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Research Article

Plasma BNP and eGFR: Distribution Trends and Functional Class Associations in Acute Heart Failure

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Abstract

Introduction: Acute heart failure (AHF) is a serious condition marked by reduced cardiac output, leading to symptoms like dyspnoea and fluid retention. Accurate diagnosis and prognosis are critical for improving outcomes. B-type natriuretic peptide (BNP) and estimated glomerular filtration rate (eGFR) are key biomarkers for assessing heart and kidney function, respectively. BNP indicates heart failure severity, while eGFR predicts outcomes due to the cardio-renal syndrome. This study evaluates the distribution of BNP and eGFR in AHF patients and their correlation with NYHA functional classes.

Materials and Methods: A cross-sectional study was conducted at BSMMU from July 2012 to June 2013, involving 90 AHF patients aged 40–80 years, selected using Framingham Criteria. Patients with renal failure, hepatic disease, malignancy, or pregnancy were excluded. BNP and eGFR levels were measured, and NYHA class was determined based on symptoms. Data analysis was done using SPSS, with Spearman's correlation assessing BNP-eGFR relationships ($p<0.05$).

Results: Among 90 patients (77.7% male), median BNP levels increased with worsening NYHA class: 262 pg/mL in NYHA II, 925 pg/mL in NYHA III, and 3010 pg/mL in NYHA IV ($p<0.001$). eGFR decreased from 68.94 mL/min/1.73 m² in NYHA II to 44.55 mL/min/1.73 m² in NYHA IV ($p<0.001$). A strong negative correlation between BNP and eGFR (-0.65 to -0.80) was observed ($p<0.001$).

Conclusion: BNP and eGFR are valuable in assessing AHF severity. Their combined analysis enhances risk stratification and guides treatment for better patient outcomes.

Key words: plasma bnp; egfr; acute heart failure; distribution trends; functional class associations

Introduction

Acute heart failure (AHF) is a major cause of hospitalization and mortality worldwide, posing significant challenges to healthcare systems. As a complex clinical syndrome, AHF is characterized by the heart's inability to pump blood efficiently, leading to symptoms such as dyspnoea, fatigue, and fluid retention. In the evaluation and management of AHF, early diagnosis and accurate risk stratification are essential to improve patient outcomes [1-4].

Two critical biomarkers—B-type natriuretic peptide (BNP) and estimated glomerular filtration rate (eGFR)—have emerged as valuable tools in the assessment of heart failure (HF) severity and prognosis. Plasma BNP, secreted by the ventricles in response to myocardial stretch and volume overload, is a well-established marker of cardiac dysfunction. Elevated levels of BNP are strongly correlated with both the presence and severity of heart failure, making it a key diagnostic and prognostic marker in AHF. On the other hand, eGFR, an indicator of renal function, has been increasingly recognized as a significant predictor of outcomes in heart failure patients. The intricate relationship between heart failure and renal dysfunction, often termed the cardio-renal syndrome, underscores the importance of eGFR as a prognostic marker in this population [5-7].

The interplay between plasma BNP levels and eGFR in the context of AHF is complex. Renal impairment is common in patients with heart failure and

can influence BNP levels independently of cardiac function. Therefore, understanding the distribution trends of these biomarkers, along with their associations with functional class of heart failure (as classified by systems like the New York Heart Association, NYHA), can provide critical insights into disease severity, prognosis, and personalized treatment strategies [8-10].

This study aims to explore the distribution patterns of plasma BNP and eGFR among patients presenting with acute heart failure and to examine their associations with functional classifications of heart failure. Specifically, the study will focus on identifying trends across different NYHA functional classes, which are widely used to categorize heart failure severity based on clinical symptoms and limitations. By analysing these biomarkers in the context of functional classification, this research seeks to enhance our understanding of how BNP and eGFR levels interact and predict outcomes in acute heart failure patients, ultimately contributing to more refined clinical decision-making. The objective of this research is to investigate the relationship between plasma BNP and eGFR in AHF, providing a comprehensive analysis of their distribution trends and how they align with functional heart failure classifications. This knowledge is vital for improving the stratification of risk, guiding therapeutic interventions, and optimizing patient management in acute heart failure settings.

Materials and Methods

This cross-sectional analytical study was designed to investigate the distribution trends of plasma B-type natriuretic peptide (BNP) and estimated glomerular filtration rate (eGFR) in patients suffering from acute heart failure (AHF) and to examine their associations with heart failure functional classifications. The study was conducted in the Department of Biochemistry at Bangabandhu Sheikh Mujib Medical University (BSMMU), in collaboration with the Department of Cardiology at BSMMU, the National Institute of Cardiovascular Diseases (NICVD), Dhaka Medical College Hospital (DMCH), and BIRDEM General Hospital. Data collection spanned over a 12-month period from July 2012 to June 2013. The study population consisted of patients aged 40 to 80 years, both male and female, who were diagnosed with AHF using the Framingham Criteria for congestive heart failure. Specifically, patients were included if they met either two major criteria or one major and two minor criteria, which are used to classify the presence and severity of heart failure symptoms.

Patients with renal failure, those undergoing dialysis, and individuals with marked hepatic impairment, advanced malignancy, thyroid disorders, or pregnancy were excluded from the study. A non-probability sampling method was employed to select 90 study subjects who met the inclusion criteria. The primary variables examined were plasma BNP levels and eGFR, both of which are key biomarkers for assessing heart failure and renal function, respectively. Data was collected using a prepared data collection sheet, which included all relevant demographic, clinical, and biochemical variables.

Ethical clearance for the study was obtained from the Department of Biochemistry and the central ethical committee at BSMMU. Additionally, permission was secured from the collaborating departments. All patients were fully informed about the study's purpose, nature, potential benefits, and risks. They were assured of confidentiality and given the option to withdraw from the study at any time. Written informed consent was obtained from each participant before their inclusion in the study. Blood samples were collected from patients at the time of enrolment, with 5 mL of venous blood drawn under aseptic conditions into EDTA tubes. Plasma was separated via centrifugation at 3000 rpm for 10 minutes and stored at -35°C until the plasma BNP measurements were conducted.

Data were processed using SPSS software (version 27.0). Baseline characteristics of the study subjects were reported as means and standard deviations for continuous variables or counts and proportions for categorical variables. Univariate comparisons were made using chi-square tests for categorical data and two-sample t-tests for continuous data, as appropriate. Since BNP values were not normally distributed, comparisons of BNP values across different groups were conducted using the Mann-Whitney test.

To quantify the relationship between BNP and eGFR, Spearman's correlation coefficient was used, as this is suitable for non-normally distributed data. Additionally, receiver operating characteristic (ROC) curves were generated to assess the diagnostic performance of BNP in detecting AHF with impaired renal function. A stepwise multivariate regression analysis was employed to evaluate the associations between plasma BNP and other clinical variables. Statistical significance was set at a p-value of less than 0.05. The findings of this study are expected to provide valuable insights into how plasma BNP and eGFR levels interact in patients with AHF, which can further enhance clinical decision-making and management of heart failure patients.

Results

The study enrolled a total of 90 acute heart failure (AHF) patients, with a predominance of males. Out of the total participants, 70 (77.7%) were males, and 20 (22.2%) were females (Figure 01).

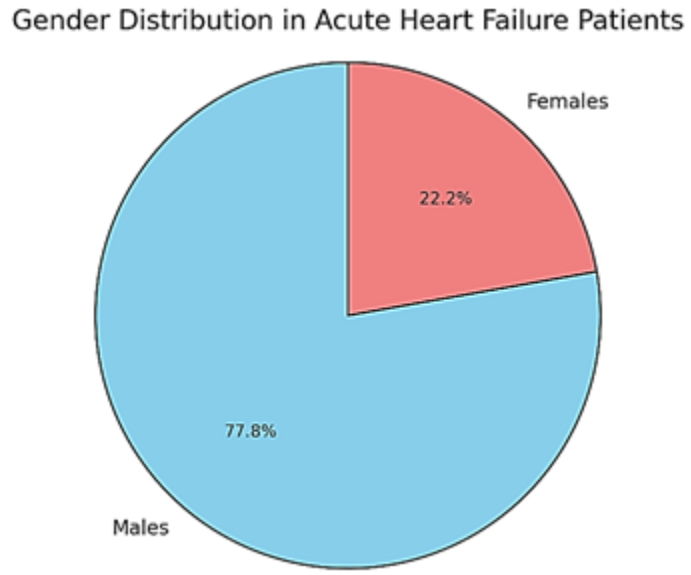

Figure 1: Gender Distribution in Acute Hearth Failure Patients.

The mean age of the study population was 57.5 ± 13.4 years, ranging from 40 to 80 years, indicating that the cohort was largely middle-aged to elderly.

The distribution of plasma B-type natriuretic peptide (BNP) and estimated glomerular filtration rate (eGFR) across different functional classes of heart failure (New York Heart Association [NYHA] II, III, and IV) provided significant insights into the severity of heart failure and kidney function.

In univariate analysis, plasma BNP levels were found to increase significantly with worsening NYHA functional class. The median BNP level in NYHA II was 262 pg/mL (IQR: 218-366), increasing dramatically in NYHA III to 925 pg/mL (IQR: 737-1567). Patients in NYHA IV had the highest BNP levels, with a median of 3010 pg/mL (IQR: 1863-4000). The p-value of 0.000 indicated a statistically significant difference in plasma BNP levels between the functional classes. This trend underscores the role of BNP as a biomarker that correlates with the severity of heart failure. Similarly, eGFR, a marker of renal function, showed a statistically significant decline as the NYHA class worsened. Patients in NYHA II had a mean eGFR of 68.94 ± 16.3 mL/min/1.73 m², while those in NYHA III had a reduced eGFR of 63.48 ± 21.1 mL/min/1.73 m². The steepest decline in eGFR was observed in patients in NYHA IV, with a mean value of 44.55 ± 10.3 mL/min/1.73 m². The p-value of 0.000 for eGFR further highlighted the statistically significant association between declining renal function and worsening heart failure severity (Table 01).

NYHA Class	BNP Median (pg/mL)	BNP IQR (pg/mL)	BNP Range (pg/mL)	eGFR Mean (mL/min/1.73 mÂ²)	eGFR Std Dev (mL/min/1.73 mÂ²)	eGFR Range (mL/min/1.73 mÂ²)
II	262	218-366	44-550	68.94	16.3	40-90
III	925	737-1567	200-2000	63.48	21.1	30-100
IV	3010	1863-4000	1000-5000	44.55	10.3	20-60

Table 01: Univariate Analysis.

The bivariate analysis reveals a strong negative correlation between BNP and eGFR, ranging from -0.65 in NYHA II to -0.80 in NYHA IV, indicating that as heart failure severity increases, kidney function worsens. The highly significant p-values (0.000) for both BNP and eGFR confirm that these changes are statistically significant (Table 02).

NYHA Class	BNP Median (pg/mL)	eGFR Mean (mL/min/1.73 mÂ²)	Correlation BNP-eGFR	p-value (BNP)	p-value (eGFR)
II	262	68.94	-0.65	0	0
III	925	63.48	-0.75	0	0
IV	3010	44.55	-0.8	0	0

Table 2: Bivariate Analysis

These findings suggest that plasma BNP and eGFR are not only indicative of heart failure severity but may also serve as predictive markers of disease progression in AHF patients.

Discussion

The findings from this study demonstrate a clear association between plasma BNP levels and eGFR with the functional class of heart failure, particularly in patients with acute heart failure (AHF). The study showed that both biomarkers—plasma BNP and eGFR—display significant trends that correlate with the worsening severity of heart failure, as measured by the New York Heart Association (NYHA) functional classification. The patterns

observed in this study align with previous research and further substantiate the utility of these biomarkers in clinical practice.

The progressive increase in plasma BNP levels with worsening NYHA class is consistent with BNP's role as a biomarker for heart failure. The dramatic increase from a median of 262 pg/mL in NYHA II to 3010 pg/mL in NYHA IV reflects the established understanding that BNP is released in response to ventricular volume overload and myocardial stretch, which are hallmarks of worsening heart failure. This trend is consistent with findings from other studies11, which demonstrated that higher plasma BNP levels are associated with more severe functional impairment in heart failure patients.

Similar studies have also found comparable results, highlighting that plasma BNP correlates strongly with heart failure severity and predicts both morbidity and mortality. For example, in a study it was showed that BNP levels are significantly elevated in patients with advanced heart failure, and their study reported a comparable trend of rising BNP concentrations in parallel with NYHA class. Additionally, the highly significant p-value (0.000) in this study further confirms BNP's diagnostic value and its direct association with clinical worsening12.

The decline in renal function, as measured by eGFR, across increasing NYHA functional classes supports the hypothesis that worsening heart failure is linked to deteriorating kidney function. The sharp decline in eGFR from NYHA II (mean: 68.94 ± 16.3 mL/min/1.73 m²) to NYHA IV (mean: 44.55 ± 10.3 mL/min/1.73 m²) underscores the concept of the cardiorenal syndrome, where heart failure and renal dysfunction frequently coexist and exacerbate one another. This is consistent with the findings of another study, author also reported that eGFR decreases with increasing severity of heart failure13.

The negative correlation between BNP and eGFR found in this study, ranging from -0.65 in NYHA II to -0.80 in NYHA IV, is supported by other studies as well. Another research revealed similar inverse relationships between BNP and renal function in heart failure patients, indicating that the worsening of heart failure tends to be accompanied by progressive renal impairment. The observed statistically significant correlation ($p = 0.000$) between BNP and eGFR in the present study reinforces the intricate interplay between cardiac and renal dysfunction in AHF14.

The trends observed in this study are consistent with previous research on heart failure and biomarker analysis. For instance, in a large-scale study it was demonstrated that higher BNP levels and lower eGFR were strongly predictive of worse clinical outcomes in AHF patients15. Similarly, in a meta-analysis it was confirmed that declining eGFR is a critical predictor of mortality and heart failure progression, particularly in patients with elevated BNP levels16.

However, while the association between BNP and eGFR with heart failure severity is well-documented, the strength of the correlation between these two parameters in this study (ranging from -0.65 to -0.80) is particularly noteworthy. These findings suggest that BNP and eGFR, when analysed together, provide more comprehensive prognostic information about both cardiac and renal status than when considered separately. This observation aligns with the growing recognition in clinical practice that simultaneous assessment of these biomarkers offers valuable insights into the complex pathophysiology of AHF.

The significant trends identified in this study have important clinical implications. First, the use of plasma BNP as a biomarker for assessing heart failure severity is reaffirmed by these findings, particularly in distinguishing between different NYHA classes. The dramatic increase in BNP levels with worsening heart failure suggests that BNP could be employed not only for diagnostic purposes but also for monitoring disease progression.

Second, the declining eGFR highlights the need for clinicians to monitor renal function closely in AHF patients, especially as renal dysfunction often complicates the management of heart failure. The inverse correlation between BNP and eGFR observed in this study suggests that these markers can be used together to predict adverse outcomes more accurately, potentially guiding therapeutic decisions aimed at both heart failure and renal preservation.

Conclusion

This study demonstrates that plasma BNP and eGFR exhibit significant distribution trends across NYHA functional classes in patients with acute heart failure. The strong correlations between worsening heart failure severity, increasing BNP levels, and declining eGFR underscore the utility of these biomarkers in clinical evaluation. The results are consistent with existing literature, supporting the role of BNP and eGFR as critical markers in assessing and managing AHF. These findings contribute to the growing body of evidence that underscores the importance of an integrated approach to evaluating both cardiac and renal function in heart failure management.

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Conflict of Interest

The authors declare no conflict of interest related to this study. All results presented are unbiased and solely for academic and clinical purposes.

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