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Contents

Monthly Volume 15 Number 9 September 26, 2023

MINIREVIEWS

ORIGINAL ARTICLE

Retrospective Study

Observational Study

CASE REPORT

World Journal of Cardiology

Monthly Volume 15 Number 9 September 26, 2023

Contents

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ORIGINAL ARTICLE

Retrospective Study

Immediate in-hospital outcomes after percutaneous revascularization of acute myocardial infarction complicated by cardiogenic shock

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Abstract

BACKGROUND

Cardiogenic shock (CS) is a life-threatening complication of acute myocardial infarction with high morbidity and mortality rates. Primary percutaneous coronary intervention (PCI) has been shown to improve outcomes in patients with CS.

AIM

To investigate the immediate mortality rates in patients with CS undergoing primary PCI and identify mortality predictors.

METHODS

We conducted a retrospective analysis of 305 patients with CS who underwent primary PCI at the National Institute of Cardiovascular Diseases, Karachi, Pakistan, between January 2018 and December 2022. The primary outcome was immediate mortality, defined as mortality within index hospitalization. Univariate and multivariate logistic regression analyses were performed to identify predictors of immediate mortality.

RESULTS

In a sample of 305 patients with 72.8% male patients and a mean age of 58.1 ± 11.8 years, the immediate mortality rate was found to be 54.8% (167). Multivariable analysis identified Killip class IV at presentation [odds ratio (OR): 2.0; 95% confidence interval (CI): 1.2-3.4; $P = 0.008$], Multivessel disease (OR: 3.5; 95%CI: 1.8-6.9; $P < 0.001$), and high thrombus burden (OR: 2.6; 95%CI: 1.4-4.9; $P = 0.003$) as independent predictors of immediate mortality.

CONCLUSION
Immediate mortality rate in patients with CS undergoing primary PCI remains high despite advances in treatment strategies. Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) were identified as independent predictors of immediate mortality. These findings underscore the need for aggressive management and close monitoring of patients with CS undergoing primary PCI, particularly in those with these high-risk characteristics.

Key Words: Acute myocardial infarction; Cardiogenic shock; Primary percutaneous coronary intervention; Mortality; Predictors

Core Tip: Cardiogenic shock (CS) is a severe form of acute myocardial infarction (AMI) associated with low blood pressure, poor organ perfusion, and high mortality rates. Overall, primary percutaneous coronary intervention (PCI) plays a crucial role in the management of patients with CS by improving blood flow to the heart, restoring cardiac function, and reducing mortality rates. However, the success of primary PCI depends on several factors, including the timeliness of treatment, the skill and experience of the operators performing the procedure, and the patient's overall health status. Therefore, it is essential to identify high-risk patients and provide timely appropriate treatment to achieve the best outcomes. Therefore, we conducted a retrospective analysis of 305 patients with CS complicated AMI undergone primary PCI at our center. It has been observed the immediate mortality rate was unacceptably high at 54.8% with cardiac arrest followed by renal failure, multi-organ dysfunction, sepsis, hypoxic brain injury and cerebrovascular accident as a cause of mortality. Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) were identified as independent predictors of immediate mortality in multivariable analysis.

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INTRODUCTION

The prevalence of myocardial infarction is estimated to vary by age group, with reported rates of 3.8% among individuals under 60 years of age and a higher prevalence of 9.5% among those aged 60 years and above. Within the context of acute myocardial infarction (AMI), a critical complication known as cardiogenic shock (CS) emerges as a life-threatening concern[1]. This condition stands as the leading cause of mortality associated with AMI, with reported incidence rates ranging from 5% to 15%[2,3]. CS is a medical emergency that occurs when the heart is unable to pump enough blood to meet the body's needs. It can be caused by a variety of conditions, including myocardial infarction (heart attack), cardiomyopathy, and valvular heart disease[3]. Management of CS involves identifying and treating the underlying cause and providing supportive care to stabilize the patient's condition[4]. In AMI, CS is a life-threatening complication with a high morbidity and mortality rate[5]. Primary percutaneous coronary intervention (PCI) has emerged as the preferred reperfusion strategy in patients with AMI and CS[6]. The main goal of primary PCI in patients with CS is to restore blood flow to the affected area of the heart, which can help to improve cardiac function and reduce mortality rates[4]. Compared to other revascularization strategies, such as thrombolysis or medical therapy alone, primary PCI has been shown to be more effective in restoring blood flow and improving outcomes in patients with CS[7].

Patients with CS are at risk of developing several in-hospital complications, which include; acute kidney injury (AKI) as a result of reduced kidney perfusion due to a decreased cardiac output and low blood pressure[8], arrhythmias such as atrial fibrillation and ventricular tachycardia[9], pulmonary edema due to excessive fluid administration or impaired cardiac function[10], and multi-organ failure due to impaired perfusion to vital organs as a result of prolonged hypotension and decreased cardiac output[10]. Additionally, invasive procedures such as PCI can increase the risk of bleeding complications[11], catheter-related bloodstream infections, and ventilator-associated pneumonia[12]. Also, CS is associated with an increased risk of thromboembolic events, as patients with reduced cardiac output and immobility are at increased risk of developing deep vein thrombosis and pulmonary embolism[10]. The development of these complications can further worsen the prognosis of patients with CS. Therefore, close monitoring and prompt management of these complications are essential in improving patient outcomes.

The management of CS requires a multidisciplinary approach involving cardiology, critical care, and interventional teams. Clinical precautions in the management of CS include several essential considerations. Firstly, early identification and diagnosis of CS is crucial, as early interventions have been shown to improve survival rates[13]. Therefore, healthcare providers should be vigilant for signs and symptoms of CS, such as hypotension, tachycardia, and decreased urine

output. Secondly, revascularization procedures such as PCI and coronary artery bypass grafting are essential in managing CS caused by myocardial infarction[6]. Early revascularization can restore blood flow to the heart muscle and prevent further damage. Thirdly, the use of inotropes and vasopressors should be carefully titrated to avoid complications such as arrhythmias and excessive vasoconstriction[14]. Adequate fluid resuscitation is necessary to maintain blood pressure and cardiac output, but excessive fluid administration can lead to pulmonary edema and worsen CS[14]. Fourthly, mechanical circulatory support devices such as intra-aortic balloon pump (IABP) and extracorporeal membranous oxygenation (ECMO) may be necessary in refractory cases of CS[15]. However, these devices have risks and complications, such as bleeding and infection, which should be carefully monitored and managed[16]. Finally, closely monitoring hemodynamic parameters such as blood pressure, heart rate, and cardiac output is essential to guide management and assess response to therapy[16]. Patients with CS require close attention and frequent assessments to identify and manage any complications that may arise.

The management of patients with CS undergoing primary PCI has evolved significantly over the last few decades. Despite these advances, the mortality rate in this patient population remains high[17]. There is a need to identify factors associated with poor immediate outcomes after primary PCI in patients with CS to help identify high-risk patients and guide treatment decisions[13]. Understanding the predictors of mortality and other immediate outcomes after primary PCI in patients with CS can also provide valuable insights for further refining the management of these patients. Therefore, this study aimed to investigate the immediate mortality rate in patients with CS undergoing primary PCI and identify mortality predictors.

MATERIALS AND METHODS

This retrospective analysis was conducted at the largest tertiary care cardiac hospital in Karachi, Pakistan, after approval from the institutional ethical review committee (ERC/46/2022). For this analysis, the de-identified data were extracted from the hospital records for the consecutive patients with CS who underwent primary PCI at our institution between January 2018 and December 2022. Patients with missing information on study variables were excluded from the analysis, and patients who did not undergo primary PCI were also excluded.

The primary outcome was immediate mortality, defined as mortality within index hospitalization. Baseline demographics, clinical characteristics, and procedural data were collected. Data regarding the hospital course of the patients were also extracted, which included IABP placement, intubation, temporary pacemaker, inotropic support, and in-hospital complications such as sepsis, renal dysfunction, cardiac arrest, cerebrovascular accident, hypoxic brain injury, and multi-organ dysfunction.

Data regarding demographics, clinical characteristics, procedural, and hospital course were compared between the two groups of patients based on immediate survival status with the help of an independent sample t-test/Mann-Whitney U test or Chi-square test/Fisher exact test. Univariate and multivariable binary logistic regression analyses were performed to identify predictors of immediate mortality. All the variables with P value < 0.20 in the univariate analysis were included in the multivariable analysis[18]. All the statistical analyses were formed with the help of IBM SPSS version 21, and $P < 0.05$ was the set criteria for statistical significance.

RESULTS

A total of 305 patients were included, of which 222 (72.8%) were male, and the mean age of the study sample was 58.1 ± 11.8 years. Most patients were in Killip class IV, 186 (61.0%), at the time of presentation. The immediate mortality rate was found to be 54.8% (167). The mean age was 59.4 ± 12.0 *vs* 56.5 ± 11.5; $P = 0.031$, Killip IV at presentation was 68.3% *vs* 52.2%; $P = 0.004$, and diabetes was present in 54.5% *vs* 41.3%; $P = 0.022$ among expired and survived patients, respectively (Table 1).

The multivessel disease was observed in 90.4% *vs* 68.1%; $P < 0.001$, high thrombus burden (grade ≥ 4) in 85.6% *vs* 67.4%; $P < 0.001$, bifurcations lesion in 29.9% *vs* 16.7%; $P = 0.007$, intraluminal defect in 89.8% *vs* 81.9%; $P = 0.045$, need of temporary pacemaker was for 60.5% *vs* 1.4%; $P < 0.001$, need of intubation for 78.4% *vs* 2.2%; $P < 0.001$, need of inotropic support was 76.0% *vs* 1.4%; $P < 0.001$, need of IABP was 48.5% *vs* 21.7%; $P < 0.001$, and left ventricular dysfunction was observed in 91.0% *vs* 75.4%; $P < 0.001$ among expired and survived patients, respectively (Table 2).

Multivariate analysis identified Killip class IV at presentation [odds ratio (OR): 2.0; 95% confidence interval (CI): 1.2-3.4; $P = 0.008$], Multivessel disease (OR: 3.5; 95%CI: 1.8-6.9; $P < 0.001$), and high thrombus burden (OR: 2.6; 95%CI: 1.4-4.9; $P = 0.003$) as independent predictors of immediate mortality (Table 3).

A 12.0% (20/167) of the total deaths were deaths on the catheterization table. Cardiac arrest was the most common cause of death observed in 95.8% (160/167). Among other causes, renal failure was observed in 25.1% (42/167), multi-organ dysfunction in 19.8% (33/167), sepsis in 18.0% (30/167), hypoxic brain injury in 6.6% (11/167), and cerebrovascular accident in 0.6% (1/167) patient.

DISCUSSION

CS is a severe complication of AMI associated with low blood pressure, poor organ perfusion, and high mortality rates.

Table 1 Distribution of demographics and clinical characteristics patients with cardiogenic shock stratified by immediate outcome after primary percutaneous coronary intervention

	Total	Immediate outcome		*P* value
		Mortality	Survived	
Total (*n*)	305	167	138	
Gender				
Male	222 (72.8)	114 (68.3)	108 (78.3)	0.051
Female	83 (27.2)	53 (31.7)	30 (21.7)	
Age (years)	58.1 ± 11.8	59.4 ± 12	56.5 ± 11.5	0.031
Body mass index (kg/m^2)	25.7 ± 2.9	25.6 ± 2.9	25.9 ± 3	0.346
Underweight	2 (0.7)	2 (1.2)	0 (0.0)	0.470
Healthy	150 (49.2)	84 (50.3)	66 (47.8)	
Overweight	131 (43)	71 (42.5)	60 (43.5)	
Obese	22 (7.2)	10 (6)	12 (8.7)	
Killip Class				
III	119 (39)	53 (31.7)	66 (47.8)	0.004
IV	186 (61)	114 (68.3)	72 (52.2)	
Known risk factors				
Diabetes	148 (48.5)	91 (54.5)	57 (41.3)	0.022
Hypertension	181 (59.3)	95 (56.9)	86 (62.3)	0.336
Smoke	80 (26.2)	40 (24)	40 (29)	0.320
Family history	8 (2.6)	4 (2.4)	4 (2.9)	0.784
Dyslipidemia	7 (2.3)	4 (2.4)	3 (2.2)	0.898
Chest pain to ER (min)	240 (120-360)	210 (120-360)	240 (120-360)	0.718
ER to lab time (min)	55 (39-76)	55 (35-70.11)	55 (40-80)	0.337
Total ischemic time (min)	285 (190-415)	280 (180-413)	287 (200-440)	0.672
ST depression in AVR	56 (18.4)	33 (19.8)	23 (16.7)	0.487

ER: Emergency room; AVR: Augmented vector right.

Overall, primary PCI plays a crucial role in managing patients with CS by improving blood flow to the heart, restoring cardiac function, and reducing mortality rates. However, the success of primary PCI depends on several factors, including the timeliness of treatment, the skill and experience of the operators performing the procedure, and the patient's overall health status. Therefore, it is essential to identify high-risk patients and provide timely and appropriate treatment to achieve the best outcomes. Therefore, we conducted a retrospective analysis of 305 patients with CS-complicated AMI who had undergone primary PCI at our center. It has been observed the immediate mortality rate was unacceptably high at 54.8%, with cardiac arrest followed by renal failure, multi-organ dysfunction, sepsis, hypoxic brain injury, and cerebrovascular accident as a cause of mortality. In multivariable analysis, Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) were identified as independent predictors of immediate mortality.

Despite advancements in the therapeutic and technical management of CS, the rate of adverse events remains unacceptably high. Studies have reported varying mortality rates in-hospital, short-term, and long-term depending on the definition of CS and follow-up duration. Similar to our study, Hayıroğlu *et al*[5] surveyed 319 CS complicated ST-elevation myocardial infarction (STEMI) patients treated with primary PCI and reported a high in-hospital mortality rate of 61.3%. This study found several predictors of in-hospital mortality, including final thrombolysis in myocardial infarction flow, chronic kidney disease, left ventricular ejection fraction, tricuspid annular plane systolic excursion, blood urea nitrogen level, lactate level, and plasma glucose level. Similarly, other studies, including Wang *et al*[19] and Backhaus *et al*[13], reported 65.3% and 37%-50% in-hospital mortality rates, respectively. The use of IABP has decreased over the years, and improvements in therapeutic management, such as increased use of drug-eluting stents, prasugrel, and ticagrelor, have resulted in better long-term prognosis for these patients[13]. Kawaji *et al*[20] conducted a registry-based study on 466 STEMI patients with CS and reported high 30-d, one-year, and five-year mortality rates of 25.4%,

Table 2 Distribution of angiographic and procedural characteristics patients with cardiogenic shock stratified by immediate outcome after primary percutaneous coronary intervention

	Total	Immediate outcome		*P* value
		Mortality	Survived	
Total (*n*)	305	167	138	
Number of involved vessels				
Single vessel disease (SVD)	56 (18.4)	15 (9)	41 (29.7)	< 0.001
Two vessel disease (2VD)	80 (26.2)	43 (25.7)	37 (26.8)	
Three vessel disease (3VD)	145 (47.5)	100 (59.9)	45 (32.6)	
Left main (LM)	2 (0.7)	1 (0.6)	1 (0.7)	
LM + SVD	2 (0.7)	0 (0)	2 (1.4)	
LM + 2VD	7 (2.3)	2 (1.2)	5 (3.6)	
LM + 3VD	13 (4.3)	6 (3.6)	7 (5.1)	
Infarct related artery				
Left anterior descending artery	191 (62.6)	106 (63.5)	85 (61.6)	0.917
Right coronary artery	78 (25.6)	42 (25.1)	36 (26.1)	
Left circumflex	31 (10.2)	17 (10.2)	14 (10.1)	
Left main	5 (1.6)	2 (1.2)	3 (2.2)	
Only LHC done	17 (5.6)	12 (7.2)	5 (3.6)	0.177
Only POBA	32 (10.5)	19 (11.4)	13 (9.4)	0.579
Lesion length (cm)	20 (15-26)	20 (15-26)	20 (15-26)	0.948
Bifurcations lesion	73 (23.9)	50 (29.9)	23 (16.7)	0.007
Side branch	57 (18.7)	37 (22.2)	20 (14.5)	0.087
Pre-procedure TIMI flow				
0	290 (95.1)	152 (91)	138 (100)	0.005
I	8 (2.6)	8 (4.8)	0 (0.0)	
II	6 (2)	6 (3.6)	0 (0.0)	
III	1 (0.3)	1 (0.6)	0 (0.0)	
Post-procedure TIMI flow				
0	14 (4.6)	9 (5.4)	5 (3.6)	0.124
I	9 (3)	7 (4.2)	2 (1.4)	
II	39 (12.8)	26 (15.6)	13 (9.4)	
III	243 (79.7)	125 (74.9)	118 (85.5)	
Tissue Myocardial Perfusion				
0	20 (6.6)	10 (6)	10 (7.2)	0.731
I	18 (5.9)	11 (6.6)	7 (5.1)	
II	62 (20.3)	37 (22.2)	25 (18.1)	
III	205 (67.2)	109 (65.3)	96 (69.6)	
Thrombus grading				
G0-No	8 (2.6)	2 (1.2)	6 (4.3)	0.003
G1-Possible	14 (4.6)	7 (4.2)	7 (5.1)	
G2-Small	8 (2.6)	1 (0.6)	7 (5.1)	
G3-Moderate	39 (12.8)	14 (8.4)	25 (18.1)	

G4-Large	55 (18)	32 (19.2)	23 (16.7)	
G5-Total	181 (59.3)	111 (66.5)	70 (50.7)	
Intraluminal defect	263 (86.2)	150 (89.8)	113 (81.9)	0.045
Export catheter use	138 (45.2)	62 (37.1)	76 (55.1)	0.002
Needed temporary pacemaker	103 (33.8)	101 (60.5)	2 (1.4)	< 0.001
ER	8 (7.8)	8 (7.9)	0 (0.0)	0.806
Cath lab	85 (82.5)	83 (82.2)	2 (100)	
CCU	10 (9.7)	10 (9.9)	0 (0)	
Needed intubation	134 (43.9)	131 (78.4)	3 (2.2)	< 0.001
ER	30 (22.4)	30 (22.9)	0 (0)	0.397
Cath lab	60 (44.8)	59 (45)	1 (33.3)	
CCU	44 (32.8)	42 (32.1)	2 (66.7)	
Needed inotropic support	129 (42.3)	127 (76)	2 (1.4)	< 0.001
ER	74 (57.4)	74 (58.3)	0 (0.0)	0.065
Cath lab	35 (27.1)	33 (26)	2 (100)	
CCU	20 (15.5)	20 (15.7)	0 (0.0)	
Needed IABP	111 (36.4)	81 (48.5)	30 (21.7)	< 0.001
LV dysfunction	256 (83.9)	152 (91)	104 (75.4)	< 0.001
Ejection fraction (%)	30 (30-40)	30 (30-40)	35 (30-45)	0.014

LV: Left ventricular; LHC: Left heart cath; TIMI: Thrombolysis in Myocardial Infarction; POBA: Plain old balloon angioplasty; IABP: Intra-aortic balloon pump; ER: Emergency room; CCU: Coronary care unit.

Table 3 Clinical predictors of immediate mortality after primary percutaneous coronary intervention of patients with cardiogenic shock

	Univariate		Multivariable	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Female	1.7 (1.0-2.8)	0.052	1.8 (1.0-3.3)	0.059
Age (years)	1.0 (1.0-1.0)	0.032	1.0 (1.0-1.0)	0.257
Killip class IV	2.0 (1.2-3.1)	0.004	2.0 (1.2-3.4)	0.008
Diabetes mellitus	1.7 (1.1-2.7)	0.022	1.5 (0.9-2.5)	0.126
Hypertension	0.8 (0.5-1.3)	0.337	-	-
Smoker	0.8 (0.5-1.3)	0.320	-	-
Total ischemic time ≥ 4 h	1.0 (0.6-1.7)	0.870	-	-
Multivessel disease	4.4 (2.4-8.3)	< 0.001	3.5 (1.8-6.9)	< 0.001
Bifurcations lesion	2.1 (1.2-3.7)	0.008	1.7 (0.8-3.5)	0.169
Side branch	1.7 (0.9-3.1)	0.090	0.9 (0.4-2.1)	0.839
Thrombus grade ≥ 4	2.9 (1.6-5.0)	< 0.001	2.6 (1.4-4.9)	0.003
Intraluminal defect	2.0 (1.0-3.8)	0.048	1.2 (0.6-2.6)	0.655
Left ventricular dysfunction	3.3 (1.7-6.4)	< 0.001	2.2 (0.8-6.3)	0.146
Ejection fraction (%)	1.0 (0.9-1.0)	0.002	1.0 (1.0-1.0)	0.542

OR: Odds ratio; CI: Confidence interval.

38.7%, and 51.4%, respectively.

Additionally, the identification of clinical predictors of mortality can help guide treatment decisions and improve patient outcomes. Our study identified Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) as independent predictors of immediate mortality. Several clinical predictors of mortality in patients with CS have been identified in the literature, including age: Advanced age is a significant predictor of mortality in patients with CS[21]. Older patients have more comorbidities and are at higher risk of complications. The severity of shock: The degree of hemodynamic compromise, measured by the cardiac index, central venous pressure, and mean arterial pressure, is strongly associated with mortality[21]. AKI: AKI is a common complication in patients with CS and is associated with increased mortality[8]. Delayed revascularization: Delayed revascularization, defined as a time to revascularization of more than 24 h, is associated with increased mortality in patients with CS due to myocardial infarction[22]. Elevated lactate levels: Elevated lactate levels indicate tissue hypoxia and are a marker of poor prognosis in patients with CS[23]. Presence of comorbidities: Patients with preexisting comorbidities such as diabetes, hypertension, and chronic kidney disease have a higher risk of mortality[24]. Use of mechanical circulatory support: Mechanical circulatory support devices such as IABP and ECMO are associated with increased mortality, likely due to the severity of illness in patients requiring these interventions[25].

Further research is necessary to oversee and manage patients with STEMI complicated by CS. To achieve this, some researchers have proposed risk stratification scoring systems that have demonstrated good predictive value for the risk stratification of 30-d mortality[19,26,27]. Along with reperfusions, multidisciplinary management of CS patients is mandatory to improve outcomes. Several studies have reported a significant increase in the incidence of CS complicating STEMI, with one study reporting an incidence of 9% in 2006, which rose to 16% over ten years[13]. Similarly, an analysis of a United States nationwide database found that the incidence of STEMI complicated by CS increased from 6.5% to 10.1% between 2003 and 2010[28]. As a result, targeted research efforts are required to improve outcomes for these high-risk patients. While emergency revascularization of the culprit artery is the only proven effective method thus far, evidence for other supportive and medical therapies is unsatisfactory, and the use of IABP has shown no clinical benefit; however, the use of ECMO and Impella may yield better outcomes[29].

Certain limitations of the study need to be acknowledged. It was a single center-based retrospective study with a relatively small sample; hence, the generalizability of study findings may be limited.

CONCLUSION

In conclusion, immediate mortality rates in patients with CS undergoing primary PCI remain high despite advances in treatment strategies. Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) were identified as independent predictors of immediate mortality. Such predictors can help guide treatment decisions and risk stratification in patients with CS. These findings underscore the need for aggressive management and close monitoring of patients with CS undergoing primary PCI, particularly those with these high-risk characteristics.

ARTICLE HIGHLIGHTS

Research background

Cardiogenic shock (CS) is a life-threatening complication of acute myocardial infarction with high morbidity and mortality rates.

Research motivation

The management of CS requires a multidisciplinary approach involving cardiology, critical care, and interventional teams. Early identification and diagnosis of CS is crucial, as early interventions have been shown to improve survival rates.

Research objectives

This study aimed to investigate the immediate mortality rates in patients with CS undergoing primary percutaneous coronary intervention (PCI) and identify mortality predictors.

Research methods

We conducted a retrospective analysis of 305 patients with CS who underwent primary PCI and immediate mortality rate was analyzed.

Research results

In a sample of 305 patients, the immediate mortality rate was found to be 54.8% with Killip class IV at presentation, multivessel disease, and high thrombus burden as independent predictors of immediate mortality.

Research conclusions

Immediate mortality rate in patients with CS undergoing primary PCI remains high despite advances in treatment

strategies. Killip class IV at presentation, multivessel disease, and high thrombus burden (grade ≥ 4) were identified as independent predictors of immediate mortality.

Research perspectives

These findings underscore the need for aggressive management and close monitoring of patients with CS undergoing primary PCI, particularly in those with these high-risk characteristics.

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FOOTNOTES

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