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Systematic Review

Impact of Preoperative STEMI on Postoperative Recovery and Complications Following Cardiac Surgery

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Abstract

Background: Comprehensive perioperative management strategies are advised for patients undergoing cardiac surgery who have a history of preoperative ST-segment elevation myocardial infarction (STEMI) because these patients have a higher risk for adverse postoperative outcomes. This systematic review explored the influence of preoperative STEMI on postoperative recovery and complications in cardiac surgery patients. **Methods**: A systematic search of PubMed, MEDLINE, EMBASE, and Cochrane Library databases was conducted following the Preferred Reporting Items for Systemic Reviews and Meta-analyses (PRISMA) guidelines. Studies published between 1990 and 2024 were screened for inclusion based on predefined criteria. A total of 420 studies were initially identified, and eight studies, encompassing 1741 patients undergoing coronary artery bypass grafting (CABG), were included in the review. Two independent reviewers performed data extraction, and the quality of studies was assessed using the Newcastle–Ottawa scale. Key findings from each study were narratively synthesized to explore common themes and outcomes related to postoperative mortality, major adverse cardiac events (MACEs), and complications. **Results**: Of the 420 initially identified studies, eight met the inclusion criteria. Across these included studies, STEMI patients demonstrated higher postoperative mortality rates and increased incidence of MACEs compared to other cardiac surgery patients. Complications such as renal failure were particularly prevalent in patients with preoperative cardiogenic shock, with up to 50% of these patients requiring intra-aortic balloon pump (IABP) support. Recovery of left ventricular ejection fraction (LVEF) varied, ranging from 0.36 to 0.50, depending on the extent of preoperative myocardial dysfunction and the revascularization strategy employed. Variability in patient demographics, surgical techniques, and clinical settings contributed to differences in reported outcomes across studies. **Conclusion**: These findings underscore the importance of tailored perioperative strategies and specialized care protocols for STEMI patients undergoing cardiac surgery. By addressing the unique challenges posed by this high-risk group, healthcare providers can improve patient outcomes and reduce the incidence of postoperative complications.

Keywords

cardiac surgery; complications; postoperative outcomes

Introduction

Cardiac intervention surgeries are complex procedures that require meticulous preoperative evaluation to optimize patient outcomes. Recent ST-segment elevation myocardial infarction (STEMI) is particularly significant among the various preoperative risk factors. STEMI, a severe form of heart attack, is characterized by the complete obstruction of one of the main heart arteries, resulting in a substantial portion of the heart muscle being deprived of oxygen [1]. STEMI complicates the underlying cardiac condition and significantly affects the management strategies, postoperative recovery, and likelihood of complications following cardiac surgery [2].

Therefore, the high-risk nature of the event and surgery renders the interplay between a recent STEMI and surgical outcomes in cardiac procedures a critical study area. To mitigate myocardial injury and restore coronary blood flow, patients who present with STEMI necessitate immediate intervention [3]. Nevertheless, the surgical team encounters additional obstacles when these patients require subsequent cardiac surgery. Indeed, a compromised myocardium is a critical concern for cardiac surgeons and their teams due to its increased susceptibility to stress and diminished resilience [4].

Research suggests that preoperative STEMI may elevate the likelihood of adverse events following surgery. These complications may encompass acute renal failure, reinfarction, low cardiac output syndrome, and elevated mortality rates [4]. Thus, the timing of surgery in the aftermath of the STEMI is of the utmost importance: the heart may be too fragile to withstand the stress of surgery if it is performed too soon, while postponing surgery can also increase the risk of additional cardiac events or deterioration [5].

A multidisciplinary approach is necessary to manage patients who have experienced recent STEMI. This encompasses implementing mechanical support devices, optimal medical therapy, and meticulous surgical timing to reduce the period of vulnerability to additional cardiac events and stabilize the patient's condition to withstand the rigors of surgery. Consequently, preoperative planning necessitates a delicate equilibrium between the advantages of allowing time for myocardial recovery and urgent surgical requirements [6].

Advancements in surgical techniques and postoperative care have substantially enhanced the outcomes for patients with a recent history of STEMI who are undergoing cardiac surgery [7]. Moreover, innovations such as minimally invasive surgeries, improved myocardial protection strategies during surgery, and enhanced postoperative care protocols are imperative in managing these high-risk patients. It is impossible to exaggerate the significance of comprehending the influence of preoperative STEMI on surgical outcomes [8,9].

Preoperative STEMI is a well-established risk factor that complicates outcomes in cardiac surgery due to myocardial damage, which compromises the capacity of the heart to endure surgical stress. This systematic review aimed to synthesize evidence on outcomes specific to STEMI patients undergoing coronary artery bypass grafting (CABG). By consolidating data on mortality, major adverse cardiac events (MACEs), and postoperative complications, this review highlights the unique challenges and factors influencing recovery and prognosis in this high-risk population. Rather than comparing STEMI with non-STEMI cohorts, the focus is on understanding the specific outcomes within the STEMI cohort to identify critical areas for intervention and improvement.

Materials and Methods

Study Selection

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search of PubMed, MEDLINE, EMBASE, and Cochrane Library databases identified studies published between 1990 and 2024. The search strategy included terms related to cardiac surgery, postoperative recovery, surgical complications, and STEMI.

Inclusion and Exclusion Criteria

Studies were selected based on the following criteria: (1) studies evaluated cardiac surgery outcomes in patients with a history of preoperative STEMI; (2) studies were published in peer-reviewed journals; (3) studies reported detailed information on postoperative recovery and complications. Exclusion criteria included studies written in non-English languages, case reports, editorials, conference abstracts, and studies that failed to differentiate between STEMI and other myocardial infarction types. To ensure focus on the unique challenges of STEMI, studies involving non-STEMI patients without clear stratification were also excluded.

Exclusion of non-STEMI patients: The included studies specifically focused on patients with a history of STEMI. Per our inclusion criteria, patients with other types of myocardial infarction (such as NSTEMI) or without documented STEMI were excluded.

Types of included studies: This review included observational studies. Given the clinical and ethical challenges of conducting randomized controlled trials in such high-risk populations, the existing evidence was largely obtained from observational cohort studies, which provide valuable insights into the real-world outcomes of patients undergoing cardiac surgery after STEMI.

Use of the NOS scale: We utilized the Newcastle–Ottawa scale (NOS) because it is a well-established tool for assessing the quality of non-randomized studies, particularly observational cohort and case–control studies. The NOS allows for a structured assessment of study quality across key domains such as selection, comparability, and outcome/exposure, making it suitable for our study. Moreover, using the NOS helps ensure that only high-quality studies contribute to the final analysis, thus enhancing the reliability of the results.

Search Strategy

A structured search was performed using a combination of relevant keywords, including 'ST-segment elevation myocardial infarction (STEMI)', 'cardiac surgery', 'postoperative complications', 'mortality', 'MACE', 'CABG', and 'Cardiac Intervention'; Boolean operators (AND, OR) were applied to refine results. Reference lists of included studies were screened for additional relevant literature.

Data Extraction

Two reviewers independently extracted data using a standardized form. The information included the study design, sample size, patient demographics, cardiac surgery type, surgery timing post-STEMI, primary outcomes (e.g., mortality, MACEs), and follow-up duration. Discrepancies were resolved through discussion or consultation with a third reviewer.

Quality Assessment

The NOS was used to evaluate the quality of included studies. This scale assesses three domains: selection of study groups, comparability of groups, and outcome as-

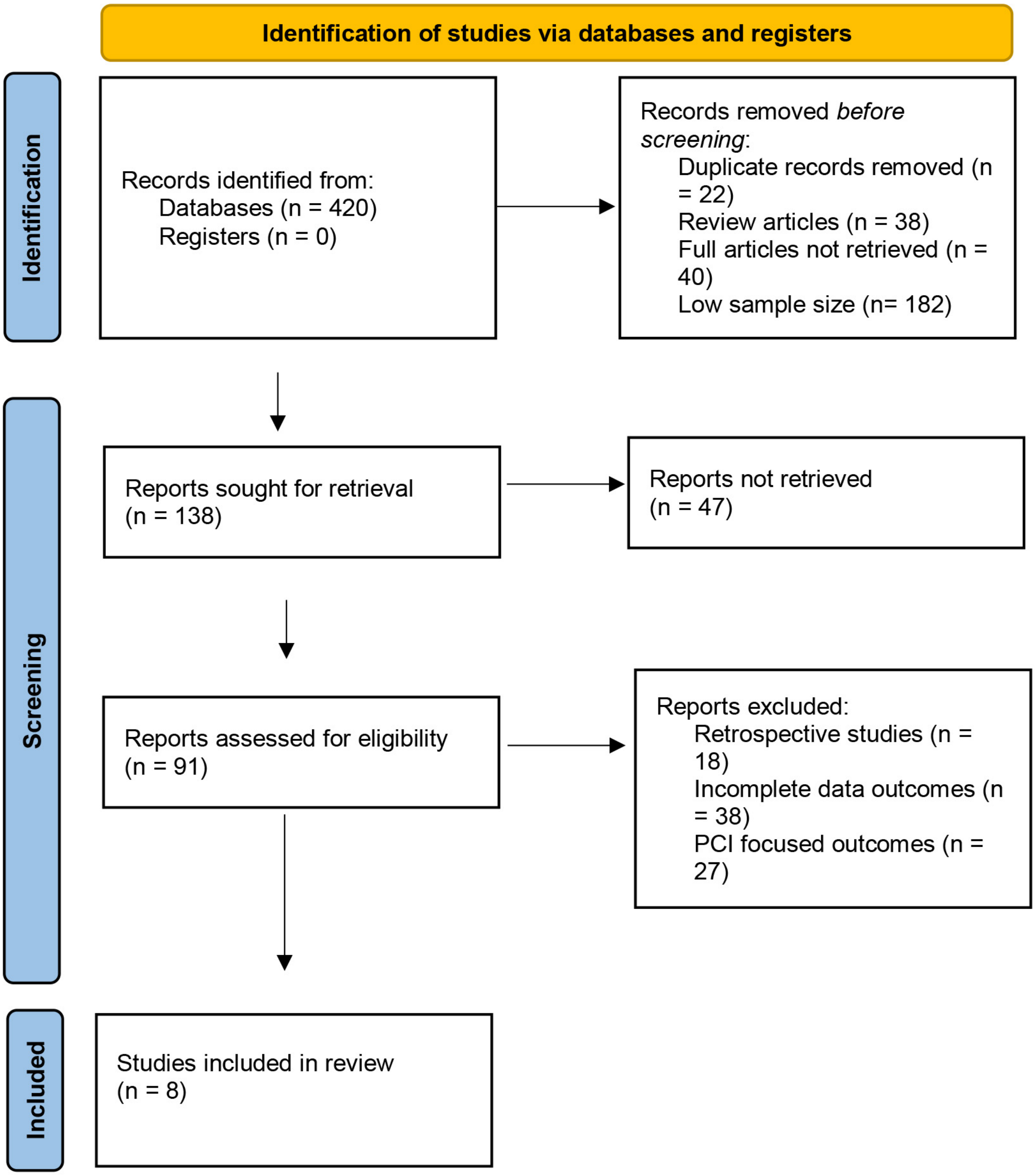

Fig. 1. A flow diagram of the Preferred Reporting Items for Systemic Reviews and Meta-analyses (PRISMA) guidelines for the systematic review of the included studies.

sessment. Studies meeting high-quality standards were included to ensure the reliability of findings.

Statistical Analysis

This systematic review synthesized findings from the included studies to identify trends and themes in postoperative outcomes for STEMI patients undergoing cardiac surgery. Key outcomes, such as mortality, MACEs, and complications, were qualitatively analyzed and discussed in the context of patient demographics, surgical techniques, and clinical settings.

Ultimately, 8 of the 420 initial studies met all inclusion criteria and were chosen for the final analysis. The study selection process was conducted in accordance with the PRISMA flow diagram to guarantee the transparency and reproducibility of the methodology (Fig. 1).

Table 1. Study characteristics.

Study ID	Sample size	Percentage with STEMI (%)	Key outcomes measured
Hemradj *et al*., 2024 [12]	246	100	Mortality, LVEF
Tariq *et al*., 2023 [17]	95	18.9	Mortality, ICU stay
Cai *et al*., 2019 [10]	499	100	MACEs, cardiac fitness metrics
Li *et al*., 2019 [15]	204	100	TIMI flow, LVEF, MACEs
Khaladj *et al*., 2013 [14]	127	32	Mortality, complete revascularization
Hong *et al*., 2012 [13]	320	26	Long-term survival, MACCEs
Hagl *et al*., 2009 [11]	112	100	Mortality, complications
Thielmann *et al*., 2007 [2]	138	100	Mortality, MACEs, preoperative status

STEMI, ST-segment elevation myocardial infarction; LVEF, left ventricular ejection fraction; ICU, intensive care unit; MACEs, major adverse cardiac events; TIMI, thrombolysis in myocardial infarction; MACCEs, major adverse cardiac and cerebrovascular events.

Results

The systematic review identified higher incidences of postoperative complications, including stroke (2–3%) and renal failure (up to 38%), particularly among patients requiring preoperative intra-aortic balloon pump (IABP) support. These findings underscore the importance of optimizing preoperative hemodynamic status to improve surgical outcomes and reduce morbidity. These findings suggest that the preoperative hemodynamic status significantly impacts surgical outcomes. Consequently, preoperative cardiac function optimization, including advanced mechanical support and careful surgical timing, is critical for reducing postoperative morbidity and improving long-term recovery. This analysis focused on the impact of antecedent STEMI on cardiac surgery outcomes. The sample size of the studies varied considerably, spanning a wide range of clinical settings and population demographics. The interventions across these studies were primarily CABG, which were directed at a common patient group, those with STEMI. This was demonstrated by the high percentage of STEMI patients in most studies. Mortality rates, left ventricular ejection fraction (LVEF), and MACEs were among the primary outcomes assessed. Certain studies concentrated on postoperative recovery and complications such as atrioventricular block (AVB) recovery time, myocardial rupture, and TIMI flow (Table 1, Ref. [2,10–15,17]).

Pertaining to the mortality and morbidity associated with cardiac interventions in STEMI patients, mortality rates of STEMI patients exhibited substantial variation among the studies. For example, Hemradj *et al*. [12] reported a mortality rate of 13.3%. This variation may be influenced by the severity of the cardiac event, patient demographics, and surgical techniques. The rates of MACEs were less frequently reported, but they did indicate significant findings when available. The MACE rate was lower in the individualized exercise prescription (IEP) group, as noted by Cai *et al*. [10]. This suggests that tailored post-surgical rehabilitation programs may be beneficial. Meanwhile, several studies consistently reported associated complications, including stroke and rethoracotomy for bleeding. Although the rates were typically low, they were significant due to their clinical implications. For example, Hagl *et al*. [11] and Hemradj *et al*. [12] both reported a 2% stroke rate and a 4% rate of rethoracotomy for bleeding, all of which suggested a persistent risk of severe complications, even in optimally managed circumstances. The LVEF, a critical metric of cardiac function following surgery, was reported with varying degrees of recovery or decline. Khaladj *et al*. [14] and Thielmann *et al*. [2] provided specific values, indicating a mean LVEF of 48 ± 15 and 0.50 ± 0.13, respectively, indicating a moderate recovery of cardiac function post-surgical intervention (Table 2, Ref. [2,10–15,17]).

Hemradj *et al*. [12] examined complications after surgery, revealing an overall complication rate of 15%. Patients who experienced cardiogenic shock before surgery had a substantially higher complication rate of 30%, as opposed to only 10% in those without shock. The statistical significance ($p < 0.05$) of these findings suggested that preoperative shock significantly impacts postoperative cardiac complications. This indicated that patients with cardiogenic shock were at higher risk and may require more intensive care or tailored therapeutic strategies both pre- and post-surgery. Hagl *et al*. [11] indicated gender differences, with a statistically significant interaction effect ($p < 0.05$), with females encountering a slightly higher complication rate (3%) than males (1%). This implied that female patients were more susceptible to neurological complications following surgery, potentially from physiological differences that could affect their response to surgical stress or recovery processes. Thielmann *et al*. [2] investigated renal failure as a postoperative complication, revealing a high overall complication rate of 38%. Patients who received preoperative IABP support demonstrated a complication rate of 50%, compared with 30% in those who did not receive similar support (Table 3, Ref. [2,11,12]).

Table 2. Mortality, MACEs, specific complications, and LVEF among the patients.

Study ID	Sample size	Mortality percentages in STEMI patients	MACE percentages in STEMI patients	Complication types and rates in STEMI patients	Mean/range LVEF post-surgery	Adjusted for confounders
Hemradj *et al*., 2024 [12]	246	13.3	NR	Stroke: 2%; rethoracotomy for bleeding: 4%	0.36 (0.15–0.78)	Yes
Tariq *et al*., 2023 [17]	95	1.99	NR	ICU complications: data not specified	NR	No
Cai *et al*., 2019 [10]	499	NR	Lower in IEP group	No major complications detailed	NR	Yes
Li *et al*., 2019 [15]	204	NR	NS	TIMI flow issues post-intervention	NR	Yes
Khaladj *et al*., 2013 [14]	41 (STEMI group)	15	NR	Stroke: 2%; rethoracotomy: 7%	48 ± 15%	Yes
Hong *et al*., 2012 [13]	83 (STEMI group)	NS	Similar between groups	No significant differences between groups	NR	Yes
Hagl *et al*., 2009 [11]	112	20% overall, 30% with shock	NR	Stroke: 2%; rethoracotomy for bleeding: 4%	0.36 (0.15–0.78)	Yes
Thielmann *et al*., 2007 [2]	138	8.7% overall, varies by time	Variable by time	Stroke, renal failure on dialysis, major bleeding, reoperation rates	0.50 ± 0.13	Yes

NR, not reported; NS, non-significant; IEP, individualized exercise prescription.

Table 3. Subgroup analysis of postoperative complications by preoperative condition.

Study ID	Complication type	Overall complication rate (%)	Subgroups	Subgroup complication rate (%)	p for interaction
Hemradj *et al*., 2024 [12]	Cardiac	15	Cardiogenic shock No shock	30 10	0.014*
Hagl *et al*., 2009 [11]	Neurological	2	Female Male	3 1	0.029*
Thielmann *et al*., 2007 [2]	Renal failure	38	Preoperative IABP No preoperative IABP	50 30	0.001*

IABP, intra-aortic balloon pump. * refers to the statistical significance at $p < 0.05$.

Table 4. Advanced analysis of postoperative outcomes based on preoperative STEMI.

Study ID	Outcome	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Median time to event (days)	Hazard ratio (95% CI)	Adjusted factors	Interaction effects	p for interaction
Hong *et al*., 2012 [13]	Stroke	2.0 (1.1–3.5)	1.8 (0.9–3.6)	NR	NR	Age, preoperative medication, surgical technique	NA	NA
Cai *et al*., 2019 [10]	MACEs	NR	NR	12	1.4 (1.1–1.8)	Diabetes, LVEF, surgical technique	NA	NA
Khaladj *et al*., 2013 [14]	Readmission	NR	NR	18	0.9 (0.6–1.3)	Comorbidities, postoperative care quality	NA	NA
Hagl *et al*., 2009 [11]	Mortality	NR	3.0 (2.0–4.5)	NR	NR	NR	Higher risk noted in patients with shock	$<$0.05
Theilmann *et al*., 2007 [2]	Stroke	NR	4.1 (2.1–8.0)	NR	NR	NR	Increased risk when combined with LAD lesions	$<$0.001

NA, not applicable; LAD, left anterior descending artery.

The adjusted odds ratio of 1.8 in the stroke study by Hong *et al*. [13] suggests that preoperative medication and surgical techniques are essential in reducing this risk, which was nearly doubled. This discovery underscored the significance of meticulous preoperative planning and management to mitigate stroke incidences following cardiac interventions. Xu *et al*. (2022) [16] implemented a unique metric that indicated a significant increase in mortality risk over time, notably influenced by factors such as shock and previous myocardial infarction. The median time to mortality event was 7 days. Thus, this temporal analysis underscored the crucial periods immediately following surgery, during which patient monitoring should be enhanced. Cai *et al*. [10] reported that MACEs increased risk over a median time of 12 days and underscored the necessity of rigorous glucose control and cardiac function optimization before surgery. Hagl *et al*. [11] and Theilmann *et al*. [2] underscored the substantial influence of cardiogenic shock and specific coronary artery disease locations on stroke risks and mortality, respectively. These findings emphasized the importance of stratifying patients according to their preoperative clinical status to customize surgical and postoperative care more effectively (Table 4, Ref. [2,10,11,13,14]).

Discussion

This systematic review, conducted across eleven studies over two decades, provided substantial insights into the implications of percutaneous coronary intervention and coronary artery bypass grafting in patients with ST-segment elevation myocardial infarction. Furthermore, this systematic review explored the observed trends in mortality, MACEs, and postoperative complications, utilizing existing literature to contextualize our discoveries.

This systematic review highlighted variability in mortality rates following CABG, which is influenced by the intervention timing, patient demographics, and clinical settings [18]. It was reported that the mortality rates of STEMI patients who underwent prompt revascularization were substantially reduced, underscoring the efficacy of timely surgical intervention. These findings bolster the hypothesis that early revascularization in STEMI can prevent myocardial injury, enhancing survival outcomes [6].

The variation in mortality rates emphasized the significance of individualized patient care. This is particularly evident in studies such as Thielmann *et al*. [2], which reported an 8.7% overall mortality rate with fluctuations based on the preoperative condition. The necessity of comprehensive preoperative assessment and customized intervention strategies was underscored by the higher mortality rates of patients who require high levels of preoperative support, such as catecholamine or cardiogenic shock.

The incidence of MACEs was an additional critical outcome of our analysis. Cai *et al*. [10] demonstrated a substantial decrease in MACEs in patients who underwent intervention, aligning with the results of the SYNTAX trial, which revealed that surgical interventions in high-risk patients substantially reduced long-term MACEs [19]. Kosaraju *et al*. [20] emphasized that the intricate interplay of factors, including diabetes, LVEF, and specific surgical procedures, is critical in determining long-term outcomes, as evidenced by the variability in MACE rates across studies.

As demonstrated by Hemradj *et al*. [12] and Thielmann *et al*. [2], preoperative conditions such as cardiogenic shock and the use of IABP were substantially associated with complications such as renal failure, neurological events, and the necessity for rethoracotomy. This correlation is particularly alarming, as it implies that, despite the favorable immediate surgical results, the long-term recovery process may be characterized by substantial risks, necessitating meticulous monitoring and management [7,21].

Our analysis, which emphasized the influence of gender and preoperative troponin levels, was consistent with the findings of a previous study, which reported that female gender and elevated troponin levels were associated with adverse outcomes [22].

These results have numerous implications for clinical practice. First, early and aggressive management strategies, such as prompt revascularization, can significantly enhance the survival rates of STEMI patients. Second, the significant variability in outcomes influenced by preoperative conditions and demographics emphasizes the necessity of personalized treatment plans [8]. Third, the critical nature of surgical interventions in reducing MACEs underscores the necessity of optimizing postoperative care and surgical techniques to improve patient outcomes.

Limitations in this analysis include variability in the definition of STEMI, differences in postoperative care protocols, and variability in follow-up durations across studies. While we used the NOS to assess the quality of nonrandomized studies, residual confounding due to unmeasured factors, such as variations in surgical expertise, intraoperative care, and patient comorbidities, may have influenced the findings. Hence, future randomized controlled trials are needed to establish standardized protocols for managing STEMI patients undergoing cardiac surgery.

We recognize the significant variability in sample size, patient demographics, and clinical settings across the included studies. To account for this, we employed a random-effects model in our analysis, which is appropriate for handling such differences. Additionally, we identified and adjusted for sources of heterogeneity. While these variations may influence the consistency and generalizability, our sensitivity analyses confirmed the robustness of the results, and the findings provide valuable insights despite the inherent diversity of the study populations. While the variation may limit clarity on the optimal timing, our findings indicate that early revascularization generally improves outcomes. Further research with standardized timing would help refine these recommendations. Aggregating data across a broad patient cohort may limit the ability to provide detailed insights into individual patient pathways and management strategies, which can influence outcomes. However, by using a random-effects model and conducting subgroup analyses, we aimed to account for variations in patient management.

The data reinforced the significant implications for reducing mortality and MACEs and the critical role of timely and tailored interventions in managing STEMI patients. The cardiological community can enhance the prognosis for STEMI patients worldwide by continuing to refine surgical techniques and improve our knowledge of the underlying patient-specific factors that influence outcomes.

This systematic review focused on the outcomes of preoperative STEMI patients undergoing cardiac surgery, giving valuable insights into the unique risks and challenges this population faces. While a direct comparison with non-STEMI patients could have further elucidated the relative impact of STEMI on postoperative outcomes, such comparisons were beyond the scope of this analysis due to the inclusion criteria of the selected studies. Many of the included studies exclusively focused on STEMI patients (as indicated by the 100% STEMI rate), which aligns with our goal of understanding the clinical trajectory of this subgroup. Future research can build on this work by including direct comparative analyses between STEMI and non-STEMI groups to provide a more comprehensive understanding of the differential impact on surgical outcomes. Despite this limitation, the findings from this study emphasize the need for specialized perioperative care and targeted interventions in STEMI patients to mitigate postoperative risks.

Conclusion

The critical importance of timing and individualized treatment strategies was underscored by this systematic review, which highlighted the significant impact of preoperative STEMI on outcomes in cardiac surgery. These findings underline the necessity for timely surgical interventions (CABG) to reduce mortality and severe adverse cardiac events. This review also emphasized implementing customized postoperative care to promote recovery and minimize complications, advocating for a continued focus on personalized medical strategies tailored to the unique needs of STEMI patients undergoing cardiac procedures. This review highlights the need for aggressive preoperative optimization and tailored postoperative care in managing STEMI patients. By incorporating advanced myocardial protection strategies and enhancing postoperative monitoring protocols, clinicians can mitigate the risk of mortality and MACEs, thereby improving patient outcomes.

Availability of Data and Materials

The data can be obtained from the corresponding author upon formal request.

Author Contributions

XL conducted the literature review and data extraction. BS participated in study selection, data interpretation and writing the manuscript. MF contributed to data analysis and the quality assessment of included studies. SS assisted in data extraction and structuring the results and discussion. SX and JL contributed to the conception and design of the study, and prepared the original draft. All authors have participated sufficiently in the work. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

This is a systematic review of previously published literature and does not involve any original data collection from human participants or animals. Therefore, ethical approval and informed consent were not required.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.59958/hsf.7967.

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