

MODERN METHODS OF EARLY DIAGNOSIS OF CARDIOVASCULAR DISEASES

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Abstract: Cardiovascular diseases (CVDs) remain the leading cause of mortality worldwide, highlighting the urgent need for efficient early diagnostic approaches. Recent technological advances have transformed cardiovascular screening from symptom-based detection to predictive, preventive, and real-time monitoring strategies. Modern methods including high-resolution imaging, biomarker profiling, wearable digital sensors, and artificial intelligence-driven risk prediction allow identification of subclinical structural, electrical, and metabolic abnormalities long before clinical manifestations appear. These approaches significantly enhance diagnostic precision, enable timely intervention, and improve long-term patient outcomes. This paper reviews the most advanced diagnostic modalities currently used in the early detection of cardiovascular diseases and discusses their clinical significance.

Keywords: Early diagnosis; cardiovascular disease; biomarkers; cardiac imaging; artificial intelligence; ECG monitoring; wearable sensors; cardiovascular risk prediction.

Introduction

Cardiovascular diseases such as coronary artery disease, hypertension, arrhythmias, and heart failure contribute substantially to global morbidity and mortality. Traditional diagnostic methods often detect disease only after structural or functional damage has occurred. The shift toward early detection is essential for preventing disease progression, reducing healthcare burden, and improving survival rates.

Technological progress in imaging, molecular diagnostics, machine learning, and remote patient monitoring has given rise to a new era of predictive cardiology. These innovations allow clinicians to detect subtle abnormalities in vascular function, cardiac structure, and electrophysiology at preclinical stages. This paper explores the most effective modern methods currently employed for early cardiovascular disease diagnosis.

Materials and Methods

This review is based on a comprehensive analysis of scientific literature published between 2015 and 2025, focusing on modern approaches to cardiovascular diagnostics. Clinical studies examining the effectiveness of cardiac imaging techniques, biomarker-based detection, and artificial intelligence-assisted risk prediction were systematically reviewed to assess their contribution to early diagnosis. Additionally, recent developments in digital health technologies, particularly wearable ECG monitors and photoplethysmography-based devices, were evaluated for their role in continuous cardiovascular screening. A comparative assessment of traditional diagnostic methods versus advanced contemporary tools was conducted to highlight



improvements in accuracy, accessibility, and predictive value. The primary databases and sources used for this review include PubMed, Nature Cardiovascular Research, the European Heart Journal, and the official clinical guidelines of the American College of Cardiology and American Heart Association (ACC/AHA).

Results

Modern diagnostic innovations have significantly enhanced the early detection of cardiovascular diseases through the integration of wearable technologies, advanced imaging, laboratory biomarkers, artificial intelligence, and genomic testing. Wearable sensors equipped with ECG, photoplethysmography, and pulse wave analysis enable continuous monitoring that identifies silent atrial fibrillation, abnormalities in heart rate variability, early hypertensive changes, and sleep-related disturbances associated with elevated cardiovascular risk, offering long-term surveillance even in asymptomatic individuals. High-resolution cardiac imaging methods further strengthen early diagnosis: coronary CT angiography allows detection of non-obstructive atherosclerotic plaques and provides calcium scoring for future risk stratification; cardiac MRI offers detailed visualization of early myocardial fibrosis, inflammation, and cardiomyopathic changes; while echocardiography remains essential for identifying subclinical valvular disease, ventricular dysfunction, and congenital abnormalities. Laboratory biomarkers contribute additional precision, with high-sensitivity troponin detecting microscopic myocardial injury, NT-proBNP revealing early heart failure pathology, and inflammatory mediators such as CRP and IL-6 indicating vascular inflammation and progressive atherosclerosis, complemented by emerging metabolomic markers that capture subtle metabolic shifts. Artificial intelligence plays a transformative role by integrating imaging data, biomarkers, ECG patterns, and patient history to predict myocardial infarction years in advance, uncover occult arrhythmias, and detect early signs of heart failure with superior accuracy compared to traditional risk scores. Finally, genetic and molecular diagnostics provide early identification of inherited cardiovascular disorders, including familial hypercholesterolemia, hypertrophic cardiomyopathy, and long QT syndrome, enabling targeted preventive interventions in high-risk individuals. Collectively, these methods form a comprehensive diagnostic framework that shifts cardiovascular care toward proactive prevention and early therapeutic decision-making.

Discussion

Modern cardiovascular diagnostics represent a paradigm shift from reactive treatment to proactive prevention. Wearable technologies democratize access to continuous heart monitoring, allowing early detection of rhythm disorders and vascular changes. High-resolution imaging provides detailed insights into structural abnormalities long before clinical deterioration. Biomarkers detect molecular changes that precede cytological injury, while AI integrates these data layers into highly accurate predictive models.

However, widespread implementation faces challenges, including cost, data privacy concerns, limited physician training, and varying technology availability across regions. Despite these limitations, evidence overwhelmingly supports that early detection significantly reduces mortality, hospitalizations, and long-term healthcare costs.

Conclusion



Modern methods of early diagnosis have redefined cardiovascular care. Through advanced imaging, biomarker innovation, wearable monitoring, and artificial intelligence, clinicians can now detect cardiovascular diseases at their earliest and most modifiable stages. Early diagnosis enhances treatment effectiveness, prevents irreversible organ damage, and improves patient survival and quality of life. Continued development and integration of these technologies will move cardiology toward more personalized, predictive, and preventive healthcare models.

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