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Procedural Success & In-Hospital Outcomes of Primary Percutaneous Coronary Intervention in ST-Elevation Myocardial Infarction: A Retrospective Cohort Study.

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Abstract

Background: Cardiovascular disease is the leading cause of mortality globally and in Pakistan, where ischemic heart disease accounts for ~29.1% of deaths. Primary percutaneous coronary intervention (PPCI) is the preferred reperfusion strategy for ST-elevation myocardial infarction (STEMI), offering superior outcomes when performed within guideline-recommended timelines. However, region-specific data from Khyber Pakhtunkhwa (KP) remain limited despite a rising burden of coronary artery disease. This study aimed to evaluate procedural success and in-hospital outcomes of primary PCI in STEMI patients at a major tertiary care center in KPK, Pakistan.

Methodology: This retrospective, single-center observational study included 800 consecutive STEMI patients undergoing primary PCI at Lady Reading Hospital MTI, Peshawar, between January 2025 to June 2025. Procedural success was defined as TIMI grade III flow with <30% residual stenosis without major adverse cardiac events (MACE). Primary endpoints included procedural success, in-hospital mortality, and MACE. Analyses were conducted using SPSS v26.0, including multivariable logistic regression.

Results: Among 800 patients (mean age 55 ± 10 years; 72% male), hypertension (44%), smoking (40%), and diabetes (36%) were common risk factors. Anterior wall MI predominated (54%), with the left anterior descending artery as the culprit in 51%. Mean door-to-balloon time was 45 ± 15 minutes, with 95.6% achieving ≤90 minutes. Procedural success was 96%, with TIMI III flow in 94%. In-hospital mortality was 2.25%, and stent thrombosis occurred in 1.25%, with no stroke, major bleeding, or emergency CABG. Cardiogenic shock was the strongest predictor of mortality (OR 8.94; $p<0.001$).

Conclusion: Primary PCI demonstrated high success and favorable outcomes, aligning with national and international benchmarks, reflecting effective guideline-based care in a resource-limited setting.

Keywords

Primary Percutaneous Coronary Intervention, ST-Elevation Myocardial Infarction, Procedural Success, In-Hospital Outcomes, TIMI Flow.

Introduction

Cardiovascular diseases (CVDs) remain the leading cause of mortality worldwide, accounting for approximately 17.9 million deaths annually, with ischemic heart disease representing the largest contributor to this burden[1,2]. In Pakistan, the epidemiological transition toward non-communicable diseases has resulted in a substantial increase in CVD prevalence, with 18.9% of households reporting cardiovascular conditions and a high prevalence of major risk factors, including diabetes (30.8%) and hypertension (37%). Despite this growing burden, healthcare expenditure remains limited, posing significant challenges to effective disease management[3-5].

Khyber Pakhtunkhwa (KP), a northwestern province of Pakistan, presents a particularly complex healthcare landscape characterized by rapid urbanization, socioeconomic disparities, and geographic barriers to timely access to care. Epidemiological data indicate a rising trend in coronary artery disease (CAD) in the region, with reported cases increasing from 998 in 2015 to 1,505 in 2017 ($p<0.001$), largely driven by modifiable risk factors such as tobacco use, hypertension, and physical inactivity[1,2]. Cultural practices, including widespread use of smokeless tobacco (naswar) and consanguineous marriages, may further influence cardiovascular risk profiles in this population[6].

Primary percutaneous coronary intervention (PPCI) has been firmly established as the gold standard for reperfusion in patients with ST-elevation myocardial infarction (STEMI), demonstrating superiority over fibrinolytic therapy in reducing mortality, reinfarction, and stroke when performed within optimal time windows. International guidelines from the European Society of Cardiology (ESC) and the American College of Cardiology/American Heart Association (ACC/AHA) emphasize a door-to-balloon (D2B) time of ≤90 minutes as a key quality indicator of STEMI care[7-10].

However, achieving these benchmarks in low- and middle-income countries (LMICs) remains challenging due to delays in patient presentation, underdeveloped emergency medical services (EMS), and limited availability of catheterization laboratory infrastructure[11,12].

Existing data from Pakistani tertiary care centers have demonstrated variable outcomes. The Armed Forces Institute of Cardiology/National Institute of Heart Diseases (AFIC/NIHD) has reported procedural success rates exceeding 96% with in-hospital mortality ranging from 1.5% to 2.1%. Similarly, data from South Punjab indicate mortality rates of approximately 3.5%, with variability in reperfusion success and total ischemic time[13-15]. While these findings provide valuable insights, there remains a paucity of comprehensive, region-specific data from KP, where healthcare delivery systems and patient demographics differ substantially from other regions.

Therefore, the present study aimed to assess the procedural success and in-hospital outcomes of primary PCI among STEMI patients presenting to LRH and to identify key predictors of adverse outcomes. By addressing a critical gap in regional data, this study seeks to inform evidence-based strategies for optimizing STEMI care pathways and improving cardiovascular outcomes in Khyber Pakhtunkhwa and similar LMIC settings.

Methodology

Study Design

This study was designed as a single-center, retrospective, observational analysis conducted to evaluate procedural success and in-hospital outcomes of primary percutaneous coronary intervention (PCI) among patients presenting with ST-elevation myocardial infarction (STEMI). The retrospective nature allowed for the inclusion of consecutive real-world cases, thereby enhancing the external validity and clinical applicability of the findings.

Ethics

The study protocol received formal approval from the Institutional Ethical Review Board of Lady Reading Hospital Medical Teaching Institution (LRH-MTI), Peshawar (Approval No: 54/LRH/MTI). All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision). Written informed consent was obtained

from all participants or their legally authorized representatives prior to inclusion in the study.

Setting

The study was carried out at the Department of Cardiology, Lady Reading Hospital MTI, Peshawar, Pakistan, a high-volume tertiary care referral center serving Khyber Pakhtunkhwa and adjacent tribal regions. The study period spanned from January 2025 to June 2025, during which standardized institutional STEMI management protocols were consistently implemented.

Participants

The study included adult patients (≥18 years) of both genders diagnosed with acute STEMI based on standard 12-lead electrocardiographic criteria, including ST-segment elevation thresholds specific to anatomical leads. Eligible patients presented within 12 hours of symptom onset, or within 12–24 hours if ongoing ischemia or hemodynamic instability was present, and underwent primary PCI as the initial reperfusion strategy. Patients were excluded if they had received prior thrombolytic therapy (facilitated PCI), had a history of previous myocardial infarction, PCI, or coronary artery bypass grafting (CABG), had advanced chronic kidney disease (eGFR <30 mL/min/1.73m²), declined consent, or had STEMI due to non-atherosclerotic causes such as coronary dissection or vasospasm.

Variables

The primary outcome variables included procedural success, defined as achievement of Thrombolysis in Myocardial Infarction (TIMI) grade III flow with residual stenosis <30% in the absence of in-hospital death, reinfarction, or emergency CABG. Secondary outcomes included in-hospital mortality and major adverse cardiac events (MACE), comprising mortality, reinfarction, stroke, cardiogenic shock, and stent thrombosis. Additional explanatory variables included demographic characteristics, cardiovascular risk factors, clinical presentation (including Killip class), angiographic findings, procedural details, and time metrics such as door-to-balloon (D2B) time and total ischemic time.

Data Sources / Measurement

Data were retrospectively extracted from hospital medical records and catheterization laboratory databases using a standardized, pre-designed proforma. Clinical assessment included immediate ECG confirmation of STEMI upon emergency department presentation. Pre-procedural management followed institutional protocols, including dual antiplatelet therapy, anticoagulation, and adjunctive pharmacotherapy. Procedural data were recorded by interventional cardiologists, including access route, stent characteristics, and adjunctive therapies such as glycoprotein IIb/IIIa inhibitors. Post-procedural outcomes were assessed during hospitalization, with echocardiographic evaluation performed within 48 hours for left ventricular function assessment.

Bias

Potential sources of bias included selection bias inherent to retrospective designs and information bias related to reliance on existing medical records. To minimize these, consecutive patient inclusion was ensured, and standardized institutional protocols were followed for diagnosis and treatment. However, unmeasured confounding variables, including operator-specific variability and evolving procedural practices, could not be fully controlled.

Study Size

The sample size was calculated using the WHO formula for estimating a single proportion, assuming an anticipated procedural success rate of 90%, a 95% confidence level (Z = 1.96), and a margin of error of 5%.

The minimum required sample size was 138; however, this was substantially increased to 800 patients to enhance statistical power, allow subgroup analyses, and improve the precision of outcome estimates[13-15].

Quantitative Variables

Continuous variables such as age, door-to-balloon time, and hemodynamic parameters were treated as quantitative variables and expressed as mean ± standard deviation or median with interquartile range depending on distribution. Categorical variables, including gender, risk factors, and clinical outcomes,

were summarized as frequencies and percentages. Time-based variables (e.g., D2B time, total ischemic time) were analyzed both as continuous measures and categorized according to guideline-recommended thresholds.

Statistical Methods

Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was assessed using the Shapiro-Wilk test. Comparative analyses were conducted using independent-sample t-tests or Mann–Whitney U tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Binary logistic regression analysis was employed to identify independent predictors of in-hospital mortality, with variables demonstrating $p < 0.25$ in univariate analysis entered into multivariate models. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs), and statistical significance was set at $p < 0.05$. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research reporting[16].

Results

Participants

During the study period, a total of 1,214 patients presented to the Emergency Department with acute chest pain, of whom 900 were confirmed to have ST-elevation myocardial infarction (STEMI) based on electrocardiographic criteria. After applying predefined exclusion criteria including prior myocardial infarction, previous PCI or CABG (n=52), prior thrombolysis (n=28), and deferred PCI (n=20) a final cohort of 800 consecutive patients undergoing primary PCI was included in the analysis. All enrolled patients completed in-hospital follow-up, with no loss to follow-up, ensuring complete outcome ascertainment.

Descriptive Data

The baseline demographic and clinical characteristics of the study population are summarized in Table 1. The mean age of the cohort was 55 ± 10 years, with a predominance of male patients (72%). The majority of patients (81%) were aged between 40–65 years, reflecting a relatively younger STEMI population compared to Western registries. Hypertension was the most prevalent cardiovascular risk factor (44%), followed by smoking (40%) and diabetes mellitus (36%). Anterior wall myocardial infarction was the most common clinical presentation (54%), consistent with the predominance of left anterior descending (LAD) artery involvement.

Angiographic and procedural characteristics are detailed in Table 2. The LAD was identified as the culprit vessel in 51% of cases, followed by the right coronary artery (32%) and left circumflex artery (14%). A radial-first strategy was adopted in 90% of procedures, reflecting contemporary best practice. Direct stenting was performed in 65% of cases, and glycoprotein IIb/IIIa inhibitors (tirofiban) were selectively administered in 55% of patients based on thrombus burden and angiographic characteristics.

Time-to-treatment metrics demonstrated high adherence to guideline-recommended targets. The mean door-to-balloon (D2B) time was 45 ± 15 minutes, with 95.6% of patients achieving the ≤90-minute benchmark. The distribution of D2B times is illustrated in Figure 1, highlighting a strong clustering within optimal time windows.

Outcome Data

Procedural and clinical outcomes are summarized in Tables 3 and 4. Final TIMI grade III flow was achieved in 94% of patients, with an overall procedural success rate of 96%. As shown in Table 3, there was a marked improvement in coronary perfusion from pre-PCI TIMI 0 flow (73%) to post-PCI TIMI III flow (94%), demonstrating effective reperfusion.

In-hospital clinical outcomes were favorable, with an overall mortality rate of 2.25% (18 patients). Stent thrombosis occurred in 1.25% of cases, while no cases of stroke, major bleeding, or emergency CABG were reported, reflecting an excellent safety profile (see Table 4). Accelerated idioventricular rhythm (AIVR), a recognized marker of successful reperfusion, was observed in 30% of patients. Hemodynamic complications included cardiogenic shock in 8% and acute left ventricular failure in 11% of patients. The median length of hospital stay was 3 days (IQR: 2–5), indicating efficient post-procedural recovery.

Main Results

The primary analysis demonstrated that primary PCI at this high-volume tertiary care center achieved a high procedural success rate (96%) with low in-hospital mortality (2.25%) and minimal complication rates. Multivariable and univariate analyses identified key predictors of in-hospital mortality (Table 5). Cardiogenic shock at presentation emerged as the strongest independent predictor (OR 8.94; 95% CI: 3.71–21.54; p<0.001), followed by failure to achieve TIMI III flow (OR 6.78), door-to-balloon time exceeding 90 minutes (OR 4.12), and age >65 years (OR 3.82). These findings underscore the critical importance of early hemodynamic stabilization, rapid reperfusion, and achievement of optimal angiographic outcomes in improving survival. Furthermore, the consistently high rate of guideline-recommended D2B times and radial access utilization supports the effectiveness of streamlined institutional protocols in delivering high-quality STEMI care.

Table 1: Baseline Demographic and Clinical Characteristics.

Variables		N(%)
Age (years), mean ± SD		55 ± 10
Age Group	< 40 years	72 (9.0%)
	40-65 years	648 (81.0%)
	> 65 years	80 (10.0%)
Gender	Male	576 (72.0%)
	Female	224 (28.0%)
Risk Factors	Diabetes mellitus	288 (36.0%)
	Hypertension	352 (44.0%)
	Current smoking	320 (40.0%)
	Dyslipidemia	192 (24.0%)
	Family history of CAD	128 (16.0%)
Clinical Presentation	Anterior wall MI	432 (54.0%)
	Inferior wall MI	280 (35.0%)
	Inferior + RV MI	64 (8.0%)
	Lateral MI	24 (3.0%)

Table 2: Angiographic and Procedural Characteristics.

Variables		N(%)
Culprit Artery	Left anterior descending (LAD)	408 (51.0%)
	Right coronary artery (RCA)	256 (32.0%)
	Left circumflex (LCX)	112 (14.0%)
	Obtuse marginal (OM)	16 (2.0%)
	Left main (LMCA)	8 (1.0%)
Access Route	Transradial approach	720 (90.0%)
	Transfemoral approach	80 (10.0%)
Procedural Interventions	Direct stenting	520 (65.0%)
	GP IIb/IIIa inhibitor use (tirofiban)	440 (55.0%)
	Thrombus aspiration	96 (12.0%)

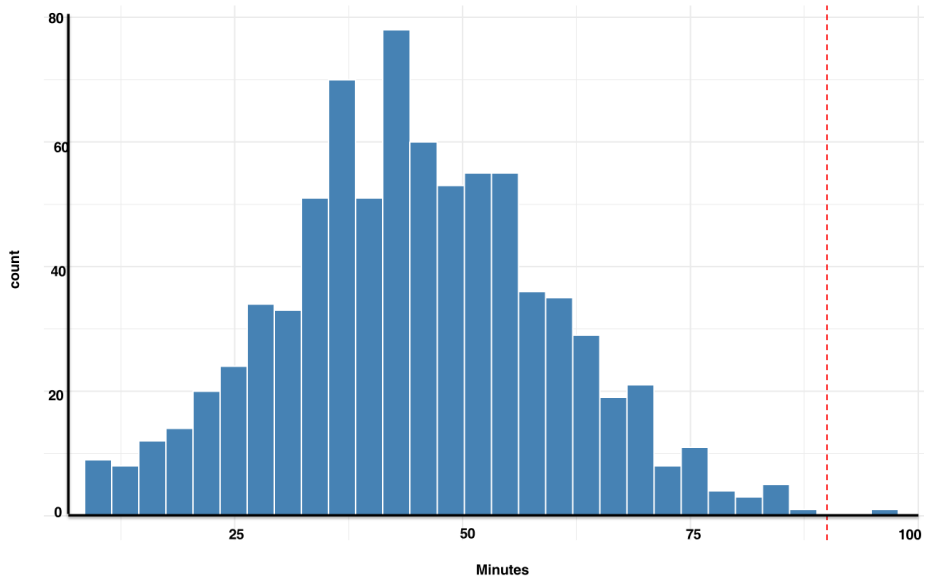

Figure 1: Histogram of door-to-balloon (D2B) times among STEMI patients undergoing primary PCI.

Table 3: TIMI Flow Grades Pre- and Post-PCI.

TIMI Flow Grade	Pre-PCI N(%)	Post-PCI N(%)
TIMI 0 (No flow)	584 (73.0%)	10 (1.25%)
TIMI I (Penetration, no perfusion)	128 (16.0%)	6 (0.75%)
TIMI II (Partial perfusion)	64 (8.0%)	32 (4.0%)
TIMI III (Normal flow)	24 (3.0%)	752 (94.0%)
Procedural Success	-	768 (96.0%)

Table 4: In-Hospital Clinical Outcomes.

Outcome		N(%)
All-cause mortality		18(2.25%)
Stent thrombosis (definite)		10(1.25%)
Stroke (hemorrhagic/ischemic)		-
Major bleeding (TIMI criteria)		-
Emergency CABG		-
Accelerated idioventricular rhythm		240(30.0%)
Hemodynamic Complications	Cardiogenic shock	64(8.0%)
	Acute left ventricular failure	88(11.0%)
Length of stay days; [(Median(IQR)]		3 (2-5)

Table 5: Univariate Predictors of In-Hospital Mortality.

Variables	Univariate OR	95% CI	p-value
Age > 65 years	3.82	1.58-9.24	0.003
Female gender	1.45	0.62-3.38	0.392
Diabetes mellitus	2.18	0.94-5.05	0.069
Cardiogenic shock at admission	8.94	3.71-21.54	<0.001
D2B time > 90 minutes	4.12	1.52-11.16	0.005
Anterior MI	2.34	0.92-5.96	0.074
Multi-vessel disease	1.87	0.81-4.32	0.141
Failed TIMI III flow	6.78	2.45-18.75	<0.001

Discussion

This study provides one of the most comprehensive evaluations of primary percutaneous coronary intervention (PPCI) outcomes from Khyber Pakhtunkhwa, demonstrating that high procedural success (96%) and low in-hospital mortality (2.25%) can be achieved in a resource-constrained setting. These outcomes align closely with those reported from established Pakistani centers, including AFIC/NIHD and the Multan cohort, as well as multicenter European STEMI registries, thereby supporting comparability with recognized national and international benchmarks[9,13,14,15]. Importantly, these results highlight that structured, protocol-driven systems of care can deliver outcomes comparable to higher-resource settings.

The demographic profile of this cohort reflects the evolving epidemiology of cardiovascular disease in Pakistan. The predominance of male patients (72%) and a relatively younger mean age (55 years) are consistent with both national and international STEMI registries[13,15]. The high burden of modifiable risk factors particularly hypertension (44%), smoking (40%), and diabetes (36%) underscores the ongoing epidemiological transition and highlights the need for targeted preventive strategies. The cultural context of KP, including the widespread use of smokeless tobacco (naswar), likely contributes to the elevated cardiovascular risk observed in this population[17].

The procedural success rate of 96% and achievement of TIMI III flow in 94% of patients are consistent with contemporary benchmarks. These findings are comparable to AFIC/NIHD outcomes (96.3%) and within the range reported internationally, where successful reperfusion is achieved in approximately 90–95% of cases[13,15,18,19]. The predominance of left anterior descending artery involvement (51%) and anterior wall myocardial infarction (54%) is also in line with established pathophysiological patterns and reflects the higher morbidity associated with large-territory infarctions[20].

One of the most notable findings of this study is the excellent door-to-balloon (D2B) time performance, with a mean of 45 ± 15 minutes and 95.6% of patients achieving the ≤90-minute guideline target. These results compare favorably with national and international data, including AFIC/NIHD (median 51.75 minutes) and New Zealand registry data (67 minutes)[13,21]. The consistent achievement of these targets reflects the effectiveness of streamlined emergency department–to–catheterization laboratory workflows and adherence to ESC/ACC guideline-recommended care pathways[9,10]. Furthermore, the observed association between D2B times >90 minutes and increased mortality reinforces the critical importance of minimizing treatment delays[22,23].

The low in-hospital mortality rate (2.25%) and absence of major complications such as stroke, major bleeding, or emergency CABG indicate an excellent safety profile. These outcomes are comparable to those reported from major Pakistani registries and fall well below mortality rates reported in some international cohorts[13-15,24]. The

high utilization of radial access (90%) likely contributed significantly to the absence of major bleeding complications, consistent with evidence demonstrating reduced bleeding risk with transradial approaches[25,26]. Additionally, the observed stent thrombosis rate (1.25%) remains within acceptable limits for contemporary PCI practice.

The selective use of glycoprotein IIb/IIIa inhibitors (tirofiban) in 55% of cases reflects a tailored, risk-based approach aligned with current ESC/ACC recommendations[9,10]. Rather than routine administration, the use of these agents in patients with high thrombus burden or slow-flow phenomena appears to balance efficacy and safety, as evidenced by the absence of major bleeding events in this cohort.

The occurrence of accelerated idioventricular rhythm (AIVR) in 30% of patients serves as a supportive physiological marker of successful reperfusion. AIVR is widely recognized as a benign reperfusion arrhythmia and correlates with restoration of microvascular perfusion, further reinforcing the high procedural success observed in this study[27].

Cardiogenic shock at presentation emerged as the strongest independent predictor of in-hospital mortality (OR 8.94), consistent with global evidence and established risk stratification models such as the GRACE and TIMI scores[28,29]. Failure to achieve TIMI III flow and prolonged D2B time were also significant predictors, underscoring the central role of both timely and effective reperfusion. These findings emphasize the need for early risk stratification, rapid intervention, and optimization of procedural success to improve clinical outcomes.

The findings of this study have important implications for STEMI care delivery in KP and similar low- and middle-income settings. First, they demonstrate that high-quality PPCI outcomes are achievable with standardized protocols and efficient systems of care. Second, the success of radial-first strategies and selective pharmacotherapy provides a model for optimizing both safety and resource utilization. Third, while in-hospital metrics are excellent, improvements in pre-hospital care including emergency medical services, public awareness, and early diagnosis remain critical to reducing total ischemic time[11,12]. Finally, participation in national registries such as the Cardiac Registry of Pakistan (CROP) will be essential for benchmarking and continuous quality improvement[30].

This study has several limitations that should be considered when interpreting the findings. First, as a single-center retrospective analysis, the generalizability of the results to other institutions within KP or across Pakistan may be limited. Second, the absence of long-term follow-up restricts the evaluation of outcomes beyond the in-hospital period, including restenosis, recurrent ischemic events, and long-term survival. Third, symptom-to-door times were not systematically recorded, limiting the ability to assess total ischemic time and pre-hospital delays, which are critical determinants of STEMI outcomes. Fourth, although procedures were performed by experienced interventional cardiologists following standardized departmental protocols, operator-specific variability and evolving practices over time were not formally quantified and may have introduced residual heterogeneity. Finally, certain region-specific risk factors, including detailed patterns of smokeless tobacco (naswar) use, dietary habits, and socioeconomic determinants, were not comprehensively captured, which may influence cardiovascular risk and outcomes in this population.

Conclusion

Primary percutaneous coronary intervention at Lady Reading Hospital, Peshawar, demonstrated high procedural success (96%) and low in-hospital mortality (2.25%), with an excellent safety profile characterized by the absence of stroke, major bleeding, and emergency CABG. These outcomes are consistent with those reported from major Pakistani registries, including AFIC/NIHD and the Multan cohort, and fall within the range observed in contemporary European STEMI registries,

supporting comparability with established national and international benchmarks. The consistently short door-to-balloon times (mean 45 minutes; 95.6% ≤90 minutes) and high radial access utilization (90%) reflect the successful implementation of standardized emergency department–to–catheterization laboratory workflows, radial-first strategies, and adherence to ESC/ACC guideline-directed care.[8][9] The selective use of glycoprotein IIb/IIIa inhibitors further contributed to favorable outcomes while minimizing bleeding risk. Cardiogenic shock at presentation and failure to achieve optimal reperfusion (TIMI III flow) were the strongest predictors of adverse outcomes, highlighting the importance of early risk stratification and timely, effective intervention. While in-hospital outcomes are encouraging, future efforts should focus on improving pre-hospital systems of care, including early symptom recognition, emergency medical services, and referral pathways, to further reduce total ischemic time.

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