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Impact of Percutaneous Coronary Intervention on Prognosis and Left Ventricular Function in Patients with Ischemic Cardiomyopathy

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Abstract

Background: While coronary artery bypass grafting (CABG) has demonstrated clinical benefit in the management of ischemic cardiomyopathy (ICM), the therapeutic role of percutaneous coronary intervention (PCI) in this setting continues to be a topic of active investigation and clinical controversy. A significant gap in evidence remains regarding the influence of PCI on myocardial function and durable clinical prognosis in ICM patients.

Aim of Study: The aim of the study is to determine the clinical impact of PCI on left ventricular (LV) function and clinical endpoints in ICM patients, assessed at three and six months post-procedure.

Patients and Methodology: This prospective cohort study was undertaken Cardiology Department of Alexandria Main University Hospitals. Sixty patients with stable ICM, characterized by a left ventricular ejection fraction (LVEF) below 40% combined with significant coronary artery disease (CAD), were enrolled in this study. PCI was conducted following established clinical guidelines. Patients were monitored at 3-month and 6-month intervals post-intervention. The outcomes comprised alterations in LVEF and clinical prognosis, encompassing hospitalization and cardiovascular mortality.

Results: LVEF significantly improved from 35.2% ± 5.1 at baseline to 39.8% ± 6.0 at six months ($p < 0.01$). Cardiac-related hospitalizations and mortality significantly improved. Statistically significant associations were observed between changes in LVEF and clinical prognosis. At the 6-month time point, statistically meaningful differences in EF were noted based on PCI location, specifically for left anterior descending (LAD) PCI ($p = 0.019$), left circumflex (LCX) PCI ($p = 0.025$), and right coronary artery (RCA) PCI ($p = 0.044$).

Conclusion: PCI in ICM patients led to significant improvements in LV function, which were strongly associated with improved clinical outcomes, reduced improvements in EF were linked to increased rates of hospitalization and mortality.

Key Words: *Percutaneous coronary intervention (PCI), prognosis, Ischemic cardiomyopathy (ICM).*

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Introduction

ISCHEMIC cardiomyopathy (ICM) is characterized by significant LV systolic dysfunction, typically defined by a LVEF of less than 40%, and is primarily a result of severe CAD or acute myocardial infarction (AMI). **[1]** ICM is the leading etiological factor of heart failure (HF) and impaired LV function. **[2]** Globally, ischemic

Abbreviations and Acronyms:

6MWT	: Six-Minute Walk Test
ACS	: Acute Coronary Syndrome
AMI	: Acute myocardial infarction
BCIS-JS	: British Cardiovascular Intervention Society Myocardial Jeopardy Score
BP	: Blood Pressure
CABG	: Coronary Artery Bypass Grafting
CAD	: Coronary Artery Disease
CCS	: Canadian Cardiovascular Society
CMR	: Cardiac Magnetic Resonance
CTO	: Chronic Total Occlusion
CVD	: Cardiovascular disease
DM	: Diabetes Mellitus
DSE	: Dobutamine Stress Echocardiography
EF	: Ejection Fraction
HF	: Heart Failure
HR	: Heart Rate
HTN	: Hypertension
ICM	: Ischemic Cardiomyopathy
IHD	: Ischemic Heart Disease
INR	: International Normalised Ratio
LAD	: Left Anterior Descending
LCX	: Left Circumflex
LM	: Left Main
LV	: Left Ventricle
LVEF	: Left Ventricular Ejection Fraction
MR	: Mitral Regurgitation
NYHA	: New York Heart Association
OMT	: Optimal Medical Therapy
PCI	: Percutaneous Coronary Intervention
PDA	: Posterior Descending Artery
PET	: Positron Emission Tomography
PT	: Prothrombin Time
PTT	: Partial Thromboplastin Time
REVIVED-BCIS2	: Revascularization for Ischemic Ventricular Dysfunction–British Cardiovascular Intervention Society Trial 2
RCA	: Right Coronary Artery
SVG	: Saphenous Vein Grafts
STICH	: Surgical Treatment for Ischemic Heart Failure
SYNTAX	: Synergy between PCI with Taxus and Cardiac Surgery Score
WMSI	: Wall Motion Score Index.

heart disease (IHD) persists as the predominant factor associated with adverse health outcomes and mortality. **[3]** In Egypt, cardiovascular disease (CVD) has remained the leading cause of premature mortality since the 1990s. In 2017, CVD was responsible for 46.2% of all deaths across the country. **[4]** The Egyptian cross-sectional CardioRisk project further emphasized the high prevalence of premature acute coronary syndrome (ACS), affecting 46% of men aged below 55 years and 67% of women aged below 65 years. **[5]** According to 2020 World Health Organization (WHO) data, coronary heart disease accounted for 173,871 deaths in Egypt, representing 32.40% of all-cause mortality. The age-adjusted death rate was reported at 268.11 per 100,000 population, placing Egypt 15th globally in coronary heart disease-related mortality. **[6]**

The predominant indication for coronary revascularization in ICM is the reduction of persistent myocardial ischemia and the restoration of function in hibernating myocardium. **[7]** Although the precise relationships among measures of resting coronary flow, flow reserve and indices of myocardial performance remain a subject of ongoing debate, revascularization offers multiple potential benefits. **[8]** At the cellular level, revascularization improves metabolic function within ischemic myocardial tissue. **[9]** Restoration of coronary blood flow leads to enhanced metabolic processes and improved cellular function. **[8,10]** Furthermore, revascularization may facilitate the reversal of LV remodeling, resulting in improved LV volumes and contractile performance. **[11]** Data derived from observational research and meta-analytic reviews have indicated that restoration of function in dysfunctional myocardial segments is linked to improved clinical outcomes, including a reduction in HF symptoms and mortality. **[12]** However, robust evidence demonstrating the superiority of revascularization over optimal medical management alone in improving LV function or clinical outcomes remains limited. **[13]**

The most appropriate revascularization approach for patients with ICM remains undetermined, owing largely to the scarcity of contemporary randomized controlled trial data to support evidence-based clinical decision-making. A significant lack of controlled randomized studies exists directly comparing CABG and PCI in advanced ICM patients. Although randomized key trials including STICH **[14]** and REVIVED-BCIS2 **[15]** have contributed important insights into strategies for coronary revascularization, they have not comprehensively addressed the comparative efficacy of these modalities within this specific patient population. The need for further RCTs is emphasized to validate findings from observational studies, particularly in light of contemporary advancements in PCI techniques and medical therapy, which may influence patient outcomes. **[16]**

Heart team-based decision-making continues to be emphasized as a critical component in individualizing revascularization strategies, especially in complex cases involving severe LV dysfunction or multiple comorbidities. This shift underscores a more cautious approach in recommending routine revascularization, particularly PCI, for exhibiting significant left ventricular dysfunction secondary to IHD. **[17]** Current guidelines prioritize careful patient selection through a multidisciplinary approach, evaluating individual risks, comorbidities, and the feasibility of achieving complete revascularization. **[18]** While CABG remains the preferred approach in this patient cohort, the decision should be made based on a careful consideration of survival benefits, procedural risks, and patient-specific factors. **[19]**

Aim of The Study:

The study aims to assess the therapeutic effect of PCI–based revascularization on the clinical prognosis of ICM patients, specifically with respect to HF hospitalizations, cardiovascular mortality, and LV function. Outcomes were assessed at three- and six-month follow-up intervals through echocardiographic assessment of LVEF, the grading of mitral regurgitation (MR) and changes in left ventricular wall motion score index (WMSI).

Ethics Approval:

All data obtained from participants were treated with strict confidentiality. The identities of study participants were not disclosed in any reports or publications associated with this research. Before enrollment within the study, participants were thoroughly notified of the objectives, design, the potential risks and the potential advantages of participating in the research. All participants provided informed consent. Ethical clearance for the study was granted from the Ethics Committee of the Faculty of Medicine, Alexandria University, under approval number 0107765.

Patients and Methods

Research Cohort

This study involved 60 patients with a diagnosis of ICM who were subjected to PCI at Alexandria University Hospital, Smouha University Hospital and International Cardiac Center from April 2023 till April 2024 with three and six month follow-up after PCI. Patients' selection and inclusion was done based on the following inclusion criteria: (1) Patients who presented with LV systolic dysfunction due to IHD and an estimated EF of 40% or less, (2) patients should be on optimal Guidelines Directed Medical Therapy (GDMT) according to recent HF guidelines **[20]** which was subsequently titrated and customized according to tolerability.

The exclusion criteria were: (1) AMI within 4 weeks prior to enrollment. (2) acute decompensated HF within 72 hours before enrolment, (3) persistent ventricular arrhythmias occurring during the 72-hour period preceding enrollment.

Study design:

This study included 60 ICM patients eligible for PCI at Alexandria University Hospital, Smouha University Hospital and International Cardiac Center from April 2023 till April 2024 with three and six month follow-up after PCI. Patients were assigned to a treatment strategy involving PCI in conjunction with optimal medical managment. The protocol mandated that revascularization was performed on all affected proximal coronary vessels.

Assessment:

On admission, all patients underwent the following assessments: (1) detailed history taking with an emphasis on complaints, drug history, -coexisting comorbid conditions, including smoking, diabetes mellitus (DM), hypertension (HTN), and dyslipidemia, history of myocardial infarction, previous PCI or CABG; (2) comprehensive physical assessment; (3) Laboratory tests, such as complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), as well as hepatic and renal function tests, PT, PTT, INR and electrolyte levels (Sodium and Potassium); (4) Standard 12-lead electrocardiography (ECG) to identify arrhythmias, QRS complex width, presence of pathological Q waves or abnormalities in ST-segment and T-wave morphology; (5) Echocardiographic variables were analyzed in compliance with the American Society of Echocardiography recommendations: - LVEF assessed by biplane modified Simpson's method, grade of MR (Mild, moderate and severe) - WMSI **[21]**: The 16-segments LV WMSI, which involves a comprehensive assessment of LV contractility utilizing six standard echocardiographic views: parasternal long axis at basal, mid, and apical levels, along with apical 4-chamber, 3-chamber, and 2-chamber views. WMSI was determined using the standardized 17-segment model, in which each myocardial segment is assigned a score according to systolic function: normal (N) = 1, hypokinesis (H) = 2, and akinesis (A) = 3. WMSI is obtained through division of the sum of individual wall motion scores across all 17 myocardial segments by 17; (6) Coronary Angiography and PCI data: SYNTAX score **[22]** is calculated and PCI to the subtended territories is done. Residual SYNTAX score is calculated. Follow-up was conducted three and six months after PCI to assess the prognosis including HF hospitalization and cardiovascular mortality, LVEF, grade of MR and change in LV WMSI measured by echocardiography.

Statistical Methodology:

The data were digitally recorded and analyzed using IBM SPSS Statistics software, version 20.0 (Armonk, NY: IBM Corp). Qualitative data were presented as frequencies and percentages. The Shapiro-Wilk test was employed to assess the normality of data distribution. Quantitative data were summarized using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). Statistical significance was set at a p-value of less than 0.05. The Chi-square test was used to compare categorical variables across different groups. Fisher's Exact test was applied as a correction to the Chi-square test when more than 20% of the cells had an expected count of less than 5. The Student's t-test was utilized to compare normally distributed quantitative variables between the two groups. The Mann-Whitney test was applied for the comparison of abnormally distributed quantitative variables between the two groups.

Results

Demographic characteristics and clinical details

The age range of participants was 42 to 79 years, with a mean (± SD) age of 58.88 ± 9.92 years. The cohort was predominantly male, comprising 76.7% of the participants, while females constituted 23.3%. With respect to smoking status, 70.0% of the participants were current smokers, whereas 30.0% were non-smokers. DM was present in 48.3% of the cohort, while 51.7% were non-diabetic. HTN was identified in 48.3% of the participants. A history of previous ACS was the most commonly reported comorbidity, affecting 81.7% of the individuals. Prior PCI or CABG was documented in 35.0% of the cohort. Chronic kidney disease (CKD) was identified in 23.3% of participants, chronic total occlusion (CTO) was present in 41.7%, and multi-vessel CAD was prevalent in 81.7% of the study population. (Table 1)

According to the NYHA functional classification, none of the study patients were stratified into Class I or Class IV categories. A total of 51.7% of the patients were classified as Class II, while 48.3% were classified as Class III. Regarding the CCS angina grading, the majority of patients were classified as Stage 2 (55.0%) or Stage 3 (41.7%), with a minority classified as Stage 1 (3.3%).

Table (1): Demographic data.

	Number	Percent
Age (years)		
Range	42-79	
Mean±S.D.	58.88±9.920	
Gender		
Male	46	76.7
Female	14	23.3
Smoking		
No	18	30.0
Yes	42	70.0
DM	29	48.3
HTN	29	48.3
Previous ACS	49	81.7
Previous PCI or CABG	21	35.0
CKD	14	23.3
CTO	25	41.7
Multi vessel disease	49	81.7

ACS: Acute Coronary Syndrome CABG: Coronary Artery Bypass Graft
CKD: Chronic Kidney Disease CTO: Chronic Total Occlusion
DM: Diabetes Mellitus HTN: Hypertension
PCI: Percutaneous Coronary Intervention

Echocardiographic Findings

At baseline, all patients exhibited an ejection fraction (EF) of 40% or less. The EF values ranged from 25.0% to 40.0%, with a mean of 36.10 ± 4.11%. At baseline, the WMSI ranged from 1.60 to 2.50, with a mean of 1.90 ± 0.19. Assessment of mitral regurgitation (MR) at baseline revealed that 45.0% of patients had no MR, 38.3% demonstrated mild MR, 13.3% showed moderate MR, and 3.3% exhibited severe MR.

Coronary Angiographic and PCI Data

With regard to coronary angiographic findings, Left main (LM) CAD was detected in 5.0% of patients, while CTO was observed in 41.7% of cases. The number of diseased coronary vessels ranged from one to four, with a mean of 2.13 ± 0.72 vessels and a median of 2.0 vessels (interquartile range [IQR]: 2.0–3.0). The degree of coronary stenosis revealed that 71.7% of patients exhibited stenoses greater than 90%, whereas 28.3% had stenoses ranging from 70% to 90%. In terms of PCI targets, the LAD artery was the most commonly treated vessel, involved in 71.7% of cases. The LCX artery was treated in 35.0% of patients, then affecting the RCA in 28.3%, and the LM artery in 1.7% of cases. Additionally, interventions were performed on the ramus branch (3.3%), saphenous vein grafts (SVG) (1.7%), and the posterior descending artery (PDA) (1.7%). At baseline, the range of SYNTAX score was 8 to 35, with a mean of 15.78 ± 7.53. Post-procedurally, the range of the residual SYNTAX score was 0 to 25, with a mean value of 4.92 ± 7.43. (Table 2)

Follow-up Outcomes: Hospitalization and Mortality Rates

Throughout the duration of the follow-up, 68.3% of participants did not require hospitalization, whereas 31.7% were hospitalized for cardiac-related causes. No hospitalizations for non-cardiac causes were reported. The overall survival rate was 95.0%, with 5.0% of participants (n = 3) experiencing mortality during the follow-up. The total sample size comprised 60 participants.

Table (2): Coronary Angiographic and PCI Data (n = 60)

	No.	%
LM Disease	3	5.0
CTO	25	41.7
Number of diseased vessels		
Min. – Max.	1.0 – 4.0	
Mean ± SD.	2.13 ± 0.72	
Median (IQR)	2.0 (2.0 – 3.0)	
SYNTAX Score		
Min. – Max.	8 – 35	
Mean ± SD.	15.78±7.533	
Residual SYNTAX Score		
Min. – Max.	0 – 25	
Mean ± SD.	4.92±7.426	
Degree of stenosis		
70-90%	17	28.3
>90%	43	71.7
PCI		
LAD	43	71.7
LM	1	1.7
LCX	21	35.0
RCA	17	28.3
Ramus	2	3.3
SVG	1	1.7
PDA	1	1.7

Echocardiographic Data During Follow-Up

LVEF

At baseline, all patients had an EF of 40% or lower. At 3 months, 80.0% of patients maintained an EF of 40% or less, 15.0% showed improvement to a mildly reduced EF, and 5.0% achieved an EF of 50% or greater. At 6 months, 62.0% of patients remained in the reduced EF category, 29.3% improved to mildly reduced EF, and 8.6% reached an EF of 50% or more. At baseline, 6.7% of patients exhibited a LVEF below 30%, which decreased to 5.0% at 3 months but subsequently increased to 13.8% at 6 months. EF values between 30–34% were observed in 13.3% at baseline, 21.7% at 3 months, and 8.6% at 6 months. For EF between 35–40%, the percentages were 80.0% at baseline, 53.3% at 3 months, and 39.7% at 6 months. No patients had an EF in the range of 41–45% at baseline; however, 15.0% and 24.1% were recorded in this category at 3 months and 6 months, respectively. EF values between 46–50% were absent at baseline but were observed in 5.0% of patients at 3 months and 10.3% at 6 months. EF ≥50% was not present at baseline or 3 months but was recorded in 3.4% of patients at 6 months.

The minimum and maximum EF values ranged from 25.0% to 40.0% at baseline, 25.0% to 50.0% at 3 months, and 25.0% to 55.0% at 6 months. The mean EF improved from 36.10 ± 4.11% at baseline to 37.53 ± 5.59% at 3 months and 38.64 ± 6.95% at 6 months. The median EF (IQR) increased from 35.50 (35.0–40.0) at baseline to 38.0 (33.0–40.0) at 3 months and 39.0 (35.0–43.0) at 6 months. The changes in EF over time demonstrated statistical significance (p = 0.001). Statistically significant differences in LVEF were observed in pairwise comparisons between baseline and three months (p = 0.044), baseline and six months (p = 0.007), and between three months and six months (p = 0.021).

Among the 58 patients, 10.3% experienced a decline in EF, while 53.4% demonstrated a change of less than 5 percentage points. A 5-point improvement in EF was observed in 15.5% of patients, and 20.7% exhibited a 10-point improvement. Ten patients showed an EF improvement of 10 points or more, exceeding 40%. (Table 3)

Table (3): Ejection Fraction Follow-up at 3 and 6 Months

	Baseline (n = 60)		3months (n = 60)		6months (n = 58)		Test of Sig.	P
	No.	%	No.	%	No.	%		
EF								
≤40	60	100.0	48	80.0	36	62.1	Fr= 34.0*	<0.001*
41 – 49	0	0.0	9	15.0	17	29.3		
≥50	0	0.0	3	5.0	5	8.6		
Min. – Max.	25.0 – 40.0		25.0 – 50.0		25.0 – 55.0		F= 8.453*	0.003*
Mean ± SD.	36.10 ± 4.11		37.53 ± 5.59		38.64 ± 6.95			
Median (IQR)	35.50(35.0 – 40.0)		38.0(33.0 – 40.0)		39.0(35.0 – 43.0)			
Sig. bet. periods	p_1=.044*, p_2=0.007*, p_3=0.021*							

IQR: **Inter quartile range** SD: **Standard deviation** Fr: **Friedman test** *: Statistically significant p ≤ 0.05
F: F test (ANOVA) with repeated measures, significance between periods was assessed **by the Post Hoc Test with Bonferroni** adjustment
p: p value for comparisons between the studied periods
p_1: p value for comparisons between **Baseline** and **3months**
p_2: p value for comparisons between **Baseline** and **6months**
p_3: p value for comparisons between **3months** and **6months**

WMSI:

At baseline, WMSI varied from 1.60 to 2.50, with a mean of 1.90 ± 0.19. At three months, WMSI demonstrated improvement, ranging from 1.30 to 2.40, with a mean of 1.73 ± 0.207. This change was statistically significant, with a mean difference of –0.17 ± 0.195 (p < 0.001). At six months, further improvement in WMSI was observed, with values ranging from 1.23 to 2.40 and a mean of 1.72 ± 0.25. The mean change at six months was –0.18 ± 0.22, which was also statistically significant (p < 0.001).

Grading of MR

At baseline, 45.0% of patients exhibited no MR, 38.3% showed mild MR, 13.3% demonstrated moderate MR, and 3.3% presented with severe MR. At six months, the proportion of patients without MR increased to 60.3%, while the prevalence of mild MR decreased to 29.3%. The rates of moderate and severe MR remained relatively unchanged, observed in 6.9% and 3.4% of studied population, respectively. No statistically meaningful change was found in MR severity from baseline to six months (p = 0.149). (Figure 1)

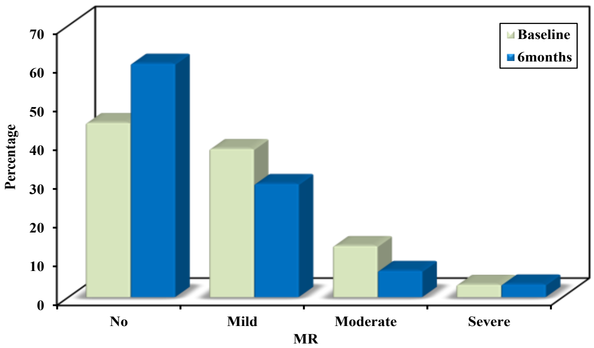

Figure (1): Analysis of MR Severity Across Baseline And Six-Month Follow-Up

Correlations of Echocardiographic Data
LVEF

Changes in LVEF were statistically significantly associated with clinical prognosis, including hospitalization and mortality. These findings suggest that improvement in EF is meaningfully related to better clinical outcomes, with higher rates of hospitalization and mortality associated with lesser improvement in EF. (Table 4)

Changes in EF were not significantly associated with any of the baseline characteristics such as gender, age, DM, HTN, history of ACS, prior PCI or CABG, presence of LM disease, degree of stenosis (p = 0.683), or the presence of CTO. This indicates that in this cohort, EF improvement was relatively independent of these parameters. Additionally, Changes in EF were not significantly correlated with the SYNTAX score.

At 3-month follow-up, revascularization of the LAD artery via PCI was significantly linked to a greater enhancement in EF, whereas PCI of other vessels did not show significant associations. Significant improvements in EF were observed by the six-month follow-up based on PCI location, specifically for LAD PCI (p = 0.019), LCX PCI (p = 0.025), and RCA PCI (p = 0.044). A mild negative correlation was observed between the number of diseased vessels and EF at both three months (r = –0.135, p = 0.304) and six months (r = –0.154, p = 0.247), although neither correlation reached statistical significance.

Table (4): Relation Between Changes in Ejection Fraction and Clinical Prognosis (n = 58)

	EF change								Test of Sig.	p
	Decline (n = 6)		< 5 points (n = 31)		5 points (n = 9)		10 points (n = 12)			
	No.	%	No.	%	No.	%	No.	%		
Hospitalization										
No	1	16.7	22	71.0	7	77.8	11	91.7	χ^2= 9.836*	^{MC}p= 0.013*
Cardiac cause	5	83.3	9	29.0	2	22.2	1	8.3		
Non-Cardiac cause	0	0.0	0	0.0	0	0.0	0	0.0		
Mortality	1	16.7	0	0.0	0	0.0	0	0.0	χ^2= 5.410	^{MC}p= 0.103

IQR: **Inter quartile range** SD: **Standard deviation** F: **F for One way ANOVA test**
H: H for **Kruskal Wallis test** χ^2: **Chi square test** **MC: Monte Carlo test**
p: p-value for the association between changes in EF and multiple variables *: Statistically significant p ≤ 0.05

WMSI

Changes in the WMSI were significantly associated with hospitalization during the follow-up periods at 3 and 6 months, with patients rehospitalized for cardiac causes demonstrating higher WMSI values compared to those who remained free of hospitalization.

No significant associations were found between WMSI and baseline clinical characteristics, including gender, age, DM, HTN, history of ACS, previous PCI) or CABG, presence of LM CAD, degree of stenosis, or presence of CTO. Furthermore, the SYNTAX score and the WMSI were not significantly correlated.

Significant differences in the WMSI were observed at three months post-intervention pertaining to the site of PCI, particularly among patients treated with interventions on the LAD and LCX (p = 0.034 and p = 0.011, respectively), Nevertheless, no substantial change was detected for PCI of the RCA (p = 0.102).

At six months post-intervention, significant differences in the WMSI were observed across all major coronary territories. PCI involving the LAD (p = 0.024), LCX (p = 0.005), and RCA (p = 0.040) showed significant associations with variations in WMSI.

Discussion

This prospective cohort study offers a detailed evaluation of patients with ICM undergoing PCI, with an emphasis on prognostic outcomes, including rates of hospitalization and mortality, as well as key parameters of LVEF, severity of MR, and WMSI. The findings were analyzed in relation to landmark clinical trials, including STICH **[14]**, REVIVED-BCIS2 **[15]**, ISCHEMIA **[23]**, among others, to situate the results within the context of existing evidence and to better elucidate their clinical significance.

Demographic Characteristic

The participants' mean age was 58.88 ± 9.92 years, comparable to cohorts in the STICH and ISCHEMIA trials **[14,23]**, and notably younger than participants in the REVIVED-BCIS2 trial **[15]**, where the mean age was approximately 70 years. The study cohort was predominantly male (76.7%), aligning with the male predominance observed in other major trials—88% in STICH, 88.4% in REVIVED, and 78.2% in ISCHEMIA. Common comorbid conditions included DM and HTN, each present in 48.3% of patients, which is consistent with prevalence rates reported in REVIVED (40% for DM, 70% for HTN) and ISCHEMIA (41% for DM, 70% for HTN). The prevalence of smoking was notably high in this cohort at 70%, comparable to REVIVED and significantly higher than the 21% reported in STICH.

The relatively younger age of participants in this study may have contributed to more favorable recovery outcomes, including greater improvement in EF and lower rates of hospitalization, in comparison to the older population studied in the REVIVED trial. Younger patients typically exhibit a lower burden of comorbidities and possess greater myocardial reserve, which may enhance their responsiveness to revascularization. Conversely, the treatment of CAD in elderly remains complex, as the high prevalence of multiple coexisting comorbidities often complicates therapeutic decision-making and may accelerate the progression of other systemic conditions. **[24]**

Yamaji et al. **[25]** reported that within the overall cohort, as well as in the subgroup aged ≥74 years, patients treated with PCI demonstrated a significantly elevated all-cause mortality rate in comparison to those who underwent CABG, even after adjusting for confounding variables. Notably, this difference in mortality was not observed in the younger age groups, this finding highlights a notable interaction between patient age and the mortality risk comparison of PCI and CABG.

The prevalence of DM in this cohort was 48.3%, comparable to that observed in the REVIVED-BCIS2 (39%) and STICH (40%) trials, underscoring the substantial metabolic burden associated with ICM. HTN was present in 48% of patients, closely aligning with the prevalence reported in REVIVED (53%) and slightly lower than that in the STICH population (60%). A prior history of AMI was reported in 81% of the study population, similar to the 76% reported in STICH and higher than the 50% reported in REVIVED. Additionally, A higher prevalence of prior revascularization procedures was observed among this cohort compared to those reported in both the STICH and REVIVED trials.

The high prevalence of smoking (70%) and multi-vessel coronary artery disease (81.7%) in this cohort represent key contributors to severe myocardial ischemia and LV dysfunction. Despite these adverse risk factors, the outcomes following PCI were favorable, potentially reflecting advancements in interventional techniques and contemporary medical therapy since the completion of prior landmark trials. In a comprehensive review of 37 studies, Ma et al. **[26]** established that cigarette smoking is a significant contributor to increased all-cause mortality risk following coronary revascularization, whether performed via PCI or CABG. These findings highlight the essential role of smoking cessation in the management of CAD among patients who have undergone revascularization.

Echocardiographic Findings

Ejection Fraction Categories and Temporal Changes

In this study, changes in EF were analyzed both as a continuous variable and by categorical percentage changes. Among the entire cohort, 10.3% of patients exhibited a decline in EF, while 53.4% demonstrated minimal improvement (<5 percentage points). A 5-point improvement was observed in 15.5% of patients, and 20.7% achieved an improvement of 10 percentage points. At six months, 10 patients (17.2%) attained an EF ≥40% along with a 10-point increase. A sustained improvement in EF was noted across all categories over time, with statistical significance ($p < 0.001$).

While the original STICH trial did not define a specific threshold for improvement in LVEF, subsequent analyses of its data have commonly used an absolute increase of ≥10% in LVEF to signify meaningful improvement. Perrone-Filardi et al. **[27]** investigated the attributes of the participants included in STICH trial to identify factors associated with an LVEF increase of ≥10% at 24 months. Among the 1,212 participants, 618 had echocardiographic LVEF measurements available both at baseline and following a 24-month follow-up. In the cohort randomized to medical treatment in addition to CABG, the 58 patients (19%) experienced a ≥10% increase in LVEF, whereas the 51 patients (16%) in the group receiving only medical therapy showed equivalent improvement; however, statistical analysis revealed the difference to be non-significant ($p = 0.30$). The analysis indicated that a ≥10% increase in LVEF during the longitudinal follow-up over 24 months was relatively uncommon among patients with ischemic cardiomyopathy (ICM), the treatment groups did not differ significantly in statistical terms. However, both an improvement in LVEF exceeding 10% ($p = 0.004$) and assignment to the CABG group ($p = 0.004$) demonstrated an independent association with decreased mortality risk. **[27]**

In the REVIVED-BCIS2 trial, no predefined threshold for enhancement in EF was established by the investigators. Instead, they evaluated changes in LVEF as a continuous variable to assess the impact of PCI in conjunction with OMT versus OMT. Statistical analysis showed no significant difference in LVEF improvement between the two groups at the 12-month evaluation. This approach was in accordance with the trial's primary focus on clinical endpoints including overall mortality rate and hospitalization rates for HF, rather than specific LVEF improvement thresholds. The results from the REVIVED trial indicated that LVEF was comparable between the PCI and OMT groups at both 6 and 12 months. Although there was a median improvement in LVEF of nearly 5% within the first 6 months, the change in LV function did not differ significantly between the groups.

Wang et al. **[28]** undertook a cohort study on patients having reduced EF (EF ≤40%) undergoing revascularization and EF was reassessed via echocardiographic study three months post-procedure. Post-revascularization, patients exhibiting reduced EF, approximately 10% experienced a worsening of EF at follow-up, 30% showed no change in EF, and 60% demonstrated EF improvement. The study showed that a 5-unit increase in EF corresponded to a 20% decrease in mortality risk. Patients with either worsened or unchanged EF, compared to those with improved EF, demonstrated markedly increased risk of both overall mortality and cardiovascular mortality.

Ndrepepa et al. **[29]** executed a prospective cohort study to explore the correlation between post-PCI changes in EF and clinical outcomes. The change in LVEF was determined by subtracting the baseline LVEF, measured at the time of the initial angiography, from the LVEF measured 6 to 8 months after the angiography. Among the 8,181 patients, EF was reduced in 4,172 (51.0%), mildly improved in 2,964 (36.2%), and significantly improved in 1,045 (12.8%). The study found that LVEF showed slight improvement six to eight months after PCI. Patients with severe or moderate LV dysfunction at baseline showed more pronounced improvements in LVEF, whereas those with normal baseline LVEF experienced either minimal changes or a slight reduction in LV function. Factors independently associated with greater improvements in LVEF included patients who were younger, female, had a lower baseline LVEF, had a history of arterial HTN, did not have DM, had a lower body mass index, were non-smokers, had no previous history of AMI or CABG, presented with STEMI, and received coronary stents other than second-generation drug-eluting stents. In patients who survived for more than 6 months following PCI, changes in LVEF were independently linked to mortality risk, even after controlling for baseline LVEF. A 5% increase in the change in LVEF was linked to a 9% decrease in the adjusted risk of 5-year all-cause mortality and a 14% decrease in the risk of cardiac mortality. The change in LVEF was found to be a valuable prognostic indicator, particularly in patients with reduced LV function (LVEF <50%). Moreover, a deterioration in LV function was a more significant determinant of mortality than an improvement in LV function.

The PROTECT II study **[30]** reported a significant absolute improvement in EF of 13.2% ($p < 0.001$), resulting from reverse remodeling. The improvement was more commonly seen in patients who underwent more comprehensive revascularization and led to a significant decline in the incidence of major adverse cardiovascular outcomes, along with an improvement in clinical symptoms. **[30]**

Velagaleti et al. **[31]** explored the relationship between changes in LVEF, defined as the difference between LVEF measured within one year after revascularization and LVEF measured within one year before revascularization (either via PCI or CABG), and the mortality risk or hospitalization due to HF in ICM patients with a baseline LVEF of less than 50%. In the PCI cohort, each 5% improvement in LVEF corresponded to a 6% lower risk of mortality. Additionally, patients with a change in LVEF ≥5% had a 30% decreased mortality risk compared to individuals with alterations in LVEF ≤ 5%, over a 5-year mean follow-up period.

The exact mechanisms behind the improvement in LVEF following PCI are not fully elucidated. Initially, the clinical advantage of revascularization in individuals with reduced LV function was thought to result from the restoration of function in hibernating myocardium. **[7]** However, recent studies challenge this hypothesis, suggesting that the enhancement in LVEF observed following revascularization in ICM patients may not be attributable to the recovery of hibernating myocardium. **[32]** Based on the findings from our study and other relevant trials, we infer that PCI has a beneficial effect on LVEF as an absolute value, although the magnitude of this effect may not be as pronounced as that of optimal guideline-directed medical therapies. Whether PCI-induced improvements in LV function translate into clinical benefit remains an area of ongoing investigation.

Changes in MR Severity

The lack of significant improvement in MR severity in our study contrasts with CABG-based studies, such as the STICH trial, where MR severity often improved following revascularization combined with mitral valve (MV) surgery. The STICH trial indicated that CABG alone did not lead to a statistically significant improvement in MR severity in patients with moderate to severe MR, indicating that direct mitral valve intervention during surgery may be required for meaningful improvement. Kang et al. **[33]** concluded that despite the superior effectiveness of mitral valve repair in alleviating ischemic functional MR, CABG alone might be a better treatment choice for patients having moderate MR who are at increased surgical risk, including older adults and patients with atrial fibrillation.

PCI Data

In our study, most patients who underwent PCI had a low SYNTAX score (ranging from 0 to 22), though a subset presented with higher SYNTAX scores (above 33), indicating the presence of more anatomically challenging or advanced coronary lesions. The LAD artery was the most frequently treated vessel, consistent with its significant contribution to ischemic burden and scar formation. Multi-vessel PCI was performed in a notable proportion of patients. LM PCI was conducted in 5% of patients, which was associated with moderate improvement in EF. CTO PCI was performed in 40% of patients, resulting in modest EF recovery, though it was linked to greater procedural complexity. Apart from the SYNTAX score and PCI to the LAD, no significant correlation was found between EF improvement and any other PCI variables.

The mean residual SYNTAX score was 4.92 ± 7.426. In the REVIVED trial, the degree of coronary artery revascularization was appraised using the British Cardiovascular Intervention Society (BCIS) jeopardy score in conjunction with the anatomical revascularization index. The index was determined using the formula: [(pre-PCI jeopardy score - post-PCI jeopardy score) ÷ pre-PCI jeopardy score] × 100, a value of 100% denoted that complete revascularization was achieved for all angiographically significant coronary artery lesions. **[34]**

Prognosis: Hospitalization and Mortality Outcomes

Prognosis in Our Study: Higher hospitalization rates were observed in patients with more pronounced symptoms. Only three deaths were reported during the follow-up period, indicating that PCI is safe for this high-risk cohort.

Mortality rates following revascularization in ICM have been examined in several pivotal trials, yielding varying results. The STICH trial initially reported that CABG in conjunction with medical therapy did not lead to a significant reduction in overall mortality over the course of 5 years, relative to the exclusive use of medical therapy. However, the STICHES extension study (2016) **[35]** demonstrated a meaningful increase in survival outcomes at 10 years (59% vs. 66%) in favor of CABG. The REVIVED-BCIS2 trial, in which PCI was compared with OMT, found no survival advantage with PCI, raising questions about its role in ICM. In contrast, the CASS trial **[36]** demonstrated sustained survival advantage observed with CABG among patients with severe impairment of LV function, thereby reinforcing the clinical benefit of surgical revascularization in this high-risk cohort. Additionally, the COURAGE trial, **[37]** which recruited patients with stable IHD, found insignificant decrease in mortality with PCI in comparison to OMT; nonetheless, it is crucial to highlight that the study population did not primarily enroll individuals presenting with severe LV dysfunction. Meta-analyses and observational studies, including those from the SYNTAX and FREEDOM trials, **[38,39]** suggest that CABG offers superior sustained survival benefits in comparison to PCI, especially in patients with multivessel coronary disease and DM.

Conclusion

The study emphasizes the substantial therapeutic advantages of PCI in ICM, particularly in terms of improving clinical prognosis by reducing hospitalization and mortality rates, as well as enhancing LVEF and WMSI.

Recommendation

Prospective investigations are warranted to determine the extended consequences of PCI in individuals diagnosed with ICM, with particular emphasis on those presenting with elevated SYNTAX scores and extensive myocardial fibrosis. Direct comparative studies are essential to evaluate the relative effectiveness of PCI in comparison to CABG in advanced ICM patients with complex coronary anatomy, with the goal of identifying the optimal revascularization strategy. Additional research is required to identify optimal strategies for mitigating MR following PCI, as this remains a limitation in current interventional outcomes. In patients diagnosed with multivessel CAD, multi-vessel PCI should be taken into account where clinically appropriate, as it may enhance functional recovery and ventricular performance. The development and implementation of structured patient education and support interventions are crucial for enhancing compliance with post-procedural care and GDMT, thereby facilitating enduring enhancements in quality of life and overall survival.

Study Limitation

This study has several limitations. The lack of randomization and a control group may introduce selection bias and limit the strength of causal inferences. Additionally, the relatively small cohort and constrained follow-up time may reduce the broader relevance and extended applicability of the findings. Furthermore, potential inter-observer variability in the evaluation of LVEF at baseline and during follow-up may have affected the consistency and accuracy of the echocardiographic measurements.

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There are no conflicts of interest to report.

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تأثير التدخل التاجي عن طريق الجلد على التكهن ووظيفة البطين الأيسر لدى المرضى المصابين باعتلال عضلة القلب الإقفاري

اعتلال عضلة القلب الإقفاري هو سبب رئيسي لقصور القلب، يتميز بخلل في وظيفة البطين الأيسر نتيجةً لمرض الشريان التاجي الخطير. على الرغم من أن جراحة مجازة الشريان التاجي أثبتت فائدتها السريرية لدى هذه الفئة، إلا أن دور التدخل التاجي عن طريق الجلد لا يزال موضع نقاش مستمر. ولا تزال هناك فجوة معرفية ملحوظة فيما يتعلق بالنتائج الوظيفية والسريرية المرتبطة بالتدخل التاجي عن طريق الجلد لدى مرضى اعتلال عضلة القلب الإقفاري.

الهدف من هذه الدراسة هو تقييم تأثير التدخل التاجي عن طريق الجلد على التكهن ووظيفة البطين الأيسر في المرضى الذين يعانون من اعتلال عضلة القلب الإقفاري على فترات متابعة تتراوح بين ثلاثة وستة أشهر.

أُجريت هذه الدراسة الاستباقية في قسم أمراض القلب بمستشفيات جامعة الإسكندرية الرئيسية. شارك في الدراسة ٦٠ مريضًا يعانون من اعتلال عضلة القلب الإقفاري المستقر نسبة القذف البطيني الأيسر < ٤٠٪ ومرض الشريان التاجي الخطير. أُجري التدخل التاجي عن طريق الجلد وفقًا للإرشادات السريرية المعمول بها. وتمت متابعة المرضى بعد ثلاثة وستة أشهر من التدخل. وشملت النتائج الأولية تغيرات في نسبة القذف البطيني الأيسر والتشخيص السريري، بما في ذلك دخول المستشفى والوفيات الناجمة عن أمراض القلب والأوعية الدموية.

تحسنت نسبة قذف العضلة القلبية الرضفية بشكل ملحوظ من ٣٥,٢٪ ± ٥,١ عند بداية الدراسة إلى ٣٩,٨٪ ± ٦,٠ بعد ستة أشهر (قيمة الاحتمال < ٠,٠١). كما تحسنت حالات الاستشفاء والوفيات المتعلقة بأمراض القلب بشكل ملحوظ. ولوحظت ارتباطات ذات دلالة إحصائية بين التغيرات في قذف العضلة القلبية الرضفية والتشخيص السريري. وبعد متابعة ستة أشهر، لوحظت فروق ذات دلالة إحصائية في قذف العضلة القلبية الرضفية بناءً على موقع قسطرة الشريان التاجي، وتحديدًا في قسطرة الشريان التاجي الأمامي الأيسر (قيمة الاحتمال = ٠,٠١٩)، وقسطرة الشريان التاجي المحيطى الأيسر (قيمة الاحتمال = ٠,٠٢٥)، وقسطرة الشريان التاجي الأيمن (قيمة الاحتمال = ٠,٠٤٤).