Cureus
Part of SPRINGER NATURE

Open Access Original Article

Integrated Assessment of Biomarkers, Hemodynamic Parameters, and Comorbidities for Predicting Short-Term Mortality in Critically Ill Patients With Acute Cardiac Conditions Presenting to the Emergency Department

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Review began 10/08/2026
Review ended 11/03/2026
Published 11/06/2026

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DOI: 10.7759/cureus.119236

Abstract

Background: Critically ill patients presenting with acute cardiac conditions have a high risk of short-term mortality. Early identification of high-risk patients may be improved by combining biomarkers, hemodynamic parameters, and comorbidity burden.

Objective: To evaluate the integrated predictive value of biomarkers, hemodynamic parameters, and comorbidities for 30-day mortality in critically ill patients with acute cardiac conditions presenting to the emergency department.

Methods: This retrospective observational cohort study was conducted at the Department of Cardiology, Punjab Institute of Cardiology, Lahore, from January 2025 till June 2025 and included 160 adult patients with acute cardiac conditions.

Results: Of 160 patients, 34 (21.3%) died within 30 days. Non-survivors were older than survivors (72.91 ± 11.84 vs. 61.82 ± 13.21 years; $p < 0.001$) and had higher Charlson Comorbidity Index (CCI) scores (5.82 ± 2.01 vs. 3.61 ± 1.89; $p < 0.001$). They also had a higher shock index (1.27 ± 0.38 vs. 0.79 ± 0.22), lactate (5.18 ± 2.71 vs. 2.21 ± 1.34 mmol/L), and NT-proBNP levels, with a lower left ventricular ejection fraction (LVEF; 30.74 ± 9.63% vs. 41.62 ± 10.81%), all significantly different. Independent predictors of 30-day mortality included lactate >4 mmol/L (adjusted OR: 4.82), cardiogenic shock (OR: 4.36), LVEF <35% (OR: 3.44), shock index ⩾1.0 (OR: 3.21), CCI ⩾5 (OR: 3.09), NT-proBNP >4,000 pg/mL (OR: 2.67), chronic kidney disease (OR: 2.41), and age ⩾70 years (OR: 2.18). The integrated model showed the highest predictive accuracy (area under the ROC curve (AUC): 0.92) compared with hemodynamic parameters (0.84), biomarkers (0.81), and comorbidities alone (0.72).

Conclusion: An integrated assessment of biomarkers, hemodynamic parameters, ventricular function, and comorbidity burden demonstrated excellent discriminatory performance for predicting 30-day mortality in critically ill patients with acute cardiac conditions (AUC: 0.92). Further prospective, multicenter validation and clinical impact studies are required to determine whether implementing this model improves clinical decision-making or patient outcomes.

Categories: Other, Cardiology, Healthcare Technology
Keywords: acute cardiac conditions, biomarkers, ckd (chronic kidney disease), outcomes, patients

Introduction

Acute cardiac conditions are one of the most critical types of presentations to the ED and can rapidly progress to hemodynamic instability, multiorgan dysfunction, cardiogenic shock, and death [1]. Patients with acute coronary syndromes, acute decompensated heart failure, severe arrhythmias, and cardiogenic shock are a heterogeneous group where early recognition of patients at risk for death is critical to ensure that they receive the appropriate triage and prompt intensive care treatment [2]. Cardiogenic shock especially remains associated with significant short-term mortality despite the progress in pharmacologic therapy, revascularization, and mechanical circulatory support [3]. Hemodynamic abnormalities immediately give information about the severity of cardiac compromise. Symptoms of insufficient cardiac output and progressive circulatory failure include hypotension, tachycardia, decreased mean arterial pressure, hypoxemia, and impaired peripheral perfusion [4]. Heart rate and systolic blood pressure (HRBP) shock index (SI) is a simple bedside tool and has been discovered to be a prognostic indicator of acute heart

failure and acute myocardial infarction (AMI) mortality in the short-term period [5]. Early hemodynamic evaluation is a key factor in early risk stratification, and a higher admission SI has been shown to correlate with higher 7-day and 30-day mortality after ST-elevation myocardial infarction [6]. Biochemical biomarkers are other useful parameters for use in risk assessment, reflecting myocardial injury, ventricular stress, tissue hypoperfusion, and organ dysfunction. Cardiac troponin and natriuretic peptide are commonly used for the assessment of myocardial damage and cardiovascular stress, and serum creatinine, blood urea nitrogen, sodium, glucose, and liver-related parameters may reflect systemic effects of severe cardiovascular diseases [7]. In critically ill cardiac patients, lactic acid levels are especially significant because of the fact that raised levels are a reflection of reduced tissue perfusion and metabolic stress [8]. Previous studies have shown that higher lactate levels at the time of AMI with congestive heart failure (CHF) and at the time of cardiogenic shock are prognostic for short-term mortality [9]. Lactate clearance may also give prognostic information as a measure of the response to initial resuscitation and restoration of tissue perfusion [10].

Prognosis is also affected by the patient's characteristics. Physiological reserve and vulnerability may be diminished during acute cardiac illness, due to advanced age, diabetes mellitus, hypertension, chronic kidney disease, prior ischemic heart disease, heart failure, cerebrovascular disease, and other coexisting medical conditions [11]. Chronic disease burden, using comorbidity indices, has been shown to have independent associations with both in-hospital and 30-day mortality, thus supporting the addition of chronic disease burden to clinical risk assessment [12]. Thus, using a single biomarker or physiological parameter may not give a complete picture of mortality risk [13]. In the acute heart failure setting, combining biological data with clinical and hemodynamic data has been found to improve mortality prediction over the use of any one parameter alone [14]. An integration, for instance, of congestion-related parameters with biomarkers such as natriuretic peptides and lactate, for instance, has improved discrimination for in-hospital mortality [15]. A combination of biomarkers, hemodynamic status, and comorbidity burden may then offer a more clinically relevant picture of disease severity [16]. The present study evaluated these shared clinical characteristics as potential indicators of short-term mortality across different acute cardiac presentations. Rather than developing a condition-specific prediction tool, the study explored whether combining information from multiple clinical domains could provide greater apparent discrimination for 30-day mortality than evaluating individual domains separately.

Objective

To evaluate and compare the discriminatory performance of an integrated prediction model combining biomarkers, hemodynamic parameters, and comorbidity burden with individual-domain models based on biomarkers, hemodynamic parameters, and comorbidities alone for predicting 30-day all-cause mortality in critically ill patients presenting to the ED with acute cardiac conditions.

Materials And Methods

This retrospective observational cohort study was conducted at the Department of Cardiology, Punjab Institute of Cardiology, Lahore, from January 2025 to June 2025. It included 160 critically ill adult patients presenting to the emergency department with acute cardiac conditions. The sample size was determined by the availability of eligible patient records during the six-month study period (January-June 2025). A total of 160 patients who fulfilled the predefined inclusion and exclusion criteria were included using non-probability consecutive sampling. As this was a retrospective observational study, no formal a priori sample size calculation was performed. The sample included 34 deaths within 30 days (21.3%), allowing an exploratory assessment of mortality-associated factors and predictive model discrimination. However, the limited number of mortality events may have affected the precision and stability of multivariable estimates, highlighting the need for validation in larger prospective cohorts. The current research project was reviewed and assessed by the ethical review committee of the Punjab Institute of Cardiology, Lahore, with approval number RTPGME-Research-725. Patients aged ⩾18 years with a confirmed diagnosis of acute coronary syndrome, acute decompensated heart failure, significant cardiac arrhythmia, or cardiogenic shock who required emergency stabilization, intensive monitoring, or critical care admission were included. Patients with incomplete clinical or laboratory data, cardiac arrest before hospital admission for which no resuscitation was attempted, terminal malignancy, major trauma, or sepsis in the absence of a primary cardiac diagnosis were excluded, as were those who had just had a major surgery or been transferred from another hospital following definitive treatment. The primary outcome was short-term all-cause mortality within 30 days of ED presentation. Completeness of clinical documentation and laboratory measurements was considered during patient selection. Records lacking essential information required for eligibility assessment or the planned analyses were excluded according to the predefined exclusion criteria. A total of 160 eligible patients were included in the reported analysis.

Data collection

With approval of the Institutional Ethical Review Committee, a non-probability consecutive sampling technique was used to identify eligible patients from the electronic records created in the emergency department and hospital. Demographic and clinical data, such as age, gender, BMI, smoking history, presenting cardiac diagnosis, prior ischemic heart disease, hypertension, diabetes mellitus, chronic kidney disease, chronic heart failure, cerebrovascular disease, and chronic pulmonary disease, were documented. The Charlson Comorbidity Index (CCI) [17] was also used to determine the burden of comorbidities.

Comorbidity burden was assessed using the original CCI, without age adjustment, with higher scores indicating a greater burden of coexisting diseases. Age was evaluated separately as a predictor of 30-day mortality. Before multivariable logistic regression, multicollinearity among related predictors, including age, chronic kidney disease, CCI score, cardiogenic shock, SI, serum lactate, and left ventricular ejection fraction (LVEF), was evaluated using variance inflation factors (VIFs) and tolerance values. A VIF ⩾5 or tolerance <0.20 was considered indicative of potentially important multicollinearity. Hemodynamic parameters measured initially included mean arterial pressure, heart rate, respiratory rate, oxygen saturation, systolic blood pressure, and SI (heart rate/systolic blood pressure). Laboratory parameters at presentation were high-sensitivity cardiac troponin, BNP/NT-proBNP (where available), serum lactate, creatinine, blood urea nitrogen, hemoglobin, white blood cell count, serum sodium, potassium, and glucose, as well as C-reactive protein. When available, LVEF and ECG and echo parameters were recorded. Other management parameters, such as vasopressor/inotropic support, mechanical ventilation, coronary intervention, and intensive care unit admission, were also documented. Thirty-day outcome was used to determine if the patient survived or died, and determine the outcome. Information regarding intensive care unit admission, vasopressor or inotropic support, mechanical ventilation, coronary intervention, acute kidney injury, major arrhythmic events, recurrent ischemic events, and length of hospitalization was also collected.

Statistical analysis

The analysis of the data was performed in Statistical Product and Service Solutions (SPSS, version 26.0; IBM SPSS Statistics for Windows, Armonk, NY). Distributions of continuous variables were reported as mean ± standard deviation or median with interquartile range, and categorical variables were reported as frequencies and percentages. Independent t-test, Mann-Whitney U test, chi-square test, or Fisher's exact test were used for continuous variables and categorical variables, respectively, to compare survivors and non-survivors. Univariate analysis was used to identify variables that were statistically significantly associated with mortality and included in a multivariable binary logistic regression to determine independent predictors of 30-day mortality, along with adjusted odds ratios and 95% confidence intervals. The discriminatory performance of individual biomarkers, hemodynamic parameters, comorbidity burden, and the integrated prediction model was assessed using receiver operating characteristic curve analysis. The areas under the curve were used to compare the combined model to determine whether it could predict mortality better. P values of ⩽ 0.05 were deemed statistically significant.

Results

Among 160 patients, 126 survived, and 34 died within 30 days. Non-survivors were older (72.91 ± 11.84 vs. 61.82 ± 13.21 years, $p < 0.001$) and more frequently had cardiogenic shock (29.4% vs. 6.3%), diabetes (58.8% vs. 38.1%), ischemic heart disease (52.9% vs. 34.1%), chronic heart failure (44.1% vs. 23.8%), and chronic kidney disease (41.2% vs. 17.5%). Their CCI was also higher (5.82 ± 2.01 vs. 3.61 ± 1.89; $p < 0.001$) (Table *1*).

Characteristic	Total (n=160)	Survivors (n=126)	Non-survivors (n=34)	p-value
Age (years), Mean ± SD	64.18 ± 13.72	61.82 ± 13.21	72.91 ± 11.84	<0.001
Male, n (%)	101 (63.1)	78 (61.9)	23 (67.6)	0.538
BMI, kg/m², Mean ± SD	26.41 ± 4.38	26.62 ± 4.27	25.63 ± 4.72	0.238
Current smoker, n (%)	59 (36.9)	45 (35.7)	14 (41.2)	0.558
Acute coronary syndrome, n (%)	73 (45.6)	62 (49.2)	11 (32.4)	0.081
Acute decompensated heart failure, n (%)	48 (30.0)	38 (30.2)	10 (29.4)	0.931
Significant arrhythmia, n (%)	21 (13.1)	18 (14.3)	3 (8.8)	0.411
Cardiogenic shock, n (%)	18 (11.3)	8 (6.3)	10 (29.4)	<0.001
Hypertension, n (%)	104 (65.0)	78 (61.9)	26 (76.5)	0.113
Diabetes mellitus, n (%)	68 (42.5)	48 (38.1)	20 (58.8)	0.030
Ischemic heart disease, n (%)	61 (38.1)	43 (34.1)	18 (52.9)	0.046
Chronic heart failure, n (%)	45 (28.1)	30 (23.8)	15 (44.1)	0.019
Chronic kidney disease, n (%)	36 (22.5)	22 (17.5)	14 (41.2)	0.003
Cerebrovascular disease, n (%)	19 (11.9)	12 (9.5)	7 (20.6)	0.078
Charlson Comorbidity Index, Mean ± SD	4.08 ± 2.11	3.61 ± 1.89	5.82 ± 2.01	<0.001

TABLE 1: Baseline Demographic, Clinical, and Comorbidity Characteristics According to 30-Day Outcome

BMI, body mass index; SD, standard deviation

Non-survivors had lower systolic BP (91.47 ± 21.88 vs. 119.84 ± 24.16 mmHg), MAP (69.30 ± 15.41 vs. 88.19 ± 15.72 mmHg), oxygen saturation (88.91 ± 7.12% vs. 94.52 ± 4.31%), and LVEF (30.74 ± 9.63% vs. 41.62 ± 10.81%), while heart rate (112.74 ± 23.16 vs. 92.48 ± 19.54/min), shock index (1.27 ± 0.38 vs. 0.79 ± 0.22), and lactate (5.18 ± 2.71 vs. 2.21 ± 1.34 mmol/L) were higher (all $p < 0.001$). Troponin, N-terminal pro-B-type natriuretic peptide (NT-proBNP), creatinine, blood urea nitrogen (BUN), white blood cell count (WBC), and C-reactive protein (CRP) were also significantly higher, while sodium and hemoglobin were lower (Table *2*).

Parameter	Survivors (n=126)	Non-survivors (n=34)	p-value
Systolic BP, mmHg, Mean ± SD	119.84 ± 24.16	91.47 ± 21.88	<0.001
Diastolic BP, mmHg, Mean ± SD	72.36 ± 13.88	58.21 ± 14.32	<0.001
Mean arterial pressure, mmHg, Mean ± SD	88.19 ± 15.72	69.30 ± 15.41	<0.001
Heart rate, beats/min, Mean ± SD	92.48 ± 19.54	112.74 ± 23.16	<0.001
Respiratory rate, breaths/min, Mean ± SD	21.16 ± 4.82	27.38 ± 6.14	<0.001
Oxygen saturation, %, Mean ± SD	94.52 ± 4.31	88.91 ± 7.12	<0.001
Shock index, Mean ± SD	0.79 ± 0.22	1.27 ± 0.38	<0.001
Serum lactate, mmol/L, Mean ± SD	2.21 ± 1.34	5.18 ± 2.71	<0.001
hs-Troponin, ng/L, Median (IQR)	684 (214-1860)	1642 (612-4280)	0.002
NT-proBNP, pg/mL, Median (IQR)	1850 (720-4260)	5170 (2150-9880)	<0.001
Serum creatinine, mg/dL, Mean ± SD	1.34 ± 0.71	2.08 ± 1.12	<0.001
BUN, mg/dL, Mean ± SD	31.72 ± 15.86	48.65 ± 22.41	<0.001
Serum sodium, mmol/L, Mean ± SD	137.18 ± 4.56	133.91 ± 5.21	0.001
Hemoglobin, g/dL, Mean ± SD	12.41 ± 2.01	11.36 ± 2.18	0.009
WBC count, $\times 10^9$/L, Mean ± SD	11.82 ± 4.67	15.46 ± 5.71	<0.001
CRP, mg/L, Median (IQR)	18 (7-42)	46 (19-91)	<0.001
LVEF, %, Mean ± SD	41.62 ± 10.81	30.74 ± 9.63	<0.001

TABLE 2: Hemodynamic Parameters and Biomarkers at Emergency Department Presentation

BP, blood pressure; BUN, blood urea nitrogen; CRP, C-reactive protein; hs-Troponin, high-sensitivity troponin; IQR, interquartile range; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal pro-B-type natriuretic peptide; SD, standard deviation; WBC, white blood cell

ICU admission (85.3% vs. 49.2%), vasopressor/inotropic support (70.6% vs. 19.0%), and mechanical ventilation (58.8% vs. 13.5%) were significantly more frequent among non-survivors (all $p < 0.001$). Acute kidney injury occurred in 55.9% versus 15.9%, and major arrhythmias in 32.4% versus 11.1%. Mean hospital stay was longer among non-survivors (9.24 ± 6.78 vs. 7.18 ± 4.82 days; $p = 0.041$). Overall, 7-day and 30-day mortality were 13.1% and 21.3%, respectively (Table *3*).

Outcome/Management	Total (n=160)	Survivors (n=126)	Non-survivors (n=34)	p-value
ICU admission, n (%)	91 (56.9)	62 (49.2)	29 (85.3)	<0.001
Vasopressor/inotropic support, n (%)	48 (30.0)	24 (19.0)	24 (70.6)	<0.001
Mechanical ventilation, n (%)	37 (23.1)	17 (13.5)	20 (58.8)	<0.001
Coronary intervention, n (%)	61 (38.1)	52 (41.3)	9 (26.5)	0.116
Acute kidney injury, n (%)	39 (24.4)	20 (15.9)	19 (55.9)	<0.001
Major arrhythmic event, n (%)	25 (15.6)	14 (11.1)	11 (32.4)	0.002
Recurrent ischemic event, n (%)	15 (9.4)	9 (7.1)	6 (17.6)	0.067
Length of hospital stay, days, Mean ± SD	7.62 ± 5.34	7.18 ± 4.82	9.24 ± 6.78	0.041
7-day mortality, n (%)	21 (13.1)	-	21 (61.8)*	-
30-day mortality, n (%)	34 (21.3)	0 (0.0)	34 (100.0)	-

TABLE 3: Treatment Requirements and Short-Term Clinical Outcomes

*Among patients who died within 30 days, 21 deaths occurred during the first seven days. Values are presented as n (%) or mean ± SD. Length of hospital stay was defined as the number of days from hospital admission to discharge or in-hospital death. For patients who died after discharge within 30 days, only the duration of the index hospitalization was considered. Patients were classified according to their 30-day survival status.

ICU, intensive care unit; SD, standard deviation

The strongest independent predictors of 30-day mortality were lactate >4 mmol/L (OR: 4.82), cardiogenic shock (OR: 4.36), LVEF <35% (OR: 3.44), shock index ⩾1.0 (OR: 3.21), CCI ⩾5 (OR: 3.09), NT-proBNP >4,000 pg/mL (OR: 2.67), chronic kidney disease (OR: 2.41), and age ⩾70 years (OR: 2.18), all statistically significant. The integrated model showed the best predictive performance (AUC: 0.92), compared with hemodynamic parameters (0.84), biomarkers (0.81), and comorbidities alone (0.72) (Table *4*).

Predictor	Adjusted OR (95% CI)	p-value
Age ≥70 years	2.18 (1.01-4.72)	0.047
Cardiogenic shock	4.36 (1.58-12.02)	0.004
Shock index ≥1.0	3.21 (1.34-7.68)	0.009
Serum lactate >4 mmol/L	4.82 (1.97-11.79)	<0.001
NT-proBNP >4000 pg/mL	2.67 (1.13-6.31)	0.025
Chronic kidney disease	2.41 (1.02-5.70)	0.045
Charlson Comorbidity Index ≥5	3.09 (1.27-7.51)	0.013
LVEF <35%	3.44 (1.43-8.28)	0.006

TABLE 4: Independent Predictors and Discriminatory Performance for 30-Day Mortality

Adjusted odds ratios were obtained from multivariable binary logistic regression for 30-day mortality. Eight predictors were reported in the final model. The study included 160 patients overall, with 34 mortality events; the regression-specific complete-case sample size was not documented. The limited number of events relative to the number of predictors should be considered when interpreting the adjusted estimates.

OR: odds ratio; CI: confidence interval; LVEF: left ventricular ejection fraction; NT-proBNP: N-terminal pro-B-type natriuretic peptide

The integrated predictive model demonstrated the highest discriminatory ability for 30-day mortality, with an AUC of 0.92 (95% CI: 0.87-0.97; $p < 0.001$). Among the individual domains, hemodynamic parameters showed an AUC of 0.84 (95% CI: 0.77-0.91), while biomarkers alone had an AUC of 0.81 (95% CI: 0.73-0.89) (Table *5*, Figure *1*).

Predictive model	AUC (95% CI)	Reported p-value	AUC difference vs. integrated
Biomarkers alone	0.81 (0.73-0.89)	<0.001	0.11
Hemodynamic parameters alone	0.84 (0.77-0.91)	<0.001	0.08
Comorbidity model alone	0.72 (0.62-0.82)	<0.001	0.20
Integrated model	0.92 (0.87-0.97)	<0.001	Reference

TABLE 5: Discriminatory Performance of Predictive Models for 30-Day Mortality

The overall cohort included 160 patients, of whom 34 died within 30 days. The reported p-values are reproduced from the original manuscript; the underlying statistical hypothesis was not specified, and they should not be interpreted as tests comparing the AUCs. AUC differences are arithmetic differences relative to the integrated model. Formal pairwise comparisons (e.g., paired DeLong tests) were not reported.

AUC, area under the receiver operating characteristic curve; CI, confidence interval

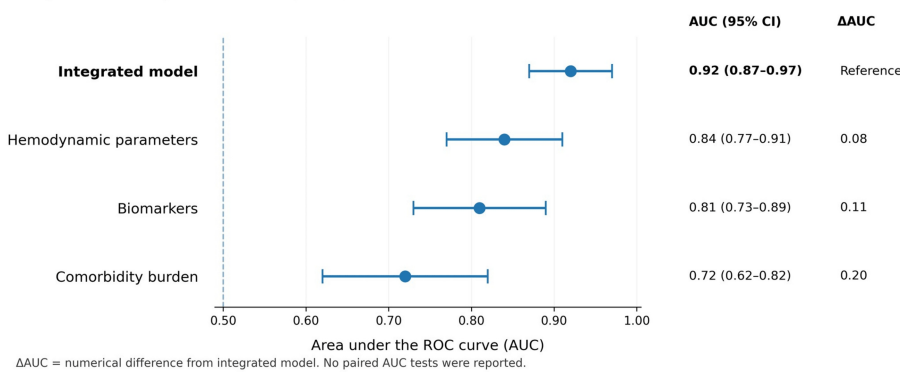


FIGURE 1: Performance of Predictive Models for 30-Day Mortality

Error bars indicate reported 95% confidence intervals. ΔAUC values are descriptive numerical differences

Discussion

The present study showed a significant short-term mortality rate in critically ill patients with acute cardiac problems, with a 30-day death rate of 0.213 and a 7-day death rate of 0.131. Non-survivors were significantly older than survivors (72.91 ± 11.84 vs. 61.82 ± 13.21 years) and more likely to have diabetes, ischemic heart disease, chronic heart failure, and chronic kidney disease. They also had a significantly higher CCI (5.82 ± 2.01 vs. 3.61 ± 1.89). The same has been found in previous studies, where a higher CCI was linked to higher mortality within the hospital stay of acute heart failure patients [18]. The presence of cardiogenic shock was a strong factor associated with poor outcome, with 29.4% of non-survivors having cardiogenic shock compared with 6.3% of survivors, and was independently linked to more than fourfold increased odds of death at 30 days (adjusted OR: 4.36). Non-survivors also showed pronounced hemodynamic compromise, including lower systolic blood pressure (91.47 ± 21.88 vs. 119.84 ± 24.16 mmHg), lower MAP (69.30 ± 15.41 vs. 88.19 ± 15.72 mmHg), and higher heart rate (112.74 ± 23.16 vs. 92.48 ± 19.54 beats/min). Cardiogenic shock and signs of cardiovascular instability were also found to be factors associated with short-term mortality in patients with acute heart failure in previous studies [19]. The shock index was significantly elevated in the non-survivors compared to the survivors (1.27 (+/- 0.38) vs 0.79 (+/- 0.22)), and a shock index ⩾1.0 was an independent predictor of death (adjusted OR: 3.21). This easy bedside parameter reflects tachycardia and hypotension and thus is an immediate sign of circulatory compromise. Elevated shock index was also shown to be predictive of adverse short-term outcomes and mortality in patients with myocardial infarction in previous studies [20]. In a previous study, those with a higher shock index had significantly higher seven-day adverse cardiovascular outcomes following ST-segment elevation myocardial infarction (STEMI) [21]. In the present study, serum lactate proved to be the most powerful laboratory predictor. Non-survivors had more than double the mean lactate (5.18 +/- 2.71 compared to 2.21 +/- 1.34 mmol/L), and a lactate >4 mmol/L was linked to almost five times greater odds of death (adjusted OR: 4.82). This finding is important in critically ill cardiac patients who have a problem with either systemic hypoperfusion or impaired oxygen utilization. Other previous studies also demonstrated that lactate was independently linked to mortality in acute HF patients, and that serum lactate was a powerful predictor of 30-day mortality in patients with mechanical circulatory support in cardiogenic shock [22].

There were also significant differences in the levels of cardiac biomarkers and ventricular function depending on the outcome. Non-survivors had higher NT-proBNP (5,170 (2,150-9,880) vs. 1,850 (720-4,260) pg/mL) and troponin (1,642 (612-4,280) vs. 684 (214-1,860) ng/L), whereas mean LVEF was markedly lower (30.74 ± 9.63% vs. 41.62 ± 10.81%). LVEF <35% (OR: 3.44) and NT-proBNP >4,000 pg/mL (OR: 2.67) were independently associated with mortality. A previous study also showed that high levels of natriuretic peptide were linked to poor outcomes in acute heart failure patients [23]. Clinical, short-term mortality differences between the various LVEF categories have also been found in previous studies where acute heart failure cohorts were evaluated [24], reinforcing the fact that ventricular dysfunction is an important risk factor in the evaluation of acute heart failure patients. Another significant characteristic of poor outcome was renal dysfunction. The non-survivors were more likely to have chronic kidney disease than the survivors (41.2% vs. 17.5%), and this was an independent predictor of mortality (adjusted OR: 2.41). Non-survivors also had higher creatinine (2.08 ± 1.12 vs. 1.34 ± 0.71 mg/dL) and BUN (48.65 ± 22.41 vs. 31.72 ± 15.86 mg/dL), while acute kidney injury developed in 55.9% compared with 15.9% of survivors. The results of previous studies also showed poorer prognosis and higher mortality in patients with chronic kidney disease who had acute myocardial infarction [25]. The non-survivors also had significantly higher rates of mechanical ventilation (58.8% versus 13.5%) and vasopressor/inotropic support (70.6% versus 19.0%) to reflect the greater severity of illness. Higher rates of mechanical ventilation (58.8% versus 13.5%) and vasopressor/inotropic support (70.6% versus 19.0%) also reflected greater severity of illness among the non-survivors. There were also more major arrhythmic events (32.4% vs. 11.1%). A previous study conducted in critically ill cardiac patients also showed that patients who needed invasive mechanical ventilation had higher levels of lactate, creatinine, NT-proBNP, more vasopressor usage, and greater mortality. The integrated prediction model, combining biomarkers, hemodynamic parameters, and comorbidities burden, had an AUC of 0.92, which was higher than those of the hemodynamic parameters (AUC: 0.84), biomarkers (AUC: 0.81), and comorbidities (AUC: 0.72). This indicates that many factors working together within several separate domains influence short-term mortality in acute cardiac illness, not just one. A previous study has also demonstrated that a combination of hemodynamic parameters, including shock index with lactate and other clinical risk factors, is helpful in predicting mortality risk in patients with acute heart failure. Selection or documentation bias, small sample sizes, and retrospective, single-center design could limit generalizability. Not all biomarkers were available at all centers, and serial changes of hemodynamic and laboratory parameters were not assessed. Further, there was no longer-term follow-up, and only 30-day mortality was evaluated. An important limitation was the relatively small number of mortality events compared with the number of predictors included in the multivariable regression model. With 34 deaths and eight predictors, the events-per-predictor ratio was approximately 4.25, increasing the possibility of overfitting, unstable odds ratios, and overly optimistic estimates of predictive performance. Furthermore, the lack of reported internal validation limited assessment of model stability and generalizability. Consequently, the identified associations and the integrated model's discriminatory performance should be interpreted cautiously. Future studies should use larger cohorts, clinically prespecified predictors, appropriate penalized regression methods, and bootstrap-based internal validation to assess model performance and reduce overfitting.

Conclusions

Short-term mortality in critically ill patients with acute cardiac conditions was strongly associated with elevated lactate, cardiogenic shock, high shock index, reduced LVEF, elevated NT-proBNP, chronic kidney disease, advanced age, and greater comorbidity burden. The present study identified significant associations between short-term mortality and elevated serum lactate, cardiogenic shock, increased shock index, reduced left ventricular ejection fraction, elevated NT-proBNP, chronic kidney disease, advanced age, and greater comorbidity burden. The integrated prediction model demonstrated promising apparent discrimination for 30-day mortality (AUC: 0.92). However, these findings should be considered exploratory because of the limited sample size, relatively few mortality events, and potential model overfitting. Furthermore, the absence of calibration assessment, internal validation, and direct statistical comparisons between models limits conclusions regarding predictive reliability and superiority. Larger prospective multicenter studies incorporating internal and external validation are required before the model can be recommended for clinical implementation.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Critical review of the manuscript for important intellectual content: Hafiza Sobia Ramzan

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Punjab Institute of Cardiology, Lahore issued approval RTPGME-Research-725. The research project titled "Integrated Assessment of Biomarkers, Hemodynamic Parameters, and Comorbidities for Predicting Short-Term Mortality in Critically Ill Patients with Acute Cardiac Conditions Presenting to the Emergency Department" was reviewed and assessed by the ethical review committee of the Punjab Institute of Cardiology, Lahore, with approval number RTPGME-Research-725. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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