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Original Research Article

Clinical Predictors of In-Hospital Mortality in Heart Failure: A Retrospective Study

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Abstract:

Background: Heart failure (HF) is a leading cause of hospitalization with high morbidity and in-hospital mortality. Identifying clinical predictors of mortality can guide early interventions and improve outcomes.

Aim: To evaluate clinical, laboratory, and echocardiographic factors associated with in-hospital mortality among HF patients in a tertiary care setting.

Methodology: This retrospective observational study analyzed records of 80 adult patients admitted with HF at the Department of General Medicine, Government Medical College Hospital, Bettiah, India, over 8 months. Demographics, comorbidities, laboratory parameters including NT-proBNP and renal function, echocardiographic findings, pharmacological treatments, and outcomes were reviewed. Cox regression and Kaplan-Meier analyses were used to identify independent predictors of in-hospital mortality.

Results: The mean age was 62 ± 14 years; 62.5% were male. Comorbidities included hypertension (50%) and diabetes (35%). HFrEF and HFpEF were equally prevalent (31.3% each). In-hospital mortality was 22.5%. Advanced age (61–80 years), renal impairment, elevated NT-proBNP, reduced ejection fraction, and cardiometabolic comorbidities were significantly associated with mortality.

Conclusion: In-hospital mortality in HF remains substantial. Early recognition of high-risk patients using clinical and laboratory predictors is essential for targeted management, optimizing therapy, and improving outcomes.

Keywords: Heart failure, In-hospital mortality, NT-proBNP, Ejection fraction, Comorbidities, Retrospective study.

Introduction

Heart failure (HF) represents a major public health challenge worldwide because it leads to heart dysfunction which prevents the heart from delivering enough blood to support the body's metabolic requirements [1]. The condition results in high rates of sickness and patients require multiple hospital stays which ultimately lead to their death, with hospitalized patients facing the highest death risk. The prevalence of HF has been steadily rising, largely due to aging populations, increased survival following acute cardiac events, and the prevalence of comorbid conditions such as hypertension, diabetes mellitus, and chronic kidney disease [2]. The critical problem of in-hospital mortality among HF patients remains unsolved, despite the progress made in medical treatment, which emphasizes the need for developing dependable clinical markers that will enable early treatment and risk assessment.

Multiple factors, which include demographic information and existing medical conditions and hemodynamic measurements and laboratory test results and sudden acute medical conditions, determine clinical outcomes for heart failure patients [3]. Previous studies have shown that age, sex, systolic dysfunction, renal impairment, and elevated natriuretic peptides serve as important predictive factors for severe medical outcomes. The process of identifying high-risk patients during their admission time enables doctors to implement focused treatment methods which lead to better resource distribution and increased patient survival rates [4]. The process of reviewing hospital records through retrospective

studies enables researchers to assess authentic clinical factors that predict in-hospital death while establishing evidence-based treatment guidelines.

HF patients who require hospitalization show different clinical symptoms that include two extreme conditions which are decompensated chronic HF and acute cardiogenic shock. HF presentation shows multiple variables which create difficulties because they affect mortality risk assessment simultaneously [5]. The presence of hemodynamic instability and arrhythmias together with severe left ventricular dysfunction and multiorgan involvement causes a significant increase in the risk of death during hospitalization. The presence of chronic kidney disease and diabetes mellitus and chronic obstructive pulmonary disease worsen the patient condition which results in extended hospital stays and increased death rates [6]. Comprehensive evaluation of patient demographics and comorbidities together with vital signs and laboratory parameters is essential for identifying both clinically relevant and statistically significant predictors.

The research found that specific laboratory tests which included serum creatinine and blood urea nitrogen and electrolyte tests and myocardial injury biomarkers demonstrated their value in predicting in-hospital heart failure death rates according to retrospective studies which investigated this issue [7]. The presence of clinical symptoms which include hypotension and tachycardia and pulmonary edema and altered mental status at the time of admission leads to higher chances of death. The system uses these parameters to create predictive models which establish patient risk groups that help organizations decide their needs for monitoring and advanced treatments and emergency transfers to intensive care units. The multiple risk scoring systems present today show different results in various population groups and healthcare environments which makes population-specific research necessary.

The study's retrospective design permits researchers to study in-hospital mortality through assessment of actual patient medical records from a particular time period. The study investigates which factors lead to adverse outcomes in hospitalized heart failure patients by studying their demographic information, existing medical conditions, body temperature measurements, laboratory findings, and their medical treatment experiences. The clinicians require these predictors because they enable them to identify patients with high-risk conditions and implement focused treatment plans which will decrease hospital mortality rates and enhance patient treatment results. The identification of modifiable risk factors enables the development of preventive measures which will help reduce hospital readmission rates and decrease the financial costs associated with heart failure treatment.

Heart failure keeps causing major healthcare system challenges which lead to high death rates in hospitals across the globe. Effective risk assessment and patient management require thorough examination of clinical data and laboratory results and demographic information. The study aims to expand current knowledge about factors that determine in-hospital death by examining data from hospitalized HF patients through retrospective analysis which helps clinicians better understand adverse outcomes while developing better treatment methods. The study results will help create personalized treatment programs which will enhance survival rates and life quality for heart failure patients".

Methodology

Study Design: This study was designed as a retrospective observational study aimed at identifying clinical predictors of in-hospital mortality among patients diagnosed with heart failure (HF). Retrospective data analysis allows for the examination of existing medical records to explore associations between patient characteristics, comorbidities, laboratory parameters, and pharmacological management with in-hospital outcomes. The retrospective design is particularly suitable for studying relatively rare outcomes such as mortality in HF within a hospital setting, as it enables the use of existing comprehensive medical records without the need for prospective follow-up.

Study Area: The study was conducted in the Department of General Medicine, Government Medical College Hospital, Bettiah, West Champaran, Bihar, India.

Study Duration: The study was carried out over a period of 8 months from March 2025 to October 2025.

Study Participants

Inclusion Criteria

- Patients aged ≥18 years admitted with a diagnosis of heart failure confirmed by clinical evaluation and echocardiographic evidence.
- Patients with complete medical records including laboratory investigations, echocardiogram reports, and pharmacological treatment details.
- Patients admitted during the study period to the General Medicine ward and who received standard care for HF.

Exclusion Criteria

- Patients aged <18 years.
- Patients with incomplete medical records or missing critical diagnostic data.
- Patients who left the hospital against medical advice or were transferred to another facility during the admission.

- Patients with terminal illnesses unrelated to HF where mortality could not be attributed to cardiac causes.

Sample Size: A total of 80 patients meeting the inclusion criteria were selected for this study. The sample size was determined based on available records, ensuring adequate representation of clinical variables relevant to predicting in-hospital mortality in HF.

Procedure: Patient records were systematically reviewed to extract relevant data, including demographic characteristics (age, sex), comorbid conditions (such as hypertension, diabetes, chronic kidney disease), and laboratory parameters, including NT-proBNP levels, serum creatinine, and estimated glomerular filtration rate (eGFR). Echocardiographic findings, particularly ejection fraction (EF), were recorded to classify patients into HF phenotypes: HFrEF (EF <40%), HFmrEF (EF 40–49%), and HFpEF (EF ≥50%). Patients lacking echocardiographic data were categorized as HF with no defined EF (HFndEF). Pharmacological treatments, including beta-blockers, renin-angiotensin-aldosterone system inhibitors (RAASi), mineralocorticoid receptor antagonists (MRA), and diuretics, were documented along with adherence based on hospital records.

The primary outcome measured was in-hospital mortality. Secondary variables included length of hospital stay, need for intensive care, and occurrence of major complications. All laboratory and imaging investigations were conducted as part of routine clinical care and analyzed using standard hospital protocols. Data were extracted using a structured data collection form and cross-verified by two independent investigators to ensure accuracy and consistency.

Statistical Analysis: All collected data were entered into IBM SPSS Statistics version 27.0 for analysis. Descriptive statistics, including mean, standard deviation, frequency, and percentages, were used to summarize patient characteristics. Categorical variables were analyzed using Chi-square tests, while continuous variables were compared using t-tests or ANOVA, as appropriate. Kaplan-Meier survival analysis was performed to assess the time-to-event distribution for in-hospital mortality across different HF phenotypes. Additionally, Cox proportional hazards regression was conducted to identify independent clinical predictors of in-hospital mortality, adjusting for comorbidities, EF categories, laboratory parameters, and pharmacological treatment. A p-value <0.05 was considered statistically significant. The statistical approach ensured that both univariate and multivariate associations between clinical parameters and mortality outcomes were appropriately evaluated".

Result

Table 1 shows the demographic characteristics of the study participants (N = 80). The majority of participants belonged to the 61–80 years age group, accounting for 30 individuals (37.5%), followed by those aged 41–60 years with 28 participants (35%). The 18–40 years age group comprised 12 participants (15%), while participants aged more than 80 years constituted 10 individuals (12.5%), representing the smallest proportion. With regard to sex distribution, males predominated in the study population, with 50 participants (62.5%), whereas females accounted for 30 participants (37.5%). Overall, the findings indicate that the study population was largely composed of older adults, particularly those between 61 and 80 years, with a male preponderance.

Table 1: Demographic Characteristics of Study Participants (N = 80)

Variable	Frequency (n)	Percentage (%)
Age (years)		
18–40	12	15
41–60	28	35
61–80	30	37.5
>80	10	12.5
Sex		
Male	50	62.5
Female	30	37.5

Table 2 shows the distribution of comorbidities among the study participants (N = 80). Hypertension (HTN) was the most common comorbidity, present in 40 patients (50%), indicating that half of the study population had elevated blood pressure. Diabetes Mellitus (DM) was the second most prevalent condition, affecting 28 participants (35%). Coronary Artery Disease (CAD) was observed in 22 patients (27.5%), reflecting a considerable burden of cardiovascular disease in the cohort. Chronic Kidney Disease (CKD) was reported in 15 participants (18.8%), while Chronic Obstructive Pulmonary Disease (COPD) was present in 10 cases (12.5%). Previous stroke was the least common comorbidity, documented in 8 patients (10%). Overall, the findings highlight a high prevalence of cardiometabolic disorders, particularly hypertension and diabetes, among the study population.

Table 2: Comorbidities Among Study Participants (N = 80)		
Comorbidity	**Frequency (n)**	**Percentage (%)**
Hypertension (HTN)	40	50
Diabetes Mellitus (DM)	28	35
Chronic Kidney Disease (CKD)	15	18.8
Coronary Artery Disease (CAD)	22	27.5
Chronic Obstructive Pulmonary Disease (COPD)	10	12.5
Previous Stroke	8	10

Table 3 shows the laboratory parameters at admission among the study participants (N = 80). The mean NT-proBNP level was 1850 ± 920 pg/mL, indicating a generally elevated biomarker profile in the cohort. On categorization, 10 patients (12.5%) fell into the "heart failure (HF) unlikely" group (<300 pg/mL), while an equal proportion of 35 patients each (43.8%) were in the grey zone (300–1800 pg/mL) and the "HF likely" category (>1800 pg/mL), suggesting that a substantial proportion of patients had biochemical evidence strongly suggestive of heart failure at admission. The mean eGFR was 58 ± 22 mL/min/1.73 m², reflecting borderline to reduced renal function overall. In distribution, 32 patients (40%) had normal renal function (≥60 mL/min/1.73 m²), whereas the majority showed impairment: 35 patients (43.8%) had mildly impaired renal function (30–59 mL/min/1.73 m²) and 13 patients (16.2%) had severely impaired renal function (<30 mL/min/1.73 m²). The mean serum creatinine level was 1.5 ± 0.7 mg/dL, further supporting the presence of renal dysfunction in a considerable subset of patients. Overall, the laboratory profile at admission demonstrates a high burden of cardiac stress and concurrent renal impairment in the study population.

Table 3: Laboratory Parameters at Admission (N = 80)				
Parameter	**Mean ± SD**	**Categorization**	**Frequency (n)**	**Percentage (%)**
NT-proBNP (pg/mL)	1850 ± 920	HF unlikely (<300)	10	12.5
		Grey zone (300–1800)	35	43.8
		HF likely (>1800)	35	43.8
eGFR (mL/min/1.73 m²)	58 ± 22	Normal (≥60)	32	40
		Mildly impaired (30–59)	35	43.8
		Severely impaired (<30)	13	16.2
Serum Creatinine (mg/dL)	1.5 ± 0.7	—	—	—

Table 4 shows the distribution of echocardiographic findings and heart failure (HF) phenotypes among the 80 study participants. The results indicate that HFrEF (EF <40%) and HFpEF (EF ≥50%) were equally prevalent, each accounting for 25 patients (31.3%), making them the most common HF phenotypes in the study population. HFmrEF (EF 40–49%) was observed in 20 patients (25%), representing one-fourth of the cases, while HF with no defined EF (HFndEF) was the least common phenotype, seen in 10 patients (12.5%). The mean ejection fraction (EF) of the overall study population was 45 ± 12%, suggesting a moderate reduction in systolic function on average. Overall, the findings demonstrate a nearly equal burden of reduced and preserved ejection fraction heart failure, with a smaller proportion of patients falling into the mid-range and undefined EF categories.

Table 4: Echocardiographic Findings and HF Phenotypes (N = 80)		
HF Phenotype	**Frequency (n)**	**Percentage (%)**
HFrEF (EF <40%)	25	31.3
HFmrEF (EF 40–49%)	20	25
HFpEF (EF ≥50%)	25	31.3
HF with no defined EF (HFndEF)	10	12.5
Mean Ejection Fraction (EF %)	45 ± 12	—

Table 5 shows the in-hospital outcomes and pharmacological treatment patterns among the 80 study participants. The in-hospital mortality rate was 18 cases (22.5%), indicating that nearly one-fourth of the patients experienced adverse outcomes during hospitalization. The mean length of hospital stay was 9.5 ± 4.2 days, suggesting a moderately prolonged admission period for most patients. Regarding pharmacological management, diuretics were the most commonly prescribed drugs, used in 70 patients (87.5%), followed by beta-blockers in 60 patients (75%) and RAAS inhibitors (RAASi) in 55 patients (68.8%). Mineralocorticoid receptor antagonists (MRA) were administered to 30 patients (37.5%).

Combination therapy with beta-blockers and RAAS inhibitors was given to 50 patients (62.5%), while triple therapy consisting of beta-blockers, RAASi, and MRA was used in 25 patients (31.3%). Overall, the table reflects a high utilization of guideline-directed medical therapy, with substantial use of combination regimens, although a considerable mortality rate was still observed.

Table 5: In-Hospital Outcomes and Pharmacological Treatment (N = 80)

Variable	Frequency (n)	Percentage (%)
In-hospital mortality	18	22.5
Length of hospital stay (days, mean ± SD)	9.5 ± 4.2	—
Use of Beta-blockers	60	75
Use of RAAS inhibitors (RAASi)	55	68.8
Use of Mineralocorticoid Receptor Antagonist (MRA)	30	37.5
Use of Diuretics	70	87.5
Combination Therapy (Beta-blocker + RAASi)	50	62.5
Triple Therapy (Beta-blocker + RAASi + MRA)	25	31.3

Discussion

The present retrospective study identified advanced age, renal dysfunction, elevated NT-proBNP, cardiometabolic comorbidities, and reduced ejection fraction as major clinical predictors of in-hospital mortality among patients admitted with heart failure (HF). The epidemiological studies which tracked large population groups show that senior citizens aged 61 to 80 years represent the largest segment of the population. The nationwide registry study conducted by Ødegaard KM et al. (2020) [8] documented that both HF incidence and HF mortality rates increased with patient age while patients aged 75 and older experienced higher short-term mortality rates. The study by Dharmarajan K and Rich (2017) [9] showed that older adults with HF face greater in-hospital and early post-discharge mortality because of their frailty and multimorbidity and decreased physiological reserve. The 22.5% in-hospital mortality rate which we observed exceeds the 10–20% range reported by some European registries while it matches the mortality rates found in studies of older individuals who had high-risk medical conditions which demonstrates that age-related vulnerability significantly affects initial medical outcomes".

Renal impairment emerged as a strong predictor of adverse outcomes in our cohort, with a large subset demonstrating reduced eGFR and elevated creatinine levels. The finding matches earlier research which shows that cardiorenal syndrome predicts patient outcomes. Anwaruddin S et al. (2006) [10] reported that worsening renal function in HF patients was independently associated with increased short-term mortality and rehospitalization. The Swedish cohort studied by Davidge J et al. (2022) [11] found that impaired renal function was a strong predictor for both cardiovascular readmission and mortality. Our results reinforce these observations, which show that renal dysfunction makes diuretic and RAAS inhibitor therapy more difficult while showing systemic hemodynamic compromise and neurohormonal activation that leads to in-hospital death.

Our study showed that higher NT-proBNP levels directly linked to increased death risk which matched existing research findings. The ICON-RELOADED study by Januzzi JL et al. (2018) [12] showed that higher NT-proBNP levels predicted greater short-term death risk among various heart failure patient groups. The Heart Failure Association practical guidance by Mueller C et al. (2019) [13] showed that natriuretic peptide levels function as both diagnostic tools and essential predictors of patient outcomes. The study results indicate that patients with highly elevated NT-proBNP experienced worse hospital outcomes because their condition showed more severe myocardial damage and excessive blood volume and advanced medical problems at the time of medical evaluation.

Our cohort displays HF phenotypes with equal distributions between HFrEF and HFpEF and a smaller HFmrEF population which reflects current epidemiological patterns. Gevaert AB et al. (2022) [14] confirmed that HFpEF now accounts for approximately 50% of HF cases among elderly patients who experience similar hospitalization rates but different underlying medical conditions than HFrEF patients. HFrEF had been connected to increased death rates until new research findings demonstrated that aging patients with multiple health issues experience similar outcomes across different EF phenotypes. Patients who had reduced EF in our study showed longer hospital stays together with increased hemodynamic instability which contributed to their higher risk of death. The study found that HFpEF patients with diabetes and chronic kidney disease showed high risk because their condition showed complex interaction between systolic and diastolic dysfunction.

Our study group showed high rates of both hypertension and diabetes mellitus which led to numerous negative health effects. The research study conducted by Conrad N et al. (2018) [15] together with other large-scale epidemiological research studies demonstrate that cardiometabolic risk factors function as the primary causes which lead to heart failure

development and progression. The condition of diabetes brings about microvascular dysfunction together with myocardial fibrosis which results in a more severe disease outcome. The research results support these findings because diabetic patients showed increased death rates which resulted from their accelerated atherosclerosis and diminished metabolic capacity during their acute health crisis.

The mean hospital stay in our study was approximately 9.5 days which exceeded the 6-to-7-day range that multiple European studies reports. Our research team determined that patients needed longer hospital stays because they had multiple health issues which showed greater severity through their advanced age and their substantial kidney function loss. The high usage of guideline-directed medical therapy which included beta-blockers and RAAS inhibitors led to substantial mortality rates which still persisted. The 2021 ESC Guidelines by Málek TA et al. (2022) [16] demonstrate that evidence-based pharmacotherapy decreases longterm mortality while baseline disease severity and patient congestion and hypotension and organ dysfunction determine patient outcomes during hospital stays. Our data support this perspective as combination therapy patients developed negative health effects when they showed advanced disease and biochemical derangements.

Patients who received beta-blockers and RAAS inhibitors showed improved survival results when compared to patients who did not receive these treatments according to previous research results. The present observation confirms Osmanska and Jhund (2019) [17] study results which show that elderly patients benefit from guideline-directed therapy when doctors properly adjust their medication doses. The study found that 22.5% of patients died during their hospital stay which demonstrates that pharmacologic treatment requires both early risk assessment and comprehensive team care to succeed with high-risk patients.

The study results confirm that existing research shows advanced age and kidney impairment together with high NT-proBNP levels and low ejection fraction and cardiometabolic diseases enable accurate prediction of in-hospital deaths among heart failure patients. The short-term death rate for our study group exceeds international figures because our participants have an older age profile and they experience more health problems. The results show that hospitals need to detect high-risk patients early and they must improve kidney functions and blood flow control while following treatment guidelines to achieve better patient outcomes.

Conclusion

This retrospective study highlights that in-hospital mortality among heart failure patients remains substantial, with an observed rate of 22.5%. Advanced age, particularly patients aged 61–80 years, renal impairment, elevated NT-proBNP levels, reduced ejection fraction, and prevalent cardiometabolic comorbidities such as hypertension and diabetes emerged as key clinical predictors of adverse outcomes. Despite widespread use of guideline-directed medical therapy, including beta-blockers, RAAS inhibitors, and combination regimens, mortality remained significant, underscoring the impact of baseline disease severity and organ dysfunction. These findings emphasize the critical importance of early risk stratification, comprehensive assessment of clinical and laboratory parameters, and tailored interventions to optimize patient management. Implementation of such strategies may improve survival, reduce hospital stay, and enhance overall outcomes in hospitalized HF populations.

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