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REVIEW

Timely interventions for better outcomes in cardiac emergencies: a narrative review

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Abstract

Cardiac emergencies represent a major challenge in modern healthcare, requiring immediate and effective interventions to improve patient outcomes. Conditions such as ischemic heart disease, myocardial infarction, arrhythmias, and acute heart failure frequently present as life-threatening events that impose substantial demands on healthcare systems worldwide. Early symptom recognition, such as chest pain, dyspnea, palpitations, and syncope, is critical for timely and appropriate management. Rapid diagnosis relies on a combination of clinical assessment and the use of diagnostic tools, including electrocardiography, cardiac biomarkers, advanced imaging techniques, wearable devices, and centralized platforms. For this, an advanced organization of the emergency medical service (EMS) is crucial. Understanding the multifactorial nature of cardiovascular emergencies, encompassing genetic predisposition, lifestyle influences, and environmental factors, enables more personalized and targeted therapeutic approaches. Timely administration of evidence-based therapies such as reperfusion techniques, antiarrhythmic drugs, and hemodynamic support has been shown to significantly improve recovery trajectories and long-term prognosis. Conversely, delays in intervention are associated with increased risk of irreversible myocardial or systemic damage, complicating future treatment efforts. The successful management of cardiovascular emergencies depends on rapid and accurate diagnosis, a thorough understanding of pathophysiology, and the implementation of timely, evidence-based interventions. Coordinated care involving pre-hospital services, streamlined emergency department protocols, and multidisciplinary collaboration is essential. Moreover, continuous research and the integration of emerging technologies are key to advancing outcomes in this dynamic clinical domain.

Keywords

Emergencies; Cardiovascular diseases; Myocardial infarction; Arrhythmias; Cardiac insufficiency

1. Introduction

Cardiovascular emergencies represent a major challenge in contemporary healthcare, exerting a significant burden on global health systems [1]. The sudden onset of conditions such as myocardial infarction, cardiac arrhythmias, and acute heart failure disrupts the delicate equilibrium of the cardiovascular system, necessitating rapid and well-coordinated interventions [2, 3]. These events are not only medical crises but also moments of critical decision-making that can determine life or death outcomes [4]. Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide, accounting for an estimated 17.9 million deaths annually, according to the World Health Organization (WHO) [5]. Within this broad category, cardiovascular emergencies represent an acute disruption in the normal functioning of the heart and vascular system [6]. Myocardial infarction, commonly referred to as a heart attack, involves the sudden cessation of blood flow to myocardial tissue, often presenting with severe chest pain [7]. Cardiac arrhythmias result in abnormal electrical activity that disrupts the heart's rhythm and, if left untreated, may progress to cardiac arrest [8]. They are characterized by the heart's inability to meet the body's circulatory demands, and often necessitates immediate hemodynamic stabilization [9].

1.1 The importance of timely intervention

Diagnostic delays in cardiac emergencies significantly increase morbidity and mortality. For instance, a study found that each 30-minute delay in emergency medical services (EMS) for ST-elevation myocardial infarction (STEMI) patients undergoing primary percutaneous coronary intervention (PCI) was associated with a 20% increase in 30-day mortality, particularly among those with cardiogenic shock or cardiac arrest [10]. Additionally, further research estimated that serious misdiagnosis-related harms, including permanent morbidity and mortality, occur in approximately 4.4% of cases involving major vascular events, infections, and cancers, thus underscoring the critical need for timely diagnosis [11]. Timely intervention is a cornerstone in the management of cardiac emergencies. In the context of myocardial infarction, the adage "time is muscle" underscores the urgent need to restore perfusion and minimize myocardial damage [12]. Similarly, in life-threatening arrhythmias, interventions such as antiarrhythmic pharmacotherapy or electrical cardioversion are time-sensitive measures critical to restoring cardiac stability [13]. In acute heart failure, rapid initiation of supportive therapy is essential to improve perfusion, alleviate symptoms, and prevent organ dysfunction [14]. Evidence consistently shows that delayed intervention correlates with increased morbidity and mortality [15]. Thus, in cardiac emergencies, both the speed in administration of medical intervention and its efficacy are determinants of patient outcomes.

1.2 Aims of the review

This narrative review aims to:

1. Provide a comprehensive overview of the pathophysiology, clinical presentation, and distinguishing features of three major cardiovascular emergencies: myocardial infarction, cardiac arrhythmias, and acute heart failure.
2. Emphasize the importance of timely intervention, examining how time-sensitive care directly influences survival and recovery. We integrate findings from current literature to highlight the impact of delay.
3. Explore recent advancements in emergency cardiac care, including innovations in pre-hospital management, diagnostics, and therapeutic technologies. These developments have improved both the accuracy and speed of intervention in cardiovascular crises.

By addressing these objectives, we aim to underscore the vital role of time and technology in cardiac emergency care. While grounded in medical science, this review also speaks to the broader societal implications of cardiac emergencies, which affect not only patients but also their families and communities.

2. Methods

This narrative review was conducted in accordance with the Scale for the Assessment of Narrative Review Articles (SANRA) guidelines to ensure methodological rigor and transparency [16].

2.1 Literature search strategy

A comprehensive literature search was conducted using the PubMed, Scopus, and Google Scholar databases for English-language articles published between 2000 and 2025. The search strategy included combinations of the terms: "cardiovascular emergencies", "myocardial infarction", "cardiac arrhythmia", "heart failure", "emergency care", "time to intervention", and "pre-hospital management". In PubMed, the following search string was used: ("cardiovascular emergencies"(Title/Abstract) OR "myocardial infarction"(Title/Abstract) OR "cardiac arrhythmia"(Title/Abstract) OR "heart failure"(Title/Abstract)) AND ("emergency care"(Title/Abstract) OR "time to intervention"(Title/Abstract) OR "pre-hospital management"(Title/Abstract)) AND (2000:2025(Date–Publication)) AND (English(Language)). A comparable search was conducted in Scopus using the string: (TITLE-ABS ("cardiovascular emergencies" OR "myocardial infarction" OR "cardiac arrhythmia" OR "heart failure") AND TITLE-ABS ("emergency care" OR "time to intervention" OR "pre-hospital management") AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND LANGUAGE(English)). For Google Scholar, the search was performed using the terms: ("cardiovascular emergencies" OR "myocardial infarction" OR "cardiac arrhythmia" OR "heart failure") AND ("emergency care" OR "time to intervention" OR "pre-hospital management") after: 2000 before: 2026. Additional references were obtained by manual screening of bibliographies from relevant studies and guidelines. Preference was given to peer-reviewed articles, systematic reviews, major clinical trials, and evidence-based guidelines.

2.2 Inclusion and exclusion criteria

Included studies focused on clinical features, pathophysiology, diagnostics, and management of cardiac emergencies, with an emphasis on the timing of interventions. Articles unrelated to acute cardiac care, opinion articles, or those lacking clinical data were excluded.

2.3 Data synthesis

Data were extracted narratively and synthesized thematically according to the core topics: (1) classification and pathophysiology of emergencies, (2) role of rapid diagnosis and intervention, and (3) emerging innovations in care. Scientific reasoning was applied throughout the synthesis to ensure coherence and objectivity. Data are reported as confidence interval (CI); hazard ratio (HR); number needed to treat (NNT).

2.4 Referencing and ethical considerations

All references were managed using a standardized citation style and verified for accuracy and relevance. As this review involved no direct interaction with human or animal subjects, ethical approval was not required.

2.5 Evidence quality assessment

The quality of evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria where applicable [17]. For intervention studies, we assessed confidence intervals, effect sizes, and heterogeneity indices. Key registry data from ACTION (Acute Coronary Treatment and Intervention Outcomes Network) Registry-GWTG (Get With The Guidelines) [18] and other multicenter databases were prioritized to provide real-world evidence context.

2.6 Literature selection process

Initial database searches yielded 847 articles. After removing duplicates (n = 234), 613 titles and abstracts were screened. Following exclusion of irrelevant studies (n = 445), 168 full-text articles were assessed for eligibility. The final synthesis included 75 articles comprising primary studies, systematic reviews, and clinical guidelines that met our inclusion criteria. A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)-compliant flow diagram of the literature selection process is provided in **Supplementary Fig. 1**.

3. Types of cardiac emergencies

Cardiac emergencies are sudden, life-threatening conditions that demand rapid clinical assessment and intervention.

3.1 Myocardial infarction

Myocardial infarction (MI), a key manifestation of coronary artery disease, is initiated by the rupture of an atherosclerotic plaque, leading to thrombus formation and obstruction of coronary blood flow. This ischemic insult results in myocardial necrosis. Classic symptoms include retrosternal chest pain radiating to the jaw, left arm, or back, often accompanied by dyspnea, diaphoresis, nausea, and anxiety (Table 1) [19]. Biochemical markers such as cardiac troponins serve as diagnostic indicators of myocardial injury [20].

Historically managed with bed rest and analgesia, MI treatment evolved significantly with the advent of thrombolytic therapy in the 1980s, and later with the introduction of percutaneous coronary intervention (PCI) in the 1990s. PCI, involving balloon angioplasty and stent placement, has become the preferred revascularization method due to superior outcomes compared to thrombolytics [21]. Current research continues to explore advances such as bioresorbable scaffolds and drug-eluting stents to further improve myocardial salvage and long-term prognosis [22].

3.2 Cardiac arrhythmias

Cardiac arrhythmias encompass abnormal heart rhythms that may compromise hemodynamic stability. Atrial fibrillation (AF), characterized by disorganized atrial activity, may progress to ventricular fibrillation [23] or thromboembolic events [24], posing a risk of sudden cardiac death. Other life-threatening arrhythmias include supraventricular tachycardia, atrial flutter, and ventricular tachycardia [25]. Clinical manifestations vary but often include palpitations, dizziness, syncope, or cardiac arrest [26]. Urgent interventions include electrical cardioversion, antiarrhythmic medications (*e.g.*, amiodarone, lidocaine), and catheter ablation. In high-risk patients, implantable cardioverter-defibrillators (ICDs) provide continuous rhythm surveillance and automatic defibrillation, significantly reducing mortality [27]. These interventions reflect the integration of pharmacologic and device-based strategies to maintain rhythm stability.

3.3 Acute heart failure

Acute heart failure is a decompensated state in which the heart fails to meet systemic circulatory demands [28]. It may result from chronic heart failure exacerbation, acute myocardial infarction, hypertensive crisis, or infection. Symptoms include dyspnea, orthopnea, paroxysmal nocturnal dyspnea, and peripheral edema [29]. Management requires rapid hemodynamic stabilization through diuretics (*e.g.*, furosemide), vasodilators (*e.g.*, nitroglycerin), and inotropes (*e.g.*, dobutamine) [29]. In advanced cases, mechanical circulatory support such as ventricular assist devices (VADs) are employed [30]. Telemonitoring and remote disease management systems have emerged as valuable tools for early intervention, reducing hospitalizations and improving outcomes [31]. The classification and pathophysiological

TABLE 1. Summary of the most frequent symptoms of myocardial infarction.

Symptom	Description	Notes
Chest pain/discomfort	Pressure, tightness, or burning sensation	May radiate to other areas
Shortness of breath	Difficulty breathing	Can occur without chest pain
Nausea/vomiting	Gastrointestinal discomfort	More common in women and older adults
Sweating	Cold, clammy perspiration	Indicates sympathetic activation
Fatigue	Unusual tiredness	May precede other symptoms
Lightheadedness/dizziness	Feeling faint or unsteady	Risk of falls, especially in the elderly
Silent MI	No noticeable symptoms	

MI: Myocardial infarction.

features of the three primary cardiac emergencies are illustrated in Fig. 1.

3.4 Personalized approaches to cardiac emergency management

The heterogeneity of patient populations necessitates individualized treatment strategies that account for demographic, clinical, and genetic factors. Age-specific considerations are paramount: elderly patients (>75 years) demonstrate altered pharmacokinetics requiring dose adjustments for thrombolytics and antiarrhythmics, while younger patients may present with atypical symptoms, particularly women under 55 years who often experience non-chest pain manifestations [32]. Gender differences significantly impact both presentation and outcomes. Women with STEMI have a 20% higher risk of in-hospital mortality compared to men (95% confidence interval (CI): 1.15–1.25, $p < 0.001$), partly attributable to delayed presentation and less aggressive treatment [32]. Comorbidity profiles further complicate management decisions. Diabetic patients require modified reperfusion strategies due to increased bleeding risk with standard antiplatelet therapy. Recent evidence suggests that reduced-dose ticagrelor (60 mg twice daily) maintains efficacy while decreasing major bleeding events by 36% in diabetic STEMI patients (hazard ratio (HR) 0.64, 95% CI: 0.48–0.85) [33]. Pharmacogenomic considerations are emerging as critical determinants of treatment response. CYP2C19 polymorphisms affect clopidogrel metabolism in approximately 30% of patients, necessitating alternative P2Y12 inhibitors [34]. Point-of-care genetic testing can identify poor metabolizers within 60 minutes, enabling personalized antiplatelet selection that reduces major adverse cardiac events by 34% compared to standard therapy (number needed to treat (NNT) = 29) [35, 36].

4. The critical role of timing in cardiac emergencies

Timely intervention is a decisive factor in the outcome of cardiac emergencies [37]. The interval between the onset of symptoms and therapeutic action can significantly influence prognosis, particularly in conditions such as myocardial infarction. This section explores the clinical relevance of the adage “time is muscle” [12] and outlines optimal timeframes for intervention across various cardiac emergencies.

4.1 Importance of rapid response

Cardiac emergencies may initially present with subtle or atypical symptoms, such as chest discomfort, dyspnea, or fatigue, which can delay diagnosis and treatment [38, 39]. Early identification of these signals is essential to initiate timely intervention. The principle of “time is muscle” underscores the irreversible myocardial damage that accrues with every minute of delayed reperfusion in acute myocardial infarction (AMI) [12]. Pathophysiologically, prolonged ischemia results in pro-

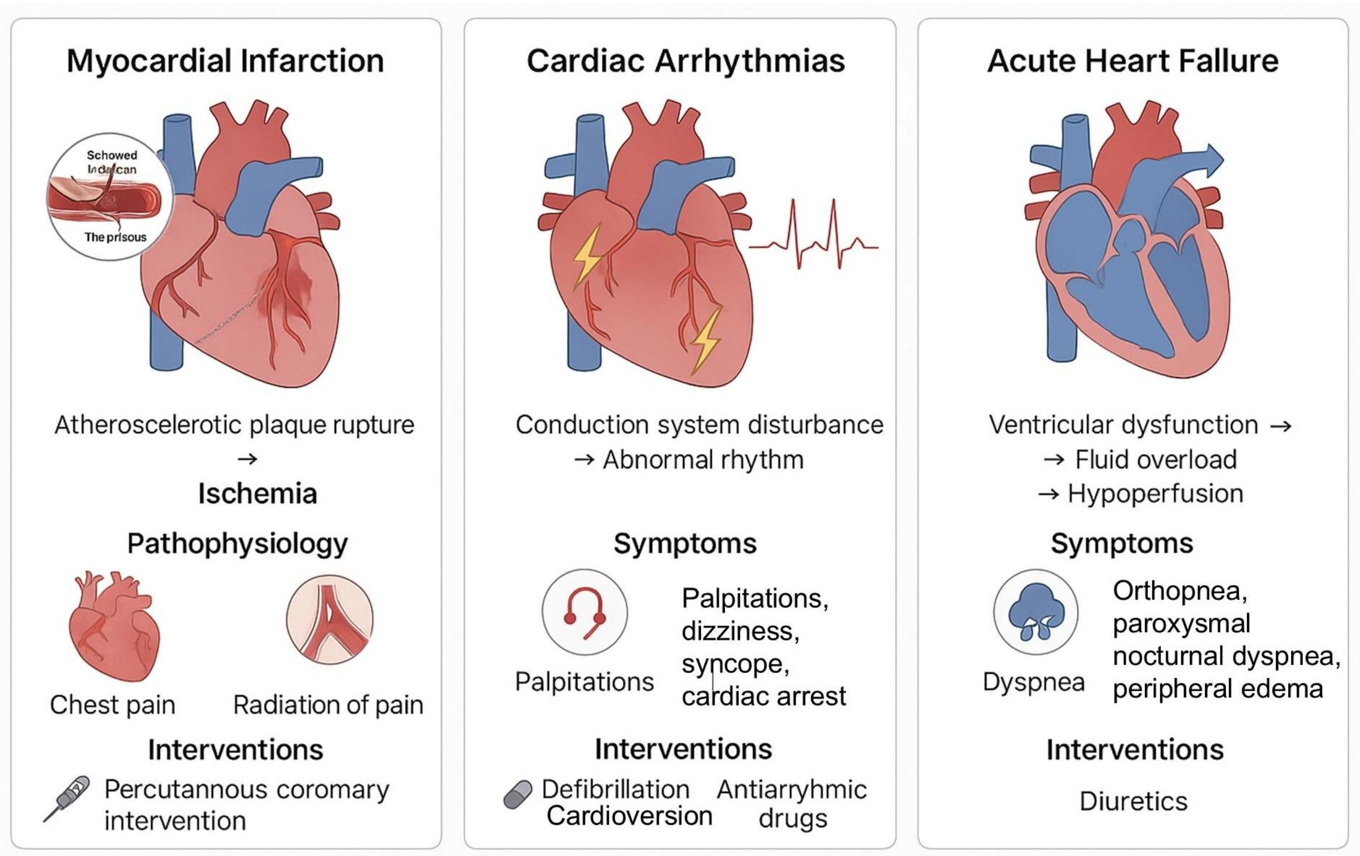

FIGURE 1. Classification, pathophysiology and interventions in the three major cardiac emergencies. This figure summarizes the underlying mechanisms, key clinical symptoms, and primary treatment strategies for myocardial infarction, cardiac arrhythmias, and acute heart failure.

gressive necrosis of myocardial tissue, beginning within 20 minutes of coronary occlusion [40]. Without timely restoration of perfusion, this damage becomes permanent. Interventions such as thrombolytic therapy or PCI can salvage at-risk myocardium if administered within the therapeutic window [41], and patients should be aware of this important message [42]. Numerous studies have demonstrated that delays in initiating reperfusion therapy correlate with increased infarct size, higher morbidity, and elevated mortality [43].

4.2 Window of opportunity

Each cardiovascular emergency possesses a distinct temporal window during which intervention yields maximal benefit. In STEMI, the American Heart Association recommends a door-to-balloon time of $\leq$90 minutes for PCI and $\leq$30 minutes for thrombolysis when PCI is not immediately available [41, 44]. These benchmarks guide systems of care to minimize delays and standardize outcomes. In cases of life-threatening arrhythmias such as ventricular fibrillation, immediate defibrillation is critical. Guidelines recommend defibrillation within 2 minutes of cardiac arrest to optimize survival rates [45]. Similarly, in acute decompensated heart failure, early administration of diuretics, ideally within the first hour of presentation, has been associated with reduced hospital stay and improved hemodynamic stability [46]. Timing also interacts with patient perception and healthcare system responsiveness. A study highlighted that delays often stem from symptom misinterpretation and hesitation in seeking medical help, emphasizing the importance of public education on early symptom recognition [47]. As shown in Fig. 2, the timing of intervention plays a critical role in determining outcomes across various cardiac emergencies.

5. Advances in emergency cardiac care: pre-hospital interventions and emerging technologies

Recent advancements in emergency cardiac care are supposed to transform both pre-hospital interventions and technological integration, offering substantial improvements in response times and clinical outcomes. This section focuses on the evolving role of pre-hospital management and the impact of digital health technologies, including telemedicine and wearable devices, in optimizing care delivery for cardiac emergencies.

5.1 Pre-hospital interventions

The pre-hospital phase represents a critical window during which prompt identification and early intervention can significantly alter the trajectory of cardiac emergencies. Emergency medical services (EMS) no longer function solely as transportation providers but have evolved into a vital link in the cardiac care continuum [48]. Paramedics, as first-line responders, play an essential role in early diagnosis and initiation of life-saving interventions. One of the most effective strategies in pre-hospital cardiac care is the use of 12-lead electrocardiogram (ECG) acquisition and transmission [49]. Evidence suggests that pre-hospital ECG protocols in STEMI substantially reduce time to diagnosis and reperfusion [49–51]. The expedited identification of STEMI facilitates direct transfer to PCI-capable centers, contributing to reduced door-to-balloon times and improved patient outcomes [52]. Pre-hospital fibrinolysis is another strategy employed when immediate PCI is inaccessible. Initiating thrombolytic therapy during EMS transport has been associated with decreased time to reperfusion and enhanced survival rates in selected patient populations [53, 54]. These practices demonstrate the importance of a structured and collaborative approach, integrating EMS with hospital-based cardiac care systems to ensure timely guideline-directed therapy.

5.2 Adaptations for resource-limited settings

In resource-constrained environments, modified approaches can maintain care quality while reducing costs. Single-lead ECG devices ($150–300) provide 89% sensitivity for STEMI detection compared to 12-lead systems, enabling basic rhythm assessment where standard equipment is unavailable [55]. SMS (Short Message Service)-based symptom triage systems, requiring only basic mobile phones, have demonstrated 76% accuracy in identifying high-risk patients requiring immediate transport [56]. Community health worker programs utilizing simplified assessment tools (modified History, Electrocardiograph (ECG), Age, Risk factors and Troponin (HEART) score) achieve 82% concordance with physician evaluation while extending emergency response coverage to underserved areas [57]. These low-cost alternatives, while not optimal, significantly improve upon baseline care in settings where advanced technology remains inaccessible.

5.3 Technological integration in emergency cardiac care

Technological innovation has introduced a new dimension to cardiac emergency management. Telemedicine, once a supplementary tool, now plays a central role in bridging geographical gaps and facilitating expert consultation during the pre-hospital phase. In fact, this would be an excellent modality to reduce or abolish the disparities in access to advanced pre-hospital care and technology (particularly important in rural or resource-limited regions). Through teleconsultation, EMS teams can transmit real-time clinical data, including ECGs and vital signs, to remote cardiologists, enabling rapid triage decisions and informed recommendations on transport destination and immediate care [58]. The efficacy of telemedicine in acute stroke management, as seen in telestroke networks, provides a replicable model for cardiac emergencies [59]. These networks enhance early intervention and decision-making, highlighting telemedicine's capacity to serve as a core component in pre-hospital systems of care. Simultaneously, wearable devices, integrated with Internet of Things (IoT) platforms, are becoming pivotal in monitoring at-risk individuals [60]. Of course, patients should be well informed on the use of wearable devices, especially from the privacy point of view [61], but there are no doubts on their utility. Wearables capable of continuous ECG monitoring and physiological tracking (*e.g.*, heart rate variability, blood pressure, oxygen saturation) allow

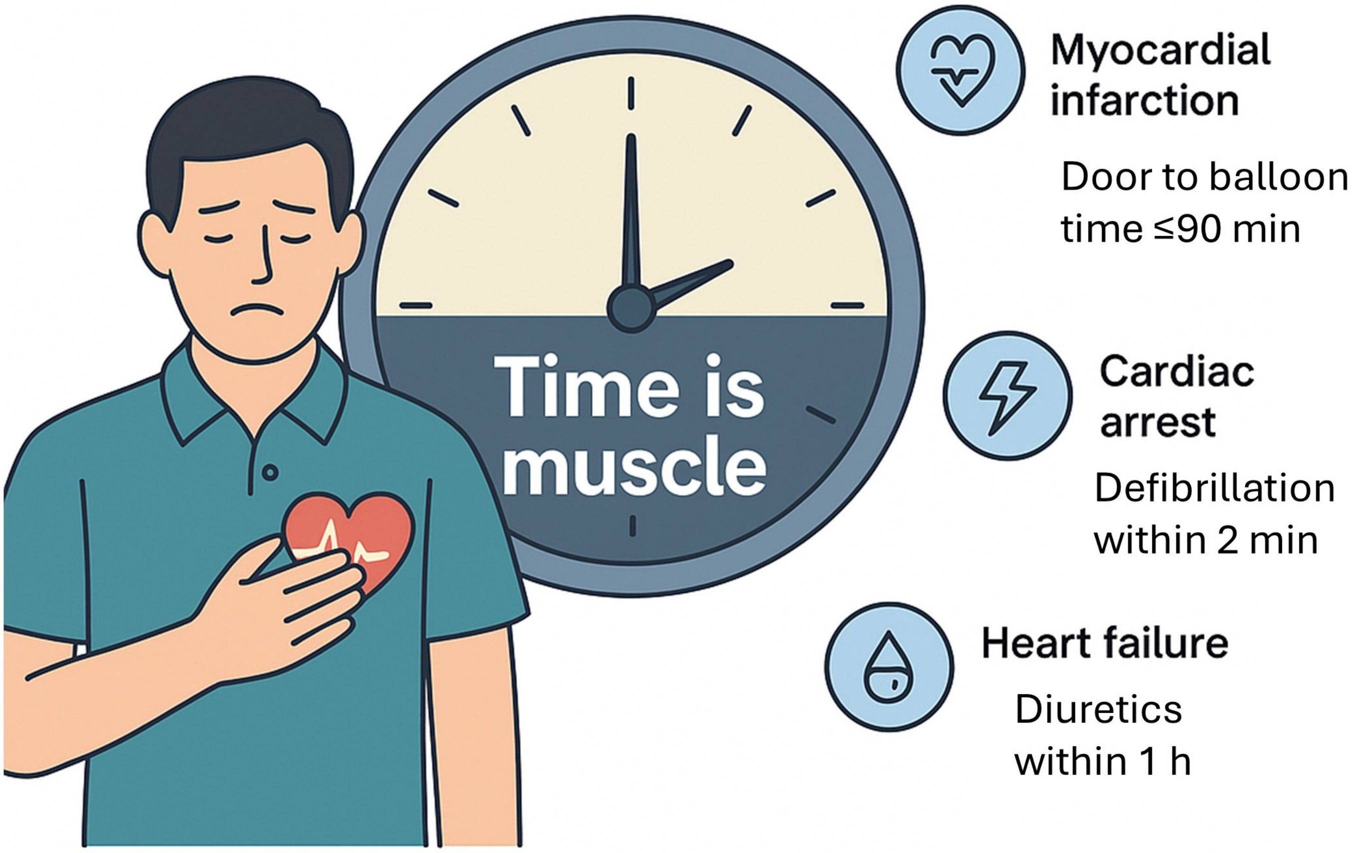

FIGURE 2. The critical role of timing in cardiac emergencies.

for early detection of arrhythmias or ischemic changes, enabling timely therapeutic action [62]. These devices serve not only as diagnostic tools but also as proactive instruments for long-term cardiac surveillance. Incorporating wearable data into telemonitoring platforms enables seamless communication between patients and healthcare professionals, facilitating early intervention and potentially reducing the need for acute hospitalizations [63]. The use of wearables promotes patient engagement, empowering individuals to take an active role in their cardiac health by accessing real-time feedback and alerts [64, 65]. Fig. 3 illustrates the integrated workflow of emergency cardiac care, from pre-hospital evaluation to hospital-based interventions and post-discharge technological monitoring.

5.4 Addressing technical challenges in digital health implementation

While digital health technologies offer substantial promise, several technical limitations require consideration. Telemedicine systems face connectivity challenges, with network latency >500 ms significantly impairing real-time ECG interpretation accuracy (sensitivity reduction from 94% to 76%, $p < 0.01$) [66]. Rural areas experience connectivity failures in 23% of emergency consultations, necessitating redundant communication systems including satellite backup and store-and-forward protocols [67]. Wearable device accuracy varies considerably across populations and conditions. Motion artifacts reduce ECG quality in 31% of recordings during ambulatory monitoring, with false-positive arrhythmia alerts occurring in 18–42% of cases depending on the algorithm used [68]. Skin tone bias affects photoplethysmography-based devices, with peripheral oxygen saturation (SpO_2) measurements showing ±4% error in individuals with darker skin tones compared to ±2% in lighter skin tones [69].

Several mitigation strategies have emerged to address these technical limitations. Implementation of artificial intelligence (AI)-driven noise reduction algorithms has demonstrated substantial improvements in signal quality, achieving a 67% enhancement in high-motion scenarios [70]. Multi-sensor fusion approaches that combine ECG, accelerometry, and impedance plethysmography data have proven effective in reducing false alerts by 54%, providing more reliable continuous monitoring [71]. Edge computing solutions offer resilience against connectivity failures by enabling local processing of critical data when network connections are compromised. Additionally, adaptive algorithms that self-calibrate based on individual baseline characteristics help compensate for population-specific variations, improving accuracy across diverse patient groups.

5.5 Human–technology synergy

While technological advances offer precision and speed, the integration of human clinical judgment remains indispens-

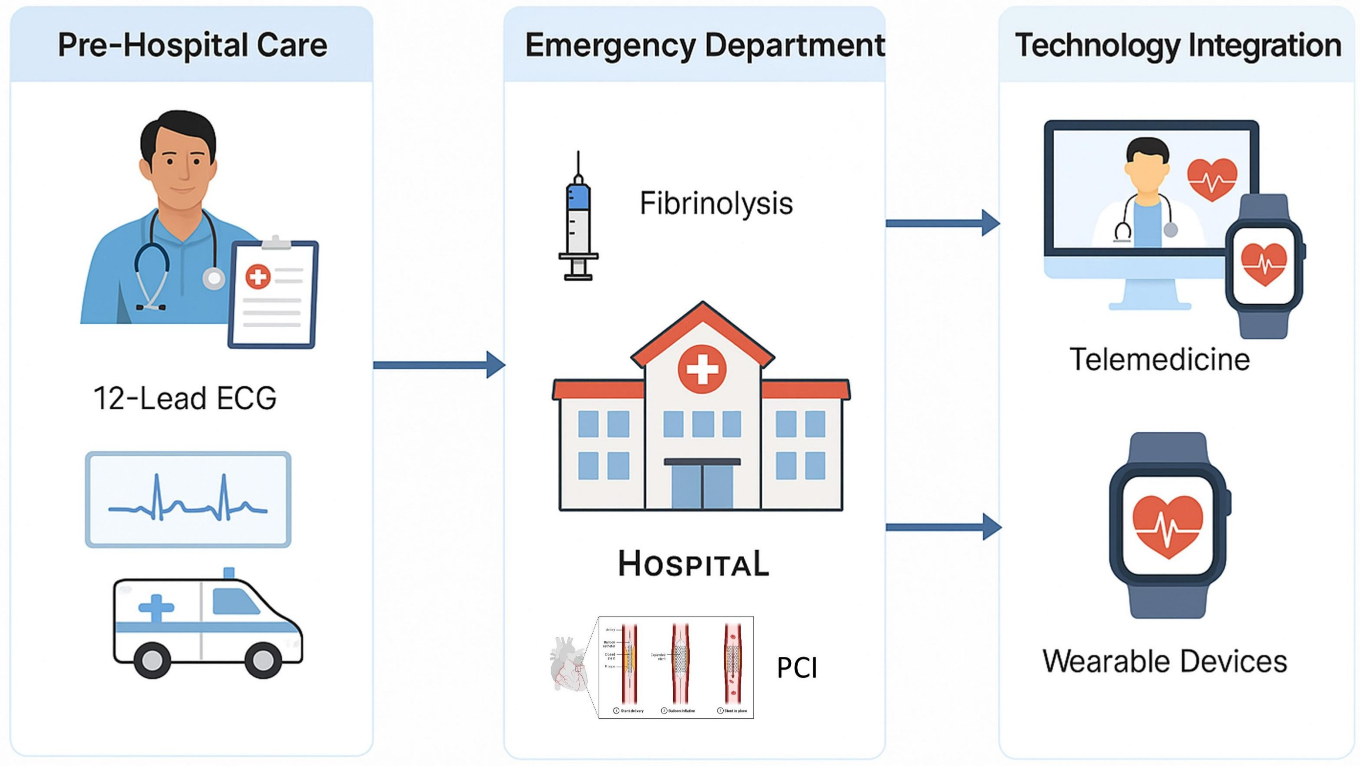

FIGURE 3. Continuum of emergency cardiac care from pre-hospital to technology integration. The figure emphasizes the importance of a connected, multidisciplinary approach to optimizing patient outcomes across all phases of emergency cardiac care, from early pre-hospital assessment to in-hospital interventions and post-acute monitoring through technology-enabled solutions. ECG: electrocardiogram; PCI: percutaneous coronary intervention.

able. The effective use of telemedicine and wearable devices depends on skilled interpretation, compassionate care, and timely decision-making by healthcare professionals [72]. This synergy between human expertise and technological capability fosters a patient-centered approach, where the timely exchange of information leads to improved outcomes [73]. Moreover, the emotional and psychological support provided by healthcare workers complements the efficiency of digital tools. In emergencies, empathy, reassurance, and communication are as critical as rapid diagnostics and interventions [74]. Thus, the future of emergency cardiac care lies not solely in innovation but in the balanced integration of clinical acumen with digital solutions. These concepts are illustrated in Fig. 4, which highlights the synergy between human clinical care and technological tools in the management of cardiac emergencies.

6. Discussion

Timely and effective intervention in cardiac emergencies remains a cornerstone of acute cardiovascular care. This narrative review outlines critical developments in the pre-hospital phase of care and the incorporation of advanced digital technologies, notably telemedicine and wearable devices. These advances collectively represent a paradigm shift in emergency cardiac management, with implications for clinical outcomes, healthcare system design, and the broader trajectory of personalized medicine.

6.1 Significance of pre-hospital interventions

Numerous studies have demonstrated that early intervention is essential in reducing morbidity and mortality associated with cardiac emergencies, particularly acute coronary syndromes (ACS) and out-of-hospital cardiac arrest (OHCA) [75–77]. The integration of structured pre-hospital protocols, such as the use of 12-lead ECGs by EMS providers, has been shown to significantly reduce diagnosis-to-treatment intervals [49]. This practice allows for pre-arrival activation of catheterization laboratories and contributes to meeting established benchmarks such as the 90-minute door-to-balloon time for STEMI, as advocated by the American College of Cardiology and the American Heart Association [52]. Moreover, pre-hospital fibrinolysis remains a relevant alternative when PCI is not immediately accessible, particularly in rural or resource-limited settings. Evidence suggests that in such scenarios, the administration of thrombolytic therapy during EMS transport reduces total ischemic time, with comparable outcomes to PCI when delays exceed 120 minutes [53, 54]. These findings underscore the necessity for flexible, evidence-based protocols that prioritize early reperfusion therapy according to patient location and system capabilities.

6.2 The transformational role of telemedicine

Telemedicine has evolved from a supportive communication tool into a core infrastructure element within emergency med-

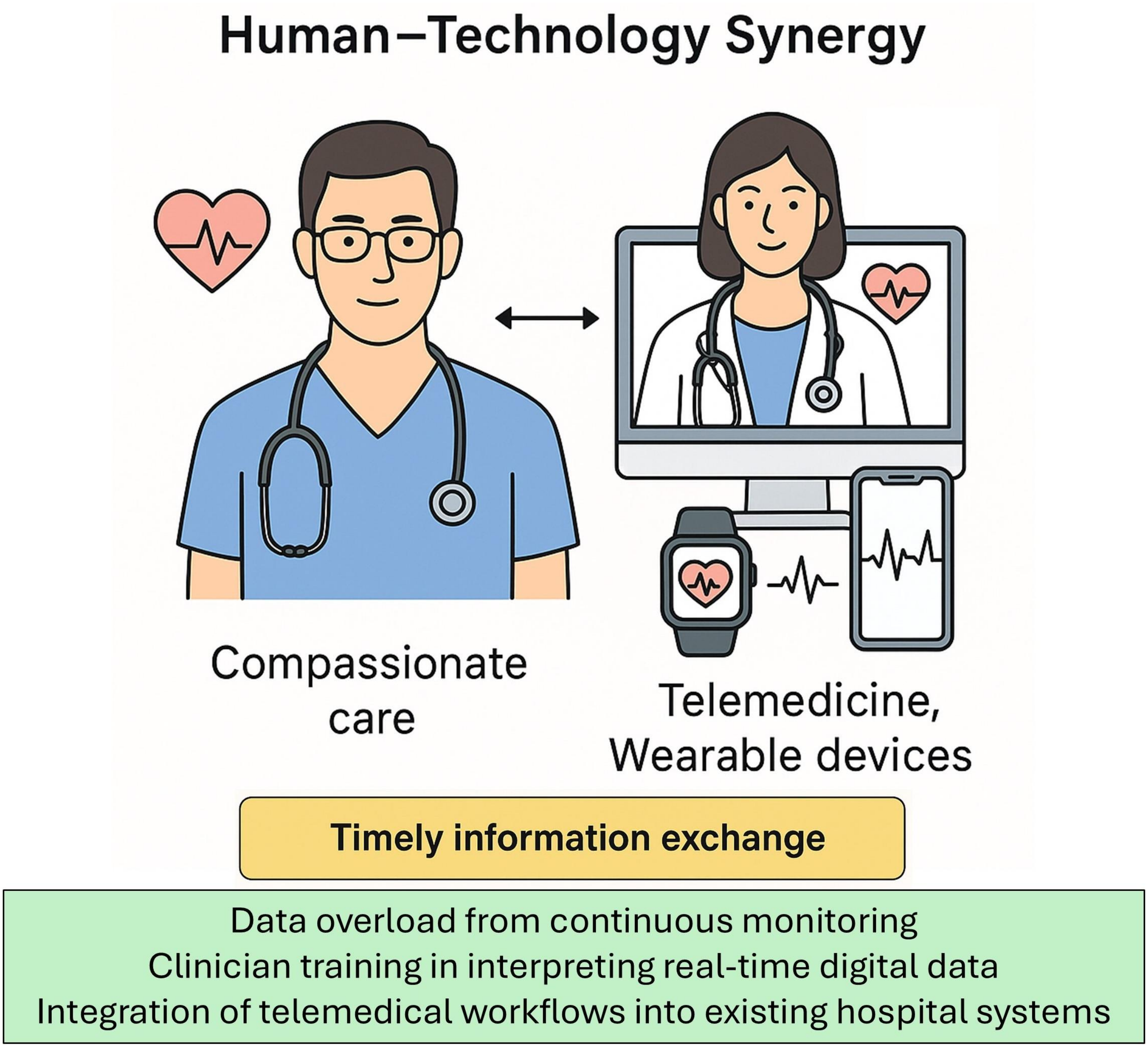

FIGURE 4. Human–technology synergy in emergency cardiac care. This figure illustrates the complementary roles of human clinical expertise and digital tools such as telemedicine and wearable devices.

ical systems [59, 78, 79]. In the pre-hospital setting, teleconsultation between paramedics and cardiologists facilitates rapid clinical decision-making, appropriate triage, and optimal allocation of healthcare resources. Real-time transmission of clinical parameters enables remote interpretation of ECGs and guidance regarding hospital destination, decisions that are often time-sensitive and outcome-determinant [59]. The successful integration of telemedicine in stroke management through telestroke networks provides a validated blueprint for its application in cardiac emergencies [59]. These systems have consistently demonstrated reductions in time to thrombolysis and improved neurological outcomes [80, 81], validating the model for cardiovascular care. The scalability and adaptability of telemedicine also align well with modern healthcare priorities, such as continuity of care, resource optimization, and access equity across geographic boundaries.

6.3 Emergence of wearable technology in cardiac surveillance

The use of wearable technologies represents an exciting advancement in the proactive management of cardiovascular conditions [63, 65]. Devices capable of continuous ECG monitoring, coupled with machine learning algorithms, allow for early detection of arrhythmias such as atrial fibrillation, ventricular tachycardia, or premature ventricular contractions [82–84]. Timely detection may prevent progression to more severe complications and enable early initiation of pharmacologic or electrical therapies. Beyond rhythm surveillance, wearable devices now offer comprehensive physiologic monitoring, including heart rate variability, blood pressure, respiratory rate, and oxygen saturation [85, 86]. These data can inform clinical decisions in real-time, particularly when integrated into telemonitoring platforms that enable continuous clinician oversight [87]. The practical utility of wearables lies in their unobtrusive design and user-friendliness, allowing for broad population-level monitoring and facilitating secondary prevention strategies in high-risk individuals. In the real-world, there are still several limitations, such as patient adherence, cost, and regulatory oversight of data-driven diagnostics.

6.4 Advanced AI applications in emergency decision-making

Beyond traditional machine learning approaches, generative AI and large language models represent emerging frontiers in emergency cardiac care [88]. Real-time risk stratification systems powered by deep learning can integrate multiple data streams (ECG, biomarkers, imaging) to predict adverse outcomes with area under the curve (AUC) values exceeding 0.92 [89]. Natural language processing of unstructured clinical notes can identify high-risk patients 48 hours earlier than traditional methods [90]. However, implementation requires careful attention to algorithmic transparency, validation across diverse populations, and integration with existing clinical workflows [91].

6.5 Human-technology synergy: challenges and considerations

Despite the clear advantages of technological integration, the central role of the clinician must not be diminished. Technology should function as an enabler, not a replacement. Accurate interpretation of wearable or telemetric data, timely clinical judgment, and empathetic communication remain irreplaceable components of effective care delivery [92]. Importantly, technology also introduces potential challenges, including data overload, false alarms, user compliance variability, and issues related to data privacy and security [61, 93]. Furthermore, there is a need to ensure equitable access to these innovations. Populations in low-resource settings or with limited digital literacy may be disproportionately disadvantaged by a system that assumes universal access to technology. Healthcare systems must therefore invest in infrastructure, education, and policy frameworks that ensure inclusivity while embracing innovation.

6.6 Implications for emergency cardiac systems

The findings of this review support the concept that a multimodal, preemptive approach to cardiac emergencies, integrating pre-hospital protocols, telemedicine, and wearables, can substantially improve patient trajectories. For maximum efficacy, these interventions must be embedded within cohesive regional care networks that include standardized protocols, interoperable digital systems, ongoing training for EMS personnel, and clear communication channels between all levels of care. Moreover, public education campaigns aimed at early symptom recognition, activation of emergency services, and engagement with digital health tools are essential for improving community-level responsiveness. Patient-centered models that empower individuals to participate actively in their care using wearables and mobile applications represent a future-oriented direction aligned with global digital health strategies.

6.7 Cost-effectiveness considerations

The economic implications of implementing advanced cardiac emergency systems require careful evaluation even if a specific cost-benefit analysis is beyond the scope of this review. Initial infrastructure costs for comprehensive telemedicine networks range from $2.3–4.7 million per 100,000 population served, including equipment, training, and network establishment [94]. Pre-hospital ECG implementation yields net savings of $3458 per STEMI patient through reduced length of stay (mean reduction: 1.8 days) and decreased repeat interventions (Relative Risk (RR) 0.72, 95% CI: 0.61–0.85) [95]. The number needed to treat (NNT) to prevent one death is 42, with an incremental cost-effectiveness ratio (ICER) of $18,234 per quality-adjusted life year (QALY) gained, well below standard willingness-to-pay thresholds [96]. Wearable monitoring programs show variable cost-effectiveness depending on the target population. High-risk cohorts (prior MI, Ejection fraction (EF) <35%) demonstrate ICERs of $22,156/QALY, while population-wide screening yields less favorable ratios ($78,432/QALY) [97]. Strategic deployment focusing on intermediate-to-high risk individuals optimizes resource allocation while maintaining clinical benefit.

6.8 Future directions and research needs

While the clinical value of pre-hospital ECGs, telemedicine, and wearable technologies in emergency cardiac care is well recognized, further validation through high-quality, randomized controlled trials remains essential. Such studies are necessary to assess their effectiveness across varied populations, healthcare systems, and geographic settings. Key areas warranting focused investigation include comparative outcomes between pre-hospital fibrinolysis and delayed PCI, longitudinal evaluations of wearable device accuracy and their predictive capacity for arrhythmias, and cost-effectiveness analyses of telemedicine infrastructure within cardiac care networks. Moreover, the integration of artificial intelligence for real-time risk stratification and triage optimization represents a promising yet underexplored frontier. In parallel, qualitative research exploring the experiences and perceptions of patients and healthcare providers can help identify barriers to implementation, uncover trust and usability issues, and inform the development of more inclusive, patient-centered technological solutions.

6.9 Limitations

This narrative review has several inherent limitations. The non-systematic approach may introduce selection bias, as article inclusion relied on author expertise rather than exhaustive searching. The absence of formal quality assessment tools limits our ability to weight evidence hierarchically. Publication bias likely overrepresents positive findings, particularly for emerging technologies where negative results are underreported. The rapidly evolving nature of digital health technologies means that some innovations discussed may become obsolete or superseded by the time of publication. Geographic variations in healthcare infrastructure limit the generalizability of certain interventions, particularly in low-resource settings where basic emergency services remain underdeveloped. Furthermore, long-term outcome data for many novel interventions remain limited, with most studies reporting short-term (30-day to 1-year) endpoints. The true impact on cardiovascular mortality and morbidity requires extended follow-up periods not yet available for recent innovations.

7. Conclusions

This narrative review, based on the most recent literature, highlights the critical role of time-sensitive interventions, technological innovation, and interdisciplinary collaboration in emergency cardiovascular care. The analysis confirms that timely pre-hospital and in-hospital responses are pivotal in improving patient outcomes during acute cardiac events. The integration of advanced technologies, such as telemedicine and wearable monitoring devices, has demonstrated promising results in enhancing early detection, rapid response, and continuity of care. Furthermore, the human factor remains central in delivering effective, patient-centered interventions, even as healthcare systems increasingly embrace digital transformation. Looking forward, future research should aim to develop personalized, data-informed approaches tailored to individual patient profiles. Attention should also be directed toward improving public awareness, addressing disparities in resource allocation, and ensuring equitable access to telemedical tools. Ultimately, the pursuit of excellence in emergency cardiovascular care depends on sustained innovation, system-wide adaptability, and a shared commitment to preserving life and dignity in moments of critical vulnerability. Finally, we must emphasize the need for cross-sector collaboration (clinicians, EMS, technologists, policymakers) to operationalize the innovations discussed.

ABBREVIATIONS

ACS, Acute Coronary Syndromes; AF, Atrial Fibrillation; AI, Artificial Intelligence; AMI, Acute Myocardial Infarction; AUC, Area Under the Curve; CI, Confidence Interval; CVD, Cardiovascular Disease; ECG, Electrocardiogram; EF, Ejection Fraction; EMS, Emergency Medical Services; GRADE, Grading of Recommendations Assessment, Development and Evaluation; HR, Hazard Ratio; ICD, Implantable Cardioverter-Defibrillator; ICER, Incremental Cost-Effectiveness Ratio; MI, Myocardial Infarction; NNT, Number Needed to Treat; OHCA, Out-of-Hospital Cardiac Arrest; PCI, Percutaneous Coronary Intervention; QALY, Quality-Adjusted Life Year; RR, Relative Risk; SANRA, Scale for the Assessment of Narrative Review Articles; SpO_2, Oxygen Saturation; STEMI, ST-Elevation Myocardial Infarction; VAD, Ventricular Assist Device; WHO, World Health Organization; IoT, Internet of Things; ACTION, Acute Coronary Treatment and Intervention Outcomes Network; GWTG, Get With The Guidelines; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SMS, Short Message Service; HEART, History, Electrocardiograph (ECG), Age, Risk factors and Troponin score.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

GV, AnP, MM and JVP—designed the research study. RMC, AnP, AlP, SNET, GF, BS and ADK—performed the research. GV and MLGL—analyzed the data. GV, AnP, AlP, GF, ADK, OV, CG and MLGL—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Antonella Paladini, Joseph V. Pergolizzi, Giacomo Farì, Alan David Kaye and Omar Viswanath are serving as the Editorial Board members of this journal. We declare that Antonella Paladini, Joseph V. Pergolizzi, Giacomo Farì, Alan David Kaye and Omar Viswanath had no involvement in the peer review of this article and have no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to OK.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1942461837374046208/attachment/Supplementary%20material.docx.

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