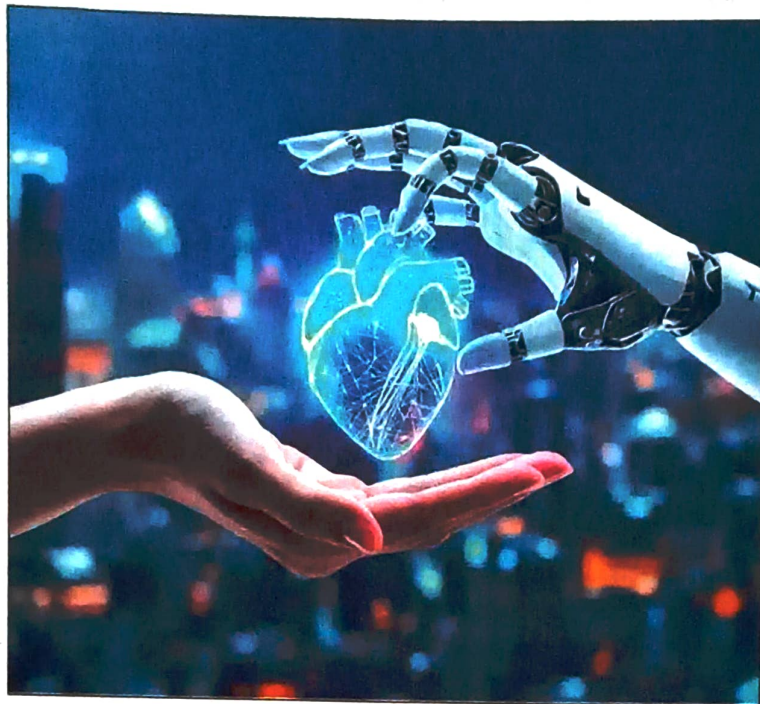


When AI reads between heartbeats

RABIN CHAKRABORTY



Calcutta: Sagnik Dutta (name changed), a 42-year-old IT executive, is a healthy young man. He has been smoking for 12 years and consumes alcohol socially. Occasionally, he experiences mild shortness of breath and atypical chest pain.

His father died in his sleep at the age of 54. Two of his uncles also have heart ailments. Sagnik does not have diabetes and his blood pressure is normal. He enjoys good food and is mildly obese.

He consulted a physician. Routine blood tests showed elevated total cholesterol and blood sugar. Further tests showed mild heart enlargement with prominent muscle mass. There were no other abnormalities.

His physician prescribed blood pressure- and cholesterol-lowering medication and advised him to stop smoking and reduce his weight. After a month with no improvement, Sagnik consulted a cardiologist, who reviewed his medical history and reports.

When his clinical symptoms, signs, investigations and family history were analysed using artificial intelligence, it was revealed that Sagnik might have a serious form of cardiomyopathy — a disease of the heart muscle that makes it harder for the heart to pump blood to the rest of the body and can even cause sudden death.

AI in medicine

In the 21st century, artificial intelligence (AI) is transforming medicine by improving diagnostics and systematically processing vast amounts of medical information to help formulate comprehensive treatment plans. Machine-learning models analyse complex medical data to help doctors make faster and more precise decisions, which may eventually lead to better outcomes.

AI is already being increasingly used in medical imaging and drug development, with innovative tools continuing to evolve. However, algorithmic bias, “black box” decision-making, flawed data-feeding methodologies, patient privacy concerns and compromises in medical ethics remain major challenges and limitations to the widespread application of AI in healthcare.

AI is the broad science of making machines mimic human thinking, reasoning and tasks. It is an umbrella term for computer software that exhibits human-like cognitive abilities. Through neural networks and multiple layers of machine learning and

● Rabin Chakraborty is a senior consultant interventional cardiologist and electrophysiologist. He is also an examiner for MRCP (UK) and an examiner for the national board, DNB, cardiology

deep learning, AI can process information rapidly.

In medical science, artificial intelligence involves integrating human physiology, pathology, and diagnostic and imaging data with complex mathematical models for treatment planning and risk prediction.

AI in heart diseases

In heart diseases, AI is rapidly transforming cardiovascular diagnostics by enhancing early disease detection, risk stratification and clinical decision-making for treatment. The use of AI to interpret ECG signals and detect abnormalities associated with heart disease is now well established.

AI can predict adverse cardiovascular outcomes even among asymptomatic individuals. Smartwatch-enabled detection of heart rhythm abnormalities and blood pressure monitoring are also being increasingly validated.

AI-enhanced analysis of cardiovascular images, including echocardiography, CT angiograms and cardiovascular MRI scans, has significantly improved the quality of predictions of cardiovascular events with a reasonable degree of accuracy.

AI has also emerged as a powerful prognostic tool, augmenting traditional risk models. In 2024, an AI-ECG biomarker was developed to predict one-year mortality, hospitalisation and rehospitalisation among patients with heart failure.

Machine-learning models can integrate coronary artery calcium scores and fat tissue around the heart to predict the risk of heart attack and cardiac death. Similarly, alterations in heart geometry, quantified through deep learning, might help

predict adverse outcomes in early cardiomyopathy.

In hypertrophic cardiomyopathy, a condition in which the heart muscle, usually the wall separating the lower chambers, becomes abnormally thick, AI can help predict disease progression through complex neural networks.

AI can also help assess and predict the clinical course and recovery of hospitalised cardiac patients, potentially aiding decisions on early discharge and long-term follow-up.

Collectively, AI can identify genetic patterns in heart patients and uncover latent prognostic signals that may be inaccessible to human interpretation, opening new avenues for early intervention and individualised risk management.

Clearly, in the management of heart disease, AI's capacity to support reliable, high-throughput clinical decision-making and to integrate seamlessly into healthcare is establishing its potential as an important complement to conventional treatment frameworks.

Limits of AI

Despite its potential, artificial intelligence also presents several challenges and limitations.

■ **Diagnostic errors:** AI relies heavily on the quality of the data it receives. If the data is incomplete, biased, or of poor quality, the results can be inaccurate. This may lead to the misinterpretation of subtle cardiac abnormalities or the failure to detect important diseases. AI is yet to fully account for a patient's clinical factors, including medical history and lifestyle, and lacks a holistic understanding of the individual.

■ **Erosion of physician expertise:** Growing dependence on AI for interpreting ECGs, echocardiograms and MRI images could lead to an overreliance on technology, risking the erosion of clinical skills.

■ **Data security and privacy concerns:** The use of AI in cardiology requires vast amounts of sensitive patient data. If not properly secured, this data could be vulnerable to cyberattacks. Additionally, AI's “black box” nature, in which decision-making processes are not transparent, can make it difficult for physicians to explain AI-driven outcomes.

■ **Algorithmic bias and healthcare inequality:** Cardiovascular disease affects diverse populations in distinct ways. If AI models are primarily trained on data from one demographic, such as Caucasian males, they may provide less accurate results for female patients, minorities or underserved groups.

■ **Impact on the doctor-patient relationship:** The use of AI in formulating treatment plans could affect the doctor-patient relationship, potentially making healthcare more impersonal. Its efficiency may also leave some patients feeling disconnected or undervalued.

■ **Legal and ethical liability:** The integration of AI into cardiovascular practice raises legal and ethical questions about accountability when errors occur. If AI makes an incorrect diagnosis or treatment recommendation, there are no clear guidelines on whether the physician or the AI developer should be held responsible.

Conclusion

Artificial intelligence has the potential to revolutionise cardiovascular care by improving risk prediction, diagnosis and treatment. In the third quarter of the 21st century, AI and machine learning are redefining the landscape of cardiovascular medicine, offering unprecedented capabilities in diagnosis, prognosis and personalised treatment. AI-enabled tools in cardiology are achieving metrics that significantly surpass those of traditional methods.

AI represents a paradigm shift in cardiovascular medicine, with the potential to significantly reduce morbidity and mortality associated with heart disease. Despite its transformative potential, the widespread adoption of AI in cardiology faces challenges, including biases in training data and limited validation.

Addressing these concerns will require robust regulatory frameworks, such as the Artificial Intelligence Act, along with comprehensive training and strong ethical safeguards. Only then can AI help improve cardiac care for all patients without widening existing inequalities or undermining trust in healthcare.