Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17085039

CLINICAL CHARACTERISTICS AND MORTALITY PREDICTORS IN CARDIOGENIC SHOCK PATIENTS ADMITTED TO THE ICU; SYSTEMATIC REVIEW

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Abstract

Objective: This systematic review aimed to identify clinical characteristics and predictors of mortality in cardiogenic shock (CS) patients, emphasizing demographic, metabolic, and hemodynamic factors, and to evaluate the prognostic value of dynamic markers and risk scores. **Methods:** This review followed PRISMA guidelines. PubMed, Scopus, and Web of Science were searched from 2021 through 2025. Eligible studies included adults with CS admitted to intensive care units (ICUs), reported predictors of in-hospital or 30-day mortality, and used observational, registry, or randomized trial designs. Study quality was assessed using QUIPS for prognostic studies and PROBAST for prediction models. **Results:** Ten studies were included: multicenter registries, trial sub-analyses, and single-center cohorts from Asia, Europe, Africa, and South America. Reported mortality ranged from 34% to 62%. Predictors of poor outcomes included advanced age, cardiac arrest, renal dysfunction, vasopressor requirement, mechanical ventilation, and failed reperfusion in STEMI-related CS. Metabolic markers—particularly hyperglycemia and lactate clearance—showed strong prognostic value, with dynamic measures outperforming static values. Novel risk models—including the PRECISE, BOS, and MA_2 scores—demonstrated promising discrimination for mortality prediction. **Conclusion:** Mortality in CS remains high and is influenced by demographic, metabolic, hemodynamic, and multi-organ failure indices. Early recognition of prognostic markers, integration of dynamic lactate monitoring, and use of validated risk scores may enhance individualized care and improve outcomes in critically ill CS patients.

Keywords: Cardiogenic Shock; Mortality Predictors; Risk Factors; Intensive Care; Lactate Clearance; Hyperglycemia; Prognostic Models; Mechanical Circulatory Support; Acute Myocardial Infarction; Critical Care Outcomes.

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INTRODUCTION

Cardiogenic shock (CS) is the most severe manifestation of acute cardiac dysfunction, characterized by systemic hypoperfusion and tissue hypoxia due to inadequate cardiac output. It is the leading cause of in-hospital mortality following acute myocardial infarction (AMI), complicating approximately 5–10% of cases and affecting 40,000–50,000 individuals annually in the United States (Samsky et al. 2021). The epidemiology of CS has shifted over recent decades. While AMI was historically the predominant etiology, recent data show its proportion has decreased to around 30%, with acute decompensated heart failure emerging as an increasingly common cause (Berg et al. 2021). AMI-related CS, however, continues to carry substantial morbidity and mortality, driven by severe left ventricular dysfunction, multiorgan failure, and complications such as ventricular septal rupture or papillary muscle rupture (Tehrani et al. 2020). The Society for Cardiovascular Angiography and Interventions (SCAI) shock classification provides a standardized staging system and demonstrates a graded association between severity and mortality across populations and etiologies (Hill et al. 2022). Integrating this classification into clinical pathways allows earlier recognition of deterioration and more tailored interventions, both critical to improving outcomes. Immediate revascularization of the infarct-related artery remains the only intervention proven to improve survival in AMI-CS. Mechanical circulatory support (MCS) devices are frequently used despite conflicting evidence regarding mortality benefit (Zhang et al. 2022). Network meta-analyses suggest variable short-term outcomes among intra-aortic balloon pump, Impella, and venoarterial extracorporeal membrane oxygenation, underscoring persistent uncertainty regarding optimal support strategies (Zhang et al. 2022). CS is a complex and heterogeneous syndrome with high mortality despite therapeutic advances. Given its diverse etiologies and clinical phenotypes, identifying predictors of mortality is essential to guide risk stratification, optimize resource allocation, and improve clinical decision-making in this critically ill population.

METHODOLOGY

This study was conducted as a systematic review of published articles focusing on clinical characteristics and predictors of mortality in patients with cardiogenic shock admitted to intensive care units. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search of PubMed, Scopus, and Web of Science was performed, covering publications through August 2025. Search terms combined controlled vocabulary and free-text keywords: cardiogenic shock, predictors, mortality, risk factors, outcome, and intensive care. Additional studies were identified through citation tracking and manual review of references from relevant articles. We included studies that enrolled adult patients (≥18 years) diagnosed with cardiogenic shock; reported predictors or risk factors associated with mortality (in-hospital or 30-day); used observational cohort, registry, or randomized controlled trial designs with prognostic analyses; and reported sufficient methodological detail to allow assessment of study quality. We excluded case reports, case series (<10 patients), conference abstracts without full texts, studies focusing exclusively on surgical or perioperative shock, and

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studies involving pediatric populations or animals. Two reviewers screened titles and abstracts. Full texts of eligible studies were retrieved and assessed against the inclusion and exclusion criteria. Disagreements were resolved by consensus. Data were extracted using a standardized form, including citation details (author, year, journal); study design and setting; sample size and population characteristics; methods for predictor and outcome measurement; statistical methods used for prognostic analysis; and reported predictors of mortality. The methodological quality of included studies was assessed independently by two reviewers using the QUIPS (Quality in Prognosis Studies) tool, which was applied to observational and prognostic-factor studies, evaluating domains of participation, attrition, prognostic-factor measurement, outcome measurement, study confounding, and statistical analysis/reporting (Table 1). PROBAST (Prediction Model Risk of Bias Assessment Tool) was applied to prediction-model development/validation studies. Each study was classified as having low, moderate, or high risk of bias across domains. Discrepancies were resolved by discussion. A qualitative synthesis was performed rather than a meta-analysis. Predictors consistently associated with mortality across multiple studies were highlighted. Studies were grouped by predictor type (lactate dynamics, glucose, organ-failure indices, and registry-based scores) to identify patterns of evidence. IRB approval was obtained from KACST with registration number HA-01-R-104.

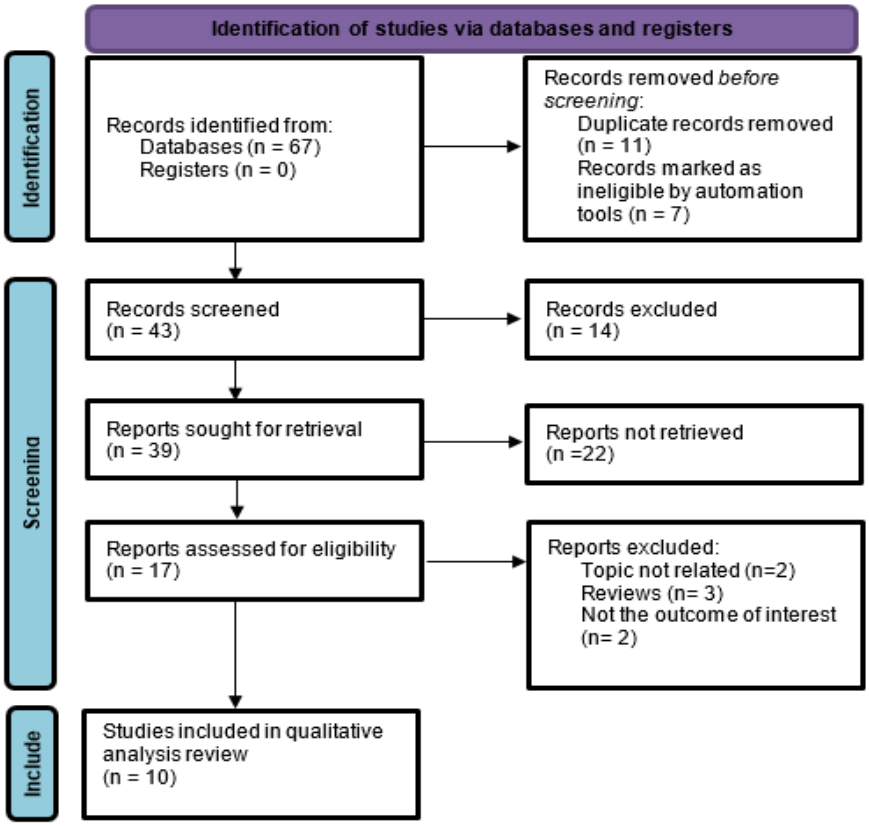

Fig 1: PRISMA consort chart of selected studies

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Table 1: quality assessment of the included studies

Citation	Study design	QA tool used	Participation	Attrition	Predictor measurement	Outcome measurement	Confounding/ Analysis	Reporting	Overall risk of bias	Notes
Fuernau et al., 2020	Secondary analysis of RCT + registry (IABP-SHOCK II)	QUIPS	Low risk	Low–Moderate (15% missing L2)	Low (standardized arterial lactate at fixed times)	Low (30-day all-cause mortality)	Moderate (multivariable Cox; residual confounding possible)	Low	Moderate	L2 (8h lactate) strongest predictor; LC weaker; adjusted models used.
JAHA, 2022 (DOREMI lactate-clearance substudy)	Post-hoc analysis of randomized trial	QUIPS	Moderate (excluded normal lactate; smaller sample)	Low	Low (serial lactate measures; defined LC/CLC)	Low (in-hospital mortality)	Moderate–High (stepwise multivariable; small N)	Low	Moderate	CLC at 12–24h associated with survival; limitations acknowledged.
Yang et al., 2021 (RESCUE registry)	Multicenter observational registry	QUIPS	Low (clear criteria; 12 centers)	Unclear	Low–Moderate (routine clinical data)	Low (in-hospital mortality)	Moderate (multivariable logistic; physician-driven care)	Low	Moderate	Large cohort; predictors include arrest, VIS, organ failure.
Egyptian Heart Journal, 2024 (multicenter CS registry)	Prospective multicenter observational registry	QUIPS	Low (six tertiary centers; explicit inclusion)	Low	Moderate (non-invasive CS definition; routine labs)	Low (30-day mortality incl. post-discharge)	Moderate (multivariable logistic; potential residual confounding)	Low	Moderate	Independent predictors: renal dysfunction, leukocytosis, arrests, multiple vasopressors.
American Journal of Cardiology, 2022 (SMART RESCUE)	Multicenter observational cohort	QUIPS	Low (consecutive CS at 12 hospitals)	Low	Low (admission glucose categories)	Low (in-hospital mortality)	Moderate (multivariable; subgroup by diabetes; residual confounding)	Low	Moderate	Hyperglycemia predicted mortality in non-diabetics after adjustment.

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JAHA, 2024 (PRECISE score)	Prediction model derivation + external calibration	PROBAST	Low (derivation from multicenter registry; external cohort)	Moderate (external validation complete-case only)	Low (predefined clinical variables)	Low (in-hospital mortality)	High (complex model; many predictors; complete-case; potential optimism)	Low	High	Strong AUC; calibration performed; missing data handled by exclusion in validation.
J Clin Med, 2024 (Vienna retrospective cohort)	Single-center retrospective cohort	QUIPS	High (64/600 included; selection risk)	Low–Moderate (some missing SAPS3)	Low (lactate at fixed times)	Low (30-day mortality)	High (limited adjustment; small n)	Low	High	24-h lactate outperformed initial/peak; very small sample.
Journal of Intensive Medicine, 2024 (6-h lactate clearance)	Single-center cohort	QUIPS	Moderate (single site)	Low	Low (0–6h lactate protocol)	Low (30-day mortality)	Moderate (Cox models with multiple adjustments)	Low	Moderate	6-h lactate clearance evaluated; multivariable models constructed.
Nair et al., 2023 (EHJ Acute CV Care)	Single-center retrospective cohort (MCS)	QUIPS	Moderate (Cleveland Clinic CICU; device-specific groups)	Low	Low (MBG over 72h)	Low (30-day mortality)	Moderate–High (hyperglycemia not independent after device adjustment)	Low	Moderate	Early hyperglycemia marked greater severity; device confounding prominent.
Current Problems in Cardiology, 2022 (ARGEN-IAM-ST CS in STEMI)	National registry (STEMI with CS)	QUIPS	Moderate (registry; STEMI subset)	Unclear	Low–Moderate (registry data; angiographic outcomes)	Low (in-hospital mortality)	Moderate (multivariable; residual confounding)	Low	Moderate	Predictors of death: age, female sex, arrest, failed PCI.

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RESULT

Ten studies were included (Table 2), which cover multicenter registries, single-center cohorts, and one randomized trial sub-analysis. Populations from South Korea, Egypt, China, Argentina, and Europe, including the SMART-RESCUE registry (Choi et al. 2022), the ARGEN-IAM-ST registry (Castillo Costa et al. 2022), an Egyptian prospective registry (Taha et al. 2024), a VA-ECMO cohort validating the PRECISE score (Jeong et al. 2024), and several cohorts assessing lactate metrics (Fuernau et al. 2020; Marbach et al. 2022; Klemm et al. 2024; Wang et al. 2024), and a tertiary Chinese ICU cohort (Yang et al. 2024). Patients were predominantly male and older, with ischemic causes being the majority. In the Egyptian registry (Taha et al. 2024), mean age was =62 years and 70% were male, with ischemic etiology accounting for two-thirds of cases. In the Korean SMART-RESCUE cohort (Choi et al. 2022), ischemic causes were =81%. In the PRECISE VA-ECMO cohort, mean age was =65 years with three-quarters male (Jeong et al. 2024).

Vasoactive agents and advanced organ support were common. In SMART-RESCUE, dopamine and norepinephrine were frequent first-line agents, and many patients required mechanical ventilation, renal replacement therapy, IABP, or ECMO (Choi et al. 2022). In the PRECISE validation cohorts, revascularization rates were high, with most patients undergoing PCI or CABG (Jeong et al. 2024). In-hospital and 30-day mortality is substantial. In SMART-RESCUE, mortality was =34% (Choi et al. 2022). In Argentina's STEMI registry, mortality in those with CS reached 62% compared to 3% in non-CS patients (Castillo Costa et al. 2022). A Chinese single-center ICU study reported =47% in-hospital mortality (Yang et al. 2024). ECMO cohorts reported variable survival depending on severity and comorbidity (Jeong et al. 2024).

Age and frailty: Older age consistently predicted mortality (Choi et al. 2022; Castillo Costa et al. 2022; Yang et al. 2024; Taha et al. 2024). Shock severity/organ failure: Cardiac arrest at presentation, renal failure, need for mechanical ventilation or renal replacement therapy, and higher vasopressor doses were linked to higher mortality (Taha et al. 2024; Castillo Costa et al. 2022; Yang et al. 2024). Reperfusion: In STEMI-CS, failed or delayed revascularization strongly predicted mortality (Castillo Costa et al. 2022; Jeong et al. 2024). Lactate metrics: Multiple studies confirmed prognostic value of lactate clearance. The Vienna cohort showed 24-h lactate levels discriminated 30-day mortality (Klemm et al. 2024). The DOREMI sub-study found lactate clearance predicted survival better than static values (Marbach et al. 2022). In Chinese AMI-CS patients, 6-h clearance ≤18% predicted higher mortality (Wang et al. 2024). In the IABP-SHOCK II sub-analysis, baseline and 8-h lactate were independent mortality predictors (Fuernau et al. 2020).

In SMART-RESCUE, admission hyperglycemia predicted worse survival in non-diabetic patients but not in diabetics (Choi et al. 2022). In the Egyptian registry, catecholamine use was associated with increased mortality (Taha et al. 2024). The PRECISE score, developed and validated in VA-ECMO patients, integrated routinely available clinical and laboratory variables and showed good discrimination for in-hospital mortality (Jeong et al. 2024) (Table 3).

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Table 2: summary table

Citation	Study Design	Sample Size	Population Characteristics	Methodology	Study Aim
Fuernau et al. 2020	Sub-analysis of IABP-SHOCK II trial and registry	671 patients	CS patients complicating AMI	Compared baseline lactate, 8h lactate, and lactate clearance	To assess prognostic value of lactate clearance
Nair et al. 2023	Retrospective cohort study	393 patients	CS patients on temporary mechanical circulatory support	Assessed early glycemic patterns (first 72h) and outcomes	To examine impact of early hyperglycemia on shock outcomes
Taha et al. 2024	Prospective multicenter observational registry	529 patients	Egyptian patients with ischemic and non-ischemic CS	Registry data collection on clinical, lab, and outcomes	To identify predictors of 30-day mortality in Egyptian CS patients
Marbach et al. 2022	Secondary analysis of DOREMI randomized trial	192 patients	Patients with CS randomized to milrinone or dobutamine	Evaluated lactate clearance vs static lactate as prognostic markers	To test lactate clearance utility in CS prognosis
Jeong et al. 2024	Retrospective multicenter registry (RESCUE)	1238 patients	CS patients receiving VA-ECMO	Developed PRECISE score using clinical and lab variables	To validate PRECISE score for mortality prediction in VA-ECMO patients
Klemm et al. 2024	Retrospective ICU cohort study	137 patients	Critically ill CS patients in tertiary ICU (Vienna)	Measured lactate and lactate clearance at multiple time points	To determine predictive value of serial lactate measures
Wang & Ji 2024	Prospective cohort study	280 patients	Chinese patients with CS from AMI	Measured lactate clearance at 6h, 12h, 24h	To evaluate prognostic role of lactate clearance in short-term mortality
Choi et al. 2022	Prospective multicenter registry (SMART RESCUE trial)	1177 patients	CS patients with and without diabetes mellitus (12 hospitals, South Korea)	Grouped by admission plasma glucose levels; in-hospital mortality assessed	To investigate prognostic impact of plasma glucose in CS with/without DM
Castillo Costa et al. 2022	Nationwide registry analysis (ARGEN-IAM-ST)	6122 STEMI patients (659 with CS)	Argentinian patients with STEMI, 10.75% developed CS	Registry-based analysis of clinical features, interventions, and mortality	To describe clinical characteristics and mortality predictors of CS in STEMI
Yang et al. 2024	Retrospective observational study	403 patients	CS patients admitted to a tertiary hospital in China	Collected demographics, clinical and laboratory variables, outcomes	To identify predictors of in-hospital mortality in CS patients

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Table 3: study findings and outcomes table

Citation	Demographic Characteristics	Main Findings	Outcomes
Fuernau et al. 2020	Mean age =70, post-AMI CS, mixed gender	Baseline and 8h lactate levels predicted 30-day mortality	Lactate clearance was a strong predictor of poor outcome
Nair et al. 2023	Median age =58, 393 CS patients on MCS	Early hyperglycemia associated with increased mortality	Hyperglycemia independently predicted worse survival
Taha et al. 2024	Median age =60, Egyptian CS registry, 529 patients	Higher lactate, renal dysfunction, and mechanical ventilation linked to mortality	Identified independent predictors of 30-day mortality
Marbach et al. 2022	Mean age =65, 192 CS patients in DOREMI trial	Lactate clearance better predictor than static lactate	Lactate clearance improved risk stratification
Jeong et al. 2024	Mean age =57, 1238 CS patients on VA-ECMO	Developed PRECISE score (age, lactate, renal/liver markers)	PRECISE score effectively predicted in-hospital mortality
Klemm et al. 2024	Mean age =66, 137 ICU patients with CS	Dynamic lactate clearance had higher prognostic accuracy than single measures	Serial lactate monitoring valuable for prognosis
Wang & Ji 2024	Median age 63, 280 Chinese patients with AMI-related CS	6h lactate clearance strongly associated with short-term survival	Early lactate clearance valuable in mortality prediction
Choi et al. 2022	1177 South Korean CS patients, 35% diabetic	Admission hyperglycemia predicted worse survival, stronger in non-DM patients	Plasma glucose an independent predictor of mortality
Castillo Costa et al. 2022	6122 STEMI patients in Argentina, 659 developed CS	Mortality 62.4% among CS patients, predictors: age, renal failure, shock severity	National registry provided predictors of mortality in STEMI-CS
Yang et al. 2024	403 CS patients, mean age 64, China	Independent predictors: older age, high lactate, low SBP, renal dysfunction	Mortality rate =47%; established prognostic factors

DISCUSSION

This systematic review discusses predictors of mortality in patients with cardiogenic shock (CS) and indicates the importance of demographic, metabolic, hemodynamic, and clinical risk factors. Advanced age emerged as a strong, non-modifiable predictor of mortality.

The American Heart Association scientific statement emphasizes that older adults with CS have higher in-hospital mortality due to multimorbidity, frailty, and reduced physiologic reserve. It cautions against using age alone for therapeutic decision-making, instead calling for a comprehensive assessment that integrates frailty and comorbidity measures (Blumer et al. 2024).

Risk-prediction models are central to identifying patients at highest risk and guiding therapeutic escalation. Multiple validated scores have been developed over the past decades, but their applicability across populations is limited.

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Kalra et al. (2021) noted that most existing scores were derived in cohorts with acute myocardial infarction–related CS, limiting generalizability to non-ischemic etiologies, and that heterogeneous definitions of CS reduce their bedside utility. Yamga et al. (2023) developed the BOS, MA_2 score, a simple six-variable tool (age ≥60 years, blood urea nitrogen ≥25 mg/dL, low oxygen saturation, hypotension, mechanical ventilation, elevated anion gap) that showed improved calibration and discrimination compared with older models.

Chang et al. (2022) applied an XGBoost algorithm to electronic health-record data and demonstrated the ability to predict CS onset up to two hours before clinical recognition (AUC 0.87). The top-contributing variables overlapped with known mortality predictors, with hypotension and end-organ dysfunction being prominent; the model was primarily designed for early detection.

Hyperglycemia at admission is a marker of poor prognosis. A recent meta-analysis confirmed that elevated glucose levels (>7.8–8 mmol/L) increase early mortality risk in CS patients, independent of diabetes status (Wu et al. 2025). Li et al. (2022) identified blood glucose—alongside age, heart rate, and INTERMACS profile—as an independent predictor of in-hospital mortality.

The predictors most strongly associated with mortality include older age, metabolic markers (notably hyperglycemia), hemodynamic severity (INTERMACS profile, hypotension, need for ventilation), and multi-organ dysfunction. While traditional risk scores offer structured assessment, novel models such as BOS, MA_2 (Yamga et al. 2023) and machine-learning tools (Chang et al. 2022) provide more precise, real-time risk prediction.

The AHA statement highlights that management decisions should be individualized, balancing predicted risk against patient goals and comorbidities (Blumer et al. 2024).

CONCLUSION

This systematic review shows that cardiogenic shock is associated with high short-term mortality despite advances in management. Independent predictors include advanced age, renal dysfunction, cardiac arrest at presentation, mechanical ventilation, vasopressor requirement, and failed reperfusion in STEMI.

Metabolic markers—including hyperglycemia and dynamic lactate clearance, provide strong prognostic value, with serial measurements outperforming static assessments. Emerging risk scores, including PRECISE and BOS, MA_2, show promise in refining prognostication.

Integrating demographic, hemodynamic, and metabolic predictors into clinical practice improves individualized care, therapeutic decision-making, and outcomes in critically ill patients with cardiogenic shock.

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