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Original Research Article

Role of Brain Natriuretic Peptide in Heart Failure

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Abstract:

Background: Heart failure is a major global health problem associated with high morbidity, mortality, and healthcare costs. Early and accurate diagnosis remains challenging because symptoms such as dyspnea may also occur in various non-cardiac conditions. Brain Natriuretic Peptide (BNP), a cardiac neurohormone released in response to ventricular pressure and volume overload, has emerged as an important biomarker for the diagnosis and assessment of heart failure severity.

Aim: To evaluate the role of Brain Natriuretic Peptide (BNP) in the diagnosis and severity assessment of heart failure.

Methodology: This hospital-based observational study was conducted in the Department of Biochemistry at Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Bihar, over a period of seven months. A total of 80 patients aged ≥18 years with clinical features suggestive of heart failure were included. Venous blood samples were collected and serum BNP levels were measured using an immunoassay method. Clinical data and NYHA functional classification were recorded, and statistical analysis was performed using SPSS version 27.0.

Results: Most patients belonged to the 41–50 years age group (25%) and were predominantly male (60%). The majority of patients were classified as NYHA Class III (37.5%). BNP levels were elevated in most participants, with 32.5% having levels between 100–400 pg/mL. Mean BNP levels increased progressively with NYHA class, from 110.45 pg/mL in Class I to 925.37 pg/mL in Class IV.

Conclusion: BNP levels show a strong positive association with the severity of heart failure and can serve as a useful biomarker for diagnosis and clinical assessment.

Keywords: Brain Natriuretic Peptide, Heart Failure, Biomarker, NYHA Classification, Dyspnea.

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Introduction

Heart failure has developed into a worldwide public health crisis which stands as one of the primary causes of both sickness and death from heart-related medical conditions according to [1]. The healthcare system faces increased challenges because heart failure rates rise together with the growing elderly population and the better treatment outcomes for other heart diseases. There are approximately five million Americans who currently experience congestive heart failure while the medical field identifies about 500000 new cases each year. Between 0.4 percent and 2.0 percent of Europeans who have heart failure show visible symptoms of the condition. The financial effects of heart failure create a major burden for healthcare systems which spend between $10 billion and $38 billion each year to treat patients [2]. The Health Care Financing Administration (which today operates as the Centers for Medicare and Medicaid Services) designated heart failure as a medical condition which needs both effective treatment and economical management solutions because of its expensive treatment costs and rising disease prevalence. The complete healthcare system expenses which relate to this condition require both precise diagnosis and appropriate medical care.

The medical field faces a significant obstacle when doctors try to quickly determine whether heart failure patients have congestive heart failure or different medical conditions that cause breathing difficulties. The symptom of dyspnea ranks as the primary reason which patients enter emergency rooms and urgent care facilities for medical help [3]. The symptom occurs in heart failure patients but also appears in various pulmonary and non-cardiac medical conditions. Emergency department staff face challenges when they attempt to establish heart failure diagnoses. Doctors need to use both clinical symptoms and physical examination results to reach a conclusive

diagnosis which often proves unworkable because these methods lack sufficient power to identify particular medical conditions. Doctors experience diagnostic uncertainty when patients show symptoms of breathing difficulties together with related medical conditions.

Although echocardiography is widely regarded as the gold standard for detecting left ventricular dysfunction, it has several practical limitations in routine clinical practice [4]. The procedure requires special equipment and specially trained personnel which makes it an expensive process that emergency departments cannot always provide. In addition, echocardiography may not always reflect the acute hemodynamic status of the patient at the time of presentation. The existing limitations of current diagnostic methods create a requirement for clinicians to have access to straightforward and quick and dependable tools which will help them diagnose heart failure during emergency medical situations.

Misdiagnosis of congestive heart failure can have serious clinical consequences [5]. The wrong diagnosis of the medical condition that causes dyspnea leads to dangerous treatment methods which result in harm to patients. The use of heart failure treatments will create negative effects for patients who have different medical conditions which show the same symptoms as heart failure. Chronic obstructive pulmonary disease (COPD) is one such condition that can closely mimic the clinical presentation of heart failure, particularly in terms of breathlessness and fatigue [6]. The process of identifying the root cause of dyspnea requires medical professionals to differentiate between cardiac and non-cardiac origins because this knowledge helps them choose suitable treatments which benefit patient results.

The investigation of biochemical markers as diagnostic and treatment tools for cardiovascular diseases has received growing interest during the past few years. B-type natriuretic peptide has become a critical cardiac dysfunction biomarker which medical professionals use to assess patient heart health [7]. BNP functions as a cardiac neurohormone which the ventricular myocardium releases into the bloodstream when its two ventricles experience both volume expansion and pressure overload. BNP functions in the body by promoting natriuresis and diuresis and vasodilation which help maintain blood pressure and fluid homeostasis in the body. Heart failure patients experience significant increases in BNP levels because the protein releases into the bloodstream whenever their ventricles endure stress.

Multiple research studies have shown that patients who experience left ventricular dysfunction show increased levels of BNP in their blood. The study results demonstrate that BNP levels in patients with heart failure show a strong relationship with the degree of heart failure experienced by patients according to the New York Heart Association (NYHA) functional classification system. Patients who experience advanced stages of heart failure show increased levels of BNP which leads to worse health results. BNP functions as a reflection of cardiac dysfunction severity while it also serves as a vital prognostic indicator. Elevated BNP levels have been linked to increased risk of hospitalization, disease progression, and mortality among patients with heart failure [8]. The study results indicate that BNP measurement will serve as an essential tool for both diagnosing and assessing patient risk throughout their heart failure management.

Researchers have studied BNP to determine its ability to predict future medical outcomes which extends beyond its basic predictive capacity. The previous study used a radioimmunoassay to detect BNP which showed that this peptide measurement could differentiate heart failure-related dyspnea from respiratory and other non-cardiac conditions. The emergency room situation benefits from this ability because medical professionals need to make quick treatment decisions. The exact cause of dyspnea needs to be identified by doctors because this knowledge allows them to select proper treatments while avoiding unnecessary harmful procedures.

The clinical value of BNP testing has increased because diagnostic technology improvements have created better testing methods. The recent pilot study showed that a rapid whole-blood assay which delivers results in fifteen minutes showed that BNP tests at the bedside enhanced doctors' capability to identify congestive heart failure in emergency medical departments. The presence of rapid diagnostic tests provides multiple benefits which include quicker medical decisions and better patient assessment and optimized healthcare resource allocation. The use of point-of-care BNP testing enables doctors to avoid ordering expensive tests which take a long time to complete thus making heart failure treatment more affordable.

The increasing use of BNP as a diagnostic tool and prognostic marker requires additional studies to confirm its clinical value across different patient groups. The actual clinical performance of BNP testing needs to be evaluated through extensive research which compares test results from actual healthcare environments. The seven-center multinational trial used BNP measurements to assess their diagnostic value for congestive heart failure in patients who experience difficulty breathing. The study results demonstrate how BNP testing functions in practical medical situations while showing its potential to become standard practice within healthcare facilities.

The research work examines how Brain Natriuretic Peptide functions in heart failure cases. The study evaluates BNP levels in patients who show symptoms of heart failure to determine its effectiveness

as a diagnostic biomarker and its ability to assist doctors in making better clinical decisions for patients with suspected heart problems.

Methodology

Study Design: The present study was designed as a hospital-based observational study aimed at evaluating the role of Brain Natriuretic Peptide (BNP) in patients diagnosed with heart failure. The study focused on assessing the serum levels of BNP among patients presenting with symptoms suggestive of heart failure and determining its clinical relevance in diagnosis and evaluation of disease severity.

Study Area: The study was conducted in the Department of Biochemistry, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar, India.

Study Duration: The duration of the study was 7 months from March 2025 to September 2025.

Study Participants

Inclusion Criteria

The following patients were included in the study:

- Patients aged 18 years and above.
- Patients presenting with clinical symptoms suggestive of heart failure, such as shortness of breath, fatigue, or edema.
- Patients diagnosed with heart failure based on clinical evaluation and supporting investigations.
- Patients who provided informed consent to participate in the study.

Exclusion Criteria

The following patients were excluded from the study:

- Patients below 18 years of age.
- Patients with acute myocardial infarction at the time of presentation.
- Patients with severe renal failure, as it may alter BNP levels.
- Patients with trauma, cardiac tamponade, or other non-cardiac causes of dyspnea.
- Patients who refused to give consent for participation in the study.

Sample Size: A total of 80 patients fulfilling the inclusion criteria were enrolled in the study. The sample size was selected based on the availability of eligible patients during the study period and feasibility of conducting laboratory investigations within the specified duration.

Procedure: Informed consent from the participants, eligible patients presenting with symptoms suggestive of heart failure were included in the study. A detailed clinical history was obtained from each participant, including demographic information, presenting complaints, past medical history, and relevant risk factors such as hypertension, diabetes mellitus, and previous cardiovascular disease. Clinical examination findings were also recorded.

Following the initial clinical evaluation, blood samples were collected from each participant under aseptic conditions. Approximately 3–5 ml of venous blood was drawn and transferred into tubes containing appropriate anticoagulant. The samples were then transported to the biochemistry laboratory for analysis. Serum or plasma was separated by centrifugation and used for the measurement of Brain Natriuretic Peptide (BNP) levels. BNP levels were measured using an immunoassay-based method designed for the quantitative determination of BNP in blood samples. The assay was performed according to the manufacturer's instructions to ensure accuracy and reliability of the results. Quality control procedures were followed during laboratory analysis to maintain the validity of the measurements.

In addition to BNP estimation, relevant clinical and diagnostic information such as electrocardiography, chest radiography, and echocardiography findings were reviewed wherever available. These investigations helped in confirming the diagnosis of heart failure and assessing its severity. The clinical diagnosis made by physicians was considered along with laboratory findings for final interpretation. All collected data, including demographic details, clinical features, and laboratory parameters, were recorded in a structured data collection form. The information was carefully reviewed to ensure completeness and accuracy before being entered into the database for statistical analysis.

Statistical Analysis: The collected data were compiled and analyzed using Statistical Package for Social Sciences (SPSS) version 27.0. Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize demographic and clinical characteristics of the participants. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as numbers and percentages. Comparative statistical tests were applied wherever required to evaluate the association between BNP levels and clinical parameters related to heart failure. A p-value of less than 0.05 was considered statistically significant. The results were presented in the form of tables and graphs to facilitate clear interpretation and discussion of the findings.

Result

Table 1 shows the distribution of study participants according to different age groups. Out of the total 80 patients included in the study, the highest proportion belonged to the 41–50 years age group with 20 patients (25%). This was followed by the 51–60 years and >60 years age groups, each comprising 18 patients (22.5%). The 31–40 years age group ac-

counted for 14 patients (17.5%), while the lowest proportion was observed in the 18–30 years age group with 10 patients (12.5%). These findings indicate that the majority of the study participants were in the middle-aged and older age groups, suggesting that the condition under study was more commonly observed among individuals above 40 years of age.

Table 1: Distribution of Study Participants According to Age Group		
Age Group (Years)	**Number of Patients (n)**	**Percentage (%)**
18–30	10	12.5
31–40	14	17.5
41–50	20	25
51–60	18	22.5
>60	18	22.5
Total	**80**	**100**

Table 2 shows the distribution of study participants according to gender. Out of the total 80 patients included in the study, the majority were male, accounting for 48 patients (60%), while females comprised 32 patients (40%). This indicates that male participants were more predominant in the study population compared to female participants. The difference in gender distribution suggests that the condition under investigation was observed more frequently among males than females within the selected sample. Overall, the study sample demonstrates a higher representation of male patients, while female patients constituted a comparatively smaller proportion of the total participants.

Table 2: Distribution of Study Participants According to Gender		
Gender	**Number of Patients (n)**	**Percentage (%)**
Male	48	60
Female	32	40
Total	**80**	**100**

Table 3 shows the distribution of patients according to the New York Heart Association (NYHA) functional classification. Out of the total 80 patients included in the study, the majority belonged to Class III, comprising 30 patients (37.5%), indicating that most participants had marked limitation of physical activity due to heart failure symptoms. This was followed by Class II with 22 patients (27.5%), suggesting a moderate level of functional limitation. Class IV, which represents patients with severe symptoms even at rest, accounted for 20 patients (25%). In contrast, the smallest proportion of patients was observed in Class I with only 8 patients (10%), indicating that a limited number of participants had no significant limitation of physical activity. Overall, the findings demonstrate that a larger proportion of patients in the study were in the advanced functional classes (Class III and IV), reflecting a higher burden of symptomatic heart failure among the study population.

Table 3: Distribution of Patients According to NYHA Functional Class		
NYHA Class	**Number of Patients (n)**	**Percentage (%)**
Class I	8	10
Class II	22	27.5
Class III	30	37.5
Class IV	20	25
Total	**80**	**100**

Table 4 shows the distribution of patients according to serum BNP levels. Out of the total 80 patients included in the study, the highest proportion of patients belonged to the BNP level range of 100–400 pg/mL, accounting for 26 patients (32.5%). This was followed by the 401–800 pg/mL category with 24 patients (30%). Patients with BNP levels greater than 800 pg/mL comprised 20 cases (25%), indicating a considerable proportion with markedly elevated BNP levels. The least number of patients were observed in the BNP level group of less than 100 pg/mL, with 10 patients (12.5%). Overall, the findings indicate that the majority of patients had moderately to highly elevated serum BNP levels.

Table 4: Distribution of Patients According to Serum BNP Levels		
BNP Level (pg/mL)	**Number of Patients (n)**	**Percentage (%)**
<100	10	12.5
100–400	26	32.5
401–800	24	30
>800	20	25
Total	**80**	**100**

Table 5 shows the comparison of mean Brain Natriuretic Peptide (BNP) levels according to the New York Heart Association (NYHA) functional classification among the study participants. A total of 8 patients belonged to NYHA Class I, with a mean BNP level of 110.45 pg/mL and a standard deviation of 35.62, indicating relatively lower BNP levels in patients with mild symptoms. In NYHA Class II, which included 22 patients, the mean BNP level increased to 285.73 pg/mL with a standard deviation of 90.14. A further rise in BNP levels was observed in NYHA Class III patients (n = 30), where the mean BNP level reached 612.58 pg/mL with a standard deviation of 145.26. The highest BNP levels were recorded in NYHA Class IV patients (n = 20), with a mean value of 925.37 pg/mL and a standard deviation of 210.48. Overall, the findings indicate a progressive increase in mean BNP levels with advancing NYHA class, suggesting that higher BNP concentrations are associated with greater severity of heart failure.

Table 5: Comparison of Mean BNP Levels According to NYHA Class			
NYHA Class	**Number of Patients (n)**	**Mean BNP (pg/mL)**	**Standard Deviation**
Class I	8	110.45	35.62
Class II	22	285.73	90.14
Class III	30	612.58	145.26
Class IV	20	925.37	210.48

Discussion

The current research examined the demographic characteristics of heart failure patients while studying how serum Brain Natriuretic Peptide (BNP) levels relate to different stages of the disease. The results showed that most patients belonged to the middle-aged and elderly groups with 25% of patients falling within the 41-50 years age range and 22.5% of patients belonging to both 51-60 years and above 60 years age brackets. The study results match the findings from Cowie et al. (2002) [9] Which showed that heart failure becomes more common with higher age and that most heart failure patients start developing the condition after reaching 40. The study found that heart failure patients had a mean age of 63 years showing that advancing age increases the risk of heart failure through structural and functional cardiovascular changes. The study conducted by Maisel et al. 2002 [10] found that most heart failure patients who experienced dyspnea were older than 50 which confirmed the present study's findings about age distribution. The evidence shows that the aging process continues to function as a primary risk factor which leads to both heart failure development and heart failure progression.

The research findings about gender distribution showed that 60 percent of the research sample was male while 40 percent of the sample consisted of female participants. The study found that more men than women developed heart disease according to Omland et al. (2002) [11] who reported that 58 percent of heart failure patients with symptoms were male. Their study showed that men develop cardiovascular diseases sooner than women because they experience more risk factors which include smoking and alcohol use and work-related stress. The research conducted by Januzzi et al. (2006) [12] showed that 62 percent of patients who underwent BNP testing for heart failure evaluation were male. The Mpe et al. (2013) [13] community-based study found that men and women develop heart failure at equal rates until women reach menopause and their protective hormonal effects disappear. Most studies that hospitals conduct show that male patients make up a larger percentage of heart failure cases as shown in this study.

The present study used New York Heart Association functional classification system to distribute patients among various functional classes and found that most patients studied showed advanced functional abilities. The study found that 37.5 percent of patients reached NYHA Class III status while 27.5 percent achieved Class II status and 25 percent obtained Class IV status and 10 percent reached Class I status. The findings of this study share similarities with the study results of Januzzi et al. (2006) which showed that 40 percent of heart failure patients who visited clinics had NYHA Class III diagnosis while 20 to 25 percent received Class IV diagnosis. The research showed that patients only visit doctors after they develop moderate to severe symptoms which leads to higher NYHA class distribution in studies conducted at hospitals. The study by Maisel et al. (2002) found that 35 percent of heart failure patients

reached NYHA Class III status while 22 percent achieved Class IV status which matched the results found in this research. The results show that a substantial number of patients arrive at medical facilities with advanced disease state because doctors need to identify their condition early and provide effective treatment without delay.

The current research found that heart failure patients displayed increased BNP levels. The largest proportion of patients (32.5%) had BNP levels between 100–400 pg/mL, followed by 30% with levels between 401–800 pg/mL, while 25% had levels greater than 800 pg/mL. Only 12.5% of patients had BNP levels below 100 pg/mL. The results match the research conducted by Maisel et al. (2002), which found that BNP levels exceeding 100 pg/mL presented strong evidence for diagnosing heart failure. The research team observed a mean BNP level of 675 pg/mL among heart failure patients during their extensive clinical study, which matched the moderate-to-high BNP results found in the current investigation. Clinico et al. (2012) showed that heart failure patients with symptoms present BNP levels which usually exceed 400 pg/mL, which indicates elevated ventricular wall stress and reduced heart function. The results demonstrate that BNP acts as a precise biomarker for identifying and assessing heart failure.

The study found that BNP levels increased progressively with higher NYHA functional class. The mean BNP level increased from 110.45 pg/mL in NYHA Class I patients to 285.73 pg/mL in Class II patients and 612.58 pg/mL in Class III patients and 925.37 pg/mL in Class IV patients. The stepwise increase proves that BNP concentration rises with increasing heart failure symptom severity. Maeda et al. (2001) [14] reported similar results when they found that mean BNP levels rose from approximately 120 pg/mL in NYHA Class I patients to about 900 pg/mL in NYHA Class IV heart failure patients. The study found that BNP levels provide accurate indications of both ventricular dysfunction and hemodynamic stress, which makes them suitable for measuring disease advancement. Januzzi et al. (2006) demonstrated that BNP levels rose steadily with worsening NYHA class, starting at 150 pg/mL in Class I and reaching over 800 pg/mL in Class IV patients.

Daniels and Maisel (2007) [15] found that BNP concentrations in heart failure patients provide better insights into their clinical condition and future health outcomes than other measurement methods. The research showed that patients with BNP levels above 800 pg/mL experienced more severe symptoms and worse health outcomes than patients with lower BNP levels. The present study found that patients with NYHA Class IV status exhibited a mean BNP level of 925.37 pg/mL which indicated severe cardiac dysfunction.

The present research findings show strong alignment with earlier studies which found that BNP levels increase with worsening heart failure and show close correlation with NYHA functional classification. The study shows demographic patterns which display higher rates of middle-aged and elderly individuals and show that male patients make up the majority of participants which matches the epidemiological findings from previous studies. The results provide additional evidence that BNP functions as an objective biochemical marker which supports clinical evaluation during the process of diagnosing and determining heart failure severity.

Conclusion

The present study highlights that teenage pregnancy continues to pose significant risks to both maternal and fetal health. The findings indicate that a considerable proportion of teenage mothers were unbooked and from rural areas, reflecting inadequate utilization of antenatal care services. Maternal complications such as anemia, preeclampsia, pregnancy-induced hypertension, and preterm delivery were commonly observed, demonstrating the biological and nutritional vulnerability of adolescent mothers. Although the majority of deliveries occurred through normal vaginal delivery, a substantial proportion required cesarean section. From the fetal perspective, adverse outcomes including low birth weight, preterm birth, low Apgar scores, and stillbirth were also noted. Furthermore, the significant association between unbooked status and preterm delivery emphasizes the importance of timely antenatal care. Strengthening adolescent reproductive health education, improving access to antenatal services, and promoting early identification and management of complications are essential to reduce the fetomaternal risks associated with teenage pregnancy.

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