

# An international survey of clinical practice during primary percutaneous coronary intervention for ST-elevation myocardial infarction with a focus on aspiration thrombectomy

Juan J. Russo<sup>1</sup>, MD; Vladimír Džavík<sup>2</sup>, MD; John A. Cairns<sup>3</sup>, MD; Sunil V. Rao<sup>4</sup>, MD; Kari O. Niemelä<sup>5</sup>, MD, PhD; Madhu K. Natarajan<sup>6</sup>, MD; Olivier F. Bertrand<sup>7</sup>, MD, PhD; Markku Eskola<sup>5</sup>, MD, PhD; Robert Welsh<sup>8</sup>, MD; Pawel Maciejewski<sup>9</sup>, MD; Asim N. Cheema<sup>10</sup>, MD, PhD; Anthony Fung<sup>3</sup>, MB, BS; Warren J. Cantor<sup>1,11</sup>, MD; Shahar Lavi<sup>12</sup>, MD; Petr Widimsky<sup>13</sup>, MD, DrSc; Sanjit S. Jolly<sup>6\*</sup>, MD

1. University of Toronto, Toronto, Ontario, Canada; 2. University Health Network, University of Toronto, Toronto, Ontario, Canada; 3. University of British Columbia, Vancouver, British Columbia, Canada; 4. Duke Clinical Research Institute, Duke University, Durham, NC, USA; 5. Tampere University Hospital and Tampere Heart Centre, Tampere, Finland; 6. McMaster University and the Population Health Research Institute, Hamilton Health Sciences, Hamilton, Ontario, Canada; 7. Quebec Heart-Lung Institute, Laval University, Quebec City, Quebec, Canada; 8. Mazankowski Alberta Heart Institute and University of Alberta, Edmonton, Alberta, Canada; 9. Department of Cardiology, Postgraduate Medical School, Grochowski Hospital, Warsaw, Poland; 10. St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada; 11. Southlake Regional Health Centre, Newmarket, Ontario, Canada; 12. London Health Sciences Centre, University of Western Ontario, London, Ontario, Canada; 13. Cardiocenter, University Hospital Vinohrady, Third Faculty of Medicine, Charles University, Prague, Czech Republic

## KEYWORDS

- pharmacology
- primary angioplasty
- STEMI

## Abstract

**Aims:** Data suggest that there is a variable use of thrombectomy during primary percutaneous coronary interventions (PPCI). We sought to evaluate practices during PPCI for ST-elevation myocardial infarction (STEMI), including the use of aspiration thrombectomy, and to determine the feasibility of conducting a definitive aspiration thrombectomy trial.

**Methods and results:** A 27-item online survey was distributed to 1,607 interventional cardiologists internationally. A total of 461 responses were received. During PPCI, aspiration thrombectomy is used routinely by 36% of respondents, and selectively by 60%. Twenty-five percent of respondents reported experiencing a complication related to thrombectomy including: vessel dissection (13%), bringing thrombus back into left main coronary artery from target vessel (5%), stroke or transient ischaemic attack (2%), and coronary artery perforation (1%). The vast majority of respondents (89%) believe that a confirmatory aspiration thrombectomy trial is needed and 85% would be willing to randomise patients in such a trial.

**Conclusions:** The majority of interventional cardiologists surveyed are not using thrombectomy routinely during PPCI. The survey results suggest that a large, confirmatory thrombectomy trial is needed and feasible in the current era. The survey also highlights a significant level of variability and underutilisation of other evidence-based therapies during PPCI.

\*Corresponding author: Interventional Cardiology, Hamilton Health Sciences, General Division, DBCVSRI Building Rm C3-118, 237 Barton Street East, Hamilton, ON, L8L 2X2, Canada. E-mail: sanjit.jolly@phri.ca

## Abbreviations

<b>GP</b>	glycoprotein
<b>IQR</b>	interquartile range
<b>MRA</b>	multiple responses accepted
<b>PPCI</b>	primary percutaneous coronary intervention
<b>TIA</b>	transient ischaemic attack
<b>TIMI</b>	thrombolysis in myocardial infarction
<b>STEMI</b>	ST-elevation myocardial infarction

## Introduction

New therapies may not be adopted widely in clinical practice due to a variety of factors, including: the perception that current evidence is insufficient to support a change in practice, the cost of new therapies, system or institutional barriers, and a lack of familiarity and training with new agents or procedures.

Thrombectomy during primary percutaneous coronary interventions (PPCI) for ST-elevation myocardial infarction (STEMI) has a class IIa recommendation in American and European STEMI guidelines<sup>1,2</sup>. The recommendation for thrombectomy use is not stronger because the evidence is derived predominantly from a single-centre trial, the TAPAS trial, which was powered for a surrogate outcome but showed an unexpected large mortality reduction associated with thrombectomy<sup>3</sup>. Data from the American College of Cardiology National Database Registry suggest that thrombectomy was used in only 19% of PPCI cases for STEMI between 2009 and 2010<sup>4</sup>. It is important to determine whether this finding is due in part to a perception amongst clinicians that further evidence is needed to support a change in practice.

We undertook an international survey to assess: perceptions regarding the current level of evidence for thrombectomy during

**Editorial, see page 1115**

PPCI, prevalence of thrombectomy use and practice patterns, variations in the use of direct stenting and periprocedural pharmacology, and choice of vascular access during PPCI for STEMI.

## Methods

We designed a 27-item closed survey to assess PPCI practices as well as the current extent and patterns of use of aspiration thrombectomy internationally. The questions addressed: 1) prevalence of aspiration thrombectomy use, 2) preferences for thrombectomy devices and adjunctive therapies, 3) complications of aspiration thrombectomy, 4) criteria for aspiration thrombectomy use, and 5) perceived need for an aspiration thrombectomy trial and willingness to randomise patients to such a trial. The survey also assessed the use of other PPCI strategies including: 1) glycoprotein (GP) IIb/IIIa inhibitors and bivalirudin, 2) pharmacologic agents to prevent no-reflow, 3) direct stenting, and 4) vascular access site preference (radial versus femoral access).

The project was approved by the Hamilton Health Sciences Research Ethics Board. We used Internet-based software (Survey Monkey, Palo Alto, CA, USA) to design and distribute the survey. During the development phase, the survey was sent to 14 experienced cardiologists for feedback on its readability, comprehensiveness,

time for completion, and validity and relevance of questions. The original version was then modified and recirculated for further feedback resulting in no additional changes.

The survey was distributed in English via e-mail to practising interventional cardiologists who were part of the international Population Health Research Institute investigator network (n=815, including investigators from Argentina, Brazil, Canada, Czech Republic, France, Germany, Greece, Italy, India, Netherlands, Russia, South Korea, Spain, United Kingdom, and the United States), DUKE STEMI investigators within the United States (n=150), members of the Canadian Association of Interventional Cardiology (n=130), and Polish (n=485), Czech (n=65), and Nordic (n=200) interventional cardiology working groups. There were 238 individuals who were on more than one e-mail list and these individuals were only counted once, for a total of 1,607 cardiologists surveyed. The survey was first sent to participants on February 1<sup>st</sup>, 2010, and a follow-up request was sent two weeks later. Survey responses were collected from February 1<sup>st</sup> to November 30<sup>th</sup>, 2010.

## Statistical analysis

The results are presented as medians and interquartile ranges for continuous variables and percentage of total responses for categorical variables. The results were divided into three regions: North America, Europe, and other. Trends across regions were analysed using the  $\chi^2$  test and Kruskal-Wallis test for categorical and continuous variables, respectively, using JMP (version 9; SAS Institute Inc., Cary, NC, USA).

## Results

A total of 461 responses were received from 1,607 cardiologists contacted, consistent with a response rate of 29%.

### DEMOGRAPHICS OF RESPONDENTS

Respondents were predominantly from Europe (66%), North America (24%), South America (5%), and India (2.3%). The demographics of respondents are summarised in **Table 1**. Sixty percent of respondents work in university-based academic centres, while the remaining 40% practise in non-university-based tertiary centres or private institutions. The majority of respondents were high-volume operators with 66% performing more than 200 PCI procedures per year. The respondents were also high-volume STEMI operators with a median of 50 PPCIs per year, and worked in centres performing a median of 250 PPCIs for STEMI per year. Most respondents (86%) had at least five years of experience performing PCI for STEMI, with 54% having more than 10 years of experience.

## Primary PCI strategies

### USE OF ASPIRATION THROMBECTOMY

The reported median use of aspiration thrombectomy during the 12 months preceding the survey was 60% of all PPCI for STEMI (**Table 2**). Only 36% of respondents reported using aspiration thrombectomy routinely while an additional 60% used this procedure selectively. Four percent of respondents reported rare or no use of aspiration thrombectomy. The median use of aspiration thrombectomy was 80%, 30%, and 10% of all PPCI for STEMI in

**Table 1. Demographic data from respondents.**

Characteristic	Total n=400* (100%)	North America n=96 (24.0%)	Europe n=263 (65.8%)	Other n=41 (10.3%)	p-value
A university-based hospital	60.0%	60.4%	62.8%	40.0%	0.06
A non-university-based tertiary hospital	37.8%	37.5%	35.6%	52.5%	
Other	2.2%	2.1%	1.6%	7.5%	
<b>Operators in centre</b>	6 (4-8)	7 (5-9)	6 (4-8)	3 (3-5)	<0.0001
Centre PPCI volume/year	250 (150-450)	200 (100-413)	300 (200-500)	100 (50-150)	<0.0001
Operator PPCI volume/year	50 (35-90)	40 (25-50)	70 (46-100)	40 (30-61)	<0.0001
<b>Operator PCI volume/year</b>					0.38
<50	1.0%	1.0%	0.8%	2.5%	
50-100	6.0%	6.3%	5.6%	7.5%	
101-200	27.0%	31.3%	23.7%	37.5%	
>200	66.0%	61.5%	69.9%	52.5%	
<b>Years of experience</b>					0.001
< 5	14.3%	15.6%	15.7%	2.5%	
5-10	31.9%	17.7%	36.9%	35.0%	
>10	53.8%	66.7%	47.4%	62.5%	

Data are percentage of total responses or median (IQR). \*61 respondents did not answer demographic data questions.

those reporting routine, selective, and rare use of thrombectomy, respectively. Reasons for not using thrombectomy included a perceived lack of evidence supporting a clear benefit, as well as increased procedural time and costs. There was no significant difference in the prevalence of aspiration thrombectomy use among regions (**Table 2**). Procedural costs affect the aspiration thrombectomy practice of 14% of respondents, with cost being a particularly important factor in centres outside North America and Europe (**Table 2**). Respondents who indicated an influence of costs on practice identified the following financial obstacles: lack of coverage for thrombectomy devices by government insurance plans, lack of patient private health insurance, and limited procedural budgets.

#### CRITERIA FOR ASPIRATION THROMBECTOMY USE

Eighty-six percent of respondents stated that they have specific criteria for the use of aspiration thrombectomy (**Table 2**). Common criteria for thrombectomy use include: a large amount of thrombus (82%), TIMI 0 or 1 flow (54%), and proximal location of the thrombus in the coronary artery (31%). Additional criteria included large infarct-related artery, no-reflow, and contraindications to GP IIb/IIIa inhibitors.

#### ASPIRATION THROMBECTOMY PROCEDURAL TECHNIQUES, DEVICES AND COMPLICATIONS

With regard to crossing the lesion, 80% of respondents initiate suction before advancing the catheter through the target lesion with significant differences among regions (**Table 2**). Twenty percent initiate suction after advancing the catheter through the target lesion and aspirate while pulling back the catheter. When removing the device, 17% of operators turn off suction before removing the catheter from the target vessel while 83% maintain suction while doing so.

The Export catheter (6 Fr) (Medtronic CardioVascular, Santa Rosa, CA, USA) was the most commonly used thrombectomy device,

utilised by 77% of operators with 31% using it exclusively. Other widely used devices included: 1) Diver CE (Invatec S.p.A., Roncadelle, Italy) used by 26%, with 5% using it exclusively, 2) Pronto V3 catheter (Vascular Solutions, Minneapolis, MN, USA) used by 25% of respondents, with 6% using it exclusively, and 3) Export XT 7 Fr (Medtronic CardioVascular, Santa Rosa, CA, USA) used by 15% of respondents, with no respondents using it exclusively.

Twenty-five percent of respondents reported experiencing at least one serious complication related to the use of aspiration thrombectomy including: thrombus aspirated back from target vessel into left main coronary artery (5%), stroke or transient ischaemic attack (TIA) (2%), left main coronary artery dissection (0.6%), and vessel dissection other than left main (12%). Additional complications identified included distal embolisation, air embolism, and no-reflow.

#### NEED FOR A LARGE-SCALE RANDOMISED TRIAL FOR ASPIRATION THROMBECTOMY

The majority (89%) of respondents stated that a large, definitive trial of aspiration thrombectomy is needed while only 11% stated that the existing evidence supports the use of thrombectomy as the standard of care. Eighty-five percent of respondents would be willing to randomise patients into a large, definitive trial of aspiration thrombectomy during PPCI.

#### ADJUNCTIVE PHARMACOLOGICAL THERAPY DURING PPCI

GP IIb/IIIa inhibitors are used routinely by 36% of respondents, selectively by 53%, and seldom or never by 11%. There were significant regional variations in the use of GP IIb/IIIa inhibitors (**Table 3**,  $p=0.02$ ) with a higher rate of routine use in North America (49%) compared to Europe (31%) and other regions (33%).

Bivalirudin is used routinely and selectively by 13% and 19% of operators, respectively, and seldom or never by 68%. Routine use

**Table 2. Aspiration thrombectomy experience, practice, and complications.**

Characteristic	Total	North America	Europe	Other	p-value
Use of aspiration thrombectomy during primary PCI for STEMI					0.32
Routinely	35.8%	30.2%	39.2%	28.2%	
Selectively	60.0%	66.7%	56.3%	66.7%	
As a bailout procedure	2.1%	1.0%	2.0%	5.1%	
Rarely or never	2.1%	2.1%	2.4%	0.0%	
Percent of total PPCI for STEMI with adjunctive thrombectomy in last 12 months	60 (24-80)	50 (20-80)	60 (25-80)	55 (20-76)	0.68
Do procedural costs affect practice: yes	14.0%	7.4%	11.7%	44.7%	<0.0001
Criteria for use of aspiration thrombectomy (multiple responses allowed*)					
Large amount of thrombus	81.5%	83.0%	80.2%	84.6%	
TIMI 0 or 1 flow	54.4%	48.9%	56.5%	56.4%	
Proximal coronary artery thrombus	31.1%	30.9%	30.8%	30.8%	
Other	9.7%	11.7%	9.3%	7.7%	
No criteria	14.2%	11.7%	16.0%	10.3%	
Catheter advancement (%)					<0.0001
Turn on suction before advancing catheter through target lesion	79.7%	89.0%	81.0%	48.8%	
Catheter removal (%)					0.79
Continue suction while removing catheter	82.8%	80.4%	83.5%	83.8%	
Complications of aspiration thrombectomy (multiple responses allowed*)					
No complication	74.7%	78.2%	73.0%	78.4%	
Left main thrombus brought back from target vessel	5.0%	4.6%	3.9%	10.8%	
Left main dissection	0.6%	1.1%	0.0%	0.0%	
Other vessel dissection	12.0%	8.0%	14.6%	5.4%	
Coronary perforation	1.1%	0.0%	1.7%	0.0%	
Stroke or TIA	1.7%	2.3%	1.3%	2.7%	
Other	12.8%	20.7%	10.7%	8.1%	
Need for RCT (%): yes	88.7%	84.1%	89.7%	91.9%	0.30
Willing to randomise patients to RCT (%): yes	85.2%	87.9%	82.3%	94.7%	0.11

Data are percentage of total responses or median (IQR). \*p-values are not provided for questions with multiple responses allowed.

of bivalirudin is more common in North America (27%) than in Europe (9%) and other regions (0%) ( $p<0.0001$ ). Thirty-seven percent of respondents reported pre-treating with microvascular vasodilators to prevent no-reflow during PPCI. In order of prevalence, pre-treatment with prophylactic intracoronary adenosine, nitroprusside, verapamil, and nicorandil are used by 20%, 16%, 10%, and 3% of operators, respectively.

#### RADIAL VS. FEMORAL ACCESS AND SHEATH SIZE

During PPCI, 56% of operators prefer femoral access, while the remaining 44% prefer a radial route. There was a statistically significant difference in access route preference among regions (Table 3,  $p=0.003$ ) with a stronger preference for radial access in Europe (50%) compared to North America (31%) and other regions (34%). The majority of operators (91%) prefer using 6 Fr catheters, while 6.7%, 1.3%, and 1.3% prefer 7 Fr, 8 Fr, and 5 Fr catheters, respectively.

#### DIRECT STENTING DURING PPCI

Direct stenting during PPCI is performed routinely by 27% of operators and selectively by 54%. There was a statistically significant difference in the use of this technique among regions (Table 3,  $p<0.0001$ ), with a higher prevalence of direct stenting in Europe (32%) compared to North America (20%) and other regions (16%). One fifth of respondents (19%) seldom or never use direct stenting.

#### Discussion

This international survey of interventional cardiologists demonstrates that, despite the benefits observed in the TAPAS trial, the majority of interventional cardiologists in contemporary practice are not using aspiration thrombectomy routinely during PPCI. Our survey suggests that complications related to this technique do occur, with approximately one quarter of respondents having experienced a complication from its use. In addition, 89% of respondents believe that a definitive randomised trial is needed, and 85%

**Table 3. Practice patterns during primary PCI for STEMI.**

Practice	Total	North America	Europe	Other	p-value
Use of GP IIb/IIIa inhibitors in primary PCI (%)					0.02
Routinely	36.1%	48.9%	30.9%	33.3%	
Selectively	53.1%	42.6%	58.5%	48.7%	
Rarely or never	10.8%	8.5%	10.6%	18.0%	
Use of bivalirudin in primary PCI (%)					<0.0001
Routinely	12.8%	26.9%	9.3%	0.0%	
Selectively	18.9%	29.0%	16.5%	8.6%	
Rarely or never	68.3%	44.1%	74.2%	91.4%	
Catheter size					0.002*
5 Fr	1.3%	1.1%	1.7%	0.0%	
6 Fr	90.6%	89.4%	92.4%	81.6%	
7 Fr	6.7%	9.6%	3.8%	18.4%	
8 Fr	1.3%	0.0%	2.1%	0.0%	
Access site					0.003
Radial	43.6%	30.9%	50.2%	34.2%	
Femoral	56.4%	69.1%	49.8%	65.8%	
Direct stenting in primary PCI					<0.0001
Routinely	27.4%	20.2%	31.8%	16.2%	
Selectively	53.9%	44.7%	57.2%	56.8%	
Rarely or never	18.7%	35.1%	11.0%	27.0%	
Strategies to prevent no-reflow (multiple responses allowed <sup>†</sup> )					
No pharmacological strategy	62.8%	61.7%	67.7%	34.2%	
Intracoronary nitroprusside pre PCI	16.2%	20.2%	13.6%	23.7%	
Intracoronary adenosine pre PCI	19.9%	27.7%	13.2%	42.1%	
Intracoronary nicorandil pre PCI	2.7%	0.0%	0.0%	26.3%	
Intracoronary verapamil pre PCI	9.7%	5.3%	10.2%	18.4%	
Other	9.2%	17.0%	6.8%	5.3%	

Data are percentage of total responses. \*Only 6 Fr and 7 Fr were included in chi-square analysis. <sup>†</sup>p-values are not provided for questions with multiple responses allowed.

would randomise patients to such a trial, supporting its feasibility. Finally, there are variations of practice in the use of other strategies during PPCI, including bivalirudin, GP IIb/IIIa inhibitors, direct stenting, and radial access.

The finding that only 36% of operators use thrombectomy routinely is surprising given the large benefit observed in the TAPAS trial and the class IIa recommendation in both American and European guidelines<sup>1-3</sup>. Data from the American College of Cardiology National Database Registry report thrombectomy use rates of only 19% during PPCI for STEMI, which is much lower than reported by respondents in our survey<sup>4</sup>. The difference may be the result of selection bias, as we surveyed operators from centres participating in clinical trials, who may be more likely to adopt new practices.

The reasons behind the lower than expected thrombectomy use rates are probably multifactorial. Nearly 90% of operators feel that a large randomised trial is needed in order to validate the routine use strategy. In addition, approximately one quarter of respondents

have experienced a serious complication related to thrombectomy use including pulling thrombus back into the left main coronary artery. While these complications may be very uncommon, they could discourage a clinician from utilising the device.

Device manufacturers recommend starting suction prior to crossing the lesion during thrombectomy to minimise distal embolisation. Therefore, it is surprising that 20% of respondents start suction only after they have passed through the lesion. This suggests that further education and training is needed in clinical practice, and future clinical trials of thrombectomy need to ensure operators use the devices in an optimal fashion.

#### UPDATE OF CLINICAL TRIALS OF THROMBECTOMY DURING STEMI

The INFUSE AMI trial (n=452) demonstrated no difference in MRI infarct size in patients with anterior STEMI treated with aspiration thrombectomy compared to PCI alone<sup>5</sup>. Currently, there are two

investigator-initiated large multicentre randomised trials evaluating thrombectomy during PPCI for STEMI that have started since this survey was performed: 1) the Thrombectomy With PCI Versus PCI Alone trial (TOTAL) which is being performed by our group (n=4,000, NCT01149044), and 2) the Thrombus Aspiration in STEMI in Scandinavia trial (TASTE) performed within the Swedish Angiography and Angioplasty registry (n=5,000, NCT01093404)<sup>6</sup>.

With regard to pharmacological therapy, our survey suggests that GP IIb/IIIa inhibitors appear to be more commonly used as a default strategy than bivalirudin. This is despite the HORIZONS-AMI trial which demonstrated reductions in bleeding and mortality with bivalirudin when compared to heparin with GP IIb/IIIa inhibitors<sup>7</sup>. In addition, vasodilators are being used to prevent no-reflow routinely by nearly one third of respondents despite the lack of evidence to support this practice.

## Limitations

First, the generalisability of the survey results is probably limited by the distribution of the survey to operators from centres participating in clinical trials, whose practice may differ significantly from operators in other centres. Second, the response rate of 29% may have contributed to a non-response bias<sup>8</sup>. Several strategies were implemented to maximise response rate including minimising time for completion, ensuring relevance of all questions through a pilot survey, and follow-up e-mails. Physician-based surveys tend to have low response rates with rates between 13-50%<sup>9,10</sup>. Third, routine use was defined as the default approach, but actual percentages were not provided to participants to define routine use. Finally, survey results are self-reported and may differ from actual practice. It is important to note that respondents were experienced operators, the majority having more than 10 years of experience and performing more than 200 PCIs per year.

## Conclusion

In contemporary practice, the majority of interventional cardiologists are not using aspiration thrombectomy routinely during PPCI. The vast majority of respondents stated that a large, definitive trial of aspiration thrombectomy was needed and this led to the design and start of the TOTAL trial (n=4,000). Finally, there is significant variability in the clinical use of evidence-based pharmacological therapies, direct stenting, and radial access during primary PCI.

## Conflict of interest statement

S. Jolly, V. Dzavik, J. Cairns, and R. Welsh have received grant support from Medtronic. P. Widimsky has received speaker honoraria from Medtronic. S. Jolly has received honoraria from Bayer Interventional. All other authors have no conflicts of interest to declare.

## References

1. Kushner FG, Hand M, Smith SC Jr, King SB 3rd, Anderson JL, Antman EM, Bailey SR, Bates ER, Blankenship JC, Casey DE Jr, Green LA, Hochman JS, Jacobs AK, Krumholz HM, Morrison DA, Ornato JP, Pearle DL, Peterson ED, Sloan MA, Whitlow PL, Williams DO; American College of Cardiology Foundation/American

Heart Association Task Force on Practice Guidelines. 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. *Circulation*. 2009;120:2271-306.

2. Van de Werf F, Bax J, Betriu A, Blomstrom-Lundqvist C, Crea F, Falk V, Filippatos G, Fox K, Huber K, Kastrati A, Rosengren A, Steg PG, Tubaro M, Verheugt F, Weidinger F, Weis M; Guidelines ESC Committee for Practice Guidelines (CPG). Management of acute myocardial infarction in patients presenting with persistent ST-segment elevation: the Task Force on the Management of ST-Segment Elevation Acute Myocardial Infarction of the European Society of Cardiology. *Eur Heart J*. 2008;29:2909-45.

3. Svilaas T, Vlaar PJ, van der Horst IC, Diercks GFH, de Smet BJGL, van den Heuvel AFM, Anthonio RL, Jessurun GA, Tan E-S, Suurmeijer AJH, Zijlstra F. Thrombus aspiration during primary percutaneous coronary intervention. *N Engl J Med*. 2008;358:557-67.

4. Owan TE, Roe MT, Messenger JC, Dai D, Michaels AD. Contemporary use of adjunctive thrombectomy during primary percutaneous coronary intervention for ST-elevation myocardial infarction in the United States. *Catheter Cardiovasc Interv*. 2012;80:1173-80.

5. Stone GW, Maehara A, Witzenbichler B, Godlewski J, Parise H, Dambrink JH, Ochala A, Carlton TW, Cristea E, Wolff SD, Brener SJ, Chowdhary S, El-Omar M, Neunteufl T, Metzger DC, Karwoski T, Dizon JM, Mehran R, Gibson CM; INFUSE-AMI Investigators. Intracoronary abciximab and aspiration thrombectomy in patients with large anterior myocardial infarction: the INFUSE-AMI randomized trial. *JAMA*. 2012;307:1817-26.

6. Fröbert O, Lagerqvist B, Gudnason T, Thuesen L, Svensson R, Olivecrona GK, James SK. Thrombus Aspiration in ST-Elevation myocardial infarction in Scandinavia (TASTE trial). A multicenter, prospective, randomized, controlled clinical registry trial based on the Swedish angiography and angioplasty registry (SCAAR) platform. Study design and rationale. *Am Heart J*. 2010;160:1042-8.

7. Stone GW, Witzenbichler B, Guagliumi G, Peruga JZ, Brodie BR, Dudek D, Kornowski R, Hartmann F, Gersh BJ, Pocock SJ, Dangas G, Wong SC, Kirtane AJ, Parise H, Mehran R; HORIZONS-AMI Trial Investigators. Bivalirudin during primary PCI in acute myocardial infarction. *N Engl J Med*. 2008;358:2218-30.

8. Asch DA, Jedrzejewski MK, Christakis NA. Response rates to mail surveys published in medical journals. *J Clin Epidemiol*. 1997;50:1129-36.

9. Scott A, Jeon SH, Joyce CM, Humphreys JS, Kalb G, Witt J, Leahy A. A randomised trial and economic evaluation of the effect of response mode on response rate, response bias, and item non-response in a survey of doctors. *BMC Med Res Methodol*. 2011;11:126.

10. VanGeest JB, Johnson TP, Welch VL. Methodologies for improving response rates in surveys of physicians: a systematic review. *Eval Health Prof*. 2007;30:303-21.