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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: Ischemic cardiomyopathy (ICM), a leading cause of heart failure, is characterized by left ventricular dysfunction secondary to significant coronary artery disease. Although coronary artery bypass grafting (CABG) has demonstrated clinical benefit in this population, the role of percutaneous coronary intervention (PCI) remains a subject of ongoing debate. A notable knowledge gap persists regarding the functional and clinical outcomes associated with PCI in patients with ICM.

Aim of Study: The objective of this study is to evaluate the impact of percutaneous coronary intervention (PCI) on prognosis and left ventricular (LV) function in patients with ischemic cardiomyopathy (ICM) at three- and six-month follow-up intervals.

Patients and Methods: This prospective cohort study was conducted at the Cardiology Department of Alexandria Main University Hospitals. A total of 60 patients with stable ischemic cardiomyopathy (LVEF <40%) and significant coronary artery disease were enrolled. Percutaneous coronary intervention (PCI) was performed in accordance with established clinical guidelines. Patients were followed at three and six months post-intervention. The primary outcomes included changes in left ventricular ejection fraction (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. By the 6-month follow-up, significant differences in EF were observed based on PCI location, specifically for LAD PCI ($p=0.019$), LCX PCI ($p=0.025$), and RCA PCI ($p=0.044$).

Conclusion: PCI in ICM patients resulted in significant improvements in left ventricular function that is meaningfully related to better clinical outcomes, with higher rates of hospitalization and mortality associated with lesser improvement in EF.

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Key Words: *Ischemic cardiomyopathy (ICM) – Percutaneous coronary intervention (PCI) – Left ventricular (LV) function and prognosis.*

Introduction

ISCHEMIC cardiomyopathy (ICM) is defined as significant left ventricular (LV) systolic dysfunction, characterized by a left ventricular ejection fraction (LVEF) of less than 40%, resulting from extensive coronary artery disease (CAD) or as a consequence

Abbreviations and Acronyms:

6MWT : Six-Minute Walk Test.
ACS : Acute Coronary Syndrome.
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.
DM : Diabetes Mellitus.
DSE : Dobutamine Stress Echocardiography.
EF : Ejection Fraction.
HR : Heart Rate.
HTN : Hypertension.
ICM : Ischemic Cardiomyopathy.
LM : Left Main.
LV : Left Ventricle.
LVEF : Left Ventricular Ejection Fraction.
NYHA : New York Heart Association.
OMT : Optimal Medical Therapy.
PCI : Percutaneous Coronary Intervention.
PET : Positron Emission Tomography.
REVIVED-BCIS2 : Revascularization for Ischemic Ventricular Dysfunction–British Cardiovascular Intervention Society Trial 2.
STICH : Surgical Treatment for Ischemic Heart Failure.
SYNTAX : Synergy between PCI with Taxus and Cardiac Surgery Score.
WMSI : Wall Motion Score Index.

of an acute myocardial infarction (AMI) [1]. ICM is the most common etiology of heart failure (HF) and left ventricular systolic dysfunction [2]. Globally, ischemic heart disease remains the leading cause of morbidity and mortality [3]. In Egypt, cardiovascular disease (CVD) has been the leading cause of premature death since the 1990s. In 2017, CVD accounted for 46.2% of all deaths nationwide [4]. The Egyptian cross-sectional CardioRisk project further emphasized the high prevalence of premature acute coronary syndrome (ACS), affecting 46% of men under the age of 55 years and 67% of women under 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 primary rationale for coronary revascularization in ICM lies in the reduction of chronic myocardial ischemia and the restoration of function in hibernating myocardium [7]. Although the precise relationships among resting coronary blood flow, coronary flow reserve, and myocardial function 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]. Observational studies and meta-analyses have indicated that the recovery of dysfunctional myocardial segments is associated with improved clinical outcomes, including a reduction in heart failure symptoms and mortality [12]. However, robust evidence demonstrating the superiority of revascularization over optimal medical therapy alone in terms of enhancing LV function or clinical outcomes remains limited [13].

The optimal revascularization strategy for patients with ICM remains uncertain, largely due to the limited availability of recent randomized controlled trial (RCT) data to guide clinical decision-making. There is a notable gap in RCTs directly comparing coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) in patients with severe ICM. Although randomized trials such as STICH [14] and REVIVED-BCIS2 [15] have provided valuable insights into revascularization approaches, 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 patients with significant LV dysfunction due to ischemic heart disease [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].

Objective:

The objective of this study is to evaluate the impact of revascularization by PCI on the prognosis of patients with ICM, specifically in relation to HF hospitalizations, cardiovascular mortality, and LV function. Outcomes were assessed at three- and six-month follow-up intervals through echocardiographic evaluation of LVEF, the severity of mitral regurgitation (MR), and changes in left ventricular wall motion score index (WMSI).

Ethics Approval:

The data that were obtained from participants are confidential. The study participants were not identified by name in any report or publication concerning this study. Before the participants were admitted in this study, the purpose and nature of the study, as well as the risk–benefit assessment was explained to them. An informed consent was obtained. Ethical approval was granted by the Ethics Committee of the Faculty of Medicine, Alexandria University, under the approval number 0107765.

Patients and Methods

Study population:

This study included 60 ICM patients who underwent 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 according to the following inclusion criteria: (1) Patients who presented with LV systolic dysfunction due to ischemic heart disease 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 in the 4 weeks before enrolment, (2) Acute decompensated HF within 72 hours before enrolment, (3) Sustained ventricular arrhythmias within 72 hours before enrolment and (4) Asymptomatic HF.

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 strategy of PCI plus optimal medical therapy. The protocol mandated that revascularization was attempted on all diseased 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, includingsmoking, diabetes mellitus (DM), hypertension(HTN), dyslipidemia, history of myocardial infarction, previous PCI or CABG; (2) Comprehensive clinical examination; (3) laboratory investigations including Complete blood count (CBC), erythrocyte sedimentation rate and C-reactive protein, liver and kidney function tests, PT, PTT, INR and electrolyte levels (Sodium and Potassium); (4) Standard 12-lead electrocardiography (ECG) to identify arrhythmias, QRS complex width, pathological Q waves or ST-segment and T-wave abnormalities; (5) Echocardiographic parameters were evaluated in accordance with the guidelines of the American Society of Echocardiography and included the following: - LVEF assessed by the Modified Simpson's method, grade of MR (Mild, moderate and severe) - WMSI *[21]*: The 16-segments LV WMSI, which implies the full analysis of LV contractility using the 6 standard views (parasternal base, mid and apical and apical 4-, 3-, and 2-chamber planes). Based on the American Society of Echocardiography score, LVEF was derived: LVEF = 90–26 × WMSI. LVEF by WMSI using the reference 17-segments method. Each segment is given a score based on its systolic function (normal N = 1, hypokinesis H = 2, akinesis A = 3). The index (WMSI) is calculated by dividing the total of the wall motion scores of each segment 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 analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level. Chi-square test used for categorical variables, to compare between different groups. Fisher's Exact used for correction for chi-square when more than 20% of the cells have expected count less than 5. Student *t*-test used for normally distributed quantitative variables, to compare between two studied groups. Mann Whitney test used for abnormally distributed quantitative variables, to compare between two studied groups.

Results

Demographic and clinical data:

The age of the study participants ranged from 42 to 79 years, with a mean age of 58.88±9.920 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 present in 23.3% of the participants, chronic total occlusion (CTO) was observed in 41.7%, and multi-vessel coronary artery disease was highly prevalent, affecting 81.7% of the study population (Table 1).

According to the NYHA functional classification, none of the patients were categorized as Class I or Class IV. 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
No	31	51.7
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

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%. The median EF was 35.50% with an interquartile range (IQR) of 35.0–40.0%. The baseline wall motion score index (WMSI) ranged from 1.60 to 2.50, with a mean value of 1.90±0.187. Assessment of mitral regurgitation (MR) at baseline revealed that 45.0% of patients had no MR, 38.3% had mild MR, 13.3% had moderate MR, and 3.3% had severe MR.

Coronary angiographic and PCI data:

With regard to coronary angiographic findings, left main (LM) disease was present in 5.0% of patients, while CTO was identified in 41.7%. The number of diseased 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%. Regarding PCI, the left anterior descending (LAD) artery was the most frequently treated vessel, involved in 71.7% of cases. Other vessels treated included the left circumflex (LCX) artery in 35.0%, the right coronary artery (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%). The baseline SYNTAX Score ranged from 8 to 35, with a mean of 15.78±7.533. The residual SYNTAX Score ranged from 0 to 25, with a mean of 4.92± 7.426 (Table 2).

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

	Number	Percent
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

Prognosis During Follow-up: Hospitalization and Mortality:

During the follow-up period, 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.

Echocardiographic data during follow-up:

LVEF:

At baseline, all patients had an ejection fraction (EF) of 40% or less. 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. The proportion of patients with EF <30% was 6.7% at baseline, 5.0% at 3 months, and 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 across the three time points were statistically significant (p = 0.001). Pairwise comparisons revealed significant differences between baseline and 3 months (p_1 = 0.044), baseline and 6 months (p_2 = 0.007), and 3 months and 6 months ($p3$ = 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)		3 months (n = 60)		6 months (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 tes
F: F test (ANOVA) with repeated measures.
Sig. bet. periods was done using Post Hoc Test (adjusted Bonferroni).
p: p-value for comparing between the studied periods.
p1: p-value for comparing between Baseline and 3 months.
p2: p-value for comparing between Baseline and 6 months.
p3: p-value for comparing between 3 months and 6 months.
*: Statistically significant at $p \leq 0.05$.

WMSI:

At baseline, the wall motion score index (WMSI) ranged from 1.60 to 2.50, with a mean value of 1.90±0.187. 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 mitral regurgitation (MR), 38.3% had mild MR, 13.3% had moderate MR, and 3.3% had 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 patients, respectively. The change in MR severity between baseline and six months was not statistically significant (p = 0.149). (Fig. 1).

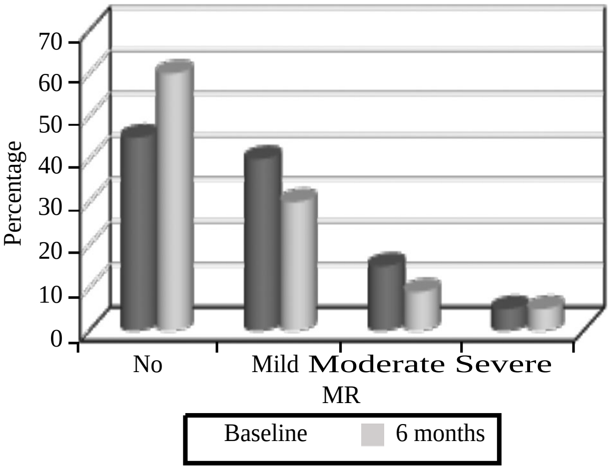

Fig. (1): Comparison between the two studied periods according to MR.

Correlations of echocardiographic data:

LVEF:

Statistically significant associations were observed between changes in LVEF and 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).

No significant associations were found between changes in EF and 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, there was no significant correlation between the SYNTAX score and changes in EF.

At the 3-month follow-up, PCI involving the LAD was significantly associated with higher EF, whereas PCI of other vessels did not show significant associations. By the 6-month follow-up, significant differences in EF were observed based on PCI location, specifically for LAD PCI ($p = 0.019$), LCX PCI ($p = 0.025$), and RCA PCI ($p = 0.044$).

A weak negative correlation between the number of diseased vessels and EF was noted at both three months ($r = -0.135, p = 0.304$) and six months ($r = -0.154, p = 0.247$); however, these correlations were not statistically significant.

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

	EF change									
	Decline (n = 6)		<5 points (n = 31)		5 points (n = 9)		10 points (n=12)		Test of Sig.	*p*
	No.	%	No.	%	No.	%	No.	%		
Hospitalization:										
No	1	16.7	22	71.0	7	77.8	11	91.7	$\chi2=9.836^*$	$^{MC}p=0.013^*$
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	$\chi2=5.410$	$^{MC}p=0.103$

IQR: Inter quartile range.
SD : Standard deviation.
F : F for One way ANOVA test.
H : H for Kruskal Wallis test.
$\chi2$: Chi square test.
MC: Monte Carlotest.
p: *p*-value for Relation between EF change with different parameters.
*: Statistically significant at $p \le 0.05$.

WMSI:

Statistically significant associations were observed between changes in WMSI and hospitalization at both the 3-month and 6-month follow-up intervals, 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, diabetes mellitus (DM), hypertension (HTN), history of acute coronary syndrome (ACS), previous percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), presence of left main coronary artery disease, degree of stenosis, or presence of chronic total occlusion. Furthermore, no significant correlation was identified between the SYNTAX score and WMSI.

At the 3-month follow-up, significant differences in WMSI were noted with respect to the site of PCI, particularly in patients undergoing LAD and LCX interventions ($p = 0.034$ and $p = 0.011$, respectively), whereas no significant difference was found for RCA PCI (p = 0.102).

By the 6-month follow-up, significant differences in 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] 57, among others, to situate the results within the context of existing evidence and to enhance the understanding of their clinical relevance.

Demographic characteristic:

The mean age of the study population was 58.88±9.92 years, comparable to the 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 management of coronary artery disease (CAD) in elderly patients 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 who underwent PCI exhibited significantly higher all-cause mortality compared to those who underwent CABG,even after adjusting for confounding variables. Notably, this difference in mortality was not observed in the younger age groups, indicating a significant interaction age and the relative mortality risk associated with PCI versus 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 history of MI was documented in 81% of patients, similar to the 76% reported in STICH and higher than the 50% reported in REVIVED. Additionally, the proportion of patients with prior revascularization procedures was greater in 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 systematic review of 37 studies, Ma et al. [26] demonstrated that cigarette smoking significantly increases the risk of all-cause mortality following coronary revascularization, whether by PCI or CABG. These findings underscore the critical importance of smoking cessation in the management of coronary artery disease in revascularized patients.

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 characteristics of patients enrolled in the 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 at both baseline and 24 months. In the cohort randomized to medical therapy plus CABG, 58 patients (19%) demonstrated an LVEF improvement of ≥10%, compared to 51 patients (16%) in the medical therapy-alone group (p = 0.30). The analysis concluded that a ≥10% improvement in LVEF over 24 months was relatively uncommon in patients with ICM and did not differ significantly between treatment groups. However, both an LVEF improvement of >10% (HR 0.61, 95% CI: 0.44–0.84, p = 0.004) and allocation to CABG (HR 0.72, 95% CI: 0.57–0.90, p = 0.004) were independently associated with a reduced risk of mortality [27].

In the REVIVED-BCIS2 trial, the investigators did not establish a predefined threshold for EF improvement. Instead, they evaluated changes in LVEF as a continuous variable to assess the effects of PCI in combination with optimal medical therapy (OMT) versus OMT alone. The study found no significant difference in LVEF improvement between the two groups at 12 months. This approach was consistent with the trial's primary focus on clinical outcomes, such as all-cause mortality and hospitalization 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 an absolute median improvement in LVEF of nearly 5% in the first 6 months, no significant difference in the change in LV function was observed between the groups.

Wang et al. [28] conducted a cohort study involving patients with reduced EF (EF ≤40%) who underwent revascularization and had their EF reassessed via echocardiography three months post-procedure. Following revascularization, among patients with 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 found that for each 5-unit increase in EF, the risk of mortality decreased by 20%. Compared to the EF improvement group, patients with either worsened or unchanged EF had a significantly higher risk of both all-cause mortality and cardiovascular death.

Ndrepepa et al. [29] conducted a prospective cohort study to examine the relationship between changes in EF after PCI and clinical outcomes. The change in LVEF (ΔLVEF) was calculated as the difference between the LVEF measured 6 to 8 months after angiography and the baseline LVEF measured at the time of the initial 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 6 to 8 months following PCI. Patients with severe or moderate LV impairment at baseline experienced greater improvements in LVEF, whereas those with preserved baseline LVEF showed little change or a slight decline in LV function. Factors independently associated with greater improvements in LVEF included younger age, female sex, lower baseline LVEF, arterial HTN, absence of DM, lower body mass index, non-smoking status, no prior history of MI or CABG, presentation with STEMI, and the use of coronary stents other than second-generation drug-eluting stents. In patients surviving beyond 6 months post-PCI, changes in LVEF were independently associated with the risk of death, even after adjusting for baseline LVEF. For every 5% increase in ΔLVEF, the adjusted risk of 5-year all-cause mortality decreased by 9%, and the risk of cardiac death decreased by 14%. ΔLVEF was found to have prognostic value, particularly in patients with impaired LV function (LVEF <50%). Moreover, a decline in LV function appeared to be a stronger predictor of mortality than an improvement in LV function.

The PROTECT II study [30] demonstrated a significant absolute increase in EF of 13.2% (p<0.001) due to reverse remodeling. This improvement was more frequently observed in patients who underwent more extensive revascularization and was associated with a substantial reduction in major adverse events as well as an enhancement in clinical symptoms [30].

Velagaleti et al. [31] examined the association between changes in LVEF (ΔLVEF), defined as the difference between LVEF measured within one year after revascularization and LVEF measured within one year prior to revascularization by either PCI or CABG, and the risk of death or hospitalization due to HF in patients with ICM (baseline LVEF <50%). In the PCI cohort, the risk of death decreased by 6% for every 5% improvement in LVEF, and by 30% when comparing patients with a ΔLVEF ≥5% to those with a ΔLVEF ≤–5%, over a mean follow-up period of 5 years.

The underlying mechanisms of PCI-related improvement in LVEF remain unclear. Initially, the therapeutic benefit of revascularization in patients with LV systolic dysfunction was thought to stem from the functional recovery of hibernating myocardium [7]. However, recent studies challenge this hypothesis, suggesting that the improvement in LVEF following revascularization in patients with ICM may not be attributable to the recovery of hibernating myocardium [32]. Based on the data from our study and other trials, we conclude 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 a subject of ongoing debate.

Changes in MR Severity:

The absence 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 significantly reduce MR severity in patients with moderate to severe MR, suggesting that direct intervention on the MV during surgery may be required for meaningful improvement. Kang et al. [33] found that although MV repair appears more effective in reducing ischemic functional MR, CABG alone may be a more appropriate treatment for patients with moderate MR who are at high operative risk, such as those with advanced age or atrial fibrillation.

PCI Data:

Regarding the PCI data, the majority of cases in our study had a low SYNTAX score (0–22), although some patients presented with higher SYNTAX scores (>33), indicating more complex coronary disease. The LAD artery was the most frequently treated vessel, consistent with its significant contribution to ischemic burden and scar formation. Multi-vessel PCI was performedin 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 extent of revascularization was evaluated using the British Cardiovascular Intervention Society jeopardy score and the anatomical revascularization index. This index was calculated as follows: [(pre-PCI jeopardy score - post-PCI jeopardy score) ÷ pre-PCI jeopardy score] × 100, with 100% indicating complete revascularization of all angiographically significant coronary 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 found no significant reduction in 5-year all-cause mortality with CABG plus medical therapy compared to medical therapy alone. However, the STICHES extension (2016)(35) revealed a significant 10-year survival benefit (59% vs. 66%) in favor of CABG. The REVIVED-BCIS2 trial, which compared PCI to OMT, found no survival advantage with PCI, raising questions about its role in ICM. In contrast, the CASS trial [36] demonstrated long-term survival improvement with CABG in patients with severe LV dysfunction, thereby supporting the benefits of surgical revascularization. Additionally, the COURAGE trial, [37] which included patients with stable ischemic heart disease, reported no significant mortality reduction with PCI compared to medical therapy, although this cohort did not specifically focus on those with severe LV dysfunction. Meta-analyses and observational studies, including those from the SYNTAX (79) and FREEDOM trials, [38,39] suggest that CABG provides superior long-term survival outcomes compared to PCI, particularly in patients with multi-vessel disease and DM.

Conclusion:

This study underscores the substantial benefits of PCI in patients with ICM, particularly in terms of improving clinical prognosis by reducing hospitalization and mortality rates, as well as enhancing LVEF and wall motion score index WMSI.

Study limitation:

This study has several limitations. The absence of randomization and a control group may introduce selection bias and limit the strength of causal inferences. Additionally, the relatively small sample size and short duration of follow-up may reduce the generalizability and long-term applicability of the findings. Furthermore, potential inter-observer variability in the assessment of LVEF at baseline and follow-up may have affected the consistency and accuracy of the echocardiographic measurements.

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Conflict of interest:

The authors declare no conflict of interest, financial or otherwise.

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تأثير التدخل التاجى عن طريق الجلد على التشخيص ووظيفة البطين الأيسر لدى المرضى المصابين باعتلال عضلة القلب الإقفارى

اعتلال عضلة القلب الإقفارى هو سبب رئيسي لقصور القلب، يتميز بخلل فى وظيفة البطين الأيسر نتيجةً لمرض الشريان التاجي الخطير. على الرغم من أن جراحة مجازة الشريان التاجى أثبتت فائدتها السريرية لدى هذه الفئة، إلا أن دور التدخل التاجى 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 الإقفارى.

الهدف من هذه الدراسة هو تقييم تأثير التدخل التاجى عن طريق الجلد على التشخيص ووظيفة البطين الأيسر فى المرضى الذين يعانون من اعتلال عضلة القلب الإقفارى على فترات متابعة تتراوح بين ثلاثة وستة أشهر.

أُجريت هذه الدراسة الاستباقية فى قسم أمراض القلب بمستشفيات جامعة الإسكندرية الرئيسية. شارك فى الدراسة ٦٠ مريضًا يعانون من اعتلال عضلة القلب الإقفاري المستقر نسبة القذف البطينى الأيسر < ٤٠٪ ومرض الشريان التاجى الخطير. أُجرى 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 البطينى الأيسر والتشخيص السريرى، بما فى 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 فى قذف العضلة القلبية الرضفية والتشخيص السريرى. وبعد متابعة ستة أشهر، لوحظت فروق ذات دلالة إحصائية فى قذف العضلة القلبية الرضفية بناءً على موقع قسطرة الشريان التاجى، وتحديدًا فى قسطرة الشريان التاجى الأمامى الأيسر (قيمة الاحتمال = ٠,٠١٩)، وقسطرة الشريان التاجى المحيطى الأيسر (قيمة الاحتمال = ٠,٠٢٥)، وقسطرة الشريان التاجى الأيمن (قيمة الاحتمال = ٠,٠٤٤).