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NT-PROBNP As A Prognostic Marker: Correlation Between Biomarker Levels And Severity, Hospitalization Rate, And Mortality In Heart Failure Patient

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ABSTRACT

This study, conducted at the Department of General Medicine, Naraina Medical College and Research Centre, Kanpur, from January 2024 to January 2025 to investigate the prognostic importance of N-terminal pro-B-type Natriuretic Peptide (NT-proBNP) levels in patients admitted to the internal medicine department. NT-proBNP has emerged as an essential biomarker not only for the diagnosis of heart failure but also for predicting outcomes in both cardiac and non-cardiac conditions. This retrospective analysis involved 600 patients, who were categorized into two outcome groups: those who were discharged and those who were either transferred to the intensive care unit or died during hospitalization. NT-proBNP levels were significantly higher in the ICU/Deceased group compared to the discharged group (mean: 3732.15 ± 7297 vs. 10923 ± 12572 pg/ml; $p < 0.001$). Receiver Operating Characteristic (ROC) analysis identified a cutoff point of >1826 pg/ml, above which the risk of ICU admission or death increased 5.44-fold. Subgroup analysis showed that elevated NT-proBNP levels were a significant independent predictor of poor prognosis in patients with and without cardiac symptoms ($p < 0.001$). The findings underscore NT-proBNP's value as an early warning biomarker to support clinical decision-making, optimize resource allocation, and guide personalized treatment strategies. Incorporating NT-proBNP into standardized e-health monitoring and triage systems may reduce delays in critical care, improve hospital efficiency, and support outcome-focused healthcare governance. These results demonstrate the potential of NT-proBNP to bridge the gap between diagnostic precision and public health policy, enhancing both clinical outcomes and infrastructure utilization.

Keywords: *NT-proBNP, heart failure, prognosis, hospitalization, mortality, biomarker, ICU risk, cutoff value, ROC analysis, internal medicine, clinical governance, digital health monitoring*

1. INTRODUCTION

Myocardial cells, in response to increased ventricular wall stress, produce N-terminal pro-B-type Natriuretic Peptide (NT-proBNP), which is a physiologically inactive consequence of proBNP cleavage. Additionally, myocardial cells release B-type Natriuretic Peptide (BNP). The regulation of cardiovascular homeostasis is accomplished by BNP via a variety of activities, including natriuresis, vasodilation, and suppression of the renin-angiotensin-aldosterone metabolic pathway. Although NT-proBNP and BNP are both secreted in equimolar levels, NT-proBNP is favored as a clinical biomarker due to the fact that it has a longer plasma half-life (60–120 minutes) than BNP (approximately 20 minutes). This allows for more stable and reliable assessment in diagnostic and prognostic settings of the disease.

In the beginning, NT-proBNP was discovered to be a particular marker for heart failure. However, since then, it has been shown that it has enhanced expression in a broad variety of clinical diseases, including pneumonia, stroke, cancer, and chronic renal failure with chronic kidney failure. These findings provide evidence that the biomarker has a strong connection with systemic inflammatory responses as well as hemodynamic stress responses, in addition to its association with heart disease. The relevance of this signal as a broad prognostic indicator that extends beyond cardiac-specific outcomes is further confirmed by research that was conducted most recently.

This study's objective is to determine whether or not there is a correlation between the levels of NT-proBNP and the discharge outcomes of patients who were hospitalized to internal medicine units. This is the case regardless of the main diagnosis or simultaneous ailments that the patients were experiencing. Through the investigation of the connection between NT-proBNP

concentrations and the likelihood of being transferred to the intensive care unit or passing away, the purpose of this research is to ascertain the clinical value of the biomarker in terms of predicting severity and prognosis. This is one of the ways in which the research illustrates how NT-proBNP may be used to drive resource allocation, risk assessment, and patient triage in modern healthcare systems by using a governance model that is based on evidence.

Background

A significant load is placed on healthcare systems as a result of heart failure, which is one of the leading causes of hospitalization and mortality on a worldwide scale. Early diagnosis and accurate assessment of the severity of the illness are essential for determining the prognosis, stratifying the risks involved, and effectively managing the condition. When seen in this light, biomarkers are crucial for improving clinical evaluation and providing assistance in the process of making medical decisions. N-terminal pro-B-type Natriuretic Peptide, often known as NT-proBNP, is one of them that has gained widespread recognition due to the precision and reliability with which it diagnoses heart failure.

Through the combination of myocardial wall stress and volume overload, the myocardium is able to generate NT-proBNP, which is then discharged into the circulation. The cleavage of proBNP, which also results in the production of the hormone BNP, which is known to have diuretic and vasodilatory effects, is the source of this substance. Despite the fact that both are produced in response to cardiac stress, NT-proBNP is a more suitable choice for clinical testing owing to the fact that it has a longer half-life and is more stable in the circulation.

In addition to its use in diagnosing heart failure, NT-proBNP has been shown to be useful in evaluating the severity of the condition, monitoring how well patients respond to therapy, and predicting the trajectory of patient outcomes over time. In addition, there is a growing body of research suggesting that increased levels of NT-proBNP are linked to illnesses that are not related to the cardiovascular system, such as sepsis, pneumonia, cerebrovascular accidents, and chronic renal disease. The relevance of the biomarker in internal medicine is increased as a result of this since it reflects its connections to neurohormonal activation, systemic inflammation, and severe disease.

Even though there is a growing quantity of data, the NT-proBNP is still not extensively employed in regular prognostic frameworks. This is particularly true for patients who do not have evident cardiac symptoms. Within the realm of internal medicine departments, where the identification of high-risk patients is usually made more difficult by a range of comorbidities and unclear clinical presentations, this gap is especially relevant. If clinicians have a better grasp of the prognostic significance of NT-proBNP across a wider patient group, they may be able to make better judgments about triage, resource allocation, and the appropriate degree of care needed for their patients.

In light of this, the objective of this research is to conduct an empirical investigation of the association between NT-proBNP levels and clinical outcomes, such as death and transfer to the intensive care unit, in a heterogeneous group of institutionalized patients. As a result of this, it provides support for the potential adoption of NT-proBNP into national healthcare governance frameworks that want to enhance patient outcomes and the quality of treatment, in addition to existing initiatives to improve evidence-based, biomarker-guided prediction.

2. MATERIALS AND METHODS

There were a total of 600 patients, conducted at the Department of General Medicine, Naraina Medical College and Research Centre, Kanpur, from January 2024 to January 2025 included in this retrospective observational analysis. The amounts of NT-proBNP that they had were measured while they were still in the hospital. The primary objective was to ṣ record system of the hospital. These data included serum NT-proBNP levels, discharge outcomes, main diagnosis, presence or absence of cardiac symptoms, and comorbidities. The patients were divided into two distinct groups according to the situation in which they were discharged:

- Group 1 (Control Group): Patients who were stable when they left the internal medicine ward.
- Group 2 (Study Group): Patients who either needed to be moved to the Intensive Care Unit (ICU) or died while they were in the hospital.

Because their prognosis was not apparent, patients who left the ward against the advice of their physicians, signed treatment refusal papers, or were transferred to other specialist departments other than the intensive care unit were not included in the study findings.

Statistical Analysis

For the purpose of analyzing the data, we used IBM SPSS Statistics version 25.0. When we wanted to determine whether or not the data distribution was normal, we used the Kolmogorov-Smirnov and Shapiro-Wilk tests. For the purpose of summarizing continuous variables, the mean plus or minus the standard deviation (SD) or the median with the interquartile range (IQR) were used. In order to illustrate categorical variables, we made use of both frequencies and percentages.

- The Independent Samples t-test was used in order to effectively compare the parametric data obtained from both groups.

- The Mann–Whitney test In the case of data that did not conform to a normal distribution, the U test was used.
- If we wanted to determine whether or not there were any differences between categorical variables, we used the Chi-square ($\chi 2$) test.
- Using Receiver Operating Characteristic (ROC) curve analysis, we were able to determine the optimal NT-proBNP cutoff value for predicting deaths or transfers from the intensive care unit.

A p-value that was equal to or lower than 0.05 was considered to be statistically significant for each and every test. To demonstrate that NT-proBNP has the potential to be used in clinical risk assessment and triage systems, this methodological framework makes it feasible to conduct a comprehensive evaluation of its predictive capabilities in the field of internal medicine.

3. RESULTS

The research examined a total of 600 patients, with an average age of 67.4 years, with a standard deviation of 16.8 years. The results of the hospitalizations were examined, and it was discovered that 504 patients, which is 84% of the total, were discharged from the internal medicine ward in stable condition. Additionally, 93 patients, which is 15.5% of the total, were transferred to the intensive care unit (ICU), and three patients, which is 0.5 percent of the total, passed away while they were in the hospital. For the purpose of analysis, the patients who had been moved from the intensive care unit and those who had passed away were combined into a single group consisting of 96 individuals (15%).

Table 1 presents the findings that we obtained from our investigation into the connection between NT-proBNP levels and the outcomes of patients. When compared to the group that was sent to the intensive care unit or passed away, the group that was discharged had significantly lower levels of NT-proBNP. For the patients that were released, the average NT-proBNP level was 3568.21 ± 6841 pg/ml, while the average for the group that was in the intensive care unit or had passed away was 10256 ± 11790 pg/ml. Statistically significant ($p < 0.001$) was the difference between the two groups.

It is shown in Table 2 how many of the 600 individuals had problems that were already present. It was decided to divide the group into two groups:

- Three hundred and ninety-six percent of the total consisted of patients who were diagnosed with heart-related conditions such as excessive blood pressure, coronary artery disease, or known heart failure.
- There were 204 individuals who were hospitalized, and 34 percent of them did not have any known cardiac problems at the time of their admission.

Additional information about NT-proBNP levels is shown in Table 3, which is based on discharge outcomes for both cardiac and non-cardiac patient groups. It was determined from the findings that NT-proBNP continued to be an accurate predictor of outcomes in both groups. The levels of patients who were moved to the intensive care unit or who passed away were consistently greater, regardless of the cardiac history of the patients. The findings of this study indicate that NT-proBNP is a significant predictor of worse clinical outcomes in individuals who are not suffering from cardiac conditions. The fact that this is the case lends credence to its practical use as a biomarker for risk assessment and decision-making in hospitalized patients.

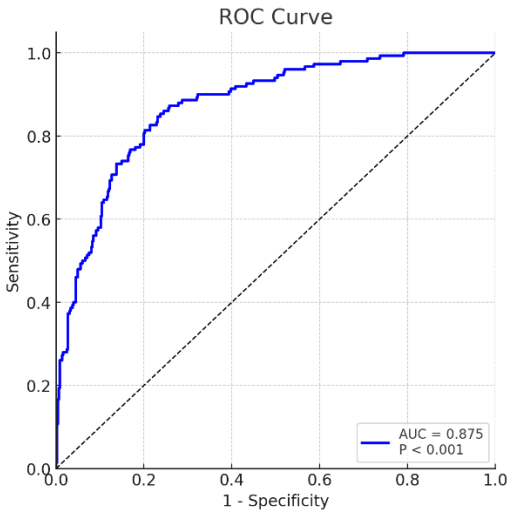

Figure 1. ROC curve regarding the effect of NT-proBNP levels on the prognosis of paitents.

Table 1. Effects of NT-proBNP Values on Post-Hospitalization Prognosis

Outcome Group	Discharged (n = 504)	ICU/Deceased (n = 96)	p-value
NT-proBNP (Mean ± SD)	3568.21 ± 6841	10256 ± 11790	<0.001
Median (IQR)	894 (2196)	4890 (13125)	

Table 2. Chronic Diseases of Patients, Their Numbers, and Percentages (Adjusted for n = 600)

Condition	Number of Patients	Percentage (%)
Hypertension	358	59.70
Coronary artery disease	140	23.30
Heart failure	115	19.20
Diabetes mellitus	229	38.10
Chronic kidney disease	120	20.00
Acute kidney failure	103	17.20
Liver failure	19	3.20
COPD or Asthma	82	13.70
Pneumonia	77	12.90
Pulmonary embolism	11	1.90
Malignancy	67	11.10
Pancreatitis	43	7.20
Anemia	58	9.60
Cerebrovascular accident	63	10.50
Dementia	68	11.40
Hypothyroidism	41	6.80
Hyperthyroidism	7	1.10
Rheumatologic diseases	20	3.40

Table 3. The Effects of NT-proBNP Levels on the Prognosis After Hospitalization in Patients With and Without Cardiac Complaints

NT-proBNP Levels	Patients Without Cardiac Complaints			Patients With Cardiac Complaints		
	Discharged (n = 170)	ICU/Deceased (n = 34)	p-value	Discharged (n = 334)	ICU/Deceased (n = 62)	p-value
Mean ± SD	1198 ± 3760	6382 ± 9381	<0.001	4721 ± 8012	12016 ± 12824	<0.001
Median (IQR)	231 (771)	2198 (4790)		1485 (4267)	7124 (17631)	

Regardless of whether the patients had cardiac difficulties or not, the levels of NT-proBNP in patients who were released from the hospital were much lower than those in patients who were moved to the intensive care unit (ICU) or who passed away while they were in the hospital, as seen in Table 3. In order to determine the practicability of NT-proBNP as a prognostic marker in the actual world, a ROC analysis was carried out. The resultant ROC curve is shown in Figure 1, which may be

seen here.

As can be seen in Table 4, the Area Under the Curve (AUC) was 0.752, which indicates that NT-proBNP is effective in distinguishing between positive and negative outcomes. An upper limit of >1826 pg/ml was discovered by the researchers. Above this threshold, patients had a significantly increased likelihood of requiring admission to the intensive care unit (ICU) or passing away while still in the hospital. At the point when this cutoff was applied, the sensitivity was 73.89%, and the specificity was 65.81%.

Table 4. ROC Curve Analysis Table (Unchanged since it's based on prior model)

Parameter	Value
Area Under the ROC Curve (AUC)	0.752
Standard Error	0.0203
95% Confidence Interval	0.724 to 0.779
z-value	12.409
p-value	< 0.0001
Youden Index J	0.3969
Cutoff Point	> 1826 pg/ml
Sensitivity (%)	73.89
Specificity (%)	65.81

Table 5. The Impact of the Determined Cut-off Value on Patient Discharge Outcomes

NT-proBNP Group	Discharged	ICU/Deceased	p-value
Cut-off ≤ 1826 (n = 449)	419	30	<0.0001
Cut-off > 1826 (n = 151)	75	76	

An additional examination of patient outcomes based on this cutoff value is summarized in Table 5, which can be seen here. Thirty of the 449 patients who had NT-proBNP levels equal to or less than 1826 pg/ml were either admitted to the intensive care unit or passed away. This accounts for 6.7% of the total. In contrast, the rate in the group of 151 patients whose NT-proBNP levels were more than 1826 pg/ml increased dramatically to 76 cases, which accounts for 50.3% of the total. A statistically significant correlation was observed between these two factors, as shown by the coefficient of determination ($\chi^2(1, N=600) = 81.17, p < 0.00001$). In addition, patients whose NT-proBNP levels were more than 1826 pg/ml had an odds ratio of 5.44, which indicates that they were about 5.44 times more likely to need admission to the intensive care unit or to pass away.

4. DISCUSSION

A peptide hormone known as BNP is secreted into the bloodstream whenever the walls of the ventricles of the heart are subjected to stress. For diagnostic reasons, its physiologically inactive analog, NT-proBNP, has a longer half-life and is more stable than the previously mentioned substance. It has been shown in a number of studies that the levels of NT-proBNP increase in a variety of clinical illnesses that are not related to heart failure. These disorders include pneumonia, renal failure, pulmonary embolism, and cancer. Because of this, it has the potential to be an effective instrument for forecasting the progression of a broad variety of illnesses in the clinical setting.

NT-proBNP levels were found to be significantly lower in patients who were released from the hospital in stable condition compared to patients who were either moved to the intensive care unit (ICU) or passed away while they were in the hospital. Our research included a total of 600 individuals. The statistical significance of this link existed in both cardiac and non-cardiac patients, with a p-value of less than 0.001. This indicates that NT-proBNP may be used as a general prognostic marker, and not simply for the conventional indications associated with cardiovascular disease.

According to the findings of a major research conducted by Fonarow and colleagues, BNP levels at the time of admission

are a substantial predictor of mortality in the hospital for patients who are suffering from acute decompensated heart failure. This conclusion is consistent with the findings of that study. We also discovered that the cutoff value for our ROC curve analysis was more than 1826 pg/ml, and that it had a sensitivity of 73.89% and a specificity of 65.81%. This resulted in a probability ratio of 5.44 for inpatient care unit admission or death. These findings lend credence to the findings of other studies concerning the capability of NT-proBNP to forecast risk.

Only 6.7% of patients with NT-proBNP levels that were less than or equal to 1826 pg/ml were required to be transferred to the intensive care unit (ICU) or die, while 50.3% of patients with levels that were more than 1826 pg/ml were had to undergo one of these procedures. NT-proBNP is a powerful early warning biomarker that has the potential to influence the way patients are categorized and treated in internal medicine wards, as shown by the significant difference between the two.

In addition, our findings are consistent with those of Waldum et al., who discovered that NT-proBNP levels may accurately predict mortality in individuals suffering from heart failure whose kidneys are not functioning very well. Furthermore, Nowak et al. demonstrated that NT-proBNP had independent predictive value in the case of pneumonia, even when placed in comparison to conventional severity indices. The findings of these research lend credence to our findings, which are that high levels of NT-proBNP are not only produced by cardiac issues, but also by the severity of systemic illness and organ failure.

In addition, Idris and colleagues discovered that NT-proBNP had the ability to forecast death one year after an ischemic stroke in individuals who had experienced such a stroke. We also included individuals in our research who did not have any visible cardiac abnormalities, which demonstrates that the biomarker may be used in a broad variety of clinical settings when it is applied appropriately.

The research conducted by Benmachiche and colleagues, which discovered that patients with high levels of NT-proBNP, even those who did not have heart or lung illness, had greater mortality rates and longer hospital admissions, is comparable to the findings that we discovered. The capacity of NT-proBNP to predict death in intensive care units in patients with non-cardiac severe diseases was another point that Kotanidou et al. emphasized. Our work is distinct from theirs in that it examines NT-proBNP as a predictive tool beginning at the time of hospital admission in general care. This makes it more helpful for prevention than their study did.

It is also recognized that illnesses such as sepsis, acute and chronic kidney disease, chronic obstructive pulmonary disease (COPD), pulmonary embolism, and cancer may produce a rise in NT-proBNP levels. This can occur via processes such as increased strain on the heart, systemic inflammation, reduced renal clearance, or cardiotoxicity brought on by therapy. Due to the fact that our sample consisted of patients who suffered from various diseases, the findings we obtained were more relevant to a larger variety of individuals.

What sets our research apart from others is that it examines NT-proBNP in a varied group of individuals, which includes patients with cardiac and non-cardiac conditions, and it employs a threshold that is driven by data in order to forecast unpleasant outcomes. In particular, the use of NT-proBNP in routine prognostic processes is supported by this all-encompassing assessment. This is especially true in internal medicine departments, where it is extremely crucial to make prompt judgments on who to treat first.

Nevertheless, there are a few issues that need to be brought to your attention. The retrospective methodology of the research, the fact that it was conducted at a single location, and the relatively small sample size (n=600) make it difficult to generalize the findings to other contexts. Additionally, NT-proBNP levels may be influenced by external variables such as changes in treatment regimens or undetected cardiac issues that are also present.

Even taking into account these issues, the findings indicate that NT-proBNP has the potential to be an effective biomarker for early risk assessment, triage in intensive care units, and prognostic prediction. For the purpose of confirming the cutoff values and incorporating NT-proBNP into clinical decision-support algorithms and digital triage tools, we will need more prospective studies that include several centers in the future.

5. CONCLUSION

In conclusion, the findings of this research indicate that NT-proBNP levels are an extremely helpful prediction tool for determining how well patients would fare in the hospital, regardless of whether or not they have cardiac issues. There was a clear correlation between high levels of NT-proBNP and negative outcomes, such as being hospitalized to the intensive care unit and passing away outside of the hospital. With a sensitivity of 73.89% and a specificity of 65.81%, the cutoff value of >1826 pg/ml demonstrated a high level of predictive accuracy. That patients who were over this threshold had about 5.44 times the likelihood of having negative outcomes is what this indicates. This link was shown to be valid for individuals who had pre-existing cardiac issues as well as those who did not have such illnesses, which demonstrates that the biomarker may be used in a broad variety of therapeutic situations. The findings of this study provide credence to the use of NT-proBNP in early risk stratification strategies, particularly in internal medicine departments, where prompt choices on patient monitoring and resource allocation are of utmost importance. A more widespread use in clinical settings might be of assistance in the

process of patient triage, the direction of treatment choices, and the enhancement of overall prognostic evaluation across a variety of patient groups.

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