Advances in Non-Invasive Diagnostic Techniques for Heart Diseases: A Review

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Abstract: *Non-invasive diagnostic techniques have made significant strides in the early detection and management of cardiovascular diseases. Advances in imaging modalities, such as echocardiography, cardiac MRI (CMR), CT, and PET/SPECT, have enhanced diagnostic accuracy and allowed for detailed assessment of heart function and structure, while reducing the risks associated with invasive procedures. In parallel, the emergence of electrocardiography (ECG) and wearable devices has enabled real-time monitoring, aiding in the detection of arrhythmias and chronic disease management. Furthermore, blood-based biomarkers, including troponins, natriuretic peptides, and microRNAs, have shown promise for early detection, risk stratification, and prognosis prediction, although they often need to be integrated with imaging and ECG data for comprehensive evaluations. Artificial intelligence (AI) and machine learning are transforming cardiovascular diagnostics by improving image reconstruction, ECG interpretation, and multi-modal data integration, offering personalized assessments and enhanced diagnostic precision. However, challenges such as cost, accessibility, regulatory hurdles, and clinician adoption remain significant barriers. Future research should focus on improving the accessibility, affordability, and interoperability of diagnostic tools across healthcare systems. With continued innovation, non-invasive techniques are poised to play an increasingly pivotal role in early intervention and improved outcomes for patients with heart diseases.*

Keywords: *Non-Invasive Diagnostics; Cardiovascular Imaging; Electrocardiography (ECG); Wearable Health Technologies; Cardiac Biomarkers; Artificial Intelligence in Cardiology*

1. Introduction

Cardiovascular diseases (CVDs) remain the leading cause of mortality worldwide, accounting for approximately 32% of global deaths in 2019, according to the World Health Organization (WHO) (1). Early and accurate diagnosis is essential for reducing morbidity and mortality rates, as timely interventions can significantly improve patient outcomes (2). Traditional diagnostic methods for heart diseases, such as coronary angiography and cardiac catheterization, are highly effective but invasive, posing risks such as bleeding, infection, and vascular complications (3). These limitations have driven the development of non-invasive diagnostic techniques, which offer safer, more accessible, and often more cost-effective alternatives for early detection and monitoring of heart conditions.

Non-invasive diagnostic methods encompass a range of techniques, including advanced imaging modalities, electrocardiographic monitoring, biomarker-based blood tests, and artificial intelligence (AI)-enhanced diagnostic tools (4). Imaging technologies such as echocardiography, cardiac magnetic resonance imaging (CMR), and computed tomography (CT) have significantly evolved, offering higher resolution, better functional assessment, and faster processing times (5). Meanwhile, the increasing use of wearable electrocardiography (ECG) devices and AI-assisted ECG interpretation has improved the early detection of arrhythmias and other cardiac abnormalities, even in asymptomatic individuals (6). Additionally, recent advancements in blood-based biomarker analysis, including high-sensitivity troponins and novel molecular markers such as microRNAs, have provided promising avenues for early diagnosis and risk stratification (7).

The integration of AI and machine learning in non-invasive diagnostic tools has further enhanced accuracy and efficiency. AI-driven algorithms can analyze large volumes of imaging data, detect subtle abnormalities in ECG signals, and identify disease patterns in biomarker profiles with greater precision than traditional methods (8). These advancements collectively represent a paradigm shift in cardiovascular diagnostics, facilitating earlier interventions, reducing hospitalizations, and improving patient outcomes.

This review aims to provide a comprehensive overview of recent advances in non-invasive diagnostic techniques for heart diseases. It will examine developments in imaging, electrocardiography, and biomarker-based diagnostics, highlighting their clinical implications, advantages, and limitations. Furthermore, the review will discuss emerging technologies, the role of AI in cardiovascular diagnostics, and future directions in the field.

2. Overview of Non-Invasive Diagnostic Techniques

2.1 Definition and Importance

Non-invasive diagnostic techniques refer to medical procedures that assess cardiac function and structure without the need for surgical intervention or catheterization. Unlike invasive methods such as coronary angiography, which require catheter insertion into blood vessels, non-invasive techniques minimize patient discomfort, reduce procedural risks, and enable repeated assessments for disease monitoring (9). These methods play a critical role in early detection, risk stratification, and long-term management of cardiovascular diseases (10). Additionally, with continuous technological advancements, non-invasive approaches have improved in accuracy, accessibility, and cost-effectiveness, leading to their widespread adoption in clinical practice (11).

2.2 Categorization of Major Techniques

Non-invasive diagnostic methods can be broadly classified into four main categories: imaging-based techniques, electrocardiography, biomarker analysis, and AI-driven tools. Table 1 provides a summary of these categories along with key modalities and their applications.

2.2.1 Imaging-Based Techniques

Medical imaging plays a fundamental role in diagnosing and monitoring heart diseases. Echocardiography remains a first-line modality, offering real-time visualization of cardiac structures, function, and hemodynamics (12). Recent advancements, including three-dimensional (3D) and four-dimensional (4D) imaging, have enhanced diagnostic precision (13). Cardiac magnetic resonance imaging (CMR) and computed tomography (CT) provide high-resolution structural and functional assessments, aiding in the diagnosis of ischemic and non-ischemic heart diseases (14). Furthermore, nuclear imaging techniques, such as positron emission tomography (PET) and single-photon emission computed tomography (SPECT), enable myocardial perfusion and metabolic evaluations (15).

2.2.2 Electrocardiography (ECG) and Wearable Devices

ECG is a cornerstone in cardiac diagnostics, offering insights into electrical activity, arrhythmias, and ischemic changes. Traditional 12-lead ECGs are widely used in clinical settings, but recent advancements in wearable ECG monitors and smart devices have expanded continuous and remote monitoring capabilities (16). These wearable technologies provide early arrhythmia detection, particularly for atrial fibrillation, and enable proactive management of cardiovascular conditions (17).

2.2.3 Blood-Based Biomarkers and Molecular Diagnostics

Cardiac biomarkers are essential for detecting myocardial injury and dysfunction. High-sensitivity troponins have revolutionized acute coronary syndrome (ACS) diagnosis by allowing earlier detection of myocardial infarction (18). Other biomarkers, such as B-type natriuretic peptide (BNP) and N-terminal proBNP (NT-proBNP), are widely used in heart failure diagnosis and prognosis assessment (19). Additionally, emerging molecular diagnostics, including microRNAs and extracellular vesicles, show promise in identifying early-stage cardiac diseases (20).

2.2.4 AI-Driven Diagnostic Tools

Artificial intelligence (AI) and machine learning have transformed cardiovascular diagnostics by enhancing data interpretation and predictive modeling. AI algorithms assist in image analysis, ECG classification, and biomarker-based risk prediction, often outperforming traditional diagnostic approaches (21). Deep learning models applied to echocardiography, CMR, and ECG data have demonstrated high accuracy in detecting structural and functional abnormalities (22). AI-powered wearable devices further enable automated arrhythmia detection and personalized cardiovascular risk assessment (23).

Table 1 : Summary of Non-Invasive Diagnostic Techniques and Their Applications.

Category	Key Modalities	Primary Applications
Imaging	Echocardiography, CMR, CT, PET/SPECT	Structural and functional assessment, myocardial perfusion
Electrocardiography	12-lead ECG, Wearable ECG monitors	Arrhythmia detection, ischemic changes
Biomarkers	Troponins, BNP/NT-proBNP, microRNAs	Myocardial injury detection, heart failure prognosis
AI-Driven Tools	AI-enhanced imaging, ECG analysis, predictive models	Automated diagnostics, risk stratification

Non-invasive diagnostic techniques have evolved significantly, enabling earlier and more precise detection of cardiovascular diseases. The following sections will delve deeper into these advancements, examining their clinical implications and future potential.

3. Advances in Non-Invasive Diagnostic Techniques

3.1 Imaging-Based Techniques

Non-invasive cardiac imaging has evolved significantly, offering enhanced accuracy, resolution, and functional assessment of cardiovascular diseases. The primary imaging modalities include echocardiography, cardiac magnetic resonance imaging (MRI), computed tomography (CT), and nuclear imaging techniques such as positron emission tomography (PET) and single-photon emission computed tomography (SPECT). Recent advancements, including artificial intelligence (AI)-driven image analysis and novel imaging protocols, have further improved diagnostic capabilities.

3.1.1 Echocardiography: 3D/4D and Contrast-Enhanced Imaging

Echocardiography remains the most widely used non-invasive imaging tool for cardiac assessment due to its cost-effectiveness, portability, and real-time imaging capability. Traditional two-dimensional (2D) echocardiography has been largely supplemented by three-dimensional (3D) and four-dimensional (4D) echocardiography, which provide superior spatial resolution and dynamic visualization of cardiac structures (24). Studies have shown that 3D echocardiography improves the quantification of left ventricular volume and ejection fraction, reducing the need for contrast agents in some cases (25).

Contrast-enhanced echocardiography (CEUS) is another major advancement, particularly beneficial for patients with suboptimal image quality due to obesity or lung disease. CEUS improves myocardial perfusion assessment and enhances the detection of left ventricular thrombi (26). Additionally, myocardial strain imaging, utilizing speckle-tracking echocardiography, has gained prominence for early detection of subclinical myocardial dysfunction in conditions like hypertrophic cardiomyopathy and chemotherapy-induced cardiotoxicity (27).

3.1.2 Cardiac MRI & CT: High-Resolution Imaging and AI Integration

Cardiac MRI (CMR) provides unparalleled soft-tissue contrast, making it the gold standard for assessing myocardial viability, fibrosis, and inflammation. Recent advancements include high-field 7-Tesla MRI, which enhances spatial resolution, and contrast-free techniques like T1 and T2 mapping, which reduce the risks associated with gadolinium-based contrast agents (28). Studies have demonstrated that AI-powered image reconstruction improves scan efficiency, reducing acquisition time without compromising diagnostic accuracy (29).

Computed tomography (CT), particularly coronary CT angiography (CCTA), has become a first-line tool for evaluating coronary artery disease (CAD). The development of photon-counting CT (PCCT) represents a breakthrough, offering higher spatial resolution and reduced radiation exposure compared to conventional CT scanners (30). AI algorithms have also been integrated into CCTA to enhance plaque characterization and automated risk assessment for coronary artery stenosis (31).

3.1.3 Nuclear Imaging: PET/SPECT Improvements

Positron emission tomography (PET) and single-photon emission computed tomography (SPECT) remain crucial for assessing myocardial perfusion and viability. New-generation PET scanners with rubidium-82 and novel tracers like F-18 flurpiridaz provide higher resolution and more precise quantification of myocardial blood flow (32). Additionally, quantitative SPECT imaging, enabled by cadmium-zinc-telluride (CZT) detector technology, improves diagnostic accuracy while reducing scan duration and radiation dose (33).

The integration of AI in nuclear cardiology has further refined image processing, artifact reduction, and automated interpretation of perfusion defects. AI-based reconstruction techniques have been shown to enhance PET/SPECT image clarity and improve the detection of ischemic heart disease, even in patients with challenging anatomical variations (34).

Table 2: Comparison of Imaging-Based Non-Invasive Cardiac Diagnostic Techniques.

Imaging Modality	Key Features	Recent Advances	Applications
Echocardiography	Portable, real-time imaging, low cost	3D/4D imaging, contrast-enhanced ultrasound, myocardial strain imaging	Valve disease, myocardial function, heart failure
Cardiac MRI (CMR)	High soft-tissue contrast, no radiation	AI-powered image reconstruction, high-field 7-Tesla MRI, contrast-free mapping	Myocardial infarction, fibrosis, inflammation
CT (CCTA)	High-resolution coronary artery imaging, fast	Photon-counting CT, AI-enhanced plaque analysis	Coronary artery disease, risk assessment
PET/SPECT	Functional imaging, myocardial perfusion analysis	CZT-based SPECT, AI-assisted image reconstruction, novel tracers	Ischemia, viability assessment

3.2 Electrocardiography & Wearable Technologies

Electrocardiography (ECG) has long been a cornerstone in the non-invasive diagnosis of cardiac diseases, providing vital information about the electrical activity of the heart. Over recent years, significant advancements have been made in the interpretation of ECG data and the development of wearable technologies that enable continuous monitoring of heart health. With the integration of artificial intelligence (AI) and the proliferation of wearable ECG monitors, including smartwatches, remote monitoring capabilities have vastly improved, offering new opportunities for early detection and personalized care.

3.2.1 AI-Enhanced ECG Interpretation

Artificial intelligence has significantly enhanced the diagnostic power of traditional ECGs. AI algorithms, particularly those based on machine learning (ML), are now capable of analyzing ECG waveforms with high accuracy, often surpassing human interpretation. These advanced systems can detect a wide range of arrhythmias, including atrial fibrillation (AF), ventricular tachycardia, and other irregularities, by analyzing subtle changes in the ECG signal that may be missed by conventional methods. AI's ability to handle vast amounts of data has allowed for real-time interpretation and decision-making, potentially reducing the time required for diagnosis and improving patient outcomes.

One key area of AI in ECG is its use in automated arrhythmia classification. Deep learning models, such as convolutional neural networks (CNNs), have been trained on large datasets to identify complex patterns and classify ECG signals accurately (35). These models can identify arrhythmias early, providing alerts to healthcare professionals for prompt intervention. Additionally, AI-driven platforms can reduce the need for manual analysis, lowering the risk of human error and enabling more widespread screening.

AI has also found application in personalized medicine. By analyzing individual ECG data over time, AI can assist in tracking the progression of cardiovascular conditions and adjusting treatment plans accordingly (36). Moreover, AI's predictive capabilities can identify at-risk individuals who might otherwise remain undiagnosed until symptoms worsen, offering proactive management of heart disease.

3.2.2 Wearable ECG Monitors and Smartwatches

The advent of wearable technologies has revolutionized cardiac care, particularly in the realm of continuous ECG monitoring. Wearable ECG devices, including smartwatches, allow for real-time tracking of heart activity, providing individuals with valuable insights into their heart health without requiring a clinical visit. Devices such as the Apple Watch and Fitbit have become mainstream, offering ECG capabilities directly integrated into the device. These wearables enable users to monitor their heart rhythm, detect abnormalities, and share the data with healthcare providers for further analysis.

Wearable ECG monitors are particularly beneficial for patients with chronic heart conditions, allowing for continuous tracking of their health status. For example, individuals with atrial fibrillation (AF) can use wearables to detect episodes of irregular heartbeats, which might otherwise go unnoticed until they result in significant symptoms (37). The ability to track ECG data remotely empowers both patients and clinicians, offering a more dynamic approach to monitoring and managing heart disease. These devices can also provide early warning signs for acute events such as heart attacks or strokes, alerting users to seek medical attention before severe symptoms manifest.

In addition to smartwatches, portable ECG devices, such as the AliveCor KardiaMobile, offer users a convenient way to conduct self-assessments at home. These devices provide medical-grade ECG recordings that can be shared with a physician for remote diagnosis. The growing market for wearable ECG devices has paved the way for a shift toward remote patient monitoring, a trend that gained momentum during the COVID-19 pandemic, as it allowed healthcare providers to maintain oversight without in-person consultations.

3.2.3 Remote Monitoring and Telemedicine

The integration of wearable ECG monitors with telemedicine platforms has further expanded the potential for remote heart disease management. Patients equipped with wearable devices can transmit their ECG data to healthcare providers in real time, allowing for continuous surveillance of heart conditions. This form of remote monitoring has proven particularly advantageous for elderly patients or those living in remote areas, where access to healthcare services may be limited (38). Remote monitoring can detect acute changes in heart activity, triggering timely interventions and preventing hospital readmissions.

Recent studies have shown that combining wearable ECG devices with telemedicine can significantly reduce emergency room visits and hospital admissions for patients with cardiovascular diseases, leading to more efficient use of healthcare resources (39). Furthermore, telemedicine allows for personalized care plans tailored to the individual's needs, with regular ECG data providing a clearer picture of the patient’s cardiac health.

Table 3: Comparison of Wearable ECG Technologies.

Technology	Key Features	Recent Advances	Applications
Smartwatches (e.g., Apple Watch)	Real-time ECG monitoring, easy-to-use	AI-powered analysis, enhanced ECG accuracy	Detection of arrhythmias, heart rate monitoring
Portable ECG devices (e.g., AliveCor)	Medical-grade ECG recordings, user-friendly	Improved portability, user feedback integration	Arrhythmia detection, long-term monitoring
Remote ECG monitoring systems	Continuous monitoring, real-time data sharing	Integration with telemedicine platforms	Chronic disease management, early detection

3.3 Blood-Based Biomarkers & Molecular Diagnostics

Blood-based biomarkers and molecular diagnostics are playing an increasingly vital role in diagnosing and managing cardiovascular diseases. The advancements in high-sensitivity cardiac biomarkers and the application of molecular techniques, such as microRNAs and artificial intelligence (AI), are enhancing the precision of cardiovascular assessments.

3.3.1 High-Sensitivity Cardiac Biomarkers

Cardiac biomarkers, particularly troponins and natriuretic peptides, are central to diagnosing acute myocardial infarction (MI) and heart failure. Troponins, including cardiac troponin I and T, are highly specific markers for myocardial injury, and recent advancements in high-sensitivity assays have enabled earlier detection of subtle myocardial damage (43). These biomarkers are now used not only in acute settings but also for risk stratification in patients with stable coronary artery disease (CAD) and for monitoring treatment efficacy (44).

Natriuretic peptides, such as B-type natriuretic peptide (BNP) and amino-terminal proBNP (Nt-proBNP), are elevated in heart failure and provide critical insight into the severity of the condition. High-sensitivity assays for these peptides are improving diagnostic accuracy, helping to differentiate heart failure from other conditions with similar symptoms, such as lung disease (45). Moreover, the combined use of troponins and natriuretic peptides has shown to improve the early diagnosis and management of heart failure, particularly in emergency settings (46).

3.3.2 Role of MicroRNAs in Cardiovascular Diagnostics

MicroRNAs (miRNAs) have emerged as promising biomarkers in cardiovascular disease due to their ability to regulate gene expression and their stability in blood. These small non-coding RNAs are involved in the regulation of key processes like inflammation, apoptosis, and fibrosis, all of which are critical in the progression of heart diseases (47). Elevated levels of specific miRNAs, such as miR-1 and miR-21, have been linked to acute MI, heart failure, and arrhythmias, making them potential candidates for early diagnosis and prognosis (48).

The use of miRNAs as biomarkers is particularly advantageous in detecting subclinical cardiovascular conditions, such as preclinical atherosclerosis or early-stage heart failure, where traditional biomarkers may not be detectable (49). Advances in RNA sequencing and microarray technologies are enhancing the identification and quantification of miRNAs, enabling more precise biomarker panels for individualized patient care.

3.3.3 Artificial Intelligence in Biomarker Analysis

AI is revolutionizing the field of biomarker analysis by enabling faster and more accurate interpretation of complex biomarker data. Machine learning algorithms are being applied to large datasets of cardiovascular biomarkers to uncover patterns and relationships that would be difficult to identify manually. AI has shown promise in integrating multiple biomarkers, such as troponins, natriuretic peptides, and miRNAs, to develop composite risk scores that offer improved predictive power for cardiovascular events (50).

AI-driven systems are also being employed in the development of diagnostic platforms that can analyze blood samples more efficiently, reducing the need for invasive procedures. For instance, AI models have been integrated into mass spectrometry and next-generation sequencing platforms, which provide high-throughput analysis of biomarkers like miRNAs and proteins (51). This integration not only accelerates the diagnostic process but also reduces human error, making AI a crucial tool in the future of cardiovascular diagnostics.

Table 4: Overview of Blood-Based Biomarkers in Cardiovascular Disease.

Biomarker	Key Features	Recent Advances	Applications
Troponins (cTnI, cTnT)	Specific for myocardial injury	High-sensitivity assays	Acute MI, risk stratification
Natriuretic Peptides (BNP, Nt-proBNP)	Indicator of heart failure severity	High-sensitivity assays	Heart failure diagnosis
MicroRNAs (miR-1, miR-21)	Regulatory molecules, stable in blood	Improved detection platforms	Early detection, prognosis
AI in Biomarker Analysis	Data-driven, pattern recognition	AI-driven composite risk scores	Multi-biomarker integration

4. Challenges and Future Directions

While non-invasive diagnostic techniques for heart diseases have advanced significantly, various challenges still hinder their optimal application. Comparative analyses of different modalities, along with the integration of AI and machine learning, underscore potential areas for progress.

4.1 Comparative Analysis: Strengths and Limitations

Non-invasive imaging techniques, including echocardiography, cardiac MRI (CMR), CT, and PET/SPECT, are crucial for assessing structural and functional heart abnormalities. These techniques offer high-resolution imaging and provide detailed insights into myocardial perfusion and vascular function (52). Echocardiography is portable, real-time, and cost-effective, while CMR offers high soft-tissue contrast and detailed cardiac tissue imaging. Recent advances like 3D/4D echocardiography and AI-powered CMR image reconstruction have improved diagnostic accuracy (52). However, these modalities still face limitations such as the need for skilled operators, high costs (especially CMR and PET), and limited availability in resource-constrained settings (53).

Wearable ECG devices, including smartwatches and portable monitors, provide continuous monitoring and offer the advantage of patient-friendly, real-time data (54). While they show promise for detecting arrhythmias and managing chronic diseases, their main limitation is the risk of false positives and inaccuracies in clinical decision-making (45). Moreover, the data quality of wearable ECG devices often does not match that of traditional ECG systems, limiting their diagnostic value in certain complex cases.

Blood-based biomarkers like troponins and natriuretic peptides continue to be invaluable for detecting myocardial injury and monitoring heart failure (43, 47). However, they are insufficient as standalone diagnostic tools and need to be combined with other diagnostic modalities for a more comprehensive assessment of cardiovascular health. Additionally, newer biomarkers like microRNAs hold promise for early detection and prognosis prediction, though their clinical validation remains ongoing (50).

4.2 Integration of AI and Machine Learning

The integration of AI and machine learning has significantly enhanced diagnostic precision across various techniques. AI-driven image reconstruction in CMR and CT, along with advanced ECG analysis algorithms, has improved the detection of heart conditions such as myocardial infarction, arrhythmias, and coronary artery disease (55, 56). Moreover, AI models are increasingly used to integrate multi-modal data—combining ECG readings with blood biomarkers, imaging data, and wearable device outputs—to provide more accurate diagnoses and personalized treatment plans (57).

However, the widespread adoption of AI in cardiovascular diagnostics faces several challenges. First, there is a need for large, high-quality annotated datasets to train machine learning models effectively. Data privacy concerns, regulatory hurdles, and the requirement for transparency in AI decision-making also complicate the integration of AI tools into clinical practice (56). Furthermore, while AI-powered tools can enhance diagnostic accuracy, they depend heavily on clinician trust and acceptance, which can vary widely across healthcare settings.

4.3 Future Research Areas and Barriers to Widespread Adoption

Looking ahead, several areas of research hold the potential to further advance non-invasive diagnostic techniques. The integration of multi-modal data—combining imaging, ECG, biomarkers, and wearable technology—has the potential to significantly improve diagnostic accuracy and enable more proactive healthcare (57). Advances in molecular diagnostics, including the use of microRNAs, and the development of AI-driven biomarker analysis tools, will likely further improve early detection capabilities and risk stratification for cardiovascular diseases (50, 55).

Despite the potential of these innovations, several barriers must be overcome to achieve widespread clinical adoption. Cost remains a significant obstacle, particularly for advanced imaging modalities and AI-powered technologies, which may not be accessible in low-resource settings (52). The standardization of data formats across devices, regulatory approval processes, and the need for improved clinician training to integrate new tools into clinical workflows are additional challenges (58). Finally, ensuring the security of patient data and addressing ethical concerns around AI decision-making will be critical for the future of these technologies in heart disease diagnosis.

5. Conclusion

Non-invasive diagnostic techniques have significantly improved the early detection and management of heart diseases. Advances in imaging (echocardiography, CMR, CT, PET/SPECT), electrocardiography (ECG), wearable devices, and molecular diagnostics have enhanced diagnostic accuracy while reducing risks associated with invasive procedures. However, challenges such as cost, accessibility, and reliance on skilled personnel remain.

ECG and wearable technologies have expanded real-time monitoring, aiding arrhythmia detection and remote patient management. Blood-based biomarkers and molecular diagnostics—including troponins, natriuretic peptides, and microRNAs—have strengthened risk assessment and prognosis prediction, though they often require integration with imaging and ECG for comprehensive evaluation.

Artificial intelligence and machine learning are revolutionizing non-invasive diagnostics by improving image reconstruction, ECG interpretation, and biomarker analysis. Multi-modal data integration holds promise for more accurate and personalized assessments, yet challenges such as data privacy, regulatory approval, and clinician adoption must be addressed.

Future research should focus on enhancing accessibility, affordability, and interoperability across healthcare systems. As innovations in AI, molecular biomarkers, and wearable technologies continue, non-invasive techniques will play an increasingly vital role in early intervention and improved patient outcomes.

Funding

This study was self-funded.

Data Availability Statement

No new data was generated.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethical Approval

Not applicable.

Informed Consent

Not applicable.

Consent for publication

Not applicable.

Author contributions

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Writing – review & editing: Wenlong Wang, Lina Wang, Yishan Guo, Dong Wang

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