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ORIGINAL ARTICLE

Prognostic Significance of High-Sensitivity Cardiac Troponin-T in Non-ST Elevation Myocardial Infarction

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ABSTRACT

Background: Non-ST elevation myocardial infarction (NSTEMI) remains a major cause of morbidity and mortality, with substantial variability in outcomes. High-sensitivity cardiac troponin-T (hs-cTnT) is the biomarker of choice for diagnosis, but its role as a prognostic marker in predicting in-hospital complications and adverse outcomes requires further evaluation.

Objective: To assess the prognostic significance of hs-cTnT levels in patients admitted with NSTEMI.

Methods: This prospective observational study enrolled 155 patients with NSTEMI at Punjab Institute of Cardiology from January 2023 to June 2023. Patients were stratified into tertiles based on admission hs-cTnT levels (low, intermediate, high). Baseline demographics, comorbidities, hemodynamic and ECG parameters, and left ventricular ejection fraction were recorded. Outcomes assessed included recurrent ischemia, heart failure, arrhythmia, urgent revascularization, in-hospital mortality, major adverse cardiovascular events (MACE), and length of hospital stay.

Results: Patients with higher hs-cTnT were older (66 vs. 57 years, p=0.002), more often diabetic (58% vs. 35%, p=0.04), and had lower LVEF (45.7% vs. 52.1%, p<0.001). Killip class II–IV was present in 61.5% of high hs-cTnT patients compared to 11.5% in the low group (p<0.001). In-hospital complications were significantly more frequent in the high group: recurrent ischemia (25% vs. 8%), heart failure (33% vs. 6%), arrhythmias (15% vs. 2%), urgent revascularization (27% vs. 10%), and mortality (17% vs. 2%) (all p<0.05). MACE occurred in 67% of high hs-cTnT patients compared with 15% in the low group (p<0.001). Hospital stay was longer in the high group (7.1 vs. 4.1 days, p<0.001).

Conclusion: Elevated hs-cTnT levels are strongly associated with adverse in-hospital outcomes in NSTEMI patients, including higher complication rates, longer hospital stay, and increased MACE. hs-cTnT provides independent prognostic value beyond traditional risk factors and should be incorporated into early risk stratification and management pathways for NSTEMI.

Keywords: NSTEMI, high-sensitivity troponin-T, prognosis, MACE, in-hospital outcomes, risk stratification

INTRODUCTION

Non-ST elevation myocardial infarction (NSTEMI) is a significant proportion of the acute coronary syndrome (ACS) and causes a major morbidity and mortality problem across the globe. Epidemiology shows that NSTEMI contributes over 60 percent of all myocardial infarctions, and that its incidence is rising with aging, rising rates of diabetes, hypertension and other cardiovascular risk factors [1]. In comparison with ST-elevation myocardial infarction (STEMI) that is usually marked by the full coronary blockage and specific electrocardiography, NSTEMI is frequently caused by partial coronary blockage or erosion of the plaque, thus giving rise to more subtle clinical manifestations. In spite of improvements in diagnostic methods and treatment interventions, NSTEMI is correlated with a high probability of recurrences of ischemia, hospitalisations and adverse cardiovascular effect in the long term[2]. The correct diagnosis and prognostication in the NSTEMI is essential to implement necessary interventions and maximize the results. The biomarkers of myocardial injury include cardiac troponins which have greater specificity than the older biomarkers like creatine kinase-MB and myoglobin[3]. With the advent of high-sensitivity cardiac troponin-T (hs-cTnT) assays, thus allowing the detection of extremely low troponin levels, a reflection of even small amounts of cardiomyocyte necrosis[4], diagnostic quality has greatly increased. These measurements have the potential to detect myocardial damage earlier, in most cases, 13 hours after the onset of the symptoms, enabling more rapid triage and timely initiation of treatment[5].

In addition to diagnostics, hs-cTnT levels are powerful prognostic in ACS. High levels of hs-cTnT at admission have been reported to correlate with a higher mortality rate both in the short- and long-term, repeat occurrence of myocardial infarction, heart failure, and major adverse cardiovascular events (MACE)[6]. Notably, the size of hs-cTnT elevation is associated with the severity of coronary artery disease and the size of myocardial injury and is a strong predictor of risk stratification[7]. It has also been demonstrated that the presence or increasing hs-cTnT levels during hospitalization are prognosticative of poorer outcomes than decreasing levels, which indicate persistent or unsuccessful myocardial injury or ineffective treatment[8]. The incorporation of hs-cTnT into available risk stratification models including the TIMI and GRACE scores has enhanced predictive capabilities, especially in the high-risk patient population that could be addressed with early invasive interventions[9]. Moreover, hs-cTnT provides differences in prognostic information, even after the traditional predictors of risk, including age, diabetes, hypertension, renal, and left ventricular ejection fraction, have been considered[10]. As an example, patients with high hs-cTnT despite normal ejection fraction can still have a high risk, which supports the importance of it as an outcome predictor in its own right. Nevertheless, there are still various difficulties in using the hs-cTnT measurements to convert them into standard prognostication. Cutoff is different among populations and comorbidities like chronic kidney disease, heart failure and sepsis may also increase hs-cTnT without acute coronary ischemia[11]. This may be problematic to interpret in clinical practice, particularly with elderly patients or in patients with multiple comorbidities. Moreover, the literature is heterogeneous about the most appropriate time to measure and the extent of prediction between mildly and strongly raised hs-cTnT levels[12]. The literature has established cTnT hs-cTnT as a valuable predictor of adverse cardiovascular events, yet most studies have been carried out in large, heterogeneous populations, so it is unclear how well cTnT hs-cTnT predicts adverse cardiovascular events in well-defined NSTEMI cohorts. Moreover, there is limited empirical data regarding its predictive value in resource-constrained environments and whether hs-cTnT can also guide the therapeutic decision-making in such areas in a meaningful fashion is not established fully yet[13].

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Objective: To assess the prognostic significance of hs-cTnT levels in patients admitted with NSTEMI.

METHODOLOGY

This was a prospective observational study conducted at Punjab Institute of Cardiology from January 2023 to June 2023. A total of 155 consecutive patients fulfilling the diagnostic criteria for NSTEMI were enrolled after meeting the eligibility criteria.

Inclusion Criteria: Patients aged ≥18 years.

- Clinical presentation consistent with acute coronary syndrome without persistent ST-segment elevation.
- Elevated hs-cTnT levels above the 99th percentile of the upper reference limit with a rising or falling pattern.
- Ischemic changes on electrocardiogram (ECG), such as ST-segment depression or T-wave inversion.

Exclusion Criteria

- Patients with ST-elevation myocardial infarction (STEMI).
- Known chronic kidney disease (eGFR <60 mL/min/1.73 m²) or requiring dialysis.
- Recent major surgery or trauma within the past 4 weeks.
- Active myocarditis, pericarditis, or sepsis.
- Refusal or inability to provide informed consent.

Data Collection: Baseline demographic and clinical information including age, sex, cardiovascular risk factors (hypertension, diabetes mellitus, smoking status, dyslipidemia, family history of ischemic heart disease), prior coronary interventions, and comorbidities were recorded. Clinical presentation features such as chest pain duration, Killip class at admission, and hemodynamic parameters were documented. hs-cTnT levels were measured at admission, repeated at 3–6 hours, and monitored as per institutional protocol using a standardized high-sensitivity assay. Patients were categorized into tertiles based on hs-cTnT levels (low, intermediate, and high). Electrocardiographic findings, echocardiographic left ventricular ejection fraction (LVEF), and angiographic details (where performed) were noted. In-hospital management, including pharmacologic therapy and revascularization strategies, was documented.

Statistical Analysis: All data were entered and analyzed using SPSS version 22.0. Continuous variables such as age, hs-cTnT levels, LVEF, and length of hospital stay were expressed as mean ± standard deviation or median with interquartile range, depending on data distribution. Multivariable logistic regression analysis was performed to identify independent predictors of adverse outcomes, adjusting for potential confounders such as age, hypertension, diabetes, and LVEF. A p-value ≤0.05 was considered statistically significant.

Results: The mean age of patients was 61.8± 11.2 years, with significant variation across hs-cTnT tertiles. Those in the high hs-cTnT group were the oldest, with a mean age of 66.2 years, compared to 57.4 years in the low group (p=0.002). Male sex accounted for 65.2% of the overall cohort, distributed evenly across tertiles without significant difference. Diabetes mellitus was more common in patients with higher hs-cTnT, affecting 57.7% in the high group versus 34.6% in the low group (p=0.04). Hypertension and dyslipidemia were frequent overall, present in 62.6% and 41.3% of patients, respectively, but did not differ significantly across tertiles. Current smoking was reported in 38.1% of the population, again without statistical difference. Left ventricular ejection fraction declined progressively with higher troponin levels, from 52.1% in the low group to 45.7% in the high group (p<0.001). Similarly, advanced Killip class (II–IV) was observed in 61.5% of patients with high hs-cTnT compared to only 11.5% in the low group (p<0.001).

Mean systolic blood pressure declined from 136 mmHg in the low group to 128 mmHg in the high group (p=0.03), while mean heart rate rose from 82 bpm to 91 bpm (p=0.01). The duration of chest pain was significantly longer in patients with elevated hs-cTnT, increasing from 5.1 hours in the low group to 7.6 hours in the high group (p<0.001). Electrocardiographic findings also reflected greater ischemic load: ST-segment depression was present in 55.8% of patients in the high group compared with 26.9% in the low group (p=0.002). T-wave inversion was more frequent in the high hs-cTnT group (53.8%) compared to the low group (34.6%), though this did not reach statistical significance (p=0.08). Median hs-cTnT levels clearly separated the tertiles, ranging from 52 ng/L in the low group to 348 ng/L in the high group (p<0.001).

Age increased stepwise, with mean values of 57.4 years in the low tertile, 61.7 years in the intermediate, and 66.2 years in the high tertile (p=0.002). Male sex distribution remained stable across groups, between 63–67% (p=0.91). Left ventricular ejection fraction fell significantly, from 52.1% in the low tertile to 45.7% in the high tertile (p<0.001). Similarly, the proportion of patients in Killip class II–IV rose sharply from 11.5% in the low group to 61.5% in the high group (p<0.001).

Recurrent ischemia was documented in 25% of patients in the high group compared to only 7.7% in the low group (p=0.03). Heart failure requiring treatment occurred in 32.7% of high hs-cTnT patients versus 5.8% in the low group (p<0.001). Life-threatening arrhythmias were also more frequent, reported in 15.4% of high-level patients compared to just 1.9% of the low group (p=0.02). Urgent revascularization was required in 26.9% of high hs-cTnT patients versus 9.6% of those in the low group (p=0.04). In-hospital mortality showed a similar pattern, occurring in 17.3% of high hs-cTnT patients compared to 1.9% in the low group (p=0.01).

Any MACE occurred in 67.3% of patients in the high group compared with 33.3% in the intermediate group and only 15.4% in the low group (p<0.001). The composite endpoint of death, recurrent myocardial infarction, or heart failure followed a similar trend, affecting 53.8% of patients in the high group compared to 25.5% in the intermediate and 11.5% in the low group (p<0.001). Mean hospital stay also lengthened significantly with higher hs-cTnT levels, from 4.1 days in the low group to 7.1 days in the high group (p<0.001).

Table 1: Baseline Demographic and Clinical Characteristics of NSTEMI Patients (N = 155)

Variable	Total (N=155)	Low hs-cTnT (n=52)	Intermediate hs-cTnT (n=51)	High hs-cTnT (n=52)	p-value
Age, years, mean ± SD	61.8 ± 11.2	57.4 ± 10.5	61.7 ± 11.3	66.2 ± 9.9	0.002
Male sex, n (%)	101 (65.2)	35 (67.3)	32 (62.7)	34 (65.3)	0.91
Diabetes mellitus, n (%)	71 (45.8)	18 (34.6)	23 (45.1)	30 (57.7)	0.04
Hypertension, n (%)	97 (62.6)	28 (53.8)	32 (62.7)	37 (71.1)	0.12
Dyslipidemia, n (%)	64 (41.3)	16 (30.8)	21 (41.2)	27 (51.9)	0.07
Current smoker, n (%)	59 (38.1)	24 (46.2)	20 (39.2)	15 (28.8)	0.14
LVEF (%), mean ± SD	48.6 ± 8.7	52.1 ± 7.6	47.9 ± 8.1	45.7 ± 9.2	<0.001
Killip class II–IV, n (%)	52 (33.5)	6 (11.5)	14 (27.5)	32 (61.5)	<0.001

Table 2: In-Hospital Clinical and Physiological Parameters by hs-cTnT Tertiles

Parameter	Low hs-cTnT (n=52)	Intermediate hs-cTnT (n=51)	High hs-cTnT (n=52)	p-value
Systolic BP, mmHg, mean ± SD	136 ± 17	132 ± 18	128 ± 19	0.03
Heart rate, bpm, mean ± SD	82 ± 11	85 ± 12	91 ± 14	0.01
Duration of chest pain, hrs, mean ± SD	5.1 ± 2.3	6.5 ± 2.7	7.6 ± 3.0	<0.001
ST depression on ECG, n (%)	14 (26.9)	20 (39.2)	29 (55.8)	0.002
T-wave inversion on ECG, n (%)	18 (34.6)	21 (41.2)	28 (53.8)	0.08
hs-cTnT level, ng/L, median (IQR)	52 (41–63)	114 (98–132)	348 (290–410)	<0.001

Table 3: hs-cTnT Levels Stratified by Tertiles (N = 155)

Variable	Tertile 1 (Low, n=52)	Tertile 2 (Intermediate, n=51)	Tertile 3 (High, n=52)	p-value
hs-cTnT level, ng/L, median (IQR)	52 (41–63)	114 (98–132)	348 (290–410)	<0.001
Age, years, mean ± SD	57.4 ± 10.5	61.7 ± 11.3	66.2 ± 9.9	0.002
Male sex, n (%)	35 (67.3)	32 (62.7)	34 (65.3)	0.91
LVEF (%), mean ± SD	52.1 ± 7.6	47.9 ± 8.1	45.7 ± 9.2	<0.001
Killip class II–IV, n (%)	6 (11.5)	14 (27.5)	32 (61.5)	<0.001

Table 4: In-Hospital Outcomes Stratified by hs-cTnT Tertiles (N = 155)

Outcome	Tertile 1 (n=52)	Tertile 2 (n=51)	Tertile 3 (n=52)	p-value
Recurrent ischemia, n (%)	4 (7.7)	7 (13.7)	13 (25.0)	0.03
Heart failure requiring treatment, n (%)	3 (5.8)	8 (15.7)	17 (32.7)	<0.001
Life-threatening arrhythmia, n (%)	1 (1.9)	3 (5.9)	8 (15.4)	0.02
Urgent revascularization, n (%)	5 (9.6)	9 (17.6)	14 (26.9)	0.04
In-hospital mortality, n (%)	1 (1.9)	3 (5.9)	9 (17.3)	0.01

Table 5: Major Adverse Cardiovascular Events (MACE) by hs-cTnT Group (N = 155)

Event	Tertile 1 (n=52)	Tertile 2 (n=51)	Tertile 3 (n=52)	p-value
Any MACE, n (%)	8 (15.4)	17 (33.3)	35 (67.3)	<0.001
Composite endpoint: death/MI/HF, n (%)	6 (11.5)	13 (25.5)	28 (53.8)	<0.001
Length of hospital stay, days, mean ± SD	4.1 ± 1.6	5.2 ± 2.0	7.1 ± 2.5	<0.001

DISCUSSION

This prospective study proves that a high level of high-sensitivity cardiac troponin-T (hs-cTnT) is highly related to poor outcomes in patients presenting with non-ST elevation myocardial infarction. Patients with greater hs-cTnT across tertiles were older and more diabetic, with lower left ventricular ejection fraction, and were higher in Killip class presentation. Such baseline differences indicate that a higher hs-cTnT might be indicative of a more comorbid subgroup with more severe cardiac dysfunction during admission. We find a strong correlation between hs-cTnT level and clinical severity. Systolic blood pressure was much lower in the highest-tertile patients, heart rates were increased, chest pain lasted longer, and ischemic ECG changes were more common. This agrees with other previous studies, which have documented that an increased hs-cTnT depicts the severity of a myocardial infarction and the hemodynamic impairment of the ischemia[14,15]. Hs-cTnT levels were also closely connected with in-hospital outcomes. Recurrent ischemia, heart failure needing therapy, arrhythmias, urgent revascularization, and mortality were all significantly greater in the highest tertile. As an example, the in-hospital death was found in 17.3% of high hs-cTnT patients, whereas it was 1.9% in low group. This progressive gradient is similar to other studies that have repeatedly demonstrated that patients with elevated troponin concentrations are under a significantly greater risk of experiencing short-term complications[16,17].

Major adverse cardiovascular events (MACE) also increased dramatically with a higher hs-cTnT with 2/3 of patients in the highest tertile affected versus 15% in the lowest tertile. The duration of stay in hospitals also improved in parallel with four days in the low group and seven days in the high group. These results align with prior studies, which found hs-cTnT to be a predictor of MACE and prolonged hospitalization, therefore, showing its value in early risk stratification[18]. Multivariable analysis validated hs-cTnT as the best independent predictor of in-hospital MACE with patients in the highest tertile being at a greater risk, more than three-fold higher than the lowest tertile. The other independent predictors were advanced age, diabetes and increased Killip class as well as decreased left ventricular ejection fraction. These findings support the gradual prognostic worth of hs-cTnT, despite the amendments of conventional risk factors. Past studies have also highlighted that hs-cTnT can predictively enhance the predictive value of clinical variables; and its inclusion in existing risk models enhance the latter[19,20]. These findings are clinically significant. Early detection of the high-risk patients will enable the management of the patients on a case-by-case basis through enhanced monitoring, vigorous medical treatment, and the fact that the early invasive intervention should be considered. In resource-constrained environments, in which more complex risk scores are not necessarily practical, hs-cTnT provides a convenient, ubiquitous biomarker with high prognostic capability. The strengths of the study are that it is designed prospectively, standardized high-sensitivity assays and a comprehensive evaluation of both clinical and lab variables. Nevertheless, some of the limitations have to be admitted. The researchers carried out the research in one facility and the sample was rather small which can restrict external validity. Only in-hospital follow-up was limited to assess the prognostic value in the long term. Also, patients with chronic kidney disease were not included; however, subclinical renal impairment could have affected the level of troponin.

CONCLUSION

It is concluded that high-sensitivity cardiac troponin-T is a powerful prognostic biomarker in patients with non-ST elevation myocardial infarction. Elevated hs-cTnT levels were significantly associated with older age, diabetes, reduced left ventricular function, and higher Killip class at admission. Patients with higher hs-cTnT experienced greater rates of recurrent ischemia, heart failure, arrhythmias, urgent revascularization, and in-hospital mortality. The incidence of major adverse cardiovascular events and prolonged hospital stay also rose in parallel with troponin elevation.

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