

NT-PROBNP AS A PREDICTOR OF MORTALITY IN ACUTE HEART FAILURE: A RETROSPECTIVE COHORT STUDY

Sheikh Muhammad Rehman Zia¹, Anam Zahra², Faisal Qadeer³, Ayla Areej⁴, Mutahir Abbas Virk⁵, Najeeb Ullah⁶

¹Cardiologist, Department of Cardiology, Army Cardiac Hospital, Lahore, Pakistan

²Speciality Registrar, Department of Cardiology, Evercare Hospital, Lahore, Pakistan

³Cardiologist, Department of Cardiology, Integrated Medical Care, Lahore, Pakistan

⁴Medical Officer, Fauji Foundation Hospital, Pakistan

⁵Consultant Interventional Cardiologist, Department of Cardiology, CMH Malir, Karachi, Pakistan

⁶Assistant Professor, Department of Internal Medicine, Fatima Memorial Hospital, College of Medicine and Dentistry, Lahore, Pakistan

*Corresponding Author: Sheikh Muhammad Rehman Zia, Email: shalamarian.ravian@gmail.com

ABSTRACT

Background: Acute heart failure is associated with substantial in-hospital morbidity and mortality. N-terminal pro-B-type natriuretic peptide (NT-proBNP) is widely used in the diagnosis of heart failure and may also provide important prognostic information regarding short-term clinical outcomes.

Objective: To evaluate the predictive value of admission NT-proBNP for in-hospital mortality in patients with acute heart failure.

Methods: This retrospective cohort study was conducted at Army Cardiac Hospital, Lahore, Pakistan from October 2025 to May 2026, included 200 adult patients admitted with acute heart failure. Demographic, clinical, laboratory, and echocardiographic data were obtained from medical records.

Results: Of 200 patients, 24 (12.0%) died during hospitalization. Non-survivors had significantly higher median NT-proBNP levels than survivors, 11,850 (IQR 7,120–18,900) versus 4,380 (2,210–7,460) pg/mL ($p < 0.001$). Mortality increased progressively from 2.0% in patients with NT-proBNP $< 2,000$ pg/mL to 28.0% in those with levels $\geq 9,000$ pg/mL ($p < 0.001$). An NT-proBNP cutoff of 6,500 pg/mL showed an AUC of 0.79 (95% CI: 0.70–0.88), sensitivity of 79.2%, specificity of 73.3%, and negative predictive value of 96.3%. NT-proBNP $> 6,500$ pg/mL remained an independent predictor of mortality (aOR 4.82; 95% CI: 1.67–13.92; $p = 0.004$), along with chronic kidney disease and systolic blood pressure < 110 mmHg.

Conclusion: It is concluded that admission NT-proBNP is a useful predictor of in-hospital mortality in patients with acute heart failure. Higher NT-proBNP levels were associated with progressively greater mortality and adverse clinical outcomes, supporting its use as part of early risk stratification.

KEYWORDS: Acute heart failure; NT-proBNP; mortality; prognostic biomarker; risk stratification; natriuretic peptide

INTRODUCTION

Acute heart failure (AHF) is a clinical syndrome of sudden onset or deterioration of heart failure symptoms and signs, which if not promptly evaluated medically, is life-threatening, and often necessitates hospitalization [1]. Although there have been significant developments in drug and device therapies, AHF is still associated with a high in-hospital and post-discharge mortality rate, and early recognition of those patients at risk is a crucial part of clinical management [2,3]. The ages, blood pressure, renal function, serum sodium, cardiac troponin, left ventricular ejection fraction and a number of circulating biomarkers are typically included in risk stratification [4]. Of those, N-terminal pro-B-type natriuretic peptide (NT-proBNP) has gained special significance as it gives clues to the presence and intensity of hemodynamic cardiac stress [5]. The NT-proBNP is released after the cleavage of proB-type natriuretic peptide due to an increase of the wall tension, pressure overload and volume expansion of the ventricles [6]. It is well established that the plasma concentration increases significantly in patients with AHF and is used extensively for supporting the diagnosis, with a plasma concentration of less than 300 pg/mL making the diagnosis of AHF unlikely in patients presenting acutely [7]. NT-proBNP is not just a diagnostic biomarker, however. There is growing evidence that higher concentrations correlate with increased functional status, hospital admissions and short and long-term mortality rates and are linked with worsening congestion [8,9]. Therefore, natriuretic peptides are now acknowledged as valuable markers to use in the prognosis of patients with heart failure [10].

NT-proBNP has been shown to be prognostic at various points during hospitalization. Previous studies demonstrated that elevated baseline NT-proBNP was independently associated with 30-day outcome of death or hospitalization, and with 180-day mortality, with persistently elevated levels of NT-proBNP after treatment being a strong predictor of a

high risk of outcome [11]. Likewise, repeated NT-proBNP measurements have shown that NT-proBNP itself is an independent predictor of cardiovascular hospitalization and mortality [12]. Absolute discharge NT-proBNP concentration and percentage reduction on admission to hospital also seem to be important; there is a graded increase in mortality rate with higher discharge NT-proBNP levels, and a reduction of $\leq 30\%$ has been correlated with a nearly twice as high death rate as discharge with a higher reduced NT-proBNP [13]. However, certain clinical factors must be taken into account in the interpretation of NT-proBNP. The circulating level of NT-proBNP may be elevated in the presence of advanced age, atrial fibrillation and renal dysfunction, and may be disproportionately low with obesity [14]. This was confirmed by the large cohort of patients (2025) hospitalized for acute heart failure who showed a graded association between admission NT-proBNP and death, but in this group renal function also modified the strength of this relationship [15].

Objective

To evaluate the predictive value of admission NT-proBNP for in-hospital mortality in patients with acute heart failure.

METHODOLOGY

This retrospective cohort study was conducted at Army Cardiac Hospital, Lahore, Pakistan from October 2025 to May 2026. A total of 200 adult patients admitted with acute heart failure were included. Acute heart failure was identified from the clinical diagnosis documented at the index hospitalization. Patients aged ≥ 18 years with a documented admission NT-proBNP level and complete outcome data were eligible for inclusion. Patients with incomplete medical records, missing NT-proBNP measurements, end-stage renal disease requiring dialysis, acute ST-elevation myocardial infarction as the primary diagnosis, or conditions known to markedly interfere with interpretation of natriuretic peptide levels were excluded. The primary outcome was all-cause in-hospital mortality. Patients were classified into survivor and non-survivor groups according to their status at discharge. Admission NT-proBNP was evaluated as the principal prognostic biomarker. Published evidence supports the use of admission NT-proBNP for mortality prediction in acute heart failure and has shown significantly higher concentrations among patients who die during hospitalization.

Data Collection

Demographic, clinical, laboratory, and echocardiographic information was retrospectively extracted from hospital records. Variables included age, gender, hypertension, diabetes mellitus, ischemic heart disease, atrial fibrillation, chronic kidney disease, systolic blood pressure, heart rate, New York Heart Association functional class, left ventricular ejection fraction, hemoglobin, serum sodium, blood urea nitrogen, serum creatinine, cardiac troponin, and admission NT-proBNP level. NT-proBNP concentration measured at admission was recorded in pg/mL. Patients were further categorized according to NT-proBNP concentration for comparison of mortality risk. Receiver operating characteristic analysis was used to determine the optimal NT-proBNP cutoff for predicting mortality rather than selecting an arbitrary threshold in advance. This approach is consistent with previous acute-heart-failure studies that identified prognostically useful admission NT-proBNP cutoffs through ROC analysis. Clinical outcomes including ICU admission, requirement for mechanical ventilation, duration of hospitalization, and in-hospital mortality were recorded. The relationship between admission NT-proBNP concentration and mortality was assessed while accounting for other important prognostic variables, particularly age and renal function, because both can substantially influence circulating NT-proBNP levels.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Normally distributed continuous variables were presented as mean $\pm$ standard deviation, while skewed variables such as NT-proBNP were presented as median with interquartile range where appropriate. Categorical variables were expressed as frequencies and percentages. Continuous variables were compared between survivors and non-survivors using the independent-samples t-test or Mann–Whitney U test, while categorical variables were compared using the chi-square test or Fisher's exact test. Receiver operating characteristic curve analysis was performed to determine the predictive ability of admission NT-proBNP for in-hospital mortality. A p-value < 0.05 was considered statistically significant.

RESULTS

Non-survivors were older than survivors, with a mean age of 73.1 ± 10.2 versus 66.8 ± 11.9 years ($p = 0.012$). Chronic kidney disease was more frequent among non-survivors, 12 (50.0%) versus 39 (22.2%) ($p = 0.003$). They also had lower mean systolic blood pressure, 108.3 ± 20.5 versus 124.6 ± 21.8 mmHg ($p < 0.001$), lower LVEF, $33.6 \pm 11.4\%$ versus $39.8 \pm 12.7\%$ ($p = 0.024$), lower serum sodium, 133.8 ± 5.3 versus 137.2 ± 4.6 mmol/L ($p = 0.001$), and higher serum creatinine, 1.94 ± 0.88 versus 1.36 ± 0.65 mg/dL ($p < 0.001$). Median NT-proBNP was also markedly higher among non-survivors, 11,850 (IQR 7,120–18,900) versus 4,380 (2,210–7,460) pg/mL ($p < 0.001$).

Table 1. Baseline characteristics according to in-hospital mortality

Characteristic	Survivors (n=176)	Non-survivors (n=24)	p-value
Age (years), Mean±SD	66.8±11.9	73.1±10.2	0.012
Male	103 (58.5%)	15 (62.5%)	0.709
Hypertension	124 (70.5%)	19 (79.2%)	0.383
Diabetes mellitus	78 (44.3%)	15 (62.5%)	0.094
Ischemic heart disease	82 (46.6%)	15 (62.5%)	0.144
Atrial fibrillation	48 (27.3%)	11 (45.8%)	0.061
Chronic kidney disease	39 (22.2%)	12 (50.0%)	0.003
Systolic BP (mmHg), mean±SD	124.6±21.8	108.3±20.5	<0.001
LVEF (%), Mean±SD	39.8±12.7	33.6±11.4	0.024
Serum sodium (mmol/L), mean±SD	137.2±4.6	133.8±5.3	0.001
Serum creatinine (mg/dL), mean±SD	1.36±0.65	1.94±0.88	<0.001
NT-proBNP (pg/mL), median (IQR)	4,380 (2,210–7,460)	11,850 (7,120–18,900)	<0.001

Mortality was 1 (2.0%) in patients with NT-proBNP <2,000 pg/mL, 3 (6.0%) at 2,000–4,499 pg/mL, 6 (12.0%) at 4,500–8,999 pg/mL, and 14 (28.0%) at ≥9,000 pg/mL. Overall, 24 (12.0%) of the 200 patients died during hospitalization, showing a significant graded association between increasing NT-proBNP and mortality ($p<0.001$).

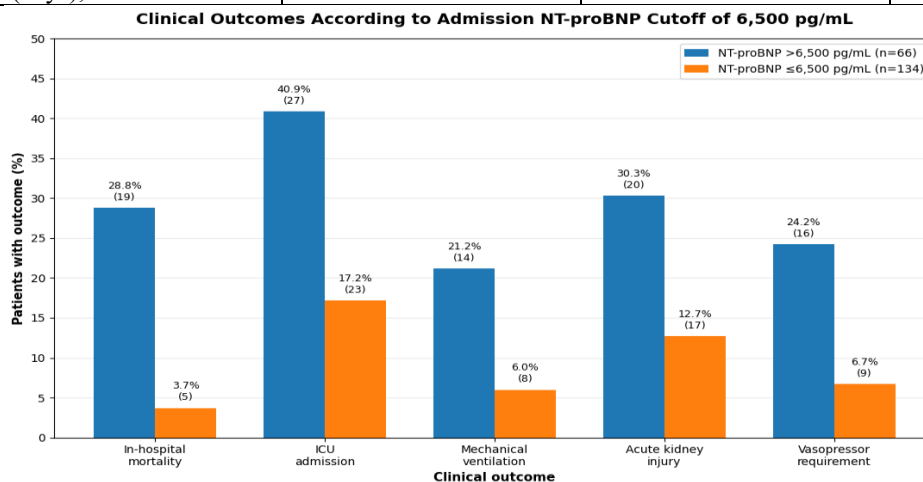
Table 2. In-hospital mortality according to admission NT-proBNP quartiles

NT-proBNP Category	n	Deaths n (%)	Survivors n (%)	p-value
Q1: <2,000 pg/mL	50	1 (2.0%)	49 (98.0%)	<0.001
Q2: 2,000–4,499 pg/mL	50	3 (6.0%)	47 (94.0%)	
Q3: 4,500–8,999 pg/mL	50	6 (12.0%)	44 (88.0%)	
Q4: ≥9,000 pg/mL	50	14 (28.0%)	36 (72.0%)	
Total	200	24 (12.0%)	176 (88.0%)	

In-hospital mortality occurred in 19 (28.8%) compared with 5 (3.7%) patients with lower levels ($p<0.001$). ICU admission was required in 27 (40.9%) versus 23 (17.2%), mechanical ventilation in 14 (21.2%) versus 8 (6.0%), acute kidney injury in 20 (30.3%) versus 17 (12.7%), and vasopressor support in 16 (24.2%) versus 9 (6.7%). Mean hospital stay was also longer, 8.3 ± 4.1 versus 5.7 ± 2.9 days ($p<0.001$).

Table 3. Clinical outcomes according to NT-proBNP cutoff of 6,500 pg/mL

Outcome	NT-proBNP >6,500 pg/mL (n=66)	NT-proBNP ≤6,500 pg/mL (n=134)	p-value
In-hospital mortality	19 (28.8%)	5 (3.7%)	<0.001
ICU admission	27 (40.9%)	23 (17.2%)	<0.001
Mechanical ventilation	14 (21.2%)	8 (6.0%)	0.001
Acute kidney injury	20 (30.3%)	17 (12.7%)	0.003
Vasopressor requirement	16 (24.2%)	9 (6.7%)	<0.001
Hospital stay (days), mean±SD	8.3 ± 4.1	5.7 ± 2.9	<0.001

**Figure 1: Clinical outcomes according to NT-proBNP**

An NT-proBNP cutoff of 6,500 pg/mL showed good predictive performance for in-hospital mortality, with an AUC of 0.79 (95% CI: 0.70–0.88; $p<0.001$). Sensitivity was 79.2% and specificity 73.3%, while positive and negative predictive values were 28.8% and 96.3%, respectively. Overall diagnostic accuracy was 74.0%, indicating particularly strong ability to identify patients at low risk of death when NT-proBNP was below the cutoff.

Table 4. Diagnostic performance of admission NT-proBNP for predicting in-hospital mortality

Parameter	Result
Optimal NT-proBNP cutoff	6,500 pg/mL
Area under ROC curve (AUC)	0.79
95% CI for AUC	0.70–0.88
Sensitivity	79.2%
Specificity	73.3%
Positive predictive value	28.8%
Negative predictive value	96.3%
Overall diagnostic accuracy	74.0%
p-value	<0.001

On multivariable analysis, NT-proBNP >6,500 pg/mL was the strongest independent predictor of in-hospital mortality, increasing the odds of death by 4.82 times (95% CI: 1.67–13.92; $p=0.004$). Chronic kidney disease was also independently associated with mortality (aOR 2.73; 95% CI: 1.10–6.79; $p=0.031$), as was systolic blood pressure <110 mmHg (aOR 2.61; 95% CI: 1.05–6.48; $p=0.039$). Age ≥ 70 years, hyponatremia, LVEF <35%, and creatinine >1.5 mg/dL did not remain statistically significant after adjustment.

Table 5. Multivariable predictors of in-hospital mortality in acute heart failure

Predictor	Adjusted OR	95% CI	p-value
NT-proBNP >6,500 pg/mL	4.82	1.67–13.92	0.004
Age ≥ 70 years	2.08	0.86–5.05	0.105
Chronic kidney disease	2.73	1.10–6.79	0.031
Systolic BP <110 mmHg	2.61	1.05–6.48	0.039
Serum sodium <135 mmol/L	2.37	0.97–5.78	0.058
LVEF <35%	1.94	0.80–4.71	0.143
Serum creatinine >1.5 mg/dL	2.18	0.91–5.24	0.081

DISCUSSION

In the present study, 200 patients with acute heart failure were studied, and the overall in-hospital mortality was 12.0%, with admission NT-proBNP showing its prognostic value. Non-survivors were significantly older than survivors (73.1 $\pm$ 10.2 vs. 66.8 $\pm$ 11.9 years; $p=0.012$) and had lower systolic blood pressure (108.3 $\pm$ 20.5 vs. 124.6 $\pm$ 21.8 mmHg; $p<0.001$), lower LVEF (33.6 $\pm$ 11.4% vs. 39.8 $\pm$ 12.7%; $p=0.024$), and lower serum sodium (133.8 $\pm$ 5.3 vs. 137.2 $\pm$ 4.6 mmol/L; $p=0.001$). Older age, low SBP, hyponatremia and impaired ventricular function, have also been demonstrated to be relevant predictors of poor outcome in hospitalised acute HF patients [16]. The most significant result was the significantly higher level of NT-proBNP in patients who died. Median admission NT-proBNP was 11,850 pg/mL (IQR 7,120–18,900) in non-survivors compared with 4,380 pg/mL (IQR 2,210–7,460) among survivors ($p<0.001$). Similar studies have also found that admission NT-proBNP levels are significantly greater in patients who died and NT-proBNP is an independent marker of poor prognosis in AHF [17]. A previous study published reported the progressive increase in all-cause and cardiovascular mortality with increasing NT-proBNP levels [18]. The dose-response association was evident within the categories of NT-proBNP. In-hospital mortality increased from 2.0% at NT-proBNP <2,000 pg/mL to 6.0% at 2,000–4,499 pg/mL, 12.0% at 4,500–8,999 pg/mL, and 28.0% at $\geq 9,000$ pg/mL ($p<0.001$). A grading mortality with higher natriuretic peptide categories has also been shown in previous studies. The mortality rates were higher in each BNP quartile in the large acute decompensated heart failure (ADHF) cohort and BNP remained independently associated with mortality even after adjusting for clinical variables [19]. Previous studies, which were published more recently, showed that those in the highest category of NT-proBNP had a greater than twofold risk of all-cause death versus those in the lowest category [18]. The in-hospital outcomes were significantly worse in patients with NT-proBNP level >6,500 pg/mL. The mortality rate was 28.8% versus 3.7% in patients with concentrations of $\leq 6,500$ pg/mL ($p<0.001$). The rates of ICU admission were 40.9% vs 17.2%, mechanical ventilation 21.2% vs 6.0%, acute kidney injury 30.3% vs 12.7%, and vasopressor use 24.2% vs 6.7%. Mean hospital stay was also longer at 8.3 $\pm$ 4.1 versus 5.7 $\pm$ 2.9 days ($p<0.001$). Earlier studies have also shown that

elevated levels of admission NT-proBNP correlate with the severity of heart failure and adverse clinical outcomes, including higher levels of ICU use, complications and death [20].

The ROC analysis demonstrated that the use of an NT-proBNP cut-off value of 6,500 pg/mL for predicting in-hospital mortality had an AUC of 0.79 (95% CI 0.70–0.88), a sensitivity of 79.2%, and a specificity of 73.3% with an overall accuracy of 74.0%. The negative predictive value was also high at 96.3%, suggesting that patients with values lower than this had a relatively low in-hospital mortality rate. A previous study set the cutoff for admission-NT-proBNP at 9,152 pg/mL, which achieved a sensitivity of 71.4%, specificity of 81.3%, and an AUC of 0.726 [21]. A variation in the optimal threshold between studies might be due to different ages, renal function, disease severity, timings of measurements, and follow-up periods. The presence of renal dysfunction also had a strong association with mortality. Fifty percent of the non-survivors had chronic kidney disease versus 22.2% of survivors ($p=0.003$) and mean serum creatinine in the non-survivors was 1.94 ± 0.88 mg/dL versus 1.36 ± 0.65 mg/dL ($p<0.001$) in the survivors. The association of chronic kidney disease with mortality was independent (aOR 2.73; 95% CI 1.10–6.79; $p=0.031$). It has been previously shown that renal dysfunction leads to elevated concentrations of NT-proBNP in the blood, but it does not decrease the usefulness of its prognostic importance. Patients with both reduced renal function and high NT-proBNP had the highest mortality rate, showing that there is a need for the simultaneous interpretation of cardiac and renal markers [22]. There were a number of limitations to this study. It was also a retrospective study and it was dependent on the fullness and correctness of medical records, which could have resulted in selection bias and documentation bias. The study was carried out in one center, and the number of patients included (200) is relatively small, and may not be generalizable to other centers. The primary assessment of NT-proBNP was at admission, and serial changes in the NT-proBNP level during hospitalization were not assessed. Despite statistical adjustment, important factors that could influence the level of NT-proBNP (such as age, obesity, atrial fibrillation, and renal dysfunction) may have also affected its ability to predict prognosis. Moreover, the study was undertaken to analyse the in-hospital mortality and long-term outcomes like 30 days and 1-year mortality were not studied.

CONCLUSION

It is concluded that admission NT-proBNP was a useful predictor of in-hospital mortality in patients with acute heart failure. Non-survivors had markedly higher NT-proBNP levels, and mortality increased progressively across higher NT-proBNP categories. A cutoff of 6,500 pg/mL showed good discriminatory performance, with high sensitivity and a particularly strong negative predictive value. NT-proBNP >6,500 pg/mL remained an independent predictor of mortality after adjustment for major clinical variables, along with chronic kidney disease and low systolic blood pressure. These findings support the use of NT-proBNP as part of early risk stratification in acute heart failure, alongside clinical and renal parameters.

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