Herz 2020 · 45:280–287
https://doi.org/10.1007/s00059-018-4716-0
Received: 11 January 2018
Revised: 23 April 2018
Accepted: 20 May 2018
Published online: 12 June 2018

Z. Zhang[1] · W. Li[2] · W. Wu[1] · Q. Xie[1] · J. Li[1] · W. Zhang[1] · Y. Zhang[3]

[1] Department of Cardiology, Panyu Central Hospital (Cardiovascular Institute of Panyu District), Guangzhou, China

[2] Department of Cardiology, Ganzhou City People's Hospital, Ganzhou, China

[3] Department of Ultrasound, Guangdong Women and Children Hospital, Guangzhou, China

Myocardial reperfusion with tirofiban injection via aspiration catheter

Efficacy and safety in STEMI patients with large thrombus burden

An important reperfusion strategy in acute ST-segment elevation myocardial infarction (STEMI) is primary percutaneous coronary intervention (PPCI) at an early stage [1]. However, in some patients, there is still no recovery of blood flow or slow reflow (no-flow or slow-flow phenomenon, respectively) even after successful infarction treatment [2]. Thrombus aspiration (TA) can reduce the incidence of these phenomena and is critical for reducing cardiovascular adverse events in STEMI patients who already have a heavy thrombus burden; however, routine TA during PPCI is not recommended [3–5]. A meta-analysis indicates that intracoronary administration of abciximab is associated with significant benefits in myocardial perfusion [6]. The 2015 American College of Cardiology/American Heart Association (ACC/AHA) STEMI guideline update [1] suggests that use of tirofiban in conjunction with heparin anticoagulation in selected STEMI patients can reduce the risk of slow-flow or no-flow. Furthermore, it is reported that the use of intracoronary tirofiban is more effective and safer in STEMI patients undergoing PPCI [7]. However, the SUIT-AMI trial (Impact of selective infarct-related artery infusion of tirofiban on myocardial reperfusion and bleeding complications in patients with acute myocardial infarction) [8] showed no improvement of myocardial reperfusion by selective injection of tirofiban after TA. Currently, the application of a TA catheter and tirofiban for STEMI patients during PPCI is under debate [3].

Our study aimed to investigate the efficacy and safety of selective tirofiban injection via TA catheter during PPCI in STEMI patients with a heavy thrombus burden.

Patients and methods

Patient enrollment

From September 2011 to January 2017, patients with acute STEMI who underwent PPCI at Panyu Central Hospital were enrolled in the study if they: (1) were aged between 18 and 75 years; (2) signed an informed consent form; (3) were available for constant follow-up; and (4) had a Thrombolysis in Myocardial Infarction (TIMI) thrombus grade of 4–5. Thrombus burden was graded [2] as: G0 = no thrombus, G1 = possible thrombus, G2 = small (greatest dimension ≤ 1/2 vessel diameter [VD]), G3 = moderate (>1/2 but <2VD), G4 = large (≥2VD), G5 = total occlusion [9]. A diagnosis of STEMI was reached when patients complained about chest pain and had ST elevation in two leads or had new-onset left bundle branch block (LBBB) on an electrocardiogram (ECG) and elevated cardiac markers (creatine kinase-MB [CK-MB] and troponin I/T). In most cases, STEMI diagnoses were made by the first physician attending the patient.

We excluded patients if they: (1) were diagnosed as having non-ST elevation myocardial infarction; (2) had severe renal or liver dysfunction; (3) had TIMI thrombus grade 0–3; (4) were lactating or pregnant women; (5) declined consent; (6) had a history of prior coronary artery bypass surgery; and (7) participated in other clinical studies.

This study was conducted based on the principles of the Declaration of Helsinki, 2008 version. The study was approved by the Panyu Central Hospital Ethics Committee and all patients signed informed consent before PPCI.

Patient grouping

In total, 122 patients with acute STEMI (<12 h) and heavy thrombus burden treated with TA during PPCI were enrolled in our study (**Fig. 1**). All the participants were randomly divided into group A ($n = 61$) and group B ($n = 61$) based on sealed envelope containing letter A and B. Group A received tirofiban injection via the TA catheter to the infarct-related artery (IRA) plus continuous intravenous injection for 48 h and

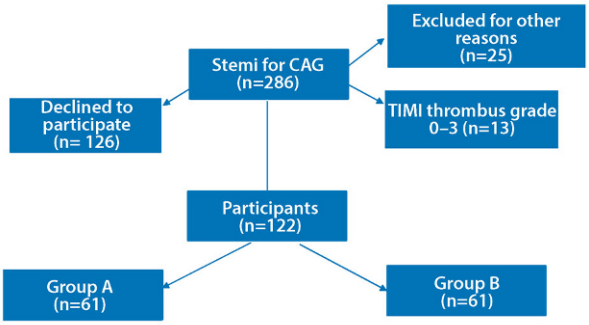

Fig. 1 ▲ Study flow diagram. *STEMI* ST-segment elevation acute myocardial infarction, *CAG* coronary angiography, *TIMI* Thrombolysis in Myocardial Infarction

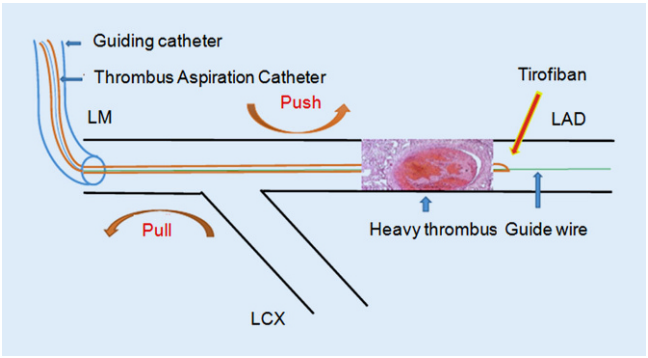

Fig. 2 ▲ Method of tirofiban injection for group A. After passing the guide wire (GW), the thrombus aspiration catheter (TAC) is pushed and pulled for aspiration. The TAC is flushed and then reintroduced into the infarct-related artery and tirofiban is injected around the blocked section. An additional GW is sometimes used to protect other branches from acute occlusion by unexpected thrombus during TA. *LAD* left anterior descending artery, *LCX* left circumflex artery, *LM* left main coronary artery

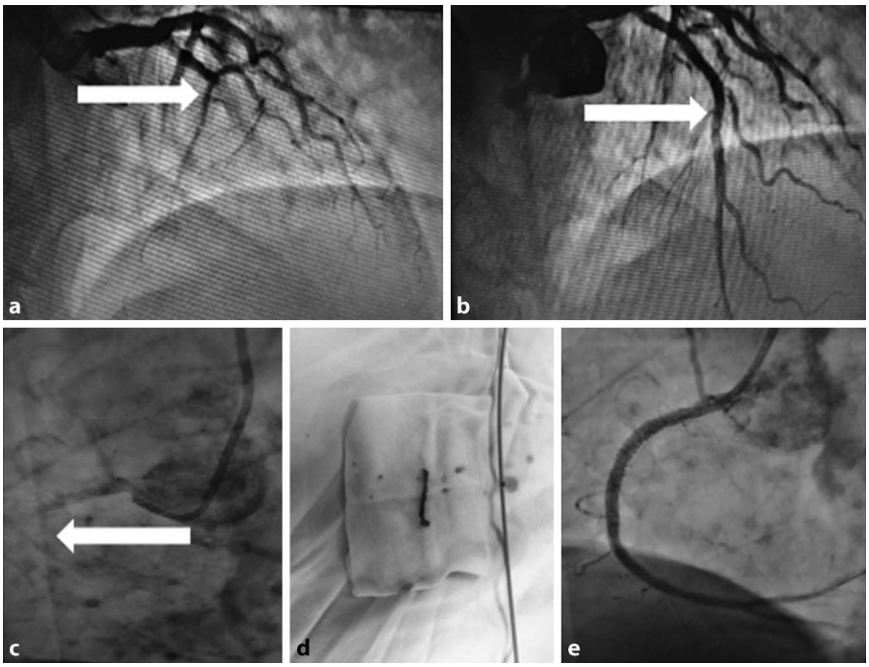

Fig. 3 ▲ Two typical clinical cases. **a** Group B: total blockage of the left anterior descending artery (*arrow*) after angiography. **b** Group B: relatively lower TIMI (Thrombolysis in myocardial Infarction) flow grade after the procedure (*arrow*). **c** Group A: total occlusion (*arrow*) in the right coronary artery. **d** Group A: a large thrombus was aspirated after passage of the guide wire; **e** Group A: normal TIMI flow grade after tirofiban injection via thrombus aspiration catheter and stenting

group B received intravenous tirofiban injection only.

Treatments

All the participants were given medications including aspirin (300 mg), clopidogrel (300 mg), and atorvastatin (40 mg) before coronary angiography (CAG), following the ACC/AHA guidelines [10]. CAG was performed according to the guidelines [10]. In brief, a ZEEK TA catheter (Zeon Medical Inc., Tokyo, Japan) was used to aspirate thrombus (push and pull). The TA catheter was reintroduced into the IRA beyond the thrombus, and selective injection of tirofiban (Wuhan Grand Pharmaceutical Group, Wuhan, China) was performed subsequently in group A (Fig. 2). Patients in group B only received TA without intracoronary injection of tirofiban. Stent implantation and balloon dilation (predilation and postdilation) were performed in both groups if needed. The routine time for maintaining intravenous infusion of tirofiban in both groups was 48 h, unless active hemorrhage was detected. Standard medications were prescribed during hospitalization according to guidelines [11].

Study variables and endpoints

Demographic data, clinical information, and angiography findings were collected for all participants. The TIMI thrombus burden grade and TIMI flow grade were judged independently by two experienced interventional cardiologists who were blinded to the clinical data of the participants.

ECG was carried out before and 90 min after the procedure to calculate the ST-segment resolution [2]. We calculated the degree of ST-segment elevation and resolution for all patients. Complete ST-segment resolution (CR) was defined as ≥70% resolution; partial ST-segment resolution (PR) [2] as between 30 and 70% resolution; no ST-segment resolution (NR) as <30% resolution. Follow-up in our outpatient department was recommended for all patients 30 days after discharge. ECGs were reexamined immediately and 30 days

Herz 2020 · 45:280–287 https://doi.org/10.1007/s00059-018-4716-0

Z. Zhang · W. Li · W. Wu · Q. Xie · J. Li · W. Zhang · Y. Zhang

Myocardial reperfusion with tirofiban injection via aspiration catheter. Efficacy and safety in STEMI patients with large thrombus burden

Abstract

Background. There is no consensus on the use of thrombus aspiration (TA) in primary percutaneous coronary intervention (PPCI), and few studies have focused on the performance of tirofiban via TA catheter after PPCI. Our study investigated the clinical outcome of tirofiban injection through TA in acute ST-segment elevation myocardial infarction (STEMI) patients with large thrombus burden undergoing PPCI treatment.

Patients and methods. The study comprised 122 STEMI patients who underwent TA during PPCI. Participants were randomly divided into two groups. Group A received intravenous tirofiban injection and tirofiban injection via a TA catheter to the infarcted coronary artery after aspiration ($n = 61$). Group B received intravenous tirofiban injection only ($n = 61$). Baseline clinical information and follow-up data were collected for both groups. Coronary angiography, electrocardiography, and echocardiography findings as well as major adverse cardiovascular events (MACE) were recorded.

Results. There were significant differences in postprocedural Thrombolysis in Myocardial Infarction (TIMI) grade 2 and 3 flow between the two groups ($p = 0.021$, $p = 0.006$, respectively). The incidence of slow-flow in group A was significantly lower than that of group B ($p = 0.011$). An increased incidence of no ST-segment resolution was observed in group B ($p = 0.011$). There were fewer major adverse cardiovascular events in group A than in group B, but the difference was not statistically significant.

Conclusion. Selective tirofiban injection via TA catheter during PPCI may improve myocardial reperfusion in STEMI patients with large thrombus burden.

Keywords

Thrombectomy · Percutaneous coronary intervention · Angioplasty · Anticoagulants · Myocardial infarction

Myokardreperfusion mit Tirofibaninjektion via Aspirationskatheter. Wirksamkeit und Sicherheit bei STEMI-Patienten mit hoher Thrombuslast

Zusammenfassung

Hintergrund. In Bezug auf die Thrombusaspiration (TA) bei der primären perkutanen Koronarintervention (PPCI) besteht kein Konsens, und den Fokus auf die Leistungsfähigkeit von Tirofiban via TA-Katheter nach PPCI legten bisher nur wenige Studien. In der vorliegenden Studie wurde das klinische Ergebnis nach Tirofibaninjektion via TA-Katheter untersucht, und zwar bei Patienten mit akutem ST-Strecken-Hebungs-Infarkt („ST-segment elevation myocardial infarction", STEMI) und hoher Thrombuslast, bei denen eine PPCI-Behandlung erfolgte.

Patienten und Methoden. Die Studie umfasste 122 STEMI-Patienten, bei denen eine TA im Rahmen der PPCI erfolgte. Die Teilnehmer wurden randomisiert in 2 Gruppen unterteilt. Gruppe A erhielt eine i.v.-Tirofibaninjektion und eine Tirofibaninjektion via TA-Katheter in die infarzierte Koronararterie nach TA ($n = 61$). Gruppe B erhielt nur eine i.v.-Tirofibaninjektion ($n = 61$). Für beide Gruppen wurden klinische Daten zu Beginn und im Verlauf erhoben. Die Befunde der Koronarangiographie, Elektrokardiographie und Echokardiographie sowie schwere kardiovaskuläre Nebenwirkungen („major adverse cardiovascular events", MACE) wurden dokumentiert.

Ergebnisse. Zwischen den beiden Gruppen bestanden signifikante Unterschiede in Bezug auf den postprozeduralen Durchfluss des Grads 2 und 3 gemäß TIMI-Klassifikation („thrombolysis in myocardial infarction"; $p = 0{,}021$ bzw. $p = 0{,}006$). In Gruppe A war die Inzidenz eines langsamen Flusses signifikant niedriger als in Gruppe B ($p = 0{,}011$). Es wurde eine erhöhte Inzidenz einer fehlenden Rückbildung der ST-Strecken-Hebung in Gruppe B ($p = 0{,}011$) beobachtet. In Gruppe A gab es weniger MACE als in Gruppe B, der Unterschied war jedoch statistisch nicht signifikant.

Schlussfolgerung. Die selektive Tirofibaninjektion via TA-Katheter während PPCI führt möglicherweise zu einer besseren Myokardreperfusion bei Patienten mit STEMI und hoher Thrombuslast.

Schlüsselwörter

Thrombektomie · Perkutane Koronarintervention · Angioplastie · Antikoagulanzien · Myokardinfarkt

after discharge. Total major adverse cardiovascular events (MACE), especially fatal bleedings, stroke, and death as endpoints, were recorded.

Statistical analysis

SPSS Statistics (IBM, Version 21.0, Armonk, NY, USA) was used to analyze the data. Continuous variables are expressed as mean ± SD and were compared using the unpaired Student *t* test or Mann–Whitney *U* test. Categorical variables are expressed as number and percentages and were compared using Fisher's exact test or Pearson chi-square test as appropriate. A *p* value less than 0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 286 STEMI patients were initially enrolled in the study. Of these patients, 126 declined to participate in our study owing to payment problems, 25 were excluded for not meeting the inclusion criteria, and 13 were excluded because of light thrombus burden, as shown in **Fig. 1**. Finally, 122 patients

Table 1 Baseline clinical characteristics

	Group A ($n=61$)	Group B ($n=61$)	p
Age (years)	61.37 ± 9.73	62.75 ± 11.33	0.473
Male	41 (67.2)	39 (63.9)	0.703
Medical insurance	36 (59.0)	38 (62.3)	0.544
Current smoking	27 (44.3)	21 (34.4)	0.300
Hypertension	50 (82.0)	45 (73.8)	0.276
Diabetes mellitus	42 (68.9)	39 (63.9)	0.565
Hyperlipidemia	35 (57.4)	31 (50.8)	0.467
CAD family history	12 (19.7)	9 (14.8)	0.472
Previous stroke	1 (1.6)	1 (1.6)	1.000
Previous intervention	2 (3.3)	3 (4.9)	1.000
Preprocedural SBP (mm Hg)	107.03 ± 9.48	109.10 ± 9.52	0.232
Preprocedural DBP (mm Hg)	72.79 ± 7.53	73.34 ± 8.07	0.694
HGB (g/l)	139.29 ± 6.55	140.10 ± 5.58	0.467
PLT count (*10^9/l)	199.13 ± 9.25	197.87 ± 10.72	0.488
Killip classification			
1–2	22 (36.1)	25 (41.0)	0.577
3–4	39 (63.9)	36 (59.0)	0.710

Values are expressed as mean ± SD or *n* (%)
CAD coronary artery disease, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *HGB* hemoglobin, *PLT* platelets

were enrolled and were randomly divided into two groups. The baseline demographics are listed in **Table 1**. There was no significant difference in baseline demographics between the two groups ($p > 0.05$).

Catheterization parameters

Angiography was performed to compare the efficacy of myocardial reperfusion between the two groups. Before that, door-to-balloon (D2B) time and first medical contact-to-PCI (FMC2B) time were calculated. Since our institute is the most important chest pain center in the Panyu district, green passageway for STEMI was performed as common practice. Green passageway is the rapid way for PPCI of STEMI patients in our hospital. Patients can go directly to the Cath lab once they gave consent, without other procedures, which could save time of D2B. Sometimes consent was given in the ambulance, in which case the ambulance stops directly at the door of the Cath lab. Coronary angiography was done to confirm STEMI in all participants. A verdict of IRA was made by the combination of ECG and angiography findings. As shown in **Table 2**, there were differences in D2B time/FMC2B time and Syntax scores between the two groups; however, none of the differences were statistically significant.

On the basis of the angiography findings, there were more patients with TIMI grade 0 in group A, but there were no significant differences between the groups ($p = 0.596$). However, there were more patients with high rates of TIMI grade 1 and 2 in group B than in group A (13.1% vs. 9.8% and 6.6% vs. 4.9%, respectively) without statistical significance. There were no patients with normal TIMI flow (grade 3) in both groups before intervention. There were no differences in the number of patients who accepted stenting, in the number of stents, in the maximum stent diameter, and in the maximum dilation pressure between group A and group B ($p > 0.05$).

There were no differences in postprocedural TIMI grade 0 and 1 between the groups. However, compared with group B, group A had significantly better results for the normal TIMI (grade 3) ratio after PCI than group B (96.7% vs. 78.7%, respectively, $p = 0.006$), and group A had a higher ratio of patients with TIMI grade 2 (14.8% vs. 1.6%, $p = 0.021$). We also calculated the incidence of slow-flow and no-flow. Although the difference in no-flow was not significant, the incidence of slow-flow in group A and B was significantly different (3.3% vs. 19.7%, respectively, $p = 0.011$; **Table 2**). Next, we measured the ST-segment elevation before and after PCI. ST-segment resolution was calculated according to the degree of elevation. The differences in complete and partial ST-segment resolution were not apparent; however, there was a higher rate of no ST-segment resolution in group A compared with group B (19.7% vs. 3.3%, respectively). No significant difference was observed in postprocedural SBP and DBP ($p > 0.05$). These results indicate that selective tirofiban injection via TA catheter can improve myocardial reperfusion.

Angiographic features

The angiographic features of two typical cases from each group are shown in **Fig. 3**. For group B, before surgery, there was severe thrombus and the left anterior descending artery was totally blocked (**Fig. 3a**). After surgery, the blood flow was improved. However, the TIMI flow grade was relatively lower and residual thrombus was observed (**Fig. 3b**). For group A, severe thrombus and total blockage of the right coronary artery was observed before the procedure (**Fig. 3c**). A large thrombus was aspirated during the procedure (**Fig. 3d**). After the procedure, there was normal TIMI flow grade and no residual thrombus was observed.

Echocardiography

We performed echocardiography to assess cardiac function within 12 h of PPCI as well as at the follow-up 30 days after discharge. There were no significant differences between the in-hospital and follow-up data between the two groups ($p > 0.05$; **Table 3**). For example, group A was not significantly different from group B in left ventricular end-systolic diameter and left ventricular end-diastolic diameter. Serum troponin I

Table 2 Catheterization parameters

	Group A ($n = 61$)	Group B ($n = 61$)	p
D2B time (min)	59.91 ± 19.43	60.21 ± 22.28	0.938
FMC2B time (min)	95.63 ± 25.62	99.62 ± 20.77	0.347
Multivessel disease	17 (27.9)	22 (36.6)	0.725
Infarct-related artery			
LM	0	0	–
LAD	29 (47.5)	34 (55.7)	0.365
LCX	11 (18.0)	18 (29.5)	0.137
RCA	16 (26.2)	14 (23.0)	0.674
Preprocedural TIMI grade flow			
0	52 (85.2)	49 (80.3)	0.596
1	6 (9.8)	8 (13.1)	0.570
2	3 (4.9)	4 (6.6)	1.000
3	0	0	–
PCI with direct stenting	57 (93.4)	54 (88.5)	0.343
Number of stents	1.15 ± 0.60	1.33 ± 0.60	0.099
Maximum stent diameter (mm)	3.17 ± 0.31	3.20 ± 0.36	0.590
Maximum dilation pressure (atm)	15.61 ± 1.96	15.93 ± 2.00	0.362
Postprocedural TIMI grade flow			
0	0	1 (1.6)	1.000
1	1 (1.6)	2 (3.3)	0.611
2	9 (14.8)	1 (1.6)	0.021*
3	59 (96.7)	48 (78.7)	0.006**
Slow-flow	2 (3.3)	12 (19.7)	0.011*
No-flow	0	1 (1.6)	1.000
ST-segment resolution			
Complete	52 (85.2)	44 (72.1)	0.077
Partial	7 (11.8)	5 (8.2)	0.543
No	2 (3.3)	12 (19.7)	0.011*
Postprocedural SBP (mm Hg)	116.08 ± 8.89	117.11 ± 9.54	0.537
Postprocedural DBP (mm Hg)	77.28 ± 6.57	77.93 ± 5.98	0.565

Values are expressed as mean ± SD or *n* (%)
D2B door to balloon, *FMC2B* first medical contact to percutaneous coronary intervention (*PCI*), *LM* left main, *LAD* left anterior descending, *LCX* left circumflex, *RCA* right coronary artery, *TIMI* Thrombolysis in Myocardial Infarction, *SBP* systolic blood pressure, *DBP* diastolic blood pressure
* $p < 0.05$, ** $p < 0.01$

and CK-MB levels were monitored at multiple time points and the peak levels were recorded during the hospital stay. The lower peak level of troponin I and CK-MB in group A was lower than that in group B, without reaching statistical significance. At the end of the procedure, the total number of MACE during the in-hospital and follow-up period was determined. Fortunately, no cases of fatal bleeding complications were found. There was five events (two heart failure, one re-infraction, one acute stent thrombosis, and one revascularization) in group A and nine events (four heart failure, one re-infraction, one acute stent thrombosis, one revascularization, one stroke, and one death) in group B. There were no statistically significant differences between the two groups for total MACE ($p = 0.726$). These results indicate that selective tirofiban injection via TA catheter is relatively safe.

Discussion

In the past few years, there has been a dramatic increase in vessel patency rates during PPCI, which is the optimal strategy for the experienced cardiologist to restore the IRA [5]. Before 2014, TA was recommended during PPCI according to international guidelines after the promising results of the Thrombus Aspiration During Primary Percutaneous Coronary Intervention (TAPAS) study [12]. However, data from large randomized control trials (RCTs) fail to demonstrate any benefit of TA on coronary microvascular function in PPCI [13, 14]. Routine use of TA is not recommended in PPCI [15] and TA is limited to cases with large thrombus burden. However, a significant residual thrombus burden was often seen in STEMI patients after aspiration, and STEMI patients with large thrombus burden had more microvascular dysfunction and greater myocardial damage compared with those with smaller thrombus burden [16]. In our study, we excluded patients with light thrombus or with an initially normal TIMI according to angiography, reflecting a true diagnosis of STEMI.

Tirofiban, a glycoprotein IIb/IIIa inhibitor, targets platelets to prevent aggregation and adhesion [17]. Sometimes, distal embolization of atherothrombotic material with subsequent obstruction can cause the phenomenon of "no-flow," even after TA, although reperfusion and direct ischemic injury are also involved [18]. Highly localized injection of tirofiban can increase the concentration in specific sites of the coronary artery, subsequently improving microcirculation [7], and is positively related to better myocardial reperfusion [19]. Consequently, we compared TA injection of tirofiban with intravenous injection.

Previous studies have focused on the feasibility and safety of aspiration thrombectomy in combination with intracoronary tirofiban administration in STEMI patients. For instance, Geng et al. [20] showed that the combination was safe and effective; moreover, tirofiban did not increase bleeding complications in patients with thrombus burden. Gao et al. reported similar results [7]. In our study, after the procedure, the rate of TIMI grade 3 flow was significantly higher and the rate of slow-flow and of no ST-segment resolution was signif-

Table 3 In-hospital and follow-up patient data

	Group A ($n = 61$)	Group B ($n = 61$)	p
In-hospital			
LVEF (%)	43.57 ± 3.85	42.36 ± 3.25	0.062
LVEDD (mm)	47.05 ± 3.22	47.92 ± 3.02	0.127
LVESD (mm)	29.79 ± 1.95	29.72 ± 1.91	0.851
Peak CK-MB (U/l)	209.49 ± 27.14	215.75 ± 28.12	0.213
Peak troponin I (ng/ml)	5.04 ± 0.53	5.10 ± 0.36	0.498
Fatal bleeding	0	0	–
Heart failure	2 (3.3)	4 (6.6)	0.675
Re-infarction	1 (1.6)	1 (1.6)	1.000
Acute stent thrombosis	1 (1.6)	1 (1.6)	1.000
Target vessel revascularization	1 (1.6)	1 (1.6)	1.000
30-day follow-up			
LVEF (%)	48.48 ± 3.76	47.21 ± 4.18	0.082
LVEDD (mm)	43.59 ± 8.02	45.15 ± 2.10	0.145
LVESD (mm)	28.16 ± 1.87	28.21 ± 1.66	0.878
Stroke (total)	0	1 (1.6)	1.000
Death (total)	0	1 (1.6)	1.000
MACE (total)	5 (8.2)	9 (14.8)	0.256

LVEF left ventricular ejection fraction, *LVESD* left ventricular end systolic diameter, *LVEDD* left ventricular end diastolic diameter, *CK-MB* creatine kinase-MB, *MACE* major adverse cardiovascular events

icantly lower in the group of patients with tirofiban TA injection. No significant differences in no-flow and in complete and partial ST-segment resolution were seen between the two groups. There may be multiple reasons for this result. First and foremost, the higher local concentration of tirofiban from TA could avoid using the medication into non-culprit vessels, which may increase the de-thrombotic effect on the culprit lesion. Second, cardiac reperfusion parameters in STEMI patients treated with TA including D2B and FMC2B were smaller without statistical significance [19]. Delayed opening of infarcted vessels will increase total ischemic time in patients with larger thrombus, which may diminish the potential benefit of thrombus removal and the long-term mortality [21]. Third, more patients had direct stent implantation after aspiration in group A, who might benefit from less predilation and high the concentration of localized tirofiban. A strategy of TA with subsequent direct stenting avoids the hazards of predilation and can result in superior visualization of the underlying lesion compared with direct stenting [3]. Following TA, selective coronary injection of tirofiban might also reduce distal embolization. Finally, the potential advantages of group A, who had a lower rate of acute occlusion of the left anterior descending artery and relatively lower blood pressure after intervention, represent positive feedback for myocardial reperfusion. Experimental findings showed an increase in the no-flow area that was positively associated with modestly elevated blood pressure [22]. A promising tendency in group A was observed in the peak CK-MB and troponin levels during the hospital stay. The result might be explained by the incomplete microvascular reperfusion, which has been linked to damaged myocardial cells following impaired left ventricular function and larger infarct size. There was no difference in the number of MACE between the two groups. Unfortunately, however, one patient in group B suffered a stroke and one patient died; this may be due to the unavoidable complications of MI.

Limitations

Our study had some limitations. First, we only used TIMI flow and ST-segment resolution rate to assess myocardial reperfusion, which should be evaluated by more parameters such as myocardial grade and TIMI frame count. The different outcomes in our study might be explained by this limitation [8]. Second, the sample size was relatively small compared with other studies on this topic; furthermore, the follow-up time was relatively short, which may have influenced the evaluation of the long-term prognosis. Despite the limitations, our study supports the synergistic role of tirofiban and TA providing a definite benefit to STEMI patients with heavy thrombus burden, in accordance with another study [23].

Practical conclusion

The application of selective tirofiban injection via an aspiration catheter after TA is relatively effective in STEMI patients undergoing PPCI. This could be used in clinical routine for patients with heavy thrombus burden and with a relatively low risk of hemorrhage.

Corresponding address

Y. Zhang
Department of Ultrasound, Guangdong Women and Children Hospital
No. 521 Xingnan Avenue, 511400 Guangzhou, China
Dr_zhangyl@163.com

Acknowledgements. This study is supported by Panyu Central Hospital (Cardiovascular Institute of Panyu District), Guangzhou Medical and Health Science and Technology General Guidance Project (No. 20171A011352) and Youth Research Funds of Panyu Central Hospital (2016–10). We thank Professor Mingcai Song and Guoqin Chen (Cardiovascular Institute of Panyu District) for their valuable advice and assistance.

Compliance with ethical guidelines

Conflict of interest. Z. Zhang, W. Li, W. Wu, Q. Xie, J. Li, W. Zhang, and Y. Zhang declare that they have no competing interests.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research

committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

References

1. Levine GN, Bates ER, Blankenship JC et al (2016) 2015 ACC/AHA/SCAI Focused Update on Primary Percutaneous Coronary Intervention for Patients With ST-Elevation Myocardial Infarction: An Update of the 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention and the 2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction. J Am Coll Cardiol 67(10):1235–1250. https://doi.org/10.1016/j.jacc.2015.10.005
2. Olsen EA, Whittaker S, Kim YH et al (2011) Clinical end points and response criteria in mycosis fungoides and Sezary syndrome: a consensus statement of the International Society for Cutaneous Lymphomas, the United States Cutaneous Lymphoma Consortium, and the Cutaneous Lymphoma Task Force of the European Organisation for Research and Treatment of Cancer. J Clin Oncol 29(18):2598. https://doi.org/10.1200/JCO.2010.32.0630
3. Mahmoud KD, Zijlstra F (2016) Thrombus aspiration in acute myocardial infarction. Nat Rev Cardiol 13(7):418–428. https://doi.org/10.1038/nrcardio.2016.38
4. Jolly SS, James S, Dzavik V et al (2017) Thrombus aspiration in ST-segment-elevation myocardial infarction: an individual patient meta-analysis: thrombectomy trialists collaboration. Circulation 135(2):143–152. https://doi.org/10.1161/circulationaha.116.025371
5. Kampinga MA, Nijsten MW, Gu YL et al (2010) Is the myocardial blush grade scored by the operator during primary percutaneous coronary intervention of prognostic value in patients with ST-elevation myocardial infarction in routine clinical practice? Circ Cardiovasc Interv 3(3):216–223. https://doi.org/10.1161/circinterventions.109.916247
6. De Luca G, Verdoia M, Suryapranata H (2012) Benefits from intracoronary as compared to intravenous abciximab administration for STEMI patients undergoing primary angioplasty: a meta-analysis of 8 randomized trials. Atherosclerosis 222(2):426–433. https://doi.org/10.1016/j.atherosclerosis.2012.02.041
7. Gao L, Cao Z, Zhang H (2016) Efficacy and safety of thrombectomy combined with Intracoronary administration of tirofiban in ST-segment elevation myocardial infarction (STEMI). Med Sci Monit 22:2699–2705
8. Chen Y, Zhou P, Yan H et al (2013) Impact of selective infarct-related artery infusion of tirofiban on myocardial reperfusion and bleeding complications in patients with acute myocardial infarction: the SUIT-AMI trial. J Invasive Cardiol 25(8):376–382
9. Sianos G, Papafaklis MI, Serruys PW (2010) Angiographic thrombus burden classification in patients with ST-segment elevation myocardial infarction treated with percutaneous coronary intervention. J Invasive Cardiol 22(10 Suppl B):6b–14b
10. Kushner FG, Hand M, Smith SC Jr. et al (2009) 2009 focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update) a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 54(23):2205–2241. https://doi.org/10.1016/j.jacc.2009.10.015
11. Vandvik PO, Lincoff AM, Gore JM et al (2012) Primary and secondary prevention of cardiovascular disease: antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest 141(2 Suppl):e637S–e668S. https://doi.org/10.1378/chest.11-2306
12. Svilaas T, Vlaar PJ, van der Horst IC et al (2008) Thrombus aspiration during primary percutaneous coronary intervention. N Engl J Med 358(6):557–567. https://doi.org/10.1056/NEJMoa0706416
13. Frohlich GM, Landmesser U (2015) Thrombus aspiration in STEMI revisited: impact on coronary microcirculation? Open Heart 2(1):e274. https://doi.org/10.1136/openhrt-2015-000274
14. Frobert O, Lagerqvist B, Olivecrona GK et al (2013) Thrombus aspiration during ST-segment elevation myocardial infarction. N Engl J Med 369(17):1587–1597. https://doi.org/10.1056/NEJMoa1308789
15. Jolly SS, Cairns JA, Yusuf S et al (2015) Randomized trial of primary PCI with or without routine manual thrombectomy. N Engl J Med 372(15):1389–1398. https://doi.org/10.1056/NEJMoa1415098
16. Higuma T, Soeda T, Yamada M et al (2016) Does residual thrombus after aspiration thrombectomy affect the outcome of primary PCI in patients with ST-segment elevation myocardial infarction?: an optical coherence Tomography study. JACC Cardiovasc Interv 9(19):2002–2011. https://doi.org/10.1016/j.jcin.2016.06.050
17. Dornbos D 3rd, Katz JS, Youssef P et al (2017) Glycoprotein IIb/IIIa inhibitors in prevention and rescue treatment of thromboembolic complications during endovascular embolization of intracranial aneurysms. Neurosurgery. https://doi.org/10.1093/neuros/nyx170
18. Crea F, Camici PG, Bairey Merz CN (2014) Coronary microvascular dysfunction: an update. Eur Heart J 35(17):1101–1111. https://doi.org/10.1093/eurheartj/eht513
19. Tian J, Liu Y, Song X et al (2016) Clinic predictive factors for insufficient myocardial reperfusion in ST-segment elevation myocardial infarction patients treated with selective aspiration Thrombectomy during primary Percutaneous coronary intervention. Biomed Res Int 2016:3823809. https://doi.org/10.1155/2016/3823809
20. Geng T, Zhang JG, Song ZY et al (2016) Aspiration thrombectomy and intracoronary tirofiban in ST-segment elevation myocardial infarction: combination treatment for patients undergoing primary percutaneous coronary intervention. Herz 41(8):732–740. https://doi.org/10.1007/s00059-016-4426-4
21. Li X, Kramer MC, Damman P et al (2016) Older coronary thrombus is an independent predictor of 1-year mortality in acute myocardial infarction. Eur J Clin Invest 46(6):501–510. https://doi.org/10.1111/eci.12619
22. Pantsios C, Kapelios C, Vakrou S et al (2016) Effect of elevated reperfusion pressure on "no reflow" area and infarct size in a porcine model of ischemia-reperfusion. J Cardiovasc Pharmacol Ther 21(4):405–411. https://doi.org/10.1177/1074248415617850
23. Valente S, Mattesini A, Lazzeri C et al (2015) Thrombus aspiration in ST-elevation myocardial infarction: does it actually impact long-term outcome? Cardiol J 22(3):306–314. https://doi.org/10.5603/CJ.a2014.0061