ORIGINAL ARTICLE

OUTCOMES OF ST-SEGMENT ELEVATION MYOCARDIAL INFARCTION IN A COHORT OF CARDIOGENIC SHOCK PATIENTS UNDERGOING PRIMARY PERCUTANEOUS CORONARY INTERVENTION

Rajesh Kumar[1], Kamran Ahmed Khan[1], Kubbra Rahooja[1], Kalsoom Chachar[1], Muhammad Qasim Khan[1], Ahsan Ali[1], Ali Bin Naseer[1], Abdul Basit[1], Muhammad Rasool[1], Uroosa Safdar[1], Abiha Urooj[1], Aisha Hussain[1], Muhammad Ishaq[1], Anesh Wadhwa[2], Fawad Farooq[1], Sohail Khan[1], Jawaid Akbar Sial[1]

[1]National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan, [2]Dow University of Health Sciences (DUHS), Karachi, Pakistan

Objectives: The objective of this study was to investigate the immediate and short-term mortality rates among patients with ST-segment elevation myocardial infarction (STEMI) complicated by cardiogenic shock (CS) who underwent primary percutaneous coronary intervention (PCI).

Methodology: This observational study was conducted at a tertiary care cardiac center in Pakistan. We included consecutive patients diagnosed with STEMI complicated by CS who underwent primary PCI. We analyzed the clinical characteristics, management strategies, and in-hospital as well as short-term follow-up outcomes of the patients.

Results: A total of 200 patients were included in the study, of which 74.5% (149) were male, and the mean age was 57.96 ± 12.52 years. The majority of patients were classified as Killip class III (64.0%, 128), while the remaining were classified as Killip class IV. On arrival, arrhythmias were observed in 37.5% (75) of the patients, 27.5% (55) were in cardiac arrest and 84.5% (169) required intubation. Intra-aortic balloon pump (IABP) placement was performed in 31.5% (63) of the patients, and temporary pacemakers (TPM) were placed in 18.5% (37). The in-hospital mortality rate was found to be 10.5% (21). During a mean follow-up period of 177 days (141.5-212.5), a cumulative major adverse cardiovascular event (MACE) was observed in 48% (96) of the patients, with an all-cause mortality rate of 28% (56). Additionally, re-infarction occurred in 7.5% (15) of the patients, and re-hospitalization due to heart failure was noted in 23.5% (47) of the patients.

Conclusion: Our study revealed an in-hospital mortality rate of 10.5% following primary PCI in patients with CS. At approximately six months after the acute event, nearly half of the patients experienced MACE, with a notable mortality rate of 28%. These findings highlight the critical nature of CS and emphasize the need for further research and interventions to improve outcomes in this high-risk patient population.

Keywords: ST-segment elevation myocardial infarction, cardiogenic shock, primary percutaneous coronary intervention, MACE

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INTRODUCTION

Clinical outcomes following ST-segment elevation myocardial infarction (STEMI) have significantly improved in the last couple of decades as a result of advancements in management strategies, devices and techniques, and adjunctive pharmacological therapies.[1] However, patients with acute myocardial infarction (MI) complicated by cardiogenic shock (CS) remained a high-risk subset of patients with immediate mortality ranging from 40% to 60% as against 3% to 4% in patients without CS.[2,3] CS is a state of the failure of the heart to maintain optimal cardiac output proportional to the increased metabolic demand of the body due to any underlying cardiovascular pathology. A range of acute cardiovascular insults contributes to the CS pathologies, such as acute myocardial infarction (AMI), exacerbation of cardiomyopathy, valvular

disease, conduction abnormalities, arrhythmia, or pericardial disease.[4]

Management of CS patients is complex and costly, epically in the healthcare setup of a developing or under-developing country; it requires the use of circulatory support mechanical devices, intensive care unit (ICU) stay, and often multidisciplinary care.[5] The hospital course of such patients varies from prolonged ICU stay to rapid death, and clinical decisions regarding most of the treatment options, such as mechanical circulatory support and revascularization, are extremely time-sensitive and warrant prompt decision-making by the caregiver as well as patient and family.[6] In clinical practice, emergency percutaneous coronary revascularization is the treatment of choice with a proven superiority over the medical stabilization of these parents.[7] There are three primary objectives of the treatment of patients with STEMI complicated by CS, first, the preservation of appropriate mean atrial pressure through circulatory support devices in order to maintain systemic organ reperfusion; second, the ventricular volume and pressure unload in order to limit the myocardial oxygen demand, and thirdly restoration of myocardial reperfusion with the opening of the occluded artery.[8]

Many cardiac care centers have developed critical protocols and pathways for the management of STEMI complicated by CS, with resultant improvements in outcomes for these high-risk patients. Management of these highly demanded patients is challenging, especially in resource-limited settings. In this study, we investigated immediate and short-term mortality of patients with STEMI complicated by CS undergoing primary percutaneous coronary intervention (PCI) at a tertiary care cardiac center in Pakistan.

METHODOLOGY

This observational study was conducted at the National Institute of Cardiovascular Diseases (NICVD) in Karachi, Pakistan, from August 2020 to July 2021. Ethical approval was obtained from the hospital's ethical review board (ERC-30/2020). The study included consecutive patients diagnosed with ST-elevation myocardial infarction (STEMI) complicated by cardiogenic shock (CS) who underwent primary percutaneous coronary intervention (PCI).

Verbal informed consent for study inclusion was obtained from the attendant or legally authorized representative of each patient, considering the hemodynamic instability of the patients. Patients with deferred consent, those requiring emergency coronary artery bypass grafting, and those with a history of resuscitation exceeding 30 minutes were excluded from the study.

STEMI was defined based on the presence of typical chest pain history and the findings of a 12-lead electrocardiogram (ECG) at the presentation. CS was defined as clinical signs of impaired end-organ perfusion and pulmonary congestion, along with the requirement of inotropes/vasopressors to maintain a systolic pressure of at least 90 mmHg for a minimum of 30 minutes. All primary PCI procedures and CS management were performed according to current guidelines and institutional policies. The decision to use an intra-aortic balloon pump (IABP) was made by the primary operator. All patients underwent IABP placement either before or after the diagnostic angiogram but prior to PCI in the catheterization laboratory.

Data for the study was extracted from patients' medical records, including demographic and clinical characteristics, laboratory parameters, hemodynamic parameters, angiographic findings, and management details. Patients were monitored for in-hospital complications, including arrhythmias, bleeding, contrast-induced nephropathy, re-infarction, cardiogenic shock, and mortality. Surviving patients were followed up for an average of six months, and the incidence of major adverse cardiovascular events (MACE) was recorded, which encompassed all-cause mortality, re-infarction, and re-hospitalization due to heart failure.

Summary statistics, such as mean ± standard deviation (SD), median (interquartile range), or frequency and percentages, were used to summarize the collected information, depending on the type of variable. Patients were further stratified based on Killip class III or IV, and data were compared between the two groups. Demographic and clinical characteristics and outcomes were compared between patients in Killip class III and Killip class IV using independent sample t-tests, Mann-Whitney U tests, or Chi-square tests/Fisher exact tests, as appropriate. The significance criterion for all statistical analyses was set at a two-sided p-value of ≤ 0.05.

RESULTS

A total of 200 patients who met the inclusion criteria were enrolled in the study. Among them, 74.5% (149) were male, and the mean age of the study sample was 57.96 ± 12.52 years. The majority of the patients were classified as Killip class III, accounting for 64.0% (128), while the remaining patients were in Killip class IV. Upon arrival at the hospital, 37.5% (75) of the

patients presented with arrhythmias, 27.5% (55) were in cardiac arrest, and 84.5% (169) required intubation. In 31.5% (63) of the cases, an intra-aortic balloon pump (IABP) was placed, and a temporary pacemaker (TPM) was placed in 18.5% (37) of the patients (refer to Table 1 for details).

The in-hospital mortality rate was found to be 10.5% (21) among the study participants. Following a mean follow-up period of 177 [141.5-212.5] days, cumulative major adverse cardiovascular events (MACE) were observed in 48% (96) of the patients. This included an all-cause mortality rate of 28% (56), re-infarction in 7.5% (15) of the patients, and re-hospitalization due to heart failure in 23.5% (47) of the patients (refer to Table 2 for details).

Table 1: Killip class stratified distribution of demographic and clinical characteristics of patients with ST-segment elevation myocardial infarction complicated by cardiogenic shock

	Total	Killip Class		P-value
		III	IV	
Total (N)	**200**	**128**	**72**	-
Gender				
Male	74.5% (149)	76.6% (98)	70.8% (51)	0.372
Female	25.5% (51)	23.4% (30)	29.2% (21)	
Age (year)	57.96 ± 12.52	58.56 ± 12.96	56.89 ± 11.72	0.366
<45 years	13% (26)	13.3% (17)	12.5% (9)	0.201
45 to 64 years	59% (118)	54.7% (70)	66.7% (48)	
≥ 65 years	28% (56)	32% (41)	20.8% (15)	
Total ischemic time (minutes)	380 [270-630]	395 [277.5-655]	360 [270-600]	0.555
Systolic blood pressure (mmHg)	110 [90-140]	130 [110-150]	80 [80-90]	<0.001
Heart rate (bpm)	110 [80-120]	110 [90-120]	110 [60-120]	0.335
Random glucose level (mg/dL)	192.5 [144.5-270]	197 [140-265]	190 [152-300]	0.555
Hemoglobin level (mg/dL)	13.46 ± 1.99	13.41 ± 1.98	13.55 ± 2	0.623
Neutrophil count (cells/µL)	10.1 [8.8-12]	10.1 [8.8-12]	10.1 [8.7-12]	0.807
Platelet count (cells/µL)	242.8 [190-273.5]	242.8 [192.5-272]	242.8 [178-285]	0.879
Serum creatinine (mg/dL) on arrival	1.13 ± 0.41	1.12 ± 0.43	1.16 ± 0.38	0.583
Type of myocardial infarction (MI)				
Anterior	61.5% (123)	61.7% (79)	61.1% (44)	0.057
Inferior	7.5% (15)	8.6% (11)	5.6% (4)	
Inferior with RV infarct	20.5% (41)	15.6% (20)	29.2% (21)	
Inferio-posterior	9.5% (19)	12.5% (16)	4.2% (3)	
Lateral	1% (2)	1.6% (2)	0% (0)	
Intubated	84.5% (169)	85.9% (110)	81.9% (59)	0.454
Arrhythmias on arrival	37.5% (75)	26.6% (34)	56.9% (41)	<0.001
Cardiac arrest on arrival	27.5% (55)	19.5% (25)	41.7% (30)	0.001
Co-morbid conditions				
Hypertension	67.5% (135)	72.7% (93)	58.3% (42)	0.038
Smoking	22.5% (45)	24.2% (31)	19.4% (14)	0.438
Diabetes mellitus	49.5% (99)	53.1% (68)	43.1% (31)	0.172
Family history of IHD	1% (2)	1.6% (2)	0% (0)	0.286
History of CVA/TIA	2.5% (5)	1.6% (2)	4.2% (3)	0.258
Chronic kidney diseases	1.5% (3)	1.6% (2)	1.4% (1)	0.923
Prior myocardial infarction	13% (26)	14.1% (18)	11.1% (8)	0.551

RV=right ventricular, IHD=ischemic heart diseases, CVA=cerebrovascular accidents, TIA=transient ischemic attack

Table 2: Killip class stratified distribution of angiographic and procedural characteristics and in-hospital and short-term outcomes of patients with ST-segment elevation myocardial infarction complicated by cardiogenic shock

	Total	Killip Class		P-value
		III	IV	
Total (N)	**200**	**128**	**72**	-
LV end-diastolic pressure (mmHg)	28.61 ± 7.04	28.39 ± 7.34	29 ± 6.51	0.558
LV ejection fraction (%)	32.08 ± 7.95	32.66 ± 7.21	31.04 ± 9.07	0.197
Temporary pacemaker implanted	18.5% (37)	12.5% (16)	29.2% (21)	0.004
Intra-aortic balloon pump placed	31.5% (63)	22.7% (29)	47.2% (34)	<0.001
Number of vessels involved				
Single vessel disease	24.5% (49)	18.8% (24)	34.7% (25)	0.024
Two vessel disease	32% (64)	32% (41)	31.9% (23)	
Three vessel disease	43.5% (87)	49.2% (63)	33.3% (24)	

Culprit Artery				
Left main	5.5% (11)	2.3% (3)	11.1% (8)	0.001
LAD; Proximal	46% (92)	46.9% (60)	44.4% (32)	
LAD: Non-Proximal	10.5% (21)	12.5% (16)	6.9% (5)	
Right coronary artery	26% (52)	21.1% (27)	34.7% (25)	
Left circumflex	12% (24)	17.2% (22)	2.8% (2)	
Pre-procedure TIMI flow				
0	75% (150)	73.4% (94)	77.8% (56)	0.174
I	8.5% (17)	7.8% (10)	9.7% (7)	
II	10% (20)	9.4% (12)	11.1% (8)	
III	6.5% (13)	9.4% (12)	1.4% (1)	
Post-procedure TIMI flow				
0	1% (2)	0% (0)	2.8% (2)	0.085
I	3.5% (7)	3.1% (4)	4.2% (3)	
II	18% (36)	14.8% (19)	23.6% (17)	
III	77.5% (155)	82% (105)	69.4% (50)	
Aggarstate used	19.5% (39)	14.8% (19)	27.8% (20)	0.027
Thrombus grade				
G1	2% (4)	3.1% (4)	0% (0)	0.346
G2	1.5% (3)	2.3% (3)	0% (0)	
G3	8% (16)	8.6% (11)	6.9% (5)	
G4	13.5% (27)	12.5% (16)	15.3% (11)	
G5	75% (150)	73.4% (94)	77.8% (56)	
Stent done				
Drug-eluting stent	92.5% (185)	91.4% (117)	94.4% (68)	0.434
POBA	7.5% (15)	8.6% (11)	5.6% (4)	
Non-compliant balloon done	69% (138)	72.7% (93)	62.5% (45)	0.136
Vessel diameter (mm)	3.44 ± 0.34	3.4 ± 0.34	3.5 ± 0.34	0.053
Lesion length (mm)	29.25 ± 14.26	29.73 ± 14.89	28.4 ± 13.11	0.530
Fluro-time (min)	15.79 ± 8.07	16.36 ± 8.8	14.79 ± 6.49	0.188
Contrast volume (ml)	119.25 ± 38.31	123.74 ± 42.83	111.25 ± 27.06	0.012
Reperfusion arrhythmias	25% (50)	25% (32)	25% (18)	>0.999
In-hospital outcomes				
In-hospital death	10.5% (21)	6.3% (8)	18.1% (13)	0.009
Contrast-induced nephropathy	20% (40)	17.2% (22)	25% (18)	0.185
Arrhythmias	14.5% (29)	14.1% (18)	15.3% (11)	0.815
Bleeding	3% (6)	1.6% (2)	5.6% (4)	0.112
Re-infarction	1.5% (3)	2.3% (3)	0% (0)	0.191
Clopidogrel	97.5% (195)	96.9% (124)	98.6% (71)	0.450
Ticagrelor	2.5% (5)	3.1% (4)	1.4% (1)	0.450
Follow-up duration (days)	177 [141.5-212.5]	177 [150-210.5]	174.5 [77-216.5]	0.076
Short-term outcomes				
All-cause mortality	28% (56)	22.7% (29)	37.5% (27)	0.025
Cardiac mortality	11.5% (23)	12.5% (16)	9.7% (7)	0.554
Hospitalization due to HF	23.5% (47)	25.8% (33)	19.4% (14)	0.310
MI needing revascularization	7.5% (15)	7.8% (10)	6.9% (5)	0.823
Major adverse cardiovascular event	48% (96)	44.5% (57)	54.2% (39)	0.190

LV=left ventricular, LAD=left anterior descending artery, TIMI=Thrombolysis in Myocardial Infarction, POBA=plain old balloon angioplasty, HF=heart failure

DISCUSSION

Management of STEMI complicated by CS is a real challenge, especially in a resource-limited healthcare setup. In this study, we evaluated clinical characteristics, management, and immediate and short-term outcomes after primary PCI of patients with STEMI complicated by CS at a tertiary care cardiac center in a developing country. We observed that even after the primary PCI, CS carries significant immediate and short-term mortality, and in-hospital mortality was found to be 1 in 10 (10.5%), and 6-months MACE was observed to be 48%. On subgroup analysis, in-hospital as well as the 6-month mortality rate was significant among patients in Killip class IV compared to Killip class III with an event rate of 18.1% vs. 6.3%; p=0.009 and 37.5% vs. 22.7%; p=0.025, respectively.

Despite therapeutic and technical advancements in the management of CS, the rate of adverse events remained unacceptably high. Various studies have reported varying rates of in-hospital, short- and long-term mortality, mainly depending on the definition of CS and secondly on the length of follow-up. A study conducted by Hayıroğlu Mİ et al.[2] studied outcomes of

319 CS-complicated STEMI patients who were treated with primary PCI at a single center and reported an in-hospital mortality rate of 61.3%. The study further reported that final TIMI flow of ≤ II, chronic kidney diseases (CKD), ejection fraction (EF), tricuspid annular plane systolic excursion (TAPSE), blood urea nitrogen level, lactate level, and plasma glucose level were the independent predictors of in-hospital mortality.[2] Lesser in-hospital mortality in our study can be attributed to the fact that 64.0% of the patients in our study were in Killip class III which was thermodynamically more stable than those in Killip class IV. Secondly, the significant predictors of in-hospital mortality identified by Hayıroğlu Mİ et al.[2], such as CKD, deranged EF, and plasma glucose level, were relatively less common in our population. Another study by Wang Y et al.[9] included 274 CS patients who were managed with primary PCI at 39 hospitals in the Hebei province of China and reported an in-hospital mortality rate of 65.3%. In-hospital mortality was found to be associated with gender, post-procedure EF, no-reflow, gender, random plasma glucose level at admission, and use of IABP.[9] Backhaus T et al.[7], in their study, reported an in-hospital mortality rate of 37% and 50% at 1-year follow-up. It has been further reported that the use of IABP has reduced over the years, and changes in therapeutical management of these patients, such as increased use of drug-eluting stents, prasugrel, and ticagrelor, has resulted in improvement in the 1-year prognosis of these patients.[7] Kawaji T et al.[10] conducted a registry-based study of 466 STEMI patients complicated by CS due to acute pump failure and reported 30-day, one-year, and five-year mortality rate of 25.4%, 38.7%, and 51.4%, respectively. It has been further observed that patients with a door-to-balloon time of ≤ 90 minutes and onset-to-balloon time of ≤3 hours had better survival with adjusted hazard ratios of 0.73 [0.53-0.98] and 0.69 [0.49-0.96], respectively.[10] It has been further evaluated in another study that delays in reperfusion of CS patients result in higher mortality. It has been observed that the target first medical contact-to-device time of less than 90 minutes was achieved in < 40% of the patients.[3] In our study sample roughly 6-month re-admission rate was observed to be 23.5%, similar to this 30-day re-admission rate of 18.6% reported in a study of 39807 AMI patients complicated by CS, and a median re-admission time of 10-days was reported.[11] Similarly, a long-term (median 4 (2.0-5.2) years) mortality of 60% was reported in a retrospective study of 465 STEMI patients complicated by CS.[12]

In light of the above discussion, more research is needed to monitor and guide the management of patients with STEMI complicated by CS. In this regard, some researchers have proposed risk stratification scoring systems with good predictive value for the risk stratification of 30-day mortality.[9, 13, 14] In addition to the reperfusions, multidisciplinary management of CS patients is mandatory for the improvement of outcomes. Patients should also be evaluated for neurohumoral and metabolic parameters such as serum lactate has been reported to be a good indicator of hyper-perfusion,[15] and it has also been found to be associated with adverse outcomes in patients with STEMI complicated by CS.[16] Studies have reported a significant increase in the incidence of CS complicating STEMI, in one study its incidence was reported to be 9% in the year 2006 which increased to 16% in the ten year-time.[7] Similarly, in the analysis of US nationwide database, the incidence of STEMI complicated by CS was observed to increase from 6.5% to 10.1% between the year 2003 and 2010.[17] Therefore, targeted research efforts are needed to improve the outcomes of these high-risk patients. So far, the only proven effective method is emergency revascularization of the culprit artery; however, evidence for other supportive and medical therapies is unsatisfactory, and the use of IABP showed no clinical benefit. However, the use of ECMO and IMPELLA might yield better outcomes.[18]

Study findings are limited by its small sample size and single-center coverage. Further studies are needed to elaborate on the outcomes of STEMI patients complicated by CS. Further investigations should focus on identifying specific factors contributing to adverse outcomes in CS patients and developing targeted interventions to mitigate these risks. This may involve optimizing treatment protocols, implementing early and aggressive management strategies, and improving access to specialized care for timely interventions. By addressing the unique needs of CS patients, we can strive to enhance their overall prognosis and quality of life.

CONCLUSION

Based on the findings of this study, it can be concluded that in-hospital mortality following primary percutaneous coronary intervention (PCI) in patients with cardiogenic shock (CS) was observed at a rate of 10%, indicating a significant risk for these individuals. Additionally, the incidence of major adverse cardiovascular events (MACE) at approximately six months after the acute event was found to be around 50%, with a notable all-cause mortality rate of 28%.

These findings underscore the urgent need for further research and interventions aimed at improving the survival rates and overall outcomes of this vulnerable subgroup of patients. It is imperative to explore novel

strategies and therapeutic approaches that can effectively address the challenges associated with CS in order to reduce morbidity and mortality rates. Continued efforts in this area have the potential to significantly impact patient care and enhance long-term prognosis for individuals with CS.

AUTHORS' CONTRIBUTION

RK and KAK: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. KR, KC, MQK, AA, ABN, AB, MR, US, AU, AH, MI, AW, FF, SK, JAS: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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Address for Correspondence:

Dr. Rajesh Kumar, Associate Professor of Cardiology at National Institute of Cardiovascular Diseases (NICVD), Rafiqui (H.J.) Shaheed Road, Karachi- 75510, Pakistan..
Email: rajeshnarsoolal@gmail.com