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221 00 Lund
+46 46-222 00 00

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Thrombus Aspiration during ST-Segment Elevation Myocardial Infarction

Ole Fröbert, M.D., Ph.D., Bo Lagerqvist, M.D., Ph.D., Göran K. Olivecrona, M.D., Ph.D., Elmir Omerovic, M.D., Ph.D., Thorarinn Gudnason, M.D., Ph.D., Michael Maeng, M.D., Ph.D., Mikael Aasa, M.D., Ph.D., Oskar Angerås, M.D., Fredrik Calais, M.D., Mikael Danielewicz, M.D., David Erlinge, M.D., Ph.D., Lars Hellsten, M.D., Ulf Jensen, M.D., Ph.D., Agneta C. Johansson, M.D., Amra Kåregren, M.D., Johan Nilsson, M.D., Ph.D., Lotta Robertson, M.D., Lennart Sandhall, M.D., Iwar Sjögren, M.D., Ollie Östlund, Ph.D., Jan Harnek, M.D., Ph.D., and Stefan K. James, M.D., Ph.D.

ABSTRACT

BACKGROUND

The clinical effect of routine intracoronary thrombus aspiration before primary percutaneous coronary intervention (PCI) in patients with ST-segment elevation myocardial infarction (STEMI) is uncertain. We aimed to evaluate whether thrombus aspiration reduces mortality.

METHODS

We conducted a multicenter, prospective, randomized, controlled, open-label clinical trial, with enrollment of patients from the national comprehensive Swedish Coronary Angiography and Angioplasty Registry (SCAAR) and end points evaluated through national registries. A total of 7244 patients with STEMI undergoing PCI were randomly assigned to manual thrombus aspiration followed by PCI or to PCI only. The primary end point was all-cause mortality at 30 days.

RESULTS

No patients were lost to follow-up. Death from any cause occurred in 2.8% of the patients in the thrombus-aspiration group (103 of 3621), as compared with 3.0% in the PCI-only group (110 of 3623) (hazard ratio, 0.94; 95% confidence interval [CI], 0.72 to 1.22; P=0.63). The rates of hospitalization for recurrent myocardial infarction at 30 days were 0.5% and 0.9% in the two groups, respectively (hazard ratio, 0.61; 95% CI, 0.34 to 1.07; P=0.09), and the rates of stent thrombosis were 0.2% and 0.5%, respectively (hazard ratio, 0.47; 95% CI, 0.20 to 1.02; P=0.06). There were no significant differences between the groups with respect to the rate of stroke or neurologic complications at the time of discharge (P=0.87). The results were consistent across all major prespecified subgroups, including subgroups defined according to thrombus burden and coronary flow before PCI.

CONCLUSIONS

Routine thrombus aspiration before PCI as compared with PCI alone did not reduce 30-day mortality among patients with STEMI. (Funded by the Swedish Research Council and others; ClinicalTrials.gov number, NCT01093404.)

From the Department of Cardiology, Örebro University Hospital, Örebro (O.F., F.C.), Department of Medical Sciences, Cardiology, and Uppsala Clinical Research Center, Uppsala University, Uppsala (B.L., O.O., S.K.J.), Department of Cardiology, Lund University Hospital, Lund (G.K.O., D.E., J.H.), Department of Cardiology, Sahlgrenska University Hospital, Gothenburg (E.O., O.A.), Department of Cardiology, Karolinska Institutet, Sodersjukhuset (M.A.), and Cardiology Unit, Department of Medicine, Karolinska University Hospital (U.J.), Stockholm, Department of Cardiology, Karlstad Hospital, Karlstad (M.D.), Department of Cardiology, Gävle Hospital, Gävle (L.H.), PCI Unit, Sunderby Hospital, Sunderby (A.C.J.), Department of Cardiology, Västerås Hospital, Västerås (A.K.), Department of Cardiology, Heart Center, Umea University, Umea (J.N.), Department of Cardiology, Borås Hospital, Borås (L.R.), Department of Radiology, Helsingborg Hospital, Helsingborg (L.S.), and Department of Cardiology, Falun Hospital, Falun (I.S.) — all in Sweden; Department of Cardiology and Cardiovascular Research Center, Landspitali University Hospital of Iceland, Reykjavik, Iceland (T.G.); and Department of Cardiology, Aarhus University Hospital, Skejby, Aarhus, Denmark (M.M.). Address reprint requests to Dr. Fröbert at the Department of Cardiology, Örebro University Hospital, Södra Grev Rosengatan, 701 85 Örebro, Sweden, or at ole.frobert@orebroll.se.

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One of the most important therapeutic challenges in the management of ST-segment elevation myocardial infarction (STEMI) is the establishment of normal coronary blood flow after percutaneous coronary intervention (PCI). Reduced flow is closely associated with reperfusion injury,[1] which can lead to arrhythmias, contractile dysfunction, microvascular impairment, and irreversible myocardial damage.[2] Reduced myocardial perfusion is also associated with heart failure and death.[3,4]

Coronary-artery thrombus aspiration, a simple, rapidly performed, and relatively inexpensive adjunct to PCI, may improve blood flow and resolution of ST-segment elevation,[5-9] although this is not a universal finding.[10-12] Previous studies of thrombus aspiration have not generally been powered for hard clinical end points. The Thrombus Aspiration during Percutaneous Coronary Intervention in Acute Myocardial Infarction Study (TAPAS), a single-center trial involving 1071 patients, in which mortality was a secondary end point, suggested a survival benefit with thrombus aspiration among patients with STEMI.[6,13] However, coronary thrombus aspiration may come at a price; a recent meta-analysis pointed to an increased risk of stroke.[14]

We conducted a randomized clinical trial to evaluate the effect of thrombus aspiration on hard clinical end points in patients with STEMI. To make this investigator-initiated undertaking economically and administratively feasible, we used national registries as online platforms for randomization, case-record forms, and follow-up data, thus conducting a registry-based randomized clinical trial.[15]

METHODS

STUDY DESIGN

The Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia (TASTE) trial was a multicenter, prospective, open-label, randomized, controlled clinical trial that used the infrastructure of a population-based registry to facilitate patient enrollment and data collection. The trial design, which has been reported previously,[15] was approved by the regional ethics review board in Uppsala, Sweden. Trial administration, data management, and statistical analyses were performed at the Uppsala Clinical Research Center at Uppsala University Hospital. The study was designed and conducted by the authors, who wrote all drafts of the manuscript and made the decision to submit the manuscript for publication (see the Supplementary Appendix, available with the full text of this article at NEJM.org, for details). All the authors vouch for the integrity and completeness of the data and analyses and for the fidelity of this report to the trial protocol, which is available at NEJM.org. None of the sponsors had access to the study data or had any role in the design or implementation of the study or the reporting of the data.

PATIENT POPULATION

We enrolled trial participants from the national comprehensive Swedish Coronary Angiography and Angioplasty Registry (SCAAR), which is part of the Internet-based Swedish Web System for Enhancement and Development of Evidence-based Care in Heart Disease Evaluated According to Recommended Therapies (SWEDEHEART) registry[16] (see the Supplementary Appendix for details). This registry holds data on consecutive patients from all 29 Swedish and 1 Icelandic coronary intervention centers, is funded solely by national health authorities, and provides immediate and continuous feedback on processes and quality-of-care measures. All baseline and procedural data are entered online, directly into the registry. For this study, an additional participating center in Denmark entered all relevant data into SCAAR. The data were monitored and adjudicated as part of the regular registry validation; we did not perform separate, dedicated monitoring and adjudication of the data for the TASTE trial.

We considered for inclusion in the trial patients with STEMI for whom PCI was planned after coronary angiography. Patients were eligible for the study if they had chest pain suggestive of myocardial ischemia for at least 30 minutes before hospital admission, if the time from the onset of symptoms to hospital admission was less than 24 hours, and if an electrocardiogram (ECG) showed new ST-segment elevation or left bundle-branch block (see the Supplementary Appendix for details). Exclusion criteria were the need for emergency coronary-artery bypass grafting, an inability to provide informed consent, an age younger than 18 years, and previous randomization in the TASTE trial.

After providing initial oral consent, patients who fulfilled all inclusion criteria and had no exclusion criteria were randomly assigned, in a 1:1 ratio, to thrombus aspiration followed by PCI

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or to PCI only. Randomization was performed by means of an online randomization module within the SCAAR database. All patients were asked to confirm their agreement to participate by providing written informed consent within 24 hours.

INVASIVE PROCEDURES

All the patients underwent coronary angiography and PCI; the use of platelet inhibitors or anticoagulants was left to the discretion of the treating physician. For patients randomly assigned to thrombus aspiration, guidewire placement was followed by thrombus aspiration with the use of a manual aspiration catheter before the PCI procedure (see the Supplementary Appendix for details). For both study groups, intracoronary administration of nitrates after the restoration of antegrade flow was recommended. Stenting was encouraged, with the type of stent left to the discretion of the physician and with optional postdilation (dilation of the stent after implantation). The administration of $P2Y_{12}$ inhibitors was left to the discretion of the physician; however, lifelong treatment with acetylsalicylic acid was recommended. Crossover from one group to the other was discouraged, but if it did occur, it was recorded in the registry and the patient continued to be followed up.

TRIAL END POINTS

The primary end point was all-cause mortality at 30 days, with data on mortality obtained from the national population registry. The secondary end points, for which data were obtained from the SWEDEHEART registry and the national discharge registry, included 30-day rates of hospitalization for recurrent myocardial infarction, stent thrombosis, target-vessel revascularization, target-lesion revascularization, and the composite of all-cause mortality or recurrent myocardial infarction. Additional secondary end points, for which data were also obtained from the registries and assessed during the index hospitalization, included complications of PCI, stroke or neurologic complications, heart failure, and length of stay in the hospital. Definitions of the end points are provided in the Supplementary Appendix. No study-specific clinical follow-up assessment was performed.

STATISTICAL ANALYSIS

On the basis of actual data on mortality from all patients with STEMI who underwent PCI in Sweden between 2008 and 2009, we assumed that the 1-month mortality with PCI alone would be 6.3%. We calculated that 456 events would need to occur for the study to have 80% power to detect a hazard ratio for death of at least 1.30 with PCI alone as compared with PCI plus thrombus aspiration, at a two-sided significance level of 5%. To meet this goal, we planned to include 4886 patients (with a total planned enrollment of 5000 to account for crossover and device failure, assuming no loss to follow-up).[15]

When enrollment approached 5000 patients, the 30-day mortality (estimated without knowledge of treatment assignments) was observed to be lower than expected (2.9%) in the study cohort. Therefore, the steering committee amended the protocol to increase the sample size and adopt a group-sequential design. Taking into consideration the hazard ratio of 1.95 for death from cardiac causes at 30 days in the TAPAS study,[6,13] and assuming 30-day mortality of 3.5% with conventional PCI, an odds ratio for death with PCI alone as compared with PCI with thrombus aspiration of at least 1.5, and one interim analysis performed when 67% of the total sample had been enrolled in which the stopping boundary for significance was set at a P value of less than 0.01 and for futility (nonbinding) at a P value of more than 0.493, it was calculated that with 7138 patients, the study would have 80% power to obtain a significant result at the 5% level with the use of two-sided tests. The data monitoring committee conducted the interim analysis in August 2012 on data from 4802 patients and recommended that the study continue.

The results were analyzed according to the intention-to-treat principle. In a post hoc per-protocol analysis, we also compared the patients in the thrombus-aspiration group who underwent thrombus aspiration with the patients in the PCI-only group who did not. The time to death within 30 days after PCI according to study group is presented in a Kaplan–Meier plot. Hazard ratios for the primary end point and for all end points assessed through 30 days were calculated with the use of a Cox proportional-hazards model with treatment as the only factor and are shown with the nominal 95% confidence interval from the Cox model and the nominal two-sided P value from a log-rank test. Odds ratios for end points assessed during the index hospitalization were estimated from a logistic-regression model, with P values calculated with the use of Pearson's chi-

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square test. Subgroup analyses were performed by including an interaction term in the proportional-hazards model. All analyses were performed with the use of SAS software, version 9.3 (SAS Institute). According to the interim analysis plan, a two-tailed P value of less than 0.0471 was considered to indicate statistical significance with respect to the primary variable.

RESULTS

STUDY POPULATION

All 29 PCI centers in Sweden as well as 1 in Iceland and 1 in Denmark participated in the trial. During the study period, 11,709 patients with STEMI in Sweden and Iceland underwent PCI and were registered in SCAAR. Of these, 7012 were enrolled in the trial. An additional 247 patients were enrolled from the center in Denmark, for a total of 7259 patients (Fig. 1). Fifteen erroneous enrollments (patients initially reported as having STEMI, for whom the diagnosis was changed by the operator and no PCI was performed) were excluded from the database, leaving 7244 patients who underwent randomization.

The baseline clinical characteristics of all the patients who underwent randomization (including patients at all the centers) and all the patients who did not undergo randomization (including patients at all the centers except the center in Denmark) are listed in Table 1. Procedural characteristics are listed in Tables S1 and S2 in the Supplementary Appendix. A total of 60% of the patients presenting with STEMI and referred for PCI in Sweden and Iceland underwent randomization in the TASTE trial during the study period.

None of the patients who underwent randomization were lost to follow-up with respect to the primary end point. However, six patients withdrew consent and were included in the analysis only until the date of withdrawal. Among patients who did not undergo randomization, we obtained complete follow-up data on all the patients in Sweden and follow-up data for all variables except mortality on patients in Iceland, but we did not obtain follow-up data on patients in Denmark who did not undergo randomization.

PROCEDURAL DATA

After undergoing randomization, 93.9% of the patients in the thrombus-aspiration group underwent thrombus aspiration; in addition, 4.9% of the patients in the PCI-only group underwent thrombus aspiration (Table S2 in the Supplementary Appendix). Patients were treated according to international guidelines, with high proportions of patients receiving platelet inhibitors and antithrombotic agents before and during the procedure and with a high proportion of PCIs performed through a radial access and including implantation of drug-eluting stents.

CLINICAL OUTCOMES

By 30 days, 2.8% of the patients randomly assigned to thrombus aspiration (103 of 3621 patients) and 3.0% of the patients randomly assigned to PCI only (110 of 3623 patients) had died (hazard ratio with thrombus aspiration, 0.94; 95% confidence interval [CI], 0.72 to 1.22; P=0.63) (Fig. 2A and Table 2). The 30-day mortality in the per-protocol analysis was 2.6% (88 of 3399 patients) with thrombus aspiration and 2.9% (101 of 3445 patients) with PCI only (hazard ratio, 0.88; 95% CI, 0.66 to 1.17; P=0.38).

The rate of rehospitalization due to reinfarction was 0.5% in the thrombus-aspiration group (19 patients) and 0.9% in the PCI-only group (31 patients) (hazard ratio, 0.61; 95% CI, 0.34 to 1.07; P=0.09) (Fig. 2B). The rates in the per-protocol analysis were 0.5% (18 of 3399 patients) and 0.8% (27 of 3445 patients) in the two groups, respectively (hazard ratio, 0.67; 95% CI, 0.36 to 1.2; P=0.19). The rates of stent thrombosis, target-lesion revascularization, and target-vessel revascularization did not differ significantly between the groups. There was no significant between-group difference in the rate of stroke or neurologic complications, perforation or tamponade, or heart failure or left ventricular dysfunction at the time of discharge, nor was there a significant difference in the length of stay in the hospital.

The primary outcome of all-cause mortality at 30 days was consistent across all prespecified subgroups, including patients with a high risk of thrombosis, such as those with Thrombolysis in Myocardial Infarction (TIMI) flow grade 0 or 1, those with thrombus grade 4 or 5 (on a scale of 0 to 5, with higher grades indicating a larger thrombus), and smokers (Fig. 3).

COHORT THAT DID NOT UNDERGO RANDOMIZATION

The reasons indicated by the operators for not enrolling patients were as follows: inability of the patient to provide oral informed consent (38% of patients who did not undergo randomization), thrombus aspiration not possible (16%), thrombus

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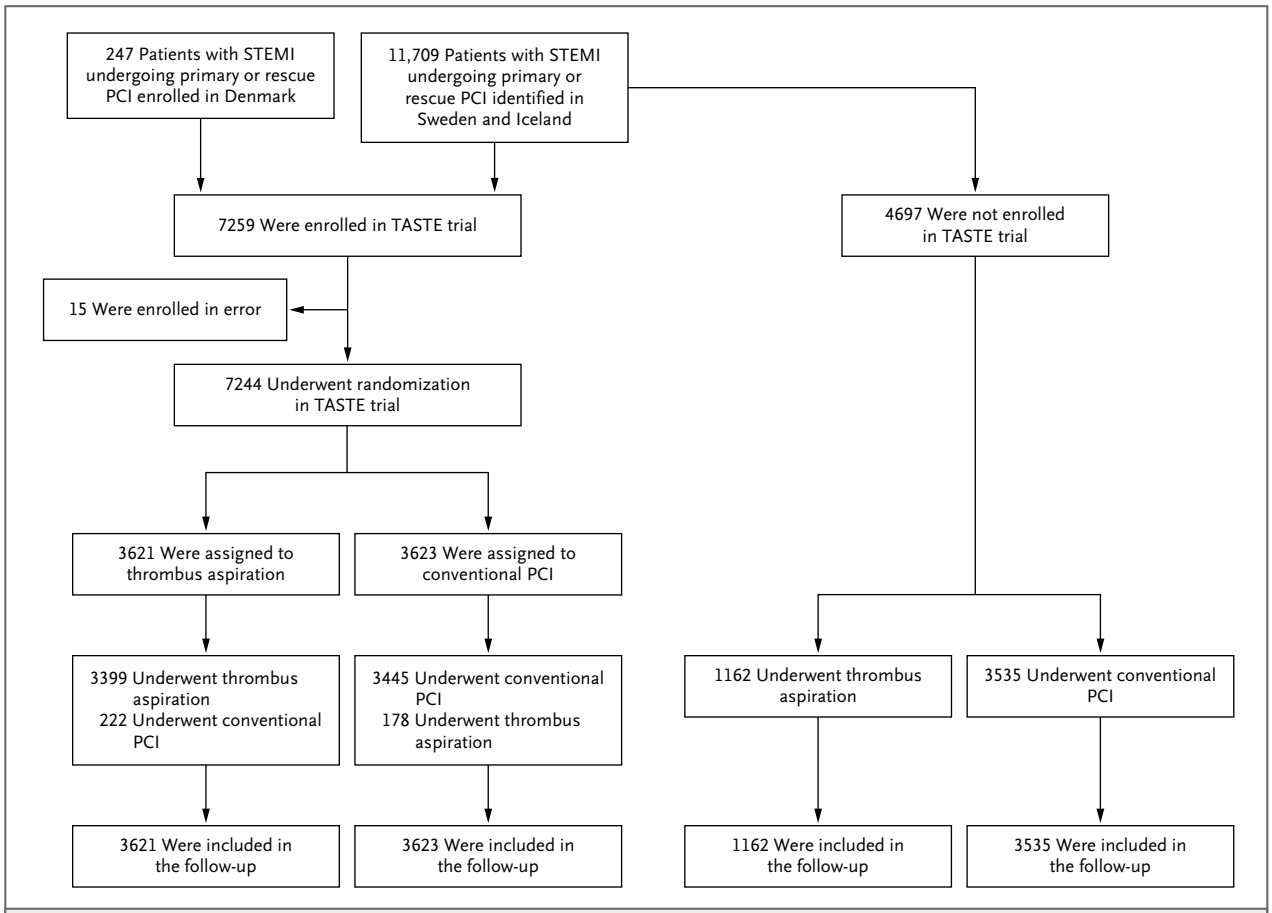

Figure 1. Enrollment, Randomization, and Follow-up.

Patients with ST-segment elevation myocardial infarction (STEMI) who were undergoing percutaneous coronary intervention (PCI) were considered for inclusion in the study. Shown are the numbers of patients who were enrolled in the study, randomly assigned to a study group, and followed up during the study period, as well as the number of patients who were not enrolled in the study (most of whom did not meet the inclusion criteria) but who were followed up during the study period. TASTE denotes Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia.

aspiration considered to be inappropriate (11%), thrombus aspiration considered to be indicated (7%), and other (28%). Of the Swedish patients who did not undergo randomization, 10.9% of the patients who subsequently underwent thrombus aspiration (124 of 1138 patients) and 10.5% of the patients who were treated with PCI only (362 of 3442 patients) had died by 30 days (Table 2).

DISCUSSION

In this investigator-initiated, registry-based randomized trial involving patients with STEMI, manual thrombus aspiration before PCI had no significant effect on the primary end point of all-cause mortality at 30 days. The neutral outcome was consistent in all patient subgroups, regardless of baseline clinical or angiographic characteristics. Furthermore, there was no significant effect of thrombus aspiration on any of the prespecified secondary end points.

Meta-analyses of randomized trials of thrombus aspiration have shown inconsistent results with respect to mortality. Some have shown a mortality benefit,[17,18] whereas others have shown no significant effect.[14,19,20] We recently reported data on all patients in Sweden undergoing PCI for STEMI between 2005 and 2010. After adjustment for a number of clinical and procedural factors, we found that mortality was higher among patients who had undergone thrombus aspiration before PCI than among patients who had been treated with PCI only.[21] The inconsistencies among these previous analyses may stem from

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Table 1. Baseline Characteristics of the Patients According to Randomization Status and Treatment Group.*

Characteristic	Patients Who Underwent Randomization		Patients Who Did Not Undergo Randomization	
	Thrombus Aspiration (N=3621)	PCI Only (N=3623)	Thrombus Aspiration (N=1162)	PCI Only (N=3535)
Age — yr†	66.5±11.5	65.9±11.7	66.8±13.5	69.4±12.5
Male sex — no. (%)	2721 (75.1)	2703 (74.6)	829 (71.3)	2360 (66.8)
Body-mass index‡	27.2±7.1	27.1±5.2	27.1±8.6	27.0±8.8
Diabetes mellitus — no. (%)	448 (12.4)	453 (12.5)	162 (13.9)	635 (18.0)†
Smoking status — no. (%)†				
Never smoked	1299 (35.9)	1153 (31.8)	362 (31.2)	1259 (35.6)
Former smoker	1037 (28.6)	1058 (29.2)	257 (22.1)	907 (25.7)
Current smoker	1083 (29.9)	1173 (32.4)	317 (27.3)	878 (24.8)
Unknown	202 (5.6)	239 (6.6)	226 (19.4)	491 (13.9)
Hyperlipidemia — no. (%)	753 (20.8)	762 (21.0)	273 (23.5)	951 (26.9)†
Hypertension — no. (%)	1545 (42.7)	1527 (42.1)	500 (43.0)	1782 (50.4)†
Previous myocardial infarction — no. (%)	402 (11.1)	439 (12.1)	191 (16.4)	644 (18.2)†
Previous PCI — no. (%)	337 (9.3)	362 (10.0)	138 (11.9)	438 (12.4)
Previous CABG — no. (%)	70 (1.9)	74 (2.0)	65 (5.6)	167 (4.7)
Therapy before PCI — no. (%)				
Warfarin	60 (1.7)	52 (1.4)	35 (3.0)	86 (2.4)
Heparin	1481 (40.9)	1460 (40.3)	310 (26.7)	1187 (33.6)†
Thrombolysis	69 (1.9)	68 (1.9)	16 (1.4)	100 (2.8)†
Time from symptom onset to PCI — min				
Median	185	182	180	210
Interquartile range	120–330	120–315	116–350	125–412
Time from diagnostic ECG to PCI — min				
Median	67	66	65	72
Interquartile range	48–94	47–93	47–95	50–108
Killip class ≥II — no. (%)	198 (5.5)	183 (5.1)	195 (16.8)	533 (15.1)

* Plus–minus values are means ±SD. There were no significant differences in baseline characteristics between the thrombus-aspiration group and the percutaneous coronary intervention (PCI)–only group in either cohort except as otherwise noted. CABG denotes coronary-artery bypass grafting, and ECG electrocardiogram.
† P<0.05 for the comparison between the thrombus-aspiration group and the PCI-only group.
‡ The body-mass index (the weight in kilograms divided by the square of the height in meters) was recorded for 97.5%, 97.5%, 93.6%, and 92.5% of patients in the four groups.

several factors, including differences in follow-up time (longer follow-up periods may increase the likelihood of detecting a benefit with respect to mortality[13]), the duration of symptoms (a short duration may be associated with a beneficial effect of thrombus aspiration[12,22]), the number of participating centers (a single-center study design is associated with a better clinical outcome than a multicenter design[23]), and the finding that mechanical thrombectomy devices may be inferior to manual aspiration catheters.[20,24]

Coronary thrombus material triggers thrombotic, inflammatory, vasoconstrictor, and other pathways, and evacuating a portion of the thrombus and plaque material addresses only a part of the pathophysiological problem. Disrupting thrombus formation pharmacologically may be more effective. This conclusion was suggested by

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the INFUSE-AMI trial (A 2 × 2 Factorial, Randomized, Multicenter, Single-Blind Evaluation of Intracoronary Abciximab Infusion and Aspiration Thrombectomy in Patients Undergoing Percutaneous Coronary Intervention for Anterior ST-Segment Elevation Myocardial Infarction).[25] In INFUSE-AMI, an intracoronary bolus of the glycoprotein IIb/IIIa inhibitor abciximab was effective in reducing the infarct size, whereas thrombectomy by means of manual aspiration was not.

Thrombus aspiration may not be a risk-free procedure. Systemic embolization can occur,[26] and in a recent meta-analysis, thrombus aspiration was associated with a trend toward an increased rate of stroke (P=0.06).[14] However, in the TASTE trial, there was no significant difference between the groups in the rates of stroke and neurologic complications.

In the TAPAS trial, thrombus aspiration, as compared with PCI only, improved myocardial reperfusion in the short term.[6] At 1 year, the secondary end point of mortality was lower in the thrombus-aspiration group than in the PCI-only group.[13] In the TASTE trial, we used a much more conservative estimate of the risk ratio for death than that in the TAPAS trial in order not to miss a mortality reduction with thrombus aspiration, although this design required the enrollment of a much larger number of patients.[15] However, since the current analysis includes only the 30-day results of the TASTE trial, it is possible that a difference in clinical events will become apparent only with longer follow-up, especially since a mortality benefit was detected in the TAPAS trial only after 1 year of follow-up.[6,13] Moreover, the reinfarction rate in the TASTE trial was 40% lower with thrombus aspiration, and this magnitude of effect was significant at 1 year in the TAPAS trial.

In the TASTE trial, we introduced a randomization module in an online, comprehensive, national clinical registry, thus combining the benefits of randomized treatment assignment with the best features of a large-scale clinical registry. Advantages of this approach include broad inclusion criteria to ensure wide clinical applicability, a simplified enrollment process to maximize the commitment and compliance of the participating hospitals, a substantial reduction in the expense associated with conducting a randomized trial since we were able to use the established registry infrastructure, and high rates of follow-up both of patients who underwent randomization and of those who did not.

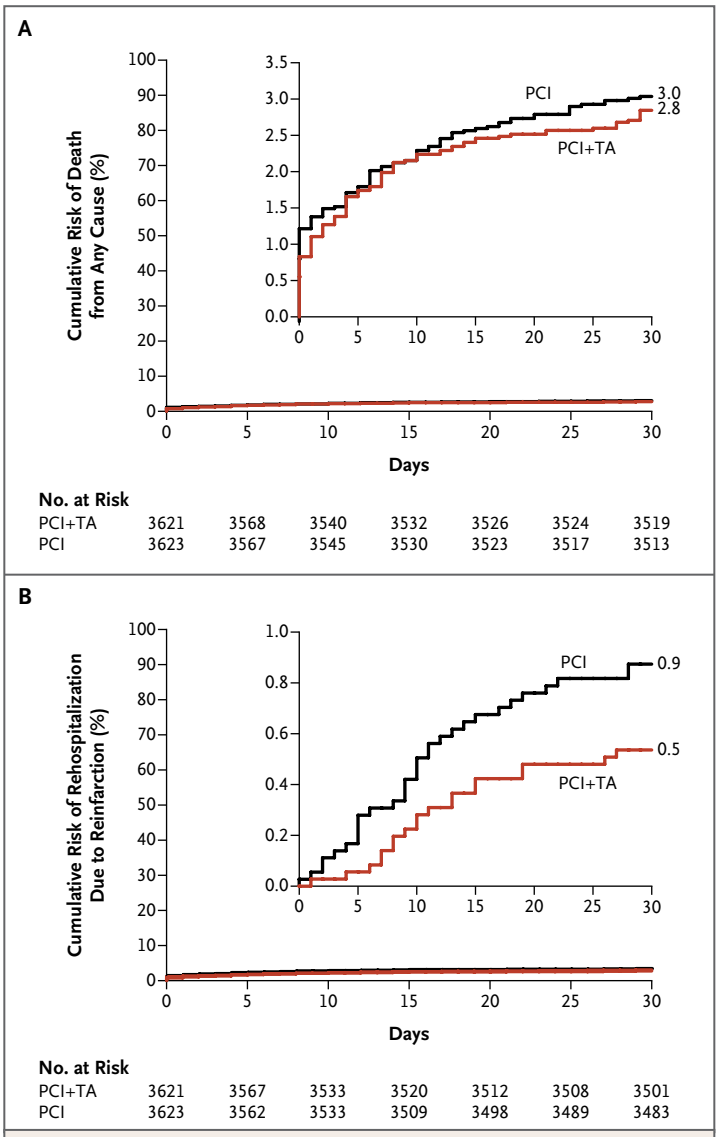

Figure 2. Kaplan–Meier Curves for Death from Any Cause and Hospitalization Due to Reinfarction.

Kaplan–Meier curves are shown for the cumulative probability of death from any cause (Panel A) and of hospitalization due to reinfarction (Panel B) up to 30 days after PCI only (PCI) or after PCI with thrombus aspiration (PCI+TA). The insets show the same data on an enlarged y axis.

A number of limitations of the TASTE trial should be noted. First, the treating physician was aware of the group to which the patient had been assigned, and that physician entered the angiographic variables into the registry; therefore, these variables were susceptible to bias. Second, we did not adjudicate events and did not review angio-

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Table 2. End Points According to Randomization Status and Treatment Group.

End Point	Patients Who Underwent Randomization				Patients Who Did Not Undergo Randomization	
	Thrombus Aspiration (N=3621)	PCI Only (N=3623)	Point Estimate (95% CI)	P Value	Thrombus Aspiration (N=1162)	PCI Only (N=3535)
30 days						
All-cause death — no./total no. (%)	103/3621 (2.8)	110/3623 (3.0)	Hazard ratio, 0.94 (0.72–1.22)	0.63	124/1138 (10.9)*	362/3442 (10.5)*
Rehospitalization due to reinfarction — no. (%)	19 (0.5)	31 (0.9)	Hazard ratio, 0.61 (0.34–1.07)	0.09	10 (0.9)	38 (1.1)
All-cause death or myocardial infarction — no./total no. (%)	121/3621 (3.3)	140/3623 (3.9)	Hazard ratio, 0.86 (0.67–1.10)	0.23	134/1138 (11.8)*	398/3442 (11.6)*
Stent thrombosis — no. (%)†	9 (0.2)	19 (0.5)	Hazard ratio, 0.47 (0.20–1.02)	0.06	5 (0.4)	18 (0.5)
Target-vessel revascularization — no./total no. (%)	63/3498 (1.8)‡	76/3499 (2.2)‡	Hazard ratio, 0.83 (0.59–1.15)	0.27	30/1162 (2.6)	80/3535 (2.3)
Target-lesion revascularization — no./total no. (%)	43/3498 (1.2)‡	57/3499 (1.6)‡	Hazard ratio, 0.75 (0.51–1.12)	0.16	25/1162 (2.2)	64/3535 (1.8)
Index hospitalization						
Stroke or neurologic complication — no. (%)	19 (0.5)	18 (0.5)	Odds ratio, 1.06 (0.55–2.02)	0.87	12 (1.0)	32 (0.9)
Perforation or tamponade — no. (%)	13 (0.4)	14 (0.4)	Odds ratio, 0.93 (0.44–1.98)	0.85	7 (0.6)	13 (0.4)
Heart failure — no. (%)	245 (6.8)	234 (6.5)	Odds ratio, 1.05 (0.87–1.27)	0.60	125 (10.8)	353 (10.0)
Left ventricular function — no. (%)§				0.33		
Normal	1572 (43.4)	1614 (44.5)			390 (33.6)	1374 (38.9)
Slightly reduced	853 (23.6)	822 (22.7)			291 (25.0)	699 (19.8)
Moderately reduced	526 (14.5)	495 (13.7)			190 (16.4)	523 (14.8)
Severely reduced	137 (3.8)	157 (4.3)			102 (8.8)	255 (7.2)
Unknown	533 (14.7)	535 (14.8)			189 (16.3)	684 (19.3)
Target-lesion revascularization — no./total no. (%)	37/3498 (1.1)‡	42/3499 (1.2)‡	Odds ratio, 0.88 (0.56–1.37)	0.57	22/1162 (1.9)	43/3535 (1.2)
Length of hospital stay — no. (%)				0.40¶		
1–3 days	501 (13.8)	493 (13.6)			146 (12.6)	535 (15.1)
4–7 days	2661 (73.5)	2670 (73.7)			713 (61.4)	2167 (61.3)
8–30 days	437 (12.1)	430 (11.9)			254 (21.9)	703 (19.9)
>30 days	12 (0.3)	23 (0.6)			14 (1.2)	43 (1.2)

* Patients from Sweden were included in this analysis; patients from Iceland and Denmark were not included.
† Stent thrombosis was defined as angiographically verified stent occlusion with an acute clinical presentation.
‡ Patients from Sweden and Iceland were included in this analysis; patients from Denmark were not included.
§ Left ventricular function was considered to be normal if the left ventricular ejection fraction (LVEF) was 50% or more, slightly reduced if the LVEF was 40 to 49%, moderately reduced if the LVEF was 30 to 39%, and severely reduced if the LVEF was less than 30%.
¶ This P value was calculated with the use of a Wilcoxon rank-sum test.

grams in a blinded fashion. We used all-cause death as the primary end point because it is the most stringent end point and because of the completeness of the national death registries in each participating country. We chose not to perform separate adjudication of secondary end points both to limit expense and because of the high reliability of the SWEDEHEART registry. Third, we did not record findings with respect to myocardial salvage, microvascular obstruction, or biochemi-

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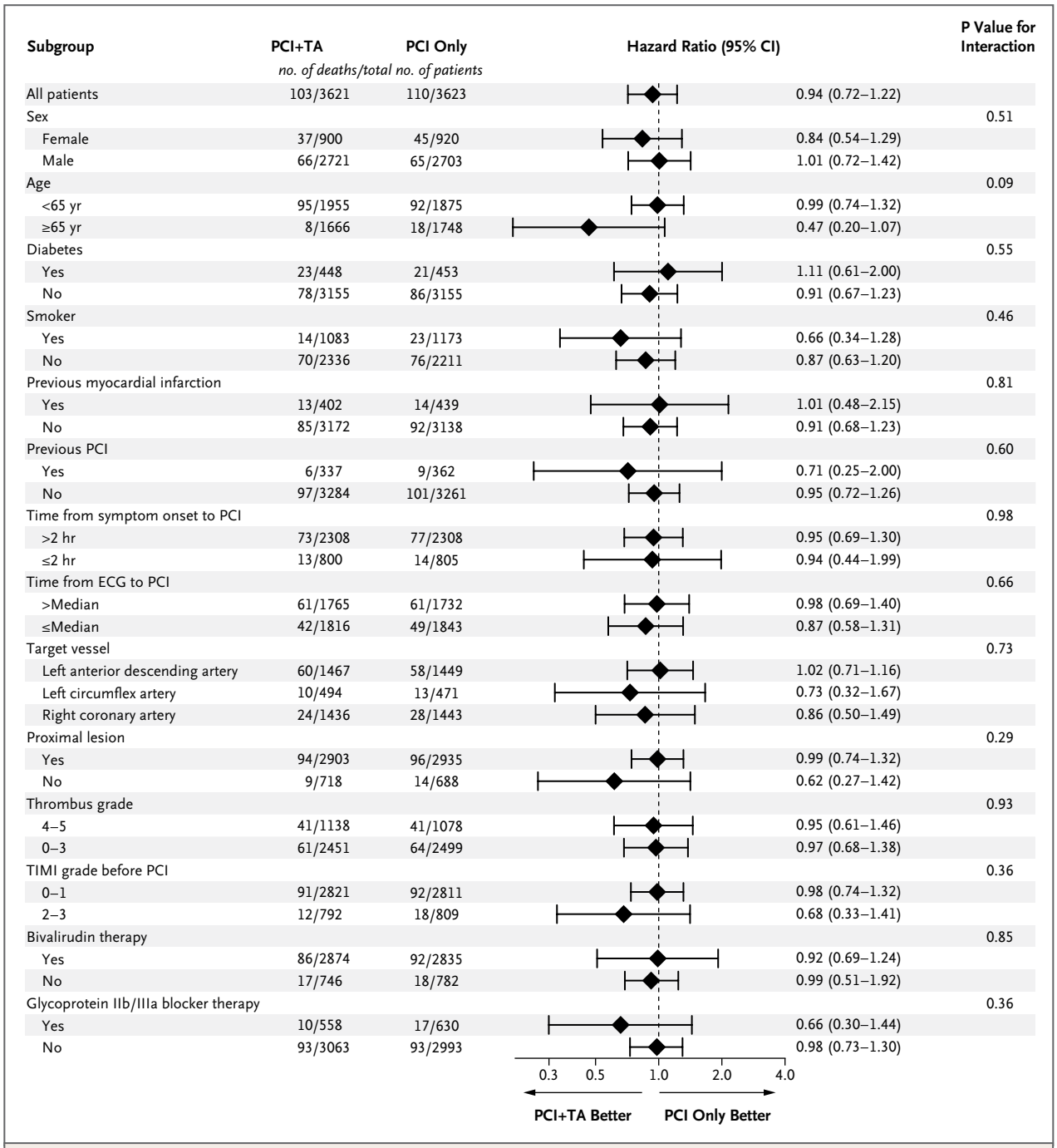

Figure 3. Hazard Ratios for the Primary End Point in Subgroups of Patients.

Hazard ratios are shown for the primary end point of mortality within 30 days after PCI. All the subgroups were prespecified except those defined by status with respect to bivalirudin therapy and glycoprotein IIb/IIIa blocker therapy, which were analyzed post hoc. ECG denotes electrocardiography, and TIMI Thrombolysis in Myocardial Infarction.

cal variables in the registry. Finally, deviations from the randomly assigned treatment occurred, although infrequently, and information about the reasons was not available.

A comparison of the clinical characteristics and outcomes between the patients who underwent randomization and those who did not indicates that the two cohorts differed significantly

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in a number of respects, most notably in mortality at 30 days (2.9% among patients who underwent randomization vs. 10.6% among those who did not). In many cases, these differences reflect the exclusion from the trial of patients who were ineligible because they were unable to provide oral consent. Even when a trial uses a population-based registry for enrollment, the trial participants cannot be fully representative of the complete range of patients.

In conclusion, in a registry-based, randomized, controlled trial comparing aspiration thrombectomy before PCI with PCI alone in patients presenting with STEMI, we found no significant benefit of aspiration thrombectomy with respect to mortality or any of several other clinical outcomes at 30 days.

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