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Thrombus aspiration during primary percutaneous coronary intervention improved outcome in patients with STEMI and a large thrombus burden

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Abstract

Background: The benefit of thrombus aspiration (TA) during primary percutaneous coronary intervention (PPCI) to patients with ST-segment elevation myocardial infarction (STEMI) remains controversial. This study aimed to assess TA's impact on the outcome and prognosis for patients with STEMI and a large thrombus burden during PPCI.

Methods: This retrospective study evaluated consecutive patients with STEMI and a large thrombus burden (thrombolysis in myocardial infraction [TIMI] thrombus grade $\geq$4) who underwent conventional PPCI (n = 126) or PPCI + TA (n = 208) between February 2017 and January 2019. The procedure outcome and clinical prognosis were compared.

Results: Postprocedural vessel diameter was larger, and corrected TIMI frame count (cTFC) was lower in the PPCI + TA compared with the PPCI group. The proportion of postprocedural TIMI 3 flow was 83.3% in the PPC group and 94.2% in the PPCI+TA group. During the 12-month follow-up, no significant differences existed in the incidence of cardiac death, reinfarction, stent thrombosis, target vessel revascularization, or stroke.

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Conclusion: Application of TA in patients with STEMI and a large thrombus burden during PPCI may improve the procedural outcome, but it showed no benefit on the clinical prognosis in the 12-month follow-up. Longer follow-up studies are needed to confirm TA's clinical implications in patients with STEMI.

Keywords
ST-segment elevation myocardial infarction, thrombus aspiration, primary percutaneous coronary intervention, thrombus burden, postprocedural vessel diameter, cardiac death, reinfarction, stent thrombosis, target vessel revascularization, stroke

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Introduction

ST-segment elevation myocardial infarction (STEMI) is one of the most severe and deadly cardiovascular diseases that is mainly caused by thrombus formation in the coronary artery, and it may lead to partial or total occlusion. Early and effective reperfusion is crucial for patients with STEMI, and primary percutaneous coronary intervention (PPCI) is recommended in the current guidelines.[1] However, PPCI may cause the thrombus to detach from its original location and move towards a distal vessel, leading to a poor prognosis.

Thrombus aspiration (TA) has been considered to be an effective approach to remove atherothrombotic material in an infarcted artery, and it is commonly used in clinical practice.[2] Early clinical trials and meta-analyses showed an improvement in myocardial blush and mortality benefit.[3,4] However, these findings have been challenged by recent multicenter studies.[5–7] Therefore, current guidelines do not recommend the routine use of TA, and these guidelines suggest that it may be considered for a large residual thrombus burden.

Consistent with the hypothesis that patients with a higher thrombus burden may benefit from TA, recent studies showed that TA can better improve myocardial reperfusion in patients with STEMI and a high thrombus load and significantly decrease the cumulative major adverse cardiac events (MACE) rate of the 1-year outcome.[8,9] However, both the TASTE and TOTAL trials did not show a benefit in the primary outcome for patients with a high thrombus burden.[6,7] To date, the benefit of TA for patients with large thrombus burden remains controversial. Therefore, this study aimed to assess the impact of TA on the outcome and prognosis for patients with STEMI and a large thrombus burden during PPCI.

Methods

Patients

This retrospective study was performed in accordance with the retrospective study guidance and was approved by Ethical Committee of Hebei General Hospital (Shijiazhang, China, Approval date: 12 June 2020). Patients enrolled in this retrospective cohort study were from the Cardiology department at Hebei General Hospital and The People's Hospital of Fuyang between February 2017 and January 2019, and each of the enrolled

patients provided written informed consent. Patients with STEMI and a large thrombus burden who underwent primary percutaneous coronary intervention (PPCI) were consecutively included. STEMI was diagnosed in patients with the presence of chest pain that was suggestive of myocardial ischemia for longer than 20 minutes, and ECG results showed a new ST-segment elevation in two or more contiguous leads or new left bundle branch block (LBBB). Angiographic assessment of the thrombus burden was judged as follows: Grade 0, no thrombus; Grade 1, possible thrombus; Grade 2, the greatest dimension of thrombus $<1/2$ vessel diameter; Grade 3, the greatest dimension of thrombus $>1/2$ to <2 vessel diameters; Grade 4, the greatest dimension of thrombus >2 vessel diameters; and Grade 5, total vessel occlusion due to thrombus. Angiographic evidence of thrombolysis in myocardial infraction (TIMI) thrombus grades 4 to 5 was defined as a large thrombus burden. PPCI was performed within 12 hours of symptom onset.

On the basis of the TA procedure application, patients were divided into the following two groups: the PPCI group, in which patients underwent conventional PPCI; and the PPCI+TA group, in which patients underwent PPCI and TA. For patients who underwent the TA procedure, a manual TA catheter (Extractor Catheter; Terumo Inc., Tokyo, Japan) was used. All patients received loading doses of aspirin and an adenosine diphosphate (ADP) receptor inhibitor (clopidogrel or ticagrelor). During the procedure, all patients received anticoagulant therapy. The type of anticoagulant was administrated at the discretion of the surgeon. Coronary angiography was performed through radial or femoral approach. Adjunctive glycoprotein (GP) IIb/IIIa inhibitors and recombinant human pro-urokinase (rhPro-UK) were administered at the surgeon's discretion. Stent implantation and balloon dilation (pre-dilation and post-dilation) were performed to improve the procedure outcome if necessary.

Laboratory examinations were conducted using venous blood samples within 24 hours after admission. Echocardiography was performed within 24 hours of admission. After the procedure and discharge, patients without contraindications were treated with acetylsalicylic acid (ASA; 100 mg daily) and clopidogrel (75 mg, once a day) or ticagrelor (90 mg, twice a day) for at least 12 months. Other drugs such as statins, beta-blockers, angiotensin-converting enzyme inhibitors (ACEI), angiotensin receptor blockers (ARB), spironolactone, recombinant human brain natriuretic peptide (rhBNP), and nicorandil were used in accordance with the guidelines.

Measurements

Baseline clinical information, treatment, auxiliary examination results, and angiography findings for all participants were collected. Two experienced interventional cardiologists reviewed all coronary angiograms.

The primary end point was the incidence of major adverse cardiac cerebrovascular events (MACCE), which are defined as cardiac death, reinfarction, stent thrombosis, target vessel revascularization (TVR), or stroke. Reinfarction is described as a twofold increase in cardiac markers and ST segment re-elevations. TVR is defined as either repeated percutaneous or surgical revascularization. Stent thrombosis is defined as definite, probable, or possible in accordance with the Academic Research Consortium definition. The secondary endpoint was the post-procedure outcome. Follow-up ended at 12 months or at the time of MACCE, whichever occurred first.

Statistical analysis

Data were presented as the percentage for categorical variables and as the mean ± standard deviation (SD). Comparisons between the groups were performed using the Chi-square test for categorical variables and an independent *t*-test or the Mann–Whitney U test for continuous variables. Logistic regression analysis was used to test the effect of TA on post-procedural TIMI 3 flow. For the association of TA and long-term MACCE, a Kaplan–Meier analysis and the log-rank test were used. Hazard ratios (HRs) and the 95% confidence interval (CI) were calculated using the Cox proportional hazards regression analysis. The multivariate analysis was adjusted for age, sex, previous PCI, hypertension, diabetes, Killip classification, duration of symptoms to procedure time, procedure access, volume of contrast, pre-procedural TIMI flow grade, multivessel disease, infarct-related vessel, GP IIb/IIIa inhibitor, rhPro-UK, pre-dilatation, number of stents, and post-stent balloon dilatation.

The following variables were included in the propensity score estimation model: age, sex, previous PCI, hypertension, diabetes, Killip classification, duration of symptoms to procedure time, procedure access, pre-procedural TIMI flow grade, multivessel disease, and infarct-related vessel.

A two-tailed p value <0.05 was considered to be significant. Statistical analysis was performed using SPSS v.22 (IBM Corp., Armonk, NY, USA).

Results

Baseline characteristics

In this study, 334 consecutive patients with STEMI and a large thrombus burden were analyzed. Among them, 126 (37.7%) patients were treated with conventional PPCI and 208 (62.3%) patients received adjunctive TA. In the PPCI group, the average age was 61.79 ± 12.60 years and there were 101 men (80.20%), whereas in the PPCI + TA group, the average age was 60.19 ± 12.00 years and there were 171 men (82.20%); these demographic results were not significantly different. The baseline, clinical, and medical treatment characteristics of TA and PPCI groups are listed in Table 1. Patients undergoing conventional PPCI had a low systolic blood pressure on admission. Owing to the early diagnosis from the onset, the prevalence of Killip classification 3 and 4 was low in the cohort in accordance with ejection fraction (EF).

Angiography and procedural characteristics

Procedural details are listed in Table 2. Most patients received PCI through radial access, and the proportion was higher in the PPCI group compared with the PPCI + TA group ($p = 0.018$). Pre-dilatation before stenting was performed more commonly in the PPCI group compared with the PPCI + TA group ($p<0.001$). Postprocedural vessel diameter was larger in the PPCI + TA group compared with the PPCI group ($p = 0.006$). The corrected TIMI frame count (cTFC) was much lower in the PPCI + TA group after the procedure compared with the PPCI group ($p = 0.001$). The proportion of postprocedural TIMI 3 flow was 83.3% in the PPCI group compared with 94.2% in PPCI + TA group ($p = 0.003$). Crude (OR 3.27, 95% CI 1.55–6.90, $p = 0.002$) and adjusted (OR 4.97, 95% CI 1.66–14.97, $p = 0.004$) logistic regression analysis showed that TA was associated with a higher rate of postprocedural TIMI 3 flow compared with PPCI alone.

Table 1. Baseline, clinical, and medical treatment characteristics before and after propensity score matching

	All patients			Propensity score-matched patients		
Items/groups	PPCI (n = 126)	PPCI+TA (n = 208)	p-value	PPCI (n = 116)	PPCI+TA (n = 116)	p-value
Age (years)	61.79 ± 12.60	60.19 ± 12.00	0.246	61.09 ± 12.41	61.52 ± 11.72	0.79
Age ≥65 years (%)	53 (42.10%)	74 (35.60%)	0.237	45 (38.80%)	46 (39.70%)	0.893
Sex (male) (%)	101 (80.20%)	171 (82.20%)	0.64	94 (81%)	90 (81%)	1
BMI (kg/m^2)	25.27 ± 2.79	25.80 ± 4.44	0.225	25.32 ± 2.83	25.84 ± 5.32	0.353
BMI ≥25 kg/m^2 (%)	65 (51.60%)	111 (53.40%)	0.752	61 (52.60%)	57 (49.10%)	0.599
Coronary artery disease (%)	20 (15.90%)	14 (11.50%)	0.256	17 (14.7%)	14 (12.10%)	0.563
Previous PCI (%)	5 (4%)	9 (4.30%)	0.874	4 (3.4%)	6 (5.20%)	0.518
Hypertension (%)	70 (55.60%)	96 (46.20%)	0.096	64 (55.20%)	59 (50.90%)	0.511
Diabetes (%)	35 (27.80%)	46(22.10%)	0.242	31 (26.70%)	33 (28.40%)	0.769
Hypercholesterolemia (%)	19 (15.10%)	27 (13%)	0.59	18 (15.50%)	16 (13.80%)	0.71
Cerebrovascular disease (%)	25 (19.80%)	31 (14.90%)	0.242	22 (19%)	16 (13.80%)	0.287
Family history of CAD (%)	20 (15.90%)	38 (18.30%)	0.575	19 (16.40%)	20 (17.20%)	0.861
Current smoking (%)	69 (54.80%)	118 (56.70%)	0.725	67 (57.80%)	66 (56.90%)	0.894
Resuscitation before arrival (%)	3 (2.40%)	10 (4.80%)	0.266	3 (2.60%)	3 (2.60%)	1
Systolic blood pressure (mmHg)	136 (118.5, 154.25)	128 (113, 143.75)	0.017	136.68 ± 27.39	131.55 ± 25.96	0.145
Diastolic blood pressure (mmHg)	85.87 ± 17.67	82.68 ± 15.57	0.086	86.09 ± 18.03	82.98 ± 15.53	0.161
Heart rate (beats/minute)	74.62 ± 17.10	73.95 ± 19.70	0.751	74.45 ± 17.19	76.59 ± 18.96	0.367
Killip classification (%)			0.489			0.721
I	110 (87.30%)	180 (86.50%)	0.842	102 (87.90%)	102 (87.90%)	
II	12 (9.50%)	19 (9.10%)	0.905	12 (10.30%)	12 (10.30%)	
III	2 (1.60%)	1 (0.50%)	0.299	0 (0.0%)	1 (0.90%)	
IV	2 (1.60%)	8 (3.80%)	0.24	2 (1.70%)	1 (0.90%)	
Postprocedural systolic blood pressure (mmHg)	117.21 ± 22.37	116.92 ± 22.72	0.909	117.87 ± 22.7	115.72 ± 22.74	0.473
Postprocedural diastolic blood pressure (mmHg)	74.41 ± 16.67	75.2 ± 15.88	0.668	75.15 ± 17	74.11 ± 15.51	0.629
Postprocedural heart rate (beats/minute)	83.4 ± 17.15	82.01 ± 17.33	0.476	83.43 ± 17.28	80.01 ± 16.08	0.12
Immediate ADP receptor inhibitor loading (%)			0.11			0.285
Clopidogrel	54 (42.90%)	71 (34.10%)		51 (44%)	43 (37.10%)	
Ticagrelor	72 (57.10%)	137 (65.90%)		65 (56%)	73 (62.90%)	

(continued)

Table 1. Continued

Items/groups	All patients			Propensity score-matched patients		
	PPCI (n = 126)	PPCI+TA (n = 208)	p-value	PPCI (n = 116)	PPCI+TA (n = 116)	p-value
Medical treatment during procedural						
Anticoagulants (%)			0.332			0.062
Low molecular weight heparin	19 (15.10%)	33 (15.90%)		18 (15.50%)	18 (15.50%)	
Unfractionated heparin	98 (77.80%)	150 (72.10%)		91 (78.40%)	80 (69%)	
Bivalirudin	9 (7.10%)	25 (12%)		7 (6%)	18 (5.5%)	
GP IIb/IIIa inhibitor (%)	23 (18.30%)	57 (27.40%)	0.058	23 (19.80%)	35 (30.20%)	0.069
rhPro-UK (%)	5 (4%)	79 (38%)	<0.001	4 (3.40%)	47 (40.50%)	<0.001
Medical treatment after procedural						
Aspirin	126 (100%)	207 (99.50%)	0.436	116 (100)	115 (99.10%)	0.316
ADP receptor inhibitors			0.803			0.753
Clopidogrel	27 (21.40%)	47 (78.60%)		25 (21.60%)	27 (23.30%)	
Ticagrelor	99 (78.60%)	161 (77.40%)		91 (78.40%)	89 (76.70%)	
rhBNP	26 (20.60%)	36 (17.30%)	0.448	22 (19%)	22 (19%)	1
Statin	121 (96%)	202 (97.10%)	0.591	111 (95.70%)	114 (98.30%)	0.25
Beta-blocker	99 (78.60%)	164 (78.80%)	0.953	93 (80.20%)	91 (78.40%)	0.746
ACEI/ARB	101 (80.20%)	141 (67.80%)	0.014	92 (79.30%)	80 (69%)	0.072
Spironolactone	101 (80.20%)	168 (80.80%)	0.891	93 (80.20%)	96 (82.80%)	0.612
Admission laboratory variables						
Creatinine (μmol/L)	85.50 ± 38.14	80.53 ± 24.38	0.192	84.37 ± 37.84	82.68 ± 29.57	0.705
Glucose (mmol/L)	7.41 ± 3.62	7.23 ± 3.22	0.639	7.41 ± 3.67	7.66 ± 3.61	0.6
TC (mmol/L)	4.56 ± 1.16	4.55 ± 1.09	0.911	4.60 ± 1.19	4.56 ± 1.05	0.831
TG (mmol/L)	1.65 ± 1.66	1.52 ± 0.99	0.357	1.67 ± 1.72	1.54 ± 1.08	0.515
HDL-C (mmol/L)	1.04 ± 0.22	1.07 ± 0.24	0.315	1.05 ± 0.22	1.06 ± 0.20	0.857
Peak CK-MB (ng/mL)	204.35 ± 168.68	220.36 ± 162.26	0.435	210.56 ± 173.23	232.33 ± 176.57	0.344
LVEF (%)	52.90 ± 9.50	52.32 ± 8.89	0.39	53.34 ± 9.33	52.97 ± 8.60	0.753
Regional wall motion abnormality (n (%))	114 (90.50%)	196 (94.20%)	0.572	104 (89.70%)	108 (93.10%)	0.349

PPCI, primary percutaneous coronary intervention; TA, thrombus aspiration; BMI, body mass index; PCI, percutaneous coronary intervention; CAD, coronary artery disease; ADP, adenosine diphosphate; rhBNP, recombinant human brain natriuretic peptide; ACEI, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; CK-MB, creatine kinase-MB; LVEF, left ventricular ejection fraction.

Table 2. Angiographic and procedural characteristics before and after propensity score matching

	All patients			Propensity-matched patients		
Items/groups	PPCI (n = 126)	PPCI+TA (n = 208)	p-value	PPCI (n = 116)	TA+PPCI (n = 116)	p-value
Symptom to procedural time (hours)	4.73 ± 3.90	4.08 ± 3.75	0.131	4.63 ± 3.88	4.67 ± 4.67	0.951
Symptom to procedural time ≥4 hours (%)	64 (50.80%)	88 (42.30%)	0.131	57 (49.10%)	51 (44.80%)	0.511
Door to balloon time (minutes)	53.25 ± 25.21	52.93 ± 26.31	0.915	51.77 ± 23.62	54.39 ± 29.01	0.451
Door to balloon time ≥60 minutes (%)	38 (30.20%)	61 (29.30%)	0.872	33 (28.40%)	38 (32.80%)	0.476
Procedural approach (%)			0.018			0.687
Radial artery	113 (89.70%)	166 (79.80%)		103 (88.80%)	101 (87.10%)	
Femoral artery	13 (10.30%)	42 (20.20%)		13 (11.20%)	15 (12.90%)	
Contrast volume (mL)	145.12 ± 72.25	151.01 ± 56.50	0.407	130 (90, 157.5)	140 (120, 180)	0.014
Multivessel disease (%)	102 (81%)	150 (72.10%)	0.069	93 (80.20%)	93 (80.20%)	1
Infarct-related vessel (%)			0.462			0.226
Left anterior descending artery	59 (46.80%)	95 (45.70%)	0.838	54 (46.60%)	57 (49.10%)	
Left circumflex artery	18 (14.30%)	20 (9.60%)	0.193	16 (13.80%)	14 (12.10%)	
Right coronary artery	47 (37.30%)	91 (43.80%)	0.246	44 (37.90%)	43 (37.10%)	
Left main coronary artery	2 (1.60%)	2 (1%)	0.61	2 (1.70%)	2 (1.70%)	
Lesion segment (%)			0.178			0.104
Proximal	43 (34.10%)	84 (40.40%)		40 (34.50%)	45 (38.80%)	
Middle	56 (44.40%)	95 (45.70%)		51 (44%)	58 (50%)	
Distal	27 (21.40%)	29 (13.90%)		25 (21.60%)	13 (11.20%)	
Preprocedural diameterstenosis (% ± SD)	98.85 ± 6.33	99.36 ± 3.12	0.324	98.76 ± 6.59	99.4 ± 2.77	0.335
Referent vessel diameter (mm)	2.86 ± 0.63	2.83 ± 0.53	0.636	2.86 ± 0.62	2.89 ± 0.56	0.695
Preprocedural TIMI flow grade (%)			0.17			0.338
0	118 (93.70%)	182 (87.50%)		108 (93.10%)	109 (94%)	
1	0	0		0	0	
2	6 (4.80%)	22 (10.60%)		6 (5.20%)	6 (5.20%)	
3	2 (1.60%)	4 (1.90%)		2 (1.70%)	1 (0.90%)	
Pre-dilatation (%)	114 (90.50%)	136 (65.40%)	<0.001	104 (89.70%)	80 (69%)	<0.001
Number of stents			0.587			0.415
0	1 (0.80%)	3 (1.40%)		1 (0.90%)	0 (0.0%)	
1	106 (84.10%)	166 (79.80%)		99 (85.30%)	95 (81.90%)	
2	19 (15.10%)	39 (18.80%)		16 (13.80%)	21 (18.10%)	

(continued)

Table 2. Continued

Items/groups	All patients			Propensity-matched patients		
	PPCI (n = 126)	PPCI+TA (n = 208)	p-value	PPCI (n = 116)	TA+PPCI (n = 116)	p-value
Poststent balloon dilatation (%)	60 (47.60%)	111 (53.40%)	0.309	57 (49.10%)	64 (55.20%)	0.358
Postprocedural vessel diameter	2.9 (2.5, 3.1)	3 (2.6, 3.4)	0.006	2.9 (2.563, 175)	2.94 (2.57, 3.4)	0.009
Residual stenosis (% ± SD)	16.31 ± 6.20	15.65 ± 6.41	0.353	16.39 ± 5.99	15.63 ± 6.19	0.342
Postprocedural TIMI flow grade			0.003			0.114
1	1 (0.80%)	3 (1.00%)		1 (0.90%)	1 (0.90%)	
2	20 (15.90%)	25 (4.80%)		18 (15.50%)	8 (6.90%)	
3	105 (83.30%)	196 (94.20%)		97 (83.60%)	107 (92.20%)	
Postprocedural cTFC (frames)	24.12 (16, 32.71)	18.31 (11.1, 28.73)	0.001	24.06 (16, 32.46)	18 (11.82, 29)	0.021
Non-target lesion management	9 (7.10%)	20 (9.60%)	0.437	8 (6.90%)	14 (12.10%)	0.179
IABP (%)	2 (1.60%)	8 (3.80%)	0.24	2 (1.70%)	4 (3.40%)	0.408

PPCI, primary percutaneous coronary intervention; TA, thrombus aspiration; SD, standard deviation; cTFC, corrected TIMI frame count; IABP, intra-aortic balloon pump; TIMI, thrombolysis in myocardial infraction.

Clinical outcomes

Clinical outcomes are summarized in Table 3. During the 12-month follow-up, there were no significant differences in the incidence of MACCE, cardiac death, reinfarction, stent thrombosis, target vessel revascularization, or stroke. MACCE occurred in eight (6.3%) of 126 patients in the PPCI group and in 15 (7.2%) of 208 patients in the PPCI + TA group. Three patients died of cardiac rupture, one patient died of cardiac shock, and one patient died of malignant arrhythmia in the PPCI group. Four patients died of cardiac rupture, four patients died of cardiac shock, and one patient died of malignant arrhythmia in the PPCI + TA group. The 12-month Kaplan–Meier overall cumulative incidence of the MACCE rate was similar between the two groups (Figure 1a). The crude (HR 1.53, 95% CI 0.59–3.95) and adjusted (HR 0.74, 95% CI 0.15–3.67) risks of MACCE were similar between two groups.

Analysis of the propensity score-matched population

After propensity score matching, there were 116 patients in each group. With the exception of rhPro-UK, pre-dilatation, and volume of contrast dye, all the other baseline clinical and medical treatment characteristics showed no significant differences between the two groups. The variables rhPro-UK, pre-dilatation, and volume of contrast dye were included in the multivariate analysis. The proportion of postprocedural TIMI 3 flow was 83.6% in the PPCI group compared with 92.2% in the PPCI + TA group. The crude (OR 2.33, 95% CI 1.01–5.39, $p = 0.048$) and adjusted (OR 4.07, 95% CI 1.09–15.16, $p = 0.04$) logistic regression analysis showed that TA was associated with a higher rate of postprocedural TIMI 3 flow. MACCE occurred in seven patients (6%) in the

Table 3. Clinical outcomes before and after propensity score matching

Items/groups	All patients			Propensity-matched patients		
	PPCI (n = 126)	PPCI + TA (n = 208)	p-value	PPCI (n = 116)	TA + PPCI (n = 116)	p-value
Major adverse cardiac cerebrovascular events	8 (6.30%)	15 (7.20%)	0.198	7 (6%)	11 (9.50%)	0.326
Cardiac death	5 (4.00%)	9 (4.30%)	0.763	4 (3.40%)	5 (4.30%)	0.734
Reinfarction	6 (4.80%)	6 (2.90%)	0.874	5 (4.30%)	5 (4.30%)	1
Stent thrombosis	1 (0.80%)	2 (1%)	0.27	1 (0.90%)	1 (0.90%)	1
Target vessel revascularization	2 (1.60%)	5 (2.40%)	0.88	2 (1.70%)	4 (3.40%)	0.408
Stroke	2 (1.60%)	2 (1%)	0.614	2 (1.70%)	1 (0.90%)	0.561

PPCI, primary percutaneous coronary intervention; TA, thrombus aspiration.

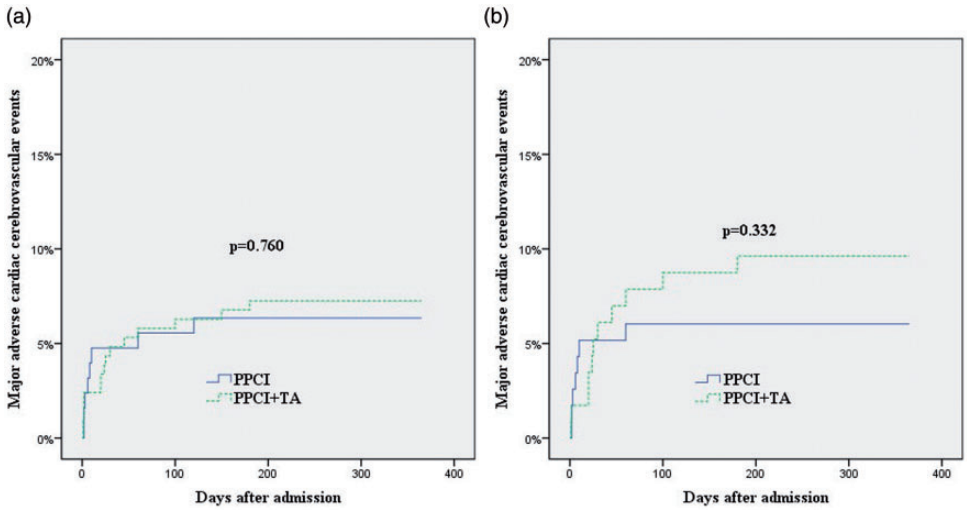

Figure 1. Kaplan–Meier curves for cumulative probability of MACCE at 12 months for patients undergoing PPCI versus PPCI+TA before propensity score matching (a) and after propensity score matching (b)
MACCE, major adverse cardiac cerebrovascular events; PPCI, primary percutaneous coronary intervention; TA, thrombus aspiration.

PPCI group and in 11 patients (9.5%) in the PPCI + TA group. The 12-month Kaplan–Meier overall cumulative incidence of the MACCE rate was similar between the two groups (Figure 1b). The crude (HR 1.59, 95% CI 0.62–4.10) and adjusted (HR 0.38, 95% CI 0.54–4.97) risk of MACCE were similar between the two groups.

Discussion

The main findings of our retrospective cohort study were that compared with conventional PPCI, PPCI with TA significantly improved the outcome in patients with STEMI and a large thrombus burden, such as a higher rate of postprocedural TIMI 3 flow, lower cTFC, and larger

postprocedural vessel diameter; however PPCI with TA did not reduce the risk of MACCE during the 1-year follow-up period. In the propensity score-matched cohort, treatment with TA improved the proportion of postprocedural TIMI 3 flow but showed no benefit on the clinical outcome after 1-year of follow-up.

TA could be beneficial for the outcome of patients with STEMI by reducing the thrombus load at the target lesion and the risk of distal embolization. The incidence of impaired myocardial blush was improved with TA, and mortality at 1 year was significantly reduced compared with conventional PPCI.[4] A subsequent meta-analysis also showed improvements in the angiographic markers of myocardial perfusion and the mortality benefit.[3] However, the beneficial effects of TA have been challenged by the results of two major randomized multicenter trials, TASTE and TOTAL, which demonstrated that routine TA increased the risk of stroke.[6,7]

A large thrombus burden is the main cause of STEMI and a significant independent predictor for mortality.[10,11] A recent study suggested that selective TA may be useful for improving the outcomes in patients with STEMI.[12] In the setting of STEMI, the TIMI flow grade could be a surrogate to identify a high thrombus burden. In patients with STEMI and an initial TIMI flow grade from 0 to 1 during PPCI, TA improved coronary flow, myocardial perfusion, and long-term clinical outcome.[13] In addition, TA reduced the incidence of MACE by more than half, including cardiac mortality, recurrent MI, stroke, coronary artery bypass graft, and repeat PCI in STEMI adults with a high thrombus burden.[9] Recent prospective randomization clinical trials confirmed that TA improved myocardial perfusion but failed to improve the prognosis, possibly because of the short follow-up period.[8] While several studies indicated that TA during PPCI was not associated with a better clinical prognosis,[14–16] a meta-analysis reported that patients with a high thrombus burden received the highest potential benefit from TA.[17] This may explain why TA may be considered for a large residual thrombus burden in the 2017 European Society of Cardiology (ESC) guideline.[1]

A previous study suggested that the effects of TA on procedural and clinical outcomes may be related to multiple factors. Although a visible thrombus could be suctioned and the epicardial coronary flow would be restored by TA, effective myocardial perfusion may not be achieved due to a nonvisible thrombus and microvasculature obstruction.[18] In addition, there was a significant difference in the efficacy of TA between different operators with myocardial reperfusion.[19]

This study has some limitations. First, this is a retrospective study. Although we adjusted the potential confounders using a multivariable analysis and performed propensity score analysis to control selection bias, several confounding variables and unmeasurable factors may still exist. Second, this is a single-center study and the sample size is relatively small. Third, the data on the modified TIMI thrombus scale for TIMI thrombus grade 5 have not been analyzed. Fourth, the follow-up period of 1 year is relatively short.

In conclusion, the application of TA in patients with STEMI and a large thrombus burden during PPCI can improve the procedural outcome, but it showed no benefit on the clinical prognosis during a 12-month follow-up. Longer follow-up studies are needed to confirm the clinical implications of TA in patients with STEMI.

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Declaration of conflicting interest

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References

1. Ibanez B, James S, Agewall S, et al. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J* 2018; 39: 119–177.
2. Mahmoud KD and Zijlstra F. Thrombus aspiration in acute myocardial infarction. *Nat Rev Cardiol* 2016; 13: 418–428.
3. Kumbhani DJ, Bavry AA, Desai MY, et al. Role of aspiration and mechanical thrombectomy in patients with acute myocardial infarction undergoing primary angioplasty: an updated meta-analysis of randomized trials. *J Am Coll Cardiol* 2013; 62: 1409–1418.
4. Vlaar PJ, Svilaas T, vander Horst IC, et al. Cardiac death and reinfarction after 1 year in the thrombus aspiration during percutaneous coronary intervention in acute myocardial infarction study (TAPAS): a 1-year follow-up study. *Lancet* 2008; 371: 1915–1920.
5. Taglieri N, Bacchi Reggiani ML, Ghetti G, et al. Efficacy and safety of thrombus aspiration in ST-segment elevation myocardial infarction: an updated systematic review and meta-analysis of randomised clinical trials. *Eur Heart J Acute Cardiovasc Care* 2019; 8: 24–38.
6. Jolly SS, Cairns JA, Yusuf S, et al. Randomized trial of primary PCI with or without routine manual thrombectomy. *N Engl J Med* 2015; 372: 1389–1398.
7. Lagerqvist B, Fröbert O, Olivecrona GK, et al. Outcomes 1 year after thrombus aspiration for myocardial infarction. *N Engl J Med* 2014; 371: 1111–1120.
8. Li P, Ruan JW, Liu M, et al. Thrombus aspiration catheter improve the myocardial reperfusion of STEMI patients with high thrombus load during the emergency PCI operation. *J Cardiothorac Surg* 2019; 14: 172.
9. Ge J, Li J, Dong B, et al. Determinants of angiographic thrombus burden and impact of thrombus aspiration on outcome in young patients with ST-segment elevation myocardial infarction. *Cathete Cardiovasc Interv* 2019; 93: E269–E276.
10. Del Portillo JH, Echeverri D and Cabrales J. Association of the use of manual thrombus aspiration with intracoronary thrombotic burden in patients with ST segment elevation myocardial infarction in the real world. *Int J Cardiol Heart Vasc* 2020; 26: 100436.
11. Jolly SS, Cairns JA, Lavi S, et al. Thrombus aspiration in patients with high thrombus burden in the TOTAL trial. *J Am Coll Cardiol* 2018; 72: 1589–1596.
12. Pereira H, Caldeira D, Teles RC, et al. Thrombus aspiration in patients with ST-elevation myocardial infarction: results of a national registry of interventional cardiology. *BMC Cardiovasc Disord* 2018; 18: 69.
13. Mangiacapra F, Wijns W, De Luca G, et al. Thrombus aspiration in primary percutaneous coronary intervention in high-risk patients with ST-elevation myocardial infarction: a real-world registry. *Cathete Cardiovasc Interv* 2010; 76: 70–76.
14. Hizoh I, Banhegyi G, Domokos D, et al. Impact of selective aspiration thrombectomy on mortality in patients with ST-segment elevation myocardial infarction. *Am J Cardiol* 2018; 121: 796–804.
15. Keskin M, Kaya A, Tatlisu MA, et al. Effect of adjunctive thrombus aspiration on in-

hospital and 3-year outcomes in patients with ST-segment elevation myocardial infarction and large native coronary artery thrombus burden. *Am J Cardiol* 2017; 120: 1708–1714.
16. Seong SW, Ahn KT, Kim M, et al. Korea acute myocardial infarction registry-national institute of health i: impact of thrombus aspiration on clinical outcomes in Korean patients with ST elevation myocardial infarction. *Chonnam Med J* 2020; 56: 36–43.
17. Jolly SS, James S, Džavík V, et al. Thrombus aspiration in ST-segment-elevation myocardial infarction: an individual patient meta-analysis: thrombectomy trialists collaboration. *Circulation* 2017; 135: 143–152.
18. Ge J, Schafer A, Ertl G, et al. Thrombus aspiration for ST-segment-elevation myocardial infarction in modern era: still an issue of debate? *Circ Cardiovasc Interv* 2017; 10: e005739.
19. Vlaar PJ, de Smet BJ, van den Heuvel AF, et al. Operator dependence of outcome after primary percutaneous coronary intervention. *EuroIntervention* 2011; 6: 760–767.