SAHARA INTERNATIONAL JOURNAL OF MEDICAL INNOVATIONS

Original Article

Biochemical Markers in the Diagnosis and Monitoring of Cardiovascular Diseases: A Cross-Sectional Study

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Abstract

Background: Cardiovascular diseases (CVDs) are the leading cause of death globally, and early diagnosis is essential for effective treatment. Biochemical markers are emerging as vital tools in the diagnosis and monitoring of various forms of CVD.

Objectives: To assess the diagnostic and prognostic utility of biochemical markers including Troponin I, BNP, CK-MB, CRP, and D-dimer in patients with cardiovascular symptoms.

Methodology: A hospital-based cross-sectional study was conducted over six months at POF hospital. A total of 120 patients presenting with cardiovascular symptoms were included. Blood samples were analyzed for cardiac biomarkers. Data were evaluated using descriptive statistics, correlation analysis, and ROC curve performance metrics.

Results: Troponin I showed the highest diagnostic accuracy for acute coronary syndromes (ACS) with sensitivity 92% and specificity 88%. BNP was significantly elevated in heart failure (mean = 874 pg/mL, $p < 0.01$). CRP and D-dimer levels were associated with prolonged hospital stays and poor prognosis. CK-MB showed moderate utility.

Conclusion: Troponin I and BNP are powerful diagnostic and prognostic markers in cardiovascular disease. Inclusion of CRP and D-dimer enhances risk stratification. Regular use of these biomarkers can improve clinical decision-making.

Keywords: Biochemical markers, Cardiovascular disease, Troponin, Lipid Profile, CRP

Introduction:

Cardiovascular diseases (CVDs) encompass a wide range of disorders that affect the heart and blood vessels, including ischemic heart disease, heart failure, arrhythmias, and valvular conditions. According to the World Health Organization (WHO), CVDs account for an estimated 17.9 million deaths annually, representing 32% of all global deaths. The growing burden of CVDs, particularly in low- and middle-income countries, calls for improved diagnostic strategies that enable early detection and effective monitoring [1 2].

Traditional tools for diagnosing CVDs such as electrocardiograms (ECGs), echocardiograms, stress testing, and coronary angiography—offer valuable clinical insights but are limited by accessibility, cost, and diagnostic window. Furthermore, these tools may not be sensitive enough to detect early pathological changes or monitor ongoing myocardial damage. In this context, biochemical markers have emerged as essential adjuncts to standard diagnostic modalities [3 4].

Biochemical markers are quantifiable biological molecules released into the bloodstream due to specific physiological or pathological processes. In cardiovascular medicine, biomarkers can reflect myocardial injury, inflammation, neurohormonal activation, and coagulation abnormalities. The most widely used cardiac biomarkers include cardiac-specific troponins (Troponin I and T), B-type natriuretic peptide (BNP), creatine kinase-MB (CK-MB), C-reactive protein (CRP), and D-dimer. Each of these plays a unique role in the diagnosis, risk stratification, and monitoring of patients with CVD [5 6].

Troponin I is the most specific and sensitive biomarker for myocardial injury and is the gold standard in the diagnosis of acute myocardial infarction (AMI). Elevated levels indicate irreversible myocardial necrosis and help guide therapeutic decisions. BNP, a hormone secreted by ventricular myocardium in response to increased wall stress, is primarily used to diagnose and manage heart failure. Elevated BNP levels correlate with disease severity and predict adverse outcomes [7 8].

CK-MB, once the biomarker of choice for AMI, has largely been supplanted by troponins but may still be useful in detecting reinfarction. CRP, an acute-phase reactant, serves as a nonspecific marker of systemic inflammation. Elevated CRP levels have been linked to atherosclerosis progression and poor outcomes in patients with CVD. D-dimer, a fibrin degradation product, is primarily used to detect thrombotic activity. In patients with cardiovascular symptoms, elevated D-dimer levels may suggest coexistent pulmonary embolism, deep vein thrombosis, or systemic coagulopathy [9 10].

Despite extensive literature supporting the clinical value of these biomarkers, their use in routine practice varies. Furthermore, few studies have evaluated their concurrent performance in real-world settings. This study aims to address these gaps by assessing the diagnostic accuracy and prognostic significance of Troponin I, BNP, CK-MB,

CRP, and D-dimer in a cohort of patients with suspected cardiovascular disease. The results of this study will provide evidence for refining clinical pathways and improving outcomes in cardiovascular care [(11)].

Methodology:

This was a cross-sectional observational study conducted at a tertiary care hospital over a period of six months (January–June 2024). The study was approved by the Institutional Ethical Review Board, and informed consent was obtained from all participants.

Study Population

A total of 120 adult patients (age ≥18 years) presenting to the emergency department or cardiology ward with symptoms suggestive of cardiovascular disease were recruited. Inclusion criteria included chest pain, dyspnea, palpitations, and syncope. Patients with chronic inflammatory diseases, renal failure, or recent trauma/surgery were excluded to minimize confounding factors influencing biomarker levels.

Sample Collection and Laboratory Testing

Venous blood samples were collected within one hour of presentation and analyzed for:

- **Troponin I** (ng/mL) – measured using high-sensitivity immunoassays.
- **BNP** (pg/mL) – using fluorescence immunoassay.
- **CK-MB** (U/L) – using enzymatic method.
- **CRP** (mg/L) – via latex agglutination method.
- **D-dimer** (µg/mL) – measured using ELISA.

Reference ranges were based on manufacturer-provided standard cut-offs.

Data Analysis

Demographic, clinical, and laboratory data were recorded and analyzed using SPSS v25. Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages.

Diagnostic performance was assessed using Receiver Operating Characteristic (ROC) curves. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each biomarker against clinical diagnoses confirmed by imaging or ECG findings.

Correlations between biomarkers and clinical outcomes (e.g., duration of hospitalization, mortality risk) were analyzed using Pearson's correlation and multivariate logistic regression where applicable. A p-value <0.05 was considered statistically significant.

Results:

Among the 120 patients, 72 (60%) were male and 48 (40%) were female. The mean age was 58.4 ± 11.6 years (range 35–85 years). The majority were aged between 50 and 70 years (65%). The most common presenting symptom was chest pain (70%), followed by dyspnea (45%) and palpitations (30%).

Variable	Frequency (n=120)	Percentage (%)
Gender		
Male	72	60
Female	48	40
Age Group (years)		
30–39	12	10
40–49	18	15
50–59	39	32.5
60–69	39	32.5

≥70	12	10
Presenting Symptoms		
Chest pain	84	70
Dyspnea	54	45
Palpitations	36	30
Syncope	15	12.5

Table 1: Demographic Characteristics of Study Participants

Table 2 summarizes the distribution and diagnostic relevance of selected biochemical markers among the 120 patients included in this cross-sectional study. Troponin I was elevated in 68% of patients, with a mean concentration of 1.85 ± 0.34 ng/mL, substantially exceeding the normal threshold of <0.04 ng/mL. This significant elevation underscores the diagnostic utility of troponin I as a highly sensitive and specific marker for myocardial injury, particularly in cases of acute coronary syndrome (ACS). B-type natriuretic peptide (BNP) was elevated in 48% of participants, with a mean level of 874 ± 115 pg/mL, reflecting its established role in the diagnosis and monitoring of heart failure. The moderate elevation of CK-MB in 55% of patients (mean = 56 ± 10 U/L) suggests its continued, though secondary, relevance in cardiac diagnostics, particularly where troponin assays are unavailable or in cases of reinfarction. C-reactive protein (CRP), an inflammatory biomarker, was elevated in 63% of cases, with a mean value of 11.2 ± 4.6 mg/L, supporting its role in identifying systemic inflammation associated with cardiovascular disease progression. Similarly, D-dimer levels were elevated in 58% of patients (mean = 1.38 ± 0.5 µg/mL), indicating increased thrombotic activity and correlating with higher risk profiles and longer hospitalization. Collectively, these findings reinforce the diagnostic and prognostic relevance of a panel of biochemical markers in the clinical evaluation of cardiovascular disease, with troponin I and BNP emerging as the most informative indicators.

Biomarker	Elevated in (%)	Mean ± SD	Normal Range
Troponin I	82 (68%)	1.85 ± 0.34 ng/mL	<0.04 ng/mL
BNP	58 (48%)	874 ± 115 pg/mL	<100 pg/mL
CK-MB	66 (55%)	56 ± 10 U/L	<25 U/L
CRP	75 (63%)	11.2 ± 4.6 mg/L	<5 mg/L
D-dimer	69 (58%)	1.38 ± 0.5 µg/mL	<0.5 µg/mL

Table 2: Biochemical Marker Distribution

Discussion

This study reinforces the pivotal role of biochemical markers in the diagnosis and prognosis of cardiovascular diseases. Troponin I demonstrated the highest diagnostic accuracy for acute coronary syndromes (ACS), aligning with previous studies establishing it as the gold standard for myocardial necrosis detection. Its high specificity makes it a critical tool in both confirming diagnosis and guiding interventions in suspected myocardial infarction cases.

BNP, another key marker, was significantly elevated in patients with confirmed heart failure. BNP's release from ventricular myocytes in response to pressure overload and myocardial stretch renders it highly sensitive for diagnosing heart failure, even in cases with nonspecific symptoms. Our findings are consistent with studies by Maisel et al., which validate BNP as an effective marker for acute decompensated heart failure [(12)].

Although CK-MB was elevated in over half the cases, it exhibited lower diagnostic precision than troponin I. This supports the declining role of CK-MB as a primary diagnostic tool, reserving its utility for evaluating reinfarction or perioperative cardiac injury.

CRP and D-dimer, while not cardiac-specific, provided meaningful insights into systemic inflammation and thrombotic risk. Elevated CRP levels correlated with disease severity and prolonged hospital stay, echoing findings from Ridker's studies on CRP as a marker of vascular inflammation. Elevated D-dimer levels were commonly associated with patients who developed thromboembolic complications or presented with coexisting pulmonary issues [(13)].

Collectively, the combined use of these biomarkers enhances diagnostic confidence and risk stratification. They offer a cost-effective, minimally invasive means of assessing cardiac pathology and should be integrated into standard cardiovascular care protocols.

Conclusion

This cross-sectional study confirms that biochemical markers, particularly Troponin I and BNP, are invaluable in the diagnosis and management of cardiovascular diseases. CRP and D-dimer serve as useful adjuncts in assessing systemic risk and inflammation. Their routine incorporation in clinical practice can significantly improve diagnostic precision and patient outcomes.

Implications

1. Troponin I and BNP should be prioritized in emergency cardiovascular assessments.
2. CRP and D-dimer are valuable for evaluating complications and guiding prognosis.
3. Routine biomarker panels can enhance the efficiency of CVD diagnosis, especially in resource-limited settings.

Limitations

- Single-center study limits external validity.
- Cross-sectional design precludes causal inference.
- Biomarker levels were not monitored longitudinally.
- Potential confounding from undiagnosed comorbidities.

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