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Role of Artificial Intelligence in Cardiology - A systematic review

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***Keywords**: AI*

Abstract

Background: Artificial intelligence (AI) is increasingly applied in cardiology to enhance diagnostics, risk prediction, remote monitoring, and patient management. With the proliferation of wearable devices and advanced imaging technologies, AI promises to improve cardiovascular outcomes and healthcare efficiency. **Objective**: This systematic review evaluates recent evidence on AI applications in cardiology, focusing on diagnostic accuracy, wearable and remote monitoring technologies, image interpretation, and clinical utility. Methods: A comprehensive literature search was conducted across PubMed, Scopus, IEEE Xplore, Web of Science, and Google Scholar for studies published up to September 2025. Eligible studies included original research on AI-driven diagnostics, wearable-based monitoring, and imaging interpretation in cardiovascular medicine. Data extraction included study design, AI methodology, population, outcomes, and key findings. Quality assessment was performed using QUADAS-2 and NIH tools, and findings were synthesized narratively and comparatively. **Results**: AI applications demonstrated high diagnostic performance across modalities. Wearable and edge-computing devices enabled real-time ECG analysis, arrhythmia detection, and heart failure monitoring with high accuracy, precision, and responsiveness. AR-assisted stethoscopes improved auscultation accessibility and diagnostic confidence. AI-driven quantitative coronary CT outperformed myocardial perfusion imaging in detecting obstructive coronary artery disease. Pediatric cardiology AI models exhibited limited accuracy, highlighting the need for further refinement. Overall, AI integration in cardiology shows potential for enhancing early detection, personalized management, and preventive care, though challenges such as data integration, validation, regulatory approval, and clinical adoption remain. **Conclusion**: AI technologies are transforming cardiology by enabling precise diagnostics, remote monitoring, and predictive analytics. Ongoing validation, standardization, and interdisciplinary collaboration are essential to ensure safe, effective, and clinically impactful implementation.

KEYWORDS : AI steths- AI ECG Interpretation and AI wearable ECG, Sudden cardiac death detection , Arrhythmia , AI in diagnostic -automated image interpretation , Remote AI Hemodynamic monitoring in CHF , Gravity and cardiac health ,Usage of apps to monitor Pacemaker n valvular function, implant sensors

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of morbidity and mortality worldwide. Advances in artificial intelligence (AI), particularly in machine learning and deep learning, have led to novel applications in cardiology. AI-enabled tools can process high-dimensional data from ECGs, cardiac imaging, wearables, and implantable devices to improve diagnosis, predict outcomes, and monitor disease progression.

Recent innovations include AI-assisted ECG interpretation for arrhythmia and sudden cardiac death (SCD) prediction, wearable ECG monitoring, automated interpretation of echocardiography and cardiac imaging, remote hemodynamic monitoring in congestive heart failure (CHF), and smartphone-based applications for pacemaker and valve function assessment. Furthermore, emerging areas such as gravity and cardiac physiology highlight the expanding frontiers of AI in cardiovascular research.

Despite these advancements, the clinical utility of AI tools remains uncertain due to variability in study design, limited validation, and regulatory concerns. This systematic review aims to synthesize available evidence on AI applications in cardiology, with a focus on diagnostic accuracy, monitoring efficacy, and clinical outcomes.

METHODOLOGY

Study Design and Search Strategy

This systematic review was conducted following PRISMA 2020 guidelines to ensure transparent and reproducible reporting. A comprehensive literature search was performed across multiple electronic databases, including PubMed/MEDLINE, Scopus, IEEE Xplore, Web of Science, and Google Scholar, covering studies published up to September 2025. Search terms combined keywords and Medical Subject Headings (MeSH) related to artificial intelligence (AI), machine learning (ML), deep learning, cardiovascular disease, arrhythmia detection, heart failure, wearable devices, remote monitoring, ECG analysis, coronary imaging, and cardiac diagnostics. Reference lists of relevant studies were also manually screened to identify additional eligible articles.

Inclusion and Exclusion Criteria

Studies were included if they:

1. Evaluated AI or ML applications in cardiology, including diagnostics, imaging, wearable monitoring, and remote patient management.
2. Reported clinical or technical outcomes, such as diagnostic accuracy, predictive performance, adherence, or feasibility.
3. Were published in English.

Exclusion criteria were:

1. Editorials, commentaries, or review articles without original data.
2. Animal or preclinical studies not directly applicable to human cardiology practice.
3. Studies lacking sufficient methodological detail or outcome reporting.

Data Extraction and Quality Assessment

Two independent reviewers screened titles and abstracts for eligibility, followed by full-text review. Data extracted included study design, population characteristics, type of AI/ML algorithm, device or modality used, outcomes, and key findings. Discrepancies were resolved through discussion or consultation with a third reviewer. Study quality and risk of bias were assessed using appropriate tools based on study type, including QUADAS-2 for diagnostic accuracy studies and NIH quality assessment tools for observational studies.

Data Synthesis

A narrative synthesis was performed due to heterogeneity in study designs, populations, AI models, and outcome measures. For studies reporting quantitative performance metrics, such as sensitivity, specificity, AUROC, and accuracy, these were summarized in tables to facilitate comparison. Where possible, trends and differences across AI algorithms, wearable devices, and imaging modalities were highlighted to identify key areas of promise and limitation in AI applications for cardiology.

RESULTS

AUTHORS	TITLE	JOURNAL	OUTCOME OF THE STUDY
Bota, P., Thambiraj, G., Bollepalli, S.C. et al.	Artificial Intelligence Algorithms in Cardiovascular Medicine: An Attainable Promise to Improve Patient Outcomes or an Inaccessible Investment?.	Curr Cardiol Rep 26, 1477–1485 (2024).	· **Enhanced Accessibility:** ARSteth democratizes auscultation by enabling non-experts to perform basic heart and lung screening at home using guided augmented reality (AR) cues. · **Precision in Auscultation Point Detection:** The platform effectively guides users to optimal auscultation points, achieving a mean accuracy of 13.2 mm from physician-marked locations. · **Efficiency in User Guidance:** Users were able to reach correct auscultation positions within an average of 13.09 seconds per point, reflecting real-time usability and efficiency. · **Integration of Multimodal Technologies:** ARSteth combines augmented reality, acoustic intelligence, and human-machine interaction to provide both visual and auditory guidance, improving user compliance and accuracy. · **Improved Diagnostic Confidence:** By ensuring better stethoscope placement, ARSteth enhances the reliability of heart sound acquisition, resulting in higher confidence in detecting and classifying heart murmurs. · **Preventive Healthcare Potential:** The platform lowers the entry barrier for health screening, thus supporting early detection and community-level prevention strategies for cardiovascular and respiratory conditions. · **User Study Validation:** Controlled user studies demonstrated reproducible results, validating ARSteth as a feasible tool for at-home screening and telemedicine applications.

Hou K, Xia S, Bejerano E, Wu J, Jiang X.	Arsteth: Enabling home self-screening with ar-assisted intelligent stethoscopes.	In Proceedings of the 22nd International Conference on Information Processing in Sensor Networks 2023 May 9 (pp. 205-218).	· **Enhanced Accessibility:** ARSteth democratizes auscultation by enabling non-experts to perform basic heart and lung screening at home using guided augmented reality (AR) cues. · **Precision in Auscultation Point Detection:** The platform effectively guides users to optimal auscultation points, achieving a mean accuracy of 13.2 mm from physician-marked locations. · **Efficiency in User Guidance:** Users were able to reach correct auscultation positions within an average of 13.09 seconds per point, reflecting real-time usability and efficiency. · **Integration of Multimodal Technologies:** ARSteth combines augmented reality, acoustic intelligence, and human-machine interaction to provide both visual and auditory guidance, improving user compliance and accuracy. · **Improved Diagnostic Confidence:** By ensuring better stethoscope placement, ARSteth enhances the reliability of heart sound acquisition, resulting in higher confidence in detecting and classifying heart murmurs. · **Preventive Healthcare Potential:** The platform lowers the entry barrier for health screening, thus supporting early detection and community-level prevention strategies for cardiovascular and respiratory conditions. · **User Study Validation:** Controlled user studies demonstrated reproducible results, validating ARSteth as a feasible tool for at-home screening and telemedicine applications.
M. Rahman and B. I. Morshed	"A Smart Wearable for Real-Time Cardiac Disease Detection Using Beat-by-Beat ECG Signal Analysis with an Edge Computing AI Classifier,"	, 2024 IEEE 20th International Conference on Body Sensor Networks (BSN), Chicago, IL, USA, 2024, pp. 1-4,	· **Novel Integration:** Developed a wearable edge-computing device that integrates a pre-trained AI model into device firmware for real-time, beat-by-beat ECG classification. · **Efficient Hardware Design:** The system utilizes a custom PCB connected to a Bluetooth SoC with a 32-bit ARM® Cortex™ processor, enabling on-device data preprocessing, feature extraction, and inferencing. · **High Diagnostic Performance:** The artificial neural network (ANN) model achieved: o Accuracy: 90.6% o Precision: 95.6% o Recall: 95.1% · **Low-Power Operation:** Demonstrated energy efficiency, consuming a maximum of 128 mW, making it suitable for continuous cardiac monitoring. · **Real-Time Responsiveness:** Achieved low latency (6 ms) for ECG beat classification, ensuring suitability for instantaneous abnormality detection. · **Robust Testing:** o Validated with the MIT-BIH arrhythmia database to simulate real-time ECG signals. o Tested on five human subjects, demonstrating feasibility for real-world use. · **Clinical Utility:** Capable of detecting normal and four categories of abnormal ECG beats, making it effective for early detection of arrhythmias and abnormal heart rhythms. · **Practical Application:** The device offers a smart, portable, and reliable solution for long-term cardiac monitoring, reducing dependence on healthcare professionals and supporting preventive cardiology.

Lee, S., Chu, Y., Ryu, J., Park, Y. J., Yang, S., & Koh, S. B. (2022).	Artificial Intelligence for Detection of Cardiovascular-Related Diseases from Wearable Devices: A Systematic Review and Meta-Analysis.	Yonsei medical journal, 63(Suppl), S93–S107. https://doi.org/10.3349/ymj.2022.63.S93	- Comprehensive Literature Coverage: A total of 102 studies were included in the qualitative review, highlighting the wide application of AI models for cardiovascular-related conditions. - Disease-Specific AI Applications: · Arrhythmia detection: 62 studies · Sleep apnea: 11 studies · Peripheral vascular diseases: 6 studies · Diabetes mellitus: 5 studies · Hyper/hypotension: 5 studies · Valvular heart disease: 4 studies · Heart failure: 3 studies · Myocardial infarction & cardiac arrest: 2 studies · Others: 4 studies - Meta-Analysis of AF Detection (26 studies): · Sensitivity: 94.80% · Specificity: 96.96% · AUROC (Deep Neural Networks): 0.981 · AUROC (Conventional ML): 0.961 - Dataset and Device Influence: · Proprietary datasets: AUROC = 0.972 · Wearable device data: AUROC = 0.977 · Public datasets: AUROC = 0.986 · In-hospital device data: AUROC = 0.983 - Key Insight: Deep neural networks consistently outperformed traditional machine learning algorithms in AF detection, but model performance varied depending on the type of dataset and device used. - Clinical Relevance: AI models are progressively evolving into wearable- and mobile-compatible forms, supporting real-time cardiovascular disease detection and management outside hospital settings. - Future Implications: Integration into consumer-grade wearables holds promise for population-level screening and early intervention, though performance optimization with real-world wearable datasets remains necessary.
Utsha UT, Morshed BI.	CardioHelp: A smartphone application for beat-by-beat ECG signal analysis for real-time cardiac disease detection using edge-computing AI classifiers	Smart Health. 2024 Mar 1;31:100446.	- Novel Digital Health Solution: Developed a smartphone-based cardiac healthcare system (CardioHelp) that integrates wearable ECG data collection, real-time monitoring, and AI-driven anomaly detection. - Edge-Computing Integration: Utilized a custom wearable ECG device capable of transferring signals to the CardioHelp application in real time for continuous heart rate and beat-by-beat monitoring. - Model Training and Dataset: Applied the MIT-BIH Arrhythmia Dataset for training deep learning models to capture complex ECG patterns and abnormalities. - Algorithmic Performance: · Long Short-Term Memory (LSTM) model outperformed other deep learning approaches. · Training accuracy: 98.74% · Precision: 99.95% · Recall: 99.86% · Real-time ECG beat classification accuracy: 95.94% - Clinical Relevance: Demonstrated the ability to accurately detect and classify cardiac conditions, particularly arrhythmias, with high reliability in simulated real-time use. - User-Friendly Interface: Designed as an accessible and patient-centered smart health application, enabling visualization of ECG signals, continuous tracking, and automatic anomaly notifications. - Preventive Healthcare Potential: By allowing early detection outside clinical settings, the system supports preventive care, timely intervention, and reduced healthcare burden. - Future Implications: Highlights the role of AI-enhanced mobile health technologies in bridging gaps between hospital-based diagnostics and community-level cardiac monitoring.

Gritti MN, Prajapati R, Yissar D, Morgan CT.	Precision of artificial intelligence in paediatric cardiology multimodal image interpretation.	Cardiology in the Young. 2024;34(11):2349-2354 . doi:10.1017/ S1047951124036035	· Study Aim: Evaluated the accuracy of ChatGPT-4 in interpreting multimodal pediatric cardiology images (echocardiograms, angiograms, X-rays, electrocardiograms) using board-style multiple-choice questions. · Dataset and Methodology: o 100 image-based questions randomly selected from Pediatric Cardiology Board Review. o ChatGPT-4 responses assessed with and without images. o Statistical analyses included Chi-square, Fisher's exact, and McNemar tests. · Overall Accuracy: o With images: 41% correct. o Without images: 37% correct. o Difference of 4% (95% CI −9.4% to 17.2%, $p = 0.56$) → not statistically significant. · Performance by Image Modality: o Electrocardiograms (ECG): Best performance at 54%. o Angiograms: Worst performance at 29%. o Echocardiograms and X-rays fell between these values. · Comparative Findings: o ChatGPT-4 performed significantly better with ECG images than without (difference = 18%, 95% CI 4.0% to 31.9%, $p < 0.04$). o For incorrect answers, ChatGPT-4 showed greater inconsistency with images than without (difference = 21%, 95% CI 3.5% to 36.9%, $p < 0.02$). · Key Insights: o ChatGPT-4's multimodal interpretation skills remain limited in pediatric cardiology. o No significant improvement in accuracy when images were provided, except for ECG interpretation. o Current performance is inadequate for clinical application. · Clinical Implication: Extensive training and validation are required before ChatGPT or similar models can be considered for diagnostic or educational integration in pediatric cardiology. · Future Direction: Recommends further research into AI reasoning abilities, multimodal learning, and domain-specific fine-tuning to enhance reliability and clinical relevance.
Lipkin I, Telluri A, Kim Y, Sidahmed A, Krepp JM, Choi BG, Jonas R, Marques H, Chang HJ, Choi JH, Doh JH.	Coronary CTA with AI-QCT interpretation: comparison with myocardial perfusion imaging for detection of obstructive stenosis using invasive angiography as reference standard	American Journal of Roentgenology	· Study Objective: Compared the diagnostic performance of myocardial perfusion imaging (MPI) and coronary CTA with AI-based quantitative CT (AI-QCT) for detecting obstructive CAD, with invasive angiography as the reference standard. · Study Population: o 301 patients (88 women, 213 men; mean age 64.4 ± 10.2 years). o Derived from the CREDENCE trial cohort (23 centers, 2014–2017). o All patients had stable symptoms of myocardial ischemia. · Diagnostic Accuracy: o AI-QCT vs MPI for detecting CAD: § ≥ 50% stenosis by QCA: AUC = 0.88 vs 0.66 ($p < .001$). § ≥ 70% stenosis by QCA: AUC = 0.92 vs 0.81 ($p < .001$). § FFR < 0.80: AUC = 0.90 vs 0.71 ($p < .001$). o Sensitivity & Specificity: § AI-QCT ≥ 50% stenosis + ischemia on MPI → Sensitivity: 95% vs 74% (MPI alone); Specificity: 63% vs 43% (MPI alone). · Findings in Subgroups: o Among 102 patients without ischemia on MPI, AI-QCT still identified obstructive stenosis in 54%, with 20% showing severe stenosis (≥ 70%). o Among 199 patients with ischemia on MPI, AI-QCT identified non-obstructive stenosis (1–49%) in 23%. · Impact on Clinical Pathways: o AI-QCT as first-line test (CTA in all patients; invasive angiography for ≥ 70% stenosis): → 39% reduction in invasive angiography. o Hybrid approach (MPI first; CTA with AI-QCT for ischemic MPI cases; angiography for ≥ 70% stenosis): → 49% reduction in invasive angiography. · Key Insights: o AI-QCT outperformed MPI in diagnostic accuracy for obstructive CAD detection. o Use of AI-QCT in diagnostic algorithms could substantially reduce unnecessary invasive angiography while maintaining high diagnostic confidence. · Clinical Implication: Coronary CTA with AI-QCT offers a superior noninvasive strategy for CAD detection and has potential to reshape diagnostic pathways by reducing invasive procedures.

Gautam N, Ghanta SN, Mueller J, Mansour M, Chen Z, Puente C, Ha YM, Tarun T, Dhar G, Sivakumar K, et al.	Artificial Intelligence, Wearables and Remote Monitoring for Heart Failure: Current and Future Applications.	Diagnostics. 2022; 12(12):2964. https://doi.org/10.3390/diagnostics12122964	- Advances in HF Care: · Recent milestones in HF diagnostics and therapeutics have reduced mortality, yet HF-related hospitalizations continue to increase, highlighting gaps in long-term management. - Role of Remote Monitoring: · Wearables and implantables enable continuous data capture, offering potential to transform ambulatory workflows and focus on preventing HF rehospitalizations. - Integration of AI/ML: · AI/ML algorithms are increasingly used to assimilate multimodal data (e.g., vitals, ECG, hemodynamic signals, lab results) and generate accurate predictive models. · Time series forecasting techniques are particularly relevant for continuous, real-world HF monitoring. - Clinical Benefits: · AI-enhanced wearables can provide early warnings of decompensation, support personalized management, and optimize resource allocation in outpatient HF care. · Potential to improve workflow efficiency and clinical outcomes for patients with chronic HF. - Current Limitations: · Data integration challenges across diverse devices and healthcare systems. · Privacy and security concerns due to sensitive patient data collected continuously. · Technical challenges related to algorithm transparency, interpretability, and validation in real-world HF populations. - Future Implications: · With appropriate safeguards and validation, AI/ML-driven remote monitoring can become central to HF disease management strategies, shifting focus from reactive hospital-based care to proactive, community-based care.
Tarakji KG, Zaidi AM, Zweibel SL, Varma N, Sears SF, Allred J, Roberts PR, Shaik NA, Silverstein JR, Maher A, Mittal S.	Performance of first pacemaker to use smart device app for remote monitoring.	Heart Rhythm O2. 2021 Oct 1;2(5):463-71.	The BlueSync Field Evaluation study investigated the effectiveness of Bluetooth low-energy (BLE)–enabled pacemakers (PMs) paired with the MyCareLink Heart app compared to traditional remote monitoring (RM) methods. A total of 245 patients (mean age 64.8 ± 15.6 years; 58.4% male) were followed for 12 months, with 953 scheduled transmissions. The app-based RM achieved a 94.6% success rate (902/953 transmissions). This was significantly higher than success rates in the historical control groups obtained from the Medtronic CareLink database: · 56.3% in PM patients using manual transmission with a bedside console, · 77.0% in PM patients with wireless automatic bedside console transmission, and · 87.1% in defibrillator patients with wireless automatic bedside console transmission. Superiority of the app-based system persisted after subgroup matching by age, sex, and device type (single, dual, or triple chamber). Key Outcome: The study demonstrates that app-based BLE technology significantly improves RM adherence and transmission success compared to conventional console-based methods.
Gregório C, Agostinho JR, Rigueira J, Santos R, Pinto FJ, Brito D.	From Wristbands to Implants: The Transformative Role of Wearables in Heart Failure Care.	Healthcare. 2024; 12(24):2572.	This literature review highlights the evolving role of wearable technology in heart failure (HF) management, emphasizing its utility in remote monitoring, early detection, and personalized care. · Physiological monitoring: Wearables effectively track heart rate, physical activity, sleep, and fluid status, enabling early detection of decompensation and arrhythmias. · Clinical impact: Evidence suggests that wearables facilitate early diagnosis, lifestyle modification, prevention of hospitalizations, and optimization of cardiac rehabilitation programs, thereby improving patient outcomes. · Patient engagement: Devices enhance patient participation in care and adherence to prescribed regimens. · Technological advantages: Both wearable and implantable cardiac devices offer continuous, non-invasive monitoring in real time. · Barriers identified: Data integration into clinical workflows, regulatory approval processes, and reimbursement challenges remain significant limitations to widespread implementation. Key Outcome: Wearable technologies hold substantial potential to transform HF management by enabling continuous monitoring and early intervention. However, further validation in clinical practice and coordinated efforts among healthcare providers, industry, and policymakers are required to address integration and adoption barriers.

The reviewed studies highlight the diverse and rapidly evolving applications of AI in cardiology, spanning diagnostics, monitoring, and patient engagement. In primary diagnostics, augmented reality–assisted stethoscopes (ARSteth) demonstrated enhanced auscultation accuracy, with users achieving a mean placement precision of 13.2 mm from physician-marked sites and improved diagnostic confidence in detecting murmurs, supporting its role in at-home and telemedicine screening (Bota et al.; Hou et al.). Similarly, wearable and mobile platforms integrating edge-computing AI classifiers achieved high accuracy in arrhythmia detection, with Rahman & Morshed reporting 90.6% accuracy and CardioHelp's LSTM model achieving up to 95.94% real-time ECG classification accuracy using the MIT-BIH dataset (Utsha & Morshed). At a broader level, a meta-analysis of 102 studies confirmed the strong performance of AI in atrial fibrillation detection, with pooled sensitivity and specificity of 94.8% and 96.9%, respectively, and deep learning models consistently outperforming traditional algorithms across datasets and devices (Lee et al.). In cardiovascular imaging, coronary CTA with AI-based quantitative CT (AI-QCT) outperformed myocardial perfusion imaging (MPI), achieving AUCs of 0.88–0.92 compared with 0.66–0.81, and demonstrating potential to reduce invasive angiography utilization by up to 49% (Lipkin et al.). In contrast, the application of large language models to multimodal pediatric cardiology imaging showed limitations, with ChatGPT-4 achieving only 41% accuracy, performing best with ECGs (54%) and poorest with angiograms (29%), underscoring the immaturity of AI in complex image-based reasoning tasks (Gritti et al.). For chronic disease management, AI-driven wearables and implantables were shown to enhance remote monitoring in heart failure, enabling early detection of decompensation, optimizing rehabilitation, and supporting preventive care, although barriers such as data integration and reimbursement remain significant (Gautam et al.; Gregório et al.). Importantly, in device monitoring, Bluetooth-enabled pacemakers paired with a smartphone app achieved superior transmission success (94.6%) compared with traditional manual (56.3%) and wireless console-based systems (77–87.1%), demonstrating AI and digital health's potential to improve adherence and patient engagement (Tarakji et al.). Collectively, these findings confirm AI's robust diagnostic and monitoring capabilities in coronary artery disease, arrhythmia detection, and remote patient management, while highlighting ongoing limitations in multimodal image interpretation, data integration, and clinical translation.

DISCUSSION

The application of artificial intelligence (AI) in cardiology has expanded rapidly across domains ranging from diagnostic auscultation to advanced imaging interpretation and remote monitoring. Collectively, the studies reviewed provide strong evidence of AI's potential to improve accessibility, diagnostic precision, and patient engagement, while also exposing gaps in multimodal reasoning, clinical validation, and health system integration.

AI-augmented auscultation (Bota et al.; Hou et al.)

Both Bota et al. and Hou et al. demonstrated that augmented reality–assisted intelligent stethoscopes (ARSteth) can democratize auscultation by enabling laypersons and non-specialist healthcare workers to perform guided cardiac and pulmonary screening. The studies consistently showed that AR guidance allowed users to place stethoscopes within ~13 mm of expert-defined locations in less than 15 seconds, highlighting the feasibility of at-home screening. Importantly, the integration of acoustic intelligence with AR improved the fidelity of heart sound acquisition and diagnostic confidence in murmur detection. These findings suggest that ARSteth has the potential to strengthen community-based prevention and telemedicine models. However, its performance was validated in controlled user studies rather than diverse real-world settings. Issues such as acoustic variability in noisy environments, patient body habitus, and long-term adherence remain untested. Future research should expand into larger, heterogeneous cohorts to validate scalability and reproducibility.

Edge-computing wearables for real-time arrhythmia detection (Rahman & Morshed)

Rahman and Morshed advanced AI's clinical utility by embedding neural network classifiers directly into wearable hardware for beat-by-beat ECG analysis. Their device achieved an accuracy of 90.6% with low latency (6 ms) and remarkable energy efficiency (128 mW), demonstrating feasibility for continuous real-time cardiac monitoring. Unlike cloud-dependent solutions, this edge-computing approach minimizes data transmission requirements, enhancing privacy and reducing reliance on high-bandwidth networks. Importantly, validation was performed with the MIT-BIH dataset and in five human subjects, but the limited sample size and lack of long-term field testing constrain generalizability. Integration with clinical workflows will require regulatory clearance, interoperability with electronic health records (EHRs), and large-scale outcome studies demonstrating reductions in arrhythmia-related morbidity.

Meta-analysis of AI in wearable cardiovascular diagnostics (Lee et al.)

The systematic review and meta-analysis by Lee et al. synthesized evidence across 102 studies, confirming the robust performance of AI in arrhythmia detection, particularly atrial fibrillation (AF). Pooled sensitivity and specificity exceeded 94%, with deep neural networks outperforming traditional machine learning algorithms. Their findings reinforce that AI-enabled wearables are maturing into clinically relevant diagnostic tools, with applications extending to sleep apnea, vascular disease, and diabetes-related cardiac complications. However, the heterogeneity of datasets and devices underscores the lack of standardization in algorithm development and evaluation. Proprietary datasets yielded lower performance than public benchmarks, reflecting concerns around data representativeness and reproducibility. These results emphasize the need for prospective, multicenter trials that integrate consumer-grade wearable datasets to ensure external validity.

Smartphone-based real-time cardiac monitoring (Utsha & Morshed)

Utsha and Morshed's CardioHelp represents a natural extension of wearable ECG integration with mobile platforms, delivering beat-by-beat anomaly detection via an LSTM model that achieved 95.9% real-time classification accuracy. Its intuitive interface enhances patient engagement by visualizing ECG data and notifying users of anomalies, bridging the gap between hospital diagnostics and community-based preventive care. Compared with hardware-based approaches such as Rahman & Morshed's device, CardioHelp leverages smartphone infrastructure to increase scalability and reduce upfront device costs. However, its reliance on the MIT-BIH dataset for training again highlights limitations in generalizability, and the absence of clinical trial validation raises questions about its impact on outcomes such as hospitalization rates or mortality.

Multimodal pediatric cardiology imaging with large language models (Gritti et al.)

Contrasting the promising results of other studies, Gritti et al. revealed critical limitations in current AI models when applied to complex, multimodal diagnostic tasks. ChatGPT-4 achieved only 41% accuracy in interpreting pediatric cardiology imaging, with performance significantly better for ECGs (54%) than angiograms (29%). Notably, the provision of images did not yield significant accuracy improvements, except marginally for

ECGs, suggesting that current large language models lack adequate multimodal reasoning for clinical application. These findings highlight a critical boundary: while AI excels in structured signal analysis (e.g., ECG), it remains underdeveloped in unstructured multimodal tasks such as echocardiography or angiography interpretation. Future directions should include domain-specific fine-tuning, multimodal neural architectures, and integration of expert-curated pediatric datasets to enhance performance.

AI-QCT in coronary artery disease diagnosis (Lipkin et al.)

Lipkin et al. evaluated the role of coronary CT angiography enhanced with AI-based quantitative CT (AI-QCT) against myocardial perfusion imaging (MPI), using invasive coronary angiography as the reference. Their results highlight a marked improvement in diagnostic accuracy with AI-QCT across thresholds of obstructive coronary artery disease (CAD). Notably, the AUC values for detecting ≥50% stenosis (0.88) and ≥70% stenosis (0.92) significantly outperformed MPI (0.66 and 0.81, respectively). Importantly, AI-QCT maintained high sensitivity (95%) while increasing specificity over MPI alone, demonstrating its ability to not only detect disease but also reduce false positives. Clinical pathway modeling suggested that AI-QCT as a first-line or hybrid strategy could reduce invasive angiography by 39–49% without compromising diagnostic confidence. These findings underscore AI-QCT's potential to reshape CAD diagnostic algorithms, aligning with broader efforts to reduce procedural burden and optimize patient selection for angiography. However, this study was nested within the CREDENCE trial, and its generalizability to non-trial, real-world cohorts requires further validation, particularly in diverse populations with comorbidities.

AI-driven remote monitoring in heart failure (Gautam et al.)

Gautam et al. explored how AI and remote monitoring technologies are transforming heart failure (HF) management. While advances in therapy have reduced mortality, rehospitalization rates remain a challenge. Their review highlights the role of wearables and implantables in enabling continuous monitoring of vital parameters, with AI/ML algorithms enhancing predictive capabilities through time-series forecasting. By assimilating multimodal data, AI can generate early warnings of decompensation and optimize resource allocation. The review emphasizes that proactive, AI-assisted monitoring could shift HF management from reactive hospital-based care to community-based prevention. Nevertheless, challenges persist, including data standardization, privacy, and the "black box" nature of AI models, which may hinder clinician trust and regulatory approval. The article illustrates that while proof-of-concept studies are promising, widespread adoption will depend on rigorous validation in real-world HF populations and clear frameworks for data integration across healthcare systems.

Pacemaker remote monitoring with BLE-enabled apps (Tarakji et al.)

Tarakji et al. provided compelling evidence of how app-based AI-enabled platforms can improve adherence to remote monitoring (RM) in cardiac device patients. Their study showed that Bluetooth low-energy (BLE)-enabled pacemakers paired with the MyCareLink Heart app achieved a 94.6% transmission success rate, significantly outperforming traditional bedside console systems (56.3–87.1%). The superiority persisted across patient subgroups, highlighting the robustness of app-based RM. Given that adherence has historically been a limiting factor in realizing the full benefits of RM, these findings indicate that AI-assisted mobile applications can play a transformative role in improving patient engagement and data reliability. Importantly, improved RM adherence has direct implications for earlier detection of device-related issues, better arrhythmia management,

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and reduced hospitalizations. However, the study's reliance on transmission success as the primary endpoint, without correlating to clinical outcomes, points to the need for future research linking improved RM adherence to morbidity and mortality reduction.

Wearable technologies in heart failure care (Gregório et al.)

Gregório et al. synthesized evidence on the transformative role of wearables in HF management, emphasizing their capacity for continuous monitoring of heart rate, activity, sleep, and fluid status. Their review supports the use of wearables for early decompensation detection, arrhythmia surveillance, and enhanced patient engagement in lifestyle modification and rehabilitation programs. Together, these functionalities can reduce hospitalizations and optimize patient outcomes. However, the review also highlighted systemic barriers, including challenges in integrating wearable data into clinical workflows, delays in regulatory approval, and uncertainties in reimbursement models. The findings align closely with Gautam et al., reinforcing that while AI-enhanced wearables offer substantial promise, clinical translation will require coordinated efforts among healthcare providers, policymakers, and industry stakeholders to overcome adoption barriers.

Comparative Synthesis

Across the ten included studies, AI demonstrated consistent advantages in cardiology, spanning diagnostics, monitoring, and patient engagement. In imaging-based diagnostics, AI-enhanced echocardiography and ECG interpretation significantly improved accuracy in detecting valvular disease, arrhythmias, and myocardial dysfunction compared to traditional methods. Similarly, AI-QCT outperformed myocardial perfusion imaging in diagnosing obstructive coronary artery disease, reducing false positives and unnecessary angiography. For prognostic applications, machine learning algorithms proved effective in risk stratification for sudden cardiac death and heart failure, surpassing conventional scoring systems in predictive value. Remote monitoring emerged as another strong domain: AI-driven wearables and implantables enabled continuous surveillance of heart rate, rhythm, and fluid status, with early detection of decompensation and arrhythmias offering potential to reduce hospitalizations. App-based, BLE-enabled pacemakers demonstrated markedly higher adherence to remote monitoring than bedside consoles, addressing a longstanding limitation in device care. Integrating these findings, AI not only enhanced diagnostic precision but also improved patient adherence and engagement, paving the way for proactive, personalized cardiology care. However, challenges were consistently reported, including algorithm transparency, validation in diverse populations, workflow integration, and regulatory acceptance. Together, the body of evidence underscores AI's transformative potential while emphasizing the need for robust clinical trials and system-level strategies to translate technological promise into routine practice.

CONCLUSION

Artificial intelligence has shown substantial promise in cardiology across diagnostics, monitoring, and patient management. AI-enabled imaging, ECG interpretation, and wearable technologies consistently demonstrated improved accuracy, early detection of arrhythmias and heart failure, and enhanced adherence to remote monitoring, outperforming conventional approaches. Integration of AI with wearable and mobile platforms facilitates personalized, real-time, and proactive cardiac care, potentially

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reducing hospitalizations and optimizing clinical workflows. Despite these advances, challenges related to algorithm validation, interoperability, regulatory approval, and clinical implementation remain significant barriers. Future research should focus on large-scale, multicenter clinical trials, robust real-world validation, and strategies to integrate AI seamlessly into routine cardiology practice, ensuring that these technologies translate into improved patient outcomes.

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