Viewpoint

Artificial Intelligence in Heart Failure: The New Role of the Cardiologist

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Introduction

Artificial intelligence (AI) is no longer a distant promise – it has become a reality in medical practice. Tools capable of interpreting tests, stratifying risk, suggesting diagnoses, and even proposing management strategies have generated growing enthusiasm among healthcare professionals. In this rapidly expanding technological landscape, an inevitable question arises: what will be the role of the medical specialist in the age of AI?

Heart failure (HF) represents one of the best models for this discussion. It is one of the diseases with the greatest clinical impact worldwide, affecting approximately 64 million people.[1,2] Despite advances in understanding its pathophysiology and in treatment options, HF remains a condition with high morbidity and mortality, with substantial residual risk even when disease-modifying therapies are implemented.[2-4] Much of this challenge lies in the complexity of its pathophysiological mechanisms, as well as the heterogeneity of clinical manifestations, disease progression, and associated comorbidities.[1,4]

One of the factors that most affects the prognosis of patients with HF is rehospitalization due to decompensation.[5] To predict which patients are at higher risk of hospitalization, numerous risk scores have been proposed for use during follow-up. However, traditional risk-prediction models tend to fail, especially when data are missing during evaluation – a common scenario, particularly within the Brazilian Unified Health System (SUS).[5,6]

In this context, AI algorithms have shown potential to enhance diagnosis, risk stratification, clinical monitoring, and even therapeutic personalization.[5,6] Yet, although these tools may expand analytical capacity and support decision-making, an important question remains: how can they be incorporated into care without losing what continues to be central in medicine – the relationship between physician and patient.

Keywords

Artificial Intelligence; Heart Failure; Machine Learning; Physician-Patient Relations.

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In this Viewpoint, we discuss how AI may transform the management of HF and argue that its greatest potential does not lie in replacing the specialist, but in expanding their ability to provide more precise, individualized, and human-centered care.

Applications of artificial intelligence in heart failure

The use of AI for predicting rehospitalization is one of the promising applications in the management of HF, but it is far from being the only one. There are numerous possibilities for applying ML in the care of these patients.[6,7]

Early in the clinical course of these individuals, AI can already be employed to achieve a more accurate diagnosis. Deep-learning strategies are now capable of analyzing electrocardiogram signals and predicting the risk of developing HF within 10 years, in addition to suggesting the diagnosis of HF and even classifying it as heart failure with preserved ejection fraction (HFpEF) with an accuracy unattainable to the human eye.[1,4,6]

Given its great heterogeneity, HFpEF has become a frequent target of ML algorithms. Because diagnosing this condition is particularly challenging, several existing approaches combine echocardiographic markers of diastolic dysfunction (such as left atrial strain, chamber volumes, and the E/e' ratio) with clinical and even laboratory data to achieve a more accurate diagnosis of HFpEF, demonstrating performance superior to currently available scores.[1-3,6]

In addition, algorithms have been developed to stratify HFpEF into different phenotypes, which is essential in evaluating these patients, since each form presents distinct clinical characteristics, progression, treatment response, and prognosis.[1,6] Recently, our research group applied artificial intelligence tools to a cohort of 160 patients and identified three possible phenotypes — hypertensive, metabolic, and senescent — which may reflect different pathophysiological mechanisms and potentially influence therapeutic response. These findings represent preliminary data and reinforce the potential of AI in characterizing the heterogeneity of HFpEF.

Beyond assisting in diagnosis and initial assessment of HF, algorithms have also been proposed for patient follow-up. Tools for predicting risk of decompensation, treatment response, and even prognosis have shown promise, with the potential to substantially transform clinical management.[1,3-6] Monitoring strategies for decompensation triggers – including tools based on voice analysis – are being explored as potential methods to anticipate clinical events and optimize patient follow-up and, although still not widely available, appear highly promising.

Another potential application of AI is in prescribing cardiac rehabilitation. The benefits of rehabilitation in heart failure are already widely recognized, and it is considered by many specialists as the fifth pillar of treatment.[8,9] However, especially within the reality of SUS, access to this intervention is quite limited. In this context, recent studies show that home-based cardiac rehabilitation, known as "telerehabilitation," when well-structured and supervised, can be effective even for high-risk patients.[10] For its proper implementation and monitoring, AI may play a fundamental role, assisting in the prescription, guidance, and follow-up of these patients.

In exploratory experiences not yet published from our center, artificial intelligence tools were evaluated as support for clinical characterization and individualized care in patients with heart failure. In a cohort of patients with heart failure with preserved ejection fraction, the application of AI-based methods suggested the possibility of identifying distinct clinical phenotypes, potentially related to different pathophysiological mechanisms. In another preliminary analysis, an AI-based prompt was used to support individualized prescription of cardiac rehabilitation in high-risk patients, with initial findings suggesting a possible improvement in functional capacity compared with usual care. These results, however, should be interpreted with caution, as they represent preliminary, unpublished, hypothesis-generating data that require confirmation in prospective studies with appropriate methodology and validation in independent samples.

The role of the specialist physician in this context

Despite the multiple possibilities offered by deep learning and its undeniable ability to enhance treatment outcomes in patients with HF, there is one role that cannot be replaced: that of the physician as the person responsible for care. After all, the best technology available is of little use if the patient does not feel secure about their treatment.

A recent study showed that supportive relationships between patients and physicians are the most beneficial factor for improving medication adherence, even surpassing technological interventions.[11,12] Along the same lines, a meta-analysis including 771 studies demonstrated that when interventions are delivered in person by healthcare professionals and guided directly by them, adherence is considerably higher.[13]

Thus, although AI provides important advances in diagnosis, treatment, follow-up, and prognostic assessment, it is the physician–patient relationship that ultimately determines the real impact this technology can have on the management of HF patients.

The cardiologist as a critical supervisor of artificial intelligence

As AI becomes incorporated into clinical practice, the role of the cardiologist shifts from being centered exclusively on data interpretation to assuming an even more complex function: the critical supervision of algorithm-generated recommendations. Although machine-learning models are capable of integrating large volumes of clinical, laboratory, imaging, and omics data – producing prognostic estimates and therapeutic suggestions with high performance – these tools remain dependent on the quality of the data used in their training and on the inherent limitations of their development. Thus, the results generated by AI should not be interpreted as autonomous decisions, but rather as probabilistic estimates that require individualized clinical validation.

In this context, the cardiologist assumes a role of clinical governance over AI. It is the specialist's responsibility to critically interpret the recommendations provided by algorithms, recognize situations in which their outputs may not be applicable, identify potential biases arising from the population used to train the models, and integrate this information with the clinical context, comorbidities, frailty, patient preferences, and shared therapeutic goals. Clinical decision-making therefore remains an exclusively human responsibility, grounded in the integration of scientific evidence, professional experience, and the patient's individual values.

Another aspect that deserves attention concerns the challenges related to the safe implementation of AI in clinical practice. Despite recent advances, many algorithms still have limited explainability (black-box models), making it difficult to understand the process that led to a given recommendation. Furthermore, the performance of these models is often demonstrated using specific datasets, making external validation indispensable before their incorporation into different populations and healthcare systems. Issues related to algorithmic bias, representativeness of training populations, reproducibility of results, and continuous model updating remain important scientific and clinical challenges.

Parallel to technical limitations, ethical and regulatory aspects play a central role in the incorporation of AI into cardiology. The use of large databases requires rigorous mechanisms for protecting privacy and information security, in accordance with data-protection legislation such as the general data protection law.

Likewise, important gaps remain regarding responsibility for clinical decisions supported by algorithms, model transparency, and the auditing mechanisms needed to ensure their safe and equitable use. In this scenario, the implementation of AI must be accompanied by robust clinical governance structures capable of ensuring quality, reliability, and accountability in decision-making.

Thus, the transformation brought about by artificial intelligence does not diminish the importance of the cardiologist; on the contrary, it expands their responsibilities. In addition to traditional clinical competencies, the specialist will need to develop skills related to the critical interpretation of algorithms, evaluation of the quality of evidence produced by intelligent systems, understanding of basic data-science concepts, and ethical oversight of the use of these technologies. The future of cardiology will not be defined by the replacement of physicians by artificial intelligence, but by the integration of computational intelligence with specialized clinical judgment, keeping the cardiologist as the primary decision-maker and the leader of individualized, safe, and patient-centered care (Figure 1).

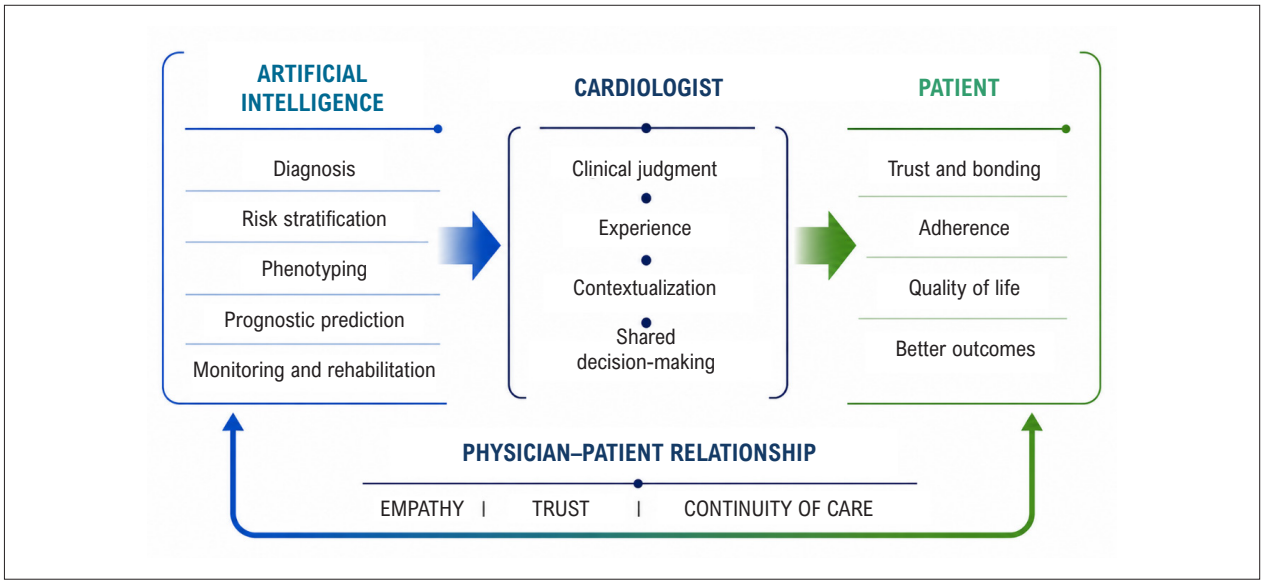


Figure 1 – *Schematic representation of the role of artificial intelligence in the management of heart failure. Artificial intelligence functions as a support tool for the cardiologist, assisting in diagnosis, risk stratification, phenotyping, monitoring, and personalization of care. Clinical judgment and the physician–patient relationship remain central to decision-making and achieving better outcomes. Figure created by the authors with the assistance of generative artificial intelligence (ChatGPT/OpenAI) and manually edited.*

Final challenges of using AI in heart failure

Considering all the points raised in this article, several challenges emerge regarding the use of AI in HF.

The first, and perhaps the most complex, is knowing all the AI possibilities available, having access to them, and understanding how to use them in the most appropriate way for each case. Within the vast universe of variables that influence the management of heart failure, incorporating an entirely new field of knowledge is not a simple task.

In addition, mastering these tools is not enough. It is essential to recognize the appropriate moment during treatment when they should be applied and to implement them at the right time, to maximize their benefits as effectively as possible.

Finally, a last challenge imposed on physicians in this new model of care is integrating all these functionalities into an individualized and human physician–patient relationship – one that welcomes, involves, and keeps the patient at the center of treatment. And for that, there is no ML prompt capable of replacing the traditional formula of good clinical care: listening, looking patients in the eye, respecting them, and sharing decisions.

The authors declare that generative artificial intelligence tools were used solely as support for linguistic revision and textual organization of the manuscript. All scientific content, critical interpretation, final review, and intellectual responsibility for the text rest entirely with the authors.

Author Contributions

Conception and design of the research: Freitas AK, Barioni CTS, Wandresen RPB, Oberderfer AB, Chiaratti BC, Kakuda GP, Mussi Neto S; Data collection and Critical revision of the manuscript for important intellectual content: Freitas AK, Bittencourt ALT, Barioni CTS, Wandresen RPB, Oberderfer AB, Chiaratti BC, Kakuda GP, Mussi Neto S; Data analysis and interpretation: Freitas AK, Bittencourt ALT; Manuscript drafting: Freitas AK.

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Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author

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