Scoping Review of Digital Intelligence Technologies for Electrocardiogram Monitoring in Acute Myocardial Infarction (Postprint)

Authors: Liyun Wu, Sun Huajing, Gu Yiqing, Mei Ziqi, Kim Seung-hee, Zhang Suju, Zhu Yun, Zhang Yao, Qin Li, Liu Xiaomiao, Wang Qing, 柏亚妹, Guihua Xu, Guihua Xu

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Abstract

Background: Acute myocardial infarction (AMI) is a highly critical and emergency condition, and early electrocardiogram (ECG) monitoring is crucial for prognosis. Traditional ECG monitoring has limitations such as poor real-time performance and insufficient capture of sudden arrhythmias. Digital intelligence technology, as a fusion of digital, information, and intelligent technologies, provides a new path for it. Objective: To systematically review the application status, clinical effects, and existing problems of digital intelligence technology in AMI ECG monitoring, providing a reference for standardized application and further research. Methods: Following the Joanna Briggs Institute (JBI) scoping review guidelines, searches were conducted in PubMed, Cochrane Library, CINAHL, Embase, Scopus, Web of Science, CNKI, CBM, VIP, and Wanfang Data. The search period ranged from database inception to 2025-02-02. Studies related to the application status of digital intelligence technology in AMI ECG monitoring were included and comprehensively analyzed. Results: A total of 21 articles were included, involving 5 countries and comprising randomized controlled trials, prospective studies, etc. Digital intelligence technologies include remote ECG monitoring systems, wearable devices, artificial intelligence-assisted diagnostic systems, and mobile devices, covering all scenarios of prehospital emergency care, inpatient monitoring, and home management. These technologies can improve the detection rate of abnormal ECGs, shorten critical treatment time windows, reduce medical costs, and improve prognosis. However, challenges remain, such as data accuracy verification, insufficient privacy protection, fragmented device functions, and compliance issues among special populations. Conclusion: Digital intelligence technology is feasible and effective in AMI ECG monitoring, enhancing diagnostic and treatment efficiency. Future

efforts should focus on technical standardization, data security and privacy protection, functional integration, and age-appropriate design to promote clinical transformation and application, aligning with the "Healthy China 2030" goals.

Full Text

Application of Digital Intelligence Technology in Electrocardiogram Monitoring for Acute Myocardial Infarction: A Scoping Review

Abstract

Background: Acute Myocardial Infarction (AMI) is a critical cardiovascular condition characterized by high morbidity and mortality. Early diagnosis and continuous monitoring are essential for improving patient prognosis. Traditional electrocardiogram (ECG) monitoring faces limitations such as poor real-time performance and the inability to capture transient arrhythmias. Digital intelligence technology—the integration of digital, information, and intelligent technologies—offers a new pathway for AMI management.

Objective: To systematically review the current application status, clinical efficacy, and existing challenges of digital intelligence technology in AMI ECG monitoring, providing a reference for standardized application and future research.

Methods: Following the Joanna Briggs Institute (JBI) scoping review guidelines, a comprehensive search was conducted across databases including PubMed, Cochrane Library, CINAHL, Embase, Scopus, Web of Science, CNKI, CBM, VIP, and Wanfang from inception to February 2, 2025.

Results: Twenty-one studies from five countries were included, encompassing randomized controlled trials and prospective studies. Digital intelligence technologies identified include remote ECG monitoring systems, wearable devices, AI-assisted diagnostic systems, and mobile health platforms. These technologies are applied across pre-hospital, in-hospital, and home-based management scenarios. Evidence suggests these tools improve the detection rate of abnormal ECG patterns, shorten critical treatment windows (such as door-to-balloon time), reduce medical costs, and improve patient outcomes. However, challenges remain regarding data accuracy validation, privacy protection, device fragmentation, and user compliance among elderly populations.

Conclusion: Digital intelligence technology is feasible and effective for AMI monitoring, significantly enhancing diagnostic and therapeutic efficiency. Future efforts should focus on technical standardization, data security, and age-appropriate design to align with "Healthy China 2030" objectives.

Keywords: Acute Myocardial Infarction; Digital Intelligence Technology; Electrocardiogram Monitoring; Scoping Review

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1. Introduction

Acute Myocardial Infarction (AMI) is a severe cardiovascular emergency characterized by rapid progression and high mortality risk. Early ECG monitoring and intervention are critical; research indicates that for every hour of delay in reperfusion therapy, mortality increases by 10%. Traditional 12-lead ECGs and 24-hour Holter monitors often fail to meet the time-sensitive demands of emergency care because they cannot transmit data in real-time or capture sudden, transient arrhythmias [?].

Digital intelligence technology integrates wearable sensors, the Internet of Things (IoT), artificial intelligence (AI), and cloud computing to enable real-time monitoring and intelligent decision-making [?]. By overcoming spatial and temporal constraints, these technologies provide early warnings and timely interventions, potentially increasing the success rate of rescue efforts [?]. However, challenges such as data accuracy, privacy security, and cross-platform integration persist [?]. This scoping review systematically maps the current landscape of these technologies in AMI care.

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2. Materials and Methods

2.1 Inclusion and Exclusion Criteria

Based on the PCC (Population, Concept, Context) framework [?]: - **Population (P):** Patients with AMI (including suspected cases) or healthcare professionals. - **Concept (C):** Digital-intelligent ECG monitoring (wearable sensors, IoT, AI, cloud computing). - **Context (C):** Emergency departments, chest pain centers, pre-hospital care, inpatient wards, and home monitoring. - **Study Design:** RCTs, quasi-experimental, prospective, and observational studies. - **Exclusion:** Non-Chinese/English literature, unavailable full texts, and grey literature (reviews, abstracts, commentaries).

2.2 Literature Search and Data Extraction

A systematic search was conducted across ten major databases (PubMed, Embase, CNKI, etc.) up to February 2025. The search strategy combined terms for "myocardial infarction" and "electrocardiographic monitoring" with digital technology keywords. Two researchers independently screened titles, abstracts, and full texts. Data extraction included technology forms, equipment types, application scenarios, and outcome measures.

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3. Results

3.1 Literature Search Results

The initial search yielded 20,829 records. After deduplication and screening, 21 documents were ultimately included. Of these, 17 were conducted in China, with others from Hungary, Spain, South Korea, and Italy.

3.2 Primary Modalities of Digital Intelligence Technology

1. **Remote ECG Monitoring Systems:** Twelve studies [?, ?, ?] focused on systems that transmit data across spatial boundaries. For example, remote Holter systems allow for immediate uploads during chest pain episodes, shortening diagnostic time for acute coronary syndrome [?].
2. **Wearable ECG Devices:** Three studies [?, ?, ?] utilized portable instruments for continuous monitoring. Patch-type devices can monitor patients for up to 14 days, identifying paroxysmal arrhythmias that traditional 24-hour monitors might miss [?].
3. **AI-Assisted Diagnostic Systems:** Two studies [?, ?] utilized cloud-based AI to analyze big data. One neural network model achieved a sensitivity of 96% and specificity of 93% in predicting sudden death and tachycardia after AMI [?].
4. **Mobile Devices:** Four studies [?] leveraged smartphones and smartwatches. By using specific contact points on the body, mobile apps can simulate multi-lead ECGs, achieving up to 100% sensitivity for detecting ST-segment changes [?].

3.3 Application Scenarios

- **Pre-hospital Emergency Care:** Real-time transmission allows ambulances to send ECG data to Chest Pain Centers, enabling pre-hospital diagnosis and shortening door-to-balloon (D2B) time to as little as 38 minutes [?, ?].
- **In-hospital Monitoring:** Remote dynamic ECGs in wards improved the detection rate of malignant arrhythmias to 96.0%, allowing for interventions within seconds of an event [?].
- **Home Management:** Post-discharge monitoring increased the detection rate of ventricular arrhythmias by 69.2% and reduced patient anxiety and medical expenses [?].

summarizes the characteristics of the included studies.

4. Discussion

4.1 Clinical Efficacy and Diagnostic Performance

Digital intelligence technologies significantly outperform traditional methods in diagnostic precision. AI models have demonstrated the ability to identify 17.32% of ST-segment changes in large populations, with 73.53% of high-risk patients receiving immediate medical intervention [**?**]. The optimization of the emergency workflow is perhaps the most critical benefit, with median D2B times compressed significantly, leading to a reduction in complications from 26.92% to 5.88% [**?**, **?**].

4.2 Challenges and Safety Concerns

Despite the benefits, several bottlenecks remain: - **Data Accuracy:** Postural shifts and skin-electrode impedance changes can lead to false positives or missing ST-segment data [**?**, **?**]. - **Privacy and Security:** Many systems lack robust encryption strategies or fail to comply with international data standards [**?**, **?**]. - **The Digital Divide:** Elderly populations often struggle with complex device operations, requiring significant training and simplified interfaces [**?**, **?**].

4.3 Future Directions

To advance the field, research should focus on: 1. **Technical Standardization:** Developing adaptive algorithms to compensate for motion artifacts and posture changes. 2. **Privacy Protection:** Implementing hierarchical defense systems and local feature extraction to minimize raw data transmission. 3. **Age-Appropriate Design:** Utilizing voice-activated operations and flexible biosensors to improve compliance among elderly patients. 4. **Systemic Integration:** Embedding lightweight monitoring terminals into the hierarchical medical system to facilitate early screening at the community level.

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5. Conclusion

Digital intelligence technology has transitioned from experimental frameworks to practical clinical tools in AMI ECG monitoring. It effectively bridges the gap between pre-hospital, in-hospital, and home care, significantly improving the "golden hour" response for myocardial infarction. Future breakthroughs will depend on the deep integration of AI-driven decision support and the establishment of unified technical and ethical standards to ensure clinical safety and data privacy.

Note: Figure translations are in progress. See original paper for figures.