

Outcomes of Coronary Artery Disease Patients with Severe Left Ventricular Dysfunction Undergoing Surgical Management

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ABSTRACT

Background: Surgical revascularization by coronary artery bypass grafting (CABG) is the gold standard treatment for coronary artery disease. But, in patients with severe left ventricular dysfunction (ischemic cardiomyopathy), the result of CABG is different from those with normal left ventricular function. The coronary artery disease pattern in the Indian subcontinent is different from the western world, due to the diffuse nature of coronary involvement, the smaller size of native vessels, increased prevalence of diabetes mellitus and other risk factors, and more prevalence of severe left ventricular dysfunction. Most of the studies regarding the surgical outcomes in ischemic cardiomyopathy come from western countries. This study attempts to assess the outcomes of surgical management of ischemic cardiomyopathy in the Indian subcontinent.

Methods: A single-center retrospective cohort study was conducted at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram. The data of CAD patients, who underwent surgical coronary revascularization for severe LV dysfunction from January 2010 to December 2014, were collected from the hospital records and through tele-phonetic interviews in a structured study proforma. A total of 146 patients satisfied the criteria and were followed up for a period of 5 years.

Results: The mean age of the study population was 55.6 (8.8) years. Male preponderance was observed (94.52%; N = 138). CABG alone was done in 62.3% (N = 91) of the study participants. CABG with linear plication was done in 23.3% (N = 34), CABG with MV repair in 7.5% (N = 11), and CABG with DORS in 6.8% (N = 10). The majority of patients (N = 54, 37%) received 4 grafts. Thirty-day mortality observed in the study population was 11 (7.5%). The causes documented were cardiac causes in 9 (82%), cerebrovascular events in one (9%), and septicemia in one (9%). The mean of 5-year survival of the study population was 94.2 (3.5) months with 95% CI 87.32, 101.13. There was a substantial improvement in the degree of mitral regurgitation. Ejection fraction (EF)

also showed improvement. The mean preoperative EF was 29.51 (4.84%) and that of post-op was 39.92 (9.0%).

Conclusion: Despite the challenges of diffusely diseased coronary arteries, severe LV dysfunction, addressing associated significant MR and ventricular aneurysms, the outcome of surgical management of CAD with severe LV dysfunction, in the Indian population can be done with acceptable results. Randomized control studies in this subset can provide more solid evidence in this regard.

INTRODUCTION

Left ventricular (LV) dysfunction is categorized as severe when the LV ejection fraction is less than or equal to 35% [Elefteriades 1997]. Surgical management of coronary artery disease (CAD) patients with severe LV dysfunction includes isolated coronary artery bypass surgery (CABG), CABG with mitral valve repair/replacement or ventricular restorative procedures or its combinations, depending on the cardiac status. Despite improvement in medical therapy and surgical techniques, the management of patients with CAD and low ejection fraction remains challenging. Patients with low ejection fraction are at higher risk of ventricular arrhythmia, worsening of heart failure due to LV dysfunction, and sudden death. In CAD, CABG is established to have a better outcome than medical therapy alone, but the results of addition of CABG to the management protocol has different results, in ischemic cardiomyopathy. Most of the evidence available in literature in this subset of patients are from the Surgical treatment for Ischemic Heart Failure (STICH) trial [Velazquez 2011] and Surgical Treatment for Ischemic

Appendix Table 1. Demographic details

Age in years	Frequency	Percentage (%)
<50	36	24.7
50-65	92	63
>65	18	12.3
Gender		
Male	138	94.52%
Female	8	5.48%

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Appendix Table 2. Preoperative details

Risk factors	Frequency	Percentage (%)
Hypertension	89	61.6
Diabetes mellitus	86	58.9
Smoking	76	52.1
*DLP	61	41.8
†PVD	8	5.4
H/o‡ CVA/syncope	5	3.4
H/o §CKD	29	19.9
H/o AKI recovered	7	4.8
H/o ¶MI	117	80.13
(i)#AWMI	71	60.68
(ii)**IWMI	32	27.35
(iii)AWMI+IWMI	14	11.97
Family h/o ††CAD/PVD/Thoraco abdominal aneurysm	37	25.3
Pre op ‡‡PCI	15	10.3
Pre op ventilation	2	1.4
Symptoms as per NYHA class		
Dyspnea		
1	29	19.9
2	71	48.6
3	43	29.5
4	3	2.1
Angina		
1	26	17.8
2	59	40.4
3	55	37.7
4	6	4.1
Number of blood vessels involved		
SVD	1	0.7
DVD	3	2.1
TVD	115	78.8
LMCA+DVD	3	2.1
LMCA+TVD	24	16.4
Investigations		
2D Echo EF (%)		
<25	23	15.8
25-30	52	35.6
31-35	71	48.6
Mitral Regurgitation		
No	6	4.1
Mild	114	78.1
Moderate	16	11

Appendix Table 2. Preoperative details [Cont.]

Risk factors	Frequency	Percentage (%)
Severe	10	6.8

i SVD, single vessel disease; ii DVD, double vessel disease; iii TVD, triple vessel disease; iv-LMCA, left main coronary artery; *DLP, dyslipidemia; †PVD, peripheral vascular disease; ‡CVA, cerebrovascular accident; §CKD, chronic kidney disease; ||AKI, acute kidney injury; ¶MI, myocardial infarction; #AWMI, anterior wall myocardial infarction; **IWMI, inferior wall myocardial infarction; ††CAD, coronary artery disease; ‡‡PCI, percutaneous coronary intervention

Heart Failure Extension Study (STICHES) trial [Velazquez 2016]. These studies established that, in patients with ischemic LV systolic dysfunction (ischemic cardiomyopathy), CABG + medical therapy resulted in higher mortality at 30 days, but with a significant improvement in long-term mortality (out to 10 years) compared with medical therapy alone.

These studies have been conducted in the western population. The pattern of coronary artery disease in India is different from the western population, due to demographic, racial, and socioeconomic differences. Cardiovascular diseases contribute to 25% of mortality on the Indian subcontinent [Ajay 2010; Jose 2019]. Acute myocardial infarction occurs earlier in the Asian population, due to increased prevalence of risk factors [Jose 2019; Varma 2014]. Coronary artery disease affects the Indian population almost a decade earlier compared with the western population [Ajay 2010]. Epidemiological studies from various parts of India have reported the rising trends and a huge burden of conventional risk factors in India [Varma 2017; Kumar 2008; Gupta 2008]. Further, the long-term case fatality following acute coronary syndrome (ACS)/CAD is considerably higher among Indians as compared with other populations [Xavier 2008]. These factors may result in an increased prevalence of ischemic cardiomyopathy among Indians. Poor socioeconomic status, lack of uniformity in healthcare delivery, differences in risk profile, and affordability to access optimal health care are the prevailing barriers existing in low- and middle-income countries compared with developed nations. These barriers make the conclusions from western studies irrelevant to patients from India. In this context, it is relevant to analyze the clinical profile and outcomes of Indian patients with ischemic cardiomyopathy who underwent surgical revascularization procedures.

The primary objective of the study was to report the five-year survival of CAD patients with severe LV dysfunction after surgical revascularization. The secondary objectives were (i) to report 30-day perioperative mortality, (ii) the change in severity of mitral regurgitation, and (iii) change in ejection fraction.

PATIENTS AND METHODS

A retrospective cohort study was done in a tertiary care center (SCTIMST) for a period of two years (January

Appendix Table 3. Intraoperative details

Types of procedure	Frequency	Percentage (%)
*CABG	91	62.3
CABG+ Linear Plication	34	23.3
CABG+†MV repair	11	7.5
CABG+‡DOR {endoventricular circular patch plasty (EVCPP)}	10	6.8
Number of grafts used		
1G	1	0.7
2G	3	2.1
3G	25	17.1
4G	54	37
5G	47	32.2
6G	15	10.3
7G	1	0.7

*CABG, coronary artery bypass graft surgery; †MV repair, mitral valve repair; ‡DOR procedure, endoventricular circular patch plasty

2019-December 2020). The data of CAD patients, who underwent surgical coronary revascularization for severe LV dysfunction from January 2010 to December 2014, were collected from hospital records and through telephone interviews in a structured study proforma. The inclusion criteria were (a) CAD patients in the age group of 18 years and above with LV ejection fraction < 35% who had undergone coronary artery bypass grafting (CABG); and (b) CAD with severe LV dysfunction patients above or equal to 18 years age, who underwent additional surgical procedures, along with CABG, directly related to the pathogenesis of severe left ventricular dysfunction, like mitral valve surgery for ischemic mitral regurgitation and ventricular restoration procedures, for associated left ventricular aneurysm. Those who underwent additional surgical procedures for lesions not directly related to ischemic cardiomyopathy (aortic valve replacement, tricuspid valve surgery, associated congenital heart surgery, etc.) were excluded from the study. A total of 146 patients were included in the final analysis. The mean age of the study population was 55.6 (8.8) years. The distribution of patients in various age groups were 24.7% (N = 36) in <50 yrs, 63% (N = 92) in 50-65 yrs, and 12.3% (N = 18) in >65 yrs. The proportion of males was 94.52% (N = 138). The details are shown in Appendix Table 1.

The patients were consecutively enrolled for the study, according to the selection criteria, and were followed up for a period of 5 years. They were followed up by clinical examination, electrocardiogram, and echocardiographic examination during the time of OP visits. Those patients, who failed to attend the OPD, were interviewed by telephone by the principal investigator. The data were collected through these interviews as well as from the hospital information system. Data collected included demographic

Appendix Table 4. Postoperative details (<30 days)

Postoperative variables	Frequency	Percentage (%)
Inotrope score		
<5	63	43.2
6-15	63	43.2
16-30	14	9.6
31-45	5	3.4
>45	1	0.7
Arrhythmias		
*AF	23	15.8
†VPC	34	23.3
AF+VPC	6	4.1
Ventilation status		
<24 hours	127	87
1-2 days	7	4.8
2-5 days	4	2.7
>5 days	2	1.4
>5 days +tracheostomy	6	4.1
ICU stay in days		
<2	42	28.8
3-5	87	59.6
6-7	5	3.4
>7	12	8.2
Mean ‡(SD)	4.0	3.3
Hospital stay in days	Mean	SD
	10.6	6.0
Details of infections	Frequency	Percentage (%)
§SSI (deep/superficial)	9	6.2
Respiratory infection	12	8.2
Blood infection	1	0.7
Urinary infection	3	2.1
Mitral regurgitation		
No	13	8.9
Mild	126	86.3
Moderate	7	4.8
Echo- EF (Mean, SD)	39.9	9.0
Mortality	Frequency	Percentage (%)
Causes	11	7.5
(i)	Cardiac	9
(ii)	Cerebrovascular event	1
(iii)	Septicemia	1

*AF, atrial fibrillation ; †VPC, ventricular premature complexes; ‡SD, standard deviation; §SSI, surgical site infection; ||EF, ejection fraction

Appendix Table 5. Follow-up readmission details

Cause for readmission	Frequency	Percentage (%)
Heart failure	10	26.3
*CAG and †PCI	9	23
‡ICD	2	5.26
Holter	4	10.5
Infections	6	15.8
§CVA	2	5.2
PE drainage	1	2.6
Dyselectrolyemia	2	5.3
Other surgeries	2	5.3
Readmission from cardiac cause	26	68.4
Readmission from non-cardiac cause	12	31.6

*CAG, coronary artery angiography; †PCI, percutaneous coronary intervention; ‡ICD, implantable cardioverter-defibrillator; §CVA, cerebrovascular accident

details, preoperative data regarding symptoms, risk factors and investigations, intraoperative data regarding the details of procedure done, and postoperative data regarding ICU stay, ventilation status, hospital stay, details of infections, and mortality. The follow-up data were about functional status, details of readmission, if any, and about 5-year mortality. All the relevant data collected in the study proforma were then entered in an access data base for analysis.

Statistical analysis: The data were analyzed using the IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, NY, USA). The summary statistics of continuous variables are represented as mean with standard deviation and that of categorical variables as frequency with percentage. All quantitative continuous variables were checked for normal distribution within each category of explanatory variable by using visual inspection of histograms and normality Q-Q plots. Shapiro-Wilk test was conducted to assess normal distribution. Shapiro-Wilk test *P*-value of >.05 was considered normal distribution. Non-normally distributed quantitative variables were summarized by median and interquartile range (IQR). For normally distributed quantitative parameters, the mean values were compared between study groups using ANOVA (>2 groups). For non-normally distributed quantitative parameters, medians and interquartile range (IQR) were compared between study groups using the Kruskal Wallis test (> 2 groups). For non-normally distributed variables, association between quantitative explanatory and outcome variables was assessed by calculating spearman correlation (rs) coefficient. Categorical outcomes were compared between study groups using Chi square test/Fisher's Exact test (if the overall sample size was < 20 or if the expected number in any one of the cells is < 5, Fisher's exact test was used.) *P*-value < .05 was considered statistically significant.

Table 1. Comparison of change in severity of MR

Severity of MR	Preop MR (N, %)	Postop MR (N, %)
No	6 (4.1)	13 (8.9)
Mild	114 (78.1)	126 (86.3)
Moderate	16 (11)	7 (4.8)
Severe	10 (6.8)	0 (0)

Table 2. Comparison of preoperative 2D ECHO EF and postoperative 2D ECHO EF

Ejection fraction (%) (2D ECHO)	Mean (SD)	95% CI	<i>P</i> -value
Preop	29.51 (4.84)	28.72, 30.31	<.0001
Postop	39.92 (9.0)	38.44, 41.39	

Kaplan Meier survival analysis was performed to assess the overall survival rate. Logrank test was used for intergroup comparisons.

Survival rate was compared across the Preoperative 2D Echo EF. Early or operative mortality and late follow-up survival time were considered as primary outcome variables.

RESULTS

Preoperative details: The preoperative variables selected for the study were risk factors, symptoms as per NYHA classification, number of blood vessels involved, 2D Echo Ejection Fraction (EF), and severity of mitral regurgitation. The major risk factors observed were history of myocardial infarction (80.1%), hypertension (61.6%), diabetes mellitus (58.9%), smoking (52.1%), and dyslipidemia (41.8%).

The most frequent symptoms observed were NYHA Class I dyspnea (48.6%) and CCS Class II angina (40.4%). When the number of blood vessels involved was examined, triple vessel involvement was the major subset seen (78.8%).

Investigations were done to find the ejection fraction and severity of mitral regurgitation (MR). The distribution of ejection fraction (EF in %) were <25 (15.8%), 25-30 (35.6%), and 31-35 (48.6%). The severity of MR was mild in 78.1%, moderate in 11%, and severe in 6.8%. The pre-op details are represented in Appendix Table 2. (Appendix Table 2)

Intraoperative details: The type of procedure and number of grafts done were considered in the study. Among the procedures, CABG alone was done in 62.3% (N = 91) of the study participants. CABG with linear plication was done in 23.3% (N = 34), CABG with MV repair in 7.5% (N = 11), and CABG with DORS in 6.8% (N = 10). The majority of the patients (N = 54, 37%) received 4 grafts. The intraoperative details are shown in Appendix Table 3.

Postoperative details (<30 days): Postoperative variables taken for the study were (i) IABP use, (ii) inotrope score [Gaies 2014], which is calculated using the formula dopamine

Table 3. Bivariate comparison of <30 days mortality with selected variables

Variables	<30-day mortality Alive (N = 135)	<30-day mortality Dead (N = 11)	Chi square	Fisher exact P-value
Gender				
Male (N = 138)	128 (94.81%)	10 (90.9%)	0.29	.58
Female (N = 8)	7 (5.18%)	1 (9.09%)		
Risk factors				
Diabetes mellitus				
Yes	78 (57.8%)	6 (54.5)	0.04	.83
No	57 (42.2%)	5 (45.5%)		
Hypertension				
Yes	85 (63.0%)	5 (45.5%)	1.31	.25
No	50 (37.0%)	6 (54.5%)		
Smoking				
Yes	69 (51.1%)	7 (63.6%)	0.64	.42
No	66 (48.9%)	4 (36.4%)		
Dyslipidemia				
Yes	55 (40.7%)	6 (54.5%)	0.79	.37
No	80 (59.3%)	5 (45.5%)		
Emergency/elective surgery				
Elective	132 (97.77%)	10 (90.9%)	1.80	.18
Emergency	3 (2.22%)	1 (9.09%)		
On-pump CABG/off-pump CABG				
On-pump	134 (99.26%)	10 (90.91%)	5.25	.15
Off-pump	1 (0.74%)	1 (9.09%)		
Types of surgical procedures				
CABG	82 (60.7%)	9 (81.8%)		
CABG+ Linear Plication	34 (25.2%)	0 (0)	0.31	
CABG+MV repair	10 (7.4%)	1 (9.1%)		
CABG+DORS	9 (6.7%)	1 (9.1%)		
Number of grafts used				
2G	3 (2.22%)	1 (9.09%)		
3G	23 (17.04%)	2 (18.18%)	2.75	.59
4G	49 (36.3%)	5 (45.45%)		
5G	45 (33.33%)	2 (18.18%)		
6G	15 (11%)	1 (9.09%)		
Postop ventilation				
<24 hours (N = 127)	125 (98.4%)	2 (1.6%)	-	<.001
1-2 days (N = 7)	4 (57.1%)	3 (42.9%)		
2-5 days (N = 4)	1 (25.0%)	3 (75.0%)		
>5 days (N = 2)	0 (0)	2 (100%)		
>5 days+tracheostomy (N = 6)	5 (83.3%)	1 (16.7%)		
Postoperative arrhythmias				
Yes	81 (60%)	2 (18.18%)	-	.007
No	54 (40%)	9 (81.2%)		

Table 4. Impact of ejection fraction on overall survival

Ejection fraction (EF)	Mean survival with standard deviation (months)	95% CI	Chi-square value	P-value
<25	71.6 (9.2)	53.66, 89.59	1.89	.38
25-30	97.0 (5.2)	86.68, 107.24		
31-35	83.8 (4.0)	75.99, 91.64		
Overall	94.2 (3.5)	87.31, 101.12		

Table 5. Impact of types of surgical procedures on survival time

Types of surgical procedures	Mean survival (months)	95% CI	Chi-square value	P-value
CABG	86.3 (4.1)	78.34, 94.31	8.09	.04
CABG+ Linear Plication	97.3 (5.6)	86.41, 108.21		
CABG+DORS	87.6 (11.5)	65.09, 110.11		
CABG+MV repair	64.8 (10.9)	43.23, 86.20		
Overall	94.2 (3.5)	87.32, 101.13		

dose (µg/kg per min) + dobutamine dose (µg/kg per min) + 100 × epinephrine dose (µg/kg per min) + 10 × milrinone dose (µg/kg per min) + 10,000 × vasopressin dose (units/kg per min) + 100 × norepinephrine dose (µg/kg per min), (iii) arrhythmias, (iv) ventilation status, (v) ICU stay and overall hospital stay in days, (vi) details of postoperative infections, (vii) postoperative mitral regurgitation status, (viii) 2D Echo ejection fraction, and (ix) mortality within 30 days.

IABP was used in 14 patients (9.6%). The majority of the patients had a postoperative inotrope score <5 (43.2%, N = 63) and 6-15 (43.2%, N = 63). In postop arrhythmias, ventricular premature complexes (VPC) were the predominant rhythm disturbance observed (23.3%), followed by atrial fibrillation (AF) (15.8%), and AF+VPC (4.1%).

The majority of patients were weaned off the ventilator in 24 hours (87%).

The mean ICU stay duration was 4 (3.3) days. The majority of patients (59.6%) had 3-5 days of ICU stay. The mean hospital stay duration was 10.6 (6.0) days.

The infections documented during this period were culture-positive respiratory infections (8.2%), SSI- surgical site infections (6.2%), urinary infections (2.1%), and bloodstream infections (0.7%).

The distribution of severity of MR was mild in 86.3% and moderate in 4.8%. There were no patients with severe MR.

The mean ejection fraction during the postoperative period was 39.9 (9.0%).

The frequency of <30-day mortality observed in the study population was 11 (7.5%). The causes documented were cardiac causes 9 (82%), cerebrovascular events 1 (9%), and septicemia 1 (9%).

The details of the postoperative findings are shown in Appendix Table 4.

Follow-up details (5 years): The reasons for readmissions during the follow-up period of 5 years were analyzed. The

major cause for readmission was cardiac events (68.4%). Worsening heart failure was the predominant cause for admission (26.3%), followed by admissions for CAG and PCI (23%), infections (15.7%), and for Holter monitoring (10.5%). The details are shown in Appendix Table 5.

The mean 5-year survival of the study population was 94.2 (3.5) months with 95% CI 87.32, 101.13.

Preoperative and postoperative comparison of severity of MR: Preoperative and postoperative MR severity were compared. During the preoperative period, there were six patients without MR and after the procedure, that became 13. The frequency of mild MR before surgery was 114 and after surgery, it was 126. In the moderate MR category before surgery, there were 16 patients and after the surgery, the frequency was 7. In the severe MR category, preoperative frequency was 10 and after the surgery, there were no patients with severe MR. This shows that after the surgery, there was definite improvement in the severity of MR and higher-grade MR category patients were shifted to less severe categories. The details are represented in Table 1.

Preoperative and postoperative comparison of ejection fraction: Comparison of preoperative and postoperative ejection fractions was done. The mean of preoperative EF was 29.51 (4.84%) and that of postop was 39.92 (9.0%). The analysis showed an overall improvement in EF after surgery with a significance of $P < .0001$. The details are shown in Table 2.

The predictors of <30 days mortality was examined. Among the variables selected for finding the predictors, only postoperative ventilation and postoperative arrhythmias were found as predictors for early mortality. The details are represented in Table 3.

Association of ejection fraction and mean survival: When the association of different grades of EF and mortality was examined, there was no association observed between these two factors. Even though the study participants had

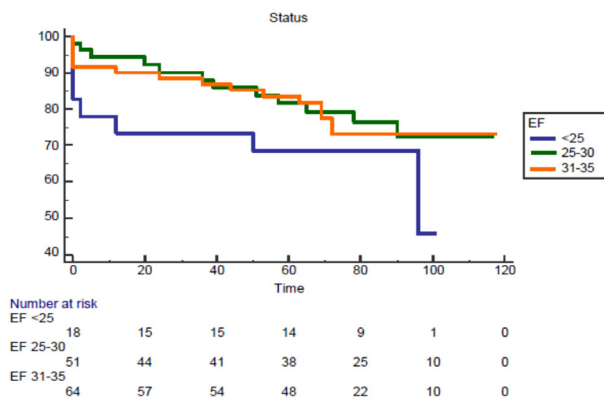


Figure 1. Kaplan-Meier curves comparing survival time across pre op ejection fraction levels.

improvement in EF after the surgery, that didn't increase their 30 days' survival. The details are represented in Table 4 and Figure 1.

When the comparison of survival time with different grades of EF was examined using Logrank test, there was no association observed between these two factors. Even though the study participants had improvement in EF after the surgery, that didn't significantly increase their <30 days' survival. The details are represented in Table 4 and Figure 1.

The comparison of survival time with type of procedure was examined by Logrank test. Among the procedures, CABG with Linear plication showed a better survival (97.3 + 5.6 months with 95% CI 86.41, 108.21) compared with other procedures with a significance of *P*.04. The details are shown in Table 5 and Figure 2.

DISCUSSION

Several studies worldwide have proven the relevance of CABG in left ventricular dysfunction [Jose 2019; Khaled 2019; Ngu 2018]. In ischemic cardiomyopathy, surgical revascularization helps to conserve the viable myocardium, reduce the ischemia, and help restore LV function. The present study attempted to examine the clinical profile and survival of CABG patients with severe LV dysfunction at different time points. This study, to the best of our knowledge, is one of the very few studies from the Indian subcontinent to explore the outcomes of surgical revascularization in ischemic cardiomyopathy patients.

The mean age of the study population was 55.6 (8.8) years, and the majority of patients were in the age group 50 to 65 years (N = 92, 63%). A male predominance was noticed (N = 138, 94.52%). The same results were seen in recent studies like Jose et al and Khalid et al [Jose 2019; Khaled 2019]. In Jose et al, it was 58.67 (9.70) years, and Khalid et al reported the same was 56.1 (12.2) years.

The major risk factors in our study were history of myocardial infarction, hypertension, diabetes mellitus, and

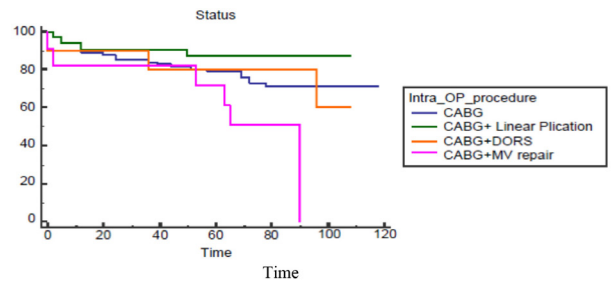


Figure 2. Kaplan-Meier curves comparing operative procedures and survival times.

smoking. Certain previous studies reported diabetes mellitus as the major risk factor [Jose 2019; Varma 2014].

Ejection fraction was <25% in 15.8% of patients. Majority of the study participants (48.6%) had EF between 31-35%. Ejection fraction improved from a mean of 29.5 (4.8 %) to 39.9 (9%) postoperatively. This improvement was statistically significant (*P* < 0.0005). The same pattern was seen in the Jose et al. and Khaled et al. studies [Jose 2019; Khaled 2019].

Most of the procedures were conducted as elective cases (97.3%). The majority of patients had NYHA class 2 or 3 symptoms of dyspnea and angina (78.1%). A history of previous acute coronary syndrome was seen in 80% of the study population. Among the 146 patients, 78.8% had triple vessel disease. All of these factors were varied in different studies [Jose 2019; Varma 2014; Davoodi 2012; Popovic 2017].

In the preoperative period, only 4% of the study patients were without any mitral regurgitation (MR). At the same time, 78% had mild MR. This shows how closely MR is associated with severe LV dysfunction, in the natural history of ischemic cardiomyopathy. Though 6.8% had severe MR preoperatively, none were found to have severe MR postoperatively. MV repair was done along with CABG in all patients with severe MR. The proportion of patients with no/mild MR increased in the postoperative group (82.2% to 95.2%), without any mitral valve intervention in most of the cases. This shows that CABG could improve the grade of mitral regurgitation, if presented in low grades before surgery.

In the study done by Campwala et al, there was decrease in grade of MR from 3.3 (0.5) to 2.3 (1.2) post-CABG. Regression of MR in the study population was associated with reductions in LV enddiastolic (*P* = .006) and endsystolic (*P* = .0005) dimensions with improvement in LVEF (*P* = .01), use of beta-blockers (*P* = .04), and lower atherosclerotic burden (*P* = .03). The study concluded that preserved myocardial viability, proper revascularization, absence of excessive atherosclerotic burden, and therapy with beta-blockers and ACE inhibitors are necessary for MR regression following CABG alone [Campwala 2005].

Average cardiopulmonary bypass (CPB) time was 124.32 (38.26) minutes and aortic cross-clamp (ACC) time was 67.45 (26.89) minutes. The CPB time in the study by Jose et al was 105.86 (27.97) minutes and the ACC time was 50.82 (17.35) minutes [Jose 2019]. Similar results were found in the study

by Khaled et al, which was 139.41 (71.10) and 91.09 (37.5) minutes, respectively [Khaled 2019]. Our study results also were compared with these studies.

Postoperative stay in hospital was found to be affected in a statistically significant manner by the development of superficial and deep wound infections, respiratory tract infections, urinary tract infections, use of intraaortic balloon pump (IABP), postoperative ventilation, and arrhythmias. In Shapira et al study, the outcomes of CABG in patients with LVEF <30% and >30% were compared [Shapira 2006]. The group with LVED <30% had a higher incidence of diabetes mellitus, COPD, peripheral vascular disease, prior MI, and fewer elective procedures compared with the group with LVEF >30%. The occurrence of respiratory (14.8% versus 1.9%, $P < .001$), renal (5.2% versus 1.0%, $P < .001$), and vascular (5.2% versus 0.5%, $P < .001$) complications was highly significant in the LV dysfunction group with a longer hospital stay (8 + 8 versus 6 + 4 days, $P < .0001$) [Ji 2017].

CABG alone group had 30-day mortality of 9.89%, while in CABG with linear plication, CABG with Dor procedure and CABG with mitral valve repair, it was 0%, 10%, and 9.09% respectively. The 30-day mortality in a similar study in patients from the Indian subcontinent by Jose et al was 11.62%. The 30-day mortality was comparable with those in other studies conducted in the western world [Elefteriades 1997; Davoodi 2012; Ji 2017]. The mean survival time was significantly less for the CABG with mitral valve repair group. This was in accordance with the western data, that higher grades of mitral valve regurgitation reduce survival rate [Elefteriades 1997; Davoodi 2012]. Mean survival in months for CABG with mitral valve repair group was 64.72 months (SD 10.96, 95% CI 43.23, 86.20) whereas the corresponding values for the CABG alone group, CABG with linear plication group, and CABG with Dor procedure group were 86.32 months (SD 4.07, 95% CI 78.34, 94.3), 97.31 months (SD 5.56, 95% CI 86.41, 108.21), and 87.6 months (SD 11.48, 95% CI 65.09, 110.11), respectively. These results clearly show that the presence of a high grade of MR, at the time of surgery, reduces the life expectancy, then the presence of a left ventricular aneurysm.

In our study, there were no associations between preoperative risk factors, such as DM, HTN, smoking, DLP, history of congestive heart failure, history of PCI, and early mortality (30-day mortality). On the contrary, some western, as well as Indian studies, showed significant associations between preoperative risk factors and perioperative mortality [Jose 2019; Khaled 2019; Shroyer 2009; Shroyer 2017].

Left internal mammary artery (LIMA) was used to graft the left anterior descending artery in 96.6% of our patients. The survival advantage of using LIMA even in patients with severe left ventricular dysfunction was shown in a study by Popovic et al. [Popovic 2017]. This could be one of the reasons for excellent midterm outcomes achieving a survival probability of up to 83%.

In 98.6% of patients, on-pump CABG was done, which is known for more complete revascularization of myocardium [Khan 2014]. This could be another reason for a better survival in our study.

CONCLUSION

Our study results have shown that surgical management offers promising results with good midterm survival in Indian patients with severe LV dysfunction after CABG and related surgical procedures. Mitral regurgitation severity is significantly reduced, and ejection fraction is improved after surgical management. This is a sicker group of patients who can have a higher incidence of postoperative complications like low cardiac output syndrome, fluid electrolyte imbalance, and arrhythmias etc, the results of which can be optimized by constant monitoring and maximizing patient care, thereby reducing the immediate mortality. Large, multi-center prospective studies with maintenance of a central registry for cardiovascular procedures are needed to evaluate and improve the morbidity and mortality associated with these procedures.

REFERENCES

- Ajay VS, Prabhakaran D. 2010. Coronary heart disease in Indians: implications of the INTERHEART study. *Indian J Med Res.* 132:561–566.
- Campwala SZ, Bansal RC, Wang N, Razzouk A, Pai RG. 2005. Factors affecting regression of mitral regurgitation following isolated coronary artery bypass surgery. *Eur J Cardiothorac Surg.* Nov;28(5):783-7.
- Davoodi S, Sheikvatan M, Karimi A, Ahmadi SH, Goodarzynejad H, Fathollahi MS. 2012. Outcomes and long-term quality of life of patients with severe left ventricular dysfunction who underwent coronary artery bypass surgery. *Gen Thorac Cardiovasc Surg.* Apr;60(4):202-12.
- Elefteriades JA, Morales DL, Gradel C, Tollis G, Levi E, Zaret BL. 1997. Results of coronary artery bypass grafting by a single surgeon in patients with left ventricular ejection fractions $\leq 30\%$. *Am J Cardiol.* 79:1573–1578.
- Gupta R, Joshi P, Mohan V, Reddy KS, Yusuf S. 2008. Epidemiology and causation of coronary heart disease and stroke in India. *Heart.* 94:16–26.
- Ji Q, Xia LM, Shi YQ, et al. 2017. Impact of severe left ventricular dysfunction on in-hospital and mid-term outcomes of Chinese patients undergoing first isolated off-pump coronary artery bypass grafting. *J Cardiothorac Surg.* 12(1):87. Published 2017 Oct 10.
- Jose R, Shetty A, Krishna N, Chathoth V, Bhaskaran R, Jayant A, Varma PK. 2019. Early and Mid-Term Outcomes of Patients Undergoing Coronary Artery Bypass Grafting in Ischemic Cardiomyopathy. *J Am Heart Assoc.* May 21;8(10):e010225.
- Khaled S, Kasem E, Fadel A, Alzahrani Y, Banjar K, Al-Zahrani W, Alsulami H, Allhyani MA. 2019. Left ventricular function outcome after coronary artery bypass grafting, King Abdullah Medical City (KAMC)-single-center experience. *Egypt Heart J.* Aug 5;71(1):2.
- Khan MS, Islam MY, Ahmed MU, Bawany FI, Khan A, Arshad MH. 2014. On pump coronary artery bypass graft surgery versus off pump coronary artery bypass graft surgery: a review. *Glob J Health Sci.* 6(3):186-193.
- Kumar S, Agarwala S, Talbot C, Nair RU. 2008. Long term survival after coronary endarterectomy in patients undergoing combined coronary and valvular surgery--a fifteen year experience. *J Cardiothorac Surg.* Mar 26;3:15.
- Ngu JMC, Ruel M, Sun LY. 2018. Left ventricular function recovery after revascularization: comparative effects of percutaneous coronary

intervention and coronary artery bypass grafting. *Curr Opin Cardiol*. Nov;33(6):633-637.

Popovic B, Maureira P, Juilliere Y, Danchin N, Voilliot D, Vanhuyse F, Villemot JP. 2017. Bilateral vs unilateral internal mammary revascularization in patients with left ventricular dysfunction. *World J Cardiol*. Apr 26;9(4):339-346.

Shapira OM, Hunter CT, Anter E, Bao Y, DeAndrade K, Lazar HL, Shemin RJ. 2006. Coronary artery bypass grafting in patients with severe left ventricular dysfunction-early and mid-term outcomes. *J Card Surg*. May-Jun;21(3):225-32.

Shroyer AL, Grover FL, Hattler B, Collins JF, McDonald GO, Kozora E, Lucke JC, Baltz JH, Novitzky D. 2009. Veterans Affairs Randomized On/Off Bypass (ROOBY) Study Group. On-pump versus off-pump coronary-artery bypass surgery. *N Engl J Med*. Nov 5;361(19):1827-37.

Shroyer AL, Hattler B, Grover FL. 2017. Five-Year Outcomes after On-Pump and Off-Pump Coronary-Artery Bypass. *N Engl J Med*. Nov 9;377(19):1898-1899.

Varma PK, Krishna N, Jose RL, Madkaiker AN. 2017. Ischemic mitral regurgitation. *Ann Card Anaesth*. 20:432-9.

Varma P, Kundan S, Ananthanarayanan C, Panicker VT, Pillai VV, Sarma PS, Karunakaran J. 2014. Demographic profile, clinical characteristics and outcomes of patients undergoing coronary artery bypass grafting-retrospective analysis of 4,024 patients. *Indian J Thorac Cardiovasc Surg*. 30:272-277.

Velazquez EJ, Lee KL, Deja MA, Jain A, Sopko G, Marchenko A, Ali IS, Pohost G, Gradi-nac S, Abraham WT, Yii M, Prabhakaran D, Szwed H, Ferrazzi P, Petrie MC, O'Connor CM, Panchavinnin P, She L, Bonow RO, Rankin GR, Jones RH, Rouleau JL; STICH Investigators. 2011. Coronary-artery bypass surgery in patients with left ventricular dysfunction. *N Engl J Med*. Apr 28;364(17):1607-16.

Velazquez EJ, Lee KL, Jones RH, Al-Khalidi HR, Hill JA, et al.; STICHES Investigators. 2016. Coronary-artery bypass surgery in patients with ischemic cardiomyopathy. *N Engl J Med*. 374:1511-1520.

Xavier D, Pais P, Devereaux PJ, Xie C, Prabhakaran D, Reddy KS, Gupta R, Joshi P, Kerkar P, Thanikachalam S, Haridas KK, Jaison TM, Naik S, Maity AK, Yusuf S. 2008. CREATE registry investigators. Treatment and outcomes of acute coronary syndromes in India (CREATE): a prospective analysis of registry data. *Lancet*. Apr 26;371(9622):1435-42.