

Study of NT-proBNP and hsTroponin-I Levels in Patients with Cardiovascular Diseases in North Karnataka¹Dr. Mahesh Kumar C.H, Associate Professor, Department of Pathology, RGSSH (OPEC), RIMS, Raichur²Dr. Sadananjali, Assistant Professor, Dept of Biochemistry, RIMS, Raichur³Dr. Vijay P.M, Associate Professor, Dept of Pathology, KRIMS, Karwar.**Corresponding Author:** Dr. Mahesh Kumar C.H, Associate Professor, Department of Pathology, RGSSH (OPEC), RIMS, Raichur.**How to citation this article:** Dr. Mahesh Kumar C.H, Dr. Sadananjali, Dr. Vijay P.M., “Study of NT-proBNP and hsTroponin-I Levels in Patients with Cardiovascular Diseases in North Karnataka”, IJMACR– September– 2026, Volume – 9, Issue – 5, P. No. 665 – 674.**Open Access Article:** © 2026 Dr. Mahesh Kumar C. H., et al. This is an open access journal and article distributed under the terms of the creative common’s attribution license (<http://creativecommons.org/licenses/by/4.0>). Which allows others to remix, tweak, and build upon the work non - commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.**Type of Publication:** Original Research Article**Conflicts of Interest:** Nil**Abstract**

Introduction: Cardiovascular diseases are major causes of morbidity and mortality, and timely identification of myocardial injury and ventricular stress is important for clinical assessment and risk stratification. Cardiac hsTroponin-I reflects myocardial injury, whereas N-terminal pro-B-type natriuretic peptide (NT-proBNP) reflects myocardial wall stress and ventricular dysfunction. Evaluation of both biomarkers may therefore provide complementary information across different cardiovascular disorders.

Aim: To evaluate the levels of NT-proBNP and cardiac hsTroponin-I in adult patients with cardiovascular diseases attending a tertiary-care hospital in Raichur, North Karnataka. This hospital-based cross-sectional observational and analytical study was conducted over a period of 6 months at Rajiv Gandhi Super Speciality Hospital (RGSSH), OPEC, Raichur, Karnataka, and

included 96 adult patients with clinically diagnosed cardiovascular disease. Venous blood samples were collected from the enrolled participants and processed in the Central Laboratory, Rajiv Gandhi Super Speciality Hospital (RGSSH), OPEC, Raichur, Karnataka. NT-proBNP and cardiac hsTroponin-I were estimated using a VIDAS automated analyser by the Enzyme-Linked Fluorescent Assay (ELFA) method. Demographic characteristics, cardiovascular risk factors, and primary cardiovascular diagnoses were documented. The relationship between NT-proBNP and hsTroponin-I levels and gender-wise differences in cardiovascular risk factors and cardiac biomarker levels were assessed using appropriate statistical methods.

Results: Among 96 participants, the mean age was 59.7 ± 11.4 years and 58 (60.4%) were male. Hypertension was present in 62 (64.6%), dyslipidaemia in 46 (47.9%), diabetes mellitus in 38 (39.6%) and smoking history in 31

(32.3%). Acute coronary syndrome was the commonest diagnosis, occurring in 32 (33.3%), followed by heart failure in 26 (27.1%), hypertensive heart disease in 18 (18.8%), valvular heart disease in 10 (10.4%) and cardiac arrhythmia in 10 (10.4%). Mean NT-proBNP was highest in heart failure (2815.7 ± 1363.6 pg/mL), whereas mean hsTroponin-I was highest in acute coronary syndrome (1.72 ± 0.72 ng/mL). Overall, NT-proBNP and hsTroponin-I demonstrated a significant positive correlation ($r=0.435$, $p<0.001$), with stronger correlations in acute coronary syndrome ($r=0.672$, $p<0.001$) and heart failure ($r=0.693$, $p<0.001$). Smoking was significantly more frequent among males than females (48.3% vs 7.9%, $p<0.001$), whereas gender differences in NT-proBNP and hsTroponin-I were not statistically significant.

Conclusion: NT-proBNP and hsTroponin-I demonstrated distinct but complementary patterns across cardiovascular diseases, with NT-proBNP highest in heart failure and hsTroponin-I highest in acute coronary syndrome. Their significant positive correlation supports combined assessment of myocardial stress and injury.

Keywords: NT-proBNP, hsTroponin-I, Cardiovascular Disease, Heart Failure, Biomarkers.

Introduction

Cardiovascular diseases remain a major cause of morbidity and mortality and constitute an important clinical and public-health burden. Early identification of myocardial injury and cardiac dysfunction is essential for accurate diagnosis, risk stratification and appropriate clinical management. Biochemical cardiac biomarkers have consequently become integral to contemporary cardiovascular evaluation because they provide objective information regarding myocardial injury and ventricular haemodynamic stress. Braunwald highlighted the

important role of biomarkers in understanding and evaluating the biological processes underlying heart failure and cardiovascular disease.¹

Cardiac hsTroponin-I (hs-cTnI) is a highly specific biomarker of myocardial injury and has an established role in the evaluation of acute coronary syndromes. The Fourth Universal Definition of Myocardial Infarction emphasizes that cardiac hsTroponin elevation should be interpreted together with clinical evidence of myocardial ischaemia when diagnosing myocardial infarction.² Beyond acute myocardial infarction, relatively low concentrations of cardiac hsTroponins may also provide clinically relevant information regarding cardiovascular risk. de Lemos et al. demonstrated that cardiac hsTroponin measurement could identify low-level myocardial injury and showed an association between detectable hsTroponin concentrations, cardiac structural abnormalities and mortality risk in the general population.³ Morrow et al. similarly emphasized the clinical utility of cardiac biomarkers in the assessment and management of patients with acute coronary syndromes.⁴

N-terminal pro-B-type natriuretic peptide (NT-proBNP) represents a complementary biological pathway. It is released in response to myocardial wall stress and ventricular pressure or volume loading and has an established role in the diagnosis and assessment of heart failure. Daniels and Maisel described natriuretic peptides as clinically useful markers of cardiac pressure and volume overload with important diagnostic and prognostic applications.⁵ Januzzi et al., through the PRIDE study, demonstrated the diagnostic usefulness of NT-proBNP among patients presenting with dyspnoea and its ability to distinguish acute congestive heart failure from other causes of dyspnoea.⁶

The complementary biological characteristics of hsTroponin-I and NT-proBNP make their combined assessment clinically relevant. hsTroponin-I predominantly reflects myocardial cellular injury, whereas NT-proBNP reflects haemodynamic stress and ventricular dysfunction. Consequently, patients with heart failure may demonstrate marked NT-proBNP elevation without a proportionate increase in hsTroponin-I, whereas patients with acute coronary syndrome may show prominent hsTroponin-I elevation accompanied by variable NT-proBNP concentrations. Maisel et al. demonstrated the diagnostic value of natriuretic peptide measurement in heart failure, while Daniels and Maisel emphasized the relationship between natriuretic peptide concentrations and ventricular loading and function.^{7,5}

The clinical relevance of these biomarkers extends beyond patients with established symptomatic cardiovascular disease. Advances in high-sensitivity assays have enabled detection of relatively low concentrations of cardiac injury biomarkers, facilitating identification of subclinical myocardial abnormalities and assessment of long-term cardiovascular risk. de Lemos et al. reported detectable cardiac hsTroponin-T in a substantial proportion of participants in a community-based cohort and demonstrated an association between detectable concentrations, structural cardiac abnormalities and mortality risk.³ More recently, Myhre et al. evaluated 2,006 older adults and reported that higher baseline NT-proBNP and high-sensitivity hsTroponin-I concentrations were associated with subsequent seven-year changes in cardiac structure and function.⁸

The burden of cardiovascular disease is closely related to conventional cardiovascular risk factors. Hypertension, diabetes mellitus, dyslipidaemia and smoking contribute substantially to the development and progression of

cardiovascular disease and may influence both myocardial injury and ventricular dysfunction. Gupta et al. described important trends in coronary heart disease epidemiology and emphasized the contribution of major modifiable cardiovascular risk factors.⁹ These factors provide an important clinical context for interpretation of NT-proBNP and hsTroponin-I concentrations in hospital-based cardiovascular populations.

Sex and gender may also influence cardiovascular disease patterns, risk profiles and clinical presentation. Regitz-Zagrosek emphasized clinically relevant differences between men and women in cardiovascular pathophysiology, risk factors and disease manifestation.¹⁰ Such differences are important when evaluating cardiovascular biomarkers because biomarker concentrations may additionally be influenced by age, sex, renal function, disease severity and analytical methodology.

Analytical characteristics are also important when interpreting cardiac biomarker concentrations. Apple and Collinson emphasized that cardiac hsTroponin assays differ in analytical performance and that assay-specific characteristics, including the 99th-percentile upper reference limit, should be considered when interpreting results.¹¹ Therefore, clinical interpretation of hsTroponin-I should be integrated with assay characteristics and the clinical presentation rather than based solely on an isolated numerical concentration.

Although NT-proBNP and cardiac hsTroponin-I are widely established biomarkers, their relative distribution across different cardiovascular diagnoses and their relationship with one another may vary according to disease spectrum, clinical severity and patient characteristics. Hospital-based regional data may therefore provide useful information regarding the

clinical profile of patients presenting to tertiary-care cardiovascular services. The present study was undertaken to determine the hospital-based distribution of major cardiovascular diseases, assess NT-proBNP and hsTroponin-I concentrations across diagnostic categories, evaluate the correlation between the two biomarkers, and compare cardiovascular risk factors and cardiac biomarker concentrations between male and female patients.

Aim

To evaluate the levels of NT-proBNP and cardiac hsTroponin-I in adult patients with cardiovascular attending a tertiary-care hospital in Raichur, North Karnataka.

Objectives

1. To determine the hospital-based distribution of major cardiovascular diseases among adult patients enrolled at the study centre in Raichur.
2. To assess the correlation between NT-proBNP and hsTroponin-I levels in patients with cardiovascular diseases.
3. To compare cardiovascular risk factors and cardiac biomarker levels between male and female patients with cardiovascular diseases.

Materials And Methods

Study Design and Setting

This hospital-based cross-sectional observational and analytical study was conducted among adult patients with clinically diagnosed cardiovascular disease attending Rajiv Gandhi Super Speciality Hospital (RGSSH), OPEC, Raichur, Karnataka. Clinical assessment and recruitment were undertaken through the relevant cardiovascular clinical services, while biochemical investigations were carried out in the Central Laboratory (RGSSH), OPEC, Raichur.

Study Period

The study was conducted over a period of 6 months, as specified in the approved study protocol.

Study Population and Sample Size

The study population comprised adult patients with clinically diagnosed cardiovascular disease who fulfilled the predefined eligibility criteria. A total of 96 eligible patients were enrolled.

Sampling Technique

Eligible patients fulfilling the inclusion and exclusion criteria were recruited by consecutive sampling during the study period.

Inclusion Criteria

Patients were included if they were aged ≥ 18 years, had a clinically diagnosed cardiovascular disease, and were willing to participate after providing written informed consent.

Exclusion Criteria

Patients with severe renal disease, chronic inflammatory diseases, or other conditions likely to substantially interfere with the interpretation of NT-proBNP or cardiac hsTroponin-I according to the approved study protocol were excluded. Patients unwilling to participate or unable to provide written informed consent were also excluded.

Clinical Data Collection

After obtaining informed consent, demographic and clinical information was recorded using a structured data-collection form. Variables included age, sex, primary cardiovascular diagnosis, hypertension, diabetes mellitus, smoking history, dyslipidaemia and other cardiovascular risk factors documented in the study protocol. The primary cardiovascular diagnosis was recorded from the treating clinician's assessment and available clinical records.

Blood Sample Collection and Processing

Venous blood samples were collected from all enrolled participants and processed in the Central Laboratory, Rajiv Gandhi Super Speciality Hospital (RGSSH), OPEC, Raichur, Karnataka. Samples were handled and processed according to standard laboratory procedures, and the appropriate serum/plasma fraction was used for estimation of NT-proBNP and cardiac hsTroponin-I.

Estimation of NT-proBNP and Cardiac hsTroponin-I

NT-proBNP and cardiac hsTroponin-I were estimated in the Central Laboratory, Rajiv Gandhi Super Speciality Hospital (RGSSH), OPEC, Raichur, Karnataka, using the VIDAS automated hormone/immunoassay analyser. The analytical principle used was Enzyme-Linked Fluorescent Assay (ELFA). The assays were performed according to the manufacturer's recommended analytical procedure and the routine quality-control practices of the laboratory.

Method of estimation

- **NT-proBNP:** Enzyme-Linked Fluorescent Assay (ELFA) using the VIDAS analyser.
- **Cardiac hsTroponin-I:** Enzyme-Linked Fluorescent Assay (ELFA) using the VIDAS analyser.

The assays were performed in accordance with the manufacturer's recommended analytical procedure and routine quality-control practices of the Clinical Biochemistry Laboratory.

Statistical Analysis

Data were analysed using SPSS software. Categorical variables were expressed as frequencies and percentages. Normally distributed continuous variables were summarized as mean $\pm$ standard deviation. The relationship between NT-proBNP and hsTroponin-I was evaluated using Pearson's correlation coefficient when parametric assumptions were satisfied, with Spearman's rank correlation considered for non-normally distributed

data. Gender-wise categorical comparisons were performed using the Chi-square test or Fisher's exact test, as appropriate, whereas continuous variables were compared using the independent-samples Student's *t*-test or Mann-Whitney U test according to data distribution. A two-tailed *p*-value <0.05 was considered statistically significant.

Results

Table 1: Demographic and Cardiovascular Risk-Profile Characteristics of the Study Population (N=96)

Parameter	n (%) / Mean $\pm$ SD
Age (years)	59.7 $\pm$ 11.4
Age 18–39 years	8 (8.3%)
Age 40–49 years	15 (15.6%)
Age 50–59 years	24 (25.0%)
Age 60–69 years	29 (30.2%)
Age ≥ 70 years	20 (20.8%)
Male	58 (60.4%)
Female	38 (39.6%)
Hypertension	62 (64.6%)
Diabetes mellitus	38 (39.6%)
Smoking history	31 (32.3%)
Dyslipidaemia	46 (47.9%)

The study included 96 patients with a mean age of 59.7 $\pm$ 11.4 years. Males constituted 58 (60.4%) and females 38 (39.6%) of the cohort. The largest age group was 60–69 years, comprising 29 (30.2%) participants, followed by 50–59 years with 24 (25.0%). Hypertension was the commonest cardiovascular risk factor, present in 62 (64.6%) patients, followed by dyslipidaemia in 46 (47.9%), diabetes mellitus in 38 (39.6%) and smoking history in 31 (32.3%).

Table 2: Distribution of Primary Cardiovascular Diagnoses and Corresponding NT-proBNP and hsTroponin-I Levels

Primary cardiovascular diagnosis	n (%)	NT-proBNP (pg/mL), Mean $\pm$ SD	hsTroponin-I (ng/mL), Mean $\pm$ SD
Acute coronary syndrome	32 (33.3%)	2248.7 $\pm$ 802.2	1.72 $\pm$ 0.72
Heart failure	26 (27.1%)	2815.7 $\pm$ 1363.6	0.37 $\pm$ 0.22
Hypertensive heart disease	18 (18.8%)	620.9 $\pm$ 390.6	0.10 $\pm$ 0.04
Valvular heart disease	10 (10.4%)	1847.8 $\pm$ 862.4	0.20 $\pm$ 0.10
Cardiac arrhythmia	10 (10.4%)	785.8 $\pm$ 471.7	0.09 $\pm$ 0.05
Total	96 (100.0%)	1902.9 $\pm$ 1236.7	0.72 $\pm$ 0.83

Overall comparison between diagnostic groups: $p < 0.001$ for NT-proBNP and $p < 0.001$ for hsTroponin-I.

Acute coronary syndrome was the most frequent cardiovascular diagnosis, accounting for 32 (33.3%) patients, followed by heart failure in 26 (27.1%), hypertensive heart disease in 18 (18.8%), valvular heart disease in 10 (10.4%) and cardiac arrhythmia in 10 (10.4%). Mean NT-proBNP was highest in heart failure at 2815.7 $\pm$ 1363.6 pg/mL, whereas mean hsTroponin-I was highest in acute coronary syndrome at 1.72 $\pm$ 0.72 ng/mL. The differences in both biomarkers across diagnostic categories were statistically significant ($p < 0.001$ for each).

Table 3: Correlation Between NT-proBNP and hsTroponin-I in the Study Population and Selected Clinical Subgroups

Study group	n	Pearson correlation coefficient (r)	p-value
Overall cardiovascular disease cohort	96	0.435	<0.001
Male patients	58	0.406	0.002
Female patients	38	0.482	0.002
Acute coronary syndrome	32	0.672	<0.001
Heart failure	26	0.693	<0.001

A significant positive correlation was observed between NT-proBNP and hsTroponin-I in the overall cohort ($r = 0.435$, $p < 0.001$). The correlation remained significant among males ($r = 0.406$, $p = 0.002$) and females ($r = 0.482$, $p = 0.002$). Stronger positive correlations were observed in acute coronary syndrome ($r = 0.672$, $p < 0.001$) and heart failure ($r = 0.693$, $p < 0.001$).

Table 4: Gender-Wise Comparison of Cardiovascular Risk Factors and Cardiac Biomarkers

Parameter	Male (n=58)	Female (n=38)	p-value
Age (years), Mean $\pm$ SD	59.3 $\pm$ 11.2	60.3 $\pm$ 11.7	0.678
Hypertension	36 (62.1%)	26 (68.4%)	0.525
Diabetes mellitus	24 (41.4%)	14 (36.8%)	0.657
Smoking history	28 (48.3%)	3 (7.9%)	<0.001
Dyslipidaemia	29 (50.0%)	17 (44.7%)	0.614

NT-proBNP (pg/mL), Mean $\pm$ SD	1850.0 $\pm$ 1200.0	1980.0 $\pm$ 1300.0	0.623
hsTroponin-I (ng/mL), Mean $\pm$ SD	0.82 $\pm$ 0.92	0.57 $\pm$ 0.63	0.117

The mean age was similar among males and females (59.3 ± 11.2 vs 60.3 ± 11.7 years; $p=0.678$). Hypertension occurred in 62.1% of males and 68.4% of females ($p=0.525$), diabetes mellitus in 41.4% and 36.8% ($p=0.657$), and dyslipidaemia in 50.0% and 44.7% ($p=0.614$), respectively. Smoking history was significantly more frequent among males than females (48.3% vs 7.9%; $p<0.001$). Mean NT-proBNP was 1850.0 ± 1200.0 pg/mL among males and 1980.0 ± 1300.0 pg/mL among females ($p=0.623$), whereas mean hsTroponin-I was 0.82 ± 0.92 ng/mL and 0.57 ± 0.63 ng/mL, respectively ($p=0.117$).

Discussion

The present study evaluated serum NT-proBNP and cardiac hsTroponin-I among 96 adults with established cardiovascular disease. The cohort had a mean age of 59.7 ± 11.4 years and comprised 60.4% males and 39.6% females. Hypertension was present in 64.6%, dyslipidaemia in 47.9%, diabetes mellitus in 39.6% and smoking history in 32.3%. Acute coronary syndrome was the commonest diagnosis at 33.3%, followed by heart failure at 27.1%, hypertensive heart disease at 18.8%, and valvular heart disease and cardiac arrhythmia at 10.4% each. Mean NT-proBNP was highest among patients with heart failure (2815.7 ± 1363.6 pg/mL), whereas mean hsTroponin-I was highest among those with acute coronary syndrome (1.72 ± 0.72 ng/mL).

The two biomarkers showed a significant positive correlation overall ($r=0.435$, $p<0.001$), with stronger correlations in acute coronary syndrome ($r=0.672$, $p<0.001$) and heart failure ($r=0.693$, $p<0.001$). These

findings indicate complementary biochemical expression of myocardial injury and haemodynamic cardiac stress. The demographic profile was consistent with the established cardiovascular risk pattern described by Gupta et al.⁹ In the present study, hypertension affected 64.6%, dyslipidaemia 47.9%, diabetes mellitus 39.6% and smoking history 32.3%. The concentration of these risk factors within a cardiovascular disease cohort provides an important background for interpreting biomarker concentrations. Myhre et al.⁸ studied 2,006 older adults with a mean age of 74.1 ± 4.2 years and reported hypertension in 75.9%, diabetes in 30.8% and current smoking in 5.3%. The present population was younger but demonstrated a higher prevalence of diabetes and smoking. Such differences are understandable because the present study consisted of patients with established cardiovascular disease rather than a predominantly community-based older population. The male predominance in the present study, with 60.4% males, is also clinically relevant. Regitz-Zagrosek¹⁰ emphasized important sex- and gender-related differences in cardiovascular disease. In the present cohort, smoking was particularly different between the sexes, occurring in 48.3% of males compared with 7.9% of females ($p<0.001$). In contrast, hypertension occurred in 62.1% of males and 68.4% of females ($p=0.525$), diabetes in 41.4% and 36.8% ($p=0.657$), and dyslipidaemia in 50.0% and 44.7% ($p=0.614$), respectively. Thus, smoking represented the only conventional risk factor demonstrating a statistically significant gender difference. The diagnostic distribution demonstrated substantial heterogeneity. Acute coronary syndrome represented 33.3% of the cohort, while heart failure accounted for 27.1%. The highest NT-proBNP concentration was observed in heart failure, at 2815.7 ± 1363.6 pg/mL. This

finding is consistent with Braunwald's¹ description of biomarkers in heart failure and with Daniels and Maisel's⁵ explanation of natriuretic peptides as markers of ventricular pressure and volume loading. Januzzi et al.⁶ demonstrated the diagnostic value of NT-proBNP in patients presenting with dyspnoea, with the PRIDE study supporting its clinical usefulness in acute heart failure. The substantially elevated NT-proBNP concentration in the present heart-failure group therefore supports the expected association between ventricular haemodynamic stress and natriuretic peptide release.

Maisel et al.⁷ similarly demonstrated the usefulness of natriuretic peptide measurement in differentiating heart failure from alternative causes of dyspnoea. Although their investigation used BNP rather than NT-proBNP, the biological principle is comparable. In the present study, NT-proBNP was also substantially elevated in valvular heart disease, with a mean concentration of 1847.8 ± 862.4 pg/mL, supporting the influence of haemodynamic loading in cardiovascular disorders beyond primary heart failure.

The hsTroponin-I pattern was distinctly different. Mean hsTroponin-I was highest in acute coronary syndrome at 1.72 ± 0.72 ng/mL, compared with 0.37 ± 0.22 ng/mL in heart failure, 0.20 ± 0.10 ng/mL in valvular heart disease, 0.10 ± 0.04 ng/mL in hypertensive heart disease and 0.09 ± 0.05 ng/mL in cardiac arrhythmia. Thygesen et al.² established cardiac hsTroponin as the preferred biomarker of myocardial injury within the universal definition of myocardial infarction, while Morrow et al.⁴ emphasized its central role in acute coronary syndrome evaluation. The markedly higher hsTroponin-I concentration in acute coronary syndrome in the present study therefore

corresponds with its principal biological role as a marker of myocardial injury.

The relationship between the two biomarkers was another major finding. The overall correlation coefficient was 0.435 ($p < 0.001$), indicating a significant positive relationship. The correlation was 0.406 among males and 0.482 among females, both statistically significant at $p = 0.002$. More pronounced relationships were observed in acute coronary syndrome ($r = 0.672$, $p < 0.001$) and heart failure ($r = 0.693$, $p < 0.001$). These findings suggest that biochemical evidence of myocardial injury and haemodynamic cardiac stress may coexist in patients with clinically established cardiovascular disease.

Myhre et al.⁸ reported a weaker correlation of approximately $r = 0.22$ between NT-proBNP and hsTroponin-I in their community-based older-adult population. Their median NT-proBNP was 87 ng/L and median hsTroponin-I was 2.6 ng/L. The stronger overall correlation of $r = 0.435$ in the present study may reflect the different clinical spectrum, as all participants had established cardiovascular disease. The even stronger correlations in acute coronary syndrome and heart failure suggest that the relationship between myocardial injury and haemodynamic stress may be more pronounced in clinically overt cardiovascular disease.

de Lemos et al.³ demonstrated that detectable hsTroponin-T was associated with cardiac structural abnormalities and mortality risk in a general population of 3,546 individuals. Although their study evaluated hsTroponin-T rather than hsTroponin-I, it reinforces the broader importance of cardiac hsTroponin as a marker of myocardial injury. The present study extends this clinical context by demonstrating a significant relationship

between hsTroponin-I and NT-proBNP in patients with established cardiovascular disease.

The particularly strong correlations in acute coronary syndrome and heart failure are clinically meaningful. In acute coronary syndrome, the mean hsTroponin-I was 1.72 ± 0.72 ng/mL and mean NT-proBNP was 2248.7 ± 802.2 pg/mL. In heart failure, NT-proBNP was even higher at 2815.7 ± 1363.6 pg/mL, while hsTroponin-I averaged 0.37 ± 0.22 ng/mL. The differing magnitude of the two biomarkers across these diagnoses supports their complementary rather than interchangeable roles.

Analytical variation must also be considered. Apple and Collinson¹¹ emphasized that cardiac hsTroponin assays differ in analytical sensitivity and performance and that assay-specific reference limits are important. Therefore, absolute hsTroponin-I concentrations should be compared cautiously across studies using different analytical platforms. The present results are most appropriately interpreted within the clinical and laboratory context in which they were generated.

Gender-wise biomarker comparison demonstrated no statistically significant difference in either marker. Mean NT-proBNP was numerically higher in females than males (1980.0 ± 1300.0 vs 1850.0 ± 1200.0 pg/mL; $p=0.623$), whereas mean hsTroponin-I was numerically higher in males (0.82 ± 0.92 vs 0.57 ± 0.63 ng/mL; $p=0.117$). Regitz-Zagrosek¹⁰ emphasized sex-related biological differences in cardiovascular disease, while Myhre et al.⁸ reported sex-related associations involving cardiac biomarkers in older adults. Nevertheless, the present study did not demonstrate statistically significant gender differences in either biomarker.

The significant gender difference in smoking deserves additional emphasis. Smoking was reported by 48.3% of males compared with 7.9% of females ($p<0.001$), whereas

the differences in hypertension, diabetes and dyslipidaemia were not statistically significant. Gupta et al.⁹ identified these factors as important components of cardiovascular disease epidemiology. The present findings indicate that smoking exposure was particularly concentrated among male participants, although the study design does not permit assessment of its independent relationship with biomarker concentrations.

Overall, the present findings demonstrate a coherent distinction between the biological information provided by NT-proBNP and hsTroponin-I. NT-proBNP was highest in heart failure, at 2815.7 ± 1363.6 pg/mL, whereas hsTroponin-I was highest in acute coronary syndrome, at 1.72 ± 0.72 ng/mL. The overall positive correlation between the biomarkers ($r=0.435$, $p<0.001$), and the stronger relationships in acute coronary syndrome ($r=0.672$, $p<0.001$) and heart failure ($r=0.693$, $p<0.001$), support their combined interpretation. The findings should, however, be interpreted as associations within a cross-sectional hospital-based cohort and should not be regarded as evidence of causality or independent prognostic prediction.

Conclusion

Among 96 patients with cardiovascular disease, acute coronary syndrome was the commonest diagnosis. NT-proBNP was highest in heart failure, whereas hsTroponin-I was highest in acute coronary syndrome. Both biomarkers showed a significant positive correlation, particularly in acute coronary syndrome and heart failure. Smoking was significantly more frequent among males, while biomarker levels did not differ significantly by gender.

Limitations

The hospital-based cross-sectional design and relatively small sample of 96 participants limit generalizability and

preclude assessment of temporal relationships. Biomarker concentrations may also be influenced by age, renal function, disease severity and assay-specific characteristics.

Recommendations

Combined assessment of NT-proBNP and hsTroponin-I may provide complementary biochemical information in cardiovascular disease. Larger prospective multicentre studies using standardized high-sensitivity assays are recommended to validate these associations and evaluate their incremental diagnostic and prognostic value.

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