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Intracoronary Thrombectomy Improves Myocardial Reperfusion in Patients Undergoing Direct Angioplasty for Acute Myocardial Infarction

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OBJECTIVES We sought to evaluate the effects of mechanical thrombectomy on myocardial reperfusion during direct angioplasty for acute myocardial infarction (AMI).

BACKGROUND Embolization of thrombus and plaque debris may occur during direct angioplasty for AMI. This may lead to distal vessel or side branch occlusion and to obstructions in the microvascular system, resulting in impaired myocardial reperfusion. Mechanical thrombectomy is used to reduce distal embolization.

METHODS Ninety-two patients with AMI and angiographic evidence of intraluminal thrombus were randomized to either intracoronary thrombectomy followed by stenting or to a conventional strategy of stenting. Thrombectomy was performed using the X-Sizer catheter (EndiCOR Inc., San Clemente, California). Myocardial reperfusion was assessed by myocardial blush and ST resolution.

RESULTS Postprocedure Thrombolysis in Myocardial Infarction-3 flow was not different between groups (93.5% vs. 95.7%, $p = 0.39$). Myocardial blush-3 was observed in 71.7% of patients undergoing thrombectomy and in 36.9% of patients undergoing conventional strategy ($p = 0.006$). ST-segment resolution ≥50% occurred more often in patients undergoing thrombectomy (82.6% vs. 52.2%, $p = 0.001$). By multivariate analysis, adjunctive thrombectomy was an independent predictor of blush-3 (odds ratio, 3.27; 95% confidence interval, 1.06 to 10.05; $p = 0.039$).

CONCLUSIONS Intracoronary thrombectomy as adjunct to stenting during direct angioplasty for AMI improves myocardial reperfusion as assessed by myocardial blush and ST resolution. (J Am Coll Cardiol 2003;42:1395–402) © 2003 by the American College of Cardiology Foundation

At present, for most patients with acute myocardial infarction (AMI), direct percutaneous coronary angioplasty (PTCA) is the best reperfusion strategy (1). This strategy, particularly when using coronary stents, has been shown to increase patency of the infarct-related artery (IRA) (2,3). However, a discrepancy between vessel patency and rescue of jeopardized myocardium after pharmacologic or interventional treatment of AMI has been documented in up to

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one-third of patients (4–8). This condition may be multifactorial and reflects damage to microvascular integrity, established both during ischemia and at the time of reperfusion. Possible related factors include damage to endothelial cells; tissue edema (9,10); release of vasoconstrictive and inflammatory mediators; intravascular plugging of leukocytes (11,12), platelets, and fibrin aggregates (13). Moreover, embolization of plaque and thrombus debris, either spontaneous or induced by percutaneous intervention, may lead to obstruction in distal coronary arterioles, limiting the efficacy and the extent of myocardial reperfusion (14). New mechanical devices to remove thrombus or to prevent embolization of thrombus and plaque during percutaneous coronary interventions have become available (15–17), but little is known regarding the effects on myocardial reperfusion during direct angioplasty (18).

The present randomized study was designed to evaluate the effects of mechanical thrombus removal on myocardial reperfusion in patients undergoing direct angioplasty for AMI.

METHODS

Patient population. Between August 2000 and October 2001, 92 patients undergoing direct PTCA within 12 h from onset of AMI were enrolled in the study.

Inclusion criteria were continuous chest pain for at least 30 min and within 12 h of onset of pain, and ST-segment elevation ≥1 mm (0.1 mV) in two or more contiguous leads on the 12-lead electrocardiogram (ECG) (ST-segment depression in the right precordial leads V_1 to V_4 was considered a sign of transmural ischemia of the posterior myocardial wall), angiographic evidence of intraluminal thrombus in the IRA, Thrombolysis In Myocardial Infarction (TIMI) flow ≤2, and/or ≥70% diameter stenosis (DS).

Exclusion criteria were presence of left bundle-branch block or pacemaker-induced rhythm at admission ECG, left main stem lesions, IRA diameter <2.5 mm.

Patients older than 75 years and patients in cardiogenic shock were not excluded from the study. After providing informed consent, patients fulfilling the inclusion criteria

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Abbreviations and Acronyms

AMI = acute myocardial infarction
CK = creatine kinase
DS = diameter stenosis
IRA = infarct-related artery
MBG = myocardial blush grade
PTCA = percutaneous transluminal coronary angioplasty
TIMI = Thrombolysis In Myocardial Infarction

were 1:1 randomly assigned to a strategy of intracoronary thrombectomy followed by stenting, or to a conventional strategy of stenting alone.

Procedure and device description. Thrombectomy was performed using the X-Sizer catheter system (ev-3, White Bear Lake, Minnesota). The device is a two-lumen over-the-wire system (available diameters 1.5, 2.0, and 2.3 mm) with a helical shape cutter at its distal tip. The cutter rotates at 2,100 rpm driven by a hand-held battery motor unit. One catheter lumen is connected to a 250-ml vacuum bottle, and aspirated debris is collected in an in-line filter. Two or three passages across the lesion from proximal to distal were performed by slowly advancing the activated catheter. Subsequently, additional balloon angioplasty and/or coronary stenting was performed (Fig. 1). Before the intervention all patients received aspirin. Heparin (70 U/kg) was given to maintain the activated clotting time >250 s. Glycoprotein IIb/IIIa inhibitors were used according to the judgment of the operator.

Angiographic analysis. The coronary angiograms were performed using digital technique (Integris 3000, Philips Medical Systems, Best, the Netherlands). Intracoronary thrombus was angiographically identified and scored in five degrees as previously described by Gibson et al. (19). Patients were enrolled if TIMI thrombus score was ≥2. Thrombus score, TIMI flow grade (20), and myocardial blush grade (MBG) as described by van't Hof et al. (8) after guidewire positioning, after thrombectomy, and at the end of the procedure were determined off-line by two experienced operators blinded to clinical data. Quantitative coronary analysis was performed using the Coronary Quantification Package (Philips Medical Systems, Eindhoven, The Netherlands). Technical success of thrombectomy was defined as the ability of the device to cross the target lesion and to increase TIMI flow by ≥1 and/or to reduce TIMI thrombus score by ≥1. Procedural success of the intervention was defined by the achievement of TIMI 3 flow grade and a residual stenosis <20%.

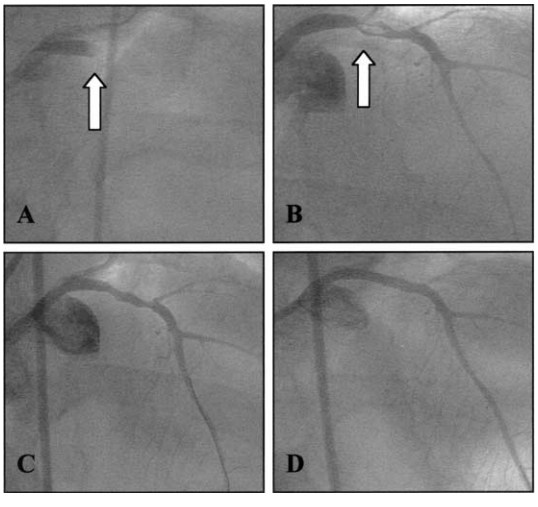

Figure 1. Angiographic images of thrombectomy procedure. **(A)** Occluded proximal left descending artery **(arrow)**. **(B)** Intraluminal thrombus **(arrow)** evidenced after crossing the lesion with a wire. **(C)** Result after thrombectomy. **(D)** Final result after direct stent deployment.

Electrocardiographic analysis. In each patient a 12-lead ECG was recorded at admission and 60 min after the procedure. The sum of ST-segment elevation was assessed at 20 ms from J-point in the leads V_1 to V_6, I, and aVL for anterior infarction and in the leads II, III, aVF, V_5, V_6 for nonanterior infarction; in the latter the ST-segment depression in leads V_1 to V_4 was also analyzed, as a sign of transmural ischemia of the posterior wall. The two ECGs were compared, and the ST-segment elevation was classified as normalized if there was no residual ST-segment elevation after the procedure, improved if a regression ≥50% was observed, unchanged if the ST-segment elevation sum appeared unchanged, worsened or regressed <50% (21).

Echocardiogaphic analysis. All patients underwent two-dimensional-transthoracic echocardiographic examination (Sonos 5500 Hewlett-Packard, Andover, Massachusetts) at admission, at discharge, and at 30-day follow-up. Left ventricular ejection fraction was calculated using the area-length method in the apical four-chamber view and the apical two-chamber view (22). All measures were given as mean value of two views.

Enzymatic infarct size. Infarct size was estimated by measurement of enzyme activity by using total creatine kinase (CK) and band fraction MB as reference enzymes. The enzymatic activity was reported as unit of activity per liter, and was assessed every 6 h in the first 48 h after admission, and then twice daily up to discharge. Peak value release from eight serial measurements up to 48 h after admission was reported.

Histopathological analysis. In 24 of 46 (52.2%) patients undergoing thrombectomy, histopathologic analysis was performed on debris collected in the filter by light microscopy after staining with hematoxylin-eosin and Azan-Mallory.

Study end points. The primary end point of this study was the occurrence of postprocedural MBG-3. Secondary end points included ST-segment regression ≥50%, enzymatic infarct size, left ventricular ejection fraction at discharge, and in-hospital occurrence of heart failure. In-hospital and 30-day occurrence of adverse events including death, nonfatal reinfarction, stroke, and major bleedings were also collected.

Follow-up. At 30 days after the procedure, the patients underwent clinical and echocardiographic evaluation.

Table 1. Baseline Clinical Characteristics

	Thrombectomy (n = 46)	No Thrombectomy (n = 46)	p Value
Age, yrs	61.3 ± 10.8	63.6 ± 11.7	0.33*
Male gender, %	82.6	71.7	0.32‡
Smokers, %			
Current	45.6	34.8	0.39‡
Former	20.5	30.4	0.34‡
Hypertension, %	60.9	65.2	0.38‡
Dyslipidemia, %	50.0	52.1	1.0‡
Diabetes, %	13.0	13.0	1.0‡
Previous MI, %	17.4	6.5	0.19§
Anterior MI, %	39.1	43.5	0.83‡
Time from onset of symptoms to hospital presentation, min	202.9 ± 204.9	165.7 ± 134.7	0.54†
Time from hospital presentation to angioplasty, min	35 ± 12	38 ± 15	0.82†
Multivessel disease, %	52.2	41.3	0.46‡
Killip class, mean	1.5 ± 1.0	1.5 ± 0.9	0.83†
Killip class IV, %	8.7	8.7	1.0§
HR > 100 beats/min, %	19.6	13.0	0.57‡
BP < 100 mm Hg, %	15.2	15.2	1.0‡

Continuous data presented as mean ± SD and were compared by Student *t* test (*) or Wilcoxon rank-sum test (†); categorical data are presented as frequency values and were compared by chi-square (‡) or Fisher exact test (§).
BP = blood pressure; HR = heart rate; MI = myocardial infarction.

Statistical analysis. The number of patients included in the study was based on the estimation of the sample size needed to identify a significant difference in the primary end point. In a pilot study on thrombectomy in patients with acute myocardial infarction, we found a rate of 60% in postprocedural MBG-3 (23). Assuming that the rate of MBG-3 is around 30% in patients treated with standard approach direct PTCA (8,24), we estimated that 45 patients would be required in each group for the study to have a power of 80% to detect an absolute difference in the occurrence of MBG-3 of 30% with a two-sided alpha value of 0.05. All analyses were performed according to intention-to-treat principle. Categorical variables are presented as frequency values and were compared by Fisher exact test and chi-square. The Fisher exact test was used when the expected event had a low frequency, particularly when at least one cell in 2-2 table had a value <5; otherwise the chi-square test was used. Continuous variables are expressed as mean ± SD, and were compared by Student *t* test or analysis of variance (ANOVA) for normally distributed variables, and by Wilcoxon rank-sum test for not normally distributed variables. Repeated measures of continuous variables of each group were analyzed by repeated measures ANOVA with Bonferroni correction for multiple comparisons. Multivariate regression analysis was performed to identify independent predictors of MBG-3 after the procedure. This model included age >65 years, infarct location, diabetes, Killip class ≥2, ischemic time, previous myocardial infarction, blood pressure <100 mm Hg, heart ratio >100 beats/min, multivessel disease, occluded IRA at baseline, the presence of collaterals, use of glycoprotein IIb/IIIa inhibitors, and thrombectomy. A p value <0.05 was interpreted as statistically significant. Statistical analysis was performed using SPSS 11.0 (SPSS Inc., Chicago, Illinois).

RESULTS

Ninety-two patients meeting the inclusion criteria were enrolled. Forty-six patients were randomly assigned to undergo thrombectomy, and 46 to conventional percutaneous coronary interventions. There were no significant differences in baseline clinical and angiographic characteristics between groups (Tables 1 and 2).

Procedural data and angiographic analysis. Procedural angiographic results are reported in Figure 2 and Table 2. The postprocedural TIMI flow was similar between patients undergoing thrombectomy and patients treated conventionally (p = 0.39). Postprocedural DS, minimal lumen diameter, and reference vessel diameter were not different between groups. The procedural success, as previously defined, was reached in 43 of 46 (93.5%) patients undergoing thrombectomy and in 44 of 46 (95.6%) patients assigned to conventional treatment (p = 0.43). Angiographic no-reflow and distal embolization tended to occur less commonly in patients randomized to thrombectomy (Table 2). Side branch occlusion was similar in both groups, and coronary perforation was not observed.

The rate of patients treated with stent implantation was similar in both groups. Likewise, the number of stents per patient, the mean stented segment length, and the stent/vessel ratio, as well as the maximum pressure of balloon inflation was not statistically different between groups. Stent implantation without balloon predilation was performed more often in patients undergoing thrombectomy (p = 0.003). The administration of glycoprotein IIb/IIIa inhibi-

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Table 2. Angiographic and Procedural Data

	Thrombectomy (n = 46)	No Thrombectomy (n = 46)	p Value
Baseline angiographic data			
Patent IRA, %	17.4	19.6	0.84‡
Collaterals, %	21.7	23.9	1.0‡
TIMI flow, mean	1.46 ± 1.24	1.48 ± 1.31	0.93†
RVD, mm	3.28 ± 0.80	3.28 ± 0.42	0.99†
MLD, mm	0.31 ± 0.53	0.21 ± 0.28	0.24†
DS, %	94.1 ± 7.2	94.2 ± 6.9	0.94†
Thrombus score, mean	3.9 ± 1.0	3.8 ± 1.1	0.36†
Final angiographic data			
TIMI flow final, mean	2.91 ± 0.35	2.89 ± 0.53	0.82†
RVD final, mm	3.39 ± 0.67	3.31 ± 0.40	0.49†
MLD final, mm	3.20 ± 0.45	3.00 ± 0.79	0.12†
DS final, %	8.0 ± 10.6	9.2 ± 20.1	0.73†
Thrombus score final, mean	0.10 ± 0.2	0.15 ± 0.3	0.10†
Procedural details			
Stent, %	93.5	91.3	1.0§
Direct stenting, %	60.8	28.3	0.002‡
Number of stents, mean	1.20 ± 0.65	1.13 ± 0.50	0.59§
Stent segment length, mm	18.9 ± 10.5	21.4 ± 12.0	0.31†
Maximum pressure, atm	14.9 ± 3.8	15.2 ± 2.9	0.78†
Stent/vessel ratio	1.00 ± 0.32	1.07 ± 0.18	0.20†
No-reflow, %	2.2	10.8	0.20§
Distal occlusion, %	4.3	15.2	0.08§
Side branch occlusion, %	2.2	2.2	1.0§
GP IIb/IIIa inhibitors, %	43.4	41.3	1.0‡
IABP, %	10.9	10.9	1.0‡

Continuous data presented as mean ± SD and were compared by Student *t* test (*) or Wilcoxon rank-sum test (†); categorical data are presented as frequency values and were compared by chi-square (‡) or Fisher exact test (§).

DS = diameter stenosis; GP = glycoprotein; IABP = intraaortic balloon pump; IRA = infarct-related artery; MLD = minimal lumen diameter; RVD = reference vessel diameter; TIMI = Thrombolysis In Myocardial Infarction.

tors and the use of intraaortic balloon pump were not different between groups.

Thrombectomy results. In 42 of 46 (91.3%) patients assigned to thrombectomy, the activated device could be advanced through the target lesion. The number of passages across the lesion was 2.6 ± 1.2. In one case (2.2%), it was not possible to reach the target lesion because of proximal vessel tortousity, and in three patients (6.5%) the device did not cross a severe lesion. Technical thrombectomy success as defined above was achieved in 40 of 46 (86.9%) attempted lesions. After thrombectomy, TIMI flow grade increased from 1.46 ± 1.24 to 2.61 ± 0.83 ($p < 0.0001$ vs. baseline), and further increased to 2.91 ± 0.35 after PTCA or stenting ($p = 0.004$ vs. thrombectomy). After thrombectomy in 34 of 46 attempted lesions (73.9%), there was no further angiographic evidence of thrombus; in eight (17.4%) the thrombus score decreased ≥1 degree, and in four (8.6%) it appeared unchanged. Among these four patients, in three the device failed to reach or to cross the lesion. The mean TIMI thrombus score significantly decreased from 3.5 ± 1.9 to 1.6 ± 0.9 after aspiration ($p = 0.04$). In 30 cases (65.2%) there was macroscopic evidence of material collected in the filter. The histopathology analysis of the aspirated material (n = 24) evidenced fibrin and platelet aggregates, typically seen in thrombus, in 86% of analyzed samples. Macrophages, amorphous lipids, and cholesterol clefts, representative of the atheromatous plaque, were identified in 21% of samples.

Assessment of myocardial reperfusion. In patients undergoing thrombectomy, MBG increased from 0.57 ± 0.83 at baseline to 2.15 ± 1.12 after thrombectomy ($p = 0.001$). After stenting, final MBG was 2.50 ± 0.91, not showing further significant increase ($p = 0.20$). In patients undergoing standard approach, MBG significantly improved from 0.89 ± 1.01 at baseline to 1.67 ± 1.21 after intervention ($p = 0.01$). In patients treated with thrombectomy, final mean MBG was significantly higher ($p = 0.001$) and final MBG-3 was observed more often ($p = 0.006$) (Figs. 2 and 3). Regardless of treatment strategy, the use of glycoprotein IIb/IIIa inhibitors did not affect the final TIMI flow, and the final MBG grade (Fig. 4). By multivariate analysis, thrombectomy was an independent predictor of postprocedural MBG-3 (odds ratio, 3.27; 95% confidence interval, 1.06 to 10.05; $p = 0.02$).

Assessing the reperfusion according to ECG criteria, postprocedural ST-segment elevation regressed ≥50% in a significantly higher percentage of patients treated with thrombectomy (82.6% vs. 52.2%; $p = 0.001$) (Table 3).

Infarct size and left ventricular function. The CK and CK-MB peak release and left ventricular ejection fraction at baseline, discharge, and at 30 days were not significantly different between groups (Table 3). Regardless of treatment

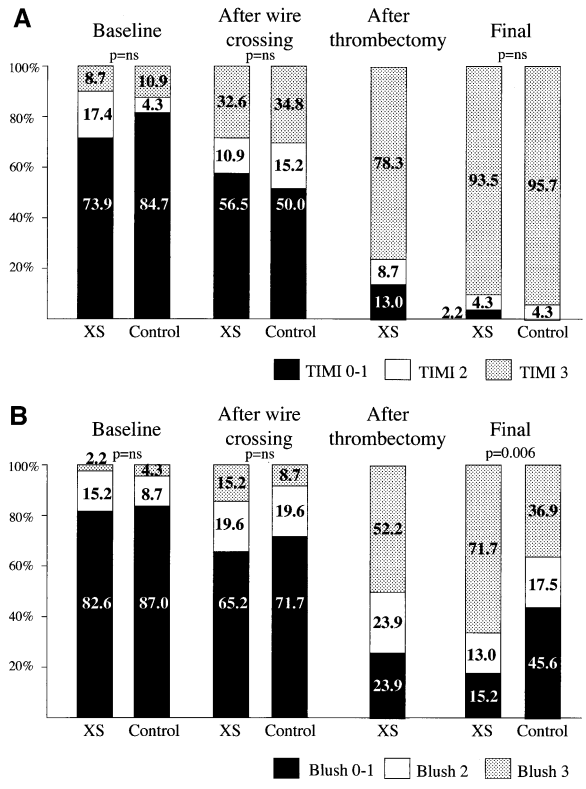

Figure 2. Thrombolysis In Myocardial Infarction (TIMI) flow grade **(A)** and myocardial blush grade (MBG) **(B)** after each step of the procedure. There were no differences between groups in TIMI flow at baseline, after wiring, and at the end of procedure **(A)**. The MBG was similar between groups at baseline and after wire crossing. At the end of procedure, the MBG was significantly higher ($p = 0.006$; chi-square) in patients undergoing thrombectomy **(B)**.

strategy, the infarct size determined by CK-MB release was larger in patients with lower postprocedural MBG (267.6 ± 262.5 UI/l in MBG ≤ 2 vs. 154.6 ± 139.9 UI/l in MBG-3; $p < 0.0001$). Stratified by postprocedural MBG, the left

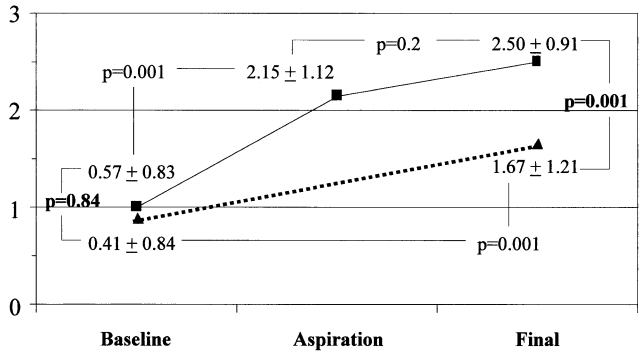

Figure 3. Changes in mean myocardial blush grade (MBG) observed during the procedure. In patients undergoing thrombectomy, the MBG was enhanced after aspiration ($p = 0.002$; analysis of variance [ANOVA]), and it did not show further significant improvement ($p = 0.20$; ANOVA) after optimizing treatment by balloon angioplasty and/or stenting. In patients undergoing conventional approach, MBG significantly improved after intervention ($p = 0.01$; ANOVA). At the end of the procedure, MBG was higher in patients undergoing thrombectomy ($p = 0.001$; ANOVA). **Solid squares** = thrombectomy; **solid triangles** = no thrombectomy.

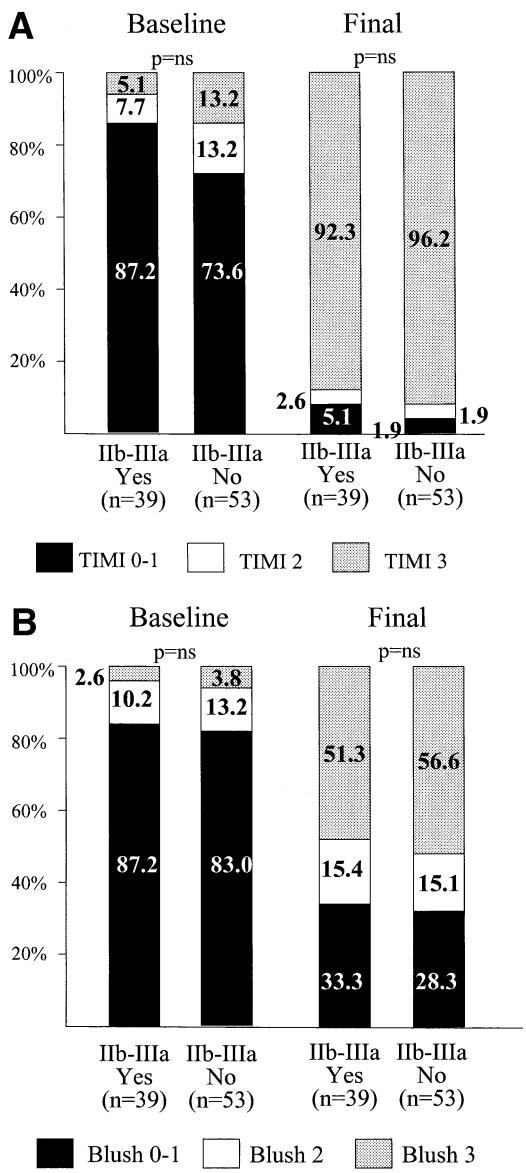

Figure 4. Thrombolysis In Myocardial Infarction (TIMI) flow grade **(A)** and myocardial blush grade (MBG) **(B)** at baseline and after the procedure according to the use or not of glycoprotein IIb/IIIa inhibitors. There were no statistically significant differences between groups in TIMI flow and in MBG (p= NS; chi-square).

ventricular ejection fraction at both discharge and 30-day follow-up was higher in MBG-3 than in MBG ≤2 (53.0 ± 6.9% vs. 46.0 ± 10.8% and 53.9 ± 7.1% vs. 47.0 ± 8.5%; $p < 0.0001$). The left ventricular ejection fraction did significantly improve from baseline to 30-day follow-up in both groups (thrombectomy: $p = 0.02$; control: $p = 0.04$). This improvement was not different between treatment groups ($p = 0.38$). Regardless of treatment strategy in patients with a final MBG-3, the left ventricular ejection fraction improved significantly from baseline to 30 days (50.1± 6.6% to 53.9 ± 7.1%; $p = 0.007$), whereas in patients with MBG ≤2 this difference was not significant (47.7 ± 6.8% to 47.0 ± 8.5%; $p = 0.9$).

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Table 3. Clinical and Electrocardiographic Outcomes

	Thrombectomy (n = 46)	No Thrombectomy (n = 46)	p Value
In-hospital			
Death, %	6.5	6.5	1.0‖
CHF, %	10.9	21.7	0.17§
Nonfatal reinfarction, %	2.2	2.2	1.0‖
Stroke, %	0	0	1.0‖
Severe bleeding, %	2.2	2.2	1.0‖
TVR, %	0	0	1.0‖
ST-segment regression, %			
≥50%	82.6	52.2	0.001§
Normalized	58.7	32.6	
Regression ≥50% <100%	23.9	19.6	
CK peak, UI/l	1,921.6 ± 1,417.4	2,285.3 ± 1,924.7	0.30†
CK-MB:			
peak, UI/l	181.9 ± 154.9	228.6 ± 253.7	0.29†
1–3 times normal, %	28.3	17.4	0.46§
3–8 times normal, %	34.8	41.3	
>8 times normal, %	36.9	39.1	
30 days			
Death, %	6.5	6.5	1.0‖
Reinfarction, %	4.3	4.3	0.2‖
Stroke	0	0	0‖
TVR, %	0	0	1.0‖
LVEF, %			
Baseline	49.3 ± 7.6	48.8 ± 5.9	0.5*
At discharge	51.0 ± 7.7	48.7 ± 10.9	0.29*
At 30 days	51.9 ± 7.9	49.9 ± 8.9	0.26*

Continuous data presented as mean ± SD and were compared by Student *t* test (*) or Wilcoxon rank-sum test (†) or ANOVA (‡); categorical data are (‡) presented as frequency values and were compared by chi-square (§) or Fisher exact test (‖).

CHF = congestive heart failure; CK = creatine kinase; LVEF = left ventricular ejection fraction; TVR = target vessel revascularization.

Clinical outcomes. The in-hospital occurrence of death, reinfarction, and severe bleeding were not statistically different between groups (Table 3). In the thrombectomy group, three patients died during hospitalization, two with refractory cardiogenic shock, and one because of refractory ventricular fibrillation. In the control group, three patients died during hospitalization, two with cardiogenic shock, and one after massive retroperitoneal bleeding. Reinfarction occurred in one patient assigned to thrombectomy because of stent thrombosis, and in one patient assigned to conventional strategy because of non-IRA occlusion. In-hospital congestive heart failure occurred more often in patients assigned to conventional strategy, but this difference was not statistically significant (21.7% vs. 10.9%, p = 0.17). Regardless of the treatment strategy, patients with postprocedural MBG 0/1/2 experienced in-hospital heart failure more frequently than patients with postprocedural MBG-3 (14/42 vs. 1/50, p = 0.0001). At 30-day follow-up there was no difference in major adverse clinical events between groups (Table 3).

DISCUSSION

Thrombus removal and myocardial reperfusion. The goal of direct angioplasty for the treatment of AMI is not only the restoration of normal epicardial flow, but also achievement of optimal myocardial tissue reperfusion (4). Myocardial reperfusion can be assessed using angiographic (8) and electrocardiographic (21,25) parameters.

Thrombus and plaque debris embolization is one of the mechanisms affecting the microvasculature at the time of reperfusion by mechanical capillary obstruction leading to endothelium dysfunction (26), and by inflammation of the myocardium (27). Using an experimental canine model, Dörge et al. (27) studied the effects of coronary microembolization on the extent of myocardial inflammation and necrosis showing that the injection of inert microspheres in the microvascular coronary circulation of the canine heart led to a similar amount of myocardial necrosis and systolic dysfunction and a more pronounced inflammatory response compared with an epicardial coronary occlusion model.

In the present randomized study, patients undergoing thrombectomy showed similar postprocedure epicardial flow but improved myocardial reperfusion documented by significantly improved myocardial blush and ST-segment resolution, compared with patients treated conventionally. It appears that effective removal of thrombotic material at the lesion site improves myocardial reperfusion by reducing distal embolization occurring during plaque manipulation with balloon and stent.

Further evidence of effective thrombus removal is given by the significant angiographic reduction in thrombus bur-

den after thrombectomy and by the presence of thrombotic debris in the aspirate in a high percentage of cases.

Myocardial damage and left ventricular function. In previous studies, myocardial blush has been related to infarct size, left ventricular function (28), and long-term mortality after AMI (8,24). In our study, patients treated with thrombectomy, despite the enhanced myocardial blush, did not show a significantly smaller myocardial damage assessed by total CK and CK-MB peak release. We observed a slight, but not significant, improvement of left ventricular function and in the occurrence of in-hospital congestive heart failure. The main explanation for this is probably that our study was not powered to demonstrate benefits in myocardial salvage and in ventricular function, but to assess surrogate markers known to be associated with these. Interestingly, patients with blush-3, regardless of the modality of treatment, showed a significant reduction in myocardial damage and a better ventricular function compared with patients with blush 0/1/2. This underlines the importance of achieving MBG-3 and supports the validity of MBG as surrogate end point in AMI studies.

Comparison with other studies. In the present study, the rate of myocardial blush-3 (71.7%) and ST-resolution ≥50% (82.6%) after adjunct thrombectomy was high compared with results of conventional balloon angioplasty and stent reported by van't Hof and by Stone (8,24) (MBG-3, 19% and 28%, respectively) and Claeys (25) (ST-resolution ≥50%: 64%). Recently, Beran and colleagues (18) reported on a randomized trial of thrombectomy versus conventional treatment including 49 patients with ST-elevation AMI. They showed a significantly improved ST-resolution but no difference in myocardial blush and coronary flow reserve after adjunctive intracoronary thrombectomy with the X-Sizer catheter. A possible explanation for the lack of benefit of thrombectomy on myocardial blush and coronary flow reserve is that in the cited study both parameters were evaluated in ST- and non-ST-elevation myocardial infarction. The EndiCor X-SIZER AMI registry (29) showed a high MBG-3 grade of 62% similar to our findings.

Other mechanical approaches to reduce embolization of thrombus during direct PTCA have been used successfully. They include rheolytic thrombectomy (15), thrombus aspiration devices (30), and distal protection devices (31). Data from randomized studies on the effects of these devices on myocardial reperfusion during direct PTCA have not been reported.

Several pharmacologic approaches to improve myocardial reperfusion during direct angioplasty have been performed. Intracoronary adenosine and verapamil (32,33) is administered to reduce the reperfusion injury but does not address the reduction of intracoronary thrombus burden. Glycoprotein IIb/IIIa receptor inhibitors in patients undergoing direct PTCA has been shown to improve microvascular function by limiting the effects of embolized thrombus and platelets, and by reducing the inflammatory response of the coronary microvasculature, as assessed by coronary flow velocity (34). Associated therapy of IIb/IIIa inhibitors and thrombolytic therapy did show a 59% rate of complete ST-segment resolution (35). In the present study, mechanical thrombectomy aiming to avoid distal embolization achieved similar good results as aggressive pharmacologic treatment aiming to reduce the consequences of distal embolization (32,33). It is unlikely that the results of the study were affected by the use of glycoprotein IIb/IIIa inhibitors, as reflected by the similar, relatively low, rate of abciximab administration in both groups (43.4% in thrombectomy arm and 41.3% in conventional arm). In a large randomized trial (36), the use of abciximab as an adjunct to direct PTCA did not enhance ST-segment resolution or improve myocardial recovery at seven months. Also, in the X-SIZER AMI registry, the use of glycoprotein IIb/IIIa inhibitors did not show an additional benefit on myocardial reperfusion in patients treated with thrombectomy (37). These data underline the importance of mechanical adjuncts to improve the procedural outcome of direct PTCA.

Study limitations. The study reflects a single-center experience in a limited number of patients, and represents a mechanical attempt to optimize myocardial reperfusion in patients undergoing direct PTCA. Apart from considerations on the safety of the X-Sizer thrombectomy device and on its effect on myocardial reperfusion, any conclusions about the clinical efficacy of intracoronary thrombectomy cannot be drawn.

The study was limited to thrombus-containing lesions in relatively large coronary arteries and did not include the entire AMI population. Another limitation of the study is that the possible treatment benefit of adjunct pharmacologic therapy was not evaluated. Myocardial reperfusion represents such a wide and complex scenario, that synergistic mechanical and pharmacologic strategies to preserve microvascular integrity will be needed.

Conclusions. Intracoronary thrombectomy with the X-Sizer catheter during catheter-based treatment of AMI improved myocardial reperfusion as assessed by myocardial blush and ST-segment resolution. Larger clinical trials are warranted to address the impact of thrombectomy on infarct size as well as on clinical outcome.

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