Does manual thrombus aspiration help optimize stent implantation in ST-segment elevation myocardial infarction?

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Abstract

AIM: To evaluate the impact of thrombus aspiration (TA) on procedural outcomes in a real-world ST-segment elevation myocardial infarction (STEMI) registry.

METHODS: From May 2006 to August 2008, 542 consecutive STEMI patients referred for primary or rescue percutaneous coronary intervention were enrolled and the angiographic results and stent implantation characteristics were compared according to the performance of manual TA.

RESULTS: A total of 456 patients were analyzable and categorized in TA group (156 patients; 34.2%) and non-TA (NTA) group (300 patients; 65.8%). Patients treated with TA had less prevalence of multivessel disease (39.7% vs 54.7%, P = 0.003) and higher prevalence of initial thrombolysis in myocardial infarction flow < 3 (P < 0.001) than NTA group. There was a higher rate of direct stenting (58.7% vs 45.5%, P = 0.009), with shorter (24.1 ± 11.8 mm vs 26.9 ± 15.7 mm, P = 0.038) and larger stents (3.17 ± 0.43 mm vs 2.93 ± 0.44 mm, P < 0.001) in the TA group as compared to NTA group. The number of implanted stents (1.3 ± 0.67 vs 1.5 ± 0.84, P = 0.009) was also lower in TA group.

CONCLUSION: In an “all-comers” STEMI population, the use of TA resulted in more efficient procedure leading to the implantation of less number of stents per lesion of shorter lengths and larger sizes.

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Key words: ST-segment elevation myocardial infarction; Primary percutaneous coronary intervention; Manual thrombus aspiration; Stent; Thrombolysis in myocardial infarction flow

Core tip: Thrombus embolization is highly detected in ST-segment elevation myocardial infarction (STEMI) leading to unfavorable clinical outcomes. To prevent thrombus embolization, manual thrombus aspiration (TA) receives a high recommendation during primary percutaneous coronary intervention (PCI) by clinical practice guidelines. However, the TASTE trial, recently published, showing no impact of manual TA on short-term mortality, has reopened the debate about the role of this technique in STEMI. This study is one the first showing that manual TA optimizes stent implantation during primary PCI resulted in more efficient procedures, leading to the implantation of fewer, shorter and larger stents.
INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) occurs as a result of atherosclerotic plaque rupture or erosion and platelet and coagulation activation leading to thrombus formation and complete coronary occlusion. Primary percutaneous coronary intervention (PCI) with stent implantation is the preferred method to restore epicardial flow in STEMI. Several thrombectomy devices have been developed with the aim to avoid any suboptimal myocardial reperfusion related to thrombus embolization, which might lead to unfavorable clinical outcome.

The randomized clinical trial (RCT) TAPAS, in particular, showed that manual thrombus aspiration (TA) improved myocardial reperfusion and reduced mortality in STEMI patients at 1-year follow-up. These results, confirmed by other studies, including a meta-analysis of 11,321 patients from 20 RCT showing lower rates of late mortality, reinfarction and stent thrombosis in patients underwent manual TA compared with conventional primary PCI, led to a recommendation class IIa for manual TA in patients undergoing primary PCI for STEMI.

Nevertheless, the use of the thrombectomy devices is still controversial and not routine in STEMI patients, especially because some studies have shown no impact on clinical outcomes, such as the TASTE trial. This RCT, recently published, did not show any impact of manual TA on mortality or any of several other clinical outcomes at 30 days. Furthermore, the potential effect of TA on optimization of stent implantation has not been elucidated yet.

Therefore, we sought to investigate the factors which can lead to the use of the manual TA in STEMI and its impact on acute angiographic success and stent implantation characteristics in a real-world STEMI population.

MATERIALS AND METHODS

Study population

Between May 2006 and August 2008, all consecutive patients with STEMI referred to our hospital for primary or rescue PCI were enrolled. There were no exclusion criteria. Clinical and angiographic characteristics of all patients were prospectively collected. All patients signed a written informed consent prior to PCI procedure and agreed to be clinically followed. At the time of the study an IRB approval was not formally necessary for observational registries that use a CE-mark approved device.

Procedure

Patients treated with primary PCI were pretreated with aspirin (300 mg), clopidogrel loading dose (300 mg) and unfractioned heparin adjusted to weight. The use of glycoprotein (GP) IIb/IIIa inhibitors was left at the discretion of the operators in case of significant thrombus, slow or non-reflow of thrombotic complications. PCI was performed according to conventional clinical practice. Manual TA; using the 6-French Pronto V3® aspiration catheter (Vascular Solutions Inc, Minneapolis, MN) and the 6-French Export® aspiration catheter (Medtronic, Minneapolis, MN), was performed according to the operator’s choice; and patients were thereafter classified in TA group and non-thrombus aspiration (NTA) group.

Manual TA technique was performed as follows. The aspiration was started 2-cm before the culprit lesion and the aspiration catheter was advanced very slowly, crossing the lesion with continuous aspiration. The catheter was removed under aspiration even into the guiding catheter, with generous backflow after retrieving the thrombectomy device. At least two or three passages were performed. Manual TA was especially considered, in case of high thrombus burden and initial slow thrombolysis in myocardial infarction (TIMI) flow.

Definitions and end-points

Time to treatment was defined as time from symptom onset to initial intracoronary therapy by TA or balloon inflation of the infarct-related coronary artery.

TIMI flow grade was evaluated pre guide-wire and post-PCI.

No-reflow was defined as a TIMI flow grade < 2 in absence of coronary dissection, coronary hematoma, occlusive coronary thrombosis or epicardial spasm.

Thrombus embolization was defined as circumscribed filling defects and/or abrupt cut off of a vessel distal to the target lesion or in other coronary vessel on the angiogram after PCI. Coronary dissection was defined by the presence of a curvilinear filling defect parallel to the vessel lumen, contrast medium outside of the vessel lumen persisting after passage of contrast medium, or a spiral-shaped filling defect partially or totally obstructing the coronary artery lumen.

ST was defined and categorized, according to Academic Research Consortium. Angiographic success was defined as final TIMI flow equals 3 plus absence of any angiographic complication.

The angiographic assessment was performed by consensus of two independent experienced interventional cardiologists. The primary end-point of this study was the rate of angiographic success, as above defined. Secondary end-points included technical and clinical issues related to the procedure as the number of implanted stents, the rates of direct stenting and post-dilatation, the maximal diameter of the implanted stents, the total stented length segment, the final TIMI flow and the resolution of the ST-segment elevation after primary PCI.
Results

Baseline clinical and angiographic features

A total of 542 patients were prospectively included during the recruitment period. Of them, 30 patients were not analyzable because impossibility to crossing the culprit lesion by the TA device and 56 patients because inability to analyze the angiographic data. The remaining 456 patients were finally studied and classified in TA (n = 156) and NTA groups (n = 300) (Figure 1).

Clinical follow-up

A clinical follow-up up to 3 years was performed by a clinical visit or telephone interview. Clinical outcomes were evaluated by measuring the rate of the major adverse cardiac events (MACE) defined as the combination of cardiac death, myocardial infarction (MI) and need for cardiac artery by-pass grafting (CABG) and its individual components, as well as the rate of all-cause death, and the need for target vessel and non-target vessel PCI revascularization. MI was defined according to the World Health Organization extended definition.

Statistical analysis

Continuous variables were explored for normal distribution with the Kolmogorov-Smirnov test. Normally distributed variables were expressed as mean (1 standard deviation) and non-normally distributed variables were expressed as median (inter-quartile range) and were compared using t-test or with Mann-Whitney tests as appropriate. Categorical variables were expressed as count (percentage) and were compared using the χ² test.

In order to exclude confounding factors in primary end-point (angiographic success), multivariable logistic regression models were fitted to assess independent predictors. The following variables were tested for the predictors of the primary end-point: manual TA, age, gender, smoking history, prior MI, primary PCI, Killip class > 1, initial TIMI flow = 0, use of GP IIb/IIIa inhibitors and the use of drug-eluting stents (DES). The result was reported as HR together with the 95%CI.

All P values were 2-tailed, with statistical significance set at a level of < 0.05. Statistical analyses were performed using SPSS Statistics 20.0 (SPSS Inc., Chicago, IL, United States).

In-hospital and long-term outcomes

In-hospital and long-term data are presented in the Table 4. No difference in major cardiac events was observed between groups during hospitalization. The only difference was a significantly higher CK peak [2563 (1284-4542) UI/L vs 1517 (744-3816) UI/L, P = 0.02] observed by the use of TA.

At three years clinical follow-up (36 ± 7 mo), no differences between manual TA and conventional PCI were observed in the rates of MACE (17.0% vs 21.6%, P = 0.25), all-cause death (17.0% vs 19.6%, P = 0.5), cardiac death (8.3% vs 7.9%, P = 0.83), MI (6.8% vs 10%, P = 0.27), need for CABG revascularization (1.4% vs 3.5%, P = 0.39),
DISCUSSION

The major findings of this study were: (1) manual TA was used more often in primary PCI and in patients with worse TIMI flow; (2) its use was subsequently related to optimization of procedural technique; and (3) TA was independently associated with acute angiographic success.

Optimization of angiographic outcomes and stent implantation by manual TA in real-world

According to clinical trials and real-world registries, our work confirms that manual TA is more often used in the presence of high thrombus burden, such as in patients with initial low TIMI flow (0-1) or primary PCI indication. This registry confirms as well that use of TA achieves better angiographic results than conventional PCI, with greater reduction in thrombus burden and higher rate of final TIMI flow 3. Of note is the recent article by Ahn et al which showed that the addition of IIb/IIIa inhibitors (Abciximab) to manual TA improves the index of microvascular obstruction assessed by cardiac magnetic resonance. This leads us to hypothesize that the optimal strategy to optimize myocardial perfusion would be the synergistic use of these two therapeutic options.

Moreover, it appeared that the use of TA allowed immediate good angiographic results before stent implantation, so that fewer, larger and shorter stents could be more often implanted. Previous clinical trials and real-world registries failed to show any differences in the length, diameter and number of implanted stents be-

| Table 1 Baseline clinical and angiographic features $n$ (%) |
|----------------------------------------------------------|
| Characteristics                                      | Thrombus aspiration | Conventional PCI | $P$ value |
| Age, mean ± SD                                       | 63.2 ± 12.8         | 64.3 ± 12.8      | 0.410     |
| Female sex                                           | 38 (24.4)           | 62 (20.7)        | 0.370     |
| Previous or current smoker                           | 94 (60.3)           | 205 (68.3)       | 0.085     |
| Hypertension                                         | 82 (52.6)           | 166 (55.3)       | 0.570     |
| Dyslipidemia                                         | 30 (19.2)           | 92 (30.7)        | 0.009     |
| Peripheral                                           | 9 (5.8)             | 19 (6.3)         | 0.800     |
| Vascularopathy                                       |                      |                  |           |
| Previous MI                                          | 10 (6.7)            | 36 (12.3)        | 0.065     |
| Previous PCI                                         | 8 (5.1)             | 29 (9.7)         | 0.092     |
| Previous CAGB                                        | 2 (1.3)             | 10 (3.3)         | 0.190     |
| Indication                                           |                      |                  | 0.013     |
| Primary                                              | 114 (73.1)          | 206 (68.7)       |           |
| Rescue                                               | 42 (26.9)           | 94 (31.3)        |           |
| Classification                                       |                      |                  | 0.650     |
| Anterolateral                                        | 69 (44.2)           | 133 (44.3)       |           |
| Inferoposterior                                      | 83 (53.2)           | 152 (50.7)       |           |
| Non-Q MI                                             | 3 (1.9)             | 12 (4)           |           |
| LBBB                                                 | 1 (0.6)             | 3 (1)            |           |
| Killip                                               |                      |                  | 0.058     |
| I                                                     | 182 (66.3)          | 228 (76.5)       |           |
| II                                                   | 13 (8.5)            | 35 (11.7)        |           |
| III                                                  | 1 (0.7)             | 7 (2.3)          |           |
| IV                                                    | 7 (4.6)             | 28 (9.4)         |           |
| Number of diseased vessels                           |                      |                  | 0.003     |
| 1                                                     | 94 (60.3)           | 136 (45.3)       |           |
| 2                                                     | 43 (27.6)           | 95 (31.7)        |           |
| 3                                                     | 19 (12.2)           | 69 (23)          |           |
| Infarct related artery                               |                      |                  | 0.650     |
| LAD                                                  | 68 (43.6)           | 137 (45.7)       |           |
| LCx                                                  | 15 (9.6)            | 35 (11.7)        |           |
| RCA                                                  | 69 (44.2)           | 116 (38.7)       |           |
| LM                                                   | 4 (2.6)             | 8 (2.7)          |           |
| Bypass                                               | 0 (0)               | 1 (0.3)          |           |
| GP IIb/IIIa inhibitors                               | 100 (65.3)          | 150 (50.6)       | 0.012     |
| IABP                                                 | 7 (4.5)             | 25 (8.4)         | 0.120     |

| Table 2 Procedural data and angiographic results $n$ (%) |
|----------------------------------------------------------|
| Characteristics                                      | Thrombus aspiration | Conventional PCI | $P$ value |
| Time to treatment, median (IQR)                        | 273 (170-477)       | 300 (180-480)    | 0.610     |
| Initial TIMI flow                                      |                      |                  | < 0.001   |
| 0                                                     | 111 (71.2)           | 143 (48.8)       |           |
| 1                                                     | 9 (5.8)              | 16 (5.5)         |           |
| 2                                                     | 16 (10.3)            | 38 (13)          |           |
| 3                                                     | 20 (12.8)            | 96 (32.8)        |           |
| Initial TIMI flow < 3                                  | 136 (87.2)           | 204 (67.2)       | < 0.001   |
| Final TIMI flow                                        |                      | 0.140            |           |
| 0                                                     | 2 (1.3)              | 9 (3.1)          |           |
| 1                                                     | 1 (0.6)              | 6 (2.1)          |           |
| 2                                                     | 19 (12.3)            | 50 (17.1)        |           |
| 3                                                     | 133 (85.8)           | 227 (77.7)       |           |
| Final TIMI flow < 3                                   | 22 (14.1)            | 65 (21.7)        | 0.040     |
| Angiographic complication                             |                      | 0.450            |           |
| Non-reflow                                            | 6 (3.8)              | 16 (5.4)         |           |
| Thrombus                                              | 7 (4.5)              | 22 (7.4)         |           |
| Embolization                                          |                      |                  |           |
| Coronary dissection                                   | 2 (1.3)              | 7 (2.4)          |           |
| Angiographic success                                  | 123 (78.8)           | 200 (68)         | 0.015     |
| Direct stenting                                       | 88 (58.7)            | 131 (45.5)       | 0.009     |
| Type of stent                                         | 0.008                |                  |           |
| BMS                                                   | 133 (88.7)           | 238 (79.3)       |           |
| DES                                                   | 17 (11.3)            | 62 (20.7)        |           |
| Length of stented segment (mm), mean ± SD             | 24.1 ± 11.8          | 26.9 ± 15.7      | 0.038     |
| Diameter of stented segment (mm), mean ± SD           | 3.17 ± 0.43          | 2.93 ± 0.44      | < 0.001   |
| Number of stents, mean ± SD                           | 1.3 ± 0.67           | 1.5 ± 0.84       | 0.009     |
| LVEF, mean ± SD                                       | 49.6 ± 9.8           | 49 ± 10.4        | 0.610     |

PCT: Percutaneous coronary intervention; MI: Myocardial infarction; CAGB: Coronary artery by-pass graft; LBBB: Left bundle branch block; LAD: Left anterior descending; LCx: Left circumflex; RCA: Right coronary artery; LM: Left main; IABP: Intra-aortic balloon pump; GP: Glycoprotein.

target vessel PCI revascularization (5.4% vs 8.9%, $P = 0.2$), and non-target vessel PCI revascularization (4.8% vs 5.7%, $P = 0.68$) and definite ST (1.4% vs 4.4%, $P = 0.15$).
Clinical outcomes of TA in real-world

This registry reflected real-world clinical practice in STEMI population as no exclusion criteria was applied. Additionally, both primary and rescue PCI patients were included.

Unlike other studies with strict inclusion criteria, this registry demonstrated no impact of TA on both short and long-term outcomes. In the TAPAS trial, only patients with primary PCI were included; in another real-world registry, only patients with primary PCI indication and TIMI flow 0-1 were included. Conversely, our clinical results are consistent with studies with broad inclusion criteria, such as the TASTE trial, that evaluated the primary endpoint at short-term and with the largest published real-world registry in manual TA that had a very extended follow-up. Both studies included patients with initial TIMI flow from 0 to 3 and rescue or primary PCI indication. Thus, differences in inclusion criteria and in follow-up periods between the various trials and inherent selection bias induced in clinical registries may explain the different impact of the TA on long-term outcome.

Furthermore, it is noteworthy that in our study MACE rate was numerically higher in NTA group, although it did not reach statistical significance, probably due to the small number of patients included in our registry.

Of note is that no difference in target-vessel revascularization or stent thrombosis was found between the two groups, despite implantation of larger and shorter stent in TA than NTA group; this finding may be explained by the higher rate of DES implanted in NTA group than TA group.

This interesting controversy will continue until the publication of the results of the TOTAL trial. The TOTAL trial is a multicenter, prospective, open, international, randomized trial with blinded assessment of outcomes which will recruit 10700 STEMI patients to compare routine manual TA with the Export aspiration catheter versus conventional PCI alone. The primary outcome will be the composite of cardiovascular death, recurrent myocardial infarction, cardiogenic shock, or new or worsening New York Heart Association class IV heart failure up to 180 d.

Study limitations

First, this study is a non-randomized, prospective registry and there were differences in baseline clinical and angiographic characteristics that could lead to a worse baseline risk profile in NTA group. Second, the use of GP IIb/IIIa inhibitors was higher in the TA group and this difference could also affect angiographic results in this group. Third, in our study manual TA was only used in one third of cases, whereas current use of manual TA in recent all-comer RCT is around two thirds of patients. This was related to the relatively lack of evidence of manual thrombectomy at the time of the recruitment of the registry. Fourth, the relative small number of patients

tween patients treated with or without TA except for one brief work that demonstrated a higher stent diameter after manual TA, in STEMI patients treated with bare metal stents. Recently, the TASTE trial also showed the need for fewer stents per procedure in manual TA group in comparison with conventional PCI. It is well known that intra-stent restenosis and ST are directly related to the characteristics of the stents. Thus; optimizing on stent implantation using fewer stents and stents of larger diameter and smaller length, during STEMI could have long-term prognostic implications by reducing the intra-stent restenosis and ST.

Besides, in light of these results we might hypothesize that TA may be cost-saving. Therefore, further studies on cost-effectiveness implications by the use of manual TA in primary PCI are warranted.

Table 3 Multivariate analysis of angiographic success

| HR (95%CI) | P     |
|-----------|-------|
| Thrombus aspiration | $2.3 \ (1.2-4.3)$ | 0.007 |
| Primary PCI | $4.4 \ (2.1-9)$ | < 0.001 |
| Active smoking | $1.76 \ (0.9-3.4)$ | 0.093 |
| Age | $1.031 \ (1.001-1.063)$ | 0.044 |
| Initial TIMI flow = 0 | $0.46 \ (0.25-0.84)$ | 0.012 |

PCI: Percutaneous coronary intervention; TIMI: Thrombolysis in Myocardial Infarction.

Table 4 In-hospital and long-term outcomes (%)  

|                      | Thrombus aspiration | Conventional PCI | P value |
|----------------------|---------------------|------------------|---------|
| In-hospital          |                     |                  |         |
| CK peak UI/L, median (IQR) | $2563 \ (1284-4542)$ | $1517 \ (744-3816)$ | 0.020 |
| ST resolution at 30 min | 75 (71.4) | 174 (74) | 0.610 |
| Intra-procedural death | 2 (1.3) | 5 (1.7) | 1.000 |
| In-hospital cardiac death | 15 (9.6) | 22 (7.3) | 0.400 |
| Non-target vessel PCI revascularization | 12 (7.7) | 41 (13.8) | 0.059 |
| CAGB                 | 0 (0)               | 1 (0.3)          | 1.000 |
| Follow-up            |                     |                  |         |
| MACE                 | 25 (17.0)           | 61 (21.6)        | 0.250 |
| All-cause death      | 26 (17.0)           | 57 (19.6)        | 0.500 |
| Cardiac death        | 13 (8.3)            | 23 (7.9)         | 0.830 |
| MI                   | 10 (6.8)            | 28 (10)          | 0.270 |
| CAGB                 | 2 (1.4)             | 10 (3.5)         | 0.390 |
| Target vessel PCI revascularization | 8 (5.4) | 25 (8.9) | 0.200 |
| Non-target vessel PCI revascularization | 7 (4.8) | 16 (5.7) | 0.680 |
| Definitive stent thrombosis | 2 (1.4) | 12 (4.4) | 0.150 |
| Probable stent thrombosis | 1 (0.7) | 2 (0.7) | 1.000 |
| Possible stent thrombosis | 2 (1.4) | 6 (2.2) | 0.720 |

PCI: Percutaneous coronary intervention; CAGB: Coronary artery bypass graft; MACE: Major adverse cardiac events; MI: Myocardial infarction; IQR: Interquartile range; ST: Stent thrombosis.
included in our study could preclude any conclusions regarding clinical efficacy of TA.

In this all-comer registry, TA was able to optimize stent implantation technique, leading to the implantation of less number of stents per lesion of shorter lengths and larger sizes, and was associated with angiographic success following PCI for STEMI.

**COMMENTS**

**Background**

In ST-segment elevation myocardial infarction (STEMI) patients, manual thrombus aspiration (TA) is effective to reduce thrombus burden. Nevertheless, the effect on optimization of stent implantation has not been elucidated yet. Therefore, the objective of this study is to evaluate the impact of manual TA on acute angiographic success and stent implantation characteristics in a real-world STEMI.

**Research frontiers**

Manual TA reduces thrombotic burden, receiving a recommendation class IIa during the performance of primary percutaneous coronary intervention. However, the TASTE trial, recently published, showing no impact of manual TA on 30-d mortality, has reopened the debate about the role of this technique in STEMI setting.

**Innovations and breakthroughs**

Thrombus embolization is detected up to 15% of STEMI population and is responsible for suboptimal myocardial reperfusion, leading to unfavorable clinical outcomes. Manual TA reduces thrombotic burden and receives a high recommendation during the performance of primary percutaneous coronary intervention. The TASTE trial, demonstrating absence of impact of manual TA on short-term mortality, has reopened the debate about the use of this technique in STEMI patients. In the present study the authors want to investigate, in a real-world STEMI population, the factors which can lead to the use of manual thrombectomy in STEMI and its impact on angiographic and stent implantation characteristics.

**Applications**

The study results suggest that manual TA during primary percutaneous coronary intervention is associated with a higher rate of angiographic success and optimization on stent implantation compared with conventional primary percutaneous coronary intervention, in a real-world population. However, it seems to have no impact on long-term clinical outcomes.

**Terminology**

STEMI: It is a type of acute coronary syndrome, which occurs when a coronary artery becomes totally blocked by a blood clot, causing the heart muscle supplied by the artery to die; Primary percutaneous coronary intervention: It is a non-surgical procedure used to open the occluded coronary arteries during primary percutaneous coronary intervention. The TASTE trial, demonstrating absence of impact of manual TA on 30-d mortality, has reopened the debate about the role of this technique in STEMI setting.

**Peer review**

In this study, Diego et al reported that the thrombus aspiration therapy in patients with AMI were associated with high procedure success and contributed to optimize the implantation of stents. As a non-randomized, prospective registry study, it provide their some new insights about the use of thrombus aspiration in the real world.

**REFERENCES**

1. Van de Werf F, Ardissino D, Betriu A, Cokkinos DV, Falk E, Fox KA, Julian D, Lengyel M, Neumann FJ, Ruzyllo W, Thygesen C, Underwood SR, Vahanian A, Verheugh FW, Wijns W. Management of acute myocardial infarction in patients presenting with ST-segment elevation. The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology. Eur Heart J 2003; 24: 28-66 [PMID: 12599937 DOI: 10.1093/eurheartj/24.1.28]

2. Wijns W, Kolh P, Danchin N, Di Mario C, Falk V, Folliguet T, Garg S, Huber K, James S, Knautt J, Lopez-Sendon J, Marco J, Menicanti L, Ostojic M, Piepoli MF, Pirlet C, Pomerol M, Reifart N, Ribiachik PL, Schalij MJ, Sergeant P, Serruys PW, Silver S, Sousa Uva M, Taggart D. Guidelines on myocardial revascularization. Eur Heart J 2010; 31: 2501-2555 [PMID: 20802248 DOI: 10.1093/eurheartj/ehq277]

3. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. Lancet 2003; 361: 13-20 [PMID: 12517460 DOI: 10.1016/S0140-6736(03)12113-7]

4. Valgimigli M, Campo G, Malagutti P, Anselmi M, Bologna L, Bibiieni F, Bocciuzzi G, de Cesare N, Rodriguez AE, Russo F, Moreno R, Biondi-Zoccai G, Penzo C, Diaz Fernandez JF, Panninello G, Ferrari R. Persistent coronary no flow after wire insertion is an early and readily available mortality risk factor despite successful mechanical intervention in acute myocardial infarction: a pooled analysis from the STRATEGY (Single High-Dose Bolus Tirofiban and Sirolimus-Eluting Stent Versus Abciximab and Bare-Metal Stent in Acute Myocardial Infarction) and MULTISTRATEGY (Multicenter Evaluation of Single High-Dose Bolus Tirofiban Versus Abciximab With Sirolimus-Eluting Stent or Bare-Metal Stent in Acute Myocardial Infarction Study) trials. JACC Cardiovasc Interv 2011; 4: 51-62 [PMID: 21251629 DOI: 10.1016/j.jcin.2010.09.016]

5. Svilaja T, Vlaar PJ, van der Horst IC, Diercks GF, de Smet BJ, van den Heuvel AF, Anthonio RL, Jessurun GA, Tan ES, Suurmeijer AJ, Zijlstra F. Thrombus aspiration during primary percutaneous coronary intervention. N Engl J Med 2008; 358: 557-567 [PMID: 18256391 DOI: 10.1056/NEJMoa0706416]

6. Vlaar PJ, Svilaja T, van der Horst IC, Diercks GF, Fokkema ML, de Smet BJ, van den Heuvel AF, Anthonio RL, Jessurun GA, Tan ES, Suurmeijer AJ, Zijlstra F. 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 [PMID: 18539223 DOI: 10.1016/S0140-6736(08)60383-8]

7. Sardella G, Mancone M, Bucciarelli-Ducci C, Agati L, Scar- dala R, Carboni I, Franchone M, Di Roma A, Benedetti G, Conti G, Fedele F. Thrombus aspiration during primary percutaneous coronary intervention improves myocardial reperfusion and reduces infarct size: the EXPIRA (thrombectomy with export catheter in infarct-related artery during primary percutaneous coronary intervention) prospective, randomized trial. J Am Coll Cardiol 2009; 53: 309-315 [PMID: 19161878 DOI: 10.1016/j.jacc.2008.10.017]

8. De Luca G, Dudek D, Sardella G, Marino P, Chevalier B, Zijlstra F. Adjunctive manual thrombectomy improves myocardial perfusion and mortality in patients undergoing primary percutaneous coronary intervention for ST-elevation myocardial infarction: a meta-analysis of randomized trials. Eur Heart J 2008; 29: 3002-3010 [PMID: 18775918 DOI: 10.1093/eurheartj/ehn389]

9. Burzotta F, De Vita M, Gu YL, Ishikhi T, Lefèvre T, Kaltof A, Dudek D, Sardella G, Orrego PS, Antonucci D, De Luca L, Biondi-Zoccai GG, Crea F, Zijlstra F. Clinical impact of thrombectomy in acute ST-elevation myocardial infarction: an individual patient-data pooled analysis of 11 trials. Eur Heart J 2009; 30: 2193-2203 [PMID: 19726457 DOI: 10.1093/eurheartj/ehc348]

10. Mangiacapra F, Wijns W, De Luca G, Muller O, Trana C, Ntalianis A, Heyndrickx G, Vanderheyden M, Bartunek J, De Bruyne B, Barbato E. Thrombus aspiration in primary percutaneous coronary intervention in high-risk patients with ST-elevation myocardial infarction: a real-world registry. Catheter Cardiovasc Interv 2010; 76: 70-76 [PMID: 20578196 DOI: 10.1002/ccd.22465]

11. Kumbhani DJ, Bavry AA, Desai MY, Bangalore S, Byrne
RA, Jieh H, Bhat DL. Aspiration thrombectomy in patients undergoing primary angioplasty: Totality of data to 2013. *Catheter Cardiovasc Interv* 2014; Epub ahead of print [PMID: 24782350 DOI: 10.1002/crd.25532]

12 Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC), Steg PG, James SK, Attar D, Badano LP, Blömström-Lundqvist C, Borger MA, Di Mario C, Dickstein K, Ducrocq G, Fernandez-Aviles F, Gershlick AH, Giannuzzi P, Halvorsen S, Huber K, Juni P, Kaehreter A, Knudt J, Lenzen MJ, Mahaffey KW, Valgimigl M, van’t Hof A, Widimsky P, Zahger D. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Eur Heart J* 2012; 33: 2569-2619 [PMID: 22922416 DOI: 10.1093/eurheartj/ehs215]

13 Chao CL, Hung CS, Lin YH, Lin MS, Lin LC, Ho YL, Liu CP, Chiang CH, Kao HL. Time-dependent benefit of initial thrombus suction on myocardial reperfusion in primary percutaneous coronary intervention. *Int J Clin Pract* 2008; 62: 555-561 [PMID: 18067361 DOI: 10.1111/j.1742-1241.2007.01542.x]

14 Chevalier B, Gilard M, Lang I, Commeau P, Roosen J, Hanssen M, Lefevre T, Carrié D, Bartorelli A, Montalecscot G, Parikh K. Systematic primary aspiration in acute myocardial percutaneous intervention: a multicentre randomised controlled trial of the export aspiration catheter. *Eurointervention* 2008; 4: 222-228 [PMID: 19110787]

15 Lister F, Grotti S, Angioli P, Falsini G,ucci D, Baldassarre S, Sabini A, Brandini R, C aparti E, Bolognesi L. Impact of thrombus aspiration on myocardial tissue reperfusion and left ventricular functional recovery and remodeling after primary angioplasty. *Circ Cardiovasc Inter* 2009; 2: 376-383 [PMID: 20031746 DOI: 10.1161/CIRCINTERVENTIONS.109.852665]

16 Silva-Orengo P, Colombo P, Bigi R, Gregori D, Delgado A, Salvade P, Oreglia J, Orrico P, de Blase A, Piccalò G, Bossi I, Khugmann S. Thrombus aspiration before primary angioplasty improves myocardial reperfusion in acute myocardial infarction: the DEAR-MI (Dethrombosis to Enhance Acute Reperfusion in Myocardial Infarction) study. *J Am Coll Cardiol* 2006; 48: 1552-1559 [PMID: 17045887 DOI: 10.1016/j.jacc.2006.03.068]

17 Mongeon FP, Belisle P, Joseph L, Eisenberg MJ, Rin fret S. Adjunctive thrombectomy for acute myocardial infarction: A bayesian meta-analysis. *Circ Cardiovasc Inter* 2010; 3: 6-16 [PMID: 20118149 DOI: 10.1161/CIRCINTERVENTIONS.109.904037]

18 Burzotta F, Testa L, Giannico F, Biondi-Zoccai GC, Trani C, Romagnoli E, Mazzari M, Mongiardo R, Siviglia M, Niccoli G, De Vita M, Porto I, Schiavoni G, Creo F. Adjunctive devices in primary or rescue PCI: a meta-analysis of randomized trials. *Int J Cardiol* 2008; 123: 313-321 [PMID: 17383756 DOI: 10.1016/j.ijcard.2006.12.018]

19 De Luca I, Sardella G, Davidson CJ, De Persio G, Beraldi M, Tommasone T, Mancone M, Nguyen BL, Agati L, Biondi-Zocca F. Thrombus aspiration improves myocardial reperfusion: the randomization validated the effect of mechanical reduction of coronary angioplasty: clinical, angiographic and therapeutic profile. *J Am Coll Cardiol* 1992; 19: 926-935 [PMID: 1552113 DOI: 10.1016/0735-1075(92)90027-4]

20 Cutlip DE, Windecker S, Mehran R, Boan A, Cohen DJ, van Es GA, Steg PG, Morel MA, Mauri L, Vranckx P, McFadden E, Lansky A, Hamon M, Krucow PW, Serruys PW. Clinical endpoints in coronary stent trials: a case for standardized definitions. *Circulation* 2007; 115: 2344-2351 [PMID: 17470709 DOI: 10.1161/CIRCULATIONAHA.106.685313]

21 Vranckx P, Cutlip DE, Mehran R, Kint PP, Silber S, Wind ecker S, Serruys PW. Myocardial infarction adjudication in contemporary all-comer stent trials: balancing sensitivity and specificity. Addendum to the historical MI definitions used in stent studies. *Eurointervention* 2010; 5: 871-874 [PMID: 20142206]

22 Ahn SG, Lee SH, Lee JK, Lee JW, Yoon YJ, Ahn MS, Kim JY, Yoo BS, Yoon J, Choe KH, Tabk SJ. Efficacy of combination treatment with intracoronary abcximab and aspiration thrombectomy on myocardial perfusion in patients with ST-segment elevation myocardial infarction undergoing primary coronary stenting. *Yonsei Med J* 2014; 55: 606-616 [PMID: 24791926 DOI: 10.3349/yjm.2014.55.3.606]

23 Burzotta F, Trani C, Romagnoli E, Mazzari MA, Reubazzi AG, De Vita M, Garramone B, Giannico F, Niccoli G, Biondi-Zoccai GC, Schiavoni G, Mongiardo R, Creo F. Manual thrombus-aspiration improves myocardial reperfusion: the randomized evaluation of the effect of mechanical reduction of distal embolization by thrombus-aspiration in primary and rescue angioplasty (REMEDIA) trial. *J Am Coll Cardiol* 2005; 46: 371-376 [PMID: 16022970 DOI: 10.1016/j.jacc.2005.04.057]

24 Bulum J, Ernst A, StroZZI M. The impact of successful manual thrombus aspiration on in-stent restenosis after primary PCI: angiographic and clinical follow-up. *Coron Artery Dis* 2012; 23: 487-491 [PMID: 22936018 DOI: 10.1097/MCA.0b013 e328587866]

25 Brodie B, Pokharel Y, Garg A, Kissling G, Hansen C, Milks S, Cooper M, McAlhany C, Stuckey T. Predictors of early, late and very late stent thrombosis after primary percutane ous coronary intervention with bare-metal and drug-eluting stents for ST-segment elevation myocardial infarction. *JACC Cardiovasc Interv* 2012; 5: 1043-1051 [PMID: 23078734 DOI: 10.1016/j.jcin.2012.06.013]

26 Cristea E, Stone GW, Mehran R, Kirtane AJ, Brener SJ. Changes in reference vessel diameter in ST-segment elevation myocardial infarction after primary percutaneous coronary intervention: implications for appropriate stent sizing. *Am Heart J* 2011; 162: 173-177 [PMID: 21742105 DOI: 10.1016/j.ahj.2011.04.016]

27 Jolly SS, Cairns J, Yusuf S, Meeks B, Shestakowska O, Tha-
Fernández-Rodríguez D et al. Thrombus aspiration optimizes stenting in STEMI

Bane L, Niemelä K, Steg PG, Bertrand OF, Rao SV, Avezum A, Cantor WJ, Pancholy SB, Moreno R, Gershlick A, Bhindi R, Welsh RC, Cheema AN, Lavi S, Rokoss M, Đžavík V. Design and rationale of the TOTAL trial: a randomized trial of routine aspiration Thrombectomy with percutaneous coronary intervention (PCI) versus PCI Alone in patients with ST-elevation myocardial infarction undergoing primary PCI. *Am Heart J* 2014; 167: 315-321.e1 [PMID: 24576514 DOI: 10.1016/j.ahj.2013.12.002]

Sabate M, Cequier A, Itiúguez A, Serra A, Hernández-Antolin R, Mainar V, Valgimigli M, Tespili M, den Heijer P, Bethencourt A, Vázquez N, Gómez-Hospital JA, Báz JA, Martin-Yuste V, van Geuns RJ, Alfonso F, Bordes P, Tcháldi M, Masetti M, Silvestro A, Backx B, Brugaletta S, van Es GA, Serruys PW. Everolimus-eluting stent versus bare-metal stent in ST-segment elevation myocardial infarction (EXAMINATION): 1-year results of a randomised controlled trial. *Lancet* 2012; 380: 1482-1490 [PMID: 22951305 DOI: 10.1016/S0140-6736(12)6122-3-9]

Räber L, Kelbaek H, Ostojic M, Baumbach A, Heg D, Tüller D, von Birgelen C, Roffi M, Moschovitis A, Khattab AA, Wenaweser P, Bonvini R, Pedrazzini G, Kornowski R, Weber K, Trelle S, Lüscher TF, Taniwaki M, Matter CM, Meier B, Juni P, Windecker S. Effect of biolimus-eluting stents with biodegradable polymer vs bare-metal stents on cardiovascular events among patients with acute myocardial infarction: the COMFORTABLE AMI randomized trial. *JAMA* 2012; 308: 777-787 [PMID: 22910785 DOI: 10.1001/jama.2012.10065]

Sabaté M, Brugaletta S, Cequier A, Itiúguez A, Serra A, Hernández-Antolin R, Mainar V, Valgimigli M, Tespili M, den Heijer P, Bethencourt A, Vázquez N, Backx B, Serruys PW. The EXAMINATION trial (Everolimus-Eluting Stents Versus Bare-Metal Stents in ST-Segment Elevation Myocardial Infarction): 2-year results from a multicenter randomized controlled trial. *JACC Cardiovasc Interv* 2014; 7: 64-71 [PMID: 24332425 DOI: 10.1016/j.jcin.2013.09.006]
