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REVIEW

Safety of Early Discharge Among Low-Risk Patients After Primary Percutaneous Coronary Intervention: An Updated Systematic Review and Meta-Analysis

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Background: Guidelines for early discharge (ED) strategies after primary percutaneous coronary intervention (PPCI) in low-risk patients still need to be informed. Previous meta-analysis evidence is considered to have limitations, from the level of heterogeneity, which is still relatively high, and the sample size still needed to be more significant.

Purpose: This study aims to identify the safety of early discharge after PPCI in low-risk patients

Methods: The literature search used five primary databases: CINAHL, PubMed, ScienceDirect, Scopus, Taylor and Francis, and one search engine: Google Scholar. Two reviewers independently screened and critically appraised studies using JBI's and Cochrane's Risk of Bias tool. Fixed and random effects model were applied to collect standardized mean differences and risk differences. Statistical analysis was performed using Review Manager 5.3 and JAMOVI version 2.4.8.0.

Results: Seven RCTs consisting of 1.780 patients and seven cohort studies consisting of 46.710 patients were included in the quantitative analysis. The results of the RCT analysis showed no significant differences in all-cause readmission (RD −0.01; 95% CI: −0.04 to 0.01; Z=1.20; p=0.23; I^2=0%) and mortality (RD 0.00; 95% CI: −0.01 to 0.01; Z=0.01; p=0.99; I^2=0%) and also significant in reducing LOS in hour (SMD −2.32; 95% CI: −3.13 to −1.51; Z=5.64; p<0.001; I^2=93%) and day (SMD −0.58; 95% CI: - 1.00 to −0.17; Z=2.76; p=0.006; I^2=84%). In addition, analysis of cohort studies showed that ED strategy was associated with all-cause readmission (RD −0.00; 95% CI: −0.01 to −0.00; Z =2.18; p=0.03; I^2=0%) and mortality (RD −0.01; 95% CI: −0.02 to −0.00; Z=2.04; p=0.04; I^2=94%).

Conclusion: ED strategies in low-risk patients after PPCI can be completely safe. This is proven by the absence of significant differences in readmission and mortality rates as well as reduce the length of stay.

Keywords: coronary heart disease, early discharge, meta-analysis, PPCI

Introduction

Acute Myocardial Infarction (AMI) is one of the causes of very high mortality and morbidity worldwide.[1] Globally, in 2020 as many as 19.05 million people died due to heart disease, including myocardial infarction.[1] The latest data shows that in the United States as many as 1.522.669 deaths caused by AMI were recorded during the last 10 years from 2012 to 2022.[1] AMI occurs due to partial or total occlusion of the coronary arteries, which requires rapid and accurate intervention.[2] The American Heart Association (AHA) determines that primary percutaneous coronary intervention (PPCI) is the leading and influential treatment reference for managing patients with myocardial infarction.[3]

Recently, much attention has been paid to identifying low-risk patient groups in post-PPCI patients who enable early discharge (ED) strategies to be feasible and safe.[4] However, the definition and criteria for low-risk patients in post-PPCI

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patients still need to be clarified.[4] Criteria for patients who can be discharged earlier after AMI can be identified using simple criteria such as Primary Angioplasty in Myocardial Infarction (PAMI-II), Zwolle primary PCI Index, or other criteria.[5] PAMI-II criteria define low-risk patients aged <70 years, with Left ventricular ejection fraction (LVEF) >45%, one or two vascular diseases, successful PCI, and no persistent arrhythmias.[5,6]

The American College of Cardiology (ACC) guidelines do not provide any recommendations regarding optimal discharge time. In contrast, the European Society of Cardiology (ESC) guidelines recommend an ED strategy within 48–72 hours for low-risk (Class IIa) AMI patients.[3,5] However, available data regarding the application of ED in clinical practice still needs to be improved.[7] Additionally, studies assessing the safety and feasibility of shorter LOS after PPCI are limited.[4,8] In fact, ED strategies in low-risk patients after PPCI can reduce the incidence of complications due to opportunistic infections, reduce LOS, save health service resources and reduce treatment costs.[4] In addition, many tertiary health centres as referral hospitals have PPCI facilities available, insufficient bed capacity is an ongoing concern and threatens to admit new cases of acute infarction which continues to increase.[9]

Previous meta-analyses have identified the safety of ED strategies in post-PPCI patients.[4,8] However, several limitations were identified in the previous meta-analysis, such as (1) the studies analyzed quantitatively were still relatively lacking and the quantitative results showed that there was no difference in mortality rates and readmission rates between the two groups; (2) the heterogeneity of reviews identifying LOS is still relatively high (I^2=95%), which means that it is considered not to be well-generalized; and (3) The sample size is relatively small, so this indicates a lack of generalization aspects of the research results.[4] In addition, in the Asad et al study, the cohort studies analyzed still needed to be improved, because only three studies.[8] This shows that there is still an opportunity to add new studies to reduce the possibility of variation errors from previous meta-analysis results. Therefore, this study aims to identify the characteristics of patients in the low-risk category after PPCI and provide the latest information regarding the safety of early discharge strategies in low-risk patients after PPCI.

Materials and Methods

Study Design

The study design used was a systematic review. This study used the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[10] This review protocol has been registered in PROSPERO with registration number CRD42023462144.

Eligibility Criteria

The research questions and eligibility criteria for this study used the PICOT (population/intervention/comparator(s)/outcomes/type of study) approach. The inclusion criteria for articles analyzed in this review were experimental and cohort studies published in full-text in English until September 2023. In addition, studies had to discuss the safety of early discharge in low-risk patients after PPCI, and there was no limitation on the year of publication in article selection. In this review, the authors excluded protocols, studies of non-English as an international language, and inaccessible full-text publications. The following is an explanation of PICOT applied in this review.

Types of Participants

Participants in the included studies were patients with ST-elevation myocardial infarction (STEMI) who have undergone a PPCI procedure. Patients in the low-risk category after undergoing PPCI were assessed based on the risk stratification used in each study.

Types of Intervention

The intervention identified is an early discharge strategy. Based on the European Society of Cardiology (ESC) guidelines, early discharge can be performed within 48–72 hours for low-risk AMI patients (Class IIa).[5] The early and standard discharge strategies were defined as ≤3 days and >3 days, respectively.

Types of Comparators

The comparison can be usual discharge, standard discharge, traditional discharge, conventional discharge, or other terms mentioned in the analyzed article.

Types of Outcome Measures

The primary outcomes in this review are readmission and mortality. Readmission is a situation where a patient is readmitted after receiving inpatient services at a hospital which previously carried out an early discharge strategy. Then, mortality is defined as the number of deaths of patients who fall into the low-risk category after undergoing PPCI carried out early discharge. In this review, the cause of mortality can be caused by cardiovascular or non-cardiovascular disease, meaning that all causes of death remain identified. In addition, the secondary outcome in this review is length of stay (LOS). LOS is the number of days a patient is hospitalized (calculated from when the patient is admitted until the patient is discharged or goes home). The identified LOS can be a matter of hours or days.

Types of Studies

In this review, criteria for including studies in this analysis were experimental and cohort studies published in English. They discussed the safety of early discharge in low-risk patients after PPCI, and we excluded protocol studies. In addition, there is no limitation on the year of publication in this study.

Data Collection and Analysis

Search Strategy

In this review, an independent systematic literature search was conducted by first author (F.S) using five primary databases: CINAHL Plus with Full Text and Academic Search Complete, PubMed, ScienceDirect, Scopus, Taylor and Francis, and one Google Scholar search engine. Boolean operators "OR" and "AND" are used in the literature search process, which aims to make it easier to find articles.

The keywords used were "coronary heart disease OR coronary artery disease OR myocardial infarction OR cardiovascular disease OR heart disease AND low-risk patients AND early discharge AND length of stay OR hospital stay OR hospitalization period AND mortality OR death AND readmission OR rehospitalization AND primary percutaneous coronary intervention OR PPCI OR primary angioplasty". For each term verified by MeSH (Medical Subject Headings), synonyms are used to retrieve all possible relevant articles. In addition, the author uses the Boolean operators "AND" and "OR" to trim or expand the search results for various tenses. More details can be seen in the extraction Table S1 in the Supplementary Files.

Study Selection

Two authors (FS and AN) independently selected studies that met eligibility criteria. The authors checked for duplication in the initial stage using Mendeley's reference manager. Then, the authors examined the title, abstract, and full text for relevance to the research topic and inclusion and exclusion criteria. The author (FS and AN) checks each complete text with the Joanna Briggs Institute (JBI) critical appraisal in the final process.[11]

Specifically, the authors calculated the critical appraisal score as the number of "yes" responses divided by the total number of "unclear", "no", and "yes" responses, excluding "no information" responses. After assessment, the authors removed all studies with a JBI score <70%. Next, all authors discuss and provide decisions if there are discrepancies in the election results. We did not experience any differences of opinion regarding the eligibility selection for the studies analyzed in this review.

Data Extraction

Data was extracted using an extraction table by one reviewer (F.S) and checked by other reviewers (Y.T, A.N, and P.S). At this stage, the authors extracted data from articles that met the criteria for which collected information related to the characteristics of each study: Author, year, study design, low-risk patient criteria, revascularization access, sample size, mean age, intervention, comparison, primary and secondary outcomes, and JBI assessment results. Primary and

secondary outcomes were identified and extracted using standard mean differences, standard deviations and risk differences based on baseline and follow-up data.

Assessment of Risk of Bias in Included Studies

Two reviewers (F.S. and A.N.) independently assessed the Risk of Bias (RoB) for the included experimental and cohort studies using the Cochrane Risk of Bias (RoB) tool. Experimental (RCT) studies consist of 5 domains: randomization process, deviation from the intended intervention, missing outcome data, outcome measurement, and selection of reported results.[12] RoB is set as "high", "low", "unclear", or "no information" for each domain.

RoB assessment for cohort studies used the Cochrane Review of Nonrandomized Intervention Studies (ROBINS-I).[13] ROBINS-I for follow-up (cohort) studies consists of 7 domains: Bias due to confounding, Bias in the selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, Bias in measurement of the outcome, and Bias in selection of the reported result. Discrepancies in the assessment results were then discussed, and review by the third and fourth authors (Y.T and P.S) determined the decision.

Data Synthesis

All statistical analysis was performed using Review Manager application version 5.4 (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark) and Jamovi version 2.4.8.0. In this review, the authors identified and extracted data on the difference in standard means and standard deviations (variable LOS) and used the combined effect in the form of risk difference (RD) with a 95% confidence interval (CI) (variable readmission and mortality). Heterogeneity was evaluated by observing the overlap of CI on the forest plots and the I^2 value.[14] If the I^2 value is <50%, the analysis model uses a fixed effect model, and if the I^2 value is >50%, the analysis uses a random effect model.

The authors used several methods to minimize heterogeneity. In this review, the LOS categories' results in the analyzed studies are different in the form of days and hours. This will impact the high I^2 value obtained, so we analyzed two LOS groups (LOS in days and hours). We also used Jamovi software version 2.3.21 when heterogeneity was high to identify outlier studies.

Publication Bias

Assessment of publication bias in this research is by funnel and forest plot analysis, Egger's test, Rank correlation test (Kendall's tau), and Regression test (Z) using Jamovi software version 2.4.8.0 with a significance level of funnel plot asymmetry $p>0.05$. If the results show $p>0.05$, there are no indications of outliers. Publication can be carried out on the three outcomes: readmission, mortality, and LOS.

Subgroup Analysis

Subgroup analysis is only performed if at least two studies have the same outcome criteria. The authors will conduct subgroup analyses to identify factors that may reduce the magnitude of the overall impact. In addition, the purpose of subgroup analysis is to reduce bias and reduce the level of heterogeneity in the results of this meta-analysis. In this review, there are two research designs, namely experimental and cohort studies, so the results of subgroup analysis will be adjusted to these two types of research. This study also conducted a subgroup analysis based on differences in LOS outcomes (days and hours), readmission and mortality based on the follow-up time obtained.

Sensitivity Analysis

Sensitivity analysis was identified by comparing the analysis results by excluding studies with a low risk of bias vs a high risk of bias and studies with significantly different sample sizes.

Results

Study Selection

Initial identification of 706 articles was obtained: 21 from EBSCO-host CINAHL, 32 from PubMed, 103 from ScienceDirect, 365 from Scopus, and 85 from Taylor and Francis. We also identified 5830 articles from Google

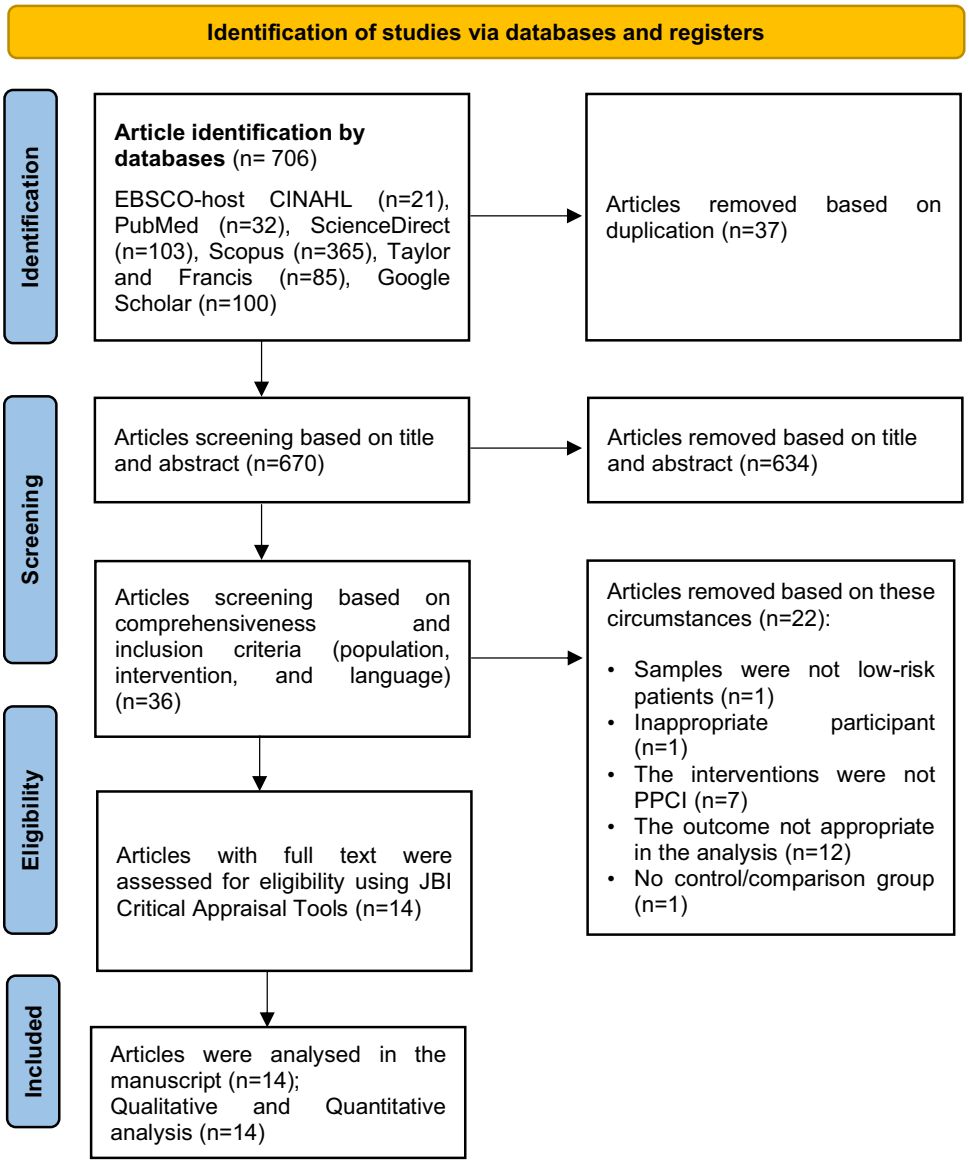

Figure 1 PRISMA Flow Diagram.
Notes: Adapted from Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. Creative Commons.[10]

Scholar, and selected the first 100 articles sorted by their level of relevance. In addition, the authors excluded 37 studies identified as duplicates and 634 other studies because the title and information in the abstract were irrelevant to this review, leaving 36 articles.

Then, the authors read 36 articles and ensured they met the inclusion criteria and 22 articles were excluded because the research sample was not included in the low-risk category (n=1), inappropriate participant (n=1), did not receive PPCI (n=7), the outcomes were not relevant to the review this (n=12), and no control/comparison group (n=1). Thus, 14 articles were included in the qualitative and quantitative analysis in this review. Figure 1 displays the study selection procedure used the PRISMA flow diagram.

Study Characteristics

The studies included in the analysis were randomized controlled trials (RCTs) (n=7) and cohort studies (n=7). All articles were included in qualitative and quantitative analysis (n=14). There were 14 articles analyzed, 3 articles were conducted

in the United Kingdom, 2 articles in the Czech Republic, and 1 article each in Canada, Norway, Turkey, Spain, Sweden, Taiwan, Kingdom of Bahrain, USA, and one study stated that the research was conducted in 5 countries, namely US, Brazil, Argentina, Japan and Spain.[15] More details can be seen in the extraction Table S2 in the Supplementary Files.

Participants, Interventions, and Comparators Characteristics

The number of participants analyzed was 50.894 respondents with a sample size of at least 54 participants,[16] and the largest was 33.920.[17] The mean age of participants is in the range of 55–76 years. In addition, the ZWOLLE Risk Score or TIMI score are the risk stratification tools used by most studies analyzed to determine low or high-risk categories of patients. Most of the participants in this study had access revascularization performed on radial access (see Table S2, in Supplementary Files).

In this review, several studies also state that during ED implementation, patients are also given education by health workers, including general nurses or specialists. In addition, almost all studies follow up on their research samples. This follow-up activity aims to determine and evaluate the intervention provided, namely ED. The follow-up process was carried out in <1 month,[18,19] one month,[7,17,19–26] 3 months,[27,28] 6 months,[15] and there are also up to 1–2 years.[19,25]

There were six comparisons that were successfully identified, such as standard discharge,[7,16,17,20,22,24,26,28,29] usual discharges (>72 hours),[21] conventional discharges (>72 hours),[27] traditional discharges (>72 hours),[15] and late discharges (>72 hours).[19,25] Furthermore, most of the comparisons in this review are standard discharge, where the discharge intervention is given for more than 3–5 days.

Risk of Bias Within Studies

In this review, RoB assessment was carried out in two types of studies, namely RCT and Cohort (see Figures 2–5). The RCT study showed that two of the seven studies were included in the high-risk category because they needed to provide information about the randomization process and selection bias of the reported results.[16,27] Three RCT studies were included in the some concerns category because the randomization process was poorly explained,[15,21] and due to missing outcome is not clearly informed.[20] Two other RCT studies were included in the low-risk category.[7,22] This is different from the RoB assessment results in cohort studies, where almost all of them are included in the low-risk category and only the study by Yip et al[24] which is included in the moderate category due to the lack of clear information related to confounding.

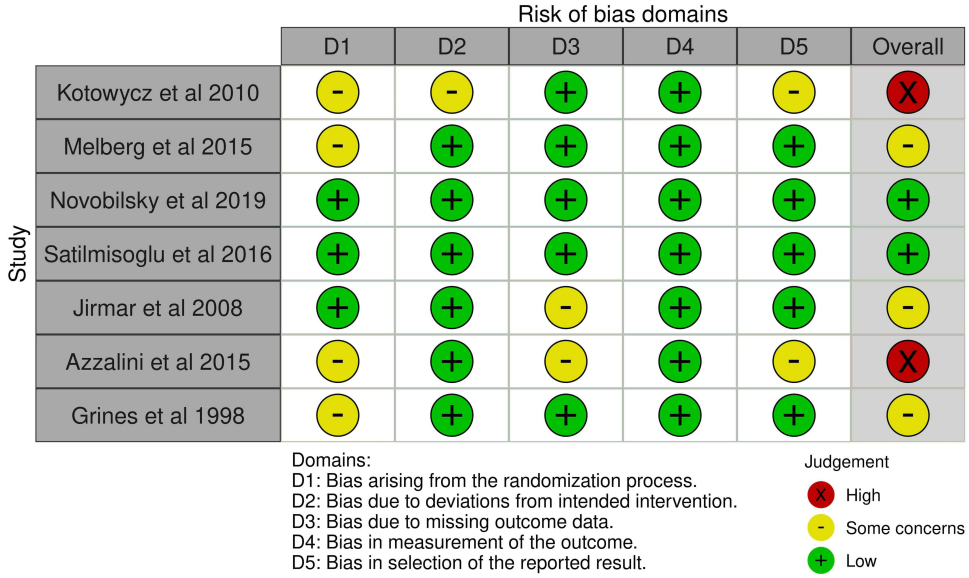

Figure 2 Risk of Bias Assessment of RCT Studies.
Notes: Data from these studies.[7,15,16,20–22,27]

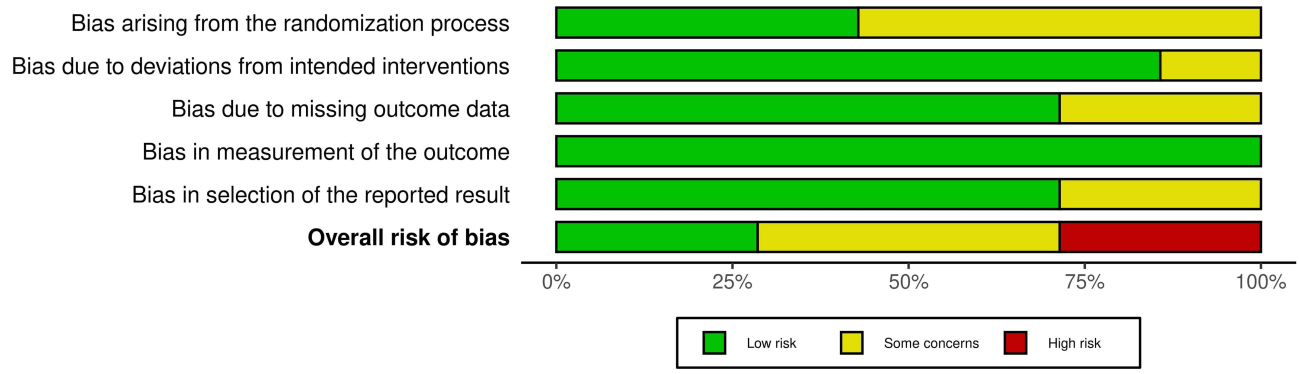

Figure 3 Summary Risk of Bias Assessment of RCT Studies.

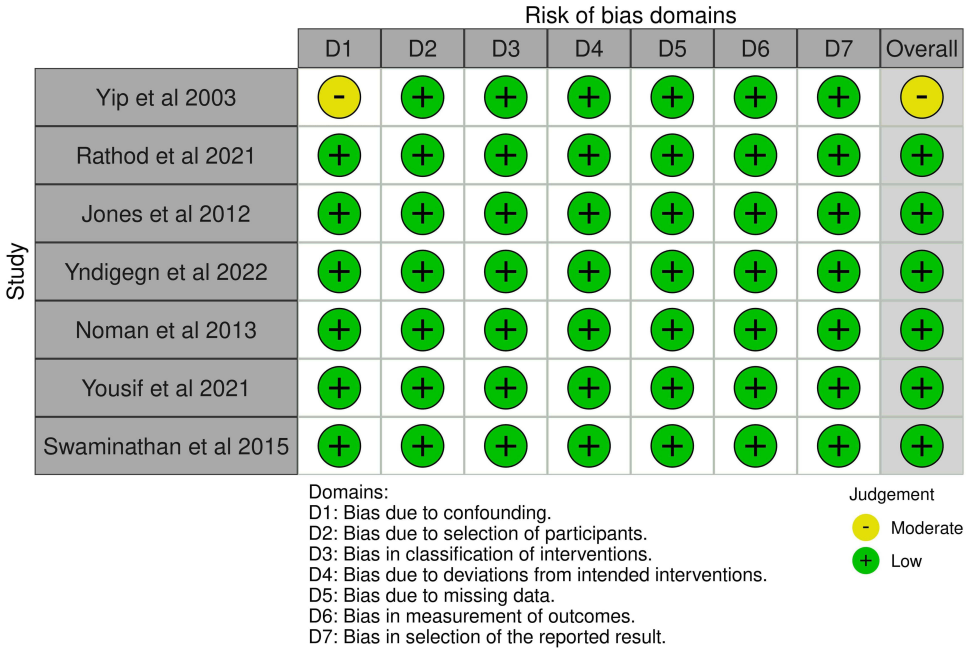

Figure 4 Risk of Bias Assessment of Cohort Studies.
Notes: Data from these studies.[17,19,24–26,28,29]

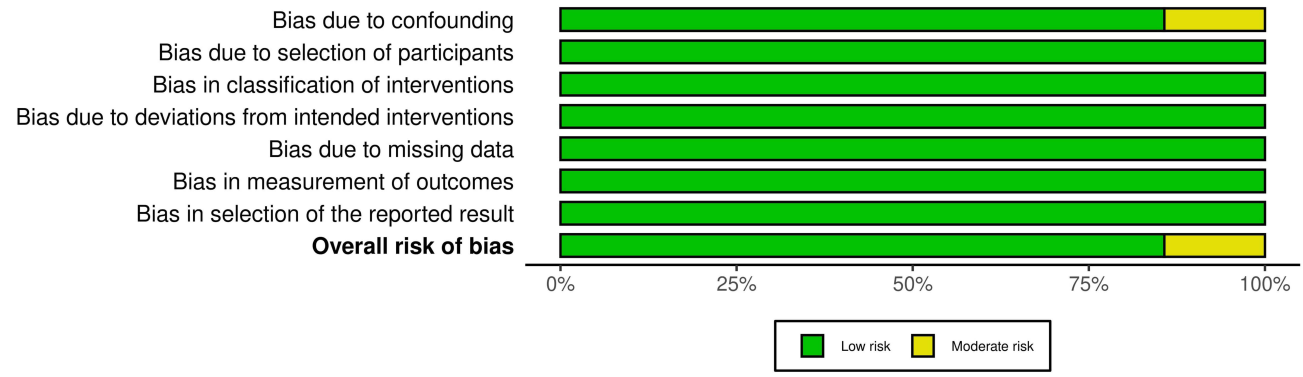

Figure 5 Summary Risk of Bias Assessment of Cohort Studies.

Sensitivity Analysis

Sensitivity was identified by comparing changes in follow-up results and excluding all studies with low vs high risk of bias. In addition, sensitivity analysis tests are also carried out in studies with very large and small sample sizes.[17] There were no significant differences when studies in the high-risk category were excluded,[16,27] in the outcomes of readmission, mortality, and LOS. Meanwhile, when the Swaminathan et al study was exclude, the previous readmission outcome was (p=0.03; I^2=0%) to (p=0.57; I^2=4%), and the previous mortality outcome was (p=0.04; I^2=94%) to (p=0.21; I^2=97%).

Publication Bias

In this review, publication can be carried out based on three outcomes: readmission, mortality, and LOS. In the readmission variable, 10 studies were included in the analysis. Based on Cook's distances, the studies were only somewhat influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry (p=1.000 and p=0.652, respectively) (see Table 1 and Figures S1–S3 in supplementary Files).[30,31]

In the mortality variable, 13 studies were included in the analysis. Based on Cook's distances, one study by Yndigegn et al can be considered too influential, but when viewed from the funnel plot, it is still within the plot line limits. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry (p=0.952 and p=0.192, respectively).[30,31]

In the LOS variable, six studies were included in the analysis. Based on Cook's distances, the studies were only somewhat influential. The Egger's Regression test indicated funnel plot asymmetry (p=0.013) but not the Begg and Mazumdar rank correlation test (p=0.719).[30,31]

Primary Findings

Readmission Rate

Six RCTs consisting of 1.626 patients reported no difference in readmission rates between groups treated with ED vs SD strategy (RD −0.01; 95% CI: −0.04 to 0.01; Z=1.20; p =0.23; I^2=0%) (see Figure 6). These results indicate no difference in the readmission rate of patients who were given ED or SD. In addition, there were five cohort studies consisting of 44.966 patients, which showed that there were differences in readmission rates in the groups that underwent ED vs SD

Table 1 Publication Bias

Test Name	Value	*p*
Readmission (n=10)		
Fail-safe N	0.000	0.355
Rank correlation test (Kendall's tau)	0.022	1.000
Regression test (Z)	0.451	0.652
Mortality (n=13)		
Fail-safe N	12.000	0.012
Rank correlation test (Kendall's tau)	0.026	0.952
Regression test (Z)	1.305	0.192
LOS (n=6)		
Fail-safe N	1314.000	<0.001
Begg and Mazumdar rank correlation	−0.200	0.719
Egger's regression	−2.484	0.013

Notes: Fail-safe N was calculated using the Rosenthal approach. Data from these studies.[30,31]

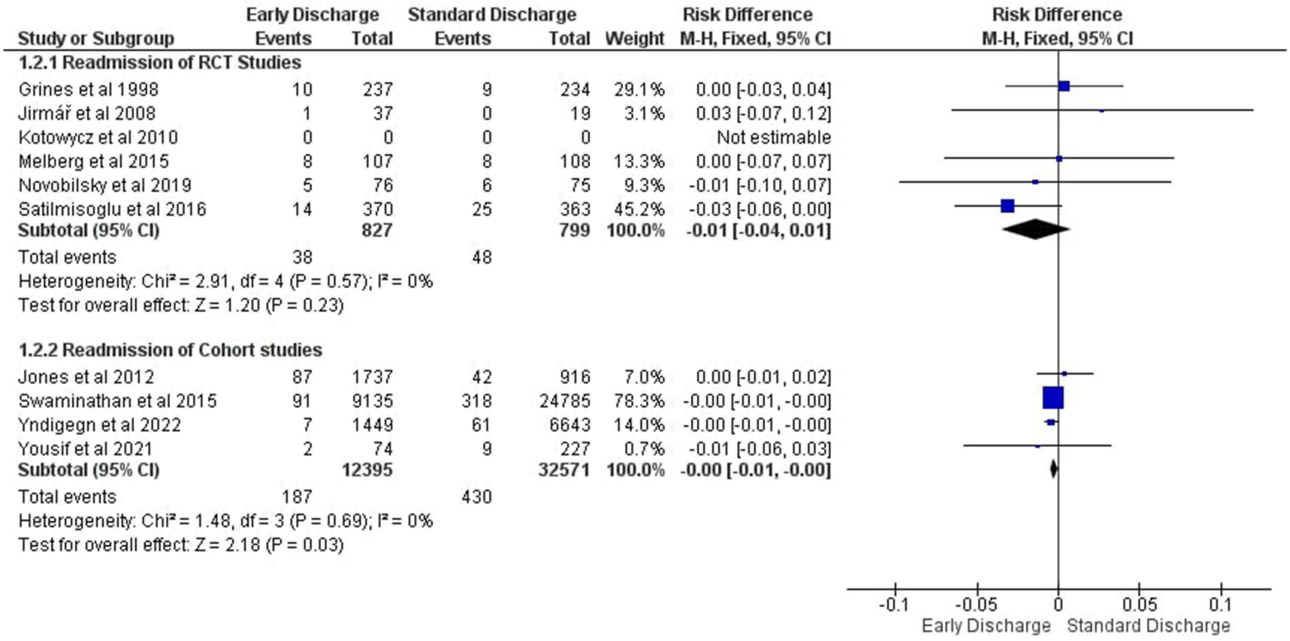

Figure 6 Forest Plot Outcome of Readmission with Early Discharge vs Standard Discharge.

strategy (RD −0.00; 95% CI: −0.01 to −0.00; Z =2.18; p=0.03; I^2=0%). This means that the group that underwent the ED strategy had a higher risk; the range was between −0.01 to −0.00 (see Figure 6).

Mortality Rate

Seven RCTs consisting of 1.780 patients reported no difference in mortality rates between groups treated with ED vs SD strategy (RD 0.00; 95% CI: −0.01 to 0.01; Z=0.01; p=0.99; I^2=0%) (see Figure 7). These results indicate no difference in the readmission rate of patients who were given ED or SD.

Seven cohort studies with a total of 46.704 patients showed that there was significant difference in mortality rates in the groups that underwent ED vs SD strategy (RD −0.01; 95% CI: −0.02 to −0.00; Z=2.04; p=0.04; I^2=94%) (see Figure 8). This means that the group that underwent the ED strategy had a higher risk; the range was between −0.02 to −0.00.

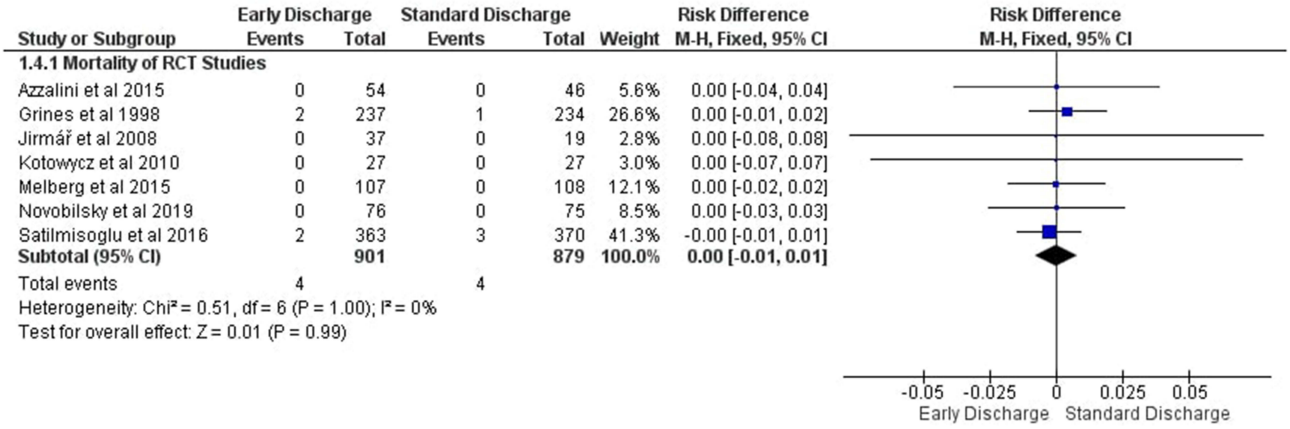

Figure 7 Forest Plot Outcome of Mortality with Early Discharge vs Standard Discharge of RCT Studies.

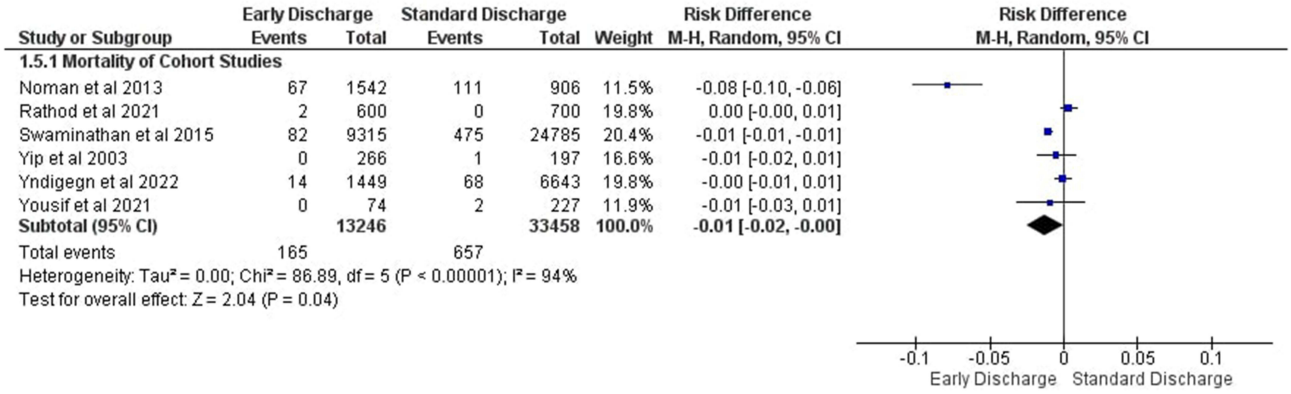

Figure 8 Forest Plot Outcome of Mortality with Early Discharge vs Standard Discharge of Cohort Studies.

Length of Stay

Figure 9 shows the results of the LOS analysis based on day and hour. From RCT studies, both hour (SMD −2.32; 95% CI: −3.13 to −1.51; Z=5.64; p<0.001; I^2=93%) and day (SMD −0.58; 95% CI: - 1.00 to −0.17; Z=2.76; p=0.006; I^2=84%) reported that hospital LOS was shorter in the ED strategy compared to the SD strategy (see Figure 9).

Subgroup Analysis

Readmission

The results of the subgroup analysis of readmission rates in this review were based on research design and follow-up time. In the readmission subgroup analysis (FU-1 month) from the four RCT studies, a total of 1.155 patients (ED=583; SD 572) reported that there was no difference in the readmission rate of patients given ED vs SD strategy (RD 0.02; 95% CI: - 0.01 to 0.05; Z=1.39; p=0.17; I^2=0%) (see Figure S4, in supplementary files). The total number of events was 39 out of 583 patients who received ED and 28 out of 572 patients who received SD strategy.

Different results in the subgroup analysis of cohort studies, a total of 34.221 patients (ED n=9.209; SD n=25.012) from three cohort studies reported that there was a difference in the readmission rate of patients given ED vs SD strategy (RD −0.00; 95% CI: - 0.01 to 0.00; Z=2.33; p=0.02; I^2=0%) (see Figure S4, in Supplementary Files). This means that the group undergoing the ED strategy had a higher risk, the range was between −0.01 to −0.00. The total number of events was 100 from 9.209 patients who underwent the ED strategy and 388 events from 25.012 patients who underwent the SD strategy.

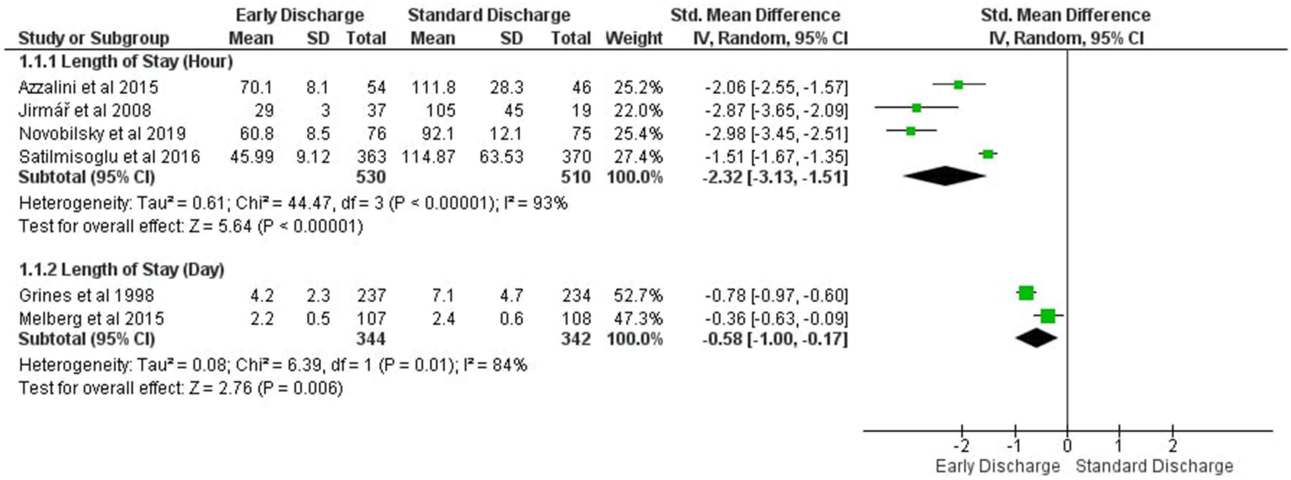

Figure 9 Forest Plot Outcome of Length of Stay with Early Discharge vs Standard Discharge.

Mortality

The results of the subgroup analysis of mortality rates were also analyzed based on the type of study and follow-up time. The results of the analysis of the four RCT studies showed that there was no difference in mortality rates between the groups that underwent ED vs SD strategy (RD −0.00; 95% CI: −0.01 to 0.01; Z=0.34; p=0.74; I^2=0%) (see Figure S5, in Supplementary Files). The total number of events was 2 out of 583 patients who underwent the ED strategy and 3 out of 572 patients who underwent the SD strategy.

In a subgroup analysis of cohort studies, after follow-up 1 month after the intervention, five studies with a total of 45,224 patients (ED n=12,466; SD n=32,758) reported no significant difference in the mortality rate of patients given the ED vs SD strategy (RD - 0.01; 95% CI: −0.01 to 0.00; Z=1.55; p=0.12; I^2=87%) (see Figure S6, in Supplementary Files). The total number of events was 99 out of 12,466 patients who underwent the ED strategy and 512 events out of 32,758 patients who underwent the SD strategy.

Discussion

This meta-analysis aims to identify the characteristics of patients in the low-risk category after PPCI and provide the latest information regarding the safety of early discharge (ED) strategies in patients in the low-risk category after PPCI. The safety of the ED strategy in this review was assessed from the rate of readmission and mortality of low-risk patients after PPCI and secondary outcomes in the form of LOS. Fourteen studies were included in the quantitative analysis.

In contrast to previous meta-analyses, this review adds several recent studies.[4,8] Compared with research by Gong et al, this study adds two RCT study on the LOS variable to reduce the heterogeneity (I^2) from 95% to 84% and increase the study sample size.[7,16] In addition, in Gong et al, the I^2 level for the readmission and mortality variables was 29.5%, while in this study, the I^2 level in the RCT study was 0%. This meta-analysis supports previous studies by increasing the number of large samples to reduce errors and increase the generalization aspect of research results. Then, this study also analyzed seven cohort studies to analyze mortality and readmission rates in low-risk category patients after PPCI who were given an ED strategy. This additional cohort study can provide comparison material with RCT studies in assessing the safety of implementing ED strategies.

Compared with the meta-analysis conducted by Asad et al, the novelty lies in the addition of three recent cohort studies (publication period 2021–2022).[25,26,28] Including these three recent studies not only increases the sample size from 36.635 to 46.710 but also provides essential real-world clinical data that increases the generalizability of the findings. In Asad et al, the analysis method for the mortality variable used a random effect model, even though the I^2 level was <50%.[8] Meanwhile, the addition of three recent cohort studies in this review has increased I^2 from 44% to 94%, so the analysis of mortality rates continues to use the random effect model. In addition, the novelty also lies in the readmission variable. In Asad et al, the I^2 value was still 59%, whereas it was 0% in this meta-analysis. Then, Asad et al also did not carry out a subgroup analysis based on the follow-up time. In this case, the follow-up process is essential to produce a more comprehensive overview of readmission and mortality data. Therefore, adding three cohort studies to this review could increase and decrease the heterogeneity level so that additional studies are needed in the future to reduce the heterogeneity and increase the sample size in research results to make them more generalizable.[8]

This meta-analysis identified the safety of an early discharge strategy in low-risk patients after PPCI therapy. The pooled estimate of RCTs shows no statistically significant difference in readmission rates (p=0.23; I^2=0%) and mortality (p=0.99; I^2=0%). In addition, the pooled estimate of RCTs also shows that the early discharge strategy can significantly reduce the LOS. Meanwhile, the pooled estimate of cohort studies shows a statistically significant difference in the readmission rate (p=0.03; I^2=0%) adan mortality rate (p=0.04; I^2=94%) related to ED strategy. These findings indicate that applying ED to early discharge patients is not completely safe.

The findings in this review align with the previous meta-analysis conducted by Gong et al. The results reported that an ED strategy was associated with a shorter LOS and no significant difference in mortality or readmission rates.[4] This result is also supported by an RCT study analysis in Asad et al, which shows no difference in mortality and readmission rates after ED strategy in low-risk patients undergoing PPCI.[8] In addition, the analysis of observational studies in Asad et al fully supports the results of this meta-analysis that there is a significant difference in the incidence of mortality in

low-risk patients treated with ED and SD.[8] These findings conclude that patients treated with ED have a higher risk of death than the SD group in the range of −0.01 to −0.00 (see Figure 6).

However, the different results lie in the analysis cohort study.[8] The addition of these three cohort studies provides significant differences and implications for the results of this meta-analysis with previous studies, especially regarding the incidence of readmission.[8] Previous studies reported that there was no difference in the incidence of patient readmissions in ED and SD.[8] Meanwhile, the results of the cohort study analysis in this study reported that there was a significant difference in the incidence of readmission, and the results of the subgroup analysis (FU-1 month) reported the same thing. Therefore, this difference in results should be reconsidered by health workers when deciding on early discharge for post-PPCI STEMI patients.

In this review, subgroup analysis was only based on a follow-up time of 1 month. Differences in follow-up time and limited data from the studies analyzed are why this study did not carry out another subgroup analysis. The results of the subgroup analysis showed the same thing as the main results, where the pooled estimate of RCTs showed no statistically significant difference in readmission and mortality rates and significantly reduced LOS in low-risk patients who underwent ED versus SD strategies. Meanwhile, the pooled estimate of cohort studies shows a statistically significant difference in readmission rates and no difference in mortality rates in patients who underwent ED versus SD strategies.

Overall, the findings of this meta-analysis indicate that early discharge strategies do not result in increased mortality and readmission rates and reduce the LOS in low-risk patients undergoing PPCI. Although the results of the cohort study data analysis reported a risk of increasing the readmission and mortality rate. However, this is not supported by findings from RCT studies.[7,15,16,20–22]

Several factors could cause the differences in findings in the two study designs in this meta-analysis. First, the blinding and control process is biased. The lack of control of confounding factors and the absence of a participant randomization process in cohort studies can impact the results of the research findings. In this case, RCT studies are more rigorous, allowing for a higher degree of internal validity than observational studies. Second, the definition and measurement of outcomes from each study. The differences in definitions and outcome measurements in RCTs and cohorts can cause variations in research results. The criteria used to define "low-risk", "early discharge", "readmission", and "mortality" patients may differ between study designs. Third, there were no additional RCT studies from previous research in this meta-analysis because no new RCT studies were found.[8] The results might be different if there were additional RCT studies. Therefore, some of these factors may influence the overall results of this meta-analysis.

Evidence shows that early discharge strategies are safe for post-PPCI patients who fall into the low-risk category.[4,8] A possible explanation for these results is the low event rate among low-risk STEMI patients considered for early discharge.[8] Apart from that, patients in the low-risk category are also indicated as not experiencing any complications.[7,15,29,32] Most complications in post-PPCI STEMI patients, such as arrhythmias, cardiogenic shock, and bleeding or recurrent ischemic events, occur within the first 24–72 hours.[33] Previous studies also reported that as many as 5745 STEMI patients treated with PPCI showed that 90% of ventricular tachycardia or ventricular fibrillation occurred within 48 hours after symptoms appeared.[34] Early discharge strategies allow the identification of these complications while still ensuring that patients without complications are promptly discharged.

Implications for Practice

The findings of this study show that only RCT studies fully support the European Society of Cardiology (2017) guidelines that recommend low-risk (Grade IIa) STEMI patients to early discharge within 48–72 hours.[5] Although the American College of Cardiology's STEMI guidelines do not provide any recommendations regarding discharge time,[3] this review provides a valuable summary. It highlights the limitations of available evidence regarding the safety of ED strategies in this population based on recent references.

The results of this study illustrate that there are differences in the use of risk stratification tools. However, most studies use Zwolle risk to categorize high and low patients. Apart from that, other tools that can be used are CADILLAC score, Primary Angioplasty in Myocardial Infarction (PAMI-II), Euroscore II, and Syntax Score or other tools.[35] Determining this category is very important and must be strict in the process so that this can prevent and reduce readmission and mortality rates, especially in post-PPCI STEMI patients.

The ED strategies have many benefits from the patient's perspective, especially in low-risk post-PPCI STEMI patients. Previous reviews reported that ED strategies carried out in low-risk patients after PPCI can reduce LOS.[4,36] LOS can have a significant impact on patient recovery, as well as overall treatment costs.[33] Also, reduced LOS has been associated with a reduced risk of opportunistic infections and treatment side effects, improved treatment outcomes and reduced mortality.[37] Therefore, the decision to determine the optimal discharge time is complex and must be made individually by professional health workers.

Strengths and Limitations of Study

This meta-analysis has several limitations. First, we did not find the latest RCT studies in the article identification process, so in this review, there were no additional RCT studies from Asad et al. During the literature search process, we did not apply any restrictions or filters to the database, including year of publication, language and research design. This indicates the need for new RCT studies in this population for further research. Second, the event rates in the included RCTs were relatively low, or no events were reported, which may have impacted the estimated results of the analysis. However, our analysis includes the best available evidence, and more extensive trials may be undertaken in the future. Third, the mortality outcomes analyzed in this review cover all causes of death, not specifically cardiovascular disease. Therefore, it is hoped that future research will pay attention to mortality outcome categories to distinguish between patients who died due to cardiovascular or non-cardiovascular disease.

Conclusion

The conclusions in this meta-analysis are based on the results of the analysis of RCT studies. The results show that the ED strategy for low-risk patients after PPCI is proven to be safe and significantly reduces patient LOS. The safety of the ED strategy is proven by the fact that there is no difference in the incidence of readmission and mortality in low-risk post-PPCI patients who received ED and SD.

These findings still need to be improved because there is no recent RCT research, so additional research is needed in this population. Future research with an RCT design is needed to improve the generalizability and safety associated with ED strategies in post-PPCI patients. Health professionals may consider the ED as a strategy to reduce patient LOS, optimizing the use of resources, such as beds, medical personnel, and other facilities.

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