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Artificial Intelligence in the Detection of Cardiovascular Diseases

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INTRODUCTION

Cardiovascular diseases remain the leading cause of mortality worldwide, posing an ongoing challenge for clinical practice and public health systems. Early detection of these conditions is essential to optimize patient prognosis and reduce the social and economic burden of their complications. Traditional methods such as electrocardiography (ECG) and echocardiography, though widely used, have significant limitations, particularly in the early stages of disease. For example, ECG interpretation can be highly subjective, which may lead to delayed diagnoses and suboptimal management.

In this context, Artificial Intelligence (AI) has emerged as a promising tool in cardiology, with significant advancements in the analysis of tests such as ECG, computed tomography (CT), and magnetic resonance imaging (MRI). Using machine learning and deep learning algorithms, AI has shown the ability to identify patterns that are imperceptible to the human eye and to anticipate subtle electrophysiological and structural changes associated with conditions such as atrial fibrillation and left ventricular systolic dysfunction (NAGARAJAN et al., 2021). Furthermore, the integration of data from wearable devices, electronic health records, and complementary tests enables continuous monitoring, supporting personalized medicine and proactive prevention.

Particularly regarding ECG analysis, AI has outperformed human interpretation in diagnostic accuracy, not only optimizing evaluation time but also expanding diagnostic capacity through models trained on large datasets. Deep neural network algorithms have demonstrated the ability to detect silent diseases, such as subclinical atrial fibrillation and left ventricular dysfunction, and even infer parameters such as biological sex, age, and serum potassium levels from ECG data (SIONTIS et al., 2021).

Given this scenario, this chapter aims to examine the current scientific evidence on the use of Artificial Intelligence in the detection and management of arrhythmias, ventricular dysfunction, and early-stage hypertension. It will discuss clinical applications in decision-making, hospitalization prediction, and the definition of personalized therapeutic strategies (CICCARELLI et al., 2023; SIRANART et al., 2024). It will also address the ethical and regulatory dimensions of this technological advancement, considering medical accountability, data protection, and challenges to the full integration of AI into clinical practice.

This analysis will be developed through a narrative literature review grounded in up-to-date and relevant articles, including those by Siontis et al. (2021), Siranart et al. (2024), Ciccarelli et al. (2023), Tolu-Akinnawo et al. (2025), and Nagarajan et al. (2021), which support the discussion on the future of AI in cardiology as a powerful ally in the health–disease continuum.

AI-Based Analysis of Cardiological Tests

The integration of AI into cardiology has enabled remarkable progress, particularly in the automated analysis of electrocardiograms (ECGs), one of the most commonly used tools in clinical practice (NAGARAJAN et al., 2021). Despite its accessibility, manual ECG interpretation still faces significant challenges: studies show that up to one-third of ECG readings may contain clinically relevant errors, mainly due to difficulties in identifying subtle patterns by the naked eye (MUZAMMIL et al., 2024). In this context, AI-ECG emerges as a promising solution, offering more accurate and sensitive diagnoses by processing large volumes of ECG data linked to clinical information.

Among the most widely used methods are deep convolutional neural networks (CNNs), which automatically learn signal patterns within ECGs. Using labeled data, these algorithms run thousands of iterations to identify, with high precision, changes associated with specific cardiovascular diseases. Recent studies have shown that CNN-based models can detect, for instance, signs of hypertrophic cardiomyopathy from a single-lead trace using saliency maps to highlight key ECG segments, such as the ST-T segment (SIONTIS et al., 2023; ATTIA et al., 2021).

Moreover, machine learning (ML) and deep learning (DL) techniques have been widely applied to arrhythmia detection, with particular emphasis on subclinical atrial fibrillation. These algorithms are trained to identify arrhythmogenic foci and slight variations in cardiac cycle intervals, which has enabled significant progress in early screening and risk stratification (NERI et al., 2023). Simultaneously, the proliferation of wearable ECG devices connected to AI systems has made real-time, continuous patient monitoring possible, achieving accuracy rates above 97% in detecting premature atrial and ventricular contractions (NERI et al., 2023).

Despite the benefits, clinical use of AI for ECG analysis still faces challenges. These algorithms often function as “black boxes,” making it difficult to understand the criteria used for clinical decision-making (Attia et al., 2021). In addition, issues such as data standardization, system interoperability, and false positives—such as misclassification of sinus rhythm as atrial fibrillation—must be addressed. Thus, the implementation of these technologies requires robust validation, transparent criteria, and qualified clinical supervision.

In summary, the combination of AI and ECG represents a major step forward in the early detection of cardiovascular diseases, expanding opportunities for screening and personalized interventions. For this innovation to become established in clinical practice, it is necessary to overcome the technical, regulatory, and ethical barriers that still hinder its large-scale adoption.

AI to Improve Diagnostic Accuracy in Cardiovascular Imaging

The integration of AI in cardiovascular imaging methods has significantly enhanced diagnostic accuracy and standardized interpretations, reducing dependence on operator expertise. Tests such as echocardiography, cardiac computed tomography (CT), cardiac magnetic resonance imaging (MRI), and nuclear imaging are essential for anatomical and functional heart assessment, but they traditionally require a high level of specialization for accurate interpretation (TOLU-AKINNAWO et al., 2025).

Recent studies have shown that AI can improve diagnostic accuracy by automatically identifying subtle abnormalities, such as coronary artery stenosis in coronary angiography (CAG) videos. Using 3D convolutional neural networks (3D-CNNs), Yabushita et al. (2021) developed a model capable of detecting ≥75% stenosis in major coronary arteries with excellent predictive performance. The model showed particularly high accuracy for the left anterior descending artery (LAD), which is frequently critical in patients with significant coronary artery disease.

AI has also been applied in CT and MRI image analysis for cardiac structure segmentation (e.g., endocardium and epicardium) and in the automated detection of myocardial fibrosis and infarcted tissue. Tolu-Akinnawo et al. (2025) emphasize that these applications not only accelerate exam interpretation but also contribute to prognostic stratification, offering valuable insights into ventricular remodeling and overall myocardial function.

In nuclear imaging, AI algorithms have demonstrated performance comparable to that of human specialists in SPECT (Single Photon Emission Computed Tomography) analysis, particularly in distinguishing normal from ischemic myocardium. According to Lim, Tison, and Delling (2020), these technologies enable fast, objective analyses, supporting clinical decision-making.

Additionally, Cheikh et al. (2022) demonstrated the use of AI in CT scans for early detection of pulmonary embolism (PE). The model increased diagnostic sensitivity, optimized radiologic workflows, and reduced diagnosis time in cardiovascular emergencies, showcasing AI's potential beyond structural cardiology.

However, despite these advances, significant challenges remain. Broad AI implementation in cardiovascular imaging requires adequate technological infrastructure, multicenter clinical validation, system interoperability, and strong ethical guarantees for data privacy (LIM, TISON & DELLING, 2020). Nevertheless, as automated segmentation and interpretation models continue to evolve, AI is expected to play an increasingly important role in the analysis of large volumes of imaging data, efficiently and safely improving diagnoses and prognoses.

AI in Real-Time Cardiac Biomarker Identification

Cardiac biomarkers are central to the early detection of various cardiovascular conditions, particularly acute myocardial infarction (AMI), which is characterized by myocardial ischemia. The introduction of Artificial Intelligence (AI) in this context has revolutionized biomarker recognition, enabling faster, more accurate diagnoses and potentially saving lives through early intervention—even in asymptomatic patients (MUZAMMIL et al., 2024; CHO et al., 2020).

Among the main methods of capturing these biomarkers is the ECG, especially in its simplified, wearable format. AI, integrated with deep learning algorithms, has been used to interpret signals from portable ECG devices with excellent performance in detecting arrhythmias, AMI, and other cardiac conditions in real time (NERI et al., 2023). ECG is favored for its accessibility, low cost, and usability in low-resource settings.

The use of convolutional neural networks (CNNs) and hybrid models such as CNNs combined with LSTMs (Long Short-Term Memory) has demonstrated high accuracy in recognizing arrhythmic patterns like atrial fibrillation (AF) and premature ventricular contractions (PVCs), with accuracies exceeding 98% in recent studies (NERI et al., 2023; NAGARAJAN et al., 2021). These technologies enable not only detection but also prediction of events using public databases such as MIT-BIH and devices like chest patches or smartwatches equipped with single-lead ECG sensors.

Beyond arrhythmias, AI has also been successfully applied in identifying myocardial ischemia through changes in the ST segment and T wave. Although 12-lead ECG remains the gold standard for infarction diagnosis, wearable single-lead ECG models have already demonstrated comparable accuracy to traditional methods, marking a significant step forward in remote and outpatient diagnosis (CHO et al., 2020; MUZAMMIL et al., 2024).

Studies such as Siontis et al. (2021) emphasize that the main current challenge is making automated ECG interpretation as comprehensive and accurate as that of human experts, with AI trained to detect subtle electrical patterns indicative of early pathology. Meanwhile, AI algorithms are being embedded in everyday wearable devices like wristbands and smartwatches, expanding the reach of real-time continuous monitoring (NERI et al., 2023).

Ultimately, AI has enabled the identification of complex, variable patterns that elude conventional human analysis. The application of deep learning techniques has raised the bar for diagnostic accuracy, making it possible to identify and manage conditions such as AMI, malignant arrhythmias, and heart failure at earlier stages (SIONTIS et al., 2021; NAGARAJAN et al., 2021).

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