Adjunctive Thrombectomy for Acute Myocardial Infarction
A Bayesian Meta-Analysis

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***Background*—**In available trials and meta-analyses, adjunctive thrombectomy in acute myocardial infarction (MI) improves markers of myocardial reperfusion but has limited effects on clinical outcomes. Thrombectomy devices simply aspirate thrombus or mechanically fragment it before aspiration. Simple aspiration thrombectomy may offer a distinct advantage.

***Methods and Results*—**We identified 21 eligible trials (16 that used a simple aspiration thrombectomy device) involving 4299 patients with ST-segment elevation MI randomized to reperfusion therapy by primary percutaneous coronary intervention with or without thrombectomy. By using Bayesian meta-analysis methods, we found that thrombectomy yielded substantially less no-reflow (odds ratio [OR], 0.39; 95% credible interval [CrI], 0.18 to 0.69), more ST-segment resolution ≥50% (OR, 2.22; 95% CrI, 1.60 to 3.23), and more thrombolysis in myocardial infarction/myocardial perfusion grade 3 (OR, 2.50; 95% CrI, 1.48 to 4.41). There was no evidence for a decrease in death (OR, 0.94; 95% CrI, 0.47 to 1.80), death, recurrent MI, or stroke (OR, 1.07; 95% CrI, 0.63 to 1.92) with thrombectomy. Restriction of the analysis to trials that used simple aspiration thrombectomy devices did not yield substantially different results, except for a positive effect on postprocedure thrombolysis in myocardial infarction grade 3 flow (OR, 1.49; 95% CrI, 1.14 to 1.99).

***Conclusions*—**In this Bayesian meta-analysis, adjunctive thrombectomy improves early markers of reperfusion but does not substantially effect 30-day post-MI mortality, reinfarction, and stroke. The use of aspiration thrombectomy devices is not associated with a reduction in post-MI clinical outcomes. Thrombectomy is one of the rare effective preventive measures against no-reflow. **(*Circ Cardiovasc Interv*. 2010;3:6-16.)**

Key Words: primary angioplasty ■ thrombus ■ myocardial infarction ■ meta-analysis ■ no-reflow

Reperfusion therapy in acute myocardial infarction (MI) aims at reducing mortality and morbidity by achieving patency of the epicardial infarct-related artery and by restoring myocardial tissue perfusion. The presence of coronary thrombus during primary percutaneous coronary intervention (PCI) has been linked to lower postprocedure thrombolysis in myocardial infarction (TIMI) myocardial perfusion grade (TMPG or myocardial blush score), no-reflow, and drug-eluting stent thrombosis.[1–3]

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Several recent small to moderate size randomized controlled trials (RCTs) have shown that device-based removal of thrombus from the coronary artery has an inconsistent effect on reperfusion surrogate and clinical end points, leading to a debate about its use in primary PCI.[4,5] Meta-analyses of adjunctive thrombectomy trials have reported a definite improvement in surrogate markers of reperfusion.[6–8] These trials tested a variety of devices that either aspirate (Diver CE, Proto, Export, TVAC, and Rescue; Table 1) or fragment (AngioJet and X-sizer; Table 1) the coronary thrombus. The importance of the mechanism of action of the devices has been highlighted by a mortality reduction when an aspiration catheter[9] or a manual thrombectomy device[10,11] was used.

Recently published meta-analyses on manual thrombectomy[10,11] excluded trials that tested the Rescue aspiration device,[12–15] which may bias the results. Other trials have not been included[16–18] in previous meta-analyses.[9–11] Together, these 7 studies added 946 patients for a new analysis. Moreover, no comprehensive meta-analysis compared all purely aspiration devices with PCI alone in acute MI. Therefore, we performed a new meta-analysis, with Bayesian methods, on all trials available to date. We tested whether

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Table 1. Thrombectomy Devices Studied in Randomized Trials

Device	Maker	Description	References
Aspiration thrombectomy devices			
Diver CE	Invatec, Brescia, Italy	Rapid exchange, 6F-compatible, thrombus-aspirating catheter. It has a central aspiration lumen running through its full length and a soft tip with multiple holes communicating with the lumen. A 30-mL luer lock syringe is connected to proximal end for blood aspiration and clot removal.	19,36
Pronto	Vasc.solutions, Minneapolis, Minn	Dual-lumen, monorail design, 6F-compatible catheter. The smaller lumen accommodates a standard 0.014-inch guidewire. The larger extraction lumen allows the removal of the thrombus, which is aspirated in a 30-mL syringe. The catheter has a rounded distal tip designed to maximize thrombus aspiration and to protect the vessel while advancing and during aspiration.	34
Export	Medtronic	6F catheter, which crosses the target lesion over a floppy guidewire and aspirates the thrombus into a 20-mL syringe. The aspiration rate is >30 mL of fluid per minute. The total usable length is 145 cm.	20,30
TVAC	Nipro, Japan	Single-lumen rapid-exchange aspiration shaft compatible with 7F guiding catheters with a dedicated vacuum pump.	28
Rescue	Boston Scientific/Scimed, Inc, Maple Grove, Minn	4.5F aspiration catheter advanced over a guidewire through a 7F guiding catheter The proximal end of the catheter has an extension tube connected to a vacuum pump (0.8 bar) with a collection bottle. The catheter is slowly advanced and pulled back through the thrombus while continuous suction is applied.	14
Mechanical thrombectomy devices			
AngioJet	Possis Medical Inc, Minneapolis, Minn	Rheolytic thrombectomy system consisting of a drive unit, a disposable pump set, and a thrombectomy catheter that tracks over a guidewire. High-velocity saline jets are directed back into the catheter, creating a low-pressure zone at the distal tip (Bernoulli principle), which results in suction, break-up, and removal of thrombus through the outflow lumen.	35
X-Sizer	eV3, White Bear Lake, Minn	Two-lumen over-the-wire system (diameters, 1.5 or 2.0 mm) with a helical shape cutter at its distal tip. The cutter rotates at 2100 rpm driven by a handheld battery motor unit. One catheter lumen is connected to a 250-mL vacuum bottle, and aspirated debris are collected in an inline filter. Two or three passages across the lesion are performed	29

thrombectomy with any device or with an aspiration device leads to better myocardial perfusion and clinical outcomes.

Methods

Search Strategy and Data Collection

We searched electronic medical databases for RCTs by using the words "thrombectomy," "thrombus," and "myocardial infarction," restricting our selection to publications in French or English. References of selected studies and programs from recent international meetings were reviewed for relevant unpublished RCTs. The search was kept updated until October 2009. Included trials (1) used adjunctive thrombectomy in primary PCI for acute ST-segment elevation MI only and (2) randomly allocated patients to primary PCI with or without thrombectomy. Trials that randomized rescue PCI patients were included, but those that tested facilitated PCI with fibrinolysis were excluded. We included RCTs published as abstracts to minimize publication bias. When trials were reported in multiple forms, priority was given to journal articles, although meeting presentations and report of substudies were also reviewed for complementary information.[19–24] These studies were counted as a single trial. Double independent abstraction of data was performed (FPM and 1 other reviewer), and discrepancies between datasets were resolved by consensus.

Outcomes and Definitions

Clinical outcomes within 30 days of primary PCI were mortality and a composite of death, MI, and stroke. Angiographic outcomes were postprocedure TIMI grade 3 flow, postprocedure TMPG 3, no reflow, and distal embolization. ST-segment resolution ≥50% was also used as an end point for myocardial reperfusion because it correlates with early post-MI mortality and heart failure.[25] Procedure time (the time spent doing PCI) and symptom onset to balloon time (STBT) were compared between thrombectomy and control groups. Outcomes were as defined by individual trials. No reflow was defined as an acute reduction in coronary flow (TIMI grade 0 to 1) in the absence of dissection, thrombus, spasm, or high-grade residual stenosis at the target lesion.[2] Assessment of angiographic outcomes by an independent core laboratory blinded to treatment groups was confirmed in 6 of 20 trials.[20,26–30] Angiograms were reviewed by blinded investigators in 9 trials.[12,14,16–19,23,31–34]

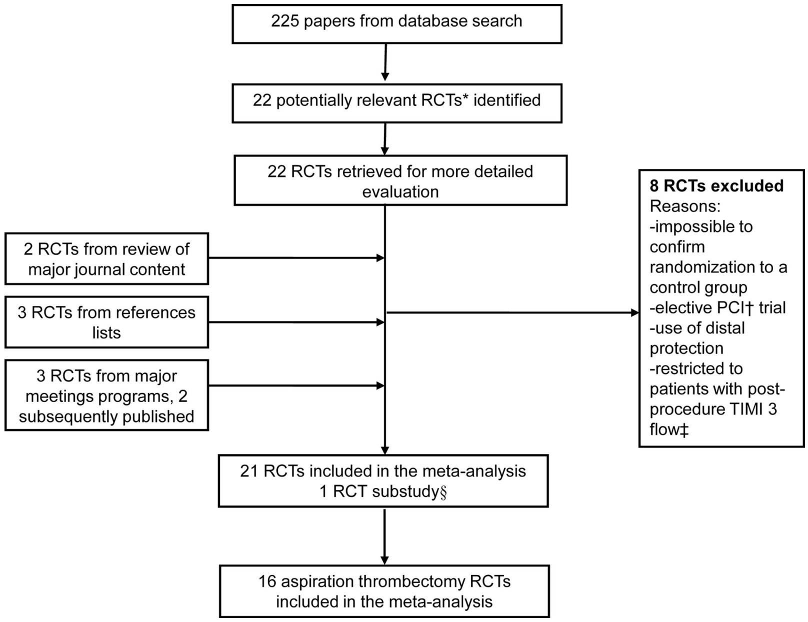

Figure 1. Flow diagram of trials selection. *RCT, randomized controlled trial; †Randomized patients without an acute MI; PCI, percutaneous coronary intervention; ‡TIMI, Thrombolysis in Myocardial Infarction; §Included for complementary information when not provided in the main publication.

Thrombectomy Devices

Six different thrombectomy devices were studied in the 21 included RCTs (Table 1). Catheters that remove thrombus with negative pressure were classified as "aspiration" devices.[9] Catheters that fragment the clot before aspirating debris[36] were classified as "mechanical" devices. Different mechanisms of action may introduce heterogeneity in treatment effects between trials. We first performed the meta-analysis including all trials, regardless of the thrombectomy technique. To test whether aspiration devices lead to better outcomes compared with standard PCI, we repeated the meta-analysis including only trials that used aspiration.[12–20,23,27,28,30,34,35,37]

Statistical Analysis

Bayesian hierarchical random-effects meta-analysis models were used for both continuous and dichotomous outcomes. These models are the Bayesian analog of standard random-effects models but have more flexibility in terms of modeling options and, unlike standard methods, are able to provide inferences of direct clinical utility, such as the probability that 1 intervention is better than another.[38] For dichotomous outcomes, the probability of an event within each group from each trial is assumed to follow a binomial distribution. The binomial success parameters are allowed to vary between both thrombectomy and control groups within each study and between each study included in the meta-analysis. To model the between-trial variability, the logarithms of the odds ratios (ORs) of each outcome variable from each trial were assumed to follow a normal distribution. The mean of the normal distribution of log OR across trials therefore represents the average treatment effect in the trials, and the variance represents the variability of the treatment effect among trials. For continuous outcomes, the differences between outcomes within each trial were assumed to follow a normal distribution, whose mean represented the overall average difference in the outcome, and whose variance represented the variability between trials in this outcome difference. Throughout all analyses, low information from the previous distributions were used, so that the final inferences are based almost entirely on the observed data and not on the information contained in the previous distributions. In particular, treatment means were normally distributed a priori with zero mean and variance of 1 million. Previous distributions for between-study variances were uniform on the range [0.001, 10], which is very wide on the log scale. All inferences were performed with WinBUGS software (version 1.4, MRC Biostatistics Unit, Cambridge, UK; WinBUGS programs are available from the authors on request). Forest plots were produced to display the OR and 95% credible intervals (CrIs) for all major outcomes pooled in our meta-analysis. CrIs are the Bayesian analog to frequentist confidence intervals.

Results

Trials, Patients, and Thrombectomy Device Characteristics

Figure 1 shows our search strategy. The analysis was performed with 21 trials (4299 patients); 16 trials (3365 patients) were included in the aspiration-only analysis. Thrombectomy was successful in most cases regardless of the device used (Table 2). There was liberal use of glycoprotein IIB/IIIA inhibitors (Table 2). Cardiovascular risk factors were well balanced between treatment and control groups in individual trials (Table 3).

Differences in Inclusion and Exclusion Criteria in Selected Trials

Typical eligibility criteria were ST-segment elevation MI referred for primary or rescue PCI presenting within 12 hours of symptoms onset. The maximal time after symptom onset was 6 hours in 1 trial,[27] 9 hours in another,[24] 24 hours in 2 trials,[15,28] and 48 hours in 1 trial.[16] Angiographically visible thrombus was required in 5 trials.[13,24,32,33,35] Patients in shock or those requiring intra-aortic balloon counterpulsation or mechanical ventilation were excluded from 11 trials,[13,15,16,18,20,24,26,29,31,34,35] and patients with previous coronary artery bypass were excluded from 9 trials.[12,14,16,18,20,24,28,34,35] Only 2 RCTs specifically excluded patients with a left ventricular ejection fraction <30%.[26,29] Six trials reported crossovers from the control to the thrombectomy group (range, 3 to 18 patients).[19,20,26,30,31,34] One trial recruited only anterior MIs.[35] Some trials required an infarct-related artery minimal reference diameter of at least 2.5 mm[13,15,20,24,28,29,31,33,39] or 2 mm.[26] Patients with left main coronary stenosis were excluded from 7 trials,[12,14,15,18,24,28,33]

Table 2. RCTs Investigating Adjunctive Thrombectomy in Acute MI

Reference	Trial Acronym	Year	Device	No. Patients		Anterior MI, %		Use of Glycoprotein IIB/IIIA Inhibitors, %		Success of Thrombectomy,* %
				Tx	Controls	Tx	Controls	Tx	Controls	
Aspiration thrombectomy trials										
Burzotta et al[19]	REMEDIA	2005	Diver CE	50	49	40.0	51.0	32	24.5	94
De Luca[35]		2006	Diver CE	38	38	100	100	NR	NR	NR
Dudek[27]	PIHRATE	2007	Diver CE	102	94	NR	NR	62	63	75
Noel et al[37]		2005	Export	24	26	NR	NR	NR	NR	96
Sardella et al[23,24]	EXPIRA	2007	Export	88	87	NR	NR	100	100	NR
Chao et al[18]		2008	Export	37	37	60	65	19	32	NR
Chevalier et al[20]	EXPORT	2008	Export	120	129	49.2	55.8	65.8	69.8	94.2
Svilaas et al[30]	TAPAS	2008	Export	535	536	NR	NR	93.4	89.9	89
Lipiecki et al[16]		2009	Export	20	24	NR	NR	30	74	100
Liistro et al[17]		2009	Export	55	56	NR	NR	100	100	100
Silva-Orrego et al[34]	DEAR-MI	2006	Pronto	74	74	42	51	100	100	89
Dudek et al[13]		2004	Rescue	40	32	40	56	0	0	87
Kunii et al[15]	NONSTOP	2004	Rescue	129	129	NR	NR	NR	NR	76.7
Kaltoft et al[14]		2006	Rescue	108	107	46	43	96	93	89
Andersen et al[12]		2007	Rescue	87	85	NR	NR	100	100	87
Ikari et al[28]	VAMPIRE	2008	TVAC	180	175	NR	NR	0	0	82.8
Mechanical thrombectomy trials										
Beran et al[32]		2002	X-Sizer	30	31	35	35	73	68	100
Napodano et al[33]		2003	X-Sizer	46	46	39.1	43.5	43.4	41.3	91.3
Lefevre et al[29]	X AMINE ST	2005	X-Sizer	100	101	54	50	55	65	87
Antoniucci et al[31]		2004	AngioJet	50	50	34	46	98	98	96
Ali et al[26]	AIMI	2006	AngioJet	240	240	NR	NR	95.0	94.2	95.4
Total				2153	2146	48.2	52.3	74.7	76.5	87.4

Tx indicates thrombectomy; REMEDIA, Randomized Evaluation of the Effect of Mechanical Reduction of Distal Embolization by Thrombus-Aspiration in Primary and Rescue Angioplasty; PIHRATE, Polish-Italian-Hungarian Randomized ThrombEctomy Trial; EXPIRA, Thrombectomy With Export Catheter in Infarct-Related Artery During Primary Percutaneous Coronary Intervention Prospective, Randomized Trial; EXPORT, Prospective, multicentre, randomized study of the Export aspiration catheter; TAPAS, Thrombus Aspiration During Percutaneous Coronary Intervention in Acute Myocardial Infarction Study; DEAR-MI, Dethrombosis to Enhance Acute Reperfusion in Myocardial Infarction; NONSTOP, Signification of acronym not specified; VAMPIRE, VAcuuM asPIration thrombus Removal; X AMINE ST, X-Sizer in AMI for Negligible Embolization and Optimal ST Resolution; AIMI, AngioJet Rheolytic Thrombectomy In Patients Undergoing Primary Angioplasty for Acute Myocardial Infarction; NR, not reported.

*Successful delivery or ability of the thrombectomy catheter to cross the target lesion.

and those with excessively calcified and tortuous arteries were excluded from 2 trials.[15,29]

Clinical End Points

Adjunctive thrombectomy with any device (OR, 0.94; 95% CrI, 0.47 to 1.80) or with an aspiration device (OR, 0.58; 95% CrI, 0.28 to 1.22) did not substantially change early post-MI mortality (Figure 2A and 2B). Although the OR point estimate suggests a trend toward lower post-MI mortality with aspiration thrombectomy, the wide CrI precludes definitive conclusions regarding any mortality benefit associated with its use. Thrombectomy did not affect the occurrence of the composite end point regardless of the type of device (Figure 3A and 3B).

ST-Segment Resolution

More patients achieved ≥50% ST-segment resolution with thrombectomy (OR, 2.22; 95% CrI, 1.60 to 3.23; Figure 4A). The OR was nearly identical when we pooled RCTs that used aspiration devices (OR, 2.24; 95% CrI, 1.53 to 3.46; Figure 4B).

Angiographic Outcomes

No reflow (OR, 0.39; 95% CrI, 0.18 to 0.69; Figure 5A) and distal embolization (OR, 0.46; 95% CrI, 0.28 to 0.70; Figure 6A) were less frequent with adjunctive thrombectomy. Aspiration thrombectomy devices had a similar effect on these outcomes (Figures 5B and 6B). No reflow was adjudicated by a core laboratory[20,26,28,29] or by blinded reviews.[17,19,33,34] Thrombectomy also lead to more TMPG 3 (OR, 2.50; 95% CrI, 1.48 to 4.41; Figure 7A). Restricting the analysis to aspiration devices reinforced this finding (OR, 3.04; 95% CrI, 1.74 to 5.78; Figure 7B). There was inconclusive evidence for improvement in postprocedure TIMI grade 3 flow with thrombectomy (OR, 1.38; 95% CrI, 0.97 to 2.01; Figure 8A).

Table 3. Baseline Patient Characteristics in Trials of Adjunctive Thrombectomy in Acute MI

		Mean Age, y		Diabetes, %		Hypertension, %		Dyslipidemia, %		Shock, %	
References	Trial Acronym	Tx	Controls	Tx	Controls	Tx	Controls	Tx	Controls	Tx	Controls
Aspiration thrombectomy trials											
Burzotta et al[19]	REMEDIA	61	60	22	18.4	62	57.1	54.0	34.7	8.0	10.2
De Luca et al[35]		66.7	64.6	23.7	18.4	39.5	50	NR	NR	NR	NR
Dudek[27]	PIHRATE	61	58	12	10	58	54	42	50	0	0
Noël et al[37]		61.2	61.2	NR	NR	NR	NR	NR	NR	NR	NR
Sardella et al[23,24]	EXPIRA	66.7	64.6	22.7	18.4	67.0	49.4	NR	NR	NR	NR
Chao et al[18]		60	62	32	22	57	57	60	57	0	0
Chevalier et al[20]	EXPORT	59.2	61.2	16.7	13.2	41.7	44.2	36.7	41.9	0	0
Svilaas et al[30]	TAPAS	63	63	10.6	12.6	33.1	37.1	23.7	27.1	NR	NR
Lipiecki et al[16]		59	59	5	8	25	33	30	21	NR	NR
Liistro et al[17]		64	65	20	12	60	53	34	30	NR	NR
Silva-Orrego et al[34]	DEAR-MI	57.3	58.9	21	15	37	46	34	25	0	0
Dudek et al[13]		56.7	59.1	10	19	75	81	NR	NR	NR	NR
Kunii et al[15]	NONSTOP	NR	NR	NR	NR	NR	NR	NR	NR	0	0
Kaltoft et al[14]		65	63	8.3	5.6	30.5	20.6	9.3	9.3	NR	NR
Andersen et al[12]		64	62	7	5	29	19	9	10	NR	NR
Ikari et al[28]	VAMPIRE	63.2	63.5	23.3	29.9	54.8	59.0	50.0	48.5	NR	NR
Mechanical thrombectomy trials											
Beran et al[32]		55.9	53.9	17	13	53	36	60	58	13	7
Napodano et al[33]		61.3	63.6	13.0	13.0	60.9	65.2	50.0	52.1	NR	NR
Lefevre et al[29]	X AMINE ST	61	62	25.0	17.8	54.0	50.5	58.0	61.4	NR	NR
Antoniucci et al[31]		53	66	18	16	36	38	46	48	6	12
Ali et al[26]	AIMI	60	59.9	16.7	15.8	42.9	42.1	22.1	25.4	0	0
Total		62.7	62.9	15.8	14.8	44.3	43.6	32.8	33.6	1.3	1.6

Tx indicates thrombectomy; NR indicates not reported. Trial acronyms as in Table 2.

It became more definite with aspiration RCTs (OR, 1.49; 95% CrI, 1.14 to 1.99; Figure 8B) and exclusion of the large and negative AiMI trial.[26]

Procedure Time and STBT

Procedure time and STBT data were available in 9 and 11 trials, respectively. On average, primary PCI was 5.8 (95% CrI, −29.2 to 40.6) minutes longer, but STBTs were −12.8 (95% CrI, −116.4 to 91.4) minutes shorter in patients receiving thrombectomy, both CrIs overlapping zero. For aspiration thrombectomy trials, the procedures were 2.2 (95% CrI, −75.6 to 80.2) minutes longer, whereas STBTs were −13.2 (95% CrI, −166.3 to 138.0) minutes shorter. Again, both CrIs crossed the null value.

Discussion

Summary of Results

This meta-analysis summarizes data from all RCTs of adjunctive thrombectomy in acute MI. Thrombectomy improved surrogate markers of myocardial reperfusion, as previously reported,[6–10] but this did not translate into improved clinical outcomes. We found a substantial reduction in the occurrence of no reflow with thrombectomy. In contrast to previous reports,[9–11] the use of aspiration devices did not produce better results, except for postprocedural TIMI grade 3 flow.

Previous Meta-Analyses

Our study is the first to use Bayesian methods. Non-Bayesian methods tend to understate uncertainty in the individual study and overall effect parameters.[38] Moreover, new trials had been published since earlier work.[6–11] In the recent patient-data pooled analysis by Burzotta et al,[11] data from 6 RCTs were not obtained from the investigators, which may have introduced a bias. Our results summarize all available data to date.

No Reflow

Our meta-analysis is the first to show that adjunctive thrombectomy reduces no reflow. Therefore, the pathophysiology of no reflow may rather involve thrombus embolization and not specifically plaque disruption as previously proposed.[40] A reduction in no reflow is an important finding because few treatments are efficacious once it occurs.

Other Surrogate Markers of Myocardial Perfusion

Adjunctive thrombectomy, with any type of device, had an overall positive effect on ST-segment resolution and TMPG

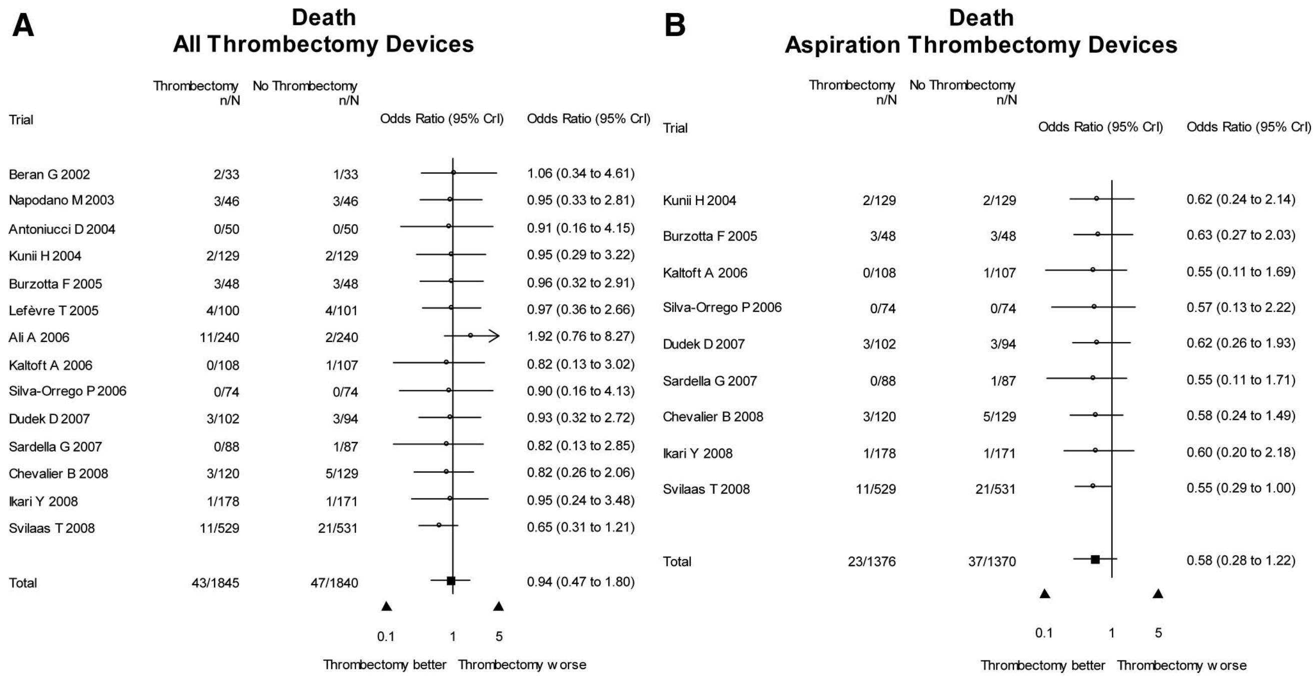

Figure 2. Thirty-day post-MI mortality. Forest plots for death in all types of device trials (A) and in aspiration thrombectomy device trials (B). White circles are individual trials OR, and black squares are meta-analytic OR; horizontal lines are 95% CrIs.

3. Aspiration thrombectomy led to more TIMI grade 3 flow. For most RCTs, the ORs of TIMI grade 3 flow are usually concordant with TMPG 3 regarding the effect of thrombectomy. The trial by Napodano et al[33] showed a clear benefit of thrombectomy on TMPG 3 with a neutral effect on TIMI grade 3 flow. These data suggest that standard PCI therapy is good at restoring epicardial flow but that thrombectomy provides additive benefit of keeping the microcirculation open. Trials that showed a negative effect of thrombectomy on TMPG 3 also failed at restoring TIMI grade 3 flow.[26]

Aspiration Thrombectomy Devices

It was conceivable that simple, less bulky, aspiration catheters that do not purposely fragment the thrombus cause less distal embolization or atheroma dislodgement. Under this

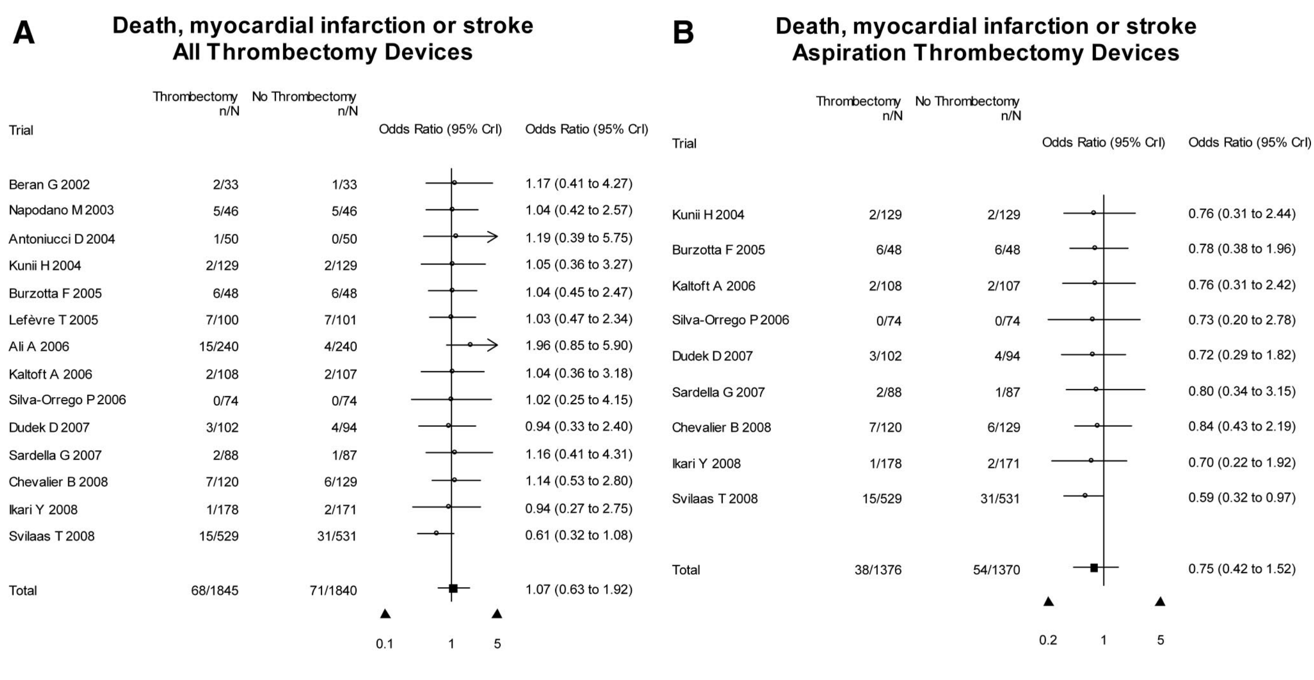

Figure 3. Thirty-day post-MI clinical events. Forest plots for death, reinfarction, and stroke for all types of device trial (A) and aspiration thrombectomy device trials (B). Graphics as in Figure 2.

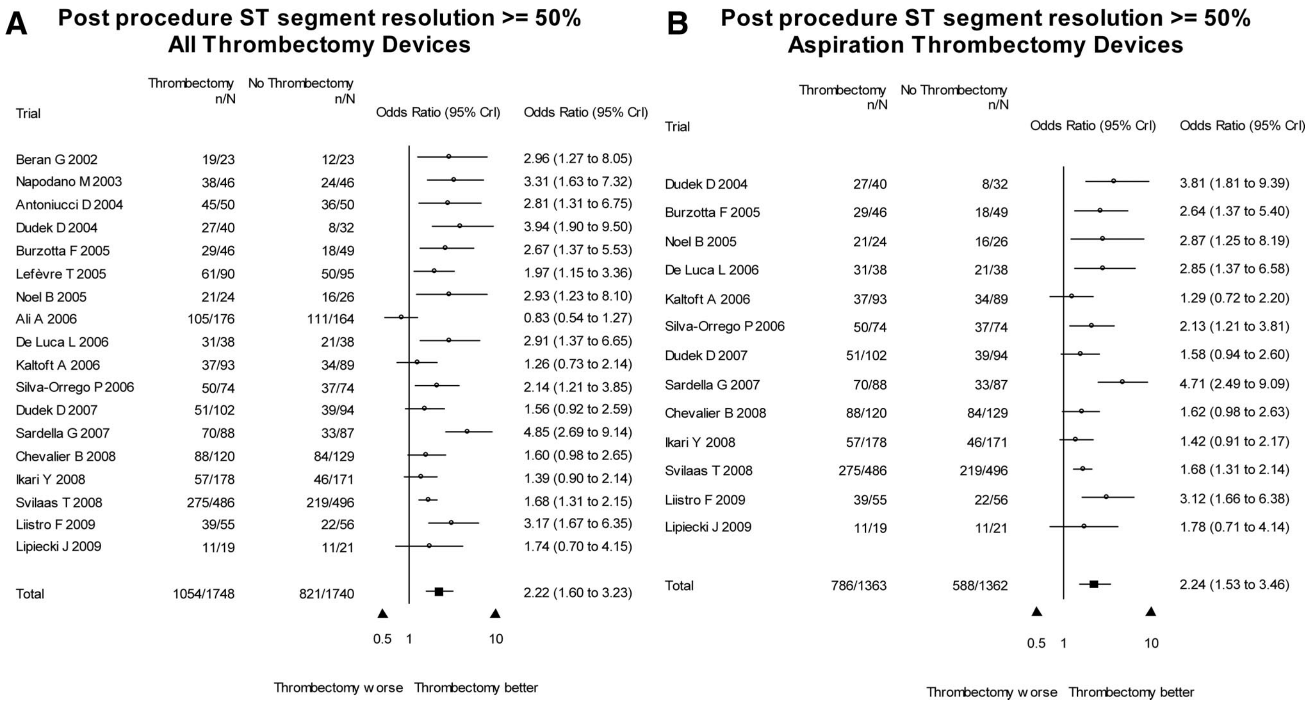

Figure 4. Post-MI ST-segment resolution. Forest plots for all types of device trials (A) and aspiration thrombectomy device trials (B). Graphics as in Figure 2.

hypothesis, a meta-analysis[10] and a patient-data pooled analysis[11] found a reduction in short- and long-term post-MI mortality with "manual thrombectomy." These analyses excluded trials[12–15] that tested the Rescue catheter (Boston Scientific) and thus the results may be misleading. We included these trials because we followed the device classification (aspiration versus mechanical thrombectomy catheters) proposed by Bavry et al.[9] Given that the reduction in no reflow and distal embolization was observed regardless of the mechanism of thrombectomy, we believe that the lack of mortality benefit with nonaspiration devices[9,11] cannot be explained by worse angiographic outcomes. Moreover, the small difference in procedural time in favor of aspiration devices is unlikely to have an effect on clinical events.

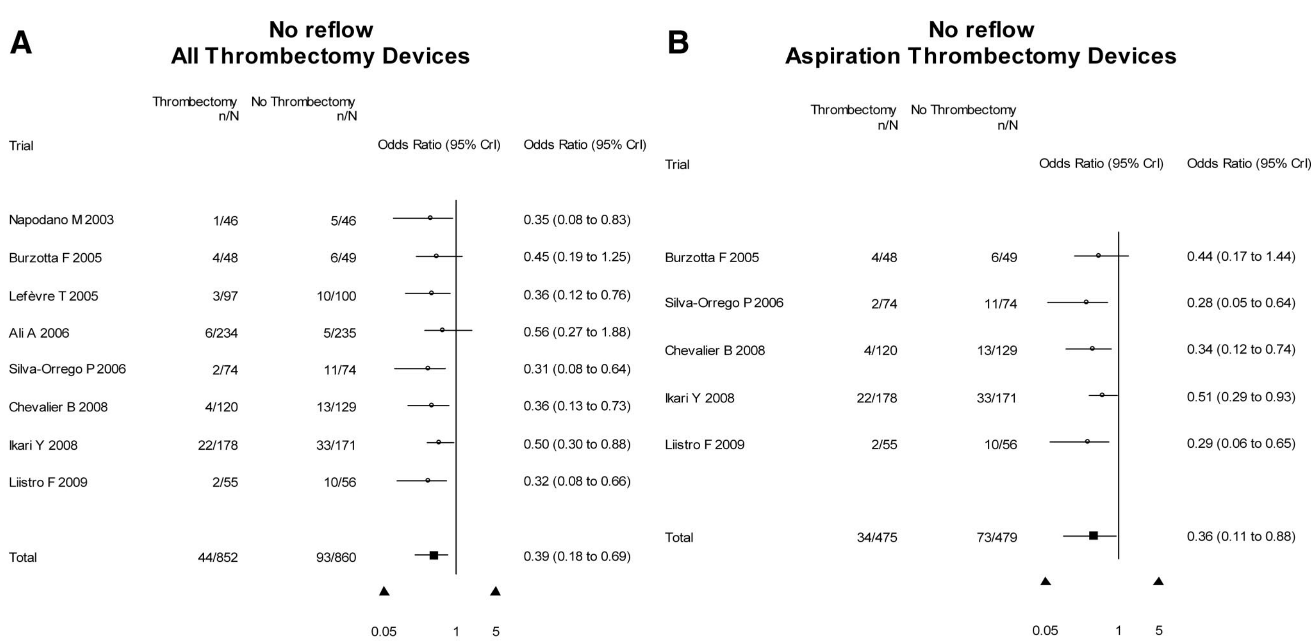

Figure 5. No reflow. Forest plots for no reflow in all types of device trials (A) and in aspiration thrombectomy device trials (B). Graphics as in Figure 2.

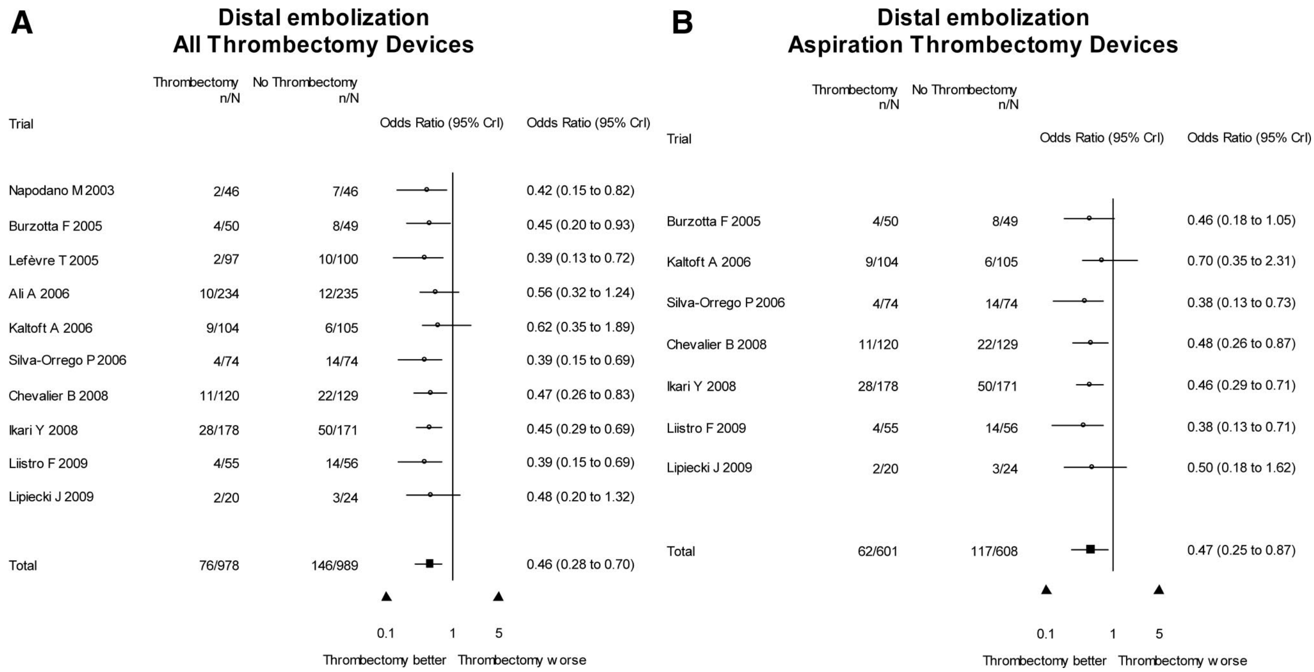

Figure 6. Distal embolization. Forest plots for distal embolization in all types of device trials (A) and in aspiration thrombectomy device trials (B). Graphics as in Figure 2.

Improved Surrogate Markers of Reperfusion Without an Effect on Clinical Outcomes

Several reasons may explain why adjunctive (aspiration or mechanical) thrombectomy did not improve early post-MI clinical outcomes despite a favorable effect on markers of reperfusion. First, we only examined the most commonly reported 30-day post-MI clinical outcomes. We cannot exclude a mortality benefit at ≥6 months after MI. Better myocardial perfusion in the acute phase of MI may lead to less left ventricular remodeling and reduced cardiovascular mortality.[41] Indeed, 1 trial[42] and 2 pooled analysis[9,11] suggested that a clinical benefit with aspiration thrombectomy may appear beyond 6 months of follow-up. Second, most studies excluded patients at higher risk, such as those with cardiogenic shock or left main coronary disease, in whom the benefits of thrombectomy may be greater. Trials randomized low-to-moderate-risk patients who had a combined incidence of death, MI, or stroke at 30 days <4%. With such low event

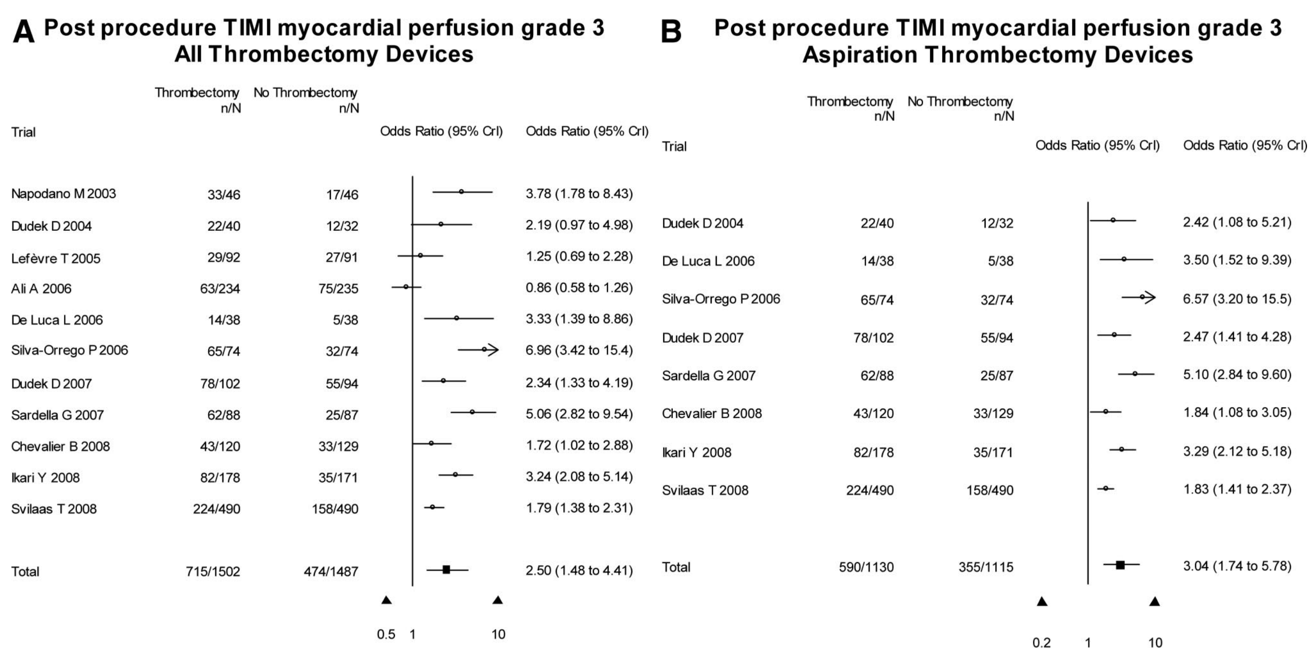

Figure 7. TMPG 3. Forest plots for TMPG 3 in all types of device trials (A) and in aspiration thrombectomy device trials (B). Graphics as in Figure 2.

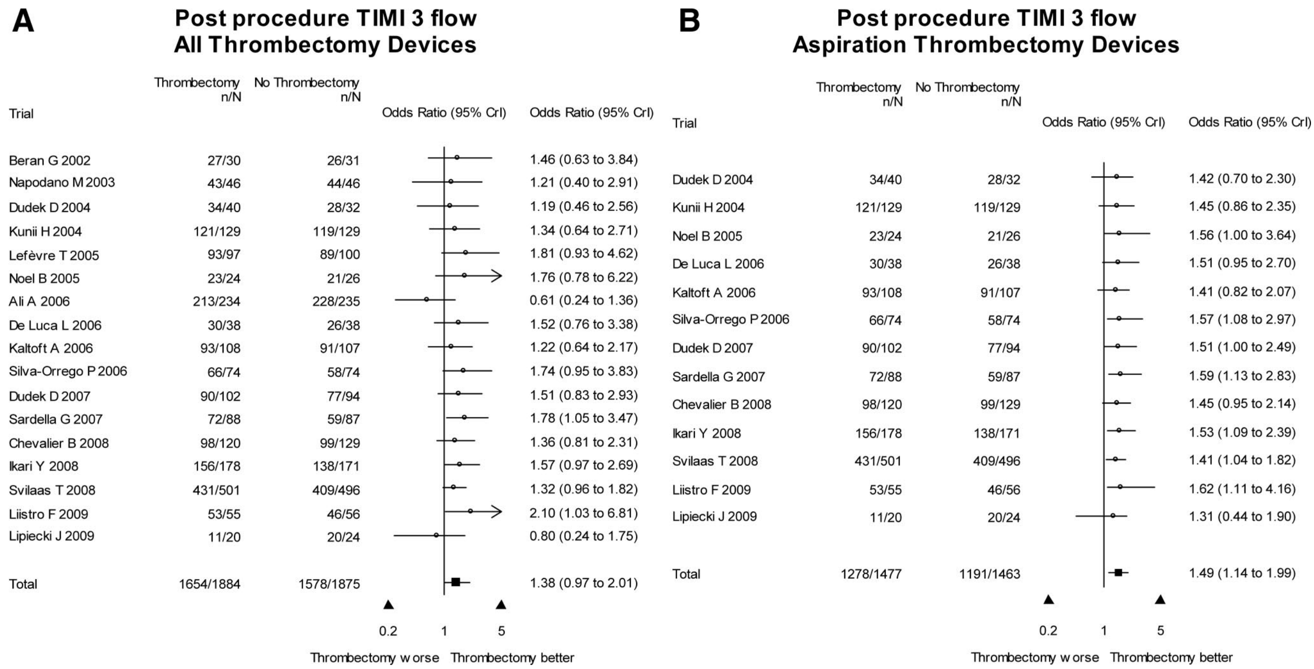

Figure 8. TIMI flow 3. Forest plots for TIMI flow 3 in all types of device trials (A) and in aspiration thrombectomy trials (B). Graphics as in Figure 2.

rates, all individual trials were substantially underpowered to demonstrate differences in clinical outcomes, and our meta-analysis, despite having 4299 patients, remains underpowered for clinical end points, as reflected by the large CrI. Third, impaired microvascular perfusion may be related to factors that are unlikely to be affected by thrombectomy,[43] such as necrosis, edema, reperfusion injury, and endothelial dysfunction.

Symptom Onset to Balloon Time

The mean STBT was shorter, though not significantly, in the thrombectomy groups compared with the control groups of included RCTs. Such a finding is not explained and is likely the result of chance because thrombectomy clearly adds procedural time. STBT was highly variable between trials (range, 189 to 432 minutes). A 12- to 13-minute difference in ischemic time in favor of thrombectomy would be expected to affect clinical outcomes just by the reduction of the infarct duration.[44] However, no short-term clinical effect of thrombectomy was achieved despite this time-to-treatment advantage.

Study Limitations

This meta-analysis is limited by the use of study-level data, and the results should be interpreted with caution. Available sample size remains limited, even with 21 trials. This leads to large CrI and less conclusive results with regard to clinical outcomes. The small sample size did not allow for more refined subgroup analyses, nor did it allow us to adjust the results of the meta-analysis for some confounding factors. There was substantial heterogeneity in trial design, thrombectomy devices, and reported outcomes. Not enough trials reported infarct size and events at ≥6 months to perform a meta-analysis on these end points. The presence of thrombus is sometimes difficult to assess by angiography, which can lead to selection of inappropriate lesions for thrombectomy. Only a few studies reported on the material retrieved by thrombectomy.[20,28] Thrombectomy is unlikely to be useful in the absence of thrombus.

Conclusions

In our Bayesian meta-analysis cumulating data from 4299 MI patients, adjunctive thrombectomy did not affect 30-day mortality, reinfarction, and stroke. Thrombectomy with an aspiration catheter had no clinical advantage when all available data are analyzed. However, thrombectomy had clearly favorable effects on several surrogate markers of myocardial reperfusion and may be 1 of the select few preventive measures against no reflow. The clinical effect of thrombectomy may only become apparent after several months.[11,42] Limited sample size and recruitment of low-to-moderate-risk patients are other likely explanations for the lack of early clinical benefits of thrombectomy. Further data on long-term clinical effects of thrombectomy are needed to justify a liberal use of these costly devices in primary PCI.

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Disclosure

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CLINICAL PERSPECTIVE

Device-based removal of thrombus from the infarct-related artery (adjunctive thrombectomy) during primary percutaneous coronary intervention for acute myocardial infarction (MI) has been the object of increasing interest. Devices can be classified on the basis of their mechanism of action. Suction of the thrombus into a catheter is termed aspiration thrombectomy, whereas mechanical thrombectomy refers to clot fragmentation before aspiration of debris. Aspiration thrombectomy is more simple to perform, and a recent pooled analysis suggested that these less bulky devices have a mortality benefit compared with mechanical devices. In this Bayesian meta-analysis, we tested whether thrombectomy with any device or with an aspiration device leads to better myocardial perfusion and clinical outcomes. Bayesian methods, unlike standard methods, are able to provide inferences of direct clinical utility, such as the probability that 1 intervention is better than another. We found that thrombectomy yielded substantially less no reflow, more ST-segment resolution ≥50%, and more thrombolysis in myocardial infarction myocardial perfusion grade 3. Thrombectomy may be 1 of the few preventive measures against no reflow, for which treatments are limited once it is established. However, there was no evidence for a decrease in 30-day post-MI death, death, recurrent MI, or stroke. Moreover, aspiration thrombectomy devices did not lead to substantially better results. It remains possible that a benefit from thrombectomy emerges ≥6 months after MI. Further data on long-term clinical effects of thrombectomy are needed to justify a liberal use of these costly devices in primary percutaneous coronary intervention. The superiority of aspiration devices remains controversial.