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REVIEW ARTICLE

Quality care in ST-segment elevation myocardial infarction

En-Shao Liu[a], Cheng Chung Hung[a], Cheng-Hung Chiang[a], Yi-Ching Tsai[b], Yun-Ju Fu[b], Yu-Lin Ko[b], Chia-Lin Wang[b], Wei-Yi Lai[b], Fu-Ting Tsai[b], Feng-You Kuo[a], Wei-Chun Huang[a,c,d,e,*]

[a]Department of critical care medicine, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, ROC; [b]Department of Medical Research, Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [c]College of Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC; [d]Department of Physical Therapy, Fooyin University, Kaohsiung, Taiwan, ROC; [e]Graduate Institute of Clinical Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan, ROC

Abstract: Over the past decades, the treatment of ST-segment elevation myocardial infarction (STEMI) has been redefined with the incorporation of evidence from multiple clinical trials. Recommendations from guidelines are updated regularly to reduce morbidity and mortality. However, heterogeneous care systems, physician perspectives, and patient behavior still lead to a disparity between evidence and clinical practice. The quality of care has been established and become an integral part of modern healthcare in order to increase the likelihood of desired health outcomes and adhere to professional knowledge. For patients with STEMI, measuring the quality of care is a multifactorial and multidimensional process that cannot be estimated solely based on patients' clinical outcomes. The care of STEMI is similar to the concept of "the chain of survival" that emphasizes the importance of seamless integration of five links: early recognition and diagnosis, timely reperfusion, evidence-based medications, control of cholesterol, and cardiac rehabilitation. Serial quality indicators, reflecting the full spectrum of care, have become a widely used tool for assessing performance. Comprehension of every aspect of quality assessment and indicators might be too demanding for a physician. However, it is worthwhile to understand the concepts involved in quality improvement since every physician wants to provide better care for their patients. This article reviews a fundamental approach to quality care in STEMI.

Keywords: Clinical outcomes; Evidence-based medications; Quality of care; ST-segment elevation myocardial infarction (STEMI)

1. INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) is a common and challenging clinical condition with a high risk of mortality and disability. Despite attempts by international societies to standardize STEMI care through the guidelines, substantial disparities between optimal care and clinical practice still exist worldwide.[1] Successful management of STEMI is a systemic issue, and the solution is not a novel intervention device or merely a cardiologist's responsibility. It requires the interplay of multiple factors, including patients' health awareness, availability of emergency medical services (EMS), prompt diagnosis, timely reperfusion therapy, use of antiplatelet agents, control of comorbidities, critical care, cardiac rehabilitation, and follow-up care.[2] A multidisciplinary approach to identify inefficient steps and defects during the process of treatment can ensure improving both the quality of health care and the outcomes in patients with STEMI.

*Address correspondence. Dr. Wei-Chun Huang, Department of Critical Care Medicine, Kaohsiung Veterans General Hospital, 386, Dazhong 1st Road, Kaohsiung 813, Taiwan, ROC. E-mail address: wchuanglulu@gmail.com (W.-C. Huang).

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2. TIMELY REPERFUSION

The downstream necrosis in STEMI is time dependent, with tissue ischemia and localized infarction progressing to a wavefront of necrosis, which extends from the subendocardium outward to the transmural injury with time. The longer the period of necrosis, the higher the risk of heart failure, disability, and mortality. Therefore, time is an essential factor, and reperfusion is the cornerstone of therapy in patients with STEMI.[3]

Primary percutaneous coronary intervention (PCI), which restores blood flow by directly reopening the occluded artery with wiring and an inflatable balloon, is the preferred reperfusion strategy over fibrinolysis. PCI needs to be performed in a timely fashion, and the door-to-balloon (D2B) or door-to-wire time benchmark is within 60 or 90 minutes, or as short as possible.[1–4] Many trials have demonstrated that longer D2B delays are associated with larger infarct sizes and higher risks of short-term mortality, increased major adverse cardiovascular events (MACE), higher reinfarction rates, and worse long-term survival.[5–8] The D2B time has become a performance measure and the focus of regional and national quality improvement initiatives.[3] Treatment delays should be recorded in every health-care system, and all process components should be regularly reviewed for continuous quality improvement. Refinements aiming to overcome shortcomings are often required to shorten the revascularization time within the projected target.

To minimize treatment delay, it is essential to increase public awareness of how to recognize the symptoms of acute coronary syndrome (ACS) and how to contact EMS. Public campaigns or health-care providers should also promote awareness that the safest way is to call EMS when ischemic symptoms occur.[1,2,9,10]

The very early stages of STEMI represent the most vulnerable period when most ventricular arrhythmias and sudden deaths occur.[11] It is also crucial to educate the general public on how to quickly respond to sudden cardiac death. Besides knowledge of cardiopulmonary resuscitation, the importance and operation of an automated external defibrillator should be introduced.[3,12]

3. REGIONAL SYSTEMS OF CARE

Patients with ACS have various ways of contacting the healthcare system (EMS vs self-transportation, non-PCI-capable vs PCI-capable hospitals). The achievement of timely reperfusion is dependent on the efficient activation of the catheterization laboratory and execution of PCI, as well as on prompt contact and transportation from a non-PCI-capable hospital to a PCI-capable hospital.[13,14] Therefore, the development of a regional system of care for patients with STEMI has been proposed,[1] with the goal of reducing delays between the first medical contact (FMC) and the STEMI diagnosis and the activation of the catheterization laboratory. Such a system is composed of trained EMS providers and networks between hospitals in a "hub-and-spoke" pattern.[14–16] The ambulance system, equipped with an electrocardiogram (ECG) recorder and defibrillator, not only provides transfer services but also plays a crucial role in enhancing early diagnosis, triage, and management of patients with STEMI.[1,16,17]

Prehospital ECG transmission is an essential component of the regional STEMI system. It enables early identification and prehospital management of patients with STEMI and influences the choice of the destination hospital.[16,17] After recording an ECG, the ambulance staff should be able to either interpret or transmit the data to an experienced physician in the emergency room or coronary care unit (CCU)/intensive cardiac care unit (ICCU). The goal is to reduce the delay between FMC and STEMI diagnosis to within 10 minutes.[1] When a STEMI diagnosis is made by the EMS in the prehospital setting, the patient should be triaged to PCI-capable hospitals and the catheterization laboratory should be immediately activated. Previous studies have variably revealed that the FMC-to-balloon time is substantially decreased by prehospital ECG recordings.[16,17] The combination of prehospital ECG and immediate activation of the catheterization laboratory not only shortens the reperfusion time but also reduces patient mortality.[13–17] In some areas, regional systems allow patients with a prehospital diagnosis of STEMI to bypass the emergency department and to be directly sent to the catheterization laboratory, which can further shorten the time from FMC to wire crossing.[18,19]

Effective regional systems of care for STEMI require a sophisticated partnership between the participating EMS and hospitals, frequent review of the system, and a strategy to ensure continuing education. To shorten the ischemic time and optimize the clinical outcome, regional leaders must unify to address constraints that hinder coordinated systems of care and overcome the barriers to implementation.

4. EVIDENCE-BASED MEDICATIONS

Patients undergoing primary PCI should receive dual antiplatelet therapy (DAPT), a combination of aspirin and a $P2Y_{12}$ inhibitor, and a parenteral anticoagulant. The common consensus is that the $P2Y_{12}$ inhibitor should be administered before PCI.[2] A previous study showed that prehospital administration of a $P2Y_{12}$ inhibitor could reduce the 30-day thrombosis risk better than in-hospital administration.[20] Some studies revealed a potential reduction in ischemic complications and improvement in preprocedural TIMI flow with prehospital $P2Y_{12}$ administration when the transfer time is >60 minutes.[21,22] Therefore, the additional effect may be more evident in patients with STEMI with prolonged prehospital transport times.

After reperfusion, patients with STEMI require continuous monitoring and specialized care in the CCU/ICCU. The unit staff must be experienced and familiar with ACS, heart failure, arrhythmia, mechanical complications, and circulatory support.

Evidence-based medications also play an important role in optimal STEMI care during hospitalization. DAPT with aspirin and a $P2Y_{12}$ inhibitor (prasugrel, ticagrelor, or clopidogrel) should be continued after PCI, with a recommended duration of 12 months. Prasugrel and ticagrelor are the preferred $P2Y_{12}$ inhibitors, in the absence of contraindications, because of their more rapid onset of action, higher potency, and superior clinical outcomes than clopidogrel.[23–25] Clopidogrel is an inactive prodrug that requires hepatic bioactivation and may cause variable platelet response, especially in patients with genetic or drug-induced reductions in hepatic metabolism. Anticoagulation is recommended during primary PCI in all patients with STEMI, especially in those with left ventricular thrombus, atrial fibrillation, or mechanical valves.[1,2] In patients with DAPT or anticoagulation treatment, the balance between the benefits of antithrombotic therapy and the risk of bleeding should be considered.[1,2,26,27] Concomitant prescription of proton pump inhibitors is recommended in patients at a high risk of gastrointestinal bleeding.[1,28,29]

In the absence of contraindications, routine use of adjunctive medications should be considered and initiated early during the hospital course in the CCU/ICCU. This includes beta-blockers, angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin II receptor blockers (ARBs), mineralocorticoid receptor antagonists (MRAs), and high-intensity statin.[1,2] In patients who are intolerant to ACEIs, an ARB, preferably valsartan, is an alternative option.[1,30] In patients using MRAs, regular monitoring of renal function and serum potassium levels is warranted.[1,31,32] Unlike the aforementioned adjunctive therapy that has a beneficial effect on outcomes, nitrates and calcium channel blockers are used to alleviate angina symptoms only; therefore, routine administration of these medications is not recommended.[1]

To achieve higher proportions of prescriptions of guideline-concordant medications, pre-set drug formularies that include recommended dosing and suggested contraindications may be a solution. They should be computerized so that physicians can easily access the list of suggested medicines and select the appropriate medications according to the patient's clinical condition.[33] Each patient's drug list should be reviewed daily until discharge, and a nurse or the information system should notify the healthcare team if medications with outcome benefits are ignored by the physician. A computerized system designed by recognizing eligible patients can assist this process to ensure accurate prescription and decrease human errors.

Before discharge, polypharmacy is not unusual in patients with STEMI, which may lead to drug nonadherence.[34–37] Nonadherence is a complex behavior and remains a challenging public health problem. Patient and caregiver education should begin early in the hospital stay. The "teach-back" technique is an evidence-based education process that ensures that patients have a proper understanding of essential clinical information.[38] During this process, patients are asked to explain, in their own words, what they need to know and how to take medicines. Providing user-friendly tools, such as discharge medication schedules, instructions, or pill boxes, may further aid patients and improve their drug adherence.[38–40]

5. CHOLESTEROL MANAGEMENT

A thorough assessment of comorbidities, including hypertension, diabetes mellitus, dyslipidemia, and chronic kidney disease, should be performed in patients with STEMI. Optimal medical control and preventive measures should be implemented to reduce the risks of subsequent cardiovascular events.[41–43] As cholesterol accumulation with low-grade chronic inflammation plays a fundamental role in mediating atherosclerosis, lipid control merits focus.

After ACS, the lipid profile tends to change, with decreases in total cholesterol, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol levels, and increases in triglyceride levels during the first days. Therefore, a lipid profile test should be performed as early as possible after admission. The test can be performed in the nonfasting state, as this has little influence on LDL-C levels.[44] Previous studies have suggested that early administration of high-intensity statin therapy is associated with rapid benefits and sustained effects for secondary prevention.[45–48] Early initiation of lipid-lowering agents was also reported to improve drug adherence after discharge.[49,50]

According to the current guidelines, high-intensity statin therapy is recommended in patients with ACS if not contraindicated, regardless of the initial LDL-C levels. The treatment goal is to achieve an at least 50% LDL-C reduction from baseline and an LDL-C level of <1.4 mmol/L (<55 mg/dL).[1,51] A more aggressive target of <1.0 mmol/L (<40 mg/dL) for LDL-C could be considered in high-risk patients who experienced recurrent events within 2 years. The lipid profile should be re-assessed 4 to 6 weeks after ACS to determine whether the treatment goals have been achieved and to check for safety issues.[51] If the target level is not reached despite the administration of the maximally tolerated dose of statin, combination treatment with ezetimibe is recommended.

Proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors have been shown to decrease LDL-C levels by up to 60%, either as a monotherapy or in combination with a statin.[52,53] Recent studies reported that PCSK9 inhibitors not only decreased the cardiovascular event risk in patients with stable atherosclerotic cardiovascular disease but also resulted in a substantial relative risk reduction in MACE and all-cause mortality in patients with ACS.[54] These trials also suggested the concept of "the lower, the better," with no lower limit for LDL-C, or a J-curve effect. Nevertheless, despite the promising results, the optimal timing of initiating PCSK9 inhibitors after ACS remains unclear.[46,51] Current guidelines recommend the initiation of PCSK9 inhibitor treatment in patients with ACS in whom the LDL-C targets are not achieved after 4 to 6 weeks of maximally tolerated statin and ezetimibe therapy.[51]

Although the benefits of lipid-lowering agents are well established and confirmed by the guidelines, the attainment of LDL-C target values has remained unsatisfactory. In addition to suboptimal patient adherence, studies have shown that lipid testing and high-intensity statin prescription are infrequent after ACS.[55,56] Even when lipid profile testing is performed, physicians still lack of activity to uptitrate the statin dose. Implementation of team-based intensification of patient care and development of health information technology have been variably reported to succeed in improving the situation.[39,55] However, no single solution exists for the complex problems of nonachievement of LDL-C target and statin nonadherence. A multifaceted effort that involves the provider, the patient, and the health-care system itself is required to improve the quality of cholesterol control.

6. CARDIAC REHABILITATION PROGRAMS

Although various preventive strategies after acute myocardial infarction have been proposed, their implementation in clinical practice remains insufficient. A comprehensive cardiac rehabilitation program not only involves exercise training but also includes psychological counseling and multiple preventive strategies (eg, smoking cessation, diet advice, comorbidity control, and lifestyle modification).[57–59] The benefits of cardiac rehabilitation are well established, including reductions in all-cause mortality, cardiac-specific mortality, rehospitalizations, and mood disorders, and improvement in functional status and quality of life. These benefits have been observed in both sexes and across all ages.[57,60] Therefore, the utilization of cardiac rehabilitation is recommended by the guidelines and has become a quality metric in ACS care. However, at present, cardiac rehabilitation remains a weak point in the overall treatment of ACS.[1,3]

The rates of cardiac rehabilitation participation are unsatisfactory, ranging from 14% to 55%, and the dropout rate is high.[39] Many potential barriers to participation in cardiac rehabilitation have been addressed, such as lack of physician recommendation, lack of insurance, and lower education. Among them, lack of referral to a cardiac rehabilitation program may be the most crucial impediment to patient enrollment. A previous study reported that >40% of patients after PCI (mostly for ACS) are not referred for cardiac rehabilitation by the time of hospital discharge.[61] Lack of insurance coverage has been reported as a reason for the low referral rate.[62] Participation in cardiac rehabilitation may also be affected by patient-specific factors such as insurance type, time away from work, distance of the rehabilitation center from the patient's home, and cost of caregiver services. Theoretically, referral should not be affected if insurance coverage is available.

Notably, physicians may preferentially refer patients who are presumed likely to participate in rehabilitation programs rather than encouraging all patients with ACS to participate in cardiac rehabilitation. Cardiac rehabilitation is an indispensable component of ACS care. To increase participation, strategies that target the process from cardiac rehabilitation referrals to program enrollment are necessary. The automatic electronic cardiac rehabilitation referral system was reported to succeed in improving the referral rates.[63] This system provides default orders for patients with eligible diagnoses, resulting in efficient automatic referrals during hospitalization. In addition, a cardiac rehabilitation team member also introduces the program to qualified patients and coordinates the transition process.[63] Further approaches to increase enrollment include scheduling the first rehabilitation appointment before discharge or modifying the program structure, such as offering home-based options or flexible hours for sessions (eg, after work or weekend hours).[64]

The incorporation of motivational and financial incentives has been reported as a strategy for improving program completion rates.[59] However, these measures may result in increased costs of program delivery and increased workload for team members. Although the task of systemizing rehabilitation referral and enrollment is challenging, the broad and compelling benefits of cardiac rehabilitation merit large efforts in overcoming barriers to participation.

7. WEARABLE TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN STEMI CARE

The rapid development of wearable technologies and mobile connectivity has changed the way humans live. From a clinical perspective, these wearable sensing devices can provide remote measurements of electrophysiological signals, which could be valuable in the early detection of ischemia, arrhythmia, and assessment of physical activities. Integrating digital health information into the health-care system is also a possible solution for improving the quality of care, especially during the COVID-19 pandemic.[65] As STEMI is a time-sensitive emergency, advances in real-time wearable technologies have vast potential in diagnosing and managing this condition.

ECG recording is not always immediately accessible to patients with suspected ACS. Smartwatch- and smartphone-based

Table 1

Selected studies of door-to-balloon time and regional systemic care in STEMI

Study	Design	Patient characteristics	Objectives	Endpoints	Results
McNamara et al 2006[5]	Cohort	STEMI patients treated with PCI within 6 h of presentation	Determine the effect of door-to-balloon time on mortality for patients with STEMI	In-hospital mortality	Longer door-to-balloon time is strongly associated with increased in-hospital mortality (>90 min vs <90 min, odds ratio: 1.42; 95% CI = 1.24-1.62).
Nielsen et al 2011[75]	Cohort	STEMI patients with the presence of symptoms for at least 30 min but less than 12 h	Assess the impact of system delay on the survival of STEMI patients treated with fibrinolysis or PCI	30-d and 8-y mortality	The short system delays were associated with reduced absolute mortality in STEMI patients receiving reperfusion therapy.
Steg et al 2006[18]	Cohort	STEMI patients; excluded patients transferred from other hospitals	Assess the impact on outcomes of direct admission (bypassing the ER) in patients with STEMI	Delays between symptom onset, admission, and reperfusion therapy; 5-d and 1-y mortality	Bypassing the ER was associated with shorter delays between symptom onset and admission (244 min vs 292 min; $p = 0.001$) and primary PCI (294 min vs 402 min; $p = 0.005$). 5-d mortality was lower in patients who bypassed ER (4.9% vs 8.6%; $p = 0.01$).
Kalla et al 2006[14]	Cohort	STEMI patients	Whether the implementation of a network responsible for diagnosis and triage of STEMI patients improves outcome	In-hospital mortality	Establishment of the network for management of STEMI resulted in increased primary PCI usage from 16% to almost 60% and a decrease of mortality from 16% to 9.5%.
Henry et al 2007[13]	Cohort	Patients with STEMI or new left bundle-branch block within 24 h of symptom onset	Establishment of a regional system to provide timely access to PCI for patients with STEMI	Door-to-balloon time and in-hospital mortality	Rapid transfer of STEMI patients from community hospitals to a PCI center is safe and feasible using a standardized protocol with an integrated transfer system.
Brown et al 2008[16]	Cohort	STEMI patients identified by prehospital ECG or by emergency department evaluation	Effect of prehospital 12-lead ECG on activation of the cardiac catheterization laboratory and door-to-balloon time in STEMI	Door-to-balloon time	Prehospital ECG and cardiac catheterization laboratory significantly reduced door-to-balloon time (73 ± 19 min vs 130 ± 66; $p < 0.001$).
Quinn et al 2014[17]	Cohort	Patients with symptoms suggestive of an acute coronary syndrome	Assess prehospital ECG use and its association with processes and outcomes of care in patients with STEMI and non-STEMI	30-d mortality	Prehospital ECG was associated with more primary PCI patients achieving call-to-balloon time <90 min (27.9% vs 21.4%; 95% CI: 1.24-1.54) and a significantly lower 30-d mortality (7.4% vs 8.2%; 95% CI: 0.91-0.96).

ECG = electrocardiogram; ER = emergency room; MI = myocardial infarction; PCI = percutaneous coronary intervention; RCT = randomized controlled trial; STEMI = ST-elevation myocardial infarction; 95% CI = 95% confidence interval.

Table 2

Selected studies of evidence-based medications in STEMI

Study	Design	Patient characteristics	Objectives	Endpoints	Results
Steinhubl et al 2002[76]	RCT	Patients who were to undergo PCI	Evaluate the benefit of long-term (12-mo) treatment with clopidogrel, in addition to aspirin, after PCI	One-year incidence of the composite of death, MI, or stroke	Long-term (1-y) clopidogrel therapy significantly reduced the risk of adverse ischemic events (26.9% relative reduction; $p = 0.02$).
Pfeffer et al 1992[77]	RCT	Patients with MI within preceding 3-16 d	Assess whether captopril could reduce morbidity and mortality after MI	Mortality and cardiovascular events (eg, heart failure, recurrent MI)	Long-term administration of captopril was associated with improved mortality (risk reduction: 19%; $p = 0.019$) and morbidity due to cardiovascular events (risk reduction: 21%; $p = 0.014$).
Dargie et al 2001[78]	RCT	Patients with MI and a left-ventricular ejection fraction of ≤40%	Evaluate the beneficial effects of beta-blockers on long-term outcome after MI	All-cause mortality or admissions for cardiovascular problems	Long-term prescription of carvedilol reduced the risk of all-cause mortality (12% vs 15%; $p = 0·03$).
Schiele et al 2005[79]	Cohort	Patients with MI	Assess the influence of the degree of guideline application on the survival of patients admitted for MI	One-year mortality	Compliance with guidelines is an independent predictor of 1-y mortality (odds ratio: 0.8; 95% CI: 0.7-0.9). The higher mortality was found in patients with lower guideline compliance.
Olivari et al 2012[80]	Cohort	Patients admitted to intensive care unit for MI	Evaluate whether the performance measurement, feedback, and interventions are associated with quality improvement	Guideline-based quality indicators (defined as compliance with the recommendations in ≥90% of patients)	A significant improvement in compliance was observed in 10 out of 30 indicators. Performance indicators can weigh the whole process of diagnosing and managing MI patients and monitoring the progress in the quality of care.

MI = myocardial infarction; PCI = percutaneous coronary intervention; RCT = randomized controlled trial; STEMI = ST-elevation myocardial infarction; 95% CI = 95% confidence interval.

Table 3

Selected studies of cholesterol management in STEMI

Study	Design	Patient characteristics	Objectives	Endpoints	Results
Cannon et al 2004[48]	RCT	Patients hospitalized for an acute coronary syndrome within the preceding 10 d	Compared the effects of 40 mg of pravastatin daily (standard) with 80 mg of atorvastatin daily (intensive therapy)	A composite of death from any cause, MI, unstable angina requiring admission, and stroke	Intensive statin regimen provided greater protection against death or major cardiovascular events (16% reduction in the hazard ratio of a primary composite endpoint; $p = 0.005$).
CTT Collaboration 2010[46]	Meta-analysis	Patients with acute coronary syndrome or stable coronary artery disease	Assess the average risk reduction and average risk reduction per 1.0 mmol/L LDL reduction between different statin regimens	Major vascular events, consisting of coronary death, non-fatal MI, stroke, and revascularization	Further reductions in LDL safely produce substantial further reductions in the incidence of major vascular events, with each 1.0 mmol/L reduction reducing the annual rate of these adverse events by just over a fifth. No evidence of threshold was found within the cholesterol range studied.
Rosenson et al 2015[56]	Cohort	Patients with a statin prescription after MI or coronary revascularization	Estimate the proportion of prescriptions for high-intensity statins after discharge for a coronary heart disease event	The percentage of filling a high-intensity statin prescription	The majority of patients experiencing coronary heart disease event do not fill high-intensity statins after hospitalization (only 27% were a high-intensity statin).
van Driel et al 2016[50]	Meta-analysis	35 RCTs, including 925 171 participants with prescriptions of statin	Evaluate adherence-enhancing interventions for lipid-lowering medications in adults with a variety of outcomes	Drug adherence and reductions of cholesterol levels	Intensification of patient care interventions improves short- and long-term medication adherence, as well as total cholesterol and LDL levels.

CTT = cholesterol Treatment Trialists; ECG = electrocardiogram; ER = emergency room; MI = myocardial infarction; PCI = percutaneous coronary intervention; RCT = randomized controlled trial; STEMI = ST-elevation myocardial infarction; 95% CI = 95% confidence interval.

devices with additional sensors (eg, AliveCor Heart Monitor) could extend the availability of ECG recordings. Although the original design of the smartwatch device is a single-lead ECG, a previous study has explored the possibility of multichannel ECG recording with proper placement of the smartwatch at appropriate locations in the abdomen and chest.[66] The ST-segment changes recorded by the smartwatch were comparable to those of standard ECGs in a small case series and may be helpful in the early diagnosis of ACS.[66] By the powerful mobile computers, the smartphone-based ECG device electronically averages the serial single-lead measurements and presents them as 12-lead equivalent tracings or 6-lead ECG. A previous investigation demonstrated that this technology had a good correlation with the standard 12-lead ECG used for STEMI diagnosis.[67] Further large-scale studies are warranted to assess the accuracy and clinical validity of wearable sensing technologies.

ECG interpretation according to the criteria of ST-segment deviation alone is often insufficient to diagnose myocardial infarction, as the changes observed in this assessment may also be seen in other manifestations, such as pericarditis, left ventricular hypertrophy, early repolarization, and left bundle branch block. Thus, rule-based automatic ECG interpretation has low reliability for

Table 4

Selected studies of rehabilitation in STEMI

Study	Design	Patient characteristics	Objectives	Endpoints	Results
Anderson et al 2016[60]	Meta-analysis	Patients with MI or angina requiring revascularization	Assess the influence of exercise-based cardiac rehabilitation on the outcome of patients with coronary heart disease	All-cause mortality, cardiovascular mortality, and risk of hospital admissions	Exercise-based cardiovascular rehabilitation reduces cardiovascular mortality (relative risk: 0.74; 95% CI: 0.64-0.86) and hospital admissions (relative risk: 0.82; 95% CI: 0.70-0.96), but no effect on all-cause mortality.
Dalal et al 2010[64]	Meta-analysis	Patients with MI, angina, heart failure, and history of revascularization	Compare the effect of home-based and supervised center-based cardiac rehabilitation on mortality, morbidity, and quality of life	Mortality, exercise capacity, control of modifiable risk factors (eg, blood pressure and lipid)	Home and center-based forms of cardiac rehabilitation are equally effective in improving quality of life outcomes in patients with a low risk of further events after MI.
Glickman et al 2010[81]	Cohort	Patients with MI	Determine whether patient satisfaction is associated with adherence to practice guidelines and outcomes	Inpatient mortality and composite guideline adherence score	Higher patient satisfaction is related to improved guideline adherence and lower inpatient mortality.
Lee et al 2008[82]	Cohort	Patients with MI	Examine patient satisfaction was associated with long-term survival	Long-term mortality and the composite endpoint of recurrent MI, angina, heart failure	Satisfaction with care was more likely in older patients, and without depression, and in those with better functional capacity, but it was not associated with the quality of MI care or survival.

ECG = electrocardiogram; ER = emergency room; MI = myocardial infarction; PCI = percutaneous coronary intervention; RCT = randomized controlled trial; STEMI = ST-elevation myocardial infarction; 95% CI = 95% confidence interval.

Table 5

Selected studies of wearable device and AI in MI

Study	Design	Patient characteristics	Objectives	Endpoints	Results
Muhlestein et al 2020[67]	Cohort	Adults with angina-like chest pain at the ER	Evaluation of the feasibility of using smartphone ECGs to detect STEMI	Comparison between the standard 12-lead and smartphone-based ECGs	Blinded, separate readings of ECG resulted in the same diagnosis of STEMI in 163 of 190 pairs (85.8%). Smartphone ECGs also demonstrated high sensitivity (0.89) and negative predictive values (0.95) for STEMI.
Spaulding et al 2019[73]	Cohort	Patients admitted for STEMI or NSTEMI	Assess whether digital health intervention leverages the benefits of self-management program	All-cause 30-d readmissions, adherence, cost-effectiveness, and ER visits	Digital health intervention could be a potential self-management tool for MI recovery, adherence, and cardiovascular risk reductions.
Maddison et al 2019[74]	RCT	Patients with documented diagnoses of coronary heart diseases within 6 mo	Evaluation of the feasibility of wearable sensor for telerehabilitation	$\dot{V}O_2$ max at 12 wk, metabolic profile, and cost utility	The remotely monitored platform with a wearable sensor is an effective and cost-efficient method for exercise-based cardiac telerehabilitation.

AI = artificial intelligence; ECG = electrocardiogram; ER = emergency room; MI = myocardial infarction; NSTEMI = non ST-elevation myocardial infarction; STEMI = ST-elevation myocardial infarction; 95% CI = 95% confidence interval.

the diagnosis of myocardial infarction. Furthermore, conventional reading methods with information from a 12-lead ECG cannot be directly applied to wearable devices or 6-lead ECGs. Artificial intelligence (AI) using neural networks for deep learning may overcome these difficulties. The most distinctive aspect of deep learning is the ability to process large amounts of data, extract features, and create an algorithm from various types of data, providing the capability to recognize subtle patterns in clinical information.[68] Previous studies have shown that AI-enabled ECG could assist in diagnosing contractile dysfunction, left ventricular hypertrophy, arrhythmia, and valvular heart disease.[69–71] In a recent study, AI-based ECG demonstrated favorable performance in detecting myocardial infarction using wearable devices and 6-lead ECGs.[72] This progress may help in the early detection of myocardial infarction and in triaging patients to timely emergency services.

In addition to providing early warning of ACS, the wearable device could be integrated into a guideline-directed self-management program for secondary prevention or telerehabilitation. Previous trials demonstrated that remote platforms comprising mobile applications and wearable sensors had promising results and were cost-effective.[73,74] However, their efficacy in maintaining long-term behavioral changes remains a concern. Because of the consequences of false testing results, the accuracy of wearable ECG measurements and analyses should be validated in larger prospective studies in the future. Although several challenges still hinder the widespread adoption of wearable devices in clinical practice, it is clear that the evolution of wearable technologies provides the opportunity to improve patient outcomes and potentially revolutionize the care of patients with cardiovascular diseases (Tables 1 to 5).

In conclusion, despite the decline in mortality rates associated with ischemic heart disease, this disease remains the single most common cause of death worldwide. The objective of STEMI treatment is to decrease the infarcted area, restore function, reduce subsequent events, and facilitate secondary prevention through the aggressive control of risk factors. Although the ideal assessment of clinical performance remains controversial, the development and implementation of performance measures to improve the quality of health care have dramatically increased in contemporary medical practice, particularly in the management of ACS. As greater consistency with evidence-based care processes has been associated with better clinical outcomes, it is recommended to establish measurable quality indicators to reduce the gap between optimal care and actual care. Ongoing quality assessment combined with multidisciplinary interventions is needed to audit practice and ensure the best chance of successful outcomes in patients with STEMI.

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