Review

Pivotal Role of Artificial Intelligence in Cardiovascular Health: Highlights from the Late Breaking Trials at the AHA Scientific Sessions 2023

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Pivotal Role of Artificial Intelligence in Cardiovascular Health: Highlights from the Late Breaking Trials at the AHA Scientific Sessions 2023

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Abstract: Cardiovascular diseases (CVDs) remain the leading cause of mortality. Traditional approaches to diagnosing and treating CVDs often involve interpretation, which can lead to errors. The emergence of Artificial Intelligence (AI) and Machine Learning aids the management of CVDs. AI examines amounts of data and identifies patterns offering solutions for disease detection, risk prediction, and patient care. The American Heart Association's 2023 Scientific Sessions (AHA23) showcased studies that highlight AIs potential to revolutionize cardiac healthcare. This article presents a review of these cutting-edge studies exploring how AI is applied in health, the outcomes of these applications, and their implications for clinical practice. The insights gained from this review will contribute to the discussion on AI's role in healthcare and its capacity to enhance outcomes.

Keywords: artificial intelligence; machine learning; coronary artery diease; heart failure; risk stratification; screening

Introduction

Artificial Intelligence (AI) has become a game changer in industries, including healthcare. Its impact on health is particularly remarkable as it brings forth solutions for disease detection, risk prediction and patient management. Cardiovascular diseases (CVDs) are the leading cause of death, impacting about 130 million patients in the USA, leading to an increased burden on the healthcare industry [1]. Traditional methods of diagnosing and treating CVDs often involve procedures and subjective interpretation. However, AI presents an alternative by leveraging its ability to analyze amounts of data, identify patterns and apply the knowledge to manage these conditions. Although medicine, including cardiology, has not fully embraced and utilized AI, there are a number of AI-based clinical applications being used in clinical practice, including echocardiogram interpretation, diastolic dysfunction, creates certification, and electrocardiogram interpretation [2–4]. AI has the potential to drive clinical practice toward a more individualized and precision-based approach over the coming years. However, this progress will have certain limitations and challenges, including the need for data quality control, external validation, patient data security, and quality studies to demonstrate better patient outcomes with AI tools [5,6]. The American Heart Association Scientific Sessions in 2023 (AHA23) provided a platform where groundbreaking studies in this field were presented. These studies demonstrated the potential of AI to revolutionize healthcare, covering areas such as the detection, diagnosis, and treatment of cardiovascular diseases. The purpose of this manuscript is to offer an overview of these state-of-the-art studies. It will explore how AI is being utilized in health, discuss the outcomes of these applications, and consider their implications for

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research and clinical practice. The valuable insights gained from this review will contribute to the discussion on the role of AI in healthcare and its ability to enhance outcomes.

Late Breaking Trials

ARISE Trial

Cardiovascular diseases are the leading cause of mortality worldwide, and among them, ST-elevated myocardial infarction (STEMI) is the most severe acute condition, with a very high in-hospital mortality of 5-6% in the United States [7,8]. The ARISE trial [9] aimed to create an AI ECG model to manage acute myocardial infarction (AMI) better. The goal of the trial was to evaluate artificial intelligence (AI)-interpreted electrocardiogram (ECG) (AI-ECG) compared with usual care among patients in the emergency department who received an ECG. The model used a combination of real-time ECG auto-diagnosis and uploading alarm message notifications to the front-line physician and the cardiologist, who then actively confirms and manages STEMI or consults STEMI mimics or equivalents. The ARISE trial was a randomized, parallel, blinded study. Patients presenting to the emergency department were randomized to AI-ECG (n = 21,989) vs. usual care (n = 22,005). The total number of enrollees was 43,9941. The duration of follow-up was until hospitalization. Patients who were 18 years of age or older and who presented to the emergency department or inpatient department were included. Patients who received at least one ECG within three days without a history of coronary angiography were also included. The primary outcome, time from ECG to the cath lab, was 43.3 minutes in the AI-ECG group vs. 52.3 minutes in the usual care group ($p = 0.003$). Secondary outcomes included ejection fraction and length of hospitalization, which were similar between treatment groups. The model demonstrated high accuracy with a positive predictive value of 88% and a negative predictive value of 99.9%.

Clinical Implications:

1. This model could potentially lead to quicker diagnosis and treatment of patients with STEMI, which is crucial as every minute counts in these cases.
2. Although the trial did not show a difference in ejection fraction or length of hospitalization, the reduced time to treatment could lead to better patient outcomes in the real-world scenario.
3. The success of the ARISE trial highlights the potential of AI to improve the efficiency of patient care.

Cordio HearO Community Study

It is well known that fluid retention and pulmonary congestion are the major contributors for heart failure hospitalizations. Frequent monitoring of volume status and pulmonary congestion have led to better patient outcomes. CardioMEMS is an implantable pulmonary artery pressure monitoring system which decreased heart failure readmissions through pulmonary artery pressure guided heart failure management [10]. However, it requires an invasive procedure and is usually used only in patients with advanced heart failure. Numerous studies have demonstrated an association between fluid overload and vocal cord vibration [11,12]. The Cordio HearO Community Study [13] focused on using a remote speech analysis using a smartphone to detect worsening heart failure. The Cordio HearO system is a non-invasive, remote patient monitoring system that uses a mobile application to record speech and cloud-based computing to identify changes in speech that could indicate worsening heart failure. The study was a multicenter, non-interventional, single-arm, open clinical study. Adult heart failure patients (both heart failure with reduced ejection fraction and heart failure with preserved ejection fraction), out-patients (NYHA II-III), and clinically stable patients who are at risk for exacerbations were included. Daily voice recordings were done for a total of 44 months. Patients who were enrolled were divided into a development group and a test group. The development group had 263 heart failure outpatients with 158,024 recording days. The test group had 153 heart failure outpatients with 94,202 total recording days. The recording compliance rate averaged around 80% in both groups. The outcome of interest was heart failure event (HFE), which included worsening heart failure, requiring hospitalization, or outpatient worsening heart failure

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requiring IV diuretic therapy. In the development group, there were 58 HFEs, while in the test group, there were 14 HFEs. The HearO system was able to detect 71% of HFEs, on average 26 days prior to the event. In the development group, the sensitivity of HearO to detect HFEs was superior to daily weight monitoring.

Clinical Implications:

1. Using this system could potentially lead to quicker diagnosis and treatment of heart failure exacerbations.
2. This study also highlights the potential of remote monitoring systems for chronic conditions like heart failure. This could lead to better patient outcomes as it allows for continuous monitoring and early intervention.

ORFAN

Vulnerable plaques are those plaques that are at an increased risk of rupture leading to coronary thrombosis and acute coronary syndromes. Most myocardial infarctions caused by plaque ruptures occur in precursor plaques with less than 50% diameter stenosis [14]. In another study, it was shown that only 26% of vulnerable plaques have more than 50% diameter stenosis [15]. The ORFAN study [16] aimed to use AI-assisted analysis of CT coronary angiography (CTCA) imaging to identify plaques that are prone to rupture and integrate patient's risk profile to predict future cardiovascular events. It was a multicenter, prospective, and observational study. It collected CTCA imaging data, patient demographics, biological material, and outcomes data to generate and validate biomarkers for cardiometabolic risk. The study included 250,000 consecutive patients at participating centers. In patients undergoing CTCA, there were two times more MACE events (cardiac death, non-fatal myocardial infarction, and new heart failure) in those without obstructive coronary artery disease (CAD) compared to those with CAD. Measuring coronary inflammation with the FAI score predicts fatal and non-fatal cardiac events. There was similar risk prediction for all vessels (left anterior descending artery, left circumflex artery and right coronary artery) independent from clinical risk scores and routine CTCA interpretation. The AI risk model reclassified about 30% of patients to a higher and about 10% of patients to a lower risk category, resulting in management changes in about 50% of the patients.

Clinical implications:

1. The new AI-driven risk classification can change risk-driven management in a significant number of patients, which could lead to early risk assessment and intervention, potentially leading to improved outcomes.
2. This AI technology also improves risk stratification for patients without significant or symptomatic CAD undergoing CTCA.
3. The study also points to the importance of measuring coronary inflammation as it can predict fatal and non-fatal cardiac events independent of risk factors and CTCA interpretation.

SPEC-AI Trial

Nigeria has the highest incidence of peripartum cardiomyopathy worldwide [17]. There is a strong need for an affordable and efficient screening tool for peripartum cardiomyopathy, especially in areas with less access to healthcare. A study by Lee, et al. found that an ECG-based deep learning model effectively detected cardiomyopathies in the peripartum period [18]. The SPEC-AI trial aimed to evaluate an AI-enabled electrocardiogram (AI-ECG) using a digital stethoscope for cardiomyopathy detection in pregnant patients in Nigeria [19]. It was a multi-center, randomized, open-label, pragmatic clinical trial. Pregnant and postpartum women were enrolled at six sites and were randomized in a 1:1 fashion. AI-guided screening using a digital stethoscope in about 1200 pregnant and postpartum women resulted in double the number of cases identified compared to usual care. Left ventricular dysfunction, defined as left ventricular ejection fraction (LVEF) <50%, was detected in 4.1% of patients in the intervention group compared to 1.8% of patients in the control group (OR 2.3; 95% CI 1.1-4.8). The AI-guided screening had an area under the curve of 0.93 for

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detection of LVEF < 50% and 0.98 for detection of LVEF < 40% which indicates good diagnostic accuracy. The sensitivity of the device was found to be 92% with a specificity of 80%.

Clinical Implications:

1. The trial has shown that using an AI-powered stethoscope can effectively screen for peripartum cardiomyopathy, which is often missed with traditional or standard methods.
2. Integrating AI in this way could change the approach to practice, moving from symptom-based methods to a more proactive one.
3. The AI-powered digital stethoscope has shown great promise to be an efficient screening tool. Detecting cardiomyopathy earlier would enable earlier management and could potentially reduce associated morbidity and mortality, especially in areas with less access to healthcare.

Future Perspectives and Challenges

By 2025, the AI in healthcare market is expected to grow from $2.1 billion to $36.1 billion [20]. As highlighted in this review, AI has numerous potential applications in the field of cardiology. Utilizing AI for data analysis can help develop treatment strategies that are tailored to each patient's individual profile and illnesses. More cardiac conditions may be detected by utilizing AI-powered devices like echocardiograms and ECGs. By using tools that can identify early indicators of decline, artificial intelligence (AI) has the potential to improve monitoring in long-term illnesses such as heart failure. Healthcare workers can make more informed clinical decisions by using AI to help with the processing and interpretation of data from EHRs. Preventive methods are made possible by the ability to forecast a patient's likelihood of developing illnesses through the deployment of AI algorithms.

With the growing usage of AI, protecting the privacy and security of patient data is a top priority. Adhering to privacy legislation and putting strict data security measures into place are essential. Biases in the training data may be reinforced by AI systems, which could result in unequal healthcare delivery. For example, most of the data we have on heart failure are from white men. Using this data to develop AI predictive models will be less precise in minorities [21]. Biases in AI model training can be reduced by using a wide variety of datasets. It can be difficult to smoothly integrate AI into the tools and workflows used in clinical practice today. The broad implementation of AI solutions in healthcare requires navigating the intricate regulatory landscape. AI tools can be made to be both user-friendly and therapeutically relevant through close collaboration between engineers and clinicians. Building clear and comprehensible AI models helps promote patient and physician trust.

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