ISAR Journal of Medical and Pharmaceutical Sciences
Vol-2, Iss-5 (May- 2024)
Abbriviate Title- ISAR J Med Pharm Sci
ISSN *(Online)*- 2584-0150
https://isarpublisher.com/journal/isarjmps
OPEN ACCESS

Post-operative Left Ventricular Ejection Fraction in Patients Undergoing Coronary Artery Bypass Grafting: A Descriptive Cross-Sectional Study

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Article History
Received: 14.04.2024
Accepted: 19.05.2024
Published: 25.05.2024

Abstract:

Introduction: Coronary artery disease (CAD) remains a significant cause of morbidity and mortality worldwide, often leading to heart failure (HF). The incidence of systolic myocardial dysfunction among CAD patients is increasing, partly due to improved survival after acute myocardial infarction (MI). Re-vascularization, particularly coronary artery bypass grafting (CABG), is recommended over percutaneous coronary intervention (PCI) in patients with reduced left ventricular ejection fraction (LVEF) and multi-vessel CAD, according to European guidelines.

Objective: To ascertain the mean post-operative left ventricular ejection fraction in patients undergoing coronary artery bypass grafting at a tertiary care hospital in Karachi.

To compare the mean post-operative left ventricular ejection fraction in patients undergoing single versus multiple arterial coronary artery bypass grafts.

Study Design: Descriptive Cross-Sectional Study

Setting: Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan.

Duration: From January 24, 2022, to October 23, 2022.

Participants: Patients meeting inclusion criteria and attending NICVD, Karachi, were enrolled after obtaining informed consent.

Data Collection: Left ventricular ejection fraction (LVEF) assessments were conducted one week post-procedure and at six months. Data were electronically recorded for analysis.

Results: The study included 105 patients with a mean age of 55.06 ± 10.02 years, comprising 71 (67.6%) males and 34 (32.4%) females. Post-operative LVEF at 1st week, 3rd month, and 6th month averaged 36.4 ± 3.1, 44.6 ± 6.1, and 52.5 ± 6.0, respectively. Comparison revealed a significant difference in mean post-operative LVEF at 6 months between patients receiving single arterial (49.6 ± 5.9) versus multiple arterial grafts (52.8 ± 6.1) (P = 0.007).

Conclusion: This study underscores a substantial difference in mean post-operative LVEF between patients undergoing single versus multiple arterial coronary artery bypass grafts. Further well-controlled prospective trials are warranted to corroborate these findings.

Keywords: *CABG, Coronary Artery Bypass Graft, Left Ventricular Ejection Fraction, Prevalence*.

Cite this article:
Hassan, D.H., Talreja, D.C., Baig, U., Kumar, D.K., Zahid, D.R., Murtaza, D.G., (2024). Post-operative Left Ventricular Ejection Fraction in Patients Undergoing Coronary Artery Bypass Grafting: A Descriptive Cross-Sectional Study. *ISAR Journal of Medical and Pharmaceutical Sciences*, *2*(5), 59-72.

Introduction

Cardiovascular diseases rank among the leading causes of morbidity and mortality globally [1]. According to the World Health Organization (WHO), approximately 17.9 million individuals succumb to cardiovascular disease annually, with projections indicating a staggering 23 million deaths by 2030 [2]. Chief among these conditions is coronary heart disease (CHD), characterized by the narrowing or blockage of cardiac arteries due to atherosclerosis. Coronary artery bypass grafting (CABG) stands as a widely performed surgical intervention aimed at enhancing myocardial perfusion. Its effectiveness in prolonging life expectancy and enhancing quality of life among patients with multi-vessel coronary disease is well-documented [3,4]. By

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grafting a healthy artery or vein from elsewhere in the body to bypass occluded coronary arteries, CABG restores vital blood flow to the heart.

While CABG remains the gold standard for coronary artery disease treatment, the use of multiple arterial grafts (MAGs) has emerged as a superior strategy, offering enhanced patency and long-term survival benefits compared to venous grafts [5]. Evidence spanning over two decades supports improved long-term survival among patients receiving multiple arterial grafts during CABG [6]. However, the adoption of MAGs in clinical practice remains limited [5]. Despite advancements in medical and surgical management, addressing coronary artery disease in patients with left ventricular (LV) dysfunction poses ongoing challenges. Studies have reported variable outcomes regarding postoperative left ventricular ejection fraction (LVEF) following CABG, with some demonstrating improvements [9,10], while others note no change [11,12] or even a decline in ventricular function [13,14]. Our study aims to determine post-operative LVEF and compare outcomes between patients undergoing single and multiple arterial coronary artery bypass grafting. The findings will inform pre- and post-operative management strategies, aiding cardiothoracic surgeons in selecting the most appropriate techniques to optimize clinical outcomes in CABG patients.

Literature Review:

Left ventricular ejection fraction (LVEF) serves as a pivotal metric in assessing cardiac function, with implications spanning diagnostic, prognostic, and therapeutic domains [15,16]. Its quantification provides insights into myocardial contractility and aids in delineating various cardiovascular pathologies [16]. Techniques for LVEF measurement include echocardiography, magnetic resonance imaging (MRI), computed tomography (CT), and nuclear cardiac imaging [17,18]. Clinical significance of LVEF extends to risk stratification in cardiovascular disease management. Notably, LVEF guides the indication for implantable cardioverter-defibrillator (ICD) placement post-myocardial infarction, as demonstrated by the MADIT II trial [19,20,27]. Additionally, LVEF influences therapeutic decisions in heart failure (HF), serving as a prognostic indicator and guiding the selection of interventions such as aortic valve replacement and mitral valve surgery [21,22,23,28].

Beyond cardiovascular disease, LVEF monitoring assumes significance in oncology, particularly during cardiotoxic chemotherapy. Reduced LVEF prompts reevaluation of cancer treatment strategies, emphasizing the interdisciplinary nature of care in cardio-oncology units [24-28]. Assessment of left ventricular function encompasses not only quantitative metrics like LVEF but also qualitative evaluations such as tissue Doppler imaging and stress echocardiography, which offer insights into myocardial mechanics and response to physiological stressors [29,30,42].

In clinical practice, understanding the determinants of left ventricular performance is crucial. Factors such as preload, after-load, and contractility influence cardiac output and thereby impact overall cardiovascular function [31-43]. Given the high morbidity and mortality associated with heart disease, effective management strategies are paramount. Comprehensive care involves risk factor modification, timely intervention based on LVEF assessment, and addressing comorbidities to optimize outcomes [44-48]. The multifaceted role of LVEF underscores its significance across various disciplines, serving as a cornerstone in cardiovascular assessment and management.

Materials & Methods:

Study Design: A descriptive cross-sectional study was conducted.

Study Setting: The study was carried out at the Department of Cardiac Surgery, National Institute of Cardiovascular Disease (NICVD), Karachi.

Duration of Study: The study spanned nine months, commencing from January 24, 2022, to October 23, 2022, following approval of the synopsis.

Sample Size: The sample size of 105 patients was determined using the WHO sample size calculator, with a mean LVEF after CABG of 35.00±10.4087, a margin of error of 2%, and a confidence level of 95%.

Sampling Technique: Non-probability consecutive sampling was employed.

Inclusion Criteria: Patients with multi-vessel coronary artery disease who underwent isolated CABG surgery (multiple/single arterial coronary bypass graft surgery), irrespective of duration. Both genders. Age between 30 to 70 years. Patients willing to provide consent.

Exclusion Criteria:

Severe LV dysfunction (ejection fraction <30% by echocardiogram). Patients who experienced an acute myocardial infarction within 24 hours before surgery. Unstable hemodynamics. Malignant ventricular arrhythmia.

Data Collection: Following approval from the Ethical Committee of NICVD Karachi, patients meeting the inclusion criteria provided written informed consent. Detailed history, physical examination, and baseline investigations were conducted. LVEF was measured using echocardiography, and a predesigned questionnaire collected demographic data, comorbidities, and smoking status. LVEF was assessed postoperatively after one week and at six months.

Data Analysis: Data was analyzed using SPSS (Version 25.0). Descriptive statistics were calculated for quantitative variables, while categorical variables were expressed as frequencies and percentages. Independent t-test/Mann Whitney U test was used to compare mean LVEF with types of CABG. Stratification was performed to control for effect modifiers, and a p value ≤0.05 was considered statistically significant.

Results:

In this study, 105 patients were included to assess the mean post-operative left ventricular ejection fraction (LVEF) in patients undergoing coronary artery bypass graft (CABG) and to compare the mean post-operative LVEF in patients undergoing single versus multiple arterial CABG at a tertiary care hospital in Karachi. The distribution of continuous variables was tested using the Shapiro-Wilk test for various parameters including age, weight, height, body mass index (BMI), duration of multi-vessel disease, preoperative LVEF, and postoperative LVEF at 1st week, 1st month, and 6th month, as shown in Table 1. The mean ± SD of age was 55.06 ± 10.02 years (95% CI: 53.12 - 57.00), weight was 61.6 ± 12.3 kg (95% CI: 59.21 - 63.98), height was 162.3 ± 16.3 cm

(95% CI: 159.14 - 165.45), and BMI was 26.5 ± 5.3 kg/m^2 (95% CI: 25.47 - 27.52), as shown in Tables 2-5, respectively.

The mean ± SD of the duration of multivessel disease was 5.9 ± 1.9 months (95% CI: 5.53 - 6.26), preoperative LVEF was 33.9 ± 2.9% (95% CI: 33.33 - 34.46), and postoperative LVEF at 1st week, 1st month, and 3rd month were 36.4 ± 3.1%, 44.6 ± 6.1%, and 52.5 ± 6.0%, respectively, as shown in Tables 6-9. In terms of gender distribution, 71 (67.6%) patients were male, and 34 (32.4%) were female, as illustrated in Figure 3. Diabetes mellitus was documented in 40 (38.1%) patients (Figure 4), hypertension in 61 (58.1%) patients (Figure 5), renal impairment in 28 (26.7%) patients (Figure 6), old ischemic heart disease in 23 (21.9%) patients (Figure 7), and dyslipidemia in 36 (34.3%) patients (Figure 8). Out of 105 patients, 49 (46.7%) were smokers, while 56 (53.3%) were non-smokers (Figure 9). Single arterial graft was noted in 50 (47.6%) patients, while 55 (52.4%) had multiple arterial grafts (Figure 10). Comparing the mean postoperative LVEF at 6th months, it was noted as 49.6 ± 5.9 versus 52.8 ± 6.1 among patients with single arterial versus multiple arterial grafts, with a significant P-value of 0.007, as shown in Table 11. Stratification of age group, gender, BMI, comorbidities (diabetes mellitus, hypertension, renal impairment, dyslipidemia, and old ischemic heart disease), and smoking status was conducted with respect to postoperative LVEF at 6th month to assess statistical differences.

TABLE # 1
DESCRIPTIVE STATISTICS OF SHAPIRO-WILK TEST
n=105

VARIABLE	MEAN±SD	P-VALUE
AGE (years)	55.06±10.02	0.072
WEIGHT (kg)	61.6±12.3	0.136
HEIGHT (cm)	162.3±16.3	0.359
BMI (kg/m²)	26.5±5.3	0.545
DURATION OF MULTI-VESSEL (days)	5.9±1.9	0.450
PREOPERATIVE LVEF (%)	33.9±2.9	0.194
POSTOPERATIVE LVEF AT 1st WEEK (%)	36.4±3.1	0.421
POSTOPERATIVE LVEF AT 3rd MONTH (%)	44.6±6.1	0.187
POSTOPERATIVE LVEF AT 6th MONTH (%)	52.5±6.0	0.840

TABLE # 2
DESCRIPTIVE STATISTICS OF AGE
n=105

MEAN	55.06 (years)
STANDARD DEVIATION	10.02
95% CONFIDENCE INTERVAL	53.12.......57.00
MINIMUM	30
MAXIMUM	70
RANGE	40

TABLE # 3
DESCRIPTIVE STATISTICS OF WEIGHT
n=105

MEAN	61.6 (kg)
STANDARD DEVIATION	12.3
95% CONFIDENCE INTERVAL	59.21.......63.98
MINIMUM	50
MAXIMUM	100
RANGE	50

TABLE # 4
DESCRIPTIVE STATISTICS OF HEIGHT
n=105

MEAN	162.3 (cm)
STANDARD DEVIATION	16.3
95% CONFIDENCE INTERVAL	159.14.......165.45
MINIMUM	138
MAXIMUM	186
RANGE	48

TABLE # 5
DESCRIPTIVE STATISTICS OF BODY MASS INDEX
n=105

MEAN	26.5 (kg/m^2)
STANDARD DEVIATION	5.3
95% CONFIDENCE INTERVAL	25.47.......27.52
MINIMUM	18
MAXIMUM	36
RANGE	18

TABLE # 6
DESCRIPTIVE STATISTICS FOR DURATION OF MULTIVESSEL DISEASE
n=105

MEAN	5.9 (days)
STANDARD DEVIATION	1.9
95% CONFIDENCE INTERVAL	5.53.......6.26
MINIMUM	1
MAXIMUM	12
RANGE	11

TABLE # 7
DESCRIPTIVE STATISTICS OF PREOPERATIVE LVEF
n=105

MEAN	33.9 (%)
STANDARD DEVIATION	2.9
95% CONFIDENCE INTERVAL	33.33.......34.46
MINIMUM	30
MAXIMUM	42
RANGE	12

TABLE # 8
DESCRIPTIVE STATISTICS OF POSTOPERATIVE LVEF AFTER 1ST WEEK
n=105

MEAN	36.4 (%)
STANDARD DEVIATION	3.1
95% CONFIDENCE INTERVAL	35.80…….36.99
MINIMUM	35
MAXIMUM	45
RANGE	10

TABLE # 9
DESCRIPTIVE STATISTICS FOR POSTOPERATIVE LVEF AT 3rd MONTHS
n=105

MEAN	44.6 (%)
STANDARD DEVIATION	6.1
95% CONFIDENCE INTERVAL	43.41…….45.78
MINIMUM	40
MAXIMUM	60
RANGE	20

TABLE # 10
DESCRIPTIVE STATISTICS FOR POSTOPERATIVE LVEF AT 6th MONTHS
n=105

MEAN	52.5 (%)
STANDARD DEVIATION	6.0
95% CONFIDENCE INTERVAL	51.33…….53.66
MINIMUM	43
MAXIMUM	64
RANGE	21

FIGURE # 3
FREQUENCY OF GENDER
n=105

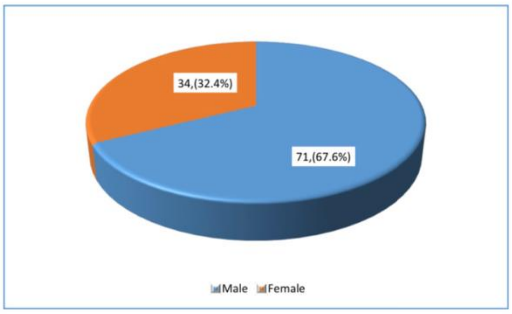

FIGURE # 4
FREQUENCY OF DIABETES MELLITUS
n=105

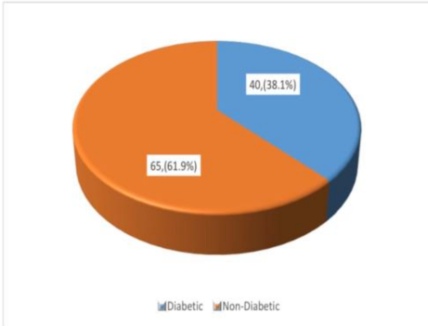

FIGURE # 5
FREQUENCY OF HYPERTENSION
n=105

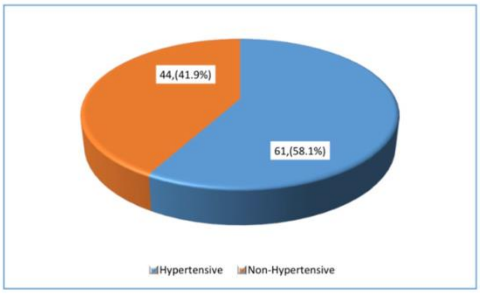

FIGURE # 6
FREQUENCY OF RENAL IMPAIRMENT
n=105

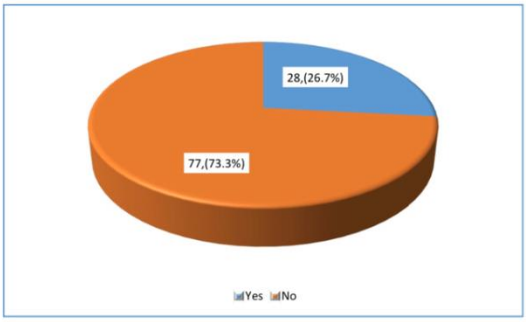

FIGURE # 7
FREQUENCY OF OLD ISCHEMIC HEART DISEASE
n=105

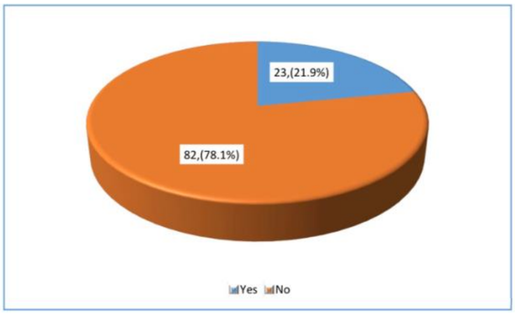

FIGURE # 8
FREQUENCY OF DYSLIPIDEMIA
n=105

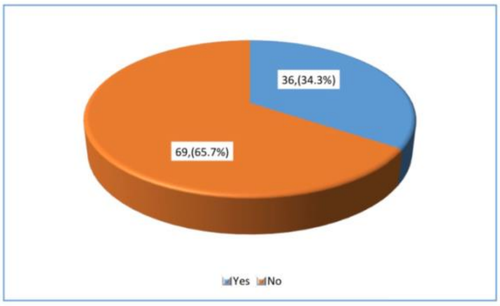

FIGURE # 9
FREQUENCY OF SMOKING STATUS
n=105

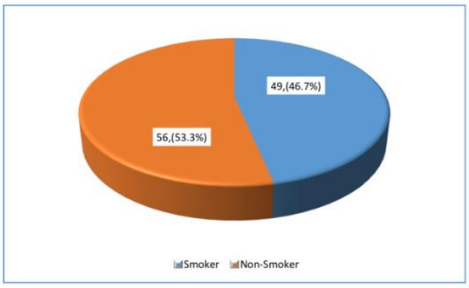

FIGURE # 10
FREQUENCY FOR TYPE OF GRAFT
n=105

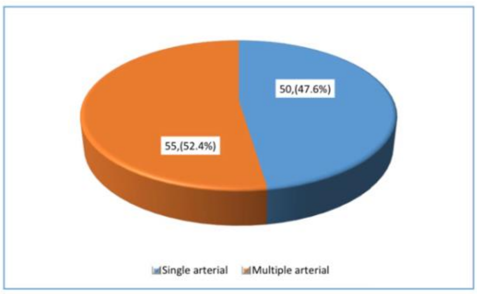

TABLE # 11
COMPARISON OF POSTOPERATIVE LVEF AT 6 MONTHS WITH TYPE OF GRAFT
n=105

TYPE	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Single Arterial	49.6	5.9	0.007
Multiple Arterial	52.8	6.1	

Applied Independent t-test

TABLE # 12
STRATIFICATION OF AGE GROUP WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

AGE GROUP [In years]	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
30 – 50	48.5	5.7	0.0005
>50	53.7	6.4	

Applied Independent t-test

TABLE # 13
STRATIFICATION OF GENDER WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

GENDER	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Male	53.4	6.2	0.036
Female	50.7	5.9	

Applied Independent t-test

TABLE # 14
STRATIFICATION OF BODY MASS INDEX WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

BMI [In kg/m^2]	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
18 – 24	47.3	5.4	0.0001
>24	56.2	6.8	

Applied Independent t-test

TABLE # 15
STRATIFICATION OF DIABETES MELLITUS WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

DIABETES MELLITUS	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Diabetic	44.8	5.5	0.0001
Non-Diabetic	58.6	6.7	

Applied Independent t-test

TABLE # 16
STRATIFICATION OF HYPERTENSION WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

HYPERTENSION	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Hypertensive	43.9	5.6	0.0001
Non-Hypertensive	59.8	6.8	

Applied Independent t-test

TABLE # 17
STRATIFICATION OF RENAL IMPAIRMENT WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

RENAL IMPAIRMENT	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Yes	45.3	5.4	0.0001
No	56.8	6.6	

Applied Independent t-test

TABLE # 18
STRATIFICATION OF DYSLIPIDEMIA WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

DYSLIPIDEMIA	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Yes	48.6	5.8	0.0001
No	54.2	6.5	

Applied Independent t-test

TABLE # 19
STRATIFICATION OF OLD ISCHEMIC HEART DISEASE WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

OLD ISCHEMIC HEART DISEASE	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Yes	47.1	5.7	0.0001
No	55.3	6.9	

Applied Independent t-test

TABLE # 20
STRATIFICATION OF SMOKING STATUS WITH POSTOPERATIVE LVEF AT 6 MONTHS
n=105

SMOKING STATUS	POSTOPERATIVE LVEF		P-VALUE
	Mean	±SD	
Smoker	48.3	5.2	0.0001
Non-Smoker	53.5	6.4	

Applied Independent t-test

Discussion:

Patients with severe coronary artery disease and advanced left ventricular dysfunction face a challenging prognosis, often leading to reluctance in considering coronary artery bypass grafting (CABG) as a viable therapeutic option. Despite the poor prognosis associated with advanced left ventricular dysfunction, there has been hesitancy in adopting CABG as an early intervention due to concerns about operative risks and doubts about its efficacy in reversing the course of the disease [45-48]. Historically, there has been controversy surrounding the role of isolated CABG in patients with severe left ventricular dysfunction. Concerns about graft patency and inadequate runoff in patients with extensive myocardial scar have contributed to the skepticism regarding the effectiveness of CABG in this patient population [49].

Studies have shown that advanced left ventricular dysfunction resulting from coronary artery disease is associated with a dismal outlook under medical therapy alone. The exclusion of patients with advanced left ventricular dysfunction from large multicenter trials of CABG further highlights the challenge in managing this patient population [50]. The selection of patients who will benefit from coronary revascularization remains a complex issue. While some patients may experience symptomatic relief and improved survival following CABG, others may not derive significant benefits. Factors such as recruitable contractile reserve and the primary indication for surgery (angina vs. heart failure) have been identified as important determinants of postoperative improvement in left ventricular function [51-54].

Comparing our study findings with those of other studies, we observed similarities in patient demographics and postoperative outcomes. The mean age of our study population and the distribution of gender were consistent with findings from previous studies [55-57]. Additionally, the postoperative LVEF values in our study were comparable to those reported in the literature [58,59]. Despite advancements in medical therapy and surgical techniques, managing patients with left ventricular dysfunction and coronary artery disease remains challenging. While CABG has demonstrated superiority over medical therapy alone in improving long-term survival, it is also associated with higher postoperative morbidity and mortality rates, particularly in patients with low ejection fraction [60-64].

Studies investigating early postoperative changes in left ventricular function have produced conflicting results, highlighting the complexity of managing these patients. Therefore, identifying predictors of adverse outcomes is crucial for guiding clinical decision-making and optimizing patient care [65]. In our study, we found significant differences in various confounders/effect modifiers with respect to postoperative LVEF at 6 months, underscoring the importance of considering these factors in patient risk stratification and treatment planning [66-80].

Our study sheds light on the complexities surrounding coronary artery bypass grafting (CABG) in patients with severe coronary artery disease and advanced left ventricular dysfunction. Despite the challenges and controversies, our findings underscore the importance of CABG as a viable therapeutic option for improving long-term survival and clinical outcomes in this patient population. The significant improvements in postoperative left ventricular ejection fraction observed in our study, along with the identification of various predictors of adverse outcomes, provide valuable insights for guiding clinical decision-making. Moving forward, further research is warranted to explore optimal patient selection criteria, refine surgical techniques, and elucidate the underlying mechanisms driving postoperative ventricular improvement. By addressing these key areas, we can enhance the efficacy and safety of CABG for patients with severe coronary artery disease and advanced left ventricular dysfunction, ultimately improving their quality of life and long-term prognosis."

Recommendations

Optimal Patient Selection: Develop refined criteria for selecting patients with severe coronary artery disease and advanced left ventricular dysfunction who are most likely to benefit from coronary artery bypass grafting (CABG). This may involve comprehensive preoperative assessment, including evaluation of ventricular function, comorbidities, and risk factors.

Surgical Techniques: Continuously refine surgical techniques to optimize outcomes in patients undergoing CABG with advanced left ventricular dysfunction. This includes exploring minimally invasive approaches, graft selection strategies, and intraoperative monitoring techniques to improve graft patency and myocardial revascularization.

Postoperative Monitoring: Implement standardized protocols for postoperative monitoring and management of patients with severe coronary artery disease and advanced left ventricular dysfunction undergoing CABG. This includes close surveillance of left ventricular function, early detection of complications, and timely interventions to prevent adverse outcomes.

Multidisciplinary Care: Foster collaboration among multidisciplinary teams, including cardiologists, cardiac surgeons, intensivists, and rehabilitation specialists, to provide comprehensive care for patients undergoing CABG with advanced left ventricular dysfunction. This integrated approach can optimize perioperative management and long-term outcomes.

Patient Education and Support: Provide tailored education and support to patients undergoing CABG with advanced left ventricular dysfunction, emphasizing the importance of adherence to medication regimens, lifestyle modifications, and cardiac rehabilitation programs to optimize postoperative recovery and long-term prognosis.

Further Research: Encourage further research to elucidate the underlying mechanisms driving postoperative ventricular improvement, identify novel therapeutic targets, and evaluate the long-term impact of CABG on survival, quality of life, and healthcare resource utilization in patients with severe coronary artery disease and advanced left ventricular dysfunction.

Implementing these recommendations can contribute to improving the efficacy, safety, and long-term outcomes of CABG in patients with severe coronary artery disease and advanced left ventricular dysfunction.

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