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Original Article

Immediate vs Standard Percutaneous Coronary Intervention Timing in Patients Presenting With Non–ST-Segment Elevation Myocardial Infarction

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ABSTRACT

Background: The optimal timing for percutaneous coronary intervention (PCI) in patients with non–ST-segment elevation myocardial infarction (NSTEMI) remains a matter of clinical debate, particularly in high-risk but stable patients. This study aimed to evaluate whether immediate PCI (within the timeframe of primary PCI) improves clinical outcomes compared with standard early PCI (within 24 hours) in high-risk NSTEMI patients.

Methods: This prospective, single-center, randomized study included 300 high-risk NSTEMI patients at Ain Shams University hospitals. Patients were randomized to either immediate PCI (n = 150) or standard PCI (n = 150). Baseline characteristics, electrocardiographic (ECG) findings, echocardiographic findings, coronary angiography results, length of hospital stay, and 1- and 6-month major adverse cardiovascular events (MACE) were assessed.

Results: Time to angiography was significantly shorter in the immediate PCI group (1.493 ± 0.288 h vs 13.200 ± 4.780 h; $P < 0.001$). Hospital stay was significantly reduced in the immediate PCI group (1.447 ± 0.651 vs 2.293 ± 0.765 d; $P < 0.001$). No significant differences were observed in ECG findings, ejection fraction, infarct-related artery occlusion rates, or vessel distribution ($P > 0.05$). At 1 month, MACE occurred in 5.33% vs 7.33% ($P = 0.477$); at 6 months, in 11.33% vs 18.67% ($P = 0.075$) in immediate vs standard PCI groups, respectively.

Conclusions: Immediate PCI does not reduce short- or mid-term MACE compared with standard PCI, but it is associated with a significantly shorter hospital stay, supporting its role in optimizing healthcare efficiency. ***(Iranian Heart Journal 2026; 27(2): 38-46)***

KEYWORDS: PCI; invasive strategy timing; MACE; hospital stay; GRACE score

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Non–ST-segment elevation acute coronary syndromes (NSTE-ACS), including non–ST-segment elevation myocardial infarction (NSTEMI), are common presentations of ischemic heart disease, which remains the leading cause of death globally, responsible for over 9 million deaths annually.[1, 2] For patients with NSTE-ACS, international guidelines recommend a routine invasive strategy, as it has been shown to improve composite ischemic outcomes compared with a selective strategy.[3-5] Nonetheless, the optimal timing for invasive intervention remains a subject of debate.[3]

Recent guidelines from the European Society of Cardiology (ESC) recommend early invasive evaluation (within 24 hours) for patients at high risk, defined by a GRACE score exceeding 140.[3, 4] While clinically unstable patients with hemodynamic compromise require immediate intervention, the best timing for stable high-risk patients is still unclear.[3] Historical evidence supports that invasive management during the index hospitalization improves major adverse cardiovascular events (MACE), especially in high-risk individuals.[6]

MACE includes a variety of clinical endpoints such as heart failure, nonfatal myocardial infarction (MI), recurrent angina, revascularization procedures, stroke, and all-cause mortality. Nevertheless, definitions vary across studies. Given the uncertainty regarding the timing of percutaneous coronary intervention (PCI) in high-risk NSTEMI patients, this study aimed to determine whether immediate percutaneous revascularization (within the time frame of primary PCI) could improve clinical outcomes compared with standard of care strategy in NSTEMI patients.

METHODS

Study Design and Population

This was a prospective, randomized, single-center study conducted at Ain Shams University hospitals. The study aimed to compare the outcomes of immediate vs standard timing of PCI in patients presenting with high-risk NSTEMI. A total of 300 eligible patients were enrolled and randomized in a 1:1 ratio into 2 groups: the immediate PCI group, who underwent coronary angiography and intervention within the timeframe typically reserved for primary PCI (within 2 hours of presentation), and the standard PCI group, who received PCI within 24 hours according to current guideline-directed management. The study was conducted in compliance with the Declaration of Helsinki and was approved by the institutional ethics committee, with written informed consent obtained from all participants.

Inclusion Criteria

Eligible participants were adults aged 18 to 80 years with a confirmed diagnosis of high-risk NSTEMI, as per the 2023 ESC guidelines.[7] High-risk features included dynamic new ST/T changes in contiguous leads, a GRACE risk score of greater than 140, or resuscitated cardiac arrest without ST-elevation or cardiogenic shock.

Exclusion Criteria

Patients were excluded if they had any very high-risk features requiring urgent revascularization, including hemodynamic instability, cardiogenic shock, refractory chest pain, life-threatening arrhythmias, mechanical complications, or acute heart failure related to NSTE-ACS. Patients with a minimum ST-segment depression of 1 mm in at least 6 leads with concurrent ST elevation in aVR and/or V_1 were also excluded, as well as those with low or intermediate risk, significant valvular disease, or referred for surgical intervention.

Baseline Assessment

All patients underwent comprehensive history taking and clinical examinations. Risk factors

assessed included age, sex, smoking, diabetes mellitus, hypertension, chronic kidney disease, obesity, previous MI or coronary intervention, and other cardiovascular or cerebrovascular comorbidities.[8]

Investigations and Risk Stratification

Initial investigations included a 12-lead ECG, high-sensitivity troponin I, lipid profile, HbA1c, and kidney function tests. Risk stratification was performed using the GRACE score, which incorporated age, heart rate, blood pressure, serum creatinine, Killip class, ST deviation, cardiac arrest, and biomarker levels. The GRACE score stratified patients into low, intermediate, or high-risk categories for in-hospital and 6-month mortality.[9, 10]

Echocardiographic Evaluation

All patients underwent bedside transthoracic echocardiography before intervention, as per the European Association of Cardiovascular Imaging guidelines. This included assessment of left ventricular ejection fraction using the biplane Simpson method and evaluation of regional wall motion abnormalities and mechanical complications.[11, 12]

Coronary Angiography and Intervention

Patients in the immediate PCI group were transferred promptly to the catheterization lab. Coronary angiography was performed via radial or femoral access using standard Judkins catheters. Multiple angiographic views were taken to assess the coronary anatomy. The infarct-related area (IRA) was identified and revascularized using drug-eluting stents. The procedure followed international guidelines, and stent sizing was left to the operator's discretion.[13]

Medical Therapy

All patients received guideline-directed medical therapy. Dual antiplatelet therapy consisted of aspirin and ticagrelor. Clopidogrel was used in patients with high bleeding risk, intolerance, or unavailability of ticagrelor. Optimal medical therapy continued after PCI as per the ESC recommendations.

Follow-up and Outcomes

Patients were followed for 6 months via scheduled telephone contacts. The primary endpoint was the occurrence of MACE, a composite of all-cause mortality, nonfatal MI, heart failure admission, ischemia-driven revascularization, and stroke. Secondary outcomes included the individual components of the primary endpoint.

Statistical Analysis

Statistical analysis was performed using IBM SPSS software, version 25. Quantitative data were expressed as mean ± standard deviation (SD), and comparisons between 2 groups were made using the unpaired Student *t* test. Categorical variables were presented as frequencies and percentages and analyzed using the χ^2 test to assess independence between variables. A *P* value of 0.05 or less was considered statistically significant.

RESULTS

Patients in the early and standard PCI groups showed no significant differences in baseline characteristics. The mean age was similar (55.9 vs 57.2 y; $P = 0.341$), and males predominated in both groups (~75%). Common risk factors—smoking, diabetes, hypertension, and obesity—were evenly distributed, with no statistical significance. Prior MI, cerebrovascular disease, and chronic kidney disease were also comparable between the groups ($P > 0.05$). Laboratory biomarkers including creatinine, troponin I, low-density lipoprotein (LDL), and HbA1c showed no significant differences (Table 1).

Table 1. General, clinical, and laboratory findings of the studied groups

	Total	Early (No. = 150)	Standard (No. = 150)	*P*
Age	56.560 ±11.873	55.907 ±11.847	57.213 ±11.903	0.341
Sex				
Male	226	112 (74.67)	114 (76)	0.789
Female	74	38 (25.33)	36 (24)	
Smoker	183 (61.00)	94 (62.67)	89 (59.33)	0.554
DM	145 (48.33)	74 (49.33)	71 (47.33)	0.729
HTN	153 (51.00)	78 (52.00)	75 (50.00)	0.729
Obesity	66 (22.00)	32 (21.33)	34 (22.67)	0.78
Prior MI	40 (13.3%)	15 (10.0%)	25 (16.7%)	0.089
Cerebrovascular disease	7 (2.3%)	2 (1.3%)	5 (3.3%)	0.251
CKD	27 (9.0%)	10 (6.7%)	17 (11.3%)	0.158
Creatinine (mg/dL)	1.073 ± 0.293	1.041 ± 0.229	1.105 ± 0.343	0.055
Troponin I (ng/mL)	3.431 ± 5.173	3.046 ± 4.053	3.815 ± 6.081	0.198
LDL (mg/dL)	129.62 ± 43.44	131.42 ± 42.38	127.81 ± 44.54	0.473
HbA1c (%)	6.859 ± 1.925	6.753 ± 1.825	6.965 ± 2.020	0.341
HbA1c > 6.4	129 (43.0%)	62 (41.3%)	67 (44.7%)	0.56

Data are presented as mean ± SD (standard deviation) and number (%).

DM: diabetes mellitus; HTN: hypertension; MI: myocardial infarction; CKD: chronic kidney disease; LDL: low-density lipoprotein; HbA1c: glycated hemoglobin.

Comparison between the early and standard groups showed no statistically significant differences in ECG or echocardiographic findings (all *P*s > 0.05). General ECG abnormalities were observed in 55.33% vs 50.00%, inferior Q waves in 12.05% vs 8.00%, inferior T-wave changes in 8.43% vs 10.67%, inferior ST depression in 15.66% vs 9.33%, anterior Q waves in 1.20% vs 0%, anterior T-wave inversion in 37.35% vs 28.00%, anterior ST depression in 28.92% vs 28.00%, lateral T-wave changes in 1.20% vs 2.67%, lateral ST depression in 3.61% vs 8.00%, and left bundle branch block in 1.20% vs 6.67% of patients, respectively. Echocardiographic assessment showed ejection fraction ranges of 30% to 70% (mean: 57.34 ± 8.92%) in the early group and 25% to 68% (mean: 56.77 ± 9.83%) in the standard group. Impaired ejection fraction was found in 22.67% vs 26.00%, and segmental wall motion abnormalities in 33.33% vs 32.00% of participants, respectively (Table 2).

Coronary intervention data revealed a significantly shorter time to angiography in the early group (1.493 ± 0.288 h; range: 1.02–2) compared with the standard group (13.200 ± 4.780 h; range 4–24), with a highly significant *t* value of −29.944 ($P < 0.001$). However, the proportion of totally occluded IRA was comparable between the groups: 36.67% in the early group vs 38.00% in the standard group ($P = 0.811$). The left anterior descending was the IRA in 34.55% vs 19.30%, the right coronary artery in 23.64% vs 38.60%, the left circumflex-obtuse marginal in 30.91% vs 35.09%, and the diagonal artery in 10.91% vs 7.02% of the early and standard groups, respectively. No significant differences were found in IRA total occlusion or affected vessel distribution (all *P*s > 0.05) (Table 3).

The early group had a significantly shorter hospital stay (mean: 1.447 ± 0.651 d; range: 1–5) than the standard group (mean: 2.293 ± 0.765 d; range: 1–7), with a highly significant *t* value of −10.329 ($P < 0.001$). At 1 month, the composite MACE occurred in 5.33% of the early and 7.33% of standard groups; mortality (0.67% vs 0.67%),

nonfatal MI (0.67% vs 1.33%), heart failure admissions (1.33% vs 2.00%), ischemia-driven revascularization (2.67% each), and stroke (0% vs 0.67%) showed no significant differences (all *P*s > 0.05). At 6 months, MACE was observed in 11.33% of the early and 18.67% of standard group patients; mortality (0.67% vs 2.00%), nonfatal MI (4.00% vs 8.67%), heart failure admissions (2.67% vs 6.67%), ischemia-driven revascularization (4.67% vs 2.67%), and stroke (1.33% each) remained statistically comparable between the groups (all *P*s > 0.05) (Table 4 and Figure 1 A-B).

Table 2. ECG and echocardiographic findings of the studied groups

ECG Finding	Total	Early (No. = 150)	Standard (No. = 150)	*P*
ECG changes	158 (52.7)	83 (55.3)	75 (50.0)	0.355
Inferior Q waves	16 (10.1)	10 (12.1)	6 (8.0)	0.4
Inferior T-wave inversion	15 (9.5)	7 (8.4)	8 (10.7)	0.633
Inferior ST depression	20 (12.7)	13 (15.7)	7 (9.3)	0.232
Anterior Q waves	1 (0.6)	1 (1.2)	0 (0.0)	0.34
Anterior T-wave inversion	52 (32.9)	31 (37.4)	21 (28.0)	0.212
Anterior ST depression	45 (28.5)	24 (28.9)	21 (28.0)	0.899
Lateral T-wave inversion	3 (1.9)	1 (1.2)	2 (2.7)	0.501
Lateral ST depression	9 (5.7)	3 (3.6)	6 (8.0)	0.235
LBBB	6 (3.8)	1 (1.2)	5 (6.7)	0.073
Echocardiographic Parameters				
EF	57.05 ± 9.38	57.34 ± 8.92	56.77 ± 9.83	0.597
Impaired EF	73 (24.33)	34 (22.67)	39 (26.00)	0.501
SWMA	98 (32.67)	50 (33.33)	48 (32.00)	0.806

Data are presented as mean ± SD (standard deviation) and number (%).

ECG: electrocardiogram; ST: ST segment; LBBB: left bundle branch block; EF: ejection fraction; SWMA: segmental wall motion abnormalities

Table 3. Angiographic findings of the studied groups

Angiographic Finding	Total	Early (No. = 150)	Standard (No. = 150)	*P*
Time from randomization to angiography (h)	7.346 ± 6.768	1.493 ± 0.288	13.200 ± 4.780	<0.001*
IRA total occlusion (n)	112 (37.33)	55 (36.67)	57 (38.00)	0.811
IRA vessel involvement				
LAD	30 (26.79)	19 (34.55)	11 (19.30)	0.168
RCA	35 (31.25)	13 (23.64)	22 (38.60)	
LCX-OM	37 (33.04)	17 (30.91)	20 (35.09)	
Diagonal	10 (8.93)	6 (10.91)	4 (7.02)	

Data are presented as mean ± SD (standard deviation) and number (%).

IRA: infarct-related artery; LAD: left anterior descending; RCA: right coronary artery; LCX-OM: left circumflex–obtuse marginal

*: significant *P* value

Table 4. Outcomes between the studied groups

Length of Hospital Stay (d)	Total	Early (No. = 150)	Standard (No. = 150)	*P*
Hospital stay	1.87 ± 0.83	1.45 ± 0.65	2.29 ± 0.77	<0.001*
1-month MACE				

Primary outcome (composite MACE)	19 (6.33)	8 (5.33)	11 (7.33)	0.477
Mortality	2 (0.67)	1 (0.67)	1 (0.67)	1
Nonfatal MI	3 (1.00)	1 (0.67)	2 (1.33)	0.562
Heart failure admission	5 (1.67)	2 (1.33)	3 (2.00)	0.652
Ischemia-driven revascularization	8 (2.67)	4 (2.67)	4 (2.67)	1
Stroke	1 (0.33)	0 (0.00)	1 (0.67)	0.317
6-month MACE				
Primary outcome (composite MACE)	45 (15.00)	17 (11.33)	28 (18.67)	0.075
Mortality	4 (1.33)	1 (0.67)	3 (2.00)	0.314
Nonfatal MI	19 (6.33)	6 (4.00)	13 (8.67)	0.097
Heart failure admission	14 (4.67)	4 (2.67)	10 (6.67)	0.101
Ischemia-driven revascularization	11 (3.67)	7 (4.67)	4 (2.67)	0.357
Stroke	4 (1.33)	2 (1.33)	2 (1.33)	1

Data are presented as mean ± SD (standard deviation) and number (%).

MACE: major adverse cardiovascular events; MI: myocardial infarction

*: significant *P* value

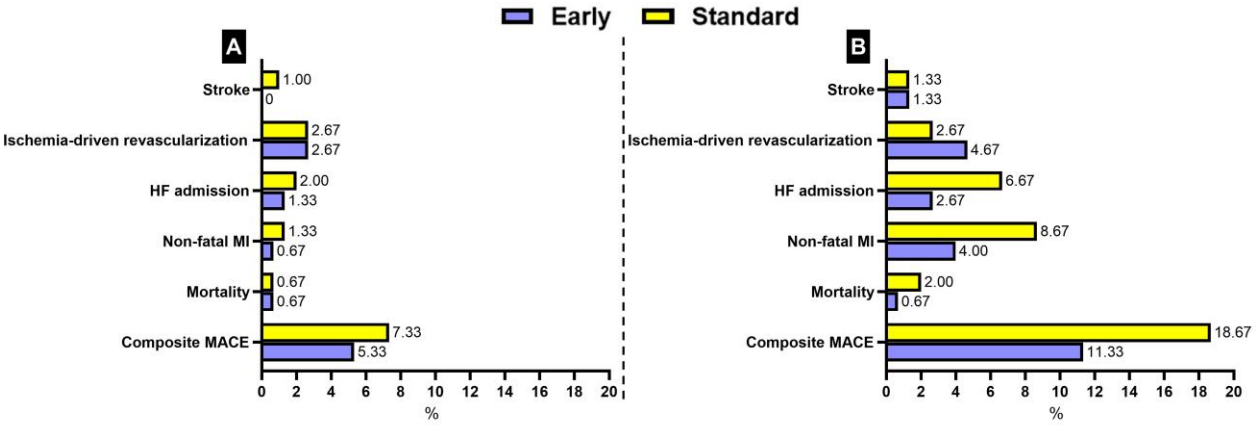

Figure 1. Comparison of 1-month (A) and 6-month (B) major adverse cardiovascular events (MACE) and individual outcomes between the early (blue) and standard (yellow) PCI groups

DISCUSSION

Timely intervention in high-risk NSTEMI patients is a cornerstone of modern cardiology, yet the ideal timing for PCI remains uncertain. While immediate revascularization offers theoretical benefits in limiting myocardial damage, real-world evidence presents a more nuanced picture.[14] Balancing urgency with clinical stability, this study explores whether faster truly means better in the race against cardiac events.

In the current study, there were no significant differences between early and standard groups in baseline characteristics, including age, sex, smoking, diabetes, hypertension, obesity, or biomarkers (creatinine, troponin I, LDL, and HbA1c). Additionally, ECG findings, ejection fraction, impaired ejection fraction, and significant wall motion abnormalities were also comparable. While the early group underwent significantly earlier angiography ($P < 0.001$), IRA occlusion rates and vessel distribution did not differ. Notably, hospital stay was significantly shorter in the early group ($P < 0.001$). One- and 6-month MACE outcomes, including mortality, nonfatal MI, heart failure admission, revascularization, and stroke, were statistically similar, though a nonsignificant

trend toward fewer events was observed in the early group.

Similar to our findings, Kite et al[15] conducted a multicenter randomized controlled study to compare very early (median: 1.5 h) vs standard (median: 44.0 h) invasive strategies in high-risk NSTE-ACS patients. At 12 months, there was no significant difference in the primary composite outcome of all-cause mortality, new MI, or heart failure hospitalization. However, hospital stay was shorter in the very early group. The trial was terminated early due to slow COVID-19-related recruitment, rendering it underpowered.

Kofoed et al[16] evaluated 2147 NSTE-ACS patients, comparing very early (within 12 h; median: 4.7) vs delayed (within 48–72 h; median: 61.6) invasive strategies. The primary composite outcome showed no significant difference between groups overall. Nonetheless, in patients with a GRACE score of greater than 140, the very early strategy was associated with improved outcomes.

In contrast, Milosevic et al[17] conducted a randomized controlled trial of 323 NSTEMI patients and compared immediate (within 2 hours) vs delayed (within 2–72 hours) invasive strategies. The primary endpoint-death or new MI at 30 days-was significantly lower in the immediate group, with benefits sustained at 1 year, mainly due to reduced risk of precatheterization MI. In contrast, our study found no significant difference in MACE between early and standard interventions. The differing outcomes may be attributed to variations in study design, patient populations, outcome definitions, and intervention timing.

Supporting our results, a comprehensive meta-analysis by Milasinovic et al[18] evaluated 17 randomized controlled trials involving 10209 NSTE-ACS patients to determine the optimal timing of invasive strategies. The analysis found no significant differences between early and delayed approaches regarding all-cause mortality, MI, heart failure admissions, repeat revascularization, major bleeding, or stroke. Still, early intervention was associated with reduced recurrent ischemia and shorter hospital stays.

Furthermore, a meta-analysis by Khan et al[19] evaluated the impact of total occlusion (TO) of the culprit artery in NSTEMI patients using data from 7 studies involving 40,777 individuals. It found that 25.5% had a totally occluded artery and that TO was associated with significantly higher risks of both short- and long-term MACE and all-cause mortality. Our study aligns with these findings, reinforcing the prognostic importance of IRA TO in NSTEMI. We observed worse clinical outcomes, impaired cardiac function, and strong associations between TO, ECG changes, and echocardiographic abnormalities, highlighting the need for early detection and management of TO in this patient population.

Limitations

This study has several limitations, including a relatively small sample size of 300 patients and a single-center design at Ain Shams University hospitals, which may limit generalizability. The 6-month follow-up period may not capture long-term outcomes, such as late mortality or MACE, unlike larger trials with extended follow-up. Additionally, although early intervention was associated with a shorter length of hospital stay, the study did not include a cost-effectiveness analysis, which could have provided insights into the economic impact of early vs delayed strategies.

CONCLUSIONS

Immediate PCI does not provide superior long-term clinical benefits over standard early intervention. However, it reduces hospital stay, highlighting the potential role of early PCI in improving logistical and economic aspects of patient care.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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