

## **Percutaneous coronary intervention versus coronary artery bypass in treatment of non-ST-segment elevation acute syndromes: a systematic review and meta-analysis study**

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### **Abstract**

The objective of this study is to compare the effectiveness and safety of Percutaneous Coronary Intervention (PCI) and Coronary Artery Bypass Grafting (CABG) in the treatment of Non-ST-Segment Elevation Acute Coronary Syndromes (NSTE-ACS). A literature search was conducted across PubMed, Scopus, and Web of Science, covering studies up to June 2024. Studies comparing PCI and CABG in patients with NSTE-ACS were included, focusing on clinical outcomes such as mortality, myocardial infarction, cerebrovascular accidents, and the need for repeat revascularization. Data extraction and quality assessment were performed. Statistical analysis was conducted using R software, with the Mantel-Haenszel method and random-effects model employed to pool effect sizes and assess heterogeneity. A total of 15 studies met the eligibility criteria, including 48,891 patients. The pooled risk ratio (RR) for mortality showed no significant difference between PCI and CABG (RR=1.09, 95% CI: 0.90-1.19, p=0.28). CABG was associated with a significantly lower risk of subsequent MI (RR=0.56, 95% CI: 0.38-0.61, p <0.01) and the need for repeat revascularization (RR=2.94, 95% CI: 2.30-3.76, p <0.01). Conversely, PCI had a lower associated risk of CVA (RR=0.58, 95% CI: 0.42-0.79, p <0.01). High heterogeneity was observed in mortality outcomes, indicating variability among studies. The findings suggest that while PCI and CABG have comparable mortality risks in NSTE-ACS patients, CABG offers superior protection against myocardial infarction and the need for repeat revascularization, whereas PCI is associated with a lower risk of cerebrovascular accidents. These results underscore the importance of individualized patient assessment in choosing the optimal revascularization strategy, considering patient-specific risk factors and clinical profiles.

**Key Words:** percutaneous coronary intervention, coronary artery bypass grafting, non-ST-segment elevation acute coronary syndrome.

Non-ST-Segment Elevation Acute Coronary Syndromes (NSTE-ACS) encompass serious cardiovascular conditions such as unstable angina and Non-ST-Segment Elevation Myocardial Infarction (NSTEMI). These conditions result from partial or intermittent obstruction of the coronary arteries, distinguishing them from ST-Segment Elevation Myocardial Infarction (STEMI), which displays a classic ST-segment elevation on an electrocardiogram.<sup>1-3</sup> NSTE-ACS contribute significantly to patient morbidity and mortality, necessitating prompt and effective therapeutic interventions to reduce the risk of adverse cardiovascular outcomes.<sup>4-6</sup>

The primary revascularization methods for treating NSTE-ACS are Percutaneous Coronary Intervention (PCI) and Coronary Artery Bypass Grafting (CABG). PCI is a minimally invasive procedure that involves inserting a catheter with an inflatable balloon to dilate the narrowed coronary artery, often followed by the placement of a stent to maintain arterial patency. This technique is favored for its less invasive nature and shorter recovery time.<sup>7,8</sup> Conversely, CABG is a more invasive surgical approach that uses grafts from other parts of the patient's body to create new routes for blood flow around blocked coronary arteries. CABG is typically reserved for patients with more severe coronary artery disease or multiple blockages, offering a potentially more lasting solution by bypassing the obstructions.<sup>7-10</sup>

The decision between PCI and CABG for patients with NSTE-ACS requires careful consideration of various patient-specific factors, such as the complexity of coronary artery disease, existing comorbidities, and overall risk profile. The literature presents mixed results concerning survival rates, symptom recurrence, and the necessity for repeat interventions, contributing to ongoing discussions in the medical community.<sup>11-13</sup> This systematic review and meta-analysis aim to provide a comprehensive comparison of PCI and CABG in managing NSTE-ACS by assessing their relative effectiveness and safety. The objective of our study is to identify the optimal revascularization strategy to improve clinical outcomes and guide treatment recommendations for NSTE-ACS patients, thus offering a clear evidence-based approach for clinicians in their decision-making processes.

## Materials and Methods

This systematic review and meta-analysis were conducted following the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>14</sup>

### Search strategy

A thorough literature search was performed across electronic databases, including Web of Science, Scopus, and PubMed, covering all records up to June 2024. The search strategy incorporated a combination of Medical Subject Headings (MeSH) and keywords, specifically targeting studies involving ("percutaneous coronary intervention" OR "PCI") AND ("coronary artery bypass grafting" OR "CABG") AND ("non-ST-segment elevation acute coronary syndrome" OR "NSTE-ACS").

### Eligibility criteria

Eligibility criteria were defined using the PICO framework: Population (P): Clinical studies involving human patients diagnosed with non-ST-segment elevation acute coronary syndrome (NSTE-ACS). Intervention (I): Percutaneous coronary intervention (PCI). Comparison (C): Coronary artery bypass grafting (CABG). Outcome (O): Clinical outcomes, including mortality rates, recurrence of angina, need for repeat revascularization, and other relevant cardiovascular events. Exclusion criteria included animal studies, case reports, studies involving other types of coronary syndromes, studies not directly comparing PCI and CABG, and those lacking clear clinical outcomes or sufficient data.

### Data extraction and outcome measures

Data extraction was carried out independently by two reviewers using a standardized data collection form. Any discrepancies were resolved through discussion with a third reviewer. The extracted data included: Authors' names, year of publication, Study design, Sample size, Details of PCI and CABG protocols, Follow-up durations, Success rates and comparison groups, mortality rates, cardiovascular events, myocardial infarction and need for unplanned revascularization among two groups.

### Statistical analysis and data synthesis

Statistical analyses were conducted using the R software (R Foundation for Statistical Computing, Vienna, Austria) and RStudio (RStudio Inc., Boston, MA). The primary measure of effect was the Risk Ratio (RR) between PCI and CABG groups. The pooled RR and its 95% Confidence Intervals (CIs) were calculated using a random-effects model. Heterogeneity among the studies was assessed using the  $I^2$  statistic. The Mantel-Haenszel method and random-effects model were employed to pool effect sizes and calculate standard deviations. A z-test was used to evaluate the overall significance of the pooled effect size and the differences between subgroups. Publication bias was assessed through the construction of funnel plots for each outcome group, and forest and funnel plots were generated to visually represent the data. This methodological approach aims to rigorously compare PCI and CABG in the treatment of NSTE-ACS, providing clear evidence on their relative effectiveness and safety to guide clinical decision-making.

## Results

Our initial search yielded 3,153 articles from PubMed, Scopus, and Web of Science, from which we eliminated 1,027 duplicates. After reviewing the titles and abstracts of the remaining 2,126 records, we retrieved 78 full-text articles for further evaluation. Ultimately, 15 studies met our eligibility criteria and were included in the systematic review (11, 12, 15-27), with 15 of these studies also included in the meta-analysis (Figure 1). Detailed characteristics of the included studies are summarized in Table 1.

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### Mortality

Our meta-analysis of mortality outcomes compared percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) in patients with non-ST-segment elevation acute coronary syndrome (NSTEMI-ACS). The pooled risk ratio (RR) for mortality indicated no significant difference between PCI and

CABG (RR=1.09, 95% CI: 0.90-1.19, p=0.28) in the random-effects model, suggesting that both revascularization strategies have comparable mortality risks (Heterogeneity:  $I^2=98\%$ ,  $\tau^2=1.0250$ ,  $p < 0.01$ ). In the subgroup analysis for mortality, the studies were categorized based on study design: Randomized Controlled Trials (RCTs), Prospective Cohort Studies (PCS), and Retrospective Cohort

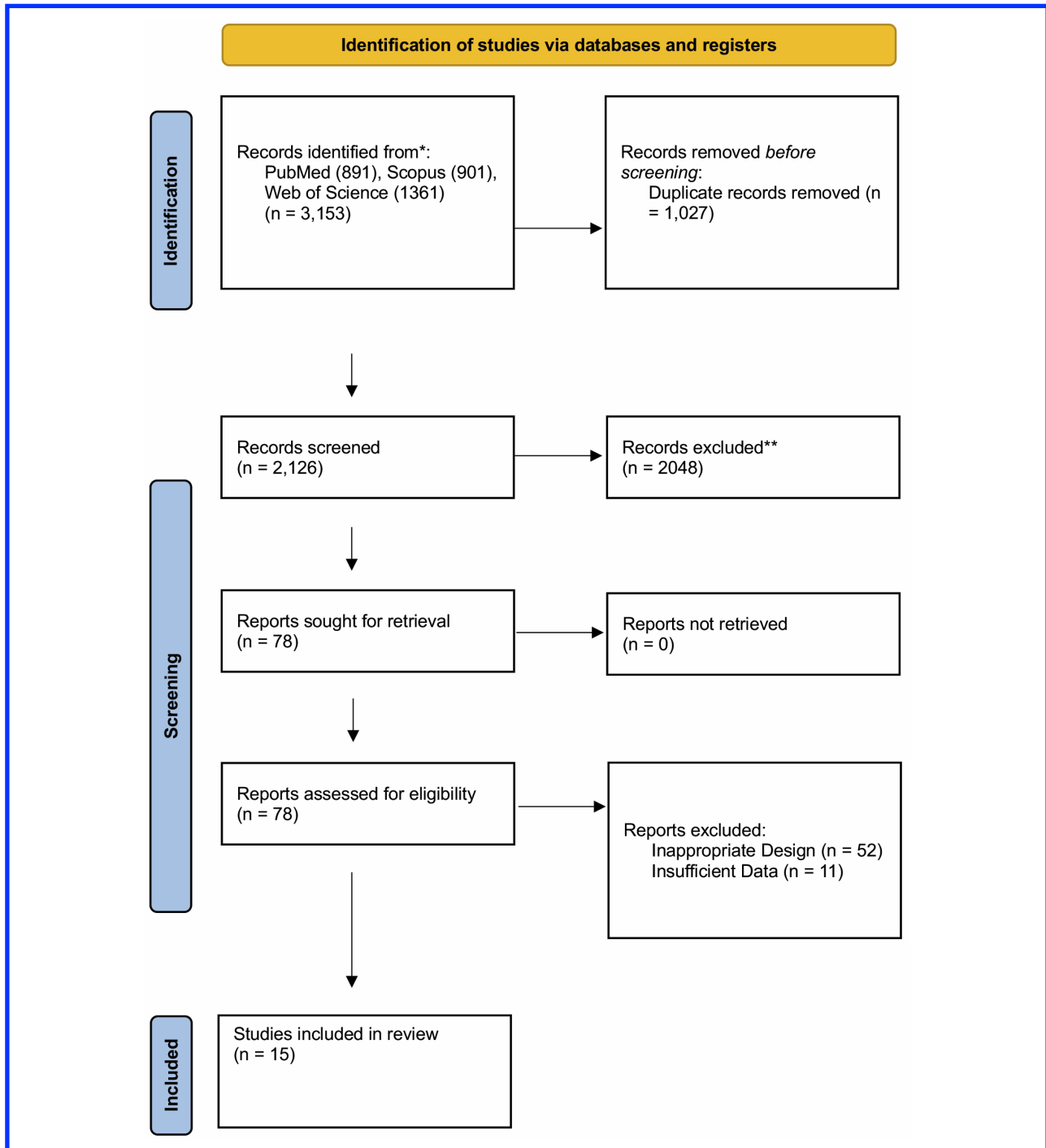


Figure 1. Flowchart of the included studies.

Studies (RCS). The pooled RR for mortality in RCTs was 1.18 (95% CI: 0.88-1.58), in PCS was 1.09 (95% CI: 1.05-1.28), and in RCS was 0.94 (95% CI: 0.38-3.61). The heterogeneity was significant in all subgroups ( $I^2=91\%$ ,  $\tau^2=0.2418$ ,  $p < 0.01$ ), indicating high variability between the studies within each subgroup (Figure 2).

**Myocardial Infarction (MI)**

The analysis of myocardial infarction outcomes showed that CABG was associated with a lower risk of subsequent MI compared to PCI (Figure 3). The pooled RR was 0.56 (95% CI: 0.38-0.61,  $p < 0.01$ ) in the random-effects model, indicating a statistically significant reduction in MI rates with CABG (Heterogeneity:  $I^2=95\%$ ,  $\tau^2=0.6363$ ,  $p < 0.01$ ). For myocardial infarction, the subgroup analysis also considered study designs. In RCTs, the pooled RR for MI was 1.83 (95% CI: 1.66-2.01), showing a significantly higher risk with PCI. In PCS, the pooled RR was 0.28 (95% CI: 0.10-4.37), and in RCS, it was 0.56 (95% CI: 0.27-1.14). Heterogeneity was high in PCS ( $I^2=95\%$ ,  $\tau^2=0.6363$ ,  $p < 0.01$ ) and moderate in RCS ( $I^2=77\%$ ,  $\tau^2=0.5385$ ,  $p < 0.01$ ).

**Cerebrovascular accidents**

For Cerebrovascular Accidents (CVA) and strokes, the comparison revealed that PCI had a lower associated risk than CABG (Figure 4). The pooled RR was 0.58 (95% CI: 0.42-0.79,  $p < 0.01$ ) in the random-effects model, indicating a significant reduction in stroke rates with PCI (Heterogeneity:  $I^2=24\%$ ,  $\tau^2 < 0.0001$ ,  $p=0.22$ ). The subgroup analysis for cerebrovascular accidents categorized by study design revealed the following: in RCTs, the pooled RR was 1.45 (95% CI: 1.18-1.78), in PCS it was 1.41 (95% CI: 1.14-1.73), and in RCS it was 1.58 (95% CI: 1.13-1.85). The heterogeneity was lower compared to other outcomes ( $I^2=24\%$ ,  $\tau^2 < 0.0001$ ,  $p=0.22$ ).

**Unplanned revascularization**

The need for repeat revascularization procedures was significantly higher in patients who underwent PCI compared to those who had CABG (Figure 5). The pooled RR for revascularization was 2.94 (95% CI: 2.30-3.76,  $p < 0.01$ ) in the random-effects model, demonstrating a statistically significant higher rate of repeat interventions in the PCI group (Heterogeneity:  $I^2=47\%$ ,  $\tau^2=0.0405$ ,  $p=0.13$ ). Sub-

**Table 1.** Summary characteristics of the included studies.

Name	Year	Country	Design	N	Death				CVA				MI			
					PCI		CABG		PCI		CABG		PCI		CABG	
					E	N	E	N	E	N	E	N	E	N	E	N
de Feyter <i>et al.</i> (15)	2002	Netherlands	RCT	1205	15	600	17	605	9	600	12	605	32	600	24	605
Chew <i>et al.</i> (16)	2008	Australia	RCT	10025	135	4579	113	1776	-	-	-	-	650	4579	490	1776
Hochholzer <i>et al.</i> (17)	2008	Switzerland	PCS	357	21	283	6	74	-	-	-	-	16	283	9	74
AL-Habib <i>et al.</i> (18)	2012	Saudi Arabia	PCS	802	31	638	8	164	1	638	1	164	14	638	3	164
Buszman <i>et al.</i> (19)	2014	USA	PCS	1858	23	929	26	929	-	-	-	-	-	-	-	-
Ben-Gal <i>et al.</i> (12)	2015	Israel	RCT	1772	74	1349	30	423	3	1349	3	423	95	1349	49	423
Kurlansky <i>et al.</i> (20)	2016	USA	PCS	3228	190	2083	65	946	-	-	-	-	-	-	-	-
Desperak <i>et al.</i> (21)	2019	Poland	PCS	1251	45	1122	6	129	5	1122	4	129	26	1122	2	129
Huckaby <i>et al.</i> (11)	2020	USA	RCS	2001	94	521	120	1480	6	521	12	1480	39	521	27	1480
Jia <i>et al.</i> (22)	2020	China	PCS	2819	90	1589	57	1230	113	1589	129	1230	133	1589	33	1230
Lee <i>et al.</i> (23)	2020	South Korea	RCS	360	12	180	10	180	7	180	9	180	29	180	10	180
Ram <i>et al.</i> (24)	2020	Israel	OCS	5112	213	4327	64	785	16	4327	2	785	95	4327	6	785
Reynolds <i>et al.</i> (25)	2021	USA	RCS	5938	69	4608	64	1330	-	-	-	-	-	-	-	-
Ram <i>et al.</i> (26)	2022	Israel	PCS	1987	35	1652	11	335	10	1652	0	335	47	1652	2	335
Wickbom <i>et al.</i> (27)	2024	Sweden	PCS	246	0	123	0	123	4	123	5	123	-	-	-	-

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group analysis for the need for repeat revascularization showed that in RCTs, the pooled RR was 2.94 (95% CI: 2.30-3.76), indicating a significantly higher rate in the PCI group. For PCS, the pooled RR was 1.40 (95% CI: 1.03-1.82), and for RCS, it was 3.89 (95% CI: 1.89-25.59). Heterogeneity was moderate to high in all subgroups ( $I^2=47%$ ,  $\tau^2=0.0405$ ,  $p=0.13$ ).

### Discussion

This study aimed to compare the effectiveness and safety of PCI and CABG in treating patients with NSTEMI-ACS. Through a systematic review and meta-analysis, we assessed key clinical outcomes such as mortality, MI, CVA, and the need for repeat revascularization. The findings indicate that while mortality rates between PCI and CABG are comparable, CABG is associated with a significantly lower risk of subsequent myocardial infarction and repeat

revascularization procedures. Conversely, PCI presents a lower risk of cerebrovascular accidents compared to CABG. These results highlight the differential impacts of the two revascularization strategies, underscoring the importance of individualized patient assessment in clinical decision-making.

The study's comprehensive analysis also included a subgroup examination based on study design, revealing consistent patterns across RCTs, prospective and retrospective cohort studies. CABG demonstrated superior outcomes in reducing MI and the need for additional revascularization, while PCI maintained a lower risk of stroke. The heterogeneity observed in mortality outcomes suggests variability in patient populations and study methodologies, necessitating further research to refine treatment guidelines. Overall, this meta-analysis provides crucial insights into the comparative efficacy of PCI and CABG, aiming to guide clinicians in selecting the most appropriate revas-

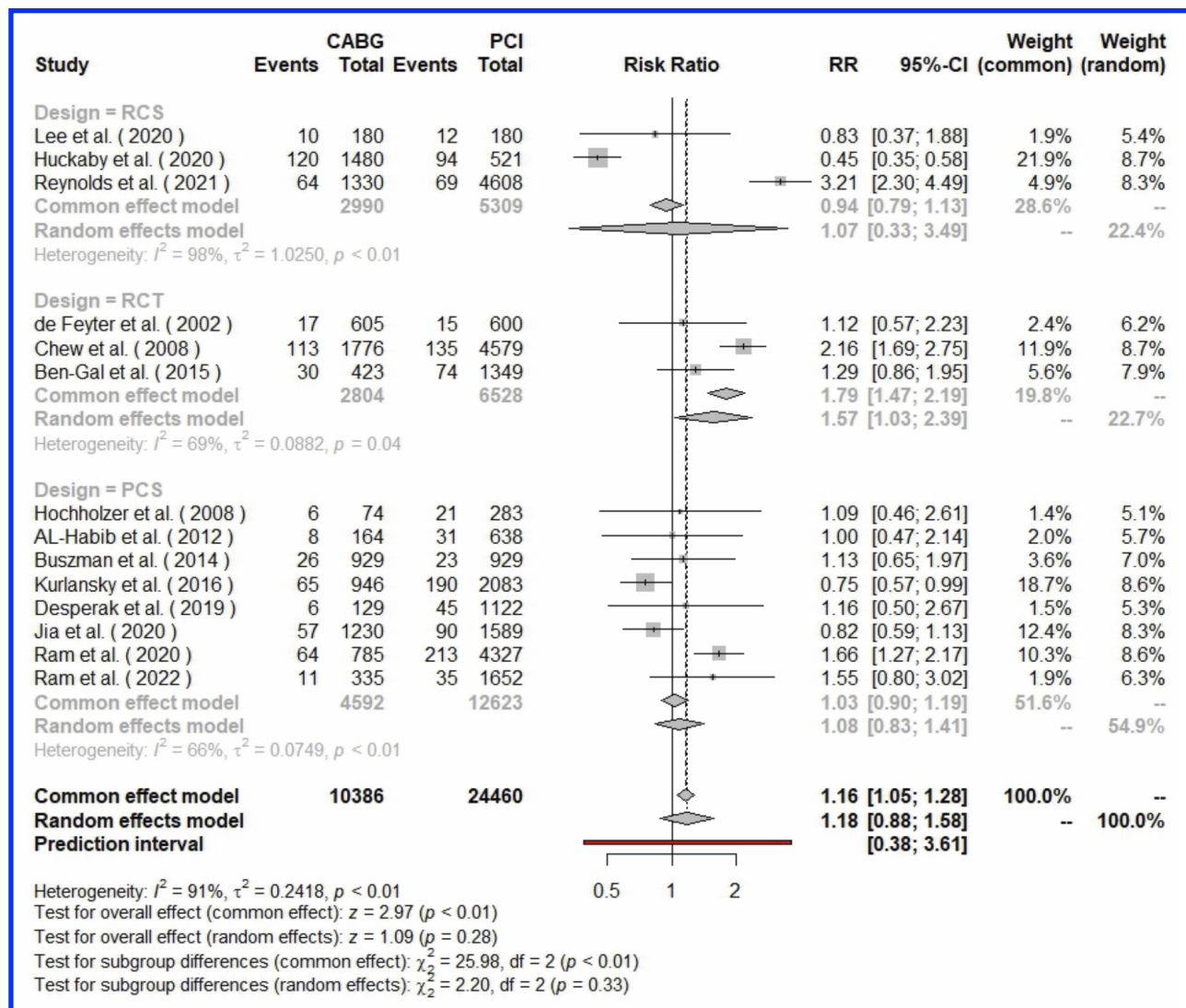


Figure 2. Forest plot of subgroup analysis regarding mortality among the two groups.

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cularization strategy for NSTEMI-ACS patients, enhancing patient outcomes through evidence-based practice. The comparison between PCI and CABG in treating patients with NSTEMI-ACS reveals no significant difference in mortality rates. This outcome is consistent with the findings of one study who also found no significant difference in long-term mortality between the two interventions. Chang's meta-analysis, which included a comprehensive review of observational studies, emphasized that both PCI and CABG offer viable revascularization options for NSTEMI-ACS patients, reflecting similar mortality outcomes over an extended follow-up period. These consistent findings across multiple studies suggest that survival rates should not be the primary deciding factor when choosing between PCI and CABG, and that patient-specific factors and clinical presentations should guide the choice of intervention.<sup>13,28-30</sup> Our analysis highlighted that CABG is significantly more effective in reducing the risk of subsequent myocardial infarction compared to PCI. This observation is supported by Lee *et al.* (2020), who found that CABG was particu-

larly beneficial in reducing MI incidence among patients with multivessel coronary artery disease.<sup>12,15-19,23,31</sup> Lee's study pointed to the anatomical and pathophysiological advantages of CABG, particularly in complex coronary anatomies where bypass grafts offer a more durable revascularization compared to stents. The ability of CABG to provide protection against both flow-limiting and non-flow-limiting stenoses likely explains its superior efficacy in preventing future myocardial infarctions, particularly in patients with extensive coronary artery disease.<sup>13,29,30</sup> Regarding CVA, our findings indicate that PCI is associated with a lower risk compared to CABG. This result aligns with the findings of Shawon *et al.* (2023), whose meta-analysis demonstrated a reduced risk of stroke with PCI, especially in the early postoperative period. Shawon's study suggests that the less invasive nature of PCI, which avoids the need for cardiopulmonary bypass and manipulation of the aorta, contributes to a lower incidence of perioperative strokes.<sup>20,28,29,32</sup> This reduced procedural risk is particularly relevant for elderly patients or those

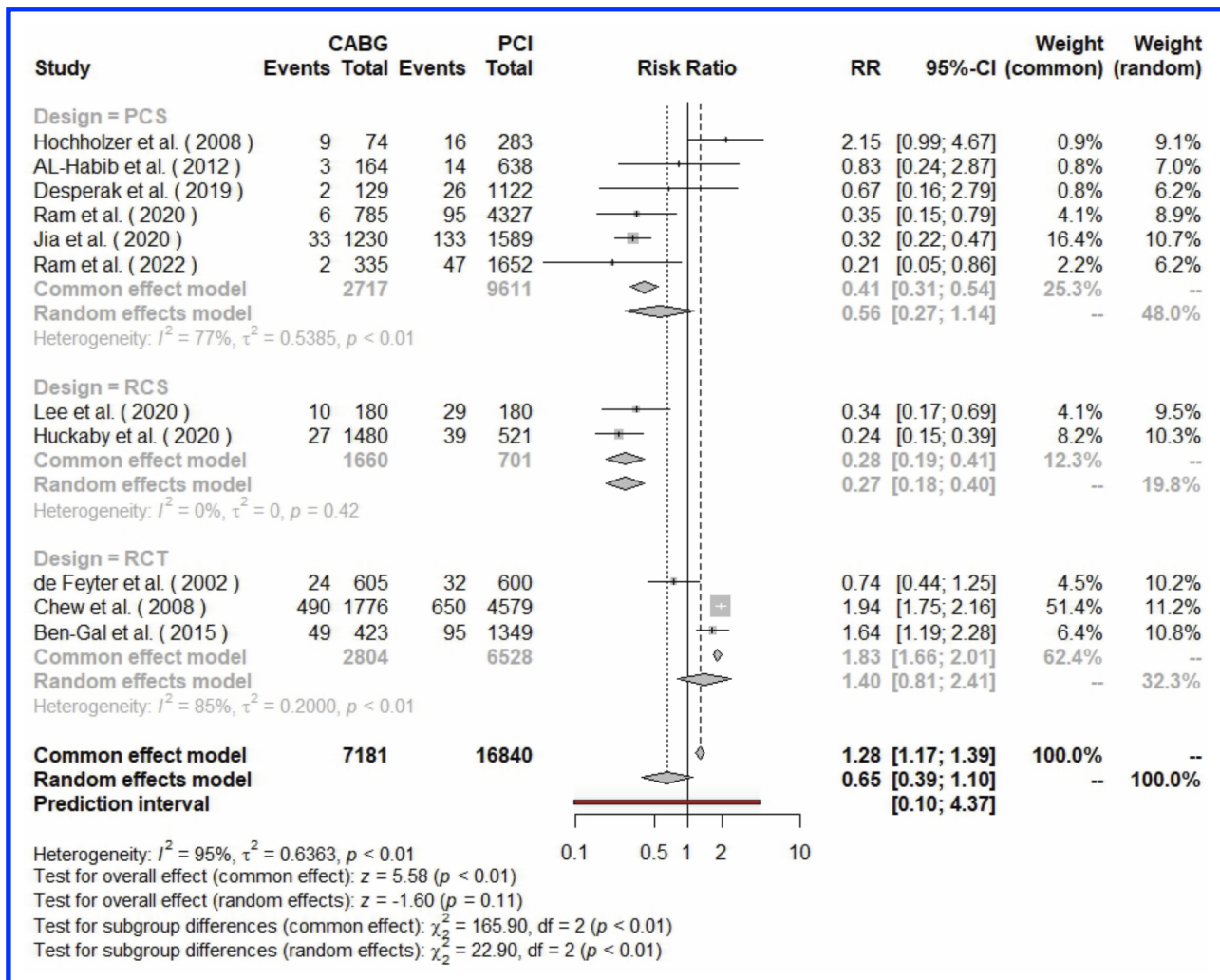


Figure 3. Forest plot of subgroup analysis regarding MI among the two groups.

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with significant comorbidities, where the lower invasiveness of PCI can be a crucial factor in deciding the revascularization strategy.<sup>9,10,27,33,34</sup>

The clinical impact of our findings is substantial, offering nuanced guidance for treatment decisions in NSTEMI-ACS patients. The comparable mortality rates between

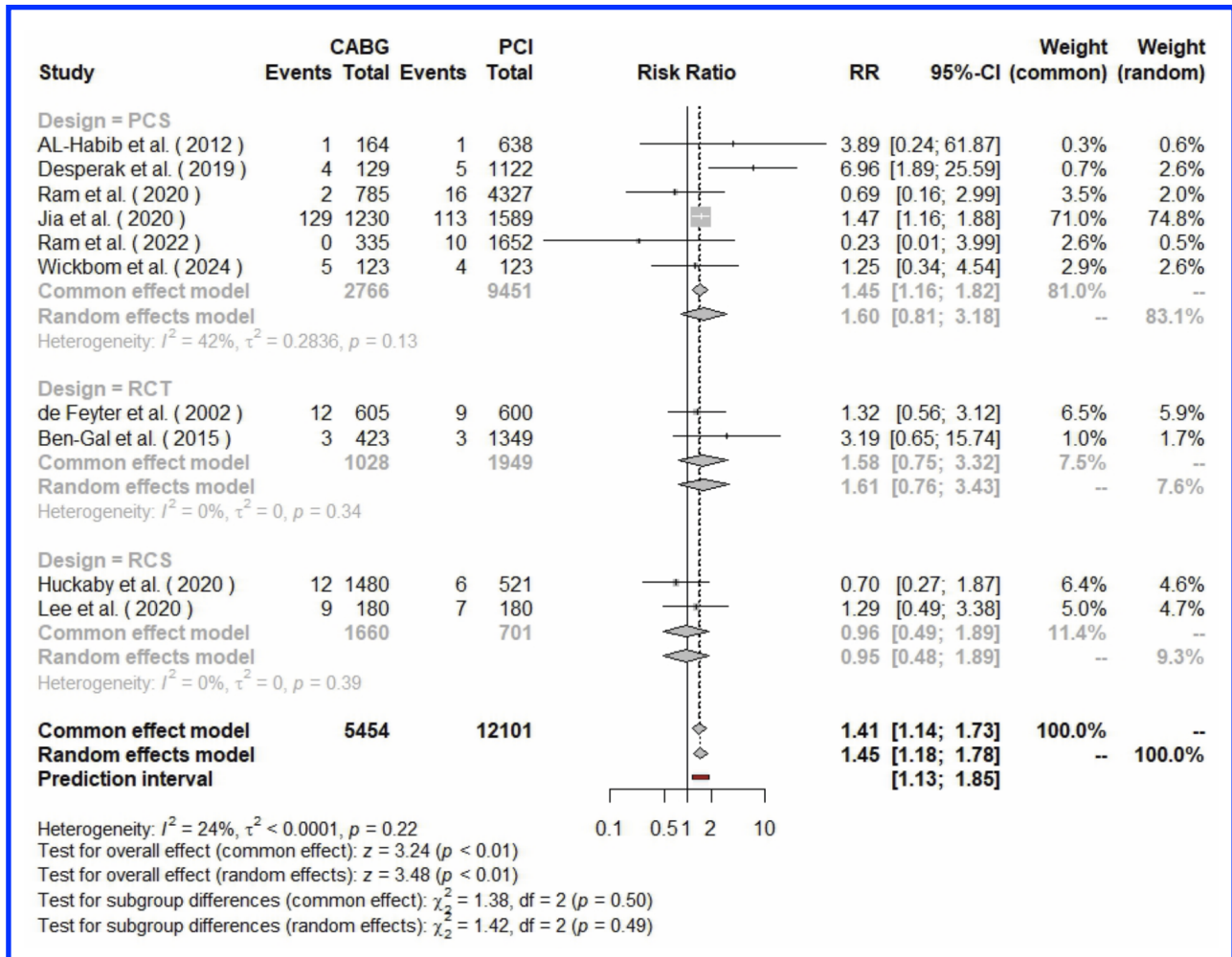


Figure 4. Forest plot of subgroup analysis regarding CVA among the two groups.

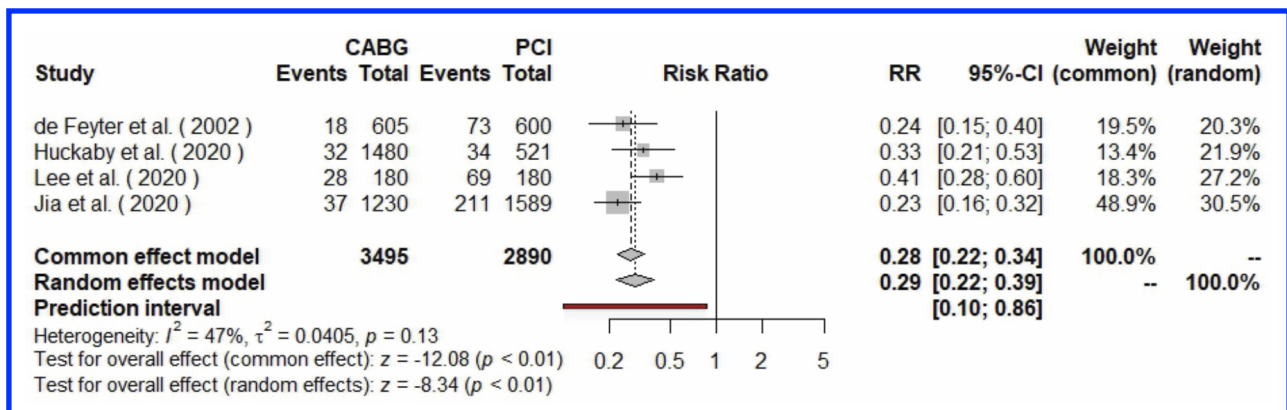


Figure 5. Forest plot of subgroup analysis regarding unplanned revascularization among the two groups.

PCI and CABG suggest that either procedure can be chosen without compromising long-term survival, allowing clinicians to consider other critical factors such as patient comorbidities, anatomical considerations, and patient preferences. The superior efficacy of CABG in reducing myocardial infarctions highlights its potential benefit for patients with extensive coronary artery disease or those at higher risk of recurrent ischemic events.<sup>8,13,26,35,36</sup> Conversely, the lower stroke risk associated with PCI underscores its suitability for patients with elevated cerebrovascular risk or those who may not tolerate more invasive surgical procedures. These insights underscore the importance of a personalized, patient-centered approach to revascularization strategy, optimizing outcomes by aligning the chosen intervention with the specific clinical profile and risks of each patient.<sup>30,37-40</sup>

The underlying physiology for these findings can be attributed to the distinct mechanisms by which PCI and CABG achieve revascularization. CABG involves the creation of new pathways for blood flow using grafts, which bypass obstructed segments of coronary arteries and provide protection against both flow-limiting and non-flow-limiting stenoses. This comprehensive revascularization can reduce the likelihood of future myocardial infarctions, as it addresses both present and potential future blockages.<sup>25,41-44</sup> On the other hand, PCI involves the placement of stents to open narrowed arteries, which is less invasive and targets specific stenoses but does not offer the same extent of protection against future obstructions. The lower stroke risk associated with PCI can be explained by its minimally invasive nature, avoiding the need for cardiopulmonary bypass and reducing the risk of embolic events during surgery. Understanding these physiological differences helps elucidate why CABG may be more effective in preventing myocardial infarctions, while PCI offers a safer profile concerning stroke risk, guiding clinicians in tailoring interventions to individual patient needs.<sup>7,11,22-24</sup>

A significant limitation of our study is the high heterogeneity observed across the included studies, particularly concerning patient populations, study designs, and follow-up durations. This variability can introduce biases and limit the generalizability of our findings. Additionally, the majority of the studies included were observational, which inherently carry a higher risk of selection bias and confounding factors compared to randomized controlled trials. The lack of uniformity in reporting outcomes and the use of different endpoints and definitions for myocardial infarction and cerebrovascular accidents across studies further complicates direct comparisons. Moreover, advancements in PCI techniques and CABG procedures over the study period may affect the applicability of older data to current clinical practice. Finally, our meta-analysis did not account for individual patient characteristics such as comorbidities, which could significantly influence the choice of revascularization strategy and subsequent outcomes, highlighting the need for personalized approaches in clinical decision-making.

## **Conclusions**

The meta-analysis findings suggest that while PCI and CABG present similar mortality risks for NSTEMI-ACS patients, they differ in other clinical outcomes. CABG offers superior protection against subsequent myocardial infarction and the need for repeat revascularization, whereas PCI is associated with a lower risk of cerebrovascular accidents. These results highlight the importance of considering individual patient profiles and clinical scenarios when choosing between PCI and CABG for NSTEMI-ACS treatment.

## **List of abbreviations**

PCI, Percutaneous Coronary Intervention  
CABG, Coronary Artery Bypass Grafting  
NSTEMI-ACS, Non-ST-Segment Elevation Acute Coronary Syndromes  
RR, Risk Ratio  
NSTEMI, Non-ST-Segment Elevation Myocardial Infarction  
STEMI, ST-Segment Elevation Myocardial Infarction  
PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses  
MeSH, Medical Subject Headings  
CIs, Confidence Intervals  
RCTs, Randomized Controlled Trials  
PCS, Prospective Cohort Studies  
RCS, Retrospective Cohort Studies  
MI, Myocardial Infarction  
CVA, Cerebrovascular Accidents

## **Conflict of interest**

The authors declare no potential conflict of interest, and all authors confirm accuracy.

## **Ethics approval**

None.

## **Informed consent and patient consent for publication**

None.

## **Availability of data and materials**

All data generated or analyzed during this study are included in this published article.

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## Percutaneous coronary intervention versus coronary artery bypass

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