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Advancements in Artificial Intelligence for Cardiovascular Disease Diagnosis and Risk Stratification

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Abstract

The article analyses the use of artificial intelligence (AI) in the different branches of cardiology including its use in predictive judgement, diagnostics, and risk evaluation. It examines narrow (applied) AI and general (strong) AI with special attention to the machine learning methods applied to data from ECG, echocardiography, sonography, CT, MRI, and PET scans. It also attempts to show how AI can improve diagnostic accuracy, minimize medical blunders, and improve AI-assisted treatment planning. It demonstrates how AI can be used for the patient telephone calls in emergency medical services and, as part

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of preventive cardiology, for the analysis of enormous databases received from tonometry, pulse wave velocity, and biochemical investigations. Attention is also given to the issues concerning AI integration, such as using LLMs for clinical documentation. Further, ethical issues relating to AI including data privacy and culpability for the actions of AI are discussed. Further, it has been highlighted that the considered aspect needs more attention, therefore, patient data security and AI tools integration in medical practice requires precise regulation to ensure that facilitated patient outcomes do not come at the cost of patient data breach. Necessary measures for successful integration of AI tools into practice of cardiology directed to improvement of patient care quality and healthcare systems effectiveness are given in conclusion.

Keywords: Artificial Intelligence, Machine Learning, Cardiovascular Diseases, Predictive Analytics, Diagnostic Tools, Risk Stratification, Electrocardiography, Echocardiography, MRI, CT, Large Language Models, Healthcare Integration, Ethical Issues.

Introduction

The technologies of artificial intelligence (A I) and machine learning (ML) have been regarded as innovative tools in the diagnosis and risk assessment of cardiovascular disease (CVD). Currently, the healthcare sector is undergoing significant transformation with the incorporation of AI, especially deep learning, owing to advanced systems in cardiovascular diagnosis and patient outcome prediction. AI facilitates the assimilations of multiple sources of clinical and imaging data,

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thereby increasing the accuracy and efficiency in the diagnoses and risk assessments of heart diseases [1].

Many studies AI has recently begun incorporating machine learning algorithms into risk prediction models at the cardiovascular level utilizing traditional risk factors combined with modern clinical data. These models were found to outperform many other models such as the Framingham risk score [2]. For example, electrocardiographic data is being fed into machine learning algorithms to automatically identify specific heart disorders and predict likelihood of major cardiovascular events such as myocardial infarction and stroke [3].

Apart from diagnostics, AI has also demonstrated its ability to forecast patient outcomes such as long-term mortality and disease progression involving the integration of biomarker, imaging, and genetic information. Machine learning models using historical data can automatically find structures in data that mere statistical evaluations cannot [4]. In addition, AI as a continuously evolving technology makes it possible to personalize treatment approaches for CVD [5].

Despite the significant potential for AI in cardiovascular care, there are competing issues that must be dealt with. There are ethical issues surrounding patient privacy, data security, and transparency of the algorithms used with respect to the AI's application in clinical routines. The deployment of AI systems needs to be done carefully to mitigate the risks of automated biases and misclassification of patients with protected characteristics [26]. In addition, these models need to be tested for validity and reliability when implemented in

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different populations and clinical settings to make sure they actually work in the real world [27].
Recent developments in AI include automated systems for analyzing medical images, including CT scans, MRIs, and even echocardiograms. These systems which have been trained on massive datasets can pick up the minute indications of diseases which human clinicians would miss when looking at the images. AI is now being utilized more and more in imaging cardiology for detecting coronary artery diseases (CAD), heart failures, and valvular disorders with great precision [28]. Moreover, AI has also been demonstrated to have a role in stroke risk estimation in patients suffering from atrial fibrillation or other forms of arrhythmias, with promising results in clinical practice [29].

While headway is being made, some skepticism still remains about placing so much trust in AI for clinical decision-making, especially with something as sensitive as CVD. AI does have the ability to help clinicians by making inferences closely based on data, but it is crucial to remember that just like every other clinical decision, it needs constant evaluation. Every patient's case is different, and granular details cannot be captured through algorithms and models alone [30].

Literature Review

In recent years, substantial efforts have been put into the development of artificial intelligence (AI) technology for its use with the diagnosis and management of cardiovascular diseases (CVD). The application of different machine learning (ML) models such as deep learning and neural networks is now common in ECG,

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echocardiography, and other cardiac imaging, which has resulted in improved accuracy and early diagnosis of the disease [6].These AI models achieve enhanced clinical diagnosis by assisting human experts with aid of trained medical images on large datasets for pattern recognition that would otherwise not be possible manually [7]. AI-assisted interpretation of echocardiograms has enabled increased detection of heart conditions that include but are not limited to, myocardial infarctions and heart valve diseases, thus minimizing the need for some diagnostic procedures to be performed invasively [8]. In addition, almost all of these processes have relied on AI to perform risk stratification by using medical history, lifestyle, and available biomarkers to predict adverse cardiovascular events for improving treatment [9].

Support vector machines (SVM), random forests, and other machine learning algorithms have been utilized to predict heart failure and the onset of arrhythmias, enabling clinicians to make important treatment and patient management decisions [10]. AI is increasingly embedded into clinical workflows to assist healthcare practitioners by providing in-depth analysis of patient information, thereby speeding up diagnosis and primary management [11]. Such systems are exceptionally helpful in emergency care situations where a quick decision is needed. Moreover, AI is demonstrating its utility in population health management by predicting severe cardiovascular events, allowing healthcare practitioners to identify and intervene within high-risk populations before the events occur [12].

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Nevertheless, the implementation of AI in cardiovascular care comes with many hurdles. One major issue is the absence of quality data that is essential for high-performance models. Several AI solutions are built with non-generalizable data, which creates biases in diagnosis and even treatment suggestions [13]. Alongside these concerns, the incorporation of AI into healthcare also poses ethical and legal issues such as privacy of patient data, understanding of the algorithms used, and responsibility for the outcomes of AI interventions [14]. It is always absolutely necessary to add the adoption of protocols with stringent verification checks on AI systems to ensure reliability and safety [15]. In any case, while anticipating the improvements with AI adoption, it should not be overlooked that its use should always augment and never substitute human clinical judgement. The complexities surrounding the issue guarantee that AI tools will be utilized alongside the insight of seasoned medical professionals for the absolute welfare of the patients [16].

The possibilities of Artificial Intelligence seem to be endless. As it progresses, its potential for transforming the detection and management of cardiovascular ailments becomes more apparent. Cardiovascular care is also promising with further developments in the machine learning methods, big data analysis, and the incorporation of AI in healthcare systems. Realizing the full benefits of AI for patient outcomes will require addressing technical, ethical, and regulation barriers [17].

AI, ML, and DL technologies are providing cardiology with advanced tools for cardiovascular diagnosis, risk assessment, and

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treatment using sophisticated technologies that analyze vast datasets like medical images and patient files to reveal patterns that are usually unnoticed by physicians [18]. Especially, cardiac imaging has witnessed the successful application of deep neural networks (DNNs) that can facilitate the early diagnosis of arrhythmias and coronary artery disease [19]. In addition, ML algorithms are being increasingly used to integrate clinical data, biomarkers, and other variables for predicting unfavorable patient outcomes such as heart failure and stroke [20]. One of the prominent innovations is using AI-powered tools for echocardiogram and electrocardiogram analysis, which enhances the accuracy of diagnosis through the elimination of tedious manual interpretation [21]. AI can also improve the quality of clinical decisions made during patient care by making timely, evidence-based recommendations and, in turn, minimize human error and neglect [22]. Even with such advancements, integrating AI into cardiology brings along some difficulties.

Certain challenges persist especially regarding the auditability and transparency of AI systems for important healthcare operations [23]. Moreover, the aspects concerning data protection, consent, and the ethical boundaries of the use of AI in the medicine field are still extensively searched and debated [24]. Owing to the myriad opportunities that AI provides, achieving its success in cardiology is only a matter of time, but the challenges have to be resolved to optimize its clinical practice [25].

There are two categories of artificial intelligence (AI): weak AI and strong AI. Weak AI, also known as narrow AI, is focused on

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performing a specific set of tasks. Specialized AI is currently the most widespread form of AI, this approach to research and development assumes that AI is a simulation and will always remain a simulation of human cognitive functions. In this view, computers may only appear to think but do not actually possess consciousness. Specialized AI simply follows predefined rules imposed by its operator and cannot go beyond these rules. A good example of applied AI is the characters in video games, who behave realistically within the context of their game characters but cannot perform any actions outside the ones defined by the developers.

On the other hand, general AI or universal AI represents a form of AI that closely mimics the general intelligence of the human mind, capable of reasoning and formulating original thoughts. While researchers are still studying universal AI, it remains a theoretical benchmark, with no publicly known examples. However, for the sake of clarity in the review, the types of AI will be differentiated based on the strength of their intelligence.

AI and ML hold transformative potential in cardiovascular care, offering improvements in diagnosis, treatment, and risk management. However, the integration of these technologies into routine clinical practice requires careful consideration of ethical, technical, and regulatory challenges.

Methodology Of The Research

AI and Cardiology

The connection between AI and cardiology is currently evolving into a comprehensive integration. Discussions among medical professionals

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about AI mostly focus on its potential applications in clinical decision-making. These discussions primarily relate to algorithms used in diagnosing and treating diseases, which predict certain outcomes using diverse (multimodal) data sources.

Objective of the Review

The goal of the review is to identify specific applications of both specialized and universal AI in the field of cardiology.

Stage I: Justification for the Study

Identifying and Analyzing Existing Systematic Reviews

The study opens with a systematic review of systematic reviews on the application of artificial intelligence in cardiology. The scope of this study is to find out what has already been covered in the research and what gaps exist, as well as how the sophistication of the AI methods used in cardiovascular diagnosis and risk stratification has evolved over time. This includes reviewing published articles, conducting clinical trials, and creating meta-analyses to thoroughly comprehend the particular technology's effectiveness in cardiology.

Defining the Basis and Characteristics of the Research Problem

The central research problem is to explore how AI can transform cardiovascular disease (CVD) diagnosis and management. We aim to identify both narrow AI applications (specific machine learning models like support vector machines and artificial neural networks) and general AI (large language models and automated decision-making systems) used within clinical cardiology. This research examines the full spectrum of AI's role from diagnostic imaging to predictive analytics and treatment personalization.

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Stage II: Protocol Development

Developing a Clear Research Query

The research question in relation to the application of artificial intelligence reads: "What is the application of artificial intelligence in the diagnosis, risk assessment and treatment planning of patients suffering from cardiovascular diseases?" The question is meant to direct the systematic review and literature synthesis to examine and evaluate the Application of AI in cardiology in regards to effectiveness, challenges, and prospects.

Strategy for Identifying Primary Research Studies

The investigations center around primary peer-reviewed articles, clinical trials, and preprint posters on the subject of AI applications in cardiology and thus a comprehensive search strategy is employed. Subsequently, the most important resources such as PubMed, MEDLINE, SpringerLink, MedRXiv, and ResearchGate were used to search for required materials. Some of the phrases that were searched for include: "AI in cardiology," "machine learning in cardiovascular diagnosis," "deep learning in CVD," and "AI risk stratification cardiovascular."

Inclusion/Exclusion Criteria

The inclusion criteria for the research are:

- Publication Years: 1990-2024.
- Source Type: Peer-reviewed articles, clinical studies, conference proceedings, reviews, and preprints from recognized medical and academic publishers.

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- Study Focus: Research that focuses on AI in diagnostic imaging, risk prediction, and management of CVD.

Exclusion criteria:

- Studies not related to AI applications in CVD.
- Non-peer-reviewed studies or unpublished work that is not available in public databases.

Data Extraction Scheme

Data will be extracted from the identified literature through an extensive review of the articles. The focus will be on gathering information on:

- AI methodologies employed (e.g., deep learning, support vector machines, neural networks).
- Applications in various cardiology fields such as electrocardiography (ECG), echocardiography, and magnetic resonance imaging (MRI).
- AI's impact on improving diagnostic accuracy, early detection, and risk prediction in cardiovascular diseases.

Development of Summarization Strategy

The categorization of AI applications in cardiology for purposes of summarization will be done methodically. It will take into consideration types of diagnostic tools, treatment predictions, and healthcare management. Main highlights from the studies will be captured under different headings such as AI for ECG interpretation, AI in MRI and CT scans, and AI in personalized medicine and risk mitigation.

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Review of Collected Information by the Research Team

In order to thoroughly analyze and review the collected data, a team approach will be taken to ensure that all perspectives on the information are captured. The research team will evaluate and integrate all the synthesized AI's application data focused on its use in cardiology, while diagnosing major concerns like scarcity of clinical AI validation and data bias in AI-supported systems.

Stage III: Literature Review and Data Study

Reviewing Literature on Clinical Studies

As part of this section, an AI application review specifically in cardiovascular medicine will be conducted. This involves a literature review of the selected articles and research papers including the relevant clinical studies of the use artificial intelligence in cardiovascular science. Primarily these studies will be evaluated based on the research design, AI applications processes, and results. Specific focus will be given to studies that assess the effectiveness of AI-based diagnosis and risk assessment of cardiovascular diseases compared to more traditional techniques.

Selection of Relevant Sources

The research team shall check all sources and, in particular, their studies' quality and relevance. Selected papers will be reviewed in full text to determine whether they fall within the scope of the research questions.

Data Extraction and Synthesis

The final step of the methodology will involve synthesizing the extracted data and organizing it into themes based on specific

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cardiology domains. The collected data will be analyzed for trends in AI usage, effectiveness, and areas where AI application still faces limitations or challenges.

Machine Learning Technologies, Specialized AI In Cardiology

Machine Learning (ML) is the basic practice of using algorithms for prediction by analyzing data and learning from them. Such models can self-learn based on previous experiences or accumulated data. Algorithms can extract important tasks from operator commands that need to be executed by generalizing examples provided as training datasets.

There are currently various types of ML algorithms. These are grouped by learning style (i.e., supervised learning, unsupervised learning, and semi-supervised learning), similarity, or function (i.e., classification, regression, decision trees, clustering, deep learning, etc.). All ML algorithms consist of three different components:

Representation: A set of classifiers in a form understandable to the computer.

Evaluation: The goal defined for the classifier model (algorithm), scores.

Optimization: The method of finding the classifier with the highest number of points.

The primary goal of ML algorithms is to generalize beyond the training sets they are given, which implies successful interpretation of data they have never processed before. The main difference between ML and AI is that ML works to increase accuracy, while AI aims to increase the chances of success.

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The three main types of ML methods are: supervised learning, unsupervised learning, and semi-supervised learning. The choice of algorithm and learning type can be based on various approaches, such as the problem at hand, the volume of data involved, or the types of data available. ML demonstrates a dynamic role in medical diagnostic applications, as it involves creating self-learning algorithms.

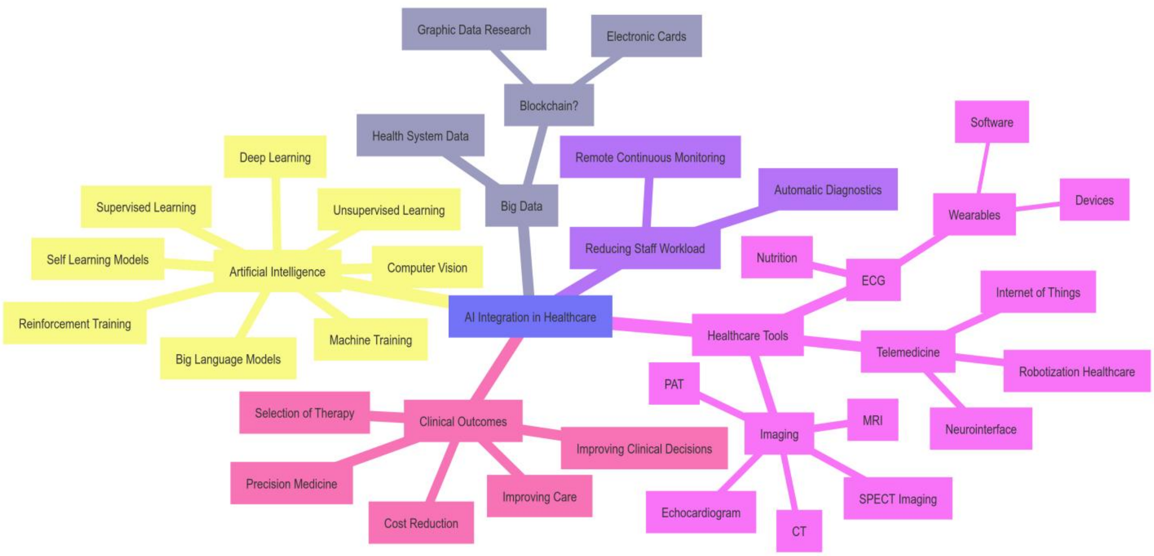

Figure.1 Model of AI Integration into Healthcare Institutions Providing Cardiology Care

The Figure 1 shows one model of how artificial intelligence (AI) can be implemented in the operations of healthcare facilities, particularly in cardiology. The diagram has several interrelated clusters representing specific areas where AI augments healthcare services. The AI techniques cluster (yellow shaded) contains a number of machine learning models including supervised / unsupervised, reinforcement / self-learning that are necessary for the processing of healthcare data and improving clinical predictive accuracy. The big language models

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division presents prospects of AI utilization in natural language understanding to achieve better communication and decision-making processes in medicine.

The healthcare integration cluster (blue section) shows how AI can be embedded in health systems for data sharing and processing using blockchain technology, and graphic data mining to improve diagnosis. This integration is particularly important in making informed clinical decisions in cardiology, one of the areas that require accurate large scale data processing and personalized predictions and care.

The cluster of healthcare tools and technologies (colored in pink) indicates AI's role in the development of diagnostic tools such as ECG, MRI, CT imaging, SPECT imaging, and echocardiography, which are important for diagnosing heart issues. The role of AI in telemedicine and wearable devices allows for remote supervision and ongoing patient care, further improving accessibility and outcomes.

The primary results section (marked in red) depicts the value AI could provide on vertical augmentation of patient care AI such as in precision medicine, cost efficiency, and decision intelligence. AI, when incorporated into treatment strategies, allows healthcare professionals to deliver more personalized care in a cost effective manner, which correlates to better patient outcomes over time. Lastly, the other key areas in purple feature one of the major advancements AI has revolutionized, automatic diagnosis and remotely supervised continual monitoring, which is crucial for timely health evaluations as well as health emergencies.

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This model highlights the importance of cardiology AI applications spanning from diagnosis, treatment and follow-up telemonitoring providing integrated healthcare system for better medical services and patient outcomes.

Cardiovascular Disease Prediction (CVD)

This involves supervised learning, as labeled data such as cardiograms are required to train a weak AI model.

AI in ECG

The goal of implementing AI in ECG is to fully automate the analysis of the cardiogram taken by medical personnel to save time for the functional diagnostics doctor and reduce labor costs for specialists. The use of both supervised and unsupervised learning for ECG analysis and interpretation has shown significant potential.

Controlled ML, such as artificial neural networks and support vector machines, can be trained for classification functions based on labeled data. In contrast, unsupervised ML can detect potential correlations in unlabeled data. In addition to ML, the recent emergence of deep learning-based ECG analysis can assist doctors in various clinical scenarios related to CVD diagnosis, prognosis, and risk stratification. Instead of manually created vectors, deep learning systems employ an end-to-end learning strategy that programs the system to learn necessary functions from raw data. The advantage of deep neural networks lies in their ability to identify new interdependencies independent of manually selected feature extraction, opening vast arrays of previously unexplored data.

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AI in Echocardiography (EchoCG)

As with traditional methods slice recognition in echocardiography remains an essential process in estimating the structure of the heart. Identifying the sections may, however, pose a problem to doctors that lack experience. The process of heart image classification has been attempted to be automated with the help of Artificial Intelligence employing convolutional neural networks. Investigations indicate that certain deep learning methods are capable of classifying EchoCG images with acceptable accuracy. The use of slices recognition through AI will increase the speed of evaluation, improve detection, and increase accuracy. The technology is known to help in areas where there is a shortage of trained personnel. A functional assessment of the left ventricle (LV) is an important aspect in the diagnostics of EchoCG. Commercial software packages ensure that measurements have maximum accuracy and good correlation with MRI measurements.

New algorithms AI-based can now measure LV in record time, by analyzing standard apical views with global longitudinal strain imaging. Ai also aids in diagnostic imaging for young specialists and significantly more accurate on mortality estimation compared to manual measurement. For clinical diagnosis, precise segmentation of the heart cavities is very essential. Automatic segmentation software makes it possible to decrease the amount of manual work and increase the objectivity of the obtained data. Artificial Intelligence is now used to identify the endocardial wall and optimally estimate the dimensions of the heart chambers. The LV is often segmented for the

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purposes of measuring the ejection fraction (EF) and evaluating myocardial motion.

This process is time-consuming concerning data segmentation needed for analysis. On the other hand, the automatic method suffers from rapid movements, respiratory noise, and ultrasound artifacts which distort the images.

Segmentation of the right ventricle (RV) is particularly difficult because of the geometry of the heart, the thinner wall structure, and lower quality of the images captured RV is problematic, however, it is crucial both for the diagnosis and understanding what is happening at the clinical level. Sparse matrix transformation and wall thickness constraints serve as one of the potential solutions to combat poor image quality. Attempts have also been made toward multichamber models to enhance segmentation and incorporate the communications between heart chambers. In lower quality images, RV segmentation precision relies strongly on previously recorded data and its correlation with other areas of the heart. At this time, utilizing AI technology for better slice recognition, functional assessment evaluation, and segmentation in EchoCG seems to yield faster and better outcome accuracy for post diagnosis evaluation.

Cardiosonography and Auscultation, Heart Murmur Analysis Using AI

AI is used to optimize the diagnostic potential of EchoCG. Below are several ways AI is used in EchoCG. AI can accelerate the assessment of patient conditions by automating deformation signal calculations, EF, and other measurements. This type of automation can increase the

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throughput of ultrasound examination rooms. A blind randomized study on heart function assessment using EchoCG and AI showed that AI-guided workflow for initial heart function evaluation outperformed the initial evaluation performed by a specialist. There has been a significant increase in interest in using AI technology for heart auscultation to identify coronary artery disease (CAD). AI algorithms have made significant progress in detecting heart murmurs. However, numerous clinical studies are required to confirm their accuracy before recommending clinical use. Previous studies confirmed the accuracy of diagnoses made by AI, although their sample sizes were small. The largest study recorded heart tones of 1,362 patients, which, to our knowledge, is the largest sample size. The authors compared AI-assisted auscultation with auscultation performed by experienced cardiologists and found that AI correctly identified heart tone changes with 97% sensitivity and 89% specificity. AI auscultation has high sensitivity and specificity for detecting abnormal heart sounds, similar to those determined by cardiologists, making AI auscultation a potentially useful screening tool for CAD. Compared to traditional algorithms, the method uses convolutional neural networks to study feature representation.

AI Analysis of CT and MRI Results

Accurate diagnosis is crucial for predicting the onset, progression, and outcomes of CVD, which in turn reduces associated risks. The most common and vital diagnostic tests include MRI and CT. High-quality heart images are obtained using MRI and CT, but these have long acquisition times, limited availability, and require radiation use.

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AI in MRI Decoding

MRI is a vital non-invasive tool for assessing heart diseases. However, it is time-consuming due to the need for high-quality images and consideration of heart and respiratory movements. Methods such as parallel imaging and compressed sensing have accelerated MRI by collecting less data and using prior knowledge. Currently, AI, particularly deep learning, is being explored to further speed up MRI.

Before AI can be widely used, technical challenges need to be overcome. Bustin et al. (2024) provided a detailed review of recent AI advancements assisting in MRI, focusing on deep learning for 2D and 3D images. The paper discusses limitations, issues, and potential future directions of these methods. Of particular interest to cardiologists is MRI phenotyping of heart failure and CAD.

AI in CT Imaging

The use of AI in heart CT is likely to play a key role in the future, reducing reporting time, providing information on coronary atherosclerotic plaques, and detecting myocardial ischemia by evaluating perfusion.

AI for Heart PET Scan Analysis

Positron Emission Tomography (PET) provides an absolute quantitative evaluation of myocardial perfusion. Results are usually summarized in topological representations known as polar maps. Currently, deep learning is improving classification performance through iterative learning of complex multidimensional patterns.

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Universal AI and its Applications in Cardiology

Although there are numerous examples of AI models developed for medical use, in recent months, there has been a rise in public awareness about large language models (LLMs), such as generative pre-trained transformers like "ChatGPT," which was released in November 2022 [32]. ChatGPT has been proclaimed a revolution [32] in the field of AI. Trained on large datasets of text available on the internet, AI models like LLMs seem to provide high-level answers. This type of AI can demonstrate medical knowledge and generate recommendations [33].

With advanced deep learning and natural language processing capabilities, such as ChatGPT and subsequent versions, like the generative pre-trained transformer-4, "GPT-4," they generate conversational questions and answers resembling human-like interactions and can be used in surveys for clinical use [34]. However, it is important for users, including doctors and patients, to know how to critically assess such LLMs, understand the regulatory environment, and be generally aware of the potential weaknesses and hidden dangers of using them [35].

Table 1 Processes that AI can Automate in Cardiology Institutions [31]

Automatable Processes	Activity Details
Medical Literature Analysis	Evaluating and collating new work in the area of treatment and therapy of cardiology. Providing cardiologists with the most recent

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	applicable research works.
Assistance in Diagnosis and Treatment Planning	Formulating possible diagnoses (including differential diagnosis) and treatment modalities considering his/her symptoms and medical history.
Patient-Specific Education	Developing individualized educational materials for patients with prevalent conditions such as myocardial infarction or heart failure.
Risk Prediction and Disease Progression	Estimating the risk in an individual for development of cardiovascular diseases as well as progression of these diseases based on textual interpretation of x-ray findings.
Report and Document Generation	Creating reports and documents including discharge summaries, referral summaries, and transfer notes.
Identification of Patterns in Electronic Medical Record Data	Detecting trends in patient data including treatment queries raised regarding blood pressure results and cholesterol levels.
Real-Time Language Translation	Offering direct language interpretation during consultations with patients from abroad. Immediate translation for telemedicine consultations with colleagues from other countries.
Automated	Preparing interpretive summaries of patient

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Consultation Summaries	consultations for doctors' notes in regards to the major points and anticipated actions.
Personalized Lifestyle and Medication Recommendations	Advising patients on pertinent changes in his/her lifestyle and treatment plans based on his/her medical history, current condition and local and international practices using lifestyle medicine.

This Table.1 provides a detailed overview of the various processes in cardiology institutions that can be automated with AI, covering aspects from diagnosis assistance to real-time language translation.

LLMs in Cardiological Care Organizations

In healthcare institutions focused on cardiology, there are numerous administrative AI applications. While AI use in this field is somewhat less revolutionary compared to its use in diagnostics and patient care, it can still significantly enhance the efficiency of healthcare and preventive institutions (Table 1). On average, a nurse spends 25% of their shift on administrative and regulatory tasks. Technologies most likely to be related to this goal include universal AI and chatbots. They can be used for various applications in healthcare, such as processing claims, clinical documentation, economic activity management in healthcare institutions, and managing automated medical record systems, as well as appointment scheduling [31, 37].

Some organizations have used chatbots to interact with patients within telemedicine frameworks. These natural language models can be useful for simple tasks such as prescription updates or appointment bookings. However, in a survey of 500 American users of

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the five most popular healthcare chatbots, patients expressed concerns about privacy issues, discussing complex health conditions, and the low convenience of use [31, 36, 37].

AI Chatbots in Cardiological Care Practices

As a strategic investment, AI indicates that changes in the current healthcare delivery models will have to be made, if not new ones created. The initial implementing of AI boasts low expenses, however, the re-skilling of employees and renovation of hospitals and clinics alongside the initial investment may raise the overall expenditure of incorporating AI into clinical practices. Strategies are needed to shift healthcare spending away from what currently accounts for a large share of national GDP towards new developing technologies that are impactful and cost-efficient. In simpler terms, when there is a scarcity of resources available, the additional expenses that new technologies incur have to be offset with their potential benefits and clinical improvements such as an enhanced quality of life or longer lifespan. These considerations are weighed against the expenditures that socially acceptable cost-effectiveness ratios put forth for healthcare.

Few comprehend the economic aspects of cardiovascular AI technologies [38, 39]. The speed at which AI technologies develop and progress may need a new approach in assessment that is much more effective than the traditional technology evaluation methods used in the development of healthcare policy.

Discussion

The realm of cardiology Artificial Intelligence (AI) is progressing rapidly and becoming an integral part of clinical practice. The

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diagnostic panorama of cardiovascular medicine is already changing because of the widespread use of machine learning (ML) based algorithms. Significant strides are already being seen in AI driven electrocardiology (ECG), echocardiography, sonogrphy, and even radiology. Machine learning algorithms assist in the analysis of massive data sets, aid in uncovering previously undetectable patters, and are superseded in the diagnosis of cardiovascular diseases (CVD) using traditional techniques. For instance, AI is proving particularly valuable in the more accurate interpretation of ECG and echocardiogram images with assistance in detection of arrhythmias, heart valve diseases, and even myocardial infarctions. Additionally, the automation of such processes not only improves efficiency, but also reduces human error enabling quicker and more reliable clinical decision making.

The development of general artificial intelligence built on large language models (LLMs) represents one of the most critical advancements in AI technology. These models have great potential regarding continuous medical education (CME), as they can provide clinicians with summaries of relevant updates in research, treatment techniques, and other useful information. These features can tremendously increase the availability and relevance of information for specialists, making it possible for them to improve their decision-making while significantly decreasing the time incurred on literature evaluations. LLMs may help in improving the quality of patient care by facilitating the creation of tailored evidence-based treatment strategies for patients. Such systems enable specialists to keep pace

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with contemporary developments, a concern that is often encountered in rapidly advancing areas like cardiology, where physicians are compelled to practice medicine on outmoded information.

Another possible area of development is AI's potential to enhance processes such as completing and assessing medical documentation. AI-powered tools are enhancing the delivery of healthcare services by lessening the administrative work needed of clinicians, thus, increasing the time available for actual patient healthcare. AI has the potential to relieve human workload and reduce errors that stem from manual data entry by automating monotonous documentation activities. Furthermore, AI is being incorporated into the automation of processes within different departments, patient data collection and processing, as well as enhancing diagnostic and prognostic activities through personalized predictive medicine. This is critical since health systems are trying to improve productivity due to the increasing patient load and limited available resources.

However, this development in technology does come with a catch, as there are several barriers that need to be sorted before LLMs or any other AI technology can be used in clinical practice. One of the major problems has to do with the ethical AI implications concerning patient care. The use of the AI system raises serious concerns of data privacy, data security, and possible algorithmic biases that may detrimentally influence the quality of care given to various patient groups. It is essential that the AI algorithms are adequately trained on

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a representative corpus to prevent the perpetuation of inequalities, be it in diagnosis or treatment based on age, gender, or ethnicity. Additionally, the need for clarifying reasoning behind decisions made by AI systems is crucial to win the confidence of clinicians and patients, with the former being particularly sensitive to such “explanations.” The ability of many AI models to remain opaque raises barriers to clinical acceptance, as healthcare providers may not be willing to accept the validity of decisions, diagnoses, and treatment options rendered by AI that is not understood by them.

Concerns also arise regarding the integration of AI in clinical practice. Healthcare professionals seem to be skeptical when it comes to fully adapting to AI-enabled tools as they do not trust their real-world accuracy or even usefulness. Clinicians tend to fear that AI might relieve them from judgment duties, especially in complicated cases that require vast clinical knowledge. The acceptance of AI technologies will progress only when the systems are deemed intuitive enough not to obfuscate clinical problems. It is clear that AI should not make decisions independently in which case the decision-making process should be collaborative in nature. This way the skill of clinicians is preserved along with their critical importance in the healthcare system – decisions remain within the realm of professionals.

Even with these challenges AI in cardiology looks promising. As AI systems become more robust and diagnostic procedures, treatment, and ethical considerations are refined, the prevention and management of cardiovascular diseases can drastically improve. The

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application of AI in Clinical Decision Support Systems, Electronic Health Records, and Predictive Modeling will enhance granularity of patient care and health outcomes. However, for widespread AI adoption in clinical practice, issues regarding data quality, model explainability, and clinician-centeredness must be improved.

Insights Formed:

- Increased Diagnostic Accuracies: AI applications in cardiology, particularly ECG, echocardiogram videos, and medical imaging have great improvements in CVDs detection rates.
- Modern Continuing Medical Education: LLMs can change the landscape of medical education by actively providing new and updated information to clinicians regarding their work and field of expertise.
- Increased Productivity: Administrative tasks like medical documentation, one of the more burdensome tasks in medicine, AI powered technologies are optimistic in promoting efficiency.
- Ethical and Professional Concerns: The challenges of data confidentiality, algorithmic bias, and skepticism from professionals need to be solved to ensure the integration of AI into clinical practice takes place smoothly.
- Future Potential: AI can currently assist in various activities, but it has the most promise in decision support systems in personalized cardiology, which then would lead to better patient outcomes.

Conclusion

AI technologies utilizing neural networks and similar constructs are already in use by many cardiologists, radiologists, and functional

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specialists across the globe. In clinical practice, machine learning is spreading to almost all areas of practice, including diagnostic imaging and prognostic marking. However, AI applications and technologies that have been clinically tested for prognosis and diagnosis are scarce despite the increased uptake. Moreover, randomized controlled studies investigating the effectiveness of these AI technologies are still in their infancy.

Albeit the hope brought forth byAAI and “strong” AI systems like large language models (LLMs) regarding the improvement of service and care in the health sector, there are many technical and ethical issues that still need to be dealt with before it can be put into full practice. For LLMs, the following issues are still pertinent:

1. Data Collection and Recording: Algorithms intended for standardization and recording of medical data often lack the necessary precision. This combined with insufficient fine-tuning of the algorithms leads to generation of clinical information that is either inappropriate or irrelevant and thus renders the algorithms useless in clinical settings.
2. Human Judgment and Experience: Although LLMs are capable of providing assistance in clinical summaries or offering education to patients, they are not able to account for the sophisticated human judgment which is indispensable for making important medical decisions.
3. Ethical Considerations: AI use in scientific research writing and grant proposals raise the question of ethical authorship, responsibility, and abuse of AI. The responsibility for the accuracy and integrity of

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AI-generate content lies with the experts and as such, requires verification by control algorithms before use.

In summary, the use of AI in cardiology is very promising, but it will require tackling issues related to technicalities, ethics, and professional conduct before it can be easily integrated into clinical practice. For success of AI in medicine, technological advancements along with strong regulations will be vital.

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