n=120)	Postoperative (n= 110)	P value
NYHA class	3.31 ± 0.56	1.50 ± 0.61	< 0.001*
CCS grade	3.11 ± 0.55	1.38 ± 0.52	< 0.001*
LVEDD (cm)	5.79 ± 0.53	5.63 ± 0.51	0.002*
LVESD (cm)	4.58 ± 0.70	4.35 ± 0.64	0.001*
EF (%)	37.49 ± 2.89	40.30 ± 8.19	< 0.001*

NYHA= New York Heart Association, CCS= Canadian cardiovascular society, EF= ejection fraction, LVEDD = left ventricular end diastolic diameter, LVESD= left ventricular end systolic

*Table 4: Factors affecting 30 days mortality. Values are presented as numbers (%) or mean + SD. * indicate significant difference between the groups (p<0.05)*

		Survival (N= 110)	Mortality (N= 10)	P value
Female		19 (17.3%)	7 (70.0%)	< 0.001*
Age (Years)		55.32 ± 7.97	61.40 ± 7.01	0.025*
BMI (Kg/m^2)		29.74 ± 4.44	32.47 ± 5.01	0.127
Smoking		54 (49.1%)	3 (30.0%)	0.247
Dyslipidemia		51 (46.4%)	7 (70.0%)	0.152
Hypertension		59 (53.6%)	6 (60.0%)	0.698
Diabetes Mellitus		57 (51.8%)	10 (100.0%)	0.003*
Preoperative NYHA class	II	6 (5.5%)	0 (0.0%)	0.222
	III	68 (61.8%)	2 (20.0%)	
	IV	36 (32.7%)	8 (80.0%)	
Preoperative LVEDD (cm)		5.76 ± 0.53	6.07 ± 0.49	0.077
Preoperative LVESD (cm)		4.55 ± 0.69	4.85 ± 0.82	0.197
Preoperative EF (%)		37.60 ± 2.95	36.20 ± 2.09	0.145
Number of grafts		3.13 ± 1.01	3.00 ± 0.67	0.691
CBP time (min)		108.49 ± 36.89	148.70 ± 40.12	0.001*
ACC time (min)		64.77 ± 22.67	88.19 ± 31.94	0.003*
Total operative time (hour)		5.38 ± 0.95	6.82 ± 1.03	< 0.001*
DC shock application (intra-operative)		44 (40.0%)	7 (70.0%)	0.066
Intra operative complications		2 (1.8%)	6 (60.0%)	< 0.001*
Re exploration for bleeding		7 (6.3%)	0 (0.00%)	0.410
Duration of mechanical ventilation (hour)		16.99 ± 21.67	28.75 ± 19.42	0.096
ICU stay (days)		3.84 ± 1.93	2.84 ± 1.70	0.116
Postoperative inotropic support		83 (75.4%)	10 (100.0%)	0.075
IABP insertion		12 (10.9%)	9 (90.0%)	< 0.001*
Arrhythmia	AF	51 (46.3%)	2 (20.0%)	0.107
	Nodal	4 (3.6%)	0 (0.00%)	0.539
	V Tach	4 (4.5%)	3 (30.0%)	0.002*
	VF	6 (5.5%)	5 (50.0%)	0.002*
Cerebrovascular events		5 (4.5%)	1 (10.0%)	0.448
Myocardial infarction		13 (11.8%)	7 (70.0%)	< 0.001*
ICU readmission		14 (12.7%)	1 (10.0%)	0.803
Early postoperative LVEED (cm)		5.63 ± 0.51	5.99 ± 0.44	0.033*
Early postoperative LVESD (cm)		4.35 ± 0.64	5.31 ± 0.37	< 0.001*
Early postoperative EF (%)		40.30 ± 8.19	21.46 ± 1.93	< 0.001*

BMI= body mass index, EF= ejection fraction, LVEDD = left ventricular end diastolic diameter, LVESD= left ventricular end systolic diameter, CPB= cardiopulmonary bypass, ACC= aortic cross clamp, DC= defibrillating cardiac ICU= intensive care unit, IABP= intra-aortic balloon pump, NYHA= New York Heart Association, EF= ejection fraction, LVEDD = left ventricular end diastolic diameter, LVESD= left

Table 4 shows factors significantly associated with 30-days mortality including female gender, older age, diabetes, longer cardiopulmonary bypass time, longer cross-clamp time, intra-aortic balloon pump (IABP) insertion, ventricular tachycardia, and ventricular fibrillation, myocardial infarction and lower ejection fraction postoperatively.

Discussion

Low ejection fraction can negatively affect the outcomes after CABG. The purpose of this study was to evaluate the impact of low EF on the results after CABG and identify the predictors of mortality. The primary outcome was the 30-days mortality which occurred in 8.3% of the patients. Operative mortality ranged from 3.4% to 4.4% in the reported series [5, 8, 9]. In our study, mortality was significantly associated with both preoperative; as well as intraoperatively risk factors. Preoperative predictors included female gender, older age, diabetes mellitus, longer cardiopulmonary bypass, cross-clamp time and operative times, IABP insertion, ventricular tachycardia, and ventricular fibrillation, myocardial infarction and lower early ejection fraction postoperatively.

Several risk factors for mortality were identified in other series and included older age, female gender, renal failure, hepatic failure, and congestive heart failure [8]. In another series, early mortality was independently associated with age ≥75 years, female gender, angina (CSS III-IV), cardiopulmonary bypass duration >97 minutes, arrhythmia and renal impairment [10].

In our study, the major adverse cardiac events (MACE) were higher in the low EF group than the control group and non-fatal cerebrovascular events (4.1% vs. 2%), non-fatal myocardial infarction (10.8% vs. 8%), heart failure (4.1% vs. 2%) and mortality rate (8.3% vs. 2%) occurred more significantly in low EF patients. Additionally, we found a significantly higher number of grafts, total operative time, adrenaline and IABP insertion in the low EF group. The mean number of grafts was 3.12 ± 1.00; the mean cardiopulmonary bypass time (min) was 111.95 ± 41.27, the mean aortic cross-clamp time (min) was 66.72 ± 24.90 and the mean total operative time (hours) was 5.53 ± 0.81. In the literature, the mean number of grafts was 3.5 ±1.1, the mean cardiopulmonary bypass time (min) was 88 ± 28.1; the mean myocardial ischemic time (min) was 40.3 ± 19 [5]. Other study reported that the mean cardiopulmonary bypass time (min) was 87.8 ± 47.3; the mean myocardial ischemic time (min) was 56.2 ± 31.1 [8]. The difference in the results could be attributed to different patients' characteristics between the reported studies.

The mean drainage was 749.35 ± 377.99 ml which is similar to other series [11]. The amount of the postoperative blood loss can differ significantly between studies due to several factors related to the patients, surgical technique and surgeons. Mechanical ventilation, ICU and hospital were significantly longer in low EF patients which is consistent with what is reported in the literature [12]. Low EF is associated with hemodynamic instability, the increased use of IABP and inotropes and these factors affect the duration of mechanical, ICU and hospital stay directly. Postoperative complications were independently related to low EF including infectious and neurological complications [8, 12].

Preoperative EF of the targeted study group improved in the immediate postoperative period, and of the improvement continued at the three months follow-up. CABG in low EF patients had superior results compared to medical therapy. The Coronary Artery Surgery Study (CASS) study demonstrated that only 38% of medically treated patients (EF 35%) were alive and free of moderate or severe limitations five years after the treatment. Surgical approaches to CAD patients with low EF include CABG, ventricular remodeling, and cardiac transplantation [13]. Alderman and associates showed that patients with an EF<35% treated with medical therapy had a 43% 5-year survival rate compared with a 63% 5-year survival in the surgically treated patients [14]. A study followed a group of CABG patients with an EF 50% for seven years and showed that 84% of the surgically treated patients were alive at seven years, whereas only 70% of medically treated patients were alive [15].

The current recommendation is using dobutamine stress echocardiography to assess myocardial viability to select patients in whom recovery of LV function would outweigh the risk of surgical revascularization [16]. Stress echocardiography was used preoperatively in the study population. We believe that several factors may have contributed to our good operative and short-term results such as good control of diabetes, use of internal mammary artery grafting and reasonable intraoperative and postoperative use of inotropic support and IABP. Additionally, complete myocardial revascularization and successful myocardial protection are important clues and predictors of favorable short- and long-term results after CABG in patients with poor LV function. The results of this study show that CABG in low EF is associated with more complications compared with normal EF patients; however, it improves the clinical and echocardiographic outcomes.

Study limitations:

This series represents a prospective non-randomized study. Patients were selected exclusively for CABG procedure and according to the presence of an adequate amount of viable myocardium. Therefore, they were not randomly assigned to a different type of therapeutic management. Changes in operative strategies along the study course occurred and, thus, may have influenced the postoperative results and related data interpretation. The small sample size was one of the limitations; the high surgical risk was a considerable reason that made several patients defer surgery.

Conclusion

In patients with low ejection fraction and viable myocardium, CABG improves the EF and heart failure symptoms; despite the higher postoperative complications. Identification of independent mortality predictors aid in risk stratification and patients' optimization by improving the modifiable risk factors.

Conflict of interest: Authors declare no conflict of interest.

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