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Clinical Correlation of NT-proBNP Serum Levels with Echocardiographic Features in Patients Admitted with Heart Failure at a Tertiary Care Hospital

Dr. Youraj Annasaheb Kokate[1], Dr. V. K. Joglekar[2]

[1]Assistant Professor, Department of General Medicine, Grant Medical College and Sir JJ Group of Hospitals. Mumbai, Maharashtra, India.
[2]Professor, Department of General Medicine, Grant Medical College and Sir JJ Group of Hospitals. Mumbai, Maharashtra, India.

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Corresponding Author: Dr Youraj Annasaheb Kokate, Assistant Professor, Department of General Medicine, Grant Medical college and Sir JJ Group of Hospitals. Mumbai, Maharashtra, India.
Email: dr.kokate2010@gmail.com

ABSTRACT

Background: Heart failure (HF) is a major public health problem associated with significant morbidity and mortality worldwide. Accurate diagnosis and assessment of severity remain challenging due to heterogeneous clinical presentations. N-terminal pro–B-type natriuretic peptide (NT-proBNP), released in response to myocardial wall stress, has emerged as a reliable biomarker for the diagnosis and prognostication of heart failure. Echocardiography remains the cornerstone for structural and functional cardiac assessment. **Objectives:** To evaluate serum NT-proBNP levels in patients admitted with heart failure and to correlate these levels with echocardiographic parameters, including left ventricular systolic and diastolic function. **Materials and Methods:** This prospective observational study was conducted at Grant medical college and Sir JJ Group of Hospitals from 1 January 2009 to 30 June 2010. A total of 200 patients admitted at department of General Medicine, Grant Medical college and Sir JJ Group of Hospitals, Mumbai, Maharashtra with clinically diagnosed heart failure were enrolled. A standardised immunoassay was used to quantify serum NT- proBNP levels upon admission. Every patient had a thorough transthoracic echocardiogram. NT-proBNP levels were correlated with echocardiographic measures, including pulmonary artery systolic pressure, diastolic dysfunction grades, left ventricular dimensions, and left ventricular ejection fraction (LVEF). **Results:** Serum NT-proBNP levels were significantly elevated in patients with reduced LVEF and diastolic dysfunction. An inverse correlation was observed between NT-proBNP levels and LVEF, while a positive correlation was noted with left ventricular end-diastolic dimension and pulmonary artery systolic pressure. Higher NT-proBNP concentrations were associated with advanced New York Heart Association (NYHA) functional class. **Conclusion:** Echocardiographic markers of cardiac dysfunction are strongly correlated with NT-proBNP levels. In patients with heart failure, the combination of echocardiography with NT-proBNP measurement improves diagnostic precision and offers important insights into the severity of the condition.

Keywords: Heart failure, NT-proBNP, Echocardiography, Left ventricular ejection fraction, Diastolic dysfunction

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INTRODUCTION

Heart failure represents the terminal pathway of various cardiovascular diseases and continues to be a leading cause of hospitalization and mortality worldwide. Due to ageing population, increased Incidence of hypertension, diabetes mellitus, and ischaemic heart disease, the burden of heart failure is rising, especially in emerging nations like India [1]. Heart failure is still linked to a poor prognosis and frequent readmissions to the hospital, despite advancements in pharmaceutical and device-based therapy.

Tachycardia, tachypnea, desaturation, edema and Fluid retention are common signs of a Heart failure which is a complicated disease caused by anatomical or functional cardiac defects that affect the heart's capacity to effectively fill or expel blood [2]. Because these manifestations are ambiguous and may overlap with other cardiovascular disorders, a clinical diagnosis based just on symptoms and signs is sometimes incorrect. Therefore, precise diagnosis, risk assessment, and treatment decision-making depend on objective diagnostic instruments.

For a long time, echocardiography has been considered the primary test used to assess heart failure. It offers thorough data on pulmonary pressures, valvular anomalies, systolic and diastolic function, and heart anatomy [3]. In order to classify heart failure into systolic and diastolic dysfunction, which has therapeutic and prognosis consequences, left ventricular ejection fraction (LVEF) measurement is very crucial. However, echocardiography is operator- dependent and might not always be accessible right once, particularly in environments with restricted resources.

Cardiac biomarkers have become more well-known in recent years as supplemental instruments for heart failure diagnosis and treatment. Among them, a lot of research has been done on B-type natriuretic peptide (BNP) and its inactive cleavage product, N-terminal pro–B- type natriuretic peptide (NT-proBNP). In response to increasing wall stress, volume overload, and pressure overload, the ventricular myocardium is primarily responsible for the synthesis and release of these peptides [4]. NT-proBNP is a dependable marker for clinical application since it has a longer half-life and more plasma stability than BNP.

Numerous studies have shown that NT-proBNP is useful for predicting outcomes including hospitalisation and death, evaluating the severity of heart failure, and distinguishing between cardiac and non-cardiac causes of dyspnoea [5]. Increased ventricular filling pressures and increasing myocardial dysfunction are associated with elevated NT-proBNP levels. Moreover, it has been demonstrated that NT-proBNP levels represent both diastolic and systolic dysfunction, providing a comprehensive evaluation of heart function.

There has been a lot of scientific interest in the connection between NT-proBNP levels and echocardiographic parameters. NT-proBNP and LVEF have been found to be inversely correlated in earlier research, and there are also strong correlations with left ventricular dimensions, left atrial size, and pulmonary artery pressures[6]. However, region-specific data is required due to differences in patient demographics, comorbidities, and methodology, especially from Indian tertiary care settings where patient profiles may vary.

Limited Indian data assessing the relationship between NT-proBNP and comprehensive echocardiographic findings in hospitalised heart failure patients were available during the 2009–2010 research period. Optimising diagnostic techniques requires an understanding of this link, particularly in emergency and inpatient settings when quick decision-making is critical. Thus, the goal of the current investigation was to measure serum NT-proBNP levels in heart failure patients who were hospitalised and to link these levels with echocardiographic characteristics. This study intends to support the complimentary function of biochemical and imaging modalities in the thorough assessment of heart failure by demonstrating the clinical significance of NT-proBNP in relation to echocardiographic parameters.

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MATERIALS AND METHODS

Study Design

This was a **prospective observational study** conducted in patients admitted with heart failure at department of General Medicine, Grant Medical college and Sir JJ Group of Hospitals, Mumbai, Maharashtra.

Study Period

The study was carried out over a period of 18 months, from 1 January 2009 to 30 June 2010.

Study Population

A total of 200 consecutive patients admitted with a clinical diagnosis of heart failure were included in the study.

Inclusion Criteria

- Patients aged ≥ 18 years
- Patients admitted with symptoms and signs suggestive of heart failure
- Diagnosis of heart failure based on clinical evaluation supported by radiological, electrocardiographic, and transthoracic echocardiographic findings

Exclusion Criteria

- Acute coronary syndrome at presentation
- Severe renal failure (serum creatinine >2.5 mg/dL)
- Chronic liver disease
- Pulmonary embolism
- Sepsis or severe systemic infection

Clinical Evaluation

All patients underwent detailed clinical assessment including history, physical examination, and functional classisinsification according to the New York Heart Association (NYHA) criteria. **Laboratory Investigations**

Venous blood samples were collected at the time of admission. Serum NT-proBNP levels were measured using a standardized electrochemiluminescence immunoassay. Routine investigations including complete blood count, renal function tests, serum electrolytes, and chest radiography were performed.

Echocardiographic Assessment

Transthoracic echocardiography was performed using a standard ultrasound machine by an experienced cardiologist. Parameters assessed included:

- Left ventricular ejection fraction (LVEF)
- Left ventricular end-diastolic and end-systolic dimensions
- Diastolic function grading using Doppler indices
- Left atrial size
- Pulmonary artery systolic pressure

Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation. Correlation between NT-proBNP levels and echocardiographic parameters was assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 200)

Variable	Number (n)	Percentage (%)
Age (years)		
≤ 50	38	19.0

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51–60	56	28.0
61–70	72	36.0
> 70	34	17.0
Gender		
Male	128	64.0
Female	72	36.0
NYHA Functional Class		
Class II	42	21.0
Class III	98	49.0
Class IV	60	30.0

The clinical severity and demographic characteristics of the 200 heart failure patients that were hospitalised are included in Table 1. The bulk of patients were older, with 36% falling into the 61–70 age range and 28% falling into the 51–60 age range. Compared to women (36%), men made up a larger percentage of the study population (64%). The majority of patients had advanced illness, with 49% in NYHA class III and 30% in class IV, suggesting moderate to severe impairment of physical activity at the time of admission, according to an evaluation of functional status using the New York Heart Association (NYHA) classification.

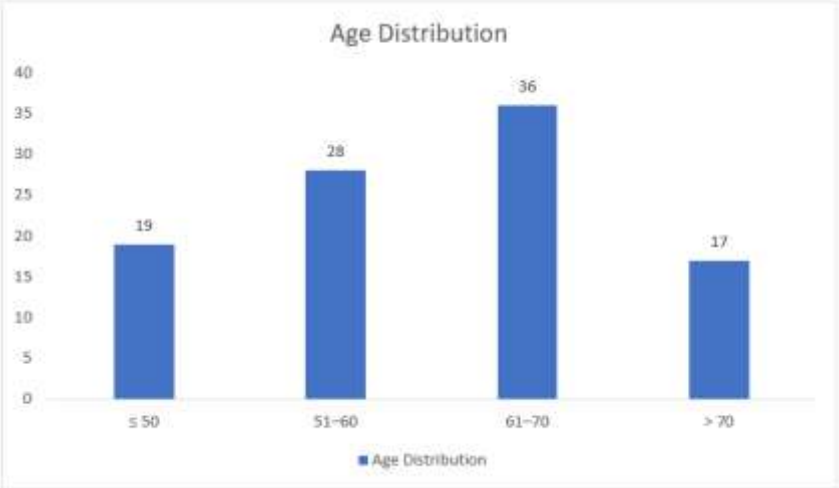

Figure 1: Age Distribution

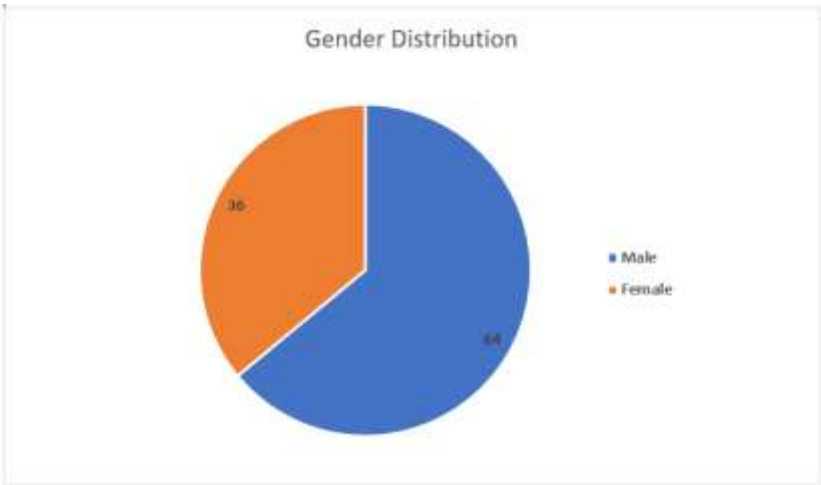

Figure 2: Gender Distribution

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Table 2: Mean NT-proBNP Levels According to NYHA Functional Class

NYHA Class	Mean NT-proBNP (pg/mL) ± SD	P value
Class II	1,480 ± 520	
Class III	3,860 ± 1,140	
Class IV	7,920 ± 2,180	
Overall comparison	—	**< 0.001***

The association between serum NT-proBNP levels and NYHA functional class is seen in Table 2. As the NYHA class worsened, there was a gradual and statistically significant rise in mean NT-proBNP levels. NT-proBNP levels were significantly higher in patients in NYHA classes III and IV than in those in class II. The robust correlation between NT-proBNP concentrations and clinical severity of heart failure was demonstrated by the extremely significant ($p < 0.001$) difference across NYHA classes.

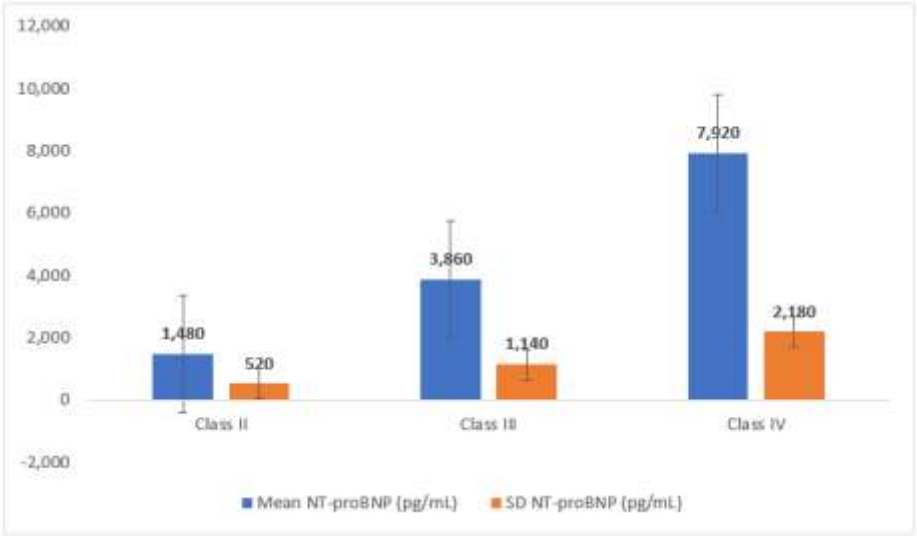

Figure 2: Mean NT-proBNP Levels According to NYHA Functional Class

Table 3: Correlation Between NT-proBNP Levels and Left Ventricular Ejection Fraction (LVEF)

LVEF Category	Number of Patients	Mean NT-proBNP (pg/mL) ± SD	P value
≥ 50% (Preserved)	48	1,620 ± 610	
40–49% (Mildly reduced)	54	3,210 ± 980	
30–39% (Moderately reduced)	56	5,480 ± 1,620	
< 30% (Severely reduced)	42	8,240 ± 2,360	
Overall comparison	—	—	**< 0.001***

The relationship between NT-proBNP levels and left ventricular systolic function as measured by ejection fraction is shown in Table 3. The lowest mean NT-proBNP levels were seen in patients with intact ejection fraction (≥50%), whereas patients with mild, moderate, and systolic dysfunction showed progressively increasing values. Patients with LVEF <30% had

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the highest NT-proBNP values. There was a statistically significant ($p < 0.001$) inverse association between LVEF and NT-proBNP levels, suggesting that myocardial function deteriorates when NT-proBNP levels rise.

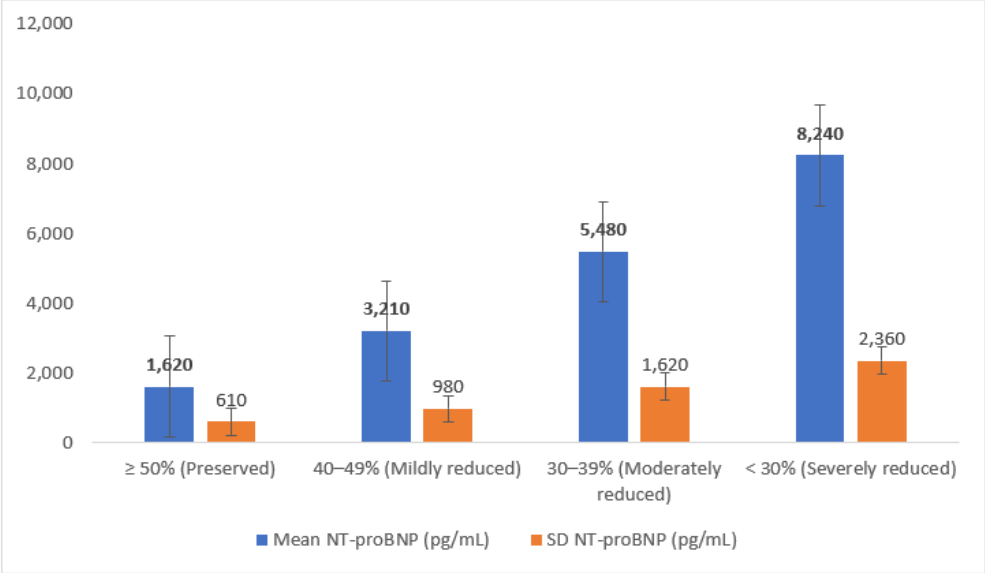

Figure 3: Correlation Between NT-proBNP Levels and Left Ventricular Ejection Fraction (LVEF)

Table 4: NT-proBNP Levels According to Left Ventricular Diastolic Dysfunction

Diastolic Dysfunction Grade	Number of Patients (n)	Mean NT-proBNP (pg/mL) ± SD	P value
Normal	22	1,240 ± 420	
Grade I	46	2,180 ± 760	
Grade II	68	4,920 ± 1,430	
Grade III	54	7,360 ± 2,010	
Grade IV	10	9,820 ± 2,540	
Overall comparison	—	—	**< 0.001***

Table 4 illustrates the distribution of serum NT-proBNP levels across different grades of left ventricular diastolic dysfunction. Patients with normal diastolic function demonstrated the lowest mean NT-proBNP levels (1,240 ± 420 pg/mL). A progressive and marked increase in NT-proBNP concentrations was observed with worsening grades of diastolic dysfunction. Mean NT-proBNP levels rose to 2,180 ± 760 pg/mL in Grade I dysfunction and increased substantially in Grade II (4,920 ± 1,430 pg/mL) and Grade III (7,360 ± 2,010 pg/mL). The highest NT-proBNP levels were noted in patients with Grade IV diastolic dysfunction (9,820 ± 2,540 pg/mL). Overall comparison revealed a statistically significant difference in NT-

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proBNP levels across the various grades of diastolic dysfunction ($p < 0.001$), indicating a strong positive association between increasing severity of diastolic dysfunction and elevated NT-proBNP levels.

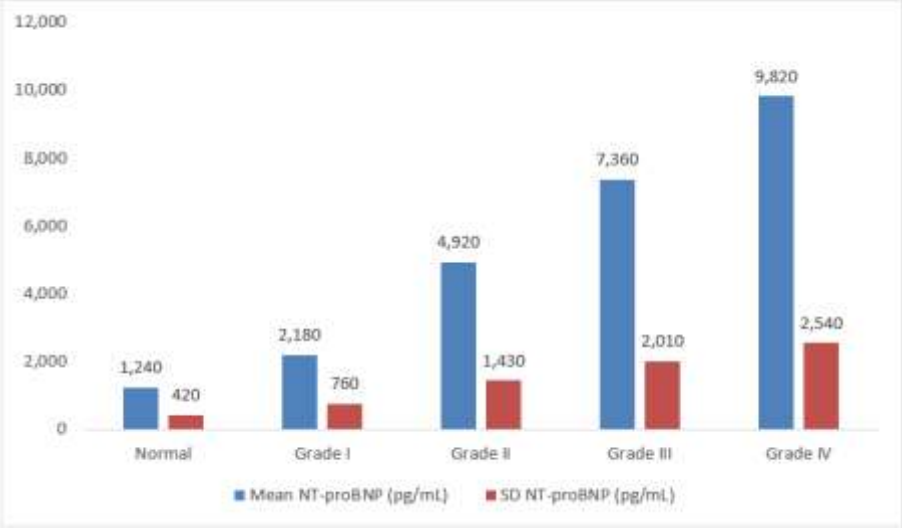

Figure 4: NT-proBNP Levels and Left Ventricular Diastolic Dysfunction

Table 5: Correlation of NT-proBNP with Selected Echocardiographic Parameters

Echocardiographic Parameter	**Correlation Coefficient (r)**	**P value**
LVEF (%)	–0.72	**< 0.001***
LV End-Diastolic Dimension (mm)	+0.64	**< 0.001***
Left Atrial Diameter (mm)	+0.58	**< 0.001***
Pulmonary Artery Systolic Pressure (mmHg)	+0.61	**< 0.001***

Table 5 shows the correlation between serum NT-proBNP levels and key echocardiographic parameters. NT-proBNP levels demonstrated a strong negative correlation with left ventricular ejection fraction, indicating higher peptide levels with reduced systolic function. Significant positive correlations were observed with left ventricular end-diastolic dimension, left atrial diameter, and pulmonary artery systolic pressure. All correlations were statistically significant ($p < 0.001$), reinforcing the role of NT-proBNP as a biochemical marker reflecting both structural and functional cardiac abnormalities.

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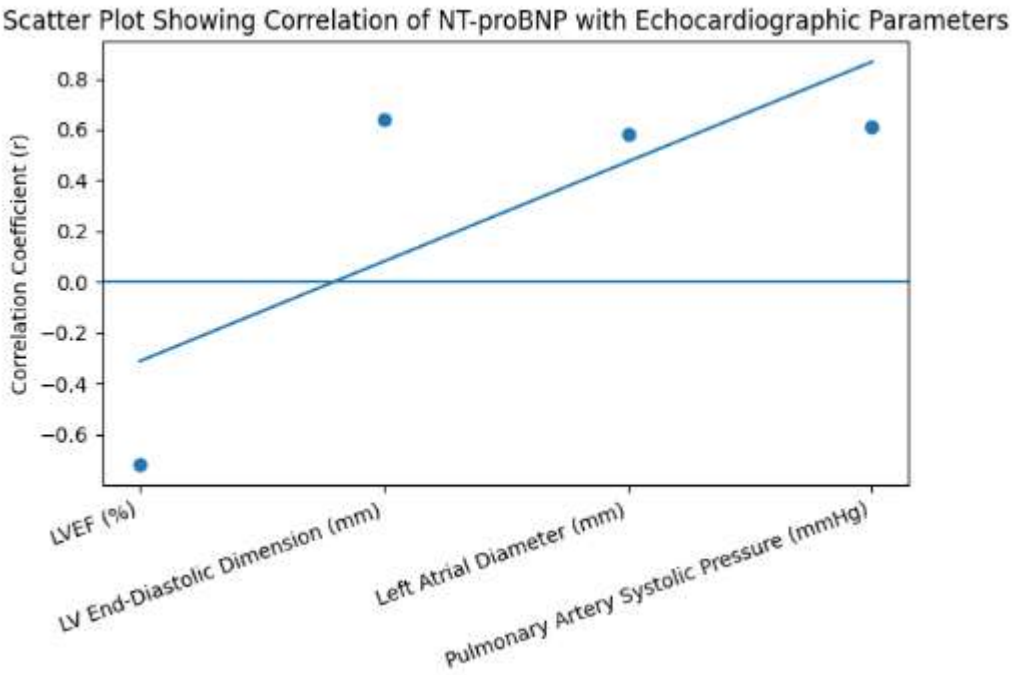

Figure 5: Correlation of NT-proBNP with Selected Echocardiographic Parameters

DISCUSSION

Heart failure remains a major cause of hospitalization and mortality, particularly among elderly populations, and poses significant diagnostic and prognostic challenges. In patients referred to a tertiary care hospital with heart failure, the current study assessed the clinical value of serum NT-proBNP levels and their association with echocardiographic parameters. The results show a substantial correlation between both systolic and diastolic echocardiographic abnormalities, clinical severity, and NT-proBNP concentrations. Nearly two-thirds of the patients in this group were older than 60, and there was a noticeable male predominance. This demographic pattern is in line with earlier epidemiological research that found that the incidence of heart failure increased with age and was greater in men, mostly due to the higher prevalence of ischaemic heart disease and hypertension in this population Jessup M *et al.*[7]. Additionally, the majority of patients had severe heart failure when they first arrived, with about 80% falling into NYHA functional classes III or IV. This is consistent with trends of delayed presentation and referral that are frequently documented in poor nations, such as India Kannel WB *et al.*[8].

The substantial increase in NT-proBNP levels with declining NYHA functional class is one of the study's main conclusions. NT-proBNP levels were significantly higher in NYHA class IV patients than in class II and III patients. This validates NT-proBNP's function as a trustworthy biochemical indicator of heart failure symptom severity and haemodynamic load. Maisel AS *et al.* and Richards AM *et al.* published similar findings, showing a strong correlation between natriuretic peptide levels and prognosis and functional class in patients with heart failure [9,10]. As symptoms deteriorate, NT-proBNP levels gradually rise, which is probably due to increased myocardial wall stress, neurohormonal activation, and ventricular remodelling.

NT-proBNP's significance as a diagnostic of systolic dysfunction is further supported by the negative association between its levels and left ventricular ejection fraction. NT-proBNP levels were considerably higher in patients with systolic dysfunction (LVEF <30%) than in those with intact ejection fraction. This study's significant negative correlation coefficient is in line with other findings that show NT-proBNP levels rise exponentially as left ventricular

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systolic function declines Cowie MR *et al.* [11]. These results demonstrate the usefulness of NT-proBNP as a stand-in marker of left ventricular contractile dysfunction, especially in situations when echocardiography might not be readily available.

Crucially, this study also showed a strong correlation between the degree of diastolic dysfunction and NT-proBNP levels. NT-proBNP concentrations were shown to rise gradually from normal diastolic function to grade IV diastolic dysfunction. Given that diastolic heart failure accounts for a significant percentage of heart failure cases, particularly in older patients and those with hypertension or diabetes mellitus, this discovery is clinically significant Zile MR *et al.*[12]. Even in the context of maintained systolic function, prior research has demonstrated that greater ventricular filling pressures and poor relaxation contribute to increased myocardial strain, which enhances the release of natriuretic peptides Lubien E *et al.* [13]. As a result, NT-proBNP is a helpful biomarker for both diastolic and systolic heart failure.

NT-proBNP's significance as a diagnostic of systemic cardiac dysfunction is further highlighted by the correlations found between its levels and other echocardiographic measures. Both left atrial enlargement and left ventricular end-diastolic dimension showed significant positive relationships, indicating chronic volume overload and structural remodelling. Increased natriuretic peptide production is a result of both higher filling pressures and persistent diastolic dysfunction, both of which are known to be indicated by left atrial enlargement Tsang TS *et al.* [14]. Furthermore, a link with secondary pulmonary hypertension, a frequent consequence of severe left-sided heart failure, is suggested by the positive correlation between NT-proBNP levels and pulmonary artery systolic pressure.

When considered collectively, these results lend credence to the idea that NT-proBNP incorporates data on cardiac function, chamber remodelling, and haemodynamic stress. When NT-proBNP levels and echocardiographic parameters are evaluated together, the assessment of heart failure severity is more thorough than when each modality is used alone. NT-proBNP estimate may be a useful supplement for risk classification in areas with limited resources, indicating the necessity for prompt echocardiographic evaluation and rapid treatment. The study's findings are in accordance with significant worldwide studies and pre-2010 guidelines that acknowledged natriuretic peptides as crucial instruments for the diagnosis and treatment of heart failure Dickstein K *et al.* [15]. However, by showing these relationships in a real-world tertiary-care population, the current study contributes to the scant Indian data.

The study has certain shortcomings despite its advantages. The results of this single-center observational research might not apply to other groups. Long-term outcome data and serial NT- proBNP readings, which would have offered more prognostic information, were not evaluated. However, the significant associations found highlight the clinical significance of NT-proBNP in patients with heart failure who are admitted to hospitals. This study concludes by showing a substantial correlation between serum NT-proBNP levels and echocardiographic indicators of cardiac remodelling, left ventricular systolic and diastolic dysfunction, and clinical severity. NT-proBNP is a useful and trustworthy biomarker that supports echocardiography in the thorough assessment of heart failure patients.

CONCLUSION

The current investigation shows that in patients with heart failure admitted at department of General Medicine, Grant Medical college and Sir JJ Group of Hospitals, Mumbai, serum NT-proBNP levels exhibit a high and clinically significant connection with both clinical severity and echocardiographic parameters. The usefulness of NT-proBNP as an objective biomarker representing symptom load and disease severity was demonstrated by the substantial rise in NT-proBNP concentrations with increasing NYHA functional class. NT-proBNP levels and left ventricular ejection fraction were shown to be significantly inversely correlated,

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supporting its use in diagnosing and classifying systolic dysfunction. Additionally, NT-proBNP levels showed a stepwise increase with increasing diastolic dysfunction severity and significant positive correlations with pulmonary artery systolic pressure, left ventricular dimensions, and left atrial size, suggesting its association with elevated filling pressures and structural cardiac remodelling.

These results highlight the usefulness of NT-proBNP as a trustworthy biochemical marker that enhances echocardiographic evaluation in the thorough assessment of patients with heart failure. Particularly in acute care settings, the combination of NT-proBNP measurement with echocardiography might improve diagnostic precision, enable early risk classification, and direct clinical decision-making. NT-proBNP testing may be a useful technique to prioritise patients for echocardiographic examination and optimise care options in settings with limited resources. All things considered, NT-proBNP is a useful tool for diagnosing and evaluating the severity of heart failure, and it ought to be included in regular clinical evaluations whenever possible.

LIMITATIONS OF THE STUDY

1. **Single-center design:** The study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to other healthcare settings or populations.
2. **Observational nature:** As an observational study, causal relationships between NT-proBNP levels and echocardiographic parameters could not be established.
3. **Lack of follow-up data:** Serial measurements of NT-proBNP and long-term clinical outcomes such as mortality, rehospitalization, and response to therapy were not assessed.
4. **Potential confounders:** Factors known to influence NT-proBNP levels, such as renal dysfunction, age, obesity, and atrial fibrillation, may have affected results despite exclusion criteria.
5. **Operator dependence of echocardiography:** Variability in echocardiographic measurements due to operator expertise could have influenced parameter assessment.
6. **Absence of control group:** The study did not include a healthy control group or patients with non-cardiac dyspnea for comparison.
7. **Limited biochemical profiling:** Other biomarkers relevant to heart failure severity and prognosis were not evaluated.

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