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Review Article

Internal Medicine Section

Navigating the Risk Landscape in ST-Elevation Myocardial Infarction Patients Post-percutaneous Coronary Intervention: A Narrative Review

UTKARSH GAUR[1], CHARUTA GADKARI[2], ADITYA PUNDKAR[3]

ABSTRACT

The ST-Elevation Myocardial Infarction (STEMI) remains one of the major contributors to death and disability worldwide. The primary Percutaneous Coronary Intervention (pPCI) has gained wide adoption as the preferred reperfusion strategy over time. The present narrative discussion highlights a wide range of factors that can confer mortality in patients with STEMI treated with PCI, focusing strongly on demographic variables and clinical presentation issues that present inherent challenges to treatment strategies. Age stands out as a predictor of poor outcomes, with the worst prognoses found in those older than 80 years. In this population, diabetes mellitus, hypertension, and reduced cardiac function all dramatically increase the risk of poor outcomes. The presence of cardiogenic shock is another prime determinant of mortality and often multiplies these risks when combined with multivessel Coronary Artery Disease (CAD) and delayed initiation of treatment. Other notable risks post-PCI include repeated myocardial infarction, arrhythmias, and in-stent thrombosis, each of which further complicates clinical management. All these factors together create a complex, high-risk profile of patients who will need individualised and directed management strategies for optimum reduction in mortality. Delays in door-to-balloon times continue to be a major challenge to achieving better outcomes in regions with limited resources. Additionally, a significant long-term challenge is the management of multivessel disease and personalised therapy for high-risk patients, particularly during the acute phase. While PCI has resulted in a substantial reduction in mortality among patients with STEMI, gaps in outcomes still exist, predominantly among older patients and those with a greater complexity of co-morbidities. Treatment protocols must be continuously refined to address these gaps. The paper underscores the need for continuous innovation and research at both pre-hospital and post-PCI management levels to reduce mortality rates and improve the long-term outcomes of high-risk STEMI patients.

Keywords: Acute coronary syndrome, Door-to-balloon time, Multivessel coronary artery diseases, Personalised therapy

INTRODUCTION

Cardiovascular Diseases (CVDs) are among the leading causes of death worldwide, with Ischaemic Heart Disease (IHD) accounting for a significant proportion of these deaths. According to the World Health Organisation, around 17 million people die each year from CVDs, of which nearly 7.4 million deaths are attributed to Acute Coronary Syndromes (ACS), such as heart attacks and strokes [1]. STEMI, which represents the most critical manifestation of ACS, remains a crucial condition contributing to global health morbidity despite major advances in diagnosis and treatment [2].

About 7.5 million of these deaths are due to atherosclerotic heart disease, while one million are attributed to Tuberculosis (TB) alone. Furthermore, 8 million deaths are due to ACS and sudden cardiac events [3]. Thus, ACS poses an enormous cardiovascular threat to affected patients. According to the data, deaths directly caused by CVDs accounted for 17.5 million annually in 2015, with 7.4 million due to ACS [4]. Statistics from the United Nations indicate that in 2019, Indonesia ranked second in deaths due to IHD [5]. Coronary heart disease results from cholesterol deposits building up in the arteries that supply blood and oxygen to the heart. Cardiovascular risk factors indicate that cigarette smoking and excessive alcohol consumption are the most common, with the highest prevalence. Additionally, diabetes mellitus, a sedentary lifestyle, and hypertension account for a significant portion of patients [6].

ACS begins with an enhanced demand for oxygen and reduced capacity for the transportation of oxygen in the blood or damaged coronary flow due to atherosclerosis and subsequent arterial constriction or occlusion [7]. There are three conditions categorised under ACS: STEMI, non STEMI (NSTEMI), and Unstable Angina Pectoris (UAP) [6,8]. The direct relationship between myocardial supply and demand is responsible for the clinical condition of angina pectoris [8]. Although ST-segment elevation is not shown on the Electrocardiogram (ECG) in NSTEMI, there is an elevation of enzyme levels. Complications of this disease may include sudden pulmonary oedema, cardiac arrest, and even death [7].

Despite technical advancements, ACS still presents one of the major challenges in the medical field. For patients with STEMI, emergent reperfusion treatment is recommended. The established and evolving therapy of choice for STEMI patients remains early and immediate pPCI [9].

The latest data from the The Swedish Web- System for Enhancement and Deveopmet of Evidence- based care in Heart Disease (SWEDEHEART) registry indicate that the mortality and morbidity of CVD have declined over the last 30 years[10]. However, this trend has not been observed in mortality due to complications, such as cardiogenic shock or in patients with ACS who required Cardiopulmonary Resuscitation (CPR), in whom high levels of fatality remain [3].

The most recent European Society of Cardiology guidelines for the management of STEMI emphasises the importance of adhering to mandatory time frames for primary PCI. They also encourage the continuation of updates in recommendations concerning complete revascularisation, enoxaparin therapy, early hospital discharge, and the utilisation of drug-eluting stents. In particular, these guidelines have downplayed the use of bivalirudin and thrombus aspiration [2].

However, complications in the management of STEMIs persist, and the unanswered questions highlight the need for further research. It remains necessary to continue research and development efforts to address the complexities surrounding STEMI.

The present narrative review focuses on the critical determinants of mortality among STEMI patients treated with PCI. It explores key demographic and clinical factors, such as age, gender, and co-morbidities, that significantly impact patient outcomes. Additionally, it highlights the challenges in managing high-risk and complex cases, including delays in treatment and the influence of health system parameters. By synthesising the current literature, the review identifies opportunities for improving survival rates and optimising care through targeted strategies and evidence-based practices.

REVIEW OF LITERATURE

Clinical Presentation and Management Approaches in STEMI Outcomes

STEMI accounts for about 74% of all myocardial infarctions and presents clinical challenges due to the severity of the diagnosis and the urgent need for immediate intervention [6]. The clinical presentation of STEMI is primarily characterised by classic symptoms such as chest pain, which remains the most common manifestation, reported in more than 80% of cases. Other symptoms include shortness of breath, palpitations, sweating, dizziness, and syncope; these occur but are less commonly reported [2,7]. These symptoms, although typical, can vary among different patient populations based on factors such as age, gender, and pre-existing co-morbidities [8,11].

Multivessel Coronary Artery Disease (CAD) further complicates the prognosis for patients with STEMI. Multivessel CAD is observed in 40-65% of STEMI cases and is associated with higher short-term and long-term mortality and morbidity rates [12]. Care strategies for these patients may vary, often involving culprit-only PCI during the initial procedure and delayed treatment for non infarct-related arteries. The management of multivessel disease depends on clinical decisions, as it can have dire outcomes for the patient, especially in cases complicated by cardiogenic shock, which is seen in 5-10% of STEMI cases [12].

Despite improvements in reperfusion therapy, the door-to-balloon time must remain minimal to achieve the best survival outcomes. In most regions, especially those with limited resources, prolonged door-to-balloon times contribute to increased mortality [13]. The American Heart Association and the European Society of Cardiology recently urged that door-to-balloon times be further reduced to less than 90 minutes for improved survival rates [14]. Diagnosis is primarily made using specific ECG alterations, particularly ST-segment elevation, and, less commonly, by the presence of Q waves, which indicate deeper myocardial necrosis [15]. These ECG alterations are also age- and gender-dependent [8,11]. Certain ECG patterns can also signal acute coronary artery occlusions, in which revascularisation may be necessary even in the absence of ST-segment elevation [15].

Therefore, outcome management in STEMI is not solely about timely PCI; it also involves managing individual risk factors such as age and co-morbid conditions while optimising the treatment of multivessel disease. The integration of these approaches plays a crucial role in improving prognosis and minimising mortality among STEMI patients worldwide.

Demographic and Health Determinants of STEMI

Mortality after PCI and the impact of age on mortality: Age is the most significant predictor of death in STEMI patients who undergo PCI. A study shows that one-year mortality is as high as 25.6 to 31.9% among patients older than 80 years of age [16]. This high risk of death is primarily due to poor cardiac function and the presence of multiple co-morbidities, which are common in older age groups [17-19]. These findings emphasise the need for proper preoperative evaluation and customised post-procedure care for elderly patients.

Gender difference in STEMI outcomes: Gender also plays an important role in STEMI outcomes. It has been observed that females have higher early mortality after PCI due to atypical symptomatology and delayed presentation for treatment [20]. These inequalities can be addressed by improving transitional care, and gender-related risks should be communicated to enhance outcomes for females who receive PCI [21-23].

Effect of Out-of-Hospital Cardiac Arrest (OHCA): Out-of-Hospital Cardiac Arrest (OHCA) significantly impacts early mortality in the context of STEMI. Studies have consistently established OHCA as a strong correlate of increased 30-day mortality, often due to the higher ischaemic load and delayed recovery associated with cardiac arrest events [24,25]. For instance, a five-year review of an Irish tertiary referral centre demonstrated that survival to hospital discharge in STEMI patients with OHCA was 77.33%, emphasising the importance of rapid Return of Spontaneous Circulation (ROSC) and timely PCI intervention in improving outcomes [26] Similarly, the 2023 European Soceity of Cardiology (ESC) Guidelines for the Management of ACS emphasise the necessity of immediate revascularisation in STEMI patients who experience OHCA, recommending PCI within two hours to optimise survival rates [27]. These findings underscore the critical need for prehospital systems that minimise response and transport times, enhance bystander resuscitation efforts, and ensure direct transfers to PCI-capable facilities.

Impact on kidney disease: Another critical factor governing post-PCI outcomes includes renal function [28]. The mortality rate following PCI is significantly higher in patients with renal dysfunction due to STEMI, partly because of the effects of contrast agents during angiography. Close follow-up of renal function, avoidance of nephrotoxic drugs, and strict adherence to contrast guidelines are necessary to improve prognosis in this high-risk group [28-30].

To provide a clearer understanding of the impact of demographic and clinical factors on STEMI mortality, the following table summarises key findings from notable studies [Table/Fig-1] [10,16,20,31-34]. These studies highlight the role of age, gender, and other health parameters in shaping patient outcomes after PCI.

Name of the author and year of the study	Population	Key findings	Risk factor analysed
Szummer K et al., (2017) [16]	STEMI patients >80 years	One-year mortality of 25.6 to 31.9%, attributed to poor cardiac function and multiple co-morbidities.	Age
Malaysian ACS registry, 2021 [31]	STEMI patients	Women had higher in-hospital mortality than men (23.6% vs. 13.9%, $p<0.001$).	Gender
Jakarta ACS registry, 2016 [32]	STEMI patients	Delays in treatment {e.g., Symptom-To-Balloon (STB) time} significantly increased mortality.	Treatment delays
Granger CB et al., 2003 [33]	ACS patients	Renal dysfunction was associated with significantly increased mortality post-PCI.	Renal function
Stone SG et al., 2014 [20]	Female STEMI patients	Gender-specific presentation caused delayed diagnosis and higher early mortality rates.	Gender disparities

Tsai TH et al., 2019 [34]	STEMI patients with cardiogenic shock	Patients with cardiogenic shock had mortality rates >40% despite PCI intervention.	Cardiogenic shock
Schubert J et al., 2024 [10]	STEMI patients >75 years	Highlighted disparities in outcomes due to regional differences in healthcare access.	Age and healthcare disparities

[Table/Fig-1]: Studies highlighting the impact of age, gender, and other risk factors on stemi mortality [10,16,20,31-34].

Prognostic improvements in STEMI management: Anaemia at the time of admission may significantly impact the course of microvascular remodeling and atherosclerosis. Chronic anemia has previously been associated with heart failure and increased mortality due to its effect on blood viscosity and afterload. Generally speaking, it is established that longer follow-up times are associated with higher mortality [6,35,36]. These findings point to the significance of proper anemia management among STEMI patients before PCI to reduce mortality and improve prognosis.

Furthermore, research findings have revealed higher mortality rates among patients with anterior wall infarctions compared to those with infarctions in other locations [37]. Studies suggest that the risks associated with an infarct in the anterior wall are increased because it is exposed to higher ejection forces and may even dilate the infarcted area [38]. Generally, prognosis are inversely correlated with the number of affected coronary arteries, further supporting the link between anterior infarction and high early mortality after PCI in patients with STEMI [34,39]. Indeed, most observations show that patients with anterior infarcts have a particularly high risk for early mortality, i.e., within 30 days of the procedure [34,40].

According to the Jakarta ACS registry, data on patient demographics, treatment timelines, procedural outcomes, and long-term follow-up results aid in analysing the state of healthcare in developing nations and optimising clinical outcomes. Such databases provide comprehensive information that can be used to study trends in patient management, assess the effectiveness of treatments like PCI, and evaluate the impacts of policies aimed at improving healthcare quality and reducing mortality rates among STEMI patients [32].

Acute STEMI risk factors: Understanding the demographic and clinical factors associated with STEMI is essential for tailoring preventive and therapeutic strategies. The present review identified several important factors, including patient age, gender, smoking history, and elevated cholesterol levels. Additionally, it was observed that men made up a significantly larger proportion of STEMI cases compared to NSTEMI and Unstable Angina (UA), with percentages of 68.1%, 54.9%, and 52.5%, respectively (p-value <0.001). Furthermore, the median age of STEMI patients was 62 years, notably younger than the median ages for NSTEMI (68.8 years) and UA (66.6 years) patients (p-value <0.001) [40].

Other risk factors observed in STEMI patients included a family history of CAD, diabetes, hypertension, abnormal lipid profiles, and smoking habits, among others [41]. Results revealed a decreasing death rate based on the nature of the intervention received. The mortality rate of 14.1% was the highest in the group of patients who were not reperfused for STEMI [42]. The mortality rate in patients receiving fibrinolysis was 8.2% [42], while the mortality rate in those who underwent primary PCI for STEMI was 7.5% [43]. These results are consistent but just marginally higher than the report from the Jakarta ACS registry published in March, where hospital mortality was found to be 9% [32].

These findings highlight the necessity of early treatment and adequate anticoagulant therapy selection in STEMI cases. The data indicate higher mortality rates in control groups, underscoring the importance of reperfusion approaches, particularly primary PCI, to improve the prognosis of STEMI patients. Additionally, detailed risk factor analysis helps in designing specific preventive measures and monitoring for early symptoms in high-risk population groups.

Mortality rates in STEMI patients: Gender differences play a significant role in the clinical outcomes of STEMI patients, with multiple studies examining how these variations impact mortality. Understanding these differences is essential for providing gender-specific care and addressing disparities in STEMI treatment [44]. Women had nearly twice as many deaths from STEMI as men, though this difference was not statistically significant [45]. For example, in India, women had a considerably higher in-hospital mortality rate than men (23.6% vs. 13.9%; unadjusted Odds Ratio (OR)=1.90; 95% Confidence Interval (CI)=1.60-2.26; p-value <0.001) [45]. Women with STEMI were generally older and more likely to have diabetes, hypertension, and congestive heart failure, though after multivariate analysis, the gender difference in in-hospital mortality was no longer significant [46]. Similarly, data from the Malaysian ACS registry showed that women with STEMI had a higher risk of in-hospital death (OR=1.29; 95% CI=1.06-1.59; p-value <0.012), but this risk difference disappeared after adjusting for other covariates [33].

Evaluating time parameters in STEMI patient care: A number of temporal indicators that represent the standard of patient care are used to evaluate the effectiveness of STEMI healthcare. The amount of time that passes between the beginning of symptoms and the First Medical Contact (FMC) is one important sign that reflects the patient's knowledge of the potential for a heart attack. The time to treatment, measured as Door-To-Needle (DTN) for fibrinolysis recipients or Door-To-Device (DTD) for primary PCI patients, is another critical metric. The time it takes for patients to get to a PCI-capable facility after being originally diagnosed at a hospital without PCI capability also plays a significant role [47].

United States (US) guidelines recommend a FMC-to-device time of 90 minutes or less for emergency transfers to PCI-capable hospitals to ensure acceptable myocardial reperfusion [47]. Regarding pre-hospital ACS management, the mean recorded time from the first symptoms to admission was six hours. The present study also confirmed that self-walking patients have a shorter onset-to-admission time than referred patients, with mean values of 6.00 and 6.75 hours, respectively (p-value=0.011). However, this difference may not accurately represent the actual FMC-to-hospital transfer time, mainly due to the long distances patients may have to travel from rural areas [48].

The Jakarta ACS registry includes Door-In to Door-Out (DI-DO) time as a parameter, defined as the time between arrival at the FMC or STEMI referral hospital and discharge [32]. The mean DI-DO time recorded was three hours, significantly exceeding the American guideline of 30 minutes. These findings underscore the urgent need to enhance the quality and efficiency of the pre-hospital phase and transfer procedures in STEMI management to meet international benchmarks and improve patient outcomes [47,49].

Review of Related Literature on PCI and Treatment Timelines in STEMI Patients

Primary PCI has been widely recommended as the standard therapy for STEMI patients due to its effectiveness in reducing the recurrence of infarction and mortality rates. However, fibrinolysis remains a viable option when PCI cannot be administered in a timely manner, defined as a FMC-to-device time exceeding 120 minutes. In the present study, the median DTN and DTD times were 50 and 144 minutes, respectively, which are beyond the suggested standards for proper reperfusion. This pattern is consistent with observations in other Southwest Asian countries. For instance, regional data represented median DTN and DTD times of 85 minutes and 122 minutes, respectively [18].

The Malaysian ACS registry reported that the mean DTN time for men is shorter than for women (49.7 minutes vs. 60.8 minutes, respectively, p-value <0.001). Similarly, DTD times in the present study were not significantly different: 110.0 minutes for men and 121 minutes for women (p-value=0.244) [31]. Consequently, DTN time can be regarded as a critical factor influencing overall mortality, with its reduction being essential. A US study demonstrated that achieving a DTN time below 30 minutes was associated with an overall in-hospital mortality of 9%, which was higher than the 4% for DTN times of 31-45 minutes, and 6% for other DTN times. Mortality rates were very low (1%) for those with DTN times under 45 minutes and slightly higher (2%) for those exceeding 45 minutes [50].

The possible delay in presentation may be due to the long travel time to the hospital. This is a common issue, as evidenced by US research indicating that only 40-75% of patients referred from other non PCI-capable hospitals receive treatment within the required 120 minutes [32]. However, accurately assessing the exact onset of symptoms is challenging due to potential recall bias or the presence of chest symptoms before the complete occlusion of coronary arteries. Nonetheless, the benefits seen in treatment during the later period (3-12 hours after the onset of symptoms) might be confounded by events such as Unstable Angina Pectoris (UAP) or spontaneous reperfusion before the development of STEMI [51].

Although the efficacy of primary PCI over fibrinolysis suggests time sensitivity, it should be noted that the precise timing of reperfusion in primary PCI is not mandated as early as in fibrinolysis trials, possibly because STEMI patients in such trials were exposed to symptoms for about 2-3 hours. During these hours, in-hospital fibrinolysis can show similar improvements as primary PCI. Thus, direct and primary fibrinolysis should be performed if the transfer to a PCI-capable center is likely to take more than two hours [52].

Anterior infarct arteries in acute myocardial infarction should be identified according to ECG features. Previous studies have found that the characteristics of ECG are useful in the diagnosis of acute myocardial infarction [53]. Combining these outcomes with coronary angiography allows for the identification of arteries requiring intervention, leading to early diagnosis, more accurate prognosis, and higher quality specialised treatment, thus improving long-term patient outcomes [54].

Previous studies have noted that treatment delays in STEMI, including the DTB and the Symptom-To-Balloon (STB) times, directly affect mortality rates. These associations form the basis of guidelines recommending a DTB time of less than 90 minutes [43,45]. Significantly decreased DTB times were observed in STEMI patients who received PCI within the first 90 minutes of admission, with subgroup analysis showing they were most protected against mortality. However, considering current trends, around 90% of patients experience DTB times of no less than 90 minutes [55]. Several factors could explain these delays, such as transportation issues, a poor emergency system, and insufficient information [56].

Numerous research investigations have shown that time spent in STB has a negligible preventative effect. In comparison to the DTB time or STB time with additional grouping criteria, it is much less effective depending on the selected grouping criterion. The fact that the clinical rates of developing delayed ST-segment elevation have not changed much over the past ten years provides further evidence regarding the entity's existence. When assessing how well the healthcare system is working, the overall STB and DTB times are highly helpful. The protective impact of total STB time is not as clearly sustained when comparing different STB grouping thresholds of three hours versus four hours [57].

The main advantage of the current evaluation is its integration and methodological rigor. Most of the studies for the present paper were retrieved from various online databases in order to analyse the existing literature. By categorising the studies according to the control levels, this approach improved the efficiency of identifying precise details on the related mortality of STEMI patients. Nevertheless, there is a need to point out a few limitations of the present research. Firstly, variations can occur in both the algorithms for assessing exposure factors and the indexes of the outcome. Secondly, the number of available proven risk variables is limited, hindering additional research to identify the sources of variance. Thirdly, the language constraint eliminated several potentially relevant studies conducted in English but published in other languages, thereby limiting the scope of the review.

CONCLUSION(S)

The present review highlights key factors influencing mortality in STEMI patients treated with PCI, including age, co-morbidities, treatment delays, and specific clinical presentations. While PCI has improved outcomes, challenges persist, especially for older and high-risk populations. Addressing modifiable factors such as door-to-balloon time and enhancing personalised care are essential for reducing mortality rates. Continuous research and innovation in pre-hospital and post-PCI management are crucial to close gaps in care and improve survival rates, particularly in resource-limited settings.

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PARTICULARS OF CONTRIBUTORS:
1. Junior Resident, Department of Emergency Medicine, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
2. Professor, Department of Emergency Medicine, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
3. Professor and Head, Department of Emergency Medicine, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Utkash Gaur,
Junior Resident, Department of Emergency Medicine, Datta Meghe Institute of Higher Education and Research, Wardha-442001, Maharashtra, India.
E-mail: utkarshgaur21@yahoo.com

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