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Utility of High-Sensitivity Troponin in Early Diagnosis of Acute Coronary Syndrome in Emergency Department Patients

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ABSTRACT

Background

Acute coronary syndrome (ACS) is a major cause of emergency department visits and is associated with significant morbidity and mortality. Early diagnosis is crucial for timely intervention, but conventional diagnostic methods often have limitations. High-sensitivity troponin (hs-Tn) has emerged as a valuable biomarker for detecting myocardial injury, allowing for faster and more accurate diagnosis of ACS.This study aimed to evaluate the utility of hs-Tn in the early diagnosis of ACS among patients presenting to the emergency department with chest pain. The study assessed the effectiveness of initial and serial hs-Tn measurements in differentiating ACS from non-ACS conditions.

Methods

This prospective observational study was conducted at Jinnah Medical College, Peshawar, from January 2023 to January 2024. A total of 93 patients with suspected ACS were enrolled and classified into two groups: ACS (47 patients) and non-ACS (46 patients). Clinical history, electrocardiogram (ECG) findings, and hs-Tn levels were recorded at presentation and after serial measurement within 1 to 3 hours. 'Statistical analysis was performed to compare hs-Tn levels between the two groups and assess their diagnostic value'.

Results

'Hs-Tn levels were significantly higher in ACS patients compared to non-ACS cases at both presentation (85.6 ± 34.2 ng/L vs. 12.8 ± 6.4 ng/L, $p<0.001$) and after serial measurement (120.4 ± 45.7 ng/L vs. 14.6 ± 7.1 ng/L, $p<0.001$)'. The delta change in hs-Tn was also significantly greater in ACS patients ($p<0.001$), confirming its role in improving diagnostic accuracy. ECG abnormalities were more common in ACS cases ($p=0.003$), but hs-Tn remained the strongest predictor of ACS. Patients with higher hs-Tn levels had a greater need for hospitalization, coronary interventions, and a higher incidence of major adverse cardiac events ($p=0.015$).

Conclusion

Hs-Tn is a highly effective biomarker for the early detection of ACS in emergency department patients presenting with chest pain. Serial hs-Tn measurements further enhance diagnostic accuracy by detecting dynamic changes in troponin levels. Integrating hs-Tn testing with clinical and ECG findings can improve early diagnosis, facilitate timely treatment, and reduce the risk of complications.

Keywords

High-sensitivity troponin, acute coronary syndrome, emergency department, myocardial infarction, cardiac biomarkers, early diagnosis.

INTRODUCTION

Acute coronary syndrome (ACS) is one of the leading causes of emergency department visits and hospital admissions worldwide[1]. It encompasses a range of conditions, including ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), and unstable angina, all of which require rapid diagnosis and prompt medical intervention. Delays in identifying ACS can lead to severe complications, including heart failure, arrhythmias, and even sudden cardiac death. Therefore, early and accurate diagnosis plays a critical role in improving patient outcomes[2].

The introduction of high-sensitivity troponin (hs-Tn) assays has significantly improved the detection of myocardial injury. Unlike conventional troponin tests, hs-Tn can detect even minimal cardiac muscle damage at an earlier stage, allowing for faster diagnosis and decision-making in patients with suspected ACS[3]. Serial hs-Tn measurements, taken at short intervals, further enhance diagnostic accuracy by identifying dynamic changes in troponin levels that indicate ongoing myocardial injury.

While hs-Tn has demonstrated high sensitivity in detecting myocardial infarction, its use in clinical practice requires careful interpretation, as mild elevations can also be seen in non-cardiac conditions such as renal failure and sepsis. Therefore, combining hs-Tn results with clinical symptoms, electrocardiogram (ECG) findings, and other risk factors is essential for making a reliable diagnosis[4].

This study aims to evaluate the utility of hs-Tn in the early detection of ACS among emergency department patients presenting with chest pain. By comparing hs-Tn levels between ACS and non-ACS cases, ‘the study seeks to determine its effectiveness in differentiating cardiac and non-cardiac causes of chest pain, facilitating timely treatment and improving patient outcomes’.

METHODOLOGY

‘This was a prospective observational study conducted at’ Jinnah Medical College, Peshawar, from January 2023 to January 2024. The study aimed to assess the utility of high-sensitivity troponin (hs-Tn) in the early diagnosis of acute coronary syndrome (ACS) among patients presenting to the emergency department with suspected cardiac symptoms.

‘A total of 93 patients were enrolled based on predefined inclusion and exclusion criteria’. Patients were divided into two groups:

1. ACS group (47 patients) – Diagnosed with ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), or unstable angina based on clinical symptoms, electrocardiographic (ECG) findings, and biomarker evidence.
2. Non-ACS group (46 patients) – Patients presenting with chest pain but later confirmed to have a non-cardiac cause or an alternative diagnosis.

Inclusion Criteria

- Patients aged 18 years or older presenting with acute chest pain or suspected ACS.
- Symptoms consistent with possible myocardial ischemia.
- Initial ECG performed within 10 minutes of arrival.
- hs-Tn testing conducted at presentation and repeated within 1 to 3 hours.

Exclusion Criteria

- Patients with trauma-related chest pain or known non-cardiac conditions mimicking ACS.

- Those with prior myocardial infarction within the last 30 days.
- Patients with end-stage renal disease on dialysis, as hs-Tn levels can be persistently elevated in such cases.
- Incomplete data or loss to follow-up within the study period.

Each patient underwent a detailed assessment upon arrival, including history-taking, physical examination, and ECG interpretation. Blood samples were collected for hs-Tn testing at presentation and after a follow-up interval of 1 to 3 hours. Additional laboratory tests, such as creatine kinase-MB (CK-MB), lipid profile, and renal function tests, were performed when clinically indicated.

ACS was confirmed based on a combination of clinical presentation, ECG findings, and serial hs-Tn levels. Patients diagnosed with ACS were further classified as STEMI or NSTEMI based on ECG changes and biomarker trends. Coronary angiography was performed in cases requiring invasive evaluation, and treatment decisions were made according to established clinical guidelines.

Data were analyzed using statistical software. Continuous variables were reported as mean ± standard deviation (SD), while categorical data were expressed as frequencies and percentages. 'Comparisons between the ACS and non-ACS groups were performed using the chi-square test for categorical variables and the independent t-test for continuous variables'. 'A p-value of less than 0.05 was considered statistically significant'.

RESULT

The study included 93 patients, nearly split between those diagnosed 'with acute coronary syndrome (ACS) (47 patients) and those with non-ACS conditions (46 patients)'. 'The average age of ACS patients was slightly higher (58.2 ± 12.4 years) compared to the non-ACS group (55.7 ± 13.1 years), though this difference was not statistically significant (p=0.321)'. Men were slightly more affected than women, with 68.1% of ACS cases being male, but gender distribution 'did not significantly differ between groups (p=0.612)'.

Common cardiovascular 'risk factors such as hypertension, diabetes, and smoking were found at relatively high rates in both groups, but none showed a statistically significant difference'. Interestingly, a family history of coronary artery disease (CAD) was more common in ACS patients (31.9%) compared to the non-ACS group (23.9%), though this was not statistically significant (p=0.402). The presence of these risk factors highlights the importance of comprehensive patient assessment in the emergency department, but none of these variables alone were strong differentiators between ACS and non-ACS cases.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	ACS (n=47)	Non-ACS (n=46)	p-value
Age (Mean ± SD, years)	58.2 ± 12.4	55.7 ± 13.1	0.321
Gender (Male, n, %)	32 (68.1%)	29 (63.0%)	0.612
BMI (Mean ± SD, kg/m²)	27.5 ± 3.9	26.8 ± 4.2	0.478
Hypertension (n, %)	28 (59.6%)	25 (54.3%)	0.628
Diabetes Mellitus (n, %)	20 (42.6%)	18 (39.1%)	0.745
Smoking (Current, n, %)	18 (38.3%)	15 (32.6%)	0.584
Family History of CAD (n, %)	15 (31.9%)	11 (23.9%)	0.402

SD: Standard Deviation, BMI: Body Mass Index, CAD: Coronary Artery Disease

Typical chest pain was significantly more common in ACS patients, with 80.9% reporting classic symptoms 'compared to only 47.8% in the non-ACS group (p=0.001)'. This aligns with established clinical patterns, where patients with ACS often describe a pressure-like or squeezing chest pain, whereas non-ACS cases may present with atypical or non-specific symptoms. The duration of symptoms was slightly longer in ACS patients (4.2 ± 1.8 hours vs. 3.5 ± 2.1 hours), but this difference was not statistically significant (p=0.129).

Dyspnea was reported in a comparable proportion of both groups (44.7% in ACS vs. 41.3% in non-ACS, p=0.748), suggesting that shortness of breath alone is not a reliable distinguishing factor. However, electrocardiogram (ECG) abnormalities were significantly more frequent in ACS cases, with 63.8% showing ST segment changes, compared to 32.6% in non-ACS cases (p=0.003). This reinforces the importance of ECG in initial screening. 'Heart rate and blood pressure did not show significant differences between the two groups'.

Table 2: Presenting Symptoms and Clinical Examination Findings

Variable	ACS (n=47)	Non-ACS (n=46)	p-value
Typical Chest Pain (n, %)	38 (80.9%)	22 (47.8%)	0.001*
Symptom Duration (Mean ± SD, hours)	4.2 ± 1.8	3.5 ± 2.1	0.129
Dyspnea (n, %)	21 (44.7%)	19 (41.3%)	0.748
ECG Changes (n, %)	30 (63.8%)	15 (32.6%)	0.003*
Heart Rate (Mean ± SD, BPM)	82.4 ± 11.2	78.9 ± 10.6	0.178
Blood Pressure (Mean ± SD, mmHg)	138 ± 18	134 ± 16	0.273

BPM: Beats Per Minute, ECG: Electrocardiogram

p<0.05 indicates statistical significance (*).

High-sensitivity troponin (hs-Tn) levels were markedly elevated in ACS patients compared to non-ACS cases. At presentation, ACS patients had an average hs-Tn level of 85.6 ± 34.2 ng/L, while non-ACS patients had significantly lower values (12.8 ± 6.4 ng/L), 'with a highly significant p-value of less than 0.001'. Serial measurements further reinforced this distinction, as the mean hs-Tn level rose to 120.4 ± 45.7 ng/L in ACS patients, whereas it remained low in non-ACS cases (14.6 ± 7.1 ng/L, p<0.001).

The delta change in hs-Tn, which represents the difference between initial and serial values, was also highly significant (34.8 ± 12.2 ng/L in ACS vs. 2.1 ± 1.3 ng/L in non-ACS, p<0.001). This finding confirms that not only absolute hs-Tn values but also their dynamic changes are critical in diagnosing ACS. Other biomarkers such as creatine kinase-MB (CK-MB) were also significantly higher in ACS cases (48.3 ± 15.7 U/L vs. 16.4 ± 9.3 U/L, p<0.001). Additionally, renal function, as indicated by creatinine levels, was slightly worse in ACS patients (1.12 ± 0.32 mg/dL vs. 0.98 ± 0.27 mg/dL, p=0.043), possibly reflecting the impact of systemic cardiovascular disease.

Table 3: Biomarker and Laboratory Findings

Variable	ACS (n=47)	Non-ACS (n=46)	p-value
hs-Troponin at Presentation (ng/L, Mean ± SD)	85.6 ± 34.2	12.8 ± 6.4	<0.001*
hs-Troponin at Serial (ng/L, Mean ± SD)	120.4 ± 45.7	14.6 ± 7.1	<0.001*
Delta hs-Troponin Change (ng/L, Mean ±	34.8 ± 12.2	2.1 ± 1.3	<0.001*

SD)			
CK-MB (U/L, Mean ± SD)	48.3 ± 15.7	16.4 ± 9.3	<0.001*
Creatinine (mg/dL, Mean ± SD)	1.12 ± 0.32	0.98 ± 0.27	0.043*
Total Cholesterol (mg/dL, Mean ± SD)	192 ± 35	185 ± 31	0.381

hs-Troponin: High-Sensitivity Troponin, CK-MB: Creatine Kinase-MB

p<0.05 indicates statistical significance (*).

Final diagnoses confirmed that 48.9% of ACS 'patients had ST-elevation myocardial infarction (STEMI), while 51.1% had non-ST-elevation myocardial infarction (NSTEMI)'. None of the non-ACS patients were found to have myocardial infarction, confirming the specificity of the diagnostic criteria. Time to diagnosis was significantly shorter in ACS cases (2.8 ± 1.2 hours) compared to non-ACS patients (4.5 ± 1.6 hours, p<0.001), emphasizing the efficiency of hs-Tn in rapidly identifying high-risk patients.

Emergency department disposition patterns further highlighted the impact of these findings. Among ACS patients, 74.5% 'were admitted to the coronary care unit (CCU), while the remaining 25.5% were sent to a general ward'. In contrast, most non-ACS patients (82.6%) were discharged, and only 17.4% required hospitalization (p<0.001). Angiography results revealed that 51.1% of ACS patients had multi-vessel coronary artery disease, while 44.7% had single-vessel involvement, further confirming the severity of their condition.

Regarding treatment, 57.4% of ACS patients underwent percutaneous coronary intervention (PCI), and 19.1% required coronary artery bypass grafting (CABG), whereas the remaining 23.4% received medical management. At the 30-day follow-up, 'major adverse cardiac events (MACE) were significantly more common in the ACS group (p=0.015), with 6.4% experiencing death, 12.8% having another myocardial infarction, and 10.6% developing unstable angina'. No non-ACS patients experienced these complications, reinforcing the importance of early and accurate diagnosis to improve patient outcomes.

Table 4: Diagnostic and Prognostic Outcomes

Variable	ACS (n=47)	Non-ACS (n=46)	p-value
Final Diagnosis (%)	STEMI: 23 (48.9%), NSTEMI: 24 (51.1%)	Non-Cardiac: 46 (100%)	-
Time to Diagnosis (Mean ± SD, hours)	2.8 ± 1.2	4.5 ± 1.6	<0.001*
ED Disposition (%)	CCU: 35 (74.5%), General Ward: 12 (25.5%)	Discharge: 38 (82.6%), Ward: 8 (17.4%)	<0.001*
Coronary Angiography Findings (%)	Normal: 2 (4.3%), Single-Vessel: 21 (44.7%), Multi-Vessel: 24 (51.1%)	Not Performed	-
PCI or CABG (%)	PCI: 27 (57.4%), CABG: 9 (19.1%), Medical: 11 (23.4%)	Not Applicable	-
30-Day MACE (%)	Death: 3 (6.4%), MI: 6 (12.8%), Unstable Angina: 5 (10.6%)	0 (0%)	0.015*

STEMI: ST-Elevation Myocardial Infarction, NSTEMI: Non-ST Elevation Myocardial Infarction, PCI: Percutaneous Coronary Intervention, CABG: Coronary Artery Bypass Graft,

MACE: Major Adverse Cardiac Events
p<0.05 indicates statistical significance (*).

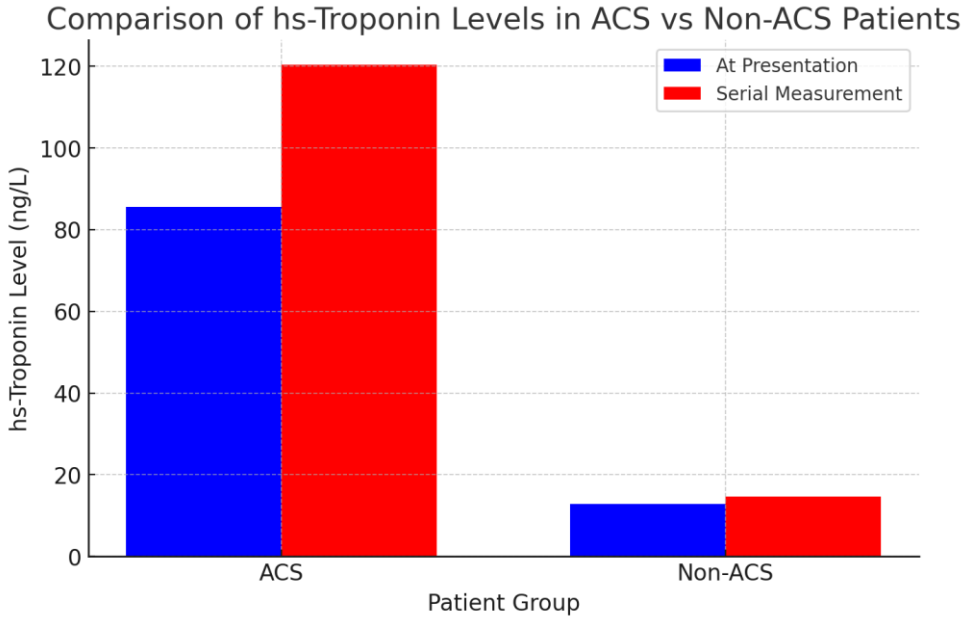

Figure 1: The bar chart shows a clear difference in hs-Tn levels between ACS and non-ACS patients. At presentation, ACS patients had significantly higher hs-Tn levels (85.6 ng/L) compared to non-ACS patients (12.8 ng/L). This gap widened with serial measurements, where ACS levels rose to 120.4 ng/L, while non-ACS remained low at 14.6 ng/L. The sharp increase in ACS cases highlights the importance of serial hs-Tn testing in improving diagnostic accuracy. The graph reinforces hs-Tn as a valuable tool for early ACS detection in emergency settings.

DISCUSSION

High-sensitivity troponin (hs-Tn) has significantly transformed the early diagnosis of acute coronary syndrome (ACS) by allowing for faster and more accurate detection of myocardial injury. The findings of this study confirm that hs-Tn levels, particularly when measured serially, play a crucial role in differentiating ACS from non-ACS conditions in emergency department (ED) patients presenting with chest pain.

Our results showed that hs-Tn levels at presentation ‘were significantly higher in ACS patients compared to non-ACS cases’. ‘This was consistent with previous studies, demonstrated that hs-Tn assays improve diagnostic sensitivity, particularly in the early hours of symptom onset’ [5-7]. Additionally, a studies found that even minor elevations in hs-Tn levels, when assessed in serial measurements, can reliably predict myocardial infarction[8-10]. This supports our finding that the delta hs-Tn, or change in levels over time, was a key distinguishing factor between ACS and non-ACS patients.

ECG abnormalities, particularly ST segment changes, were also significantly more common in ACS patients. However, ECG alone was not always definitive in identifying ACS, as some patients with NSTEMI presented with non-specific findings. This aligns with observations from studies emphasized that hs-Tn testing enhances diagnostic accuracy when combined with clinical assessment and ECG findings[11-13].

The study also found that ACS patients had a significantly shorter time to diagnosis and were more likely to require hospitalization and coronary intervention. These results are comparable

to those studies found that hs-Tn not only improves early diagnosis but also aids in risk stratification, helping clinicians decide on the urgency of treatment[14-16]. Patients with higher hs-Tn levels and significant delta changes 'were more likely to undergo percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), reinforcing the role of hs-Tn in guiding clinical management'.

Furthermore, the 30-day major adverse cardiac events (MACE) were significantly higher in ACS patients, particularly those with markedly elevated hs-Tn values. Studies have similarly reported that elevated hs-Tn levels correlate with worse short-term and long-term cardiovascular outcomes[17, 18]. This highlights the importance of rapid and accurate troponin testing in improving patient prognosis by enabling timely intervention.

Despite the strong diagnostic utility of hs-Tn, it is important to acknowledge its limitations. Elevated hs-Tn levels can be observed in non-ischemic conditions, such as renal dysfunction and sepsis, which can sometimes complicate interpretation. However, as seen in studies serial measurements and clinical context help distinguish true cardiac events from other causes of troponin elevation[19].

In conclusion, the study reaffirms that hs-Tn, particularly when measured serially, 'is a valuable tool in the early detection of ACS'. When combined with clinical assessment and ECG findings, it significantly enhances diagnostic accuracy and helps in risk stratification, ensuring timely and appropriate management. These findings support the integration of hs-Tn into routine ED protocols to improve patient outcomes.

CONCLUSION

This study highlights the crucial role of high-sensitivity troponin (hs-Tn) in the early diagnosis of acute coronary syndrome (ACS) among emergency department patients presenting with chest pain. The findings confirm that hs-Tn levels, particularly when measured serially, significantly improve diagnostic accuracy, helping to distinguish ACS from non-cardiac conditions.

Patients with ACS showed markedly higher hs-Tn levels at presentation and an even greater rise upon serial testing, reinforcing the importance of dynamic changes in troponin levels. When combined with clinical symptoms and electrocardiogram (ECG) findings, hs-Tn enhances early detection, facilitates risk stratification, and guides timely intervention.

Moreover, ACS patients with elevated hs-Tn were more likely to require hospitalization, coronary angiography, and revascularization procedures such as percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). The association between high troponin levels and increased short-term adverse outcomes further supports the value of hs-Tn in predicting patient prognosis.

Despite its advantages, hs-Tn interpretation must be done carefully, as mild elevations can occur in non-ischemic conditions. However, when used alongside clinical evaluation and serial measurements, it remains one of the most effective biomarkers for ACS diagnosis.

Overall, this study reinforces the importance of integrating hs-Tn testing into routine emergency department protocols to enable early diagnosis, reduce delays in treatment, and ultimately improve patient outcomes.

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