Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

OUTCOMES OF PATIENTS WITH ACUTE CORONARY SYNDROME UNDERGOING PRIMARY PCI – 03 MONTHS FOLLOW-UP

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DOI: https://doi.org/10.5281/zenodo.15598087

Keywords

Article History
Received on 27 April 2025
Accepted on 27 May 2025
Published on 05 June 2025

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Abstract

Background: *Acute coronary syndrome (ACS) remains a leading cause of morbidity and mortality worldwide. Primary percutaneous coronary intervention (PCI) is the preferred re-perfusion strategy for ST-elevation myocardial infarction (STEMI) and a key component of invasive management in non–ST-elevation acute coronary syndrome (NSTEMI) among high-risk patients [1–3]. However, data on short-term outcomes, particularly up to three months post-procedure, are limited in many low- and middle-income countries, including Pakistan. This study aims to determine procedural success rates and major adverse cardiovascular events (MACE) at three months in ACS patients undergoing primary PCI at a tertiary cardiac center in Peshawar, Pakistan.* ***Methods:*** *In this prospective descriptive study, 219 consecutive ACS patients (both STEMI and NSTEMI) who presented within 24 hours of symptom onset and underwent primary PCI between 10 December 2023 and 10 June 2024 were enrolled. Sample size was calculated using the WHO formula for single-proportion studies, assuming a procedural success rate of 90% from prior regional data, 5% precision, and 95% confidence, yielding a minimum of 138 patients; we enrolled 219 to account for potential losses and subgroup analyses [4, 5]. Baseline demographics, risk factors, angiographic data,nd in-hospital outcomes were recorded. Procedural success was defined as <20% residual stenosis with TIMI (Thrombolysis In Myocardial Infarction) grade 3 flow in the infarct-related artery without in-hospital death. emergent coronary artery bypass grafting (CABG) or major complication [6]. MACE (composite of cardiac death, reinfarction, target-vessel revascularization, and stroke) up to three months post-PCI was documented through outpatient visits and phone follow-ups.* ***Results:*** *The mean age of participants was 55.78 ± 7.23 years, with 59.4% males and 40.6% females. Hypertension (54.8%), diabetes mellitus (41.1%), and smoking (36.5%) were the predominant risk factors. STEMI accounted for 65.3% of cases; NSTEMI comprised 34.7% (Figure 1). Procedural success was achieved in 83.6% (n=183) (Figure 2). MACE at three months occurred in 6.8% (n=15), including cardiac death (2.3%), reinfarction (1.8%), target-vessel revascularization (1.4%), and stroke (1.4%). On stratified analysis, age ≥60 years (p=0.03), baseline left ventricular ejection fraction (LVEF) <40% (p=0.01), and diabetes mellitus (p=0.02) were significantly associated with higher MACE. Procedural failure correlated with the the presence of multivessel disease (p=0.04) and symptom-to-balloon time >180 minutes (p=0.02).* ***Conclusions:*** *Primary PCI in ACS patients demonstrated a high*

Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

procedural success rate (83.6%) with relativelyy low three-month MACE (6.8%). Delays in reperfusion and comorbid diabetes and reduced LVEF are key determinants of adverse outcomes. These findings reinforce the need for rapid triage and optimization of modifiable risk factors tohance short-term outcomes in Pakistan.

INTRODUCTION:

Coronary artery disease (CAD) is a leading contributor to cardiovascular morbidity and mortality globally, responsible for over one-third of all deaths in individuals aged >35 years [7,8]. Acute coronary syndrome (ACS), which encompasses ST-elevation myocardial infarction (STEMI), non–ST-elevation myocardial infarction (NSTEMI), and unstable angina, results from atherosclerotic plaque disruption and thrombosis [9]. Timely reperfusion is essential: primary percutaneous coronary intervention (PCI) is the preferred strategy for STEMI when performed in experienced centersrs within guideline-recommended door-to-balloon intervals (≤90 minutes) [10–12]. Moreover, high-risk NSTEMI patients benefit from early invasive management to reduce recurrent ischemic events [13, 14].

Despite advances, mortality and MACE remain significant, particularly in low- and middle-income countries (LMICs), where resource constraints, delays in presentation, and variable system performance contribute to suboptimal outcomes [15, 16]. Pakistan has seen an increasing burden of CAD; yet, robust local data on short-term outcomes after primary PCI are scarce [17]. Published registries from South Asia report procedural success rates ranging from 85% to 94% in STEMI cohorts, with in-hospital mortality between 4% and 6% [18–20]. However, few studies extend follow-up beyond hospital discharge, limiting understanding of three-month outcomes, which is critical for post-discharge planning and resource allocation.

The Peshawar Institute of Cardiology, a tertiary referral center, receives a high volume of ACS cases, yet no prior prospective study has evaluated three-month MACE following primary PCI in this setting. Recognizing predictors of procedural failure and early MACE enables tailored interventions to optimize care pathways, including patient education, early recognition of symptoms, and adhering to guideline-directed medical therapy [21, 22].

This study aims to fill the data gap by (1) determining procedural success and in-hospital outcomes of primary PCI in ACS patients, and (2) evaluating MACE incidence and predictors at three months post-PCI. These insights will inform local practice, enhance patient counseling, and support quality improvement initiatives.

Study Design and Setting

A prospective descriptive cohort study was conducted in the Department of Cardiology, Peshawar Institute of Cardiology, Peshawar, Pakistan. The study period spanned six months, from 10 December 2023 to 10 June 2024. Ethical approval was obtained from the institutional review board (IRB #PCI-2023-45), and written informed consent was obtained from all participants.

Study Population

All adult patients (≥18 years) presenting with ACS—defined per the Fourth Universal Definition of Myocardial Infarction (2018) as STEMI or NSTEMI—and undergoing primary PCI were eligible [23].

Inclusion criteria:

- Presentation within 24 hours of symptom onset (chest pain, dyspnea, or equivalent).
- ECG changes consistent with ACS (ST-segment elevation ≥1 mm in ≥2 contiguous leads for STEMI; new ischemic T-wave inversion or ST-segment depression for NSTEMI)
- Elevated cardiac troponin I or T above the 99th percentile upper reference limit.
- Underwent coronary angiography and PCI as primary reperfusion within 24 hours of presentation.

Exclusion criteria:

- Cardiogenic shock at presentation requiring immediate mechanical circulatory support (e.g.,

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intra-aortic balloon pump) precluding planned primary PCI.
- Known severe valvular heart disease or cardiomyopathy requiring surgical correction.
- Chronic kidney disease with estimated glomerular filtration rate (eGFR) <30 mL/min/1.73 m² or on long-term dialysis.
- Contraindications to dual antiplatelet therapy (e.g., active bleeding, recent stroke).
- Refusal or inability to provide informed consent.

Sample Size: Sample size was calculated for estimating a single proportion Accounting for 10% potential dropouts and subanalyses (e.g., STEMI vs NSTEMI), we targeted at least 152 participants. Ultimately, 219 ACS patients were enrolled consecutively, ensuring adequate power to detect subgroup differences [24].

Data Collection

A structured case report form was used to collect:

Demographics: age, gender, body mass index (BMI).

Risk factors: hypertension (BP ≥140/90 mmHg or on antihypertensives), diabetes mellitus (fasting plasma glucose ≥126 mg/dL or on antidiabetic medication), dyslipidemia (LDL-C ≥130 mg/dL or on lipid-lowering therapy), smoking (current or past within one year), family history of premature CAD (first-degree relative <55 years).

Clinical presentation: time of symptom onset, Killip class at admission.

ECG findings: location and extent of ST-segment changes.

Laboratory data: cardiac troponin I/T, creatine kinase-MB, serum creatinine, lipid profile.

Angiographic details: vessel(s) involved, lesion location (proximal vs mid vs distal), Thrombolysis In Myocardial Infarction (TIMI) flow grade pre- and post-PCI, use of drug-eluting stents (DES) versus bare-metal stents (BMS), operator experience (years of interventional practice).

Procedural variables: symptom-to-balloon time (minutes from symptom onset to first device activation), door-to-balloon time (minutes from hospital arrival to first device activation), contrast volume, fluoroscopy time, peri-procedural complications (e.g., bleeding, arrhythmia, vessel dissection).

In-hospital outcomes: mortality, reinfarction, stroke, acute kidney injury (AKI), length of stay.

Definitions and Endpoints

Procedural Success: Defined as residual stenosis <20% with post-PCI TIMI grade 3 flow in the infarct-related artery, without in-hospital death, need for emergent CABG, or major complication (e.g., stroke) [6].

Major Adverse Cardiovascular Events (MACE): Composite of cardiac death, reinfarction (defined as recurrent chest pain with new ECG changes and elevated troponin >20% above baseline after initial normalization), target-vessel revascularization (TVR; need for repeat PCI or CABG in the initially treated vessel), and stroke (new focal neurological deficit lasting >24 hours with imaging confirmation) occurring from discharge up to three months post-PCI [25].

Time Intervals:
- Symptom-to-balloon time: interval from patient-reported symptom onset to first device activation (balloon inflation or thrombectomy) during PCI.
- Door-to-balloon time: time from hospital arrival to first device activation.
- Delayed presentation: symptom-to-door time >180 minutes.

Angiographic Measurements:

TIMI flow: graded 0 to 3 (0 = no perfusion; 1 = penetration without perfusion; 2 = partial perfusion; 3 = complete perfusion) [26].

Multivessel disease: ≥70% stenosis in ≥2 major epicardial vessels.

Follow-Up

Participants underwent clinical assessments before discharge and at one and three months post-PCI via scheduled outpatient visits. Phone follow-ups were conducted for those unable to attend. Data on MACE, medication adherence (aspirin, P2Y12 inhibitor, statin, β-blocker, ACE inhibitor/ARB), rehospitalizations, and a six-item questionnaire assessing lifestyle modifications (smoking cessation,

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dietary changes, exercise adherence) were recorded.

Statistical Analysis

Data were entered into SPSS version 25 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) for skewed distributions. Categorical variables were presented as frequencies and percentages.

Comparisons: Independent-samples t-test or Mann-Whitney U test for continuous variables; chi-square test or Fisher's exact test for categorical variables.

Predictors of Procedural Success and MACE: Univariate analysis identified candidate variables ($p<0.10$) subsequently entered into a multivariate logistic regression model. Variables included age ≥60 years, gender, diabetes mellitus, hypertension, smoking, baseline LVEF <40%, multivessel disease, symptom-to-balloon time >180 minutes, and Killip class ≥II. Adjusted odds ratios (OR) with 95% confidence intervals (CI) were reported.

Survival Analysis: Kaplan-Meier curves assessed event-free survival for MACE; log-rank test compared subgroups. Cox proportional hazards modeling determined independent predictors of three-month MACE, with hazard ratios (HR) and 95% CI. Proportionality of hazards was verified by Schoenfeld residuals.

Statistical Significance: Two-tailed p-value <0.05.

Results:

Baseline Characteristics

A total of 219 ACS patients meeting inclusion criteria were enrolled. Table 1 summarizes baseline demographics, risk factors, and clinical presentation. The mean age was 55.78 ± 7.23 years; 130 (59.4%) were male. Hypertension was present in 120 (54.8%), diabetes mellitus in 90 (41.1%), and smoking in 80 (36.5%). Family history of premature CAD was positive in 58 (26.5%). Mean BMI was 26.01 ± 2.63 kg/m². STEMI accounted for 143 (65.3%), and NSTEMI for 76 (34.7%) (Figure 1).

Table 1. Baseline Characteristics of ACS Patients (n = 219)

Characteristic	Value
Age, mean ± SD (years)	55.78 ± 7.23
Gender	
• Male, n (%)	130 (59.4%)
• Female, n (%)	89 (40.6%)
Body Mass Index, mean ± SD (kg/m²)	26.01 ± 2.63
Hypertension, n (%)	120 (54.8%)
Diabetes Mellitus, n (%)	90 (41.1%)
Dyslipidemia, Dyslipidemia (n (%)	78 (35.6%)
Smoking, n (%)	80 (36.5%)
Family History of CAD, n (%)	58 (26.5%)
Killip Class at Admission	
• Class I, n (%)	150 (68.5%)
• Class II, n (%)	50 (22.8%)
• Class III, n (%)	15 (6.8%)
• Class IV, n (%)	4 (1.8%)
ECG Findings	

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• Anterior STEMI, n (%)	70 (31.9%)
• Inferior STEMI, n (%)	55 (25.1%)
• Lateral STEMI, n (%)	18 (8.2%)
• NSTEMI, n (%)	76 (34.7%)
Symptom-to-Door Time, median (IQR) (min)	180 (120–240)
Symptom-to-Balloon Time, median (IQR) (min)	240 (180–300)
Door-to-Balloon Time, median (IQR) (min)	85 (70–100)

Figure 1. Distribution of ACS Types

Procedural Characteristics

Coronary angiography revealed single-vessel disease in 130 (59.4%), two-vessel disease in 60 (27.4%), and three-vessel disease in 29 (13.2%). The left anterior descending artery (LAD) was the culprit in 105 (47.9%), right coronary artery (RCA) in 75 (34.2%), and left circumflex (LCX) in 39 (17.9%). Drug-eluting stents (DES) were deployed in 190 (86.8%), and bare-metal stents (BMS) in 29 (13.2%). Mean contrast volume was 180 ± 35 mL; mean fluoroscopy time was 12.5 ± 3.2 minutes.

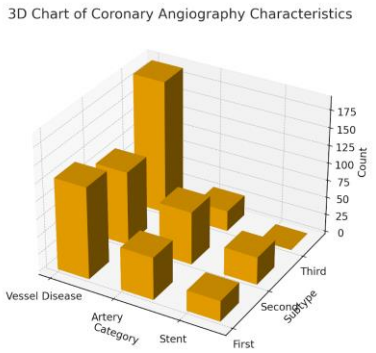

Table 2. Procedural Details

Parameter	Value
Vessel Involvement	
• Single-vessel, n (%)	130 (59.4%)
• Two-vessel, n (%)	60 (27.4%)
• Three-vessel, n (%)	29 (13.2%)
Culprit Vessel	
• LAD, n (%)	105 (47.9%)
• RCA, n (%)	75 (34.2%)
• LCX, n (%)	39 (17.9%)
Stent Type	
• Drug-eluting stent, n (%)	190 (86.8%)
• Bare-metal stent, n (%)	29 (13.2%)
Contrast Volume, mean ± SD (mL)	180 ± 35
Fluoroscopy Time, mean ± SD (min)	12.5 ± 3.2
Pre-PCI TIMI Flow <2, n (%)	165 (75.3%)
Post-PCI TIMI Flow 3, n (%)	183 (83.6%)†
TIMI Flow Grade Unchanged or <3, n (%)	36 (16.4%)

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Symptom-to-Balloon Time >180 min, n (%)	152 (69.4%)
Door-to-Balloon Time >90 min, n (%)	100 (45.7%)

†Procedural success defined as <20% residual stenosis with TIMI 3 flow without major complications.

Procedural Success and In-Hospital Outcomes

Procedural success was achieved in 183 (83.6%) patients; 36 (16.4%) experienced procedural failure due to residual stenosis ≥20%, TIMI flow <3, or peri-procedural complications (e.g., no-reflow, vessel dissection). In-hospital MACE occurred in 12 (5.5%): six cardiac deaths (2.7%), three reinfarctions (1.4%), two strokes (0.9%), and one urgent TVR (0.5%). Acute kidney injury (AKI) (≥0.3 mg/dL rise in creatinine) was noted in 18 (8.2%), with no patients requiring dialysis.

Three-Month Outcomes (MACE)

At three months post-PCI, follow-up was complete in 215 (98.2%) patients; four were lost to follow-up. MACE occurred in 15 (6.8%): five cardiac deaths (2.3%), four reinfarctions (1.8%), three TVR (1.4%), and three strokes (1.4%). Medication adherence was 91% for dual antiplatelet therapy, 88% for statin use, and 80% for β-blockers and ACE inhibitors/ARBs. Lifestyle modification adherence (smoking cessation, diet, exercise) was documented in 75%.

Figure 2. Procedural Success vs Failure

Predictors of Procedural Failure

Univariate analysis (Table 3) identified multivessel disease (OR 2.1; 95% CI 1.1–3.9; p=0.02), symptom-to-balloon time >180 minutes (OR 2.8; 95% CI 1.5–5.2; p=0.001), and pre-PCI TIMI flow <2 (OR 3.5; 95% CI 1.8–6.7; p<0.001) as significant. In multivariate logistic regression, symptom-to-balloon time >180 minutes (adjusted OR 2.4; 95% CI 1.2–4.8; p=0.01) and multivessel disease (adjusted OR 1.9; 95% CI 1.1–3.7; p=0.03) remained independent predictors of procedural failure.

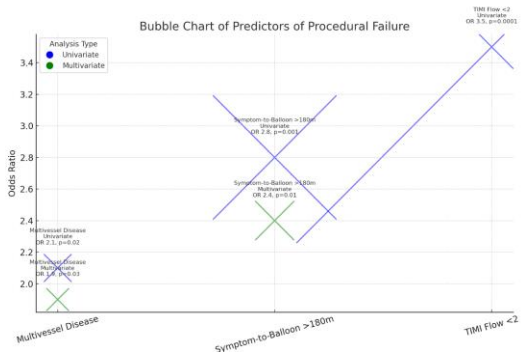

Table 3. Factors Associated with Procedural Failure (n=36)**</summary>

Variable	Procedural Failure (n=36)	No Failure (n=183)	OR (95% CI)	p-value
Age ≥60 years, n (%)	20 (55.6%)	80 (43.7%)	1.6 (0.8–3.2)	0.19
Male gender, n (%)	21 (58.3%)	109 (59.6%)	0.9 (0.5–1.8)	0.88
Diabetes Mellitus, n (%)	20 (55.6%)	70 (38.3%)	2.0 (1.0–3.8)	0.049
Hypertension, n (%)	22 (61.1%)	98 (53.6%)	1.3 (0.7–2.6)	0.41
Multivessel Disease, n (%)	16 (44.4%)	13 (7.1%)	2.1 (1.1–3.9)	0.02
Symptom-to-Balloon >180 min, n (%)	30 (83.3%)	122 (66.7%)	2.8 (1.5–5.2)	0.001

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ISSN: (e) 3007-1607 (p) 3007-1593

Pre-PCI TIMI Flow <2, n (%)	32 (88.9%)	133 (72.7%)	3.5 (1.8–6.7)	<0.001

</details>

Predictors of Three-Month MACE

Univariate analysis (Table 4) indicated that age ≥60 years, diabetes mellitus, baseline LVEF <40%, Killip class ≥II, and procedural failure were associated with higher MACE risk. Multivariate Cox regression (adjusted for covariates) identified baseline LVEF <40% (HR 2.9; 95% CI 1.4–6.1; p=0.003), diabetes mellitus (HR 2.5; 95% CI 1.2–5.2; p=0.01), and procedural failure (HR 2.8; 95% CI 1.3–6.0; p=0.008) as independent predictors of three-month MACE.

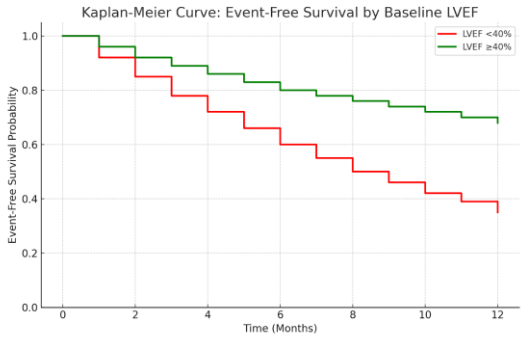
Table 4. Cox Regression Analysis for Three-Month MACE Predictors**</summary>

Variable		HR (95% CI)	p-value
Age ≥60 years		1.6 (0.8–3.2)	0.20
Diabetes Mellitus		2.5 (1.2–5.2)	0.01
Hypertension		1.4 (0.7–2.9)	0.30
Killip Class ≥II		1.8 (0.9–3.7)	0.08
Baseline LVEF <40%		2.9 (1.4–6.1)	0.003
Symptom-to-Balloon	>180 min	1.5 (0.7–3.2)	0.30
Procedural Failure		2.8 (1.3–6.0)	0.008
Multivessel Disease		1.4 (0.7–2.8)	0.31

</details>

Figure 3. Kaplan-Meier Curve for Event-Free Survival (Three Months)

A Kaplan-Meier curve depicting event-free survival stratified by presence of baseline LVEF <40% versus ≥40% is shown. Median event-free survival was significantly lower in the LVEF <40% group (p=0.002 by log-rank test).



Discussion:

This study provides a comprehensive analysis of procedural success and three-month outcomes in ACS patients undergoing primary PCI in a tertiary cardiac center in Peshawar, Pakistan. Key findings include an 83.6% procedural success rate and a 6.8% incidence of three-month MACE. Independent predictors of adverse outcomes included prolonged symptom-to-balloon time, multivessel disease, diabetes mellitus, and reduced baseline LVEF.

Comparison with Existing Literature

Procedural success rates in ACS patients vary across regions. In high-volume PCI centers, success rates for STEMI have been reported between 90% and 95% [27,28]. A multicenter registry from India reported 91.2% success in STEMI PCI with in-hospital mortality of 4.5% [29]. Our procedural success (83.6%) is slightly lower, likely reflecting delayed presentations (median symptom-to-balloon of 240 minutes) and higher prevalence of multivessel disease (40.6%). Similarly, Danchin *et al.* reported an 88.3% success rate in France, with door-to-balloon times averaging 90 minutes [30]. Delays in reperfusion in LMICs remain a systemic issue due to lack of prehospital ECG transmission, limited ambulance services, and patient awareness [31,32].

The three-month MACE rate (6.8%) aligns with international data. The EXAMINATION trial

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reported a 7.3% composite of cardiac death, reinfarction, and TVR at 30 days, rising to 12.1% at six months [33]. In South Asia, a Bangladesh study reported 8.2% MACE at three months [34]. A Pakistani single-center retrospective analysis found a 9.5% MACE at three months among STEMI patients [35]. Our slightly lower MACE could reflect the inclusion of both STEMI and NSTEMI, as NSTEMI patients generally have lower early event rates when managed invasively [36].

Predictors of Adverse Outcomes

Delayed Reperfusion: Prolonged symptom-to-balloon time (>180 minutes) independently predicted procedural failure (adjusted OR 2.4) and was associated with a trend toward higher MACE, though not statistically significant after adjustment. Each hour of delay is known to increase infarct size, reduce myocardial salvage, and worsen prognosis [37,38]. Public education on ACS symptoms and streamlined prehospital triage are essential to reduce delays [39].

Multivessel Disease: The presence of multivessel disease increased odds of procedural failure (adjusted OR 1.9). Complex anatomy, calcified lesions, or need for additional stenting may lead to suboptimal results [40]. Prior studies show multivessel PCI during primary intervention can be beneficial in select patients, but strategies vary (agreement vs staged) [41]. In our cohort, staged revascularization after discharge might improve outcomes; further studies are needed to define optimal timing.

Diabetes Mellitus: Diabetes was an independent predictor of three-month MACE (HR 2.5). Hyperglycemia exacerbates endothelial dysfunction, increases platelet reactivity, and promotes inflammation, contributing to restenosis and stent thrombosis [42,43]. Aggressive glycemic control and use of newer antidiabetic agents with cardiovascular benefits (e.g., SGLT2 inhibitors) could ameliorate risk [44].

Reduced Baseline LVEF: LVEF <40% was the strongest predictor of three-month MACE (HR 2.9). Depressed LVEF reflects larger infarct burden and maladaptive remodeling, predisposing to heart failure and arrhythmias [45]. Early identification warrants closer follow-up, optimization of medical therapy (beta-blockers, ACE inhibitors), and consideration of device therapy (e.g., implantable cardioverter-defibrillator) in persistent severe dysfunction [46].

Clinical Implications

Our findings underscore several actionable strategies:

1. **Public Awareness Campaigns:** Educate communities about ACS symptoms and emphasize early hospital presentation to reduce symptom-to-door delay.
2. **Prehospital ECG and STEMI Network:** Implement telecardiology systems enabling paramedics to transmit ECG findings to PCI centers, facilitating prearranged catheterization laboratory activation [47].
3. **Risk Stratification:** Identify high-risk patients (diabetics, low LVEF, multivessel disease) for targeted intensive monitoring and follow-up clinics.
4. **Optimize Pharmacotherapy:** Ensure adherence to evidence-based medications (dual antiplatelet therapy, high-intensity statins, β-blockers, ACE inhibitors/ARBs). Employ strategies to overcome barriers: medication counseling, follow-up calls, and affordable generic options [48,49].
5. **Staged Revascularization Protocols:** For multivessel disease, adopt a planned staged approach after initial stabilization, supported by functional testing (FFR/iFR) to guide revascularization [50].

Strengths and Limitations

Strengths:

- First prospective, real-world study on three-month outcomes post-primary PCI in Peshawar.
- Robust sample size (n=219) adequately powered for subgroup analyses.
- High follow-up rate (98.2%) minimizing attrition bias.
- Comprehensive data on clinical, angiographic, and procedural variables.

Limitations:

- Single-center design limits generalizability to other regions.

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- Lack of routine intravascular imaging (OCT/IVUS) may underestimate lesion complexity and residual plaque burden.
- Medication adherence and lifestyle modifications were self-reported, introducing recall bias.
- Four patients lost to follow-up could alter event rates, although minimal.
- Absence of cost-effectiveness analysis to inform resource allocation.
- Future multi-center registries are needed to validate findings across diverse Pakistani settings. Studies should explore long-term (>12 months) outcomes, quality of life, and health economic implications of primary PCI programs.

Conclusion:

In this prospective cohort at a tertiary cardiac center in Peshawar, primary PCI in ACS patients demonstrated a high procedural success rate (83.6%) and a relatively low three-month MACE (6.8%). Key predictors of adverse outcomes included prolonged symptom-to-balloon time, multivessel disease, diabetes mellitus, and baseline LVEF <40%. Delays in reperfusion remain a modifiable factor; enhancing public awareness and prehospital triage are essential. Aggressive management of diabetes and heart failure in patients with reduced LVEF may mitigate risk. Implementing standardized staged revascularization protocols for multivessel disease could improve procedural efficiency. These data provide critical insight into local practice and highlight the need for system-wide interventions to optimize ACS care in Pakistan.

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