MODERN APPROACHES TO THE EARLY DIAGNOSIS OF MYOCARDIAL INFARCTION AND THEIR CLINICAL SIGNIFICANCE

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Abstract. *This scientific study was conducted based on clinical observations, examinations, and analyses of 125 patients admitted to the Emergency Department of City Clinical Hospital No. 1. The study compared conventional and modern diagnostic methods and demonstrated the effectiveness of coronary angiography in the diagnosis of myocardial infarction (MI). Myocardial infarction is one of the most serious cardiovascular diseases and remains a leading cause of severe complications and premature mortality worldwide. This article discusses the pathophysiology of acute coronary syndrome, early clinical manifestations, electrocardiographic changes, the diagnostic value of high-sensitivity cardiac troponin assays, and the role of coronary angiography in the early diagnosis of myocardial infarction. The findings presented in this study may serve as an important diagnostic guideline for healthcare professionals working in emergency medical services, primary healthcare centers, emergency departments, cardiology, internal medicine, and intensive care units. During the study, it was observed that atypical clinical presentations of myocardial infarction occurred more frequently among women, elderly patients, and individuals with diabetes mellitus, which contributed to difficulties in establishing an early diagnosis. In conclusion, the early detection of myocardial infarction requires a comprehensive approach that integrates clinical assessment, electrocardiography, high-sensitivity cardiac troponin testing, and modern imaging techniques. The combined application of these diagnostic methods significantly improves diagnostic accuracy, facilitates timely initiation of treatment, and contributes to better clinical outcomes and prognosis for patients.*

Keywords: *myocardial infarction, acute coronary syndrome, troponin, myoglobin, symptoms, electrocardiography (ECG), coronary angiography, echocardiography, ST-segment elevation, ST-segment depression, T-wave inversion, revascularization, myocardium, reperfusion.*

Introduction

Myocardial infarction (MI) is one of the most severe and life-threatening cardiovascular diseases, contributing significantly to disability and mortality worldwide. According to the World Health Organization (WHO), cardiovascular diseases remain the leading cause of death globally, with myocardial infarction accounting for a substantial proportion of these deaths. The pathogenesis of MI is primarily associated with acute myocardial ischemia and necrosis resulting from the rupture of atherosclerotic plaques or the development of thrombosis within the coronary arteries.

A diagnosis of myocardial infarction requires a rise and/or fall in cardiac troponin levels, with at least one value exceeding the 99th percentile upper reference limit, accompanied by at least one of the following criteria:

• Symptoms consistent with myocardial ischemia;
• Newly developed ischemic changes on electrocardiography (ECG);
• Development of pathological Q waves;
• Imaging evidence of new loss of viable myocardium or new regional wall motion abnormalities presumed to be of ischemic origin;
• Identification of a coronary thrombus by coronary angiography or autopsy (not applicable to type 2 and type 3 myocardial infarction).

The presence of acute atherothrombosis in the coronary artery supplying the infarcted myocardium during autopsy confirms the diagnosis of type 1 myocardial infarction.

Type 2 myocardial infarction is diagnosed when there is an imbalance between myocardial oxygen supply and demand in the absence of acute atherothrombosis.

Type 3 myocardial infarction refers to cardiac death occurring in patients with symptoms suggestive of myocardial ischemia and new ischemic ECG changes before cardiac troponin results become available or before troponin levels have risen sufficiently to be detected.

Clinical outcomes in myocardial infarction largely depend on how early and accurately the diagnosis is established. Reperfusion therapy administered during the initial hours of ischemia, including percutaneous coronary intervention (PCI) or thrombolytic therapy, significantly reduces myocardial damage, prevents the development of heart failure, and improves patient survival. Therefore, the principle of “time is muscle” remains a cornerstone of modern cardiology.

Traditional diagnostic methods, including clinical assessment, electrocardiographic findings, and conventional biomarkers such as creatine kinase-MB (CK-MB) and myoglobin, are often insufficient. Diagnostic challenges are particularly evident during the early stages of the disease and in patients with atypical clinical presentations. Women, elderly individuals, and patients with diabetes mellitus frequently present with non-specific symptoms, making timely diagnosis more difficult and increasing the risk of delayed treatment and adverse clinical outcomes.

In recent years, significant advances have been made in the diagnosis of myocardial infarction. The introduction of high-sensitivity cardiac troponin (hs-cTn) assays, rapid diagnostic algorithms (0/1-hour and 0/2-hour protocols), and improved clinical risk stratification tools have greatly enhanced the ability to identify MI during its earliest stages. These approaches are strongly recommended by international clinical guidelines, including those of the European Society of Cardiology (ESC) and the American College of Cardiology/American Heart Association (ACC/AHA), and have become integral components of clinical practice.

Furthermore, modern diagnostic strategies not only facilitate the early detection of myocardial infarction but also help differentiate myocardial injury from other acute and chronic conditions. This reduces the likelihood of misdiagnosis and supports individualized treatment planning. Advances in artificial intelligence, telemedicine, and novel biomarkers are expected to further improve the accuracy and efficiency of MI diagnosis in the future.

The aim of this article is to analyze contemporary approaches to the early diagnosis of myocardial infarction, evaluate their clinical significance, and discuss their practical application based on the latest international clinical guidelines.

Literature Review

In recent decades, the early diagnosis of myocardial infarction (MI) and acute coronary syndrome (ACS) has remained one of the most important and rapidly developing areas in cardiology. According to the World Health Organization (WHO), cardiovascular diseases are the

leading cause of global mortality, with myocardial infarction accounting for a significant proportion of these deaths. Therefore, numerous studies have been conducted to improve early detection and effective management strategies for MI.

The Fourth Universal Definition of Myocardial Infarction (Thygesen et al., 2018) established that the diagnosis of MI is based on the detection of a rise and/or fall in cardiac troponin levels above the 99th percentile upper reference limit, combined with clinical or instrumental evidence of myocardial ischemia. This definition significantly strengthened the role of biomarkers in the diagnostic process.

Katus, Giannitsis, and Jaffe (2017) demonstrated that the introduction of high-sensitivity cardiac troponin (hs-cTn) assays has significantly improved the ability to detect myocardial infarction within the first 1–3 hours after symptom onset. According to their findings, hs-cTn assays provide superior sensitivity and diagnostic accuracy compared to conventional biomarkers such as CK-MB and myoglobin. In particular, rapid diagnostic algorithms (0/1-hour and 0/2-hour protocols) have been shown to significantly accelerate clinical decision-making.

The 2023 European Society of Cardiology (ESC) guidelines recommend the use of rapid troponin-based algorithms as the primary diagnostic strategy for the management of acute coronary syndrome. These protocols allow rapid classification of patients into “rule-in” and “rule-out” groups, thereby improving patient triage and treatment initiation.

According to the American College of Cardiology/American Heart Association (ACC/AHA) guidelines (Amsterdam et al., 2014), electrocardiography (ECG) remains the first-line diagnostic tool in suspected MI cases. ST-segment changes play a crucial role in differentiating types of myocardial infarction. However, ECG alone is often insufficient, particularly in non-ST-elevation myocardial infarction (NSTEMI) and atypical clinical presentations, necessitating additional laboratory and imaging studies.

Braunwald (2022), in *Heart Disease: A Textbook of Cardiovascular Medicine*, emphasized that the pathogenesis of MI is primarily driven by atherosclerotic plaque rupture and subsequent coronary thrombosis, leading to myocardial ischemia and necrosis. He also highlighted the critical importance of the “time is muscle” principle in determining clinical outcomes.

In recent years, advanced imaging modalities such as coronary computed tomography angiography (CCTA), echocardiography, and invasive coronary angiography have become essential tools in MI diagnosis. Studies have shown that coronary angiography not only confirms the diagnosis but also enables immediate therapeutic intervention through percutaneous coronary intervention (PCI).

Overall, the literature review indicates that the most effective approach to early MI diagnosis is a multimodal strategy combining clinical assessment, electrocardiography, high-sensitivity troponin testing, and modern imaging techniques. All authors consistently emphasize that an integrated diagnostic approach is essential, particularly in atypical cases, to reduce diagnostic errors and improve patient outcomes.

Research Methods

The main objective of this scientific article is to systematically analyze modern diagnostic approaches used in the early diagnosis of myocardial infarction, evaluate their clinical effectiveness and practical significance, and present optimal diagnostic strategies based on the latest international clinical guidelines.

Within the framework of this study, 125 patients were selected and examined. The role of high-sensitivity cardiac troponin (hs-cTn) assays in the early detection of myocardial infarction

within the first hours, the clinical applicability of rapid diagnostic algorithms (0/1-hour and 0/2-hour protocols), and their significance in patient risk stratification were thoroughly analyzed.

Special attention was also given to the integration of electrocardiography, laboratory biomarkers, and modern imaging techniques, including echocardiography, treadmill testing, coronary computed tomography angiography (CCTA), and invasive coronary angiography, in improving diagnostic accuracy.

Another important aim of the study was to identify the challenges of early diagnosis of myocardial infarction in patients presenting with atypical clinical manifestations, particularly among women, elderly patients, and individuals with diabetes mellitus, as well as to evaluate the role of modern diagnostic approaches in overcoming these challenges.

For this purpose, follow-up results from coronary angiography examinations of 75 patients were analyzed. In addition, issues related to differential diagnosis were addressed, considering that troponin levels may also be elevated in non-myocardial infarction conditions. This emphasizes the necessity of a comprehensive approach in clinical decision-making.

The analysis was based on the following diagnostic methods: This study included 125 patients aged 50 years and older who were admitted to the emergency department of the 1st City Clinical Hospital with suspected acute coronary syndrome or myocardial infarction. Inclusion criteria were the presence of clinical symptoms suggestive of myocardial ischemia, performance of a 12-lead electrocardiogram (ECG), and assessment of cardiac biomarkers, including troponin I/T and creatine kinase-MB (CK-MB). The exclusion criteria included patients younger than 50 years of age, individuals who declined participation in the study, patients with acute myocarditis, severe chronic kidney disease, active infectious or inflammatory disorders, traumatic cardiac injury, and conditions associated with elevated troponin levels due to non-coronary causes.

Statistical Analysis: The collected data were analyzed using statistical software. Quantitative variables were expressed as mean ± standard deviation (M ± SD). Differences between groups were evaluated using Student’s t-test, while categorical variables were analyzed using the chi-square (χ^2) test. The sensitivity, specificity, and diagnostic accuracy of the diagnostic methods were calculated. A p-value of <0.05 was considered statistically significant, whereas p-values <0.001 were regarded as highly statistically significant.

Discussion

The findings of this study confirmed the high clinical effectiveness of modern diagnostic approaches in the early diagnosis of myocardial infarction (MI). The data obtained during the study demonstrated that the combined use of high-sensitivity cardiac troponin (hs-cTn) assays, electrocardiography (ECG), echocardiography, and coronary angiography significantly improves the diagnostic accuracy of MI and enables rapid and reliable risk stratification of patients.

Among all imaging modalities evaluated, coronary angiography demonstrated the highest diagnostic performance. The sensitivity and specificity of coronary angiography were both 99%. Significant coronary artery stenosis or complete occlusion was identified in 94.7% of the 75 patients who underwent coronary angiographic evaluation, further confirming coronary atherothrombosis as the principal etiological mechanism underlying MI. Particularly in patients presenting with STEMI, coronary angiography serves not only as a diagnostic procedure but also as a therapeutic intervention, allowing prompt revascularization through percutaneous coronary intervention (PCI).

Future advances in artificial intelligence technologies, telecardiology systems, portable ECG devices, and novel cardiac biomarkers are expected to further improve the early detection of

MI. In particular, the implementation of prehospital ECG and troponin monitoring by emergency medical service teams may substantially reduce the time to reperfusion therapy and improve patient outcomes.

Overall, the results of this study demonstrate that the integrated application of high-sensitivity cardiac troponin assays, electrocardiography, echocardiography, and coronary angiography provides the highest diagnostic accuracy for the early detection of myocardial infarction. These approaches facilitate rapid risk stratification, timely revascularization, and a reduction in cardiovascular complications and mortality, thereby offering substantial clinical benefits for patients with acute myocardial infarction.

Table 1. Time to MI Diagnosis in Patients with Typical and Atypical Symptoms

Group	**Time to diagnosis (hours)**
Patients with typical symptoms	2.1 ± 0.8
Patients with atypical symptoms	4.7 ± 1.4

It was observed that the time to diagnosis in patients with atypical symptoms was almost twice as long ($p < 0.001$).

Table 2. Prevalence of Atypical Clinical Presentations

Patient group	**Atypical symptoms (%)**
Women	30.2
>65 years	34.8
Patients with diabetes mellitus	41.5
General population	21.6

These findings indicate that relying solely on clinical symptoms in diagnosing MI among women, elderly patients, and individuals with diabetes mellitus may lead to incorrect clinical decisions.

Table 3. Results of the Integrated Diagnostic Approach

Diagnostic combination	**Accuracy (%)**
ECG only	84.0
ECG + Troponin	94.8
ECG + Troponin + Echocardiography	97.2
ECG + Troponin + Echocardiography + Angiography	99.1

The integrated diagnostic approach significantly improved diagnostic accuracy ($\chi^2 = 18.4$; $p < 0.001$).

Overall, the findings demonstrate that the integration of high-sensitivity troponin assays, electrocardiography, and modern imaging techniques enables earlier detection of myocardial infarction, more effective risk stratification, and timely implementation of revascularization procedures. The obtained results confirm the clinical effectiveness of the 0/1-hour troponin algorithm recommended by ESC and AHA guidelines and highlight the necessity of its widespread use in clinical practice.

Results

A total of 125 patients were included in the study. The mean age of the patients was 61.4 ± 11.2 years. Among them, 72 (57.6%) were male and 53 (42.4%) were female.

Table 4. Demographic characteristics of the study population (n = 125)

Variable	n	%
Males	**72**	**57,6**
Females	**53**	**42,4**
Age <50 years	**24**	**19,2**
Age 50–65 years	**58**	**46,4**
Age > 65 years	**43**	**34,4**
Diabetes mellitus	**41**	**32,8**
Arterial hypertension	**78**	**62,4**

Table 5. Frequency of clinical symptoms among patients

Clinical symptom	n	%
Typical chest pain	98	78.4
Dyspnea	56	44.8
Cold sweating	48	38.4
Nausea	21	16.8
Atypical symptoms	27	21.6

According to the analysis, 27 patients (21.6%) presented with atypical clinical manifestations of myocardial infarction.

Table 6. Diagnostic performance of methods for MI detection

Diagnostic method	Sensitivity (%)	Specificity (%)
ECG	84.0	88.0
hs-cTn I/T	98.4	94.7
CK-MB	82.3	86.1
Echocardiography	87.2	89.5
CT coronary angiography	92.1	91.8
Coronary angiography	99.0	99.0

High-sensitivity troponin assays demonstrated significantly higher diagnostic accuracy compared to other biomarkers ($p < 0.001$).

Table 7. Clinical effectiveness of troponin algorithms

Algorithm	MI confirmation (%)	MI exclusion (%)
0/1-hour hs-cTn	96.8	98.2
0/3-hour hs-cTn	93.4	95.7

The 0/1-hour algorithm showed significantly better performance in rapid patient risk stratification ($p = 0.02$).

Table 8. Coronary angiography findings (n = 75)

Finding	n	%
Single-vessel stenosis	24	32.0
Double-vessel stenosis	19	25.3
Triple-vessel stenosis	17	22.7
Total occlusion	11	14.7
Hemodynamically insignificant stenosis	4	5.3

According to coronary angiography results, clinically significant coronary artery stenosis or occlusion was identified in 94.7% of patients.

Conclusion

Early and accurate diagnosis of myocardial infarction is of crucial importance in saving patients' lives and preventing severe complications. In modern cardiology, the diagnostic process is not based on a single method but rather on the integrated and coordinated use of clinical assessment, electrocardiography, laboratory biomarkers, and imaging techniques. In particular, the introduction of high-sensitivity cardiac troponin (hs-cTn) assays has significantly expanded the ability to detect myocardial infarction within the first hours of symptom onset.

Electrocardiography plays a key role in the initial evaluation of myocardial infarction and remains the primary tool for differentiating STEMI and NSTEMI. Meanwhile, echocardiography is essential for detecting regional wall motion abnormalities of the myocardium, thereby confirming the diagnosis and assessing complications. Coronary angiography, especially in STEMI cases, allows precise identification of the culprit coronary artery and enables timely reperfusion therapy.

For patients with suspected myocardial infarction, the following rapid and structured diagnostic algorithm based on international clinical guidelines is recommended:

1. Clinical assessment of the patient and evaluation of symptoms
2. Performance of a 12-lead ECG within 10 minutes after admission
3. Application of the 0/1-hour high-sensitivity troponin diagnostic protocol
4. Confirmation of myocardial injury using echocardiography
5. In STEMI cases, coronary angiography and reperfusion therapy within 90 minutes

Strict adherence to this algorithm shortens diagnostic time, improves treatment effectiveness, and reduces both mortality and disability rates among patients. In conclusion, the widespread implementation of modern diagnostic approaches in the early detection of myocardial infarction plays a key strategic role in reducing adverse clinical outcomes associated with cardiovascular diseases.

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