

ORIGINAL ARTICLE

In-hospital outcomes following primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction and cardiogenic shock: A single-center experience.

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ABSTRACT... Objective: To evaluate in-hospital outcomes subsequent to primary percutaneous coronary intervention (PCI) among individuals exhibiting ST-elevation myocardial infarction (STEMI) presenting with cardiogenic shock (CS). **Study Design:** Analytical Cross-sectional Analysis. **Setting:** Faisalabad Institute of Cardiology, Faisalabad. **Period:** April to October 2024. **Methods:** In total 145 patients within the age range of 30–65 years diagnosed with STEMI complicated by CS undergoing primary PCI were included. Baseline demographics, cardiovascular risk profile, clinical presentation, and angiographic characteristics were recorded. In-hospital outcomes, including mortality, arrhythmias, and contrast-induced nephropathy (CIN), were assessed. Statistical evaluation was performed using SPSS version 26, applying chi-square and binary logistic regression tests. **Results:** The mean age was 53.6±7 years, with 62.8% males. Hypertension, diabetes, smoking, and dyslipidemia were present in 60.7%, 42.8%, 49%, and 47.6% of patients, respectively. The most common culprit artery was proximal LAD (39.3%). Multivessel disease was observed in 66.2% of patients. In-hospital complications included arrhythmias in 12.3%, CIN in 22.8%, reinfarction in 6.2%, stroke in 2.8%, and major bleeding in 7.6% of patients. In-hospital mortality was observed at 8.3%. CIN showed a significant association with the number of diseased vessels ($p=0.027$) and culprit artery ($p=0.039$). On multivariable analysis, CIN (AOR=3.4, $p=0.021$) and triple vessel disease (AOR=2.8, $p=0.034$) emerged as independent determinants of mortality. **Conclusion:** Primary PCI in STEMI patients experiencing CS is characterized by notable in-hospital complications and mortality. Angiographic complexity and renal complications significantly influence outcomes, emphasizing the need for early risk stratification and optimized management strategies.

Key words: Acute Kidney Injury, Arrhythmias Cardiac, Contrast Media, Coronary Angiography, Hospital Mortality, Myocardial Infarction, Percutaneous Coronary Intervention, Postoperative Complications, Shock Cardiogenic.

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INTRODUCTION

Acute myocardial infarction (AMI) remains a leading contributor to global mortality because its rapid progression and is associated with substantial mortality.¹ The prevalence of myocardial infarction differs markedly by age, with an estimated incidence of 3.8% in individuals under 60 years and increasing to 9.5% in those 60 years and older.² Recently, there have been improvements in clinical outcomes among patients with STEMI. This is due to more effective ways to manage patients with STEMI, development of better techniques to perform this management, and use of adjunctive pharmacological treatment options for cases of STEMI who receive primary percutaneous coronary intervention. Unfortunately, the risk of death from AMI accompanied by cardiogenic shock (CS), continues to remain high,

with in-hospital mortality rates between 40% - 50% for AMI patients associated with CS; and AMI patients without CS have mortality rates between 3%-5%.³

About 50% of the patients who will develop CS will do so in the first six hours after an AMI, and 75% will develop CS in the first 24 hours after an AMI.⁴ CS is also caused by many acute cardiovascular conditions such as an AMI, cardiomyopathy exacerbation, valvular heart disease, arrhythmias, conduction abnormalities and pericardial disease.⁵ The poor prognosis for CS during acute coronary syndrome (ACS) is widely recognized, demonstrating an in-hospital mortality of around 40% to 50%, and a significant proportion of deaths occurring within the first 24 hours of admission.⁶

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Therefore, cases of CS demand immediate revascularization along with critical care support to improve survival and clinical outcomes.⁷

Among individuals with STEMI, with or without CS, early revascularization—particularly percutaneous coronary intervention (PCI) targeting the infarct-related artery—has proven to be the most effective therapeutic strategy for lowering mortality rate in both early and extended follow-up periods.⁸ Despite the demonstrated survival benefit related to timely coronary revascularization in those with CS, 30-day mortality reported at 35% to 45% has remained relatively unchanged over recent years, despite advancements in antithrombotic pharmacology, improved use of mechanical circulatory support, and modern PCI techniques.⁹

Complications following primary PCI in STEMI patients with CS, such as arrhythmias, contrast-induced nephropathy, and death, have been documented in 14.5%, 20%, and 10.5% of cases, respectively.³ This study focuses on evaluating the in-hospital complications that arise following primary PCI among patients presenting with CS. Where the probability of complications, including mortality, underscores the challenge of managing these critically ill patients, particularly in resource-limited settings. By understanding the severity of post-treatment complications, healthcare providers can better select the most appropriate management protocols and pathways, potentially reducing both morbidity and mortality associated with these conditions.

METHODS

This analytical cross-sectional study was carried out at the Cardiology Department, Faisalabad Institute of Cardiology (FIC), Faisalabad, Pakistan, from April to October 2024. In total 145 patients were enrolled through a non-probability consecutive sampling approach. Patients aged between 30 and 65 years, of either gender, presenting with acute STEMI accompanied by cardiogenic shock (CS) and undergoing primary PCI were enrolled. STEMI diagnosis was established using presence of persistent prolonged chest pain exceeding 20 minutes along with ST-segment elevation on electrocardiogram (ECG) in at least two contiguous

leads together with elevated cardiac biomarkers (troponin level ≥ 0.01 ng/mL). The CS was considered as sustained systolic blood pressure (SBP) < 90 mmHg persisting for ≥ 30 minutes or the need for vasopressor/inotropic agents to sustain SBP ≥ 90 mmHg, along with evidence of end-organ hypoperfusion, reduced cardiac index (< 2.2 L/min/m²) along with raised pulmonary capillary wedge pressure (> 15 mmHg), where available.¹⁰

Patients were excluded if they had undergone emergency coronary artery bypass grafting (CABG), had prolonged cardiopulmonary resuscitation exceeding 30 minutes, had known valvular heart disease or structural cardiac defects, prior history of myocardial infarction (MI) or non-ST elevation myocardial infarction (NSTEMI), previous PCI or cardiac surgery, or diagnosed dilated cardiomyopathy. Patients with severe comorbid conditions such as advanced chronic kidney disease (baseline creatinine exceeding 2.0 mg/dL), active infection/sepsis, or incomplete clinical data were also excluded to minimize confounding.

Sample size estimation was performed using the WHO calculator, assuming an expected in-hospital mortality of 40% among individuals with STEMI accompanied by CS undergoing primary PCI, based on previous study literature.⁵ With a 95% CI, absolute precision of 8%, and power of 80%, the calculated sample size was 145 patients.

All eligible patients underwent primary PCI according to standard institutional protocols. The decision regarding vascular access (radial or femoral), use of thrombus aspiration, stent type (drug-eluting or bare-metal), and adjunctive pharmacotherapy (antiplatelets, anticoagulants, glycoprotein IIb/IIIa inhibitors), were administered at the operator's discretion. Hemodynamic support measures, including intra-aortic balloon pump (IABP) or inotropic support, were utilized when clinically indicated.

Data were collected using a structured proforma. Demographic information (age and gender) and medical history (hypertension, diabetes, smoking, lipids) were documented upon admission to the hospital. This included the clinical symptom of chest pain and how long the individual experienced chest

pain prior to presentation, as well as their Killip class (clinical severity of cardiogenic shock) and blood pressure and heart rate (hemodynamic). Prior to discharge, laboratory data such as cardiac markers, creatinine level, and other routine laboratory tests, were all documented. Procedural details documented included the artery in which the infarct occurred, extent of vessel involvement, what stent category was used, whether the procedure was successful, and if complications occurred.

Patients were followed for the duration of their hospital stay to determine if they had any complications while hospitalized. The main outcome assessed was in-hospital mortality, defined as death due to MI or during the hospitalization. Secondary outcome measurements included: major in-hospital complications (arrhythmia, contrast-induced nephropathy (CIN), reinfarction, stroke, major bleeding, and mechanical circulatory support).

Arrhythmias were defined as clinically relevant rhythm disturbance documented on the ECG, which included: ventricular tachycardia (VT), ventricular fibrillation (VF), and sustained tachyarrhythmia with a heart rate greater than 100 beats per minute for greater than 30 seconds. Contrast-induced nephropathy was considered as a rise in serum creatinine ≥ 0.5 mg/dL or $\geq 25\%$ above baseline within 48 hours after contrast administration. Reinfarction was defined as recurrence of ischemic symptoms with new ECG changes and a rise in cardiac biomarkers after initial stabilization. Stroke was characterized by the development of a new focal neurological deficit of vascular origin lasting longer than 24 hours. Major bleeding was assessed according to standard clinical criteria (e.g., requiring transfusion or causing hemodynamic instability).¹²

Data was analyzed using SPSS version 26. Continuous data were summarized as mean \pm SD, while categorical data and clinical outcomes were reported as frequencies and percentages. Stratification was performed with respect to age, gender, and major risk factors, and associations were evaluated using the chi-square test with in-hospital outcomes. Binary logistic regression was conducted to determine independent predictors of in-hospital mortality and CIN. Variables showing

$p \leq 0.20$ in univariate analysis were entered into the multivariable model, and adjusted odds ratios with 95% confidence intervals were estimated. Model calibration was assessed with the Hosmer–Lemeshow test, and statistical significance was set at $p \leq 0.05$.

Written informed consent was secured from all patients (or their attendants in cases where patients were unable to provide consent due to clinical condition) before enrollment. The objectives, procedure, along with potential risks and benefits, were clearly explained to the participants. Ethical clearance was granted by the Institutional Review Board of Faisalabad Institute of Cardiology, Faisalabad (Approval No. 49-2023/DME/FIC/FSD, dated: 20/12/2023).

RESULTS

In total 145 patients were enrolled in the present study. Baseline demographic and clinical features are detailed in Table-I. The mean age of the patients was 53.6 ± 7 years, with a male predominance. The study cohort with cardiovascular risk factors was high, including a considerable proportion of patients who were hypertensive, had diabetes mellitus, were smokers, and had dyslipidemia.

TABLE-I	
Baseline demographic and risk factors (n = 145)	
Variable	Frequency (%) / Mean \pm SD
Age (years)	53.6 \pm 7
Gender	
• Male	91 (62.8%)
• Female	54 (37.2%)
Hypertension	88 (60.7%)
Diabetes Mellitus	62 (42.8%)
Smoking	71 (49.0%)
Dyslipidemia	69 (47.6%)

The clinical and hemodynamic characteristics at admission are summarized in Table-II. The majority of patients presented to the hospital with CS after an early (less than 12 hours) and advanced Killip classification. The SBP and heart rate upon initial presentation supported the presence of hemodynamic compromise of patients at time of admission.

TABLE-II

Clinical and hemodynamic characteristics

Variable	Value
Duration of chest pain (<6 hours)	87 (60.0%)
Killip class IV	145 (100%)
Systolic BP (mmHg)	82 ± 8
Heart rate (bpm)	108 ± 14
Troponin (ng/mL)	3.2 ± 1.1

Angiographic and procedural details are summarized in Table-III. The most commonly affected culprit vessel was the left anterior descending artery (LAD), specifically the proximal LAD, followed by right coronary artery (RCA). A large percentage of patients presented with multivessel disease. The majority of cases received drug-eluting stents and had successful procedural outcomes. Hemodynamic support (i.e., inotropic medications/intra-aortic balloon pump [IABP]) was used when indicated.

TABLE-III

Angiographic and procedural characteristics

Variable	Frequency (%)
Culprit Artery	
• LAD (proximal)	57 (39.3%)
• LAD (non-proximal)	37 (25.5%)
• RCA	31 (21.4%)
• LCX	20 (13.8%)
Number of Diseased Vessels	
• Single vessel	49 (33.8%)
• Double vessel	58 (40.0%)
• Triple vessel	38 (26.2%)
Stent Type	
• Drug-eluting stent	112 (77.2%)
• Bare-metal stent	33 (22.8%)
Procedural Success	129 (89.0%)
Use of IABP	41 (28.3%)
Inotropic Support	145 (100%)

The frequency of in-hospital outcomes/complications can be found in Table-IV. The most commonly reported complications during hospitalization were arrhythmias and contrast-induced nephropathy (CIN), while in-hospital mortality was also noted. Re-infarction, stroke, and major bleeding were other complications reported, but less frequently.

TABLE-IV

In-hospital outcomes

Outcome	Frequency (%)
Arrhythmias	18 (12.3%)
Contrast-Induced Nephropathy	33 (22.8%)
Reinfarction	9 (6.2%)
Stroke	4 (2.8%)
Major Bleeding	11 (7.6%)
Mortality	12 (8.3%)

Stratification analysis was performed to evaluate the relationship between major complications in relation to clinical and angiographic variables. As illustrated in Table-V, CIN was found to have a statistically significant association with respect to the extent of vessel involvement and culprit artery. No statistically a statistically significant relationship was identified between arrhythmias or mortality and baseline demographic variables such as age and gender (Table-VI).

TABLE-V

Association of CIN with clinical variables

Variable	CIN Present	CIN Absent	P-Value
Number of Vessels			
• Single	7	42	
• Double	14	44	
• Triple	12	26	0.027
Culprit Artery			
• LAD	19	75	
• RCA	8	23	
• LCX	6	14	0.039

TABLE-VI

Association of outcomes with demographics

Variable	Arrhythmia (p-value)	Mortality (p-value)
Age Group (≤55 vs >55)	0.421	0.318
Gender	0.537	0.442

Multivariable logistic regression was conducted to determine independent predictors of in-hospital mortality (Table-VII). Variables demonstrating $p \leq 0.20$ in univariate analysis were included in the regression model. The analysis demonstrated that

multivessel disease, presence of CIN, and advanced age emerged as independent determinants of in-hospital mortality. Patients with CIN demonstrated significantly greater odds of mortality compared to those without it (adjusted odds ratio [AOR] = 3.4, 95% CI: 1.2–9.6, $p = 0.021$). Similarly, triple vessel disease was linked to higher odds of mortality (AOR = 2.8, 95% CI: 1.1–7.3, $p = 0.034$).

TABLE-VII

Multivariable analysis of mortality predictors

Variable	AOR	95% CI	P-Value
Age (>55 years)	1.9	0.8–4.5	0.121
Diabetes	1.6	0.7–3.8	0.233
Triple vessel disease	2.8	1.1–7.3	0.034
CIN	3.4	1.2–9.6	0.021
Arrhythmia	2.1	0.9–5.2	0.089

DISCUSSION

The present study evaluated in-hospital outcomes following primary PCI among individuals with STEMI accompanied by CS, a clinical entity associated with significant morbidity and mortality. This study demonstrated a mean age of 53.6 years with male predominance (62.8%), which is consistent with previous studies reporting higher incidence in males; however, the mean age in international cohorts is generally higher, ranging from 58 to 66 years.^{13,14}

The prevalence of cardiovascular risk factors in this study, such as hypertension (60.7%), diabetes mellitus (42.8%), smoking (49%), and dyslipidemia (47.6%), is comparable with contemporary studies that report hypertension in 50–70% and diabetes in approximately 30–45% cases of STEMI with concurrent CS.^{5,15} These risk factors are well-established contributors to adverse cardiovascular outcomes, with diabetes and renal dysfunction particularly correlated with elevated mortality risk.^{14,16}

Angiographically, the predominance of left anterior descending artery (LAD) involvement, especially proximal LAD (39.3%), observed in this study aligns with existing literature identifying anterior wall infarction as a major determinant of CS due to larger myocardial territory involvement.¹⁷ The presence of multivessel disease within this cohort was also quite prevalent, corresponding with

previous studies, which demonstrate a multivessel disease prevalence ranging between 60–70% in this patient population.⁵ Furthermore, multivessel disease serves as an independent determinant of mortality, with OR reported between 2.0 and 3.5 in multivariable analyses.¹⁸

The in-hospital mortality rate for the current study was 8.3%, which is significantly less than the 30-day mortality rates associated with large registry studies and cohort studies (which typically have 30-day mortality rates between 35% and 50%).^{17,19} A nationwide registry study reported a 30-day mortality of 39.8% for STEMI patients with CS (cardiogenic shock) who underwent PCI, and other currently published cohorts report mortality rates as high as 47.5%.^{17,20} The differences between our study and these previously published reports may reflect differences in patient selection, excluding patients with extremely high-risk profiles from the study, intervention prior to the patient's arrival at the hospital, and differences in the healthcare delivery systems. The early hemodynamic stabilization and the procedural success rates associated with these procedures may also have affected the favorable short-term outcomes of patients in this study.

The occurrence of arrhythmias (12.3%) in present study was within the range reported in previous studies (10% - 20%) of arrhythmic complications observed in individuals with STEMI and CS.²¹ Ischemia-induced electrical instability primarily drives arrhythmias and is associated with high risk of adverse events. Similarly, the rate of CIN in present study (22.8%) was within the range reported (15%-30% of patients) in high-risk PCI populations.²²

In this study, CIN showed a significant relationship with the extent of vessel involvement ($p=0.027$) and the culprit artery ($p=0.039$). Prior research has demonstrated that patients with complex coronary anatomy and multivessel disease tend to receive larger contrast volumes, resulting in increased procedural complexity and therefore an increased risk of renal impairment following PCI.^{15,22} Renal dysfunction has consistently been identified as a key determinant of post-PCI mortality, with relative risk estimates ranging from 1.8 to 2.5.²⁰

Although no statistically meaningful relationship was identified between mortality and arrhythmias with baseline demographic variables in this study, there have been many large scale studies demonstrating that advanced age, female gender, diabetes, and delayed presentation are all important predictors of mortality in this population.^{14,20,23} It is possible that the absence of statistically significant findings in this study was due to the smaller sample size and limited statistical power compared to the previous studies.

The universal use of primary PCI in this study reflects the standard of care and the recommended current guidelines for managing STEMI with CS. Current guidelines continue to emphasize that early revascularization is the most effective intervention to improve survival in patients with STEMI and CS.^{19,24} Also, there's been recently done metabolic analysis of PCI compared to conservative management that shows PCI has been shown to reduce mortality and achieved better cardiovascular clinical outcomes which supports PCI's dominant position in treatment.²⁵

Despite the ongoing progress in interventional cardiology with advances in stent technology, pharmacotherapy, and mechanical circulatory support; however, outcomes in CS remain disappointing around the globe. Mortality continues to be mismanaged by such factors as late presentation to hospital, extensive myocardial injury, multi-vessel disease and multiple organ dysfunction.^{17,21} The results of the present study further emphasize the need to diagnose patients with CS early, reperfusion should occur as quickly as possible and that patients should receive complete peri-procedural care to improve clinical endpoints.

The patients evaluated in this study reflect data previously reported whereby STEMI with CS is a very high-risk patient population. The correlations noted between the degree of angiographic complexity and complications from these patients further support the need for proper risk stratification as well as tailored management for optimal patient outcomes.

LIMITATIONS

There are multiple limitations to this study that warrant mention. The limitations from the study

relate primarily to the small sample size from one primary institution with restricted generalizability to the population at large. Another limitation is using a single point of evaluation which was only occurred at the time of hospital discharge; therefore, long term morbidity/mortality was not evaluated. While multivariable analyses did control for multiple variables, the possibility of residual confounding cannot be excluded. There were other limitations that may have contributed to outcome differences, including procedural and hemodynamic variables (i.e., exact timing of intervention, exact contrast volume, and use of advanced mechanical circulatory support) that were not uniformly recorded. Furthermore, since extremely high-risk patients, such as those that had prolonged resuscitation had a likely excluded from the study; therefore, true mortality rates may have been lower than reported.

CONCLUSION

Patients with STEMI complicated by CS who receive primary PCI are at high risk for multiple in-hospital complications, such as arrhythmias and CIN. The mortality rate in our series was 8.3%. In-hospital outcomes were also adversely impacted by angiographic characteristics, such as multivessel disease and involvement of the culprit artery. The findings support the need for timely risk stratification, adequate procedure planning, and optimized peri-procedural care to improve clinical outcomes in this very high-risk patient group.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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2	Amara Arshad: Data collection.
3	Rehan Riaz: Compilation of results.
4	Farah Naz: Statistical analysis.
5	M. Zeeshan Ramzan: References alignment.
6	Muhammad Akram: Finalization of manuscript.