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Network Meta-analysis of percutaneous intervention-based revascularization strategies for ST-elevation myocardial infarction and concomitant multi-vessel disease

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Abstract

Background: In patients with ST elevation myocardial infarction (STEMI) and concomitant multi-vessel disease (MVD), primary percutaneous coronary intervention (PCI) of the culprit vessel is the preferred reperfusion strategy. However, optimum timing of revascularization for non-culprit artery is unclear. In this Bayesian network meta-analysis (NMA), we compared different PCI-based revascularization strategies in STEMI patients with MVD.

Methods: 11 randomized controlled trials (RCTs) were selected using MEDLINE, EMBASE and CENTRAL (Inception to September 2017). For all outcomes, median estimate of odds ratio from posterior distribution with corresponding 95% credible interval was calculated. The Surface under the Cumulative Ranking Curve (SUCRA) metric was used to estimate the relative ranking probability of each intervention. Sensitivity analysis was conducted by excluding the RCTs in which the staged intervention was performed after two weeks of the index procedure or post discharge.

Results: In this NMA of 3172 patients, CR-I (instant complete revascularization) was associated with 40% relative risk reduction in all-cause mortality compared with IRA (infarct related artery) [0.60 (0.31–0.89)]. CR-I was superior to CR-S (staged complete revascularization) [0.42 (0.22–0.70)] and IRA [0.50(0.29–0.72)] in reducing the risk of re- infarction. Both CR-I and CR-S significantly reduced the risk of repeat revascularization compared to IRA, whereas the risk of CIN (contrast induced nephropathy) and major bleeding was similar across all interventions. Sensitivity analysis showed, that CR-I was a better strategy compared with CR-S [0.34 (0.12–0.74)] and IRA (0.60 [0.36–0.97]) in reducing all-cause mortality.

Conclusions: In this NMA, CR-I was associated with reduction in all-cause mortality and re-infarction compared with IRA.

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Disclosures

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Keywords

STEMI; Multi-vessel disease; Revascularization

1. Introduction

Approximately 40%−50% of patients with ST-elevation myocardial infarction (STEMI) have been reported to have concomitant multi-vessel disease (MVD), involving at least one additional stenosis in the non-culprit vessel [1,2]. This portends worse prognosis than does single-vessel disease. However, there is uncertainty regarding the appropriate management of non-culprit vessels in such patients. Until recently, clinical practice guidelines recommended against complete revascularization in STEMI patients with MVD, who were otherwise hemodynamically stable unless electrocardiogram localization of the infarction was unclear [3]. A lack of benefit in cardiovascular outcomes with instant complete revascularization was attributed to a higher incidence of complications such as increased risk of major bleeding, CIN requiring renal replacement therapy, stroke, stent thrombosis and fluid overload in the setting of acute STEMI [4–8]. However, most of the earlier trials and meta- analysis were not powered enough to evaluate the effect of complete revascularization on estimates such as all-cause mortality. Moreover, the optimal timing of complete revascularization during the index procedure (CR-1), or as a staged procedure (CR-S) a few weeks later, and its impact on mortality also remains uncertain.

Recently, several randomized controlled trials (RCTs) have shown that complete revascularization (CR) is at least equivalent and likely superior to isolated culprit vessel revascularization in reducing major adverse cardiovascular events (MACE) in patients with STEMI and MVD [9–13]. To update the evidence, we performed a Bayesian network meta-analysis (NMA) to compare the effect of three different revascularization strategies: infarct related artery only revascularization (IRA), complete revascularization during index procedure (CR-I) and staged complete revascularization (CR-S) in patients with stable STEMI and MVD.

2. Methods

The data, analytic methods, and study materials have not been made available to other researchers for purposes of reproducing the results or replicating the procedure.

This NMA was conducted according to the Cochrane Collaboration recommendations [14], Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols (PRISMA) report, and PRISMA extension statement for network meta-analyses [15].

2.1. Inclusion criteria

Eligible studies for this NMA were RCTs that included hemodynamically stable patients with STEMI and MVD undergoing percutaneous coronary intervention (PCI), and compared at least two of the following three revascularization strategies: IRA group (revascularization of only the infarct-related artery determined by the operator), CR-I (complete revascularization of all arteries with significant stenosis by visual estimate or by FFR during

the index procedure), and CR-S (a combination approach that include revascularization of the infarct-related artery during the index procedure followed by revascularization of non-culprit arteries as a staged procedure). The staged procedure could have been performed later during the index hospitalization or following discharge. The included studies had to report at least one event in the outcomes of interest (see later text) in adults. There were no restrictions on follow-up duration, co morbidities or sample size. Patients undergoing primary PCI in the setting of cardiogenic shock, chronic total occlusion or left main disease were excluded from the study.

2.2. Study search

We searched PubMed/MEDLINE via OVID (1946 to September 2017), EMBASE via OVID (1980 to September 2017), and Cochrane Central Register of Controlled Trials (inception to September 2017). The search was performed using a combination of the following words and medical subject heading: “percutaneous coronary intervention,” “PCI,” “intervention,” “myocardial infarction,” “STEMI,” “revascularization,” “culprit lesion,” “multivessel,” “multivessel PCI,” “staged PCI,” “complete revascularization,” “infarct artery intervention,” and “randomized controlled trials.” All citations were downloaded into Zotero (Roy Rosen Zweig Center for History and New Media, Research Software, Virginia, USA), and duplicates were manually identified and eliminated by this software. The electronic search was supplemented with a manual review of the references cited in the shortlisted articles. The search was restricted to English language, full-text articles, human participants, and RCTs.

2.3. Data abstraction and quality assessment

Data abstraction on baseline characteristics, events, sample size and follow up duration of each trial was performed by two authors independently (UF and OA) using a structured data collection form. We extracted all the events at longest follow up duration. When possible, data on intention to treat analysis was abstracted. Similar to another NMA, we placed RCTs in the specific revascularization arm based on predominant revascularization strategy if studies had not clearly reported the results according to CR-I or CR-S groups [16]. For instance, in Hamza et al and Compare-Acute, outcomes were reported for CR; however, in both the studies, most of the participants in the CR group underwent CR-I. In Compare-acute, 83.4% of the patients from CR group underwent CR-I, and in Hamza et al, 58% of the patients had CRI from CR group [12,13]. On the same note, in the CvLPRIT trial [10], around 64% of the patients from the CR group underwent CR-I. These studies were included in the CR-I arm based on the pre-dominant revascularization strategy. We also reviewed appendices of the included trials for additional information. Cochrane bias risk assessment tool was used to assess the risk of bias of the included studies (Supplementary Appendix, Table 1)

2.4. Outcomes measures

The primary outcome was all-cause mortality. Secondary outcomes were re-infarction, repeat revascularization [urgent and non-urgent PCI and unplanned coronary artery bypass grafting (CABG)], contrast-induced nephropathy (CIN), and major bleeding events. The definitions of all outcomes were taken as reported in the included trials.

2.5. Statistical analysis

The Bayesian NMA, an extension of a traditional meta-analysis, was conducted using NetMetaXL 1.6.1 (Canadian Agency for Drugs and Technologies in Health, Ottawa, Canada) and WinBUGS 1.4.3 (MRC Biostatistics Unit, Cambridge, UK). The Bayesian method is a sophisticated statistical approach that allows pooling of data related to multiple interventions simultaneously, combining direct and indirect components of the evidence in a single estimate, and enables the comparison of the interventions without a direct connection on the basis of indirect information [17]. Out comes were defined using random effects model. For random effects vague priors, we assumed use the following priors: sd ~ dunif (0,2); where dunif is the density function of the uniform distribution, sd is the vector of standard deviations, and 0 and 2 describe minimum and maximum vector of quantiles, respectively. For informative variance prior, all-cause mortality informative priors were selected based on non-pharmacological intervention with objective outcomes. NetMetaXL uses these selections and bases the informative variance priors on evidence on the extent of heterogeneity noticed in prior meta-analyses, as reported in Turner et al. [18] For all analyses, we assumed vague priors on baseline [dnorm (0,10000)] and basic parameters [dnorm (0,10000)], where function “dnorm” return the value of the probability density function for the normal distribution based on given parameters. Since informative priors, when used properly, can improve modeling efficiency by providing solutions to computational issues, we ultimately applied predictive distributions (informative variance priors) to random effects analyses [18,19]. For all the outcomes, we achieved convergence at 20,000 iterations and autocorrelation was checked and confirmed. The inconsistency was assessed by comparing the deviance residuals and D1C statistics in fitted consistency and inconsistency models [20]. The assessment of between-study heterogeneity variances was interpreted as low (τ = 0.04), moderate (τ = 0.14), and high (τ = 0.40).

Estimates were reported as median estimate of odds ratio from the posterior distribution and reported it with 2.5th to the 97.5th centiles of the distribution (95% credible interval). Markov chain Monte Carlo (MCMC) modeling was used to estimate the relative ranking probability of each intervention [21]. “Rankograms” with surface under the cumulative ranking curve (SUCRA) were reported to provide a comparative hierarchy of efficacy of the interventions [22]. SUCRA is a numerical representation of the probability of effectiveness; briefly, a SUCRA of 90% indicates that the treatment of interest has achieved 90% effectiveness or the safety of that treatment relative to other groups. In all RCTs, the timing of staged intervention was during the index hospitalization or within the first two weeks, except in PRAGUE-13 [23] where staged intervention was planned between day 3–40, in PRIMA [24] around day 27 and in Politi et al [25] staged procedure was performed around day 57. This prompted a sensitivity analysis on major endpoints (all-cause mortality, repeat revascularization, re-infarction and CIN) by excluding these three studies. Publication bias was assessed using Egger’s regression test.

3. Results

The initial search yielded 2419 articles. After excluding studies based on priori inclusion criteria, ultimately 11 RCTs with 3,172 patients were selected in this NMA (Fig. 1). The

baseline characteristics of the patients in each study are summarized in Table 1 and the inclusion and exclusion criteria including the endpoint definitions of the included trials are listed in Table 2. In the included studies, the timing of staged intervention was from 72 hours up to 57 days in the CR-S group. The determination of significant stenosis in the non-infarct artery was made by visual estimate during angiography in most of the studies; whereas, FFR was used in others.

In this NMA, CR-I was associated with 40% relative risk reduction in all-cause mortality compared to IRA [0.60 (0.31–0.89)]. There was 35% decrease in all-cause mortality with CR-I compared to CR-S (0.65 [0.22–1.26)], which did not reach statistical significance (Fig. 2).

There was no significant difference between CR-S and IRA [0.93 (0.55–1.55)] with regards to all-cause mortality. CR-I was superior to CR-S [0.42 (0.22–0.70)] and IRA [0.50(0.29–0.72)] in reducing the risk of re-infarction. Both CR-I [0.26 (0.18–0.35)] and CR-S [0.36 (0.24–0.55)] significantly reduced the risk of repeat revascularization (urgent and non-urgent PCI and unplanned coronary artery bypass grafting) compared to IRA. The risk of CIN and major bleeding was similar across all the interventions.

In the CR-S group, the timing of staged intervention was heterogeneous across the included trials. Sensitivity analysis was performed after excluding the studies where staged intervention was performed after 2 weeks of the index event or post discharge. The result of sensitivity analysis showed that CR-I was associated with 40% relative risk reduction in all-cause mortality compared with IRA [0.60 (0.36–0.97)] and 66% reduction in mortality when compared with CR-S (0.34 [0.12–0.74]), that was statistically significant. There was no difference in mortality between IRA and CR-S [0.57(0.21–1.19)]. CR-I was associated with reduction in risk of re-infarction when compared with CR-S [0.34(0.15–0.89)] and IRA (0.47 [0.27–0.86]). CR-I was associated with 73% less risk of repeat revascularization compared with IRA, and CR-S was associated with 61% risk reduction in repeat revascularization compared with IRA [0.39(0.22–0.72)] (Fig. 4).

Egger’s regression test could not detect publication bias [(ICR versus SCR: P = 0.92) (SCR versus IRA: P = 0.37) (ICR versus IRA: P = 0.11)].

Probability analysis ranked CR-I as the best intervention for having the lowest risk of all-cause mortality (SUCRA, 94%), re-infarction (SUCRA, 100%), repeat revascularization (SUCRA, 96%) and CIN (SUCRA, 61%). CR-S was ranked as the best intervention to reduce the risk of major bleeding (SUCRA, 92%) (Fig. 3). These findings were consistent in the sensitivity analysis that again ranked CR-I as the most favorable strategy to decrease all-cause mortality, re-infarction, repeat revascularization and CIN (Fig. 5).

4. Discussion

In this NMA of 11 RCTs including 3,172 patients with STEMI and MVD, CR-I was associated with significant risk reduction in all-cause mortality compared with IRA. On initial analysis, decrease in all-cause mortality was observed with CR-I when compared with CR-S, however it did not reach statistical significance. Sensitivity analysis was then

performed after excluding the studies where staged intervention occurred after 2 weeks of the index event or post discharge, and it showed significant decrease in all-cause mortality with CR-I compared to CR-S and IRA. No difference in mortality was observed between CR-S and IRA A recent NMA by Bangalore et al [16], (11 trials, 3,150 patients) reported that single staged multi-vessel PCI in patients with STEMI was associated with reduction in mortality and myocardial infarction, however no difference in mortality was observed between CR-S and IRA. The mortality benefit seen with single staged multi-vessel PCI in this study is consistent with our findings. These findings demonstrate the benefit of CR-I in decreasing all-cause mortality compared to CR-S and IRA.

Prior meta-analyses have shown significant risk reduction in MACE with complete revascularization, that was primarily driven by decrease in repeat revascularization. However, statistically significant decrease in mortality with complete revascularization, particularly CR-I was not demonstrated [26–32]. This was most likely because most of these studies were either published prior to the new emerging randomized trials or had insufficient sample size, thus limiting the statistical power to determine the estimates. Additionally, most of these analysis included observational studies. A meta-analysis by Elgendy IY [32] and colleagues (10 trials, 2,285 patients) including RCTs only, showed a trend towards decrease in all-cause mortality with CR when compared to IRA intervention however it could not reach statistical significance.

Our study is one of the largest meta-analysis of randomized trials of PCI based revascularization approaches for patients with STEMI and MVD. In our meta-analysis, in addition to the earlier published studies we have incorporated data from the recently published CompareAcute trial that demonstrated reduction in MACE with fractional flow reserve (FFR)-guided complete revascularization compared to selective IRA intervention [13].

With the new emerging data from the recent RCTs, ACC/AHA/SCAI have modified the guidelines for multi-vessel PCI in hemodynamically stable patients with STEMI and MVD from class III to IIb, indicating that PCI of the non-culprit vessels either at the time of the index procedure or as a staged intervention may be considered in selected patients [33]. Also, the updated European Guidelines for STEMI have added a class IIa recommendation for staged PCI of non-culprit lesions in patients with STEMI and MVD prior to the hospital discharge [34]. Our findings and the data from the 2 most recent large meta-analysis [16,35] highlight the benefit of CR-I compared to other revascularization strategies which is a novel finding. Furthermore, with the use of new generation of drug eluting stents, better antiplatelet agents and advances in the PCI based revascularization techniques, the incidence of post procedure complications has significantly reduced [36–41]; making CR-I an effective strategy in acute setting. This novel mortality benefit warrants further validation with RCTs which may impact the current guidelines.

The strength of this meta-analysis lies in the large sample size, inclusion of high-quality RCTs, and application of sophisticated statistical approach. Furthermore, the primary end-point of interest was all-cause mortality which was consistent across the included trials. However, the present findings of decrease in all-cause mortality with CR-I compared to IRA

should be interpreted considering certain limitations. First, this study is limited by heterogeneity of the study participants, procedural techniques, variable endpoint definitions, timing of staged intervention and follow-up duration. Second, for few trials that reported outcomes for complete revascularization; these studies were assigned according to the predominant strategy, however each endpoint was measured at the longest available follow-up for each trial. Third, our results demonstrate similar incidence of CIN and bleeding across all groups, however limited number of trials were available that had reported these outcomes.

5. Conclusions

In this NMA of STEMI patients with MVD, we found that a strategy of complete revascularization during the index procedure was superior to a culprit only revascularization in reducing all-cause mortality. Our findings contend that CR-I should be considered as the preferred revascularization strategy in STEMI patients with MVD who are otherwise hemodynamically stable. Further, well-designed RCTs can validate this impression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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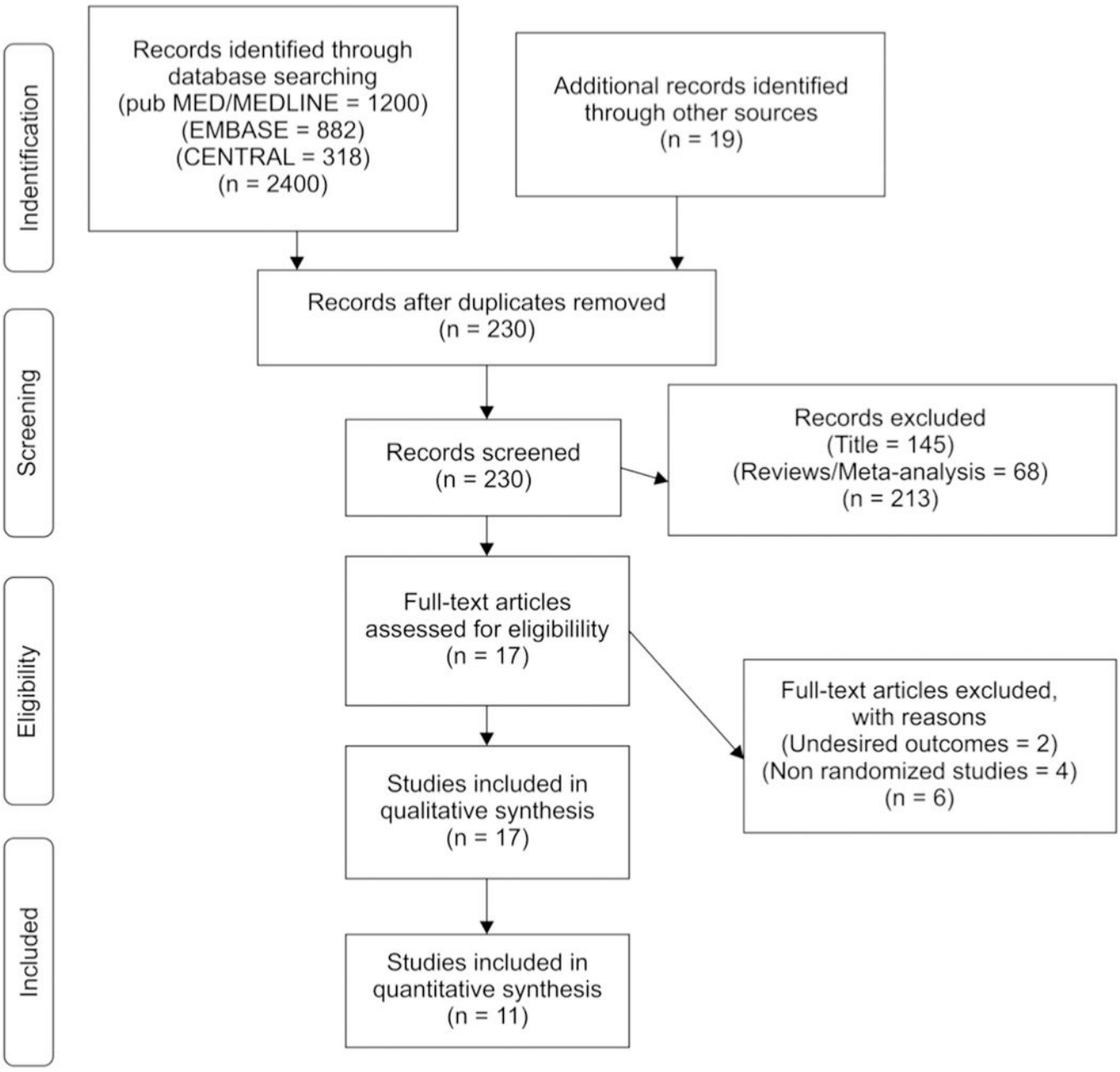

Fig. 1.

PRISMA flow diagram. Study selection flow diagram, demonstrating search methodology for identification of the eligible studies for the meta-analysis. PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analysis.

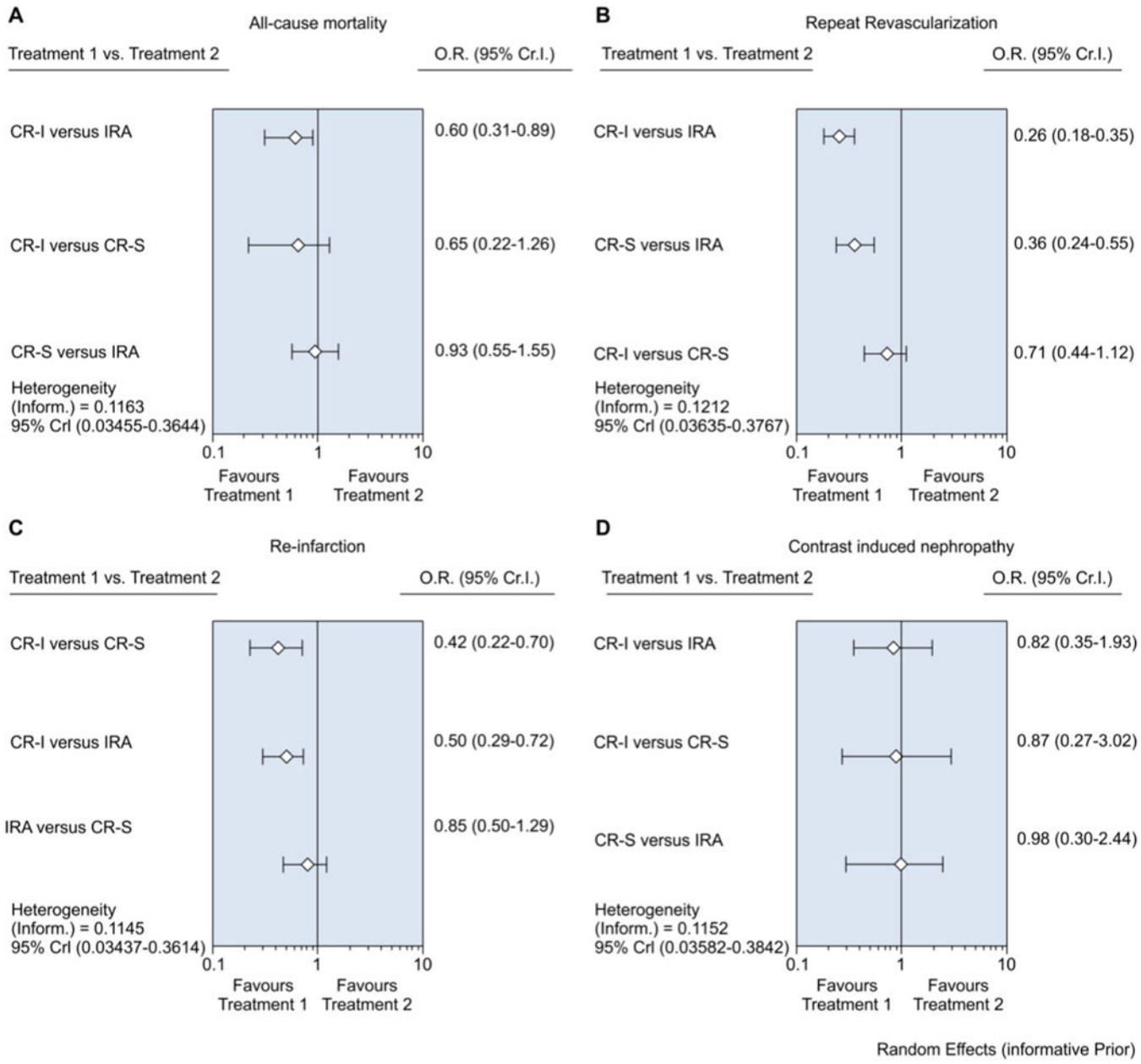

Fig. 2.

Forest plot for the network meta-analysis comparing infarct-related artery (IRA) revascularization, staged complete revascularization (CR-S), and immediate complete revascularization (CR-I) for all- cause mortality, myocardial infarction (MI), repeat revascularization and contrast induced nephropathy (CIN). The horizontal lines indicate odds ratio with 95% credible interval.

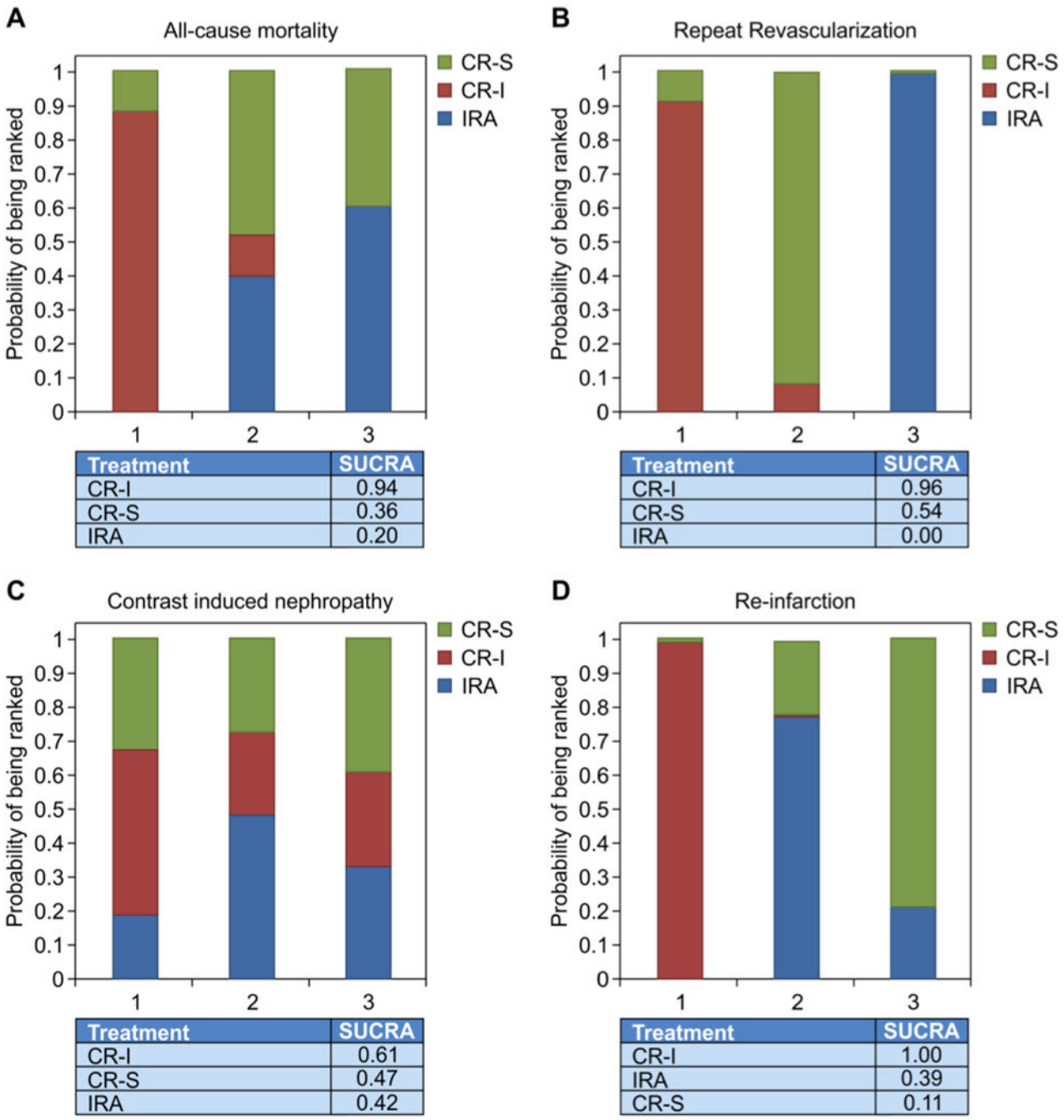

Fig. 3.

Rankograms for the network meta-analysis comparing infarct-related artery (IRA) revascularization, staged complete revascularization (CR-S), and immediate complete revascularization (CR-I) for all-cause mortality, myocardial infarction (MI), repeat revascularization and contrast induced nephropathy (CIN).

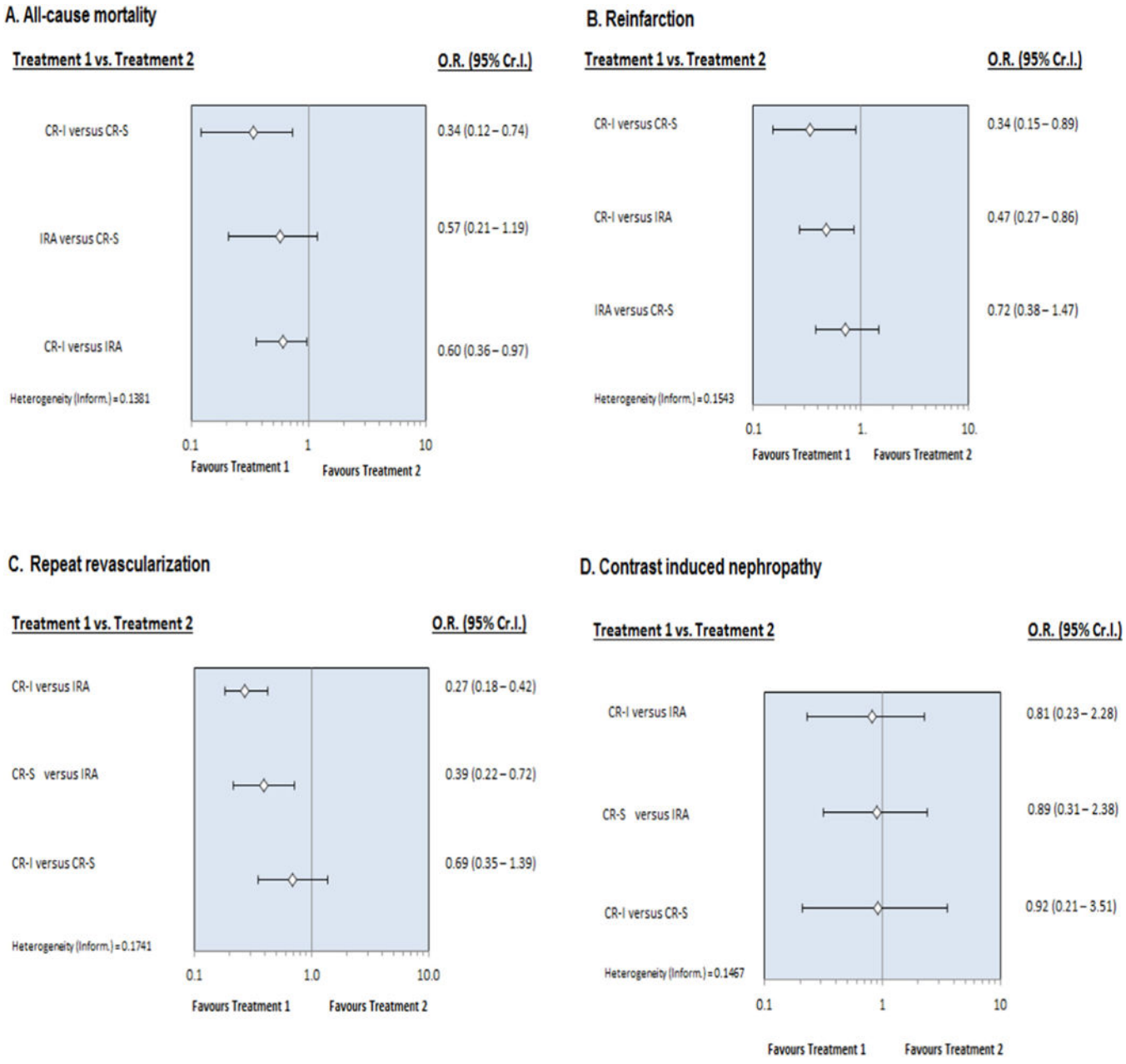

Fig. 4.

Forest plot for the sensitivity analysis (after excluding the studies where staged intervention was performed >2 weeks after the index procedure or post discharge) comparing infarct-related artery (IRA) revascularization, staged complete revascularization (CR-S), and immediate complete revascularization (CR-I) for all- cause mortality, myocardial infarction (MI), repeat revascularization and contrast induced nephropathy (CIN). The horizontal lines indicate odds ratio with 95% credible interval.

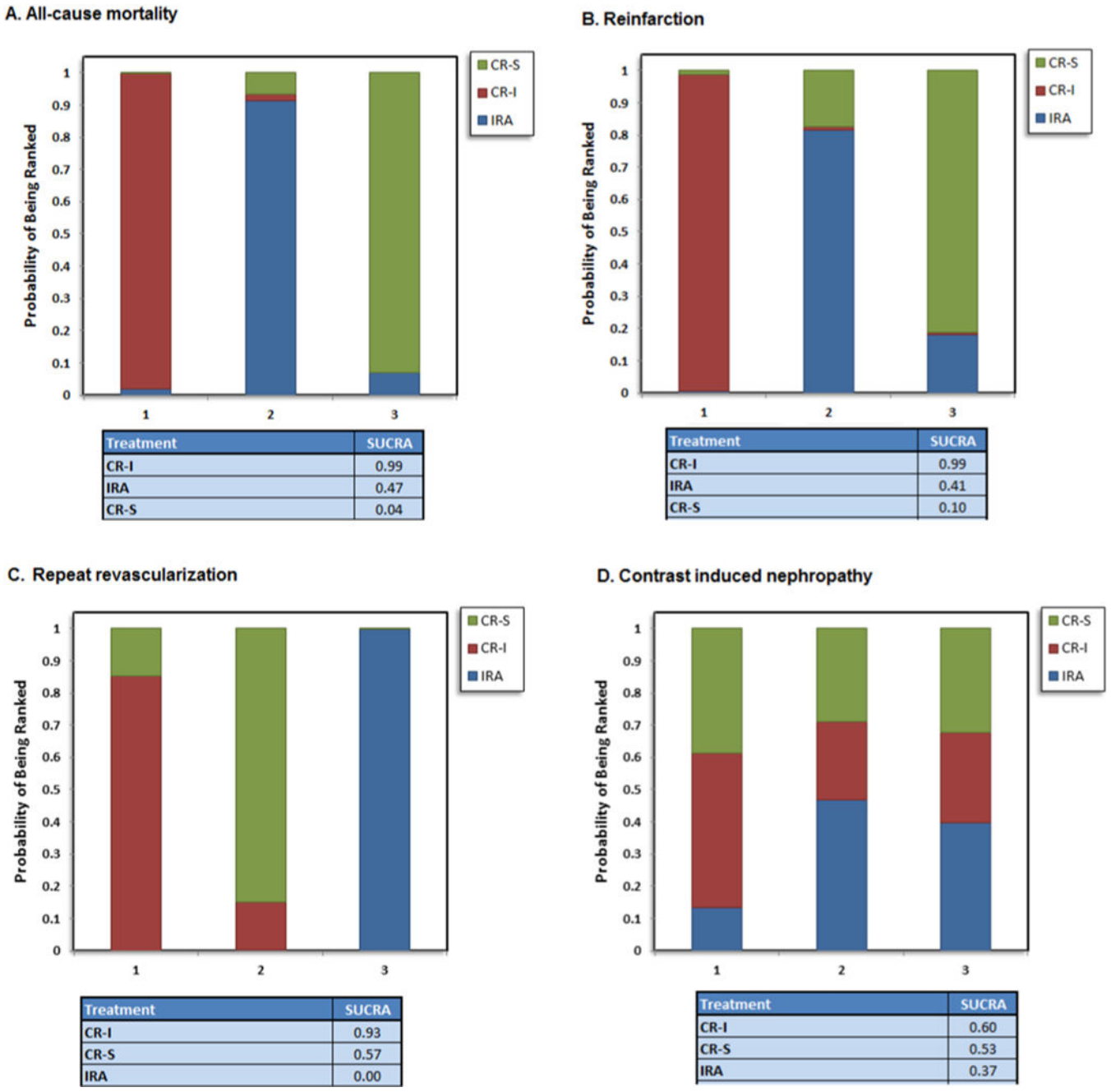

Fig. 5.

Rankograms for the sensitivity analysis (after excluding the studies where staged intervention was performed >2 weeks) comparing infarct-related artery (IRA) revascularization, staged complete revascularization (CR-S), and immediate complete revascularization (CR-I) for all-cause mortality, myocardial infarction (MI), repeat revascularization and contrast induced nephropathy (CIN).

Table 1

Baseline patient characteristics.

Studies	Arms	*N* = 3172	Mean age (year)	Men (%)	HTN (%)	DM (%)	Smoking (%)	Prior MI (%)	Follow up (months)
DANAMI-3-PRIMULTI [11]	CR-S	314	64	80	41	9	51	5	27
	IRA	313	63	81	47	13	48	9	
POLITI et al. [25]	IRA	84	67	76	60	24	N/A	N/A	29
	CR-S	65	64	80	65	19	N/A	N/A	
	CR-I	65	65	77	49	14	N/A	N/A	
CvLPRIT [10]	IRA	146	65	77	36	14	27	3.6	12
	CR (CR-I 64.6%; CR-S 35.4%)	150	65	85	37	13	34	4.8	
PRAMI [9]	CR -I	234	62	76	40	15	50	8	23
	IRA	231	62	81	40	21	45	7	
HAMZA et al.[12]	IRA	50	52	86	36	100	78	6	6
	CR (58% CR-I;42% CR-S)	50	56	82	26	100	72	10	
PRAGUE-13 [23]	CR-S	106	NA	NA	NA	NA	NA	NA	38
	IRA	108	NA	NA	NA	NA	NA	NA	
HELP-AMI [44]	IRA	17	65	85	59	41	81		12
	CR-I	52	64	88	37	12	67		
GHANI et al. [43]	CR-S	80	62	80	26	6	44	6	36
	IRA	41	61	81	43	5	48	5	
TARASOV et al. [42]	CR-I	46	59	70	96	26	0	11	6
	CR-S	43	59	58	86	21	0	5	
PRIMA [24]	CR-I	48	65	73	52	31	38	29	6
	CR-S	44	67	75	48	34	43	23	
COMPARE ACUTE [13]	CR (83.4% CR-I;16.6%CR-S)	295	62	79	46	15	41	8	12
	IRA	590	61	76	48	16	49	8	

CR-S = complete revascularization staged, CR-I = complete revascularization instant, IRA = infarctrelated artery, CR = complete revascularization, N/A = not available. HTN = hypertension, DM = diabetes mellitus, MI = myocardial infarction.

Table 2

Inclusion and Exclusion criteria and endpoints of the included trials.

Study	Year	Inclusion criteria	Exclusion criteria	Primary endpoint	Secondary endpoints
Compare-Acute [13]	2017	Patients with STEMI and MVD (>50% stenosis of the N-IRA)	LM disease, CTO, severe valve disease, Killip class III or IV, severe stenosis and complications after IRA treatment.	MACCE (all-cause mortality, nonfatal MI, any revascularization, cerebrovascular events)	NACE (cardiac death, MI, any revascularization, CVA, major bleeding).
Hamza et al. [12]	2016	Diabetic patients with STEMI and MVD (at least 80% stenosis in N-IRA)	Prior CABG, LM disease and CTO.	Composite of all- cause mortality, recurrent MI, ischemia driven revascularization with PCI or CABG.	Individual component of primary end point, major bleeding and CIN
DANAMI 3-PRIMULTI [11]	2015	Patients with STEMI, MVD (>50% stenosis in the coronary artery)	Intolerance to contrast, cardiogenic shock, increase bleeding risk, stent thrombosis, indication for CABG	Composite of all- cause mortality, reinfarction, or ischemia driven revascularization of non-IRA.	Components of primary end-point, cardiac death, urgent and non urgent PCI of non-IRA
CvLPRIT [10]	2015	STEMI or LBBB with MVD (at least one N-IRAwith >70% lesion in one plane or >50% in 2 plane)	Previous Q-wave MI, prior CABG, cardiogenic shock, VSD or severe MR, CKD, thrombosis of previous stent, CTO	MACE (all-cause mortality, MI,HF, ischemia driven PCI OR CABG).	Components of primary endpoints, CV death, stroke, major bleeding, CIN
PRAGUE-13 (23)	2015	STEMI with successful PCI or IRA, at least 1 stenosis ofN-IRA > 70% with diameter > 2.5 mm, enrolment > 48h following onset of symptoms	Stenosis ofLM, hemodynamically significant valve disease, angina > 1 month prior to STEMI and cardiogenic shock.	All cause mortality, non- fatal MI and stroke.	Hospitalization for unstable angina, revascularization of non-infarct artery, CV mortality, hospitalization for HF, non-fatal MI and all-cause mortality
Tarasov et al. [42]	2014	STEMI with MVD (>70% stenosis ofat least two or more coronary arteries), target lesion amenable to PCI and target lesion located in native artery	Single lesions, acute heart failure Killip class III-IV, LM stenosis, small vessel <2.5 mm, thrombosis of prior stent	MACE (cardiac or non-cardiac death, re-infarction, repeat coronary revascularization.	Individual components of primary endpoints
PRAMI [9]	2013	STEMI and MVD (one or more >50% stenosis of the N-IRA)	Cardiogenic shock, prior CABG, LM disease or disease at ostia ofboth circumflex and LAD and CTO.	Composite of death from cardiac cause, nonfatal MI, refractory angina.	Death from non-cardiac cause, repeat revascularization (PC I and CABG)
Ghani et al. [43]	2012	STEMI with MVD (one or more stenosis in at least 2 major epicardial arteries or the combination of side branch and a main epicardial vessel provided that they supplied different territory	Patients with indication for urgent revascularization, >80 years old, prior CABG, CTO, LM disease, chronic A fib, limited life expectancy.	Ejection fraction at 6 months.	MACE (death, non-fatal re-infarction and additional revascularization).
Politi et al. [25]	2010	MVD (>70% stenosis of 2 or more epicardial coronary artery or major branches by visual estimate), ST elevation on EKG	Cardiogenic shock, LM disease, CABG, severe valve disease	MACE (CV and Non-CV death, in hospital death, re-infarction, re-hospitalization for ACS and repeat coronary revascularization	Length ofhospitalization and CIN
PRIMA [24]	2004	STEMI with successful PCI of IRA and at least 1 significant >70% stenosis of the coronary artery other than IRA	LM disease, cardiogenic shock, target lesion in N-IRA not suitable for PCI.	Absolute improvement in the LVEF, recovery time and magnitude of EF increase were assessed.	Safety of single stage PCI. All cause mortality, MI, urgent revascularization, bleeding, unstable angina and CV hospitalization.

Study	Year	Inclusion criteria	Exclusion criteria	Primary endpoint	Secondary endpoints
HELP- AMI [44]	2004	STEMI with MVD (IRA and one or more lesion in N-IRA)	Lesion in vein graft, arterial conduits or in segments treated with angioplasty or stent implantation, recent thrombolysis, cardiogenic shock, single vessel disease, LM disease, CTO and side branch >2 mm which required to be covered by the stent.	Rate of repeat revascularization over a period of12 months.	Adverse in hospital events, procedural-cost

STEMI = ST elevation myocardial infarction, MVD = multi vessel disease, CTO = chronic total occlusion, LM = left main, N-IRA = non infarct related artery, IRA = infarct related artery, MI = myocardial infarction, CABG = coronary artery bypass grafting, CIN = contrast induced nephropathy, CVA = cerebrovascular accident, PCI = percutaneous coronary intervention, VSD = ventricular septal defect, MR = mitral regurgitation, ACS = acute coronary syndrome, HF = heart failure, MACCE = major adverse cardiovascular cerebrovascular events, NACE = net adverse clinical events.