

The Role of Artificial Intelligence in Cardiovascular Diseases: Advances, Challenges, and Perspectives

El papel de la inteligencia artificial en las enfermedades cardiovasculares: avances, retos y perspectivas

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Abstract

Cardiovascular diseases remain the leading cause of morbidity and mortality worldwide, demanding innovative approaches for prevention, diagnosis, and treatment. Artificial intelligence has emerged as a transformative tool in cardiovascular medicine by enabling the analysis of large volumes of clinical, genomic, imaging, and electrophysiological data. This editorial discusses recent advances in machine learning and deep learning applications for cardiovascular diagnosis, risk prediction, and health system optimization. It highlights evidence demonstrating superior predictive performance compared with conventional methods, particularly in electrocardiographic interpretation and risk stratification. The article also addresses implementation challenges, including infrastructure investment, workforce training, digital culture, and the ethical use of health data. Finally, it emphasizes the need for regulatory frameworks and sustained research efforts to ensure the responsible integration of artificial intelligence into cardiovascular care.

Keywords

Artificial intelligence; cardiovascular diseases; machine learning; risk prediction; cardiovascular diagnosis.

Resumen

Las enfermedades cardiovasculares continúan siendo la principal causa de morbilidad y mortalidad a nivel mundial, lo que exige enfoques innovadores para su prevención, diagnóstico y tratamiento. La inteligencia artificial se ha consolidado como una herramienta transformadora en la medicina cardiovascular al permitir el análisis de grandes volúmenes de datos clínicos, genómicos, imagenológicos y electrofisiológicos. Este editorial analiza los avances recientes en las aplicaciones del aprendizaje automático y del aprendizaje profundo para el diagnóstico cardiovascular, la predicción

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Miguel Oswaldo Pérez Pulido:

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Patricio Lopez-Jaramillo:

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Generative AI declaration

The authors declare that no generative AI tools were used in the writing, editing, data analysis, or any other part of the preparation of this manuscript.

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del riesgo y la optimización de los sistemas de salud. Asimismo, destaca la evidencia que demuestra una capacidad predictiva superior en comparación con los métodos convencionales, particularmente en la interpretación electrocardiográfica y la estratificación del riesgo. El artículo también aborda los desafíos para su implementación, entre ellos, la inversión en infraestructura, la capacitación del talento humano, la cultura digital y el uso ético de los datos en salud. Finalmente, enfatiza la necesidad de marcos regulatorios y de esfuerzos sostenidos en investigación para garantizar la integración responsable de la inteligencia artificial en la atención cardiovascular.

Palabras clave

Inteligencia artificial; enfermedades cardiovasculares; aprendizaje automático; predicción de riesgo; diagnóstico cardiovascular.

Cardiovascular diseases (CVDs) represent the leading cause of morbidity and mortality worldwide and in Latin America [1]. According to the World Health Organization, 19.8 million people die annually from CVDs, accounting for approximately 32% of all global deaths [2]. In this context, artificial intelligence (AI) has emerged as a transformative tool in cardiovascular medicine by integrating the analysis of large volumes of clinical, genomic, imaging, and electrophysiological data to improve the diagnosis, prediction, prevention, and treatment of these diseases [3].

In the field of diagnosis, machine learning and deep learning algorithms have demonstrated efficiency in analyzing electrocardiograms (ECGs), cardiac magnetic resonance imaging, echocardiograms, and computed tomography scans, detecting structural and functional abnormalities with greater speed and accuracy than conventional methods [4,5]. A recent meta-analysis [6], which included 28 studies and more than 3.5 million patients, reported that deep learning algorithms applied to ECGs achieved an area under the curve (AUC) of 0.85 for predicting cardiovascular morbidity and mortality, outperforming traditional machine learning models (AUC = 0.78). Models have also been developed to identify previous episodes of atrial fibrillation in patients in sinus rhythm, predict ventricular arrhythmias, and estimate left ventricular ejection fraction using large-scale echocardiographic databases [7].

In the field of cardiovascular risk prediction, artificial intelligence (AI) has shown superiority over traditional risk assessment scales. Spain's Centro Nacional de Investigaciones Cardiovasculares (CNIC) developed the EN-PESA algorithm, based on machine learning, capable of predicting the extent of subclinical atherosclerosis and the progression of vascular disease in middle-aged individuals previously classified as low or intermediate risk according to conventional scales [4]. More recently, researchers from the European Molecular Biology Laboratory developed Delphi-2M, a generative AI model trained on data from more than 400,000 patients from the UK Biobank and validated in 1.9 million individuals from the Danish National Patient Registry [8]. This system is capable of estimating the probability of developing more than one thousand diseases, including cardiovascular events such as myocardial infarction, over short- and medium-term time horizons.

The impact of AI extends beyond clinical practice and directly influences healthcare system management. According to a report by Accenture [3], healthcare systems adopting AI-based solutions may achieve reductions of up to 20% in operational costs by optimizing administrative processes, reducing errors, and improving

efficiency in clinical management. The World Economic Forum, in turn, highlights that AI-based diagnostic systems are democratizing access to specialized healthcare, particularly in regions with shortages of cardiology professionals, by facilitating the early detection of heart diseases with accuracy rates exceeding 93% in some classification models. This creates a unique opportunity for Latin American countries, where the burden of CVDs is high and specialized resources are limited.

A recent systematic review and meta-analysis including 35 studies aimed to evaluate the diagnostic effectiveness of AI models applied to major cardiovascular diseases, with emphasis on coronary artery disease, acute coronary syndromes, myocardial infarction, and heart failure [9]. The study reported pooled values of 0.88 for acute coronary syndromes and myocardial infarction, 0.87 for heart failure, and 0.86 for coronary artery disease. In deep learning models based on electrocardiography, sensitivity frequently reached values of 0.90 or higher, whereas specificity showed greater variability. The authors concluded that AI models demonstrated promising discriminative capacity across different cardiovascular diseases, although specificity and predictive value varied. These findings suggest that their clinical application requires external validation and local calibration before integration into routine medical practice.

In universities and research centers, AI has enabled the immediate retrieval of scientific literature and the conduct of research through meta-analyses, allowing for more efficient use of time and greater social appropriation of knowledge generated through the design and development of applications capable of positively impacting regions and addressing their needs, thereby serving as drivers of transformation and change [10].

AI is now a reality that supports decision-making and opens new pathways for innovation and territorial transformation. Companies in general are undergoing digital transformation through the use of AI by automating operational tasks and optimizing internal processes, enabling leaders to focus on higher value-added strategies. In the healthcare sector, AI has contributed to optimizing diagnoses, predicting risks, and automating medical records, all aimed at enhancing patient safety, enabling real-time interaction, and transforming consultations into spaces for physician–patient communication.

AI not only predicts but also continuously learns, adapting to changes in human behavior. Tools such as generative AI, the strategic use of prompts, machine learning, process automation, and big data are increasingly influencing decision-making and human talent management. However, significant challenges remain for its implementation, including investment in infrastructure, workforce training, digital culture, and the responsible and ethical use of data. In Latin America, the adoption of artificial intelligence in companies increased from 58% to 71% in just three years [11].

By 2030, the World Economic Forum [10] projects that the labor market will require a combination of advanced technological skills and “timeless” human abilities, with the main differentiating factor being the capacity to continuously learn and adapt in an environment shaped by AI and the green transition. Priority competencies include technological and AI literacy, analytical and critical thinking, creative thinking, and resilience, flexibility, and agility. Digital transformation in healthcare management is adopting AI as a tool to improve efficiency in healthcare delivery, reduce response times, optimize administrative processes, and support evidence-based decision-making. All of this must be achieved without losing sight of the human and ethical dimensions involved in the use of data.

In conclusion, AI represents a revolution in cardiovascular medicine with transformative potential in early diagnosis, risk prediction, treatment personalization, and healthcare system optimization. Its successful integration requires clear regulatory frameworks, sustained investment in research and training, and an unwavering ethical commitment to patient safety and dignity.

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