Novel insights in reperfusion therapy and stent thrombosis in the drug eluting stent era

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Chapter 2

In-ambulance abciximab administration in STEMI patients prior to primary PCI is associated with smaller infarct size, improved LV function and lower incidence of heart failure: Results from the Leiden MISSION! acute myocardial infarction treatment optimization program

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Eur Heart J. 2008;29 Supplement:136

ABSTRACT

Objective: Early abciximab administration before primary percutaneous coronary intervention (PPCI) for ST-segment elevation myocardial infarction (STEMI) is recommended in practice guidelines. However, optimal timing of administration remains unclear. Our aim was to evaluate the effects of early abciximab administration in the ambulance on immediate, short and long term outcomes.

Design: Single center prospective study

Setting and patients: Within a fixed protocol for PPCI, December 2006 was the cut-off point for this study. 179 consecutive patients with STEMI were enrolled, 90 patients received abciximab bolus in the hospital (late group) and 89 patients received abciximab bolus in the ambulance (early group).

Main outcome measures: Infarct related artery (IRA) patency pre-PPCI.

Results: The two groups were well matched for baseline and angiographic characteristics. The early group received abciximab within the golden period (median 63 min). The IRA patency pre-PPCI was 4 times higher in the early group than in late group (odds ratio = 4.9, 95% CI 2.4-10.1). Enzymatic infarct size was smaller in the early group (cumulative 48-h CK release 8011 vs. 11267 U/L, p = 0.004). This was associated with higher left ventricular ejection fraction (LVEF) at 90 days post-PPCI by myocardial scintigraphy (59% vs. 54%, p = 0.01), and lower incidence of heart failure through a median of 210 days of clinical follow-up (3% vs.11%, p = 0.04).

Conclusions: Early abciximab administration in the ambulance significantly improves early reperfusion in STEMI patients treated with PPCI. Moreover this is associated with a smaller infarct size, improved LV function at 3-months and a lower risk of heart failure through 7-months follow-up.

INTRODUCTION

Coronary reperfusion with primary percutaneous coronary intervention (PPCI) has been established as the treatment of choice in the majority of cases with ST-segment elevation myocardial infarction (STEMI).[1] However, favourable outcomes with PPCI may be attenuated by intra-hospital and inter-hospital transport delays from first medical contact to balloon inflation or reperfusion in the catheterization laboratory.[2]

Most critical point for PPCI is time, the golden period for myocardial salvage is the first 2 hours after onset of symptoms.[3, 4] The rationale for facilitated PCI is based on the hypothesis that combining early pharmacologically mediated reperfusion with subsequent and immediate mechanical stabilization of the ruptured plaque will overcome delays to transfer the patient to a second facility.[2] Facilitated PCI with full or reduced dose of thrombolytic drugs showed disappointing results[5-8] however still abciximab facilitated PCI is under investigation.

The purpose of the present study was to evaluate the effects of early (in the ambulance) administration of abciximab on infarct-related artery (IRA) patency, ST segment resolution, enzymatic infarct size, LV function and clinical outcome in patients with STEMI undergoing PPCI.

METHODS

Study design

This is a single center prospective study. All patients were treated according to the institutional STEMI protocol (MISSION!) implemented at Leiden University Medical Centre (LUMC) since February 2004,[9] which included standardized pre-hospital, in-hospital and outpatient clinical framework for decision making and treatment. Our hospital provides a round-the-clock service of PPCI with 6 trained PCI physicians and dedicated nurses.

Patients selection

Main results of MISSION! Study are published elsewhere.[9] For this sub-study patients were eligible if STEMI symptoms started < 9 hours before the procedure, the electrocardiogram (ECG) demonstrated STEMI (ST-segment elevation ≥ 0.2 mV in ≥ 2 contiguous leads in V1 through V3 or ≥ 0.1 mV in other leads), and received abciximab prior to PPCI. Exclusion criteria were left bundle branch block, recent surgery, recent stroke, recent spinal trauma, hemorrhagic diatheses, severe liver or kidney failure and known contraindications for therapy with abciximab, aspirin, clopidogrel or heparin.

Study groups

Halfway during the study (December 2006), a new strategy for early abciximab administration starting in the ambulance was adopted within the MISSION! protocol (Figure 1). 179 consecutive patients, who fulfilled the inclusion and exclusion criteria for this sub-study, were enrolled: 90 patients (**the late group**), in whom abciximab was initiated in the coronary care unit or catheterization laboratory before the intervention; Then 89 patients (**the early group**), in whom abciximab bolus was given in the ambulance before transport to the catheterization laboratory.

No informed consent is required, since the MISSION! protocol is the standard STEMI care regimen in the region Hollands-Midden, The Netherlands.

Abciximab and additional medication

All patients received abciximab (Centocor B.V., Leiden, the Netherlands) as a bolus injection of 0.25 mg/kg bodyweight, followed by 0.125 mcg/kg/min with a maximum of 10 mcg/min as a continuous infusion for 12 hours. All patients received an equivalent of 300 mg of acetylsalicylic acid, 600 mg clopidogrel as a loading dose and heparin given as a bolus of 5000 IU at the start of the PCI procedure. After the procedure, all patients received aspirin (75 mg/day) indefinitely and clopidogrel (75 mg/day) for one year. Other medications, including beta-blockers, ACE-inhibitors, nitrates, and statins, were prescribed according to MISSION! protocol.

Invasive procedure and angiographic evaluation

Coronary angiography was performed by the femoral approach. All patients underwent PPCI and stenting of the IRA according to standard techniques. Stent implantation was successfully completed in all patients. The choice of stent (bare-metal stent or drug-eluting stent) was left to the operator's discretion. We performed direct stenting only in cases presenting clear pictures of the arterial lesion. Otherwise, the patient was subjected to balloon angioplasty and stenting was done subsequently. Procedural success was defined as residual stenosis < 20% and TIMI flow grade 3. Initial and post procedural TIMI flow grade of the IRA[10] were assessed off-line by two experienced interventionalists (A.H. and F.vd K.) blinded to the assigned treatment. The interobserver agreement was calculated with weighted Kappa statistics and showed good agreement ($k = 0.97$, $p = 0.001$).

Electrocardiographic data

The 12-lead ECG was recorded at presentation and within 90 min after PPCI. ST segment deviation was measured manually 20 ms after the end of the QRS complex (the J point) using a hand-held caliper. The sum of ST-segment elevation in leads V1 to V6, I, and aVL was added to the sum of ST-segment depression in leads II, III, and aVF for anterior MI. For inferior MI, the sum of ST-segment elevation in leads II, III, and aVF (and I, aVL, V5, and V6, if present) were added to the sum of ST-segment depression in leads V1 to V4.[11] All ECGs were collected and analysed by an investigator blinded to the assigned treatment. Total ST-segment deviation at inclusion was compared to that taken within 90 minutes after PPCI. A complete ST-segment resolution ≥70% of the initial ST-segment deviation was calculated.

Enzymatic infarct size

Creatine kinase (CK) activity and cardiac troponin-T (TnT) concentration in plasma were determined at admission and every 6 h in the first 48 h after PPCI. Subsequently these levels were determined every day up to discharge, unless clinical events suggested repeat measurements. The cumulative release of CK in the first 48h was calculated as a measure of infarct size in each patient by an investigator blinded to the assigned treatment.[12] Other measures of infarct size were peak levels of CK and TnT in plasma.

Myocardial perfusion imaging

According to the MISSION! protocol all included patients underwent a myocardial perfusion study at 90 days post PPCI. An ECG gated SPECT acquisition at rest using intravenous Technetium 99m Tetrofosmin (MYOVIEW, Amersham, Buckinghamshire, UK) was used to measure the LV ejection fraction (LVEF) 90 days after PPCI. LVEF was calculated using an automated and validated method (QGS software, version 2.0; Cedars-Sinai Medical Center, Los Angeles, CA, USA). Detailed methods are described elsewhere.[13] Patients with a history of previous infarction were excluded from MYOVIEW analysis (6 patients (7%) of early group and 5 patients (6%) of late group), 3 patients (3%) in the early group and 3 (3%) in the late group had incomplete analysis due to technical difficulties. LVEF assessment was done by an investigator blinded to the assigned treatment.

Clinical outcome

According to the MISSION! protocol patients were scheduled at a dedicated out-patient clinic after 1, 3 and 12 months. Clinical outcome was evaluated through the monitoring of major adverse cardiac events (MACE) occurring at any time during the follow up. Death was defined as "all-cause" death at follow-up. Recurrent MI during follow-up was defined as a troponin-T rise > 0.03 µg/l with symptoms or PCI, or a re-rise of troponin-T > 25% after recent MI in the presence of symptoms or re-PCI, or the development of new Q waves on ECG.[14,15] Target vessel (TVR) and target lesion (TLR) revascularization were defined as any revascularization procedure of the target vessel or target lesion (from 5 mm distally to the stent up to 5 mm proximally to the stent), respectively. Heart failure (HF) during follow-up is defined as either the presence of rales in more than one third of the lung fields that did not clear with coughing or evidence of pulmonary oedema on chest radiograph. Only the most serious event of MACE was used to calculate the cumulative MACE per patient according to the following sequence: death > recurrent MI > TVR or TLR > HF. Major hemorrhagic events during hospitalization are defined as intracranial bleeding or bleeding associated with a decrease in hemoglobin level of ≤ 3mmol/L (5 g/dL). Other bleeding complications not fulfilling these criteria were considered minor.

End points of the study

The primary end point of the study was the presence of early reperfusion, defined as TIMI 2 or 3 flow in the IRA before angioplasty. Secondary end points were post-procedural ST-segment resolution, infarct size (measured by cumulative CK release), LV function at 90 days (evaluated by gated SPECT) and incidence of MACE during follow up.

Sample size calculation

The study was designed to have an 85% power to detect a 23% difference in coronary patency (i.e. TIMI flow 2 or 3) at initial angiography. With an overall type I error rate of 0.05 (two-sided). Sample size calculated to 76 patients. TIMI flow 2 or 3 at initial angiography was estimated to be 17% in late group and 40% in early group.[16] With regard to drop-out at least 89 patients were planned to be included in the analysis for each group.

Statistical analysis

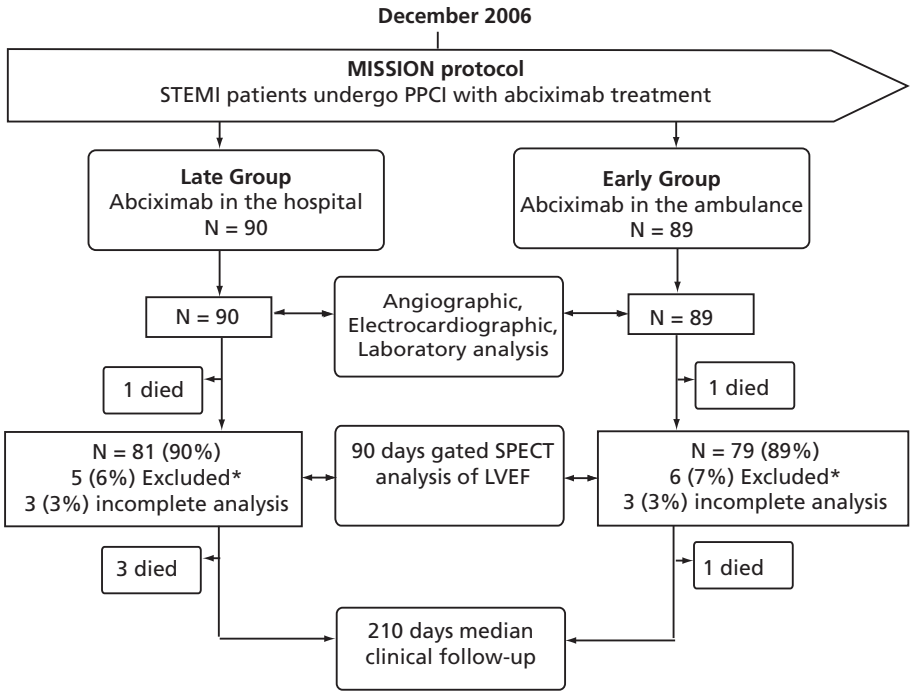
Categorical variables were presented as counts and proportions (percentages) and compared by Pearson chi-square analysis or Fisher exact test. Normal distribution of continuous data was tested using a Kolmogorov-Smirnov test. Continuous and normally distributed data are presented as mean ± 1 SD and were compared by unpaired *t* test. Not-normally distributed data are expressed as median with interquartile range (IQR), and the Mann-Whitney *U* test was used to compare differences between two groups. The interobserver agreement was calculated with weighted Kappa statistics. Multivariate logistic and linear regression analyses were performed using all potentially relevant variables to identify baseline independent predictors of initial IRA patency and LVEF. The LV function data was analyzed only in surviving patients with exclusion of patients with previous AMI. All p-values are two-tailed, and statistical significance was defined if $p < 0.05$. All analyses were performed with SPSS version 14.0 statistical software (SPSS Inc., Chicago, IL, USA).

RESULTS

Patient characteristics: The study population consists of 179 patients who underwent primary PCI and were treated with abciximab according to the MISSION! protocol (Figure 1). Baseline characteristics of the two groups are summarized in table 1.

Figure 1 Flow of patients through the study.

LVEF= left ventricular ejection fraction, PPCI= primary percutaneous coronary intervention, SPECT= single photon emission computed tomography, STEMI=ST segment elevation myocardial infarction, * Patients with previous history of myocardial infarction were excluded.



The two groups were comparable, with no significant differences in baseline characteristics. History of previous MI was found at presentation in 6 patients (7%) of the early group and in 5 patients (6%) of the late group. Table 1 reveals that there were no significant differences between groups with respect to onset of symptoms to balloon time.
The median time between symptoms onset and abciximab bolus administration for the total study population was 105 min (IQR 60-165 min) and this was significantly shorter in the early group (63 min, IQR 44-110 min) than in the late group (136 min, IQR 92-207 min).

Angiographic and procedural results

Angiographic and procedural results are summarized in table 2. Initial angiographic evaluations showed no significant differences between the 2 treatment groups prior to PPCI with exception of the higher early reperfusion rate of the IRA (TIMI 2-3 flow) at initial angiography, in the early group (52% vs. 19% ; $p < 0.001$) (Figure 2).
Multivariate binary logistic regression analysis including all risk factors, identified only early abciximab administration (odds ratio = 4.9, 95% confidence interval 2.4-10.1; $p = 0.001$) as an independent predictor of early reperfusion. Post-PCI IRA patency did not differ between the two groups (97% in early group and 92% in late group, p = n.s.). The use of drug-eluting stents and number of stents used were comparable between groups.

Electrocardiography and infarct size results

Complete ST-segment resolution of ≥ 70% at 90 min post-PCI was observed more frequently in the early group than in late group (75% vs. 50%, $p < 0.001$) (Table 3).
The baseline levels of CK were similar in early and late groups. Analysis of the peak values of CK and TnT revealed significantly lower levels in the early group compared to late group (Table 3). The cumulative 48-h CK release was significantly lower in the early group (8011 ± 7340 U/L) than in the late group (11267 ± 9170 U/L, $p = 0.004$).

Figure 2 TIMI flow at basal angiography in the early versus late groups.

Early reperfusion (TIMI 2-3) was significantly better in the early abciximab group ($p < 0.001$). TIMI= Thrombolysis In Myocardial Infarction.

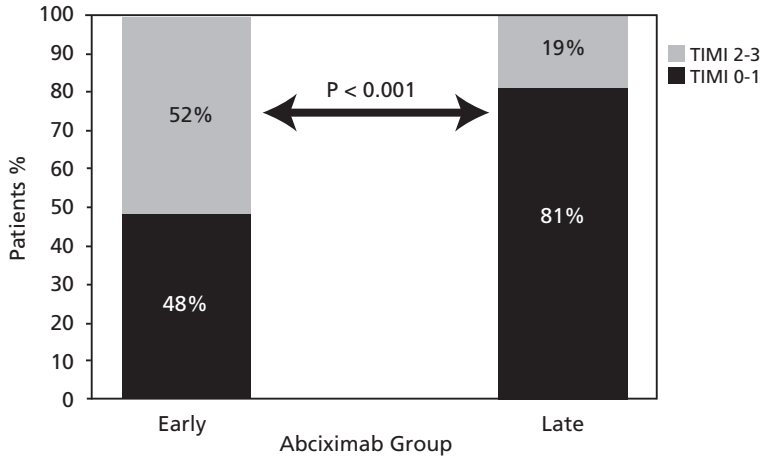


Table 1 Baseline characteristics of the study population

	Early group (n= 89)	Late group (n= 90)	P
Age (years)	61±11	59±12	NS*
Age ≥ 75 yrs, n (%)	15 (17)	11 (12)	NS†
Male gender, n (%)	65 (74)	75 (83)	NS†
Risk factors, n (%)			
Previous MI	6 (7)	5 (6)	NS†
Hypertension	36 (40)	27 (31)	NS†
Diabetes mellitus	11 (12)	10 (11)	NS†
Hypercholesterolemia	40 (45)	38 (43)	NS†
Current Smoking	57 (64)	47 (54)	NS†
Positive Family history	40 (45)	38 (43)	NS†
Killip class ≥ 2, n (%)	3 (4)	6 (7)	NS†
Site of MI, n (%)			
Inferior MI	49 (55)	44 (49)	NS†
Anterior MI	40 (45)	46 (51)	NS†
Symptoms to balloon (min)	127 (105-178)	165 (118-240)	NS‡
Symptoms to abciximab (min)	63 (44-110)	136 (92-207)	0.001‡
Start of abciximab to balloon(min)	61 (48-73)	40 (31-54)	0.001‡

Data are presented as mean ± standard deviation, number (%) of patients or median (Interquartile range). Compared using unpaired t test. † Compared using Chi-square or Fisher exact test. ‡ Compared using Mann-Whitney U test. MI = myocardial infarction; NS = not significant.*

Figure 3 Three-month LVEF by gated SPECT after PPCI in the early versus late groups.

LVEF was significantly better in the early abciximab group (p = 0.015). LVEF= left ventricular ejection fraction, PPCI= primary percutaneous coronary intervention, SPECT= single photon emission computed tomography.

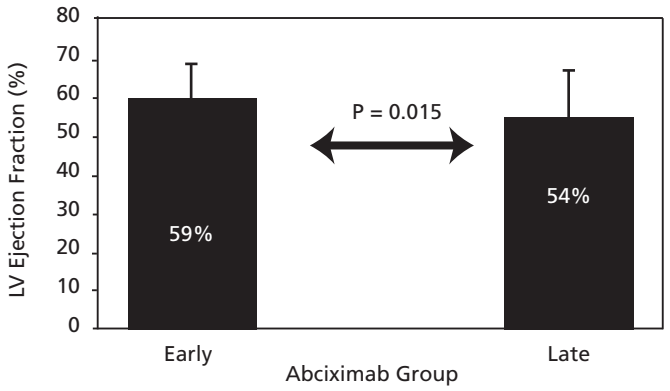


Table 2 Angiographic and procedural results of the patients included in the early and late abciximab groups

	Early group (n= 89)	Late group (n= 90)	P
Infarction related artery, n (%)			
Left main	1 (1)	1 (1)	
Left anterior descending	36 (40)	42 (47)	NS*
Circumflex artery	11 (12)	12 (13)	
Right coronary artery	41 (46)	35 (39)	
Multivessel disease, n (%)			
2-vessel	26 (29)	23 (26)	NS*
3-vessel	14 (16)	15 (17)	
Initial TIMI flow grade, n (%)			
0-1	43 (48)	73(81)	0.001*
2	20 (23)	11(12)	
3	26(29)	6 (7)	
Final TIMI flow grade, n (%)			
0-1	1 (1)	1 (1)	NS*
2	2 (2)	6 (7)	
3	86 (97)	83 (92)	
Drug eluting stents, n (%)	48 (54)	40 (44)	NS*
Number of stents	1.5 ±0.9	1.5 ±0.8	NS †
Multiple stents, n (%)	31 (35)	33 (37)	NS*

*Data are presented as number (%) or mean ± standard deviation of patients. * Compared using chi-square or Fisher exact test. †compared using unpaired t test. NS = not significant; TIMI = Thrombolysis In Myocardial Infarction.*

Table 3 Electrocardiographic and laboratory results in the early and late abciximab groups

	Early group (n= 89)	**Late group (n= 90)**	***P***
Post-PCI ST-segment resolution ≥ 70%, n (%)	67 (75)	45 (50)	< 0.001*
Basal CK (U/L)	405 ± 982	296 ± 538	NS†
Peak CK (U/L)	1978 ± 2393	2341 ± 1968	0.019†
Cumulative 48-h CK release (U/L)	8011 ± 7340	11267 ±9170	0.004†
Peak Tn-T (µg/L)	5.24 ± 6.00	6.85 ± 6.30	0.013†

*Data are presented as mean ± standard deviation or number (%) of patients. *Compared using Chi-square or Fisher exact test; †Compared using Mann-Whitney U test. CK = creatine kinase; MI = myocardial infarction; NS = not significant; PCI = percutaneous coronary intervention; Tn-T = Troponin T.*

Three-month LV function results

After 3 months, 160 LV function studies from 79 (89%) patients in the early group (6 patients excluded because of previous MI, 1 patients died and 3 patients had incomplete analysis) and from 81 (90%) patients in the late group (5 patients excluded because of previous MI, 1 patient died and 3 patients had incomplete analysis) were analysed. LVEF was significantly higher in the early group (59 ± 9%) compared to the late group (54 ± 12%, p = 0.015) (Figure 3). Multivariate linear regression analysis for LVEF using the available risk factors at baseline revealed that higher IRA patency pre-PPCI, lower enzymatic infarct size and female gender were independent factors that predict improvement in LVEF at 90 days post PPCI.

Clinical outcome results

All patients were followed for a median of 210 days (IQR 90-330 days). Cumulative MACE occurred in 29 patients; the incidence of MACE was lower in the early group than in the late group (9 % vs.23 %, p = 0.009) (Table 4). The incidence of heart failure was significantly lower in the early group than in the late group (3% vs. 11%; p = 0.04). No differences were noted between the two groups with regard to the occurrence of major bleeding complications (7 patients (8%) of the early group and 5 patients (6%) of the late group (p = 0.64)). No intracranial bleeding occurred.

Sub-analysis after exclusion of patients with previous history of MI showed that incidence of heart failure still was lower in the early group compared to the late group (1/83 (1%) vs. 7/85 (8%), p = 0.03). Incidence of MACE was significantly lower in the early group than in the late group (7/83 (8%) vs. 18/85 (21%), p = 0.02).

Table 4 Clinical outcome and complications at follow-up in early and late abciximab groups

	Early group (n = 89)	**Late group (n = 90)**	***P***
Cumulative MACE*, n (%)	8 (9)	21 (23)	**0.009†**
Death, n (%)	2 (2)	4 (4)	**NS†**
Recurrent MI, n (%)	2 (2)	6 (7)	**NS†**
Revascularization, n (%)			
TVR	3 (3)	5 (6)	NS†
TLR	1 (1)	3 (3)	
Non-TVR	3 (3)	8 (9)	
Heart failure, n (%)	3 (3)	10 (11)	**0.04†**
Major bleeding, n (%)	7 (8)	5 (6)	NS†

*Data are presented as number (%) of patients. † Compared using Chi-square or Fisher exact test. * Only the most serious event was used per patient according to the following sequence: death> MI> TVR or TLR> Heart Failure. MACE = major adverse cardiac events; MI = myocardial infarction; TLR = target lesion revascularization; TVR = target vessel revascularization.*

DISCUSSION

Key findings of the present study are: 1) In patients with STEMI treated with PPCI, early abciximab administration in the ambulance compared with late abciximab administration in the hospital significantly improves pre-procedural IRA patency (TIMI flow 2-3) and post-procedural ST-segment resolution. 2) Early abciximab therapy within the golden period is associated with a smaller infarct size, improved LV function at 3-months, and a lower risk of heart failure through a median of 7-months clinical follow-up.

Infarction related artery patency

In the present study the IRA patency rate after early abciximab administration was 4 times higher than in the late group, which is in consistent with previous randomized control trials,[17-21] the Eurotransfer registry [22]and the recent EGYPT cooperation meta-analysis.[23] In this meta-analysis, individual patients data from 11 randomized trials conducted on facilitated primary angioplasty by the use of early glycoprotein (Gp) IIb-IIIa inhibitors were collected. The early group received abciximab within a median of 100 min after symptom onset and had a higher proportion of pre-PCI TIMI flow grade 2-3 compared to the late group (23% vs. 13%, p = 0.001).

ST-segment resolution and enzymatic infarct size

ST-segment resolution post PPCI in the our study occurred more frequently in the early group than in the late group, which is consistent with previous trials.[19-21,23,24] The Eurotransfer registery[22] and the On-TIME 2 trial[25] also showed significantly more frequent ST-segment resolution post PPCI in the early group compared to late group.

Our study showed that enzymatic infarct size after early abciximab administration was lower compared with conventional abciximab therapy, consistent with the results of Rakowski et al.[20] Also the RELAx-AMI trial[19] and the FINESSE trial[6] had a trend toward lower enzymatic infarct size in the early group compared to the late group but that difference was not significant.

Left ventricular function

Myocardial salvage is the principal mechanism by which patients with STEMI benefit from reperfusion therapies especially in first 2 h after onset of symptoms (golden period) which is reflected by an improved LV systolic function.[3,4] It can be reliably quantified by technetium-99 m tetrofosmin imaging.[13] Bellandi et al.[17] showed that the myocardial salvage index by repeated gated SPECT analysis was significantly higher in the early group than in late group leading to a better recovery in LV function at 30 days (56% vs. 46%). The RELAx-AMI trial[19] also showed a significantly better LVEF at 30 days in the early group than in the late group (51% vs. 47%), assessed by serial echocardiographic evaluation. These findings are consistent with our results with a significantly better LVEF at 90 days in the early group compared to late group.

The present study is the first study evaluating the effect of early abciximab administration on LV systolic function at 90 days with gated SPECT providing a long time window for recovery of LV function post-MI. Furthermore, the exclusion of patients with previous MI provided a possibility of evaluating more precisely the effect of early abciximab therapy on LV function.

Clinical outcome

A) Safety concern

Our study provides a relatively long follow up duration (median of 210 days). The incidence of major bleeding complications did not differ between the early and the late groups in consistence with previous randomized trials,[17,19-21] Eurotransfer registery,[22] and EGYPT cooperation meta-analysis.[23] Also the FINESSE trial[6] showed no significant difference between the early and late groups for incidence of major bleeding (4.1% vs. 2.6%, p = ns) and there was no cases with intracranial hemorrhage in the early group in all these studies.

B) Efficacy concern

The incidence of heart failure in our study was significantly lower in the early group which was the main driving factor for lower frequency of cumulative MACE, in agreement with previous trials.[21,20] The Eurotransfer registry[22] also showed significant mortality reduction at 30 days in the early group. Three meta-analysis[23,26,27] involving only abciximab pretratment showed that early abciximab administration was associated with a significant reduction or a favoring trend of improved short and long-term mortality in patients undergoing PPCI. On other hand, the clinical outcomes including heart failure at 90 days in the FINESSE trial[6] did not improve in the abciximab facilitated PPCI arm, this can be attributed predominantly to the difference in study design where the FINESSE investigators excluded patients for whom the estimated time to diagnostic catheterization was 1 to 4 hours after randomization and the median time from symptom onset to abciximab was 165 min. However in our study, the median time from symptom onset to early abciximab was 63 min. Also it was 120 min in Eurotransfer registry[22], 100 min in EGYPT cooperation meta-analysis[23] and 72 min in the On-TIME 2 trial.[25] This means that those studies with very early administration of abciximab within the golden period of infarction (< 2h after the symptom onset) appear to be those were the effect of the dug on the IRA, myocardial salvage and or mortality is the most imperative.

LIMITATIONS

Our study is an interventional prospective, single-center study. No randomization is of course a possible limitation. However unfair comparison between the 2 groups was avoided as much as possible by the following measures: 1) Comparable groups. 2) Low attrition rate (3% had incomplete LVEF assessment; but 100% of patients had clinical follow-up). 3) Unequal ascertainment of the outcome was limited as the physicians evaluating angiographic, electrocardiographic, laboratory, gated SPECT and clinical outcome parameters were blinded to the assigned treatment. 4) Stratification for confounders during assessment of global LVEF and MACE. 5) Reliability testing of the primary end point. 6) Fixed MISSION protocol through-out the study period. This is a rigorously standardized protocol concerning pre-, peri- and post-PPCI treatment up to 1 year,[9] so it is unlikely that procedural changes over time other than the timing of abciximab administration have influenced the outcome.

CONCLUSIONS

In patients with STEMI treated with PPCI, early abciximab administration in the ambulance within the golden period compared with late abciximab administration in the hospital significantly improves pre-procedural IRA patency and postprocedural ST-segment resolution. Moreover, this is associated with smaller infarct size, improved LV function at 3-months, and a lower risk of heart failure on clinical follow-up.

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