Predictors and long-term prognostic significance of angiographically visible distal embolization during primary percutaneous coronary intervention

Primer perkütan koroner girişim uygulanan hastalarda anjiyografik distal embolinin öngördürücüleri ve uzun dönemde prognostik önemi

Vecih Oduncu, M.D., Ayhan Erkol, M.D.,[#] Burak Turan, M.D.,[#] Taylan Akgün, M.D.,[*] Can Yücel Karabay, M.D.,[*] İbrahim Halil Tanboğa, M.D.,[†] Selçuk Pala, M.D.,[*] Cevat Kırma, M.D.,[*] Ali Metin Esen, M.D.[*]

Department of Cardiology, Medical Park Fatih Hospital, İstanbul;
[#]Department of Cardiology, Kocaeli Derince Training and Research Hospital, Kocaeli;
[*]Department of Cardiology, Kartal Koşuyolu Heart Training and Research Hospital, İstanbul;
[†]Department of Cardiology, Atatürk University Faculty of Medicine, Erzurum

ABSTRACT

Objectives: We aimed to identify the predictors of angiographically visible distal embolization (AVDE) during primary percutaneous coronary intervention (p-PCI) as well as to assess its impact on short- and long-term clinical outcomes in patients with acute ST-segment elevation myocardial infarction (STEMI).

Study design: We retrospectively enrolled 2007 patients with STEMI who underwent p-PCI. We assessed the clinical and angiographic characteristics of patients in order to identify the predictors of AVDE and compared the outcomes of patients with and without AVDE during p-PCI.

Results: Distal embolization developed in 135 (6.7%) patients. Age (for each 10- year increase, Odds Ratio (OR) 1.34, 95% Confidence Interval (CI) 1.16-1.52, p<0.001), treatment of right coronary artery (OR 2.52, 95% CI 1.30-4.87, p=0.034), repeated balloon dilatation (OR 1.84, 95% CI 1.16-2.94, p=0.009), cut-off occlusion pattern (OR 2.17, 95% CI 1.38-3.42, p=0.001), lesion length >15 mm (OR 1.67, 95% CI 1.09-2.58, p=0.019), and reference vessel diameter >3.5 mm (OR 5.08, 95% CI 3.32-7.65, p<0.001) were independent predictors of AVDE. In-hospital (8.1% *vs.* 3.8%, p=0.014) and one-month (10.8% *vs.* 4.9%, p=0.004) all-cause mortality rates were higher in patients with AVDE. At the long-term follow-up (median: 42 months), both all-cause (21.5% *vs.* 10.4%, p<0.001) and cardiac mortality rates (18.4% *vs.* 8.0%, p<0.001) were higher in patients with AVDE.

Conclusion: AVDE is associated with worse clinical outcome at both the short- and long-term follow-up of STEMI patients treated early with p-PCI.

ÖZET

Amaç: Bu çalışmada, akut ST yükselmeli miyokart enfarktüsü (STYME) geçirmekte olan hastalarda primer perkütan koroner girişim (p-PKG) esnasında gelişen ve anjiyografik olarak görülebilen distal embolizasyonun (AVDE) öngördürücülerini belirlemek ve embolizasyonun kısa ve uzun dönem klinik sonuçlar üzerine etkisini değerlendirmeyi amaçladık.

Çalışma planı: STYME ve p-PKG yapılan 2007 hasta geriye dönük olarak çalışmaya alındı. AVDE'nin öngördürücülerini belirlemek için hastaların klinik ve anjiyografik özellikleri değerlendirildi, p-PKG esnasında AVDE gelişen ve gelişmeyen hastaların klinik sonlanımları karşılaştırıldı.

Bulgular: Distal embolizasyon 135 hastada (%6.7) gelişti. Yaş (her 10 yıl artış için, odds oranı [OO] 1.34, %95 güven aralığı [GA] 1.16-1.52, p<0.001), sağ koroner artere girişim (OO 2.52, %95 GA 1.30-4.87, p=0.034), tekrarlanan balon dilatasyon (OO 1.84 %95 GA 1.16-2.94, p=0.009), kesik (cut-off) tıkanma paterni (OO 2.17, %95 GA 1.38-3.42, p=0.001), lezyon uzunluğu >15 mm (OO 1.67, %95 GA 1.09-2.58, p=0.019), referans damar çapı >3.5 mm (OO 5.08, %95 GA 3.32-7.65, p<0.001) AVDE'nin bağımsız öngördürücüleriydi. Hastane içi (%8.1 ve %3.8, p=0.014) ve bir aylık (%10.8 ve %4.9, p=0.004) tüm nedenlere bağlı mortalite oranları AVDE gelişen hastalarda daha yüksekti. Uzun dönem takipte (medyan, 42 ay), hem tüm nedenlere bağlı (%21.5 ve %10.4, p<0.001) hem de kardiyak mortalite oranları (%18.4 ve %8.0, p<0.001) AVDE gelişen hastalarda daha yüksek idi.

Sonuç: AVDE erken dönemde p-PKG ile tedavi edilen STYME'li hastalarda, kısa ve uzun dönem takipte daha kötü klinik sonlanımla ilişkilidir.

Received: October 17, 2012 *Accepted:* May 02, 2013

Correspondence: Dr. Ayhan Erkol. Kocaeli Derince Eğitim ve Araştırma Hastanesi, 41900 Kocaeli.
Tel: +90 262 - 317 80 01 e-mail: ayhanerkol@yahoo.com

Despite the high success rates in the achievement of infarct-related artery (IRA) patency, primary percutaneous coronary intervention (p-PCI) fails to maintain microvascular reperfusion in a significant proportion of patients with acute ST-segment elevation myocardial infarction (STEMI).[1] This phenomenon of no-reflow has been shown to be associated with adverse clinical outcomes.[2] The multifactorial pathogenesis of no-reflow phenomenon has been defined by four main mechanisms: ischemic injury, reperfusion injury, individual susceptibility to injury, and distal atherothrombotic embolization.[1]

Emboli of varying sizes originating from epicardial coronary thrombosis and atherosclerotic plaque are evident in most cases of acute myocardial infarction (MI). Although the rate of microembolization has been reported to be as high as 79%,[3] angiographically visible distal embolization (AVDE) is present in only 15-19% of the cases.[4,5] Recently, thrombectomy catheters and distal protection devices have been developed in order to prevent DE. However, large multicenter randomized trials have reported conflicting data about the benefit of these devices in terms of microvascular reperfusion and prognosis.[6-8] This fact may have been related with the enrollment of patients regardless of clinical and angiographic characteristics. No-reflow has a multifactorial pathogenesis, and the predominant mechanism may vary in each patient. Thus, individualization of prevention and treatment strategies may be important. Therefore, identifying the predictors of different pathogenetic mechanisms seems to be important.

We aimed to identify the predictors of AVDE during p-PCI in patients with acute STEMI, as well as to assess its impact on tissue level reperfusion and clinical outcomes.

PATIENTS AND METHODS

Study population

We retrospectively studied 2007 patients with acute STEMI who underwent p-PCI from January 2006 to December 2008. The inclusion criteria were: 1- admission within the first 12 hours of the onset of typical ischemic chest pain, and[2] ST elevation of at least 1 mm in two or more contiguous leads (2 mm for leads V1 to V3) or new-onset left bundle branch block. Patients were divided into two groups according to the presence (AVDE, n=135) or absence (No-AVDE, n=1872) of AVDE. The study was approved by our local ethics committee, and all patients gave written informed consent for PCI.

Abbreviations:

AVDE	*Angiographically visible distal embolization*
CK	*Creatine kinase*
CRP	*C-reactive protein*
DS	*Diameter stenosis*
IRA	*Infarct-related artery*
LVEF	*Left ventricular ejection fraction*
MBG	*Myocardial blush grade*
p-PCI	*Primary percutaneous coronary intervention*
ROC	*Receiver operating characteristic*
RVD	*Reference vessel diameter*
STEMI	*ST-segment elevation myocardial infarction*
STR	*ST-segment resolution*
TIMI	*Thrombolysis in myocardial infarction*

Coronary angiography and percutaneous coronary intervention

All patients received a 300 mg chewable aspirin and a 600 mg loading dose of clopidogrel on admission, and 70 U/kg intravenous standard heparin before the procedure. The use of glycoprotein IIb/IIIa receptor antagonist (tirofiban), with 10 µg/kg bolus and 0.15 µg/kg/min intravenous infusion, was left to the primary operator's discretion. Nitroglycerin (intravenously or orally) was given to patients who had no contraindication. Coronary angiographies and interventions were performed by experienced operators with standard methods through femoral access. Conventional or direct stenting was performed according to the lesion characteristics. Preprocedural lesion characteristics, thrombus burden, retrograde filling, initial and postprocedural thrombolysis in myocardial infarction (TIMI) flow grades, and myocardial blush grade (MBG) were evaluated in at least two non-foreshortened angiographic views at the end-diastole[9] by two cardiologists who were unaware of the study groups. Quantitative analyses such as reference vessel diameter (RVD) and diameter stenosis (DS) were performed as well (QCA, Siemens Medical Systems, Germany). After the intervention, all patients were given 1 mg/kg of subcutaneous enoxaparin twice daily until discharge (dosages were adjusted according to age and renal function), 150 mg/day of acetyl salicylic acid, and 75 mg/day of clopidogrel.

Data collection and long-term follow-up

All clinical and demographic properties of the patients were recorded from hospital files and computer records. On admission, peripheral venous blood samples for hemogram, urea, creatinine, glucose, creatine kinase-MB isoform (CK-MB), troponin I, and C-re-

active protein (CRP) were obtained. Blood samples were repeated for cardiac enzymes every 6 hours until peak levels were reached, and were repeated daily thereafter. Hemographic parameters and urea and creatinine levels were also evaluated every day. ST-segment resolution (STR) was calculated as the ratio of the sum of ST-segment elevation on admission minus the sum of ST-segment elevation 60 minutes after p-PCI divided by the sum of ST-segment elevation on admission. STR >70% was defined as complete resolution.[10] Postprocedural left ventricular ejection fraction (LVEF) was calculated using biplane modified Simpson method by transthoracic echocardiography (Vivid 3-5, GE, Horten, Norway). The long-term follow-up data (median: 42 months) of the patients were obtained from follow-up visits or in-hospital clinical records of the re-hospitalized patients. In addition, all the patients were contacted by telephone. In order to learn whether the patients who could not be reached were still alive or not, we checked the records of the Statistical Institute and Birth Registration Office. Nevertheless, 56 (2.8%) patients who could not be reached because of insufficient data were excluded from the long-term follow-up.

Definitions

Multivessel disease was described as the presence of a >50% diameter stenosis in two or more major epicardial arteries. Angiographic thrombus burden was evaluated according to the TIMI thrombus scoring, and TIMI score ≥4 was noted as high-grade thrombus burden.[11] Preprocedural collateral flow was evaluated according to the Rentrop classification, and grade 2/3 was noted as well-developed collaterals.[12] AVDE was defined as persistent distal filling defect with an abrupt "cut-off" in one or more peripheral coronary branches of the IRA as a result of dislodgement of a proximal thrombus spontaneously or following wiring and balloon dilatation. Coronary occlusion patterns were evaluated according to previous definitions.[13] Re-infarction was defined as the recurrence of typical clinical symptoms and new electrocardiogram (ECG) changes with a new elevation of the CK-MB fraction levels >2 times the upper limit of normal or any rise by ≥50% above a previously elevated level.

Statistical analysis

Continuous variables are expressed as mean±standard deviation or median (interquartile range [IQR]). Categorical variables are expressed as numbers and percentages. Group means for continuous variables were compared with the use of independent samples t-test or Mann-Whitney U-test, as appropriate. Categorical variables were compared with the use of chi-square or Fisher's exact test. Multivariate logistic regression analysis was applied to identify the independent predictors of AVDE. All variables showing a significance value <0.05 on univariate analysis (age, previous PCI, Killip class >1, baseline creatinine, glucose, leukocyte, neutrophil and monocyte counts, culprit LAD, culprit RCA, TIMI thrombus score, proximal lesion location, occlusion pattern, initial TIMI flow grade, lesion length, RVD, balloon inflation pressure, repeated balloon dilatation, and direct stenting) were included in the model. Receiver operating characteristic (ROC) curve analysis was performed in order to detect optimal cut-off values of lesion length and RVD for predicting AVDE. Survival curves were calculated using the Kaplan-Meier method, with the significance evaluated using the log-rank tests. Two-tailed p values of <0.05 were considered to indicate statistical significance. The Statistical Package for the Social Sciences v. 11.5 (SPSS Inc, Chicago, IL, USA) program was used in all statistical analyses.

RESULTS

The study population consisted of 2007 patients with acute STEMI (81% male, mean age 57±12 years). DE developed in 135 (6.7%) of the 2007 patients. Patients with AVDE were older (61.2±12.8 *vs.* 56.5±12.1 years, p<0.001) than the patients without AVDE. Admission creatinine levels (1.04±0.40 *vs.* 0.94±0.47 mg/dl, p=0.022) and frequency of cardiogenic shock (11.1% *vs.* 4.2%, p<0.001) were higher in patients with AVDE compared to those without AVDE. Leukocyte count (13.3±4.3 *vs.* 12.2±3.7 x10^9 L^{-1}, p=0.002), neutrophil count (10.5±4.2 *vs.* 9.4±3.5 x10^9 L^{-1}, p=0.001) and CRP levels (13.2 (6.6-21.3) *vs.* 9.8 (5.7-16.7) mg/l, p=0.03) were significantly higher in patients with AVDE compared to those without AVDE (Table 1).

Culprit RCA (61.5% *vs.* 33.1%), proximal lesion location (68.9% *vs.* 53.6%), baseline TIMI flow grade of 0/1 (90.4% *vs.* 75.5%), and cut–off occlusion pattern (53.3% *vs.* 33.1%) were all significantly more frequent in patients with AVDE (p<0.001 for all). RVD (3.49±0.49 *vs.* 3.08±0.36 mm), lesion length (18.7±8.1 *vs.* 15.1±5.9 mm) and baseline DS (99.1±3.4 *vs.* 96.9±6.5%) were all higher in patients with AVDE

Table 1. Baseline demographics and clinical properties

	Distal embolization (+) (n=135)			Distal embolization (–) (n=1872)			*p*
	n	%	Mean±SD	n	%	Mean±SD	
Age (years)			61.2±12.8			56.5±12.1	**<0.001**
Gender (female)	26	19.2		361	19.3		0.994
Diabetes mellitus	40	29.6		424	22.6		0.063
Hypertension	61	45.2		759	40.5		0.289
Dyslipidemia	63	46.7		762	40.7		0.174
Current smoking	65	48.1		1025	54.8		0.137
Family history of CAD	32	23.7		400	21.4		0.524
Prior AMI	8	5.9		103	5.5		0.835
Prior PCI	19	14.1		160	8.5		0.030
Anterior myocardial infarction	40	29.6		941	50.3		**<0.001**
Killip class ≥2	33	24.4		293	15.7		**0.007**
Cardiogenic shock	15	11.1		78	4.2		**<0.001**
SBP (mmHg)			129.3±38.4			131.5±30.8	0.424
DBP (mmHg)			75.4±23.1			78.0±18.7	0.128
Heart rate (bpm)			75.1±20.3			76.9±15.8	0.208
Pain-to-door time (min)	150	85-270		140	80-230		0.059
Door-to-balloon time (min)			30.9±7.0			30.7±6.9	0.693
Baseline creatinine (mg/dl)			1.04±0.40			0.94 ± 0.47	0.022
Baseline glucose (mg/dl)	146	113-185		125	103-165		**<0.001**
Hemoglobin (g/dl)			13.5±1.5			13.7±1.8	0.248
Platelet count (x10³/μl)			262.0±71.6			257.3±65.9	0.423
Mean platelet volume (fL)			9.3±1.2			9.2±1.3	0.382
Leukocyte count (x10³/μl)			13.3±4.3			12.2±3.7	**0.001**
Neutrophil count (x10³/μl)			10.5±4.2			9.4±3.5	**0.001**
Monocyte count (cells/μl)			739.2±361.6			652.5±346.8	**0.005**
C-reactive protein (mg/L)	13.2	6.6-21.3		9.8	5.7-16.7		0.030
Total cholesterol (mg/dl)			177.9±46.8			176.8±43.8	0.783
LDL-cholesterol (mg/dl)			110.7±42.3			113.2±38.4	0.488
HDL-cholesterol (mg/dl)			37.8±10.9			38.5±12.2	0.516
Triglyceride (mg/dl)	124.5	89.5-174.5		115	81-165		0.058
Previous medication							
Aspirin	18	13.3		225	12.0		0.651
Statin	22	16.3		399	21.3		0.167
ACE-I	27	20.0		391	20.9		0.806
β-blocker	17	12.6		234	12.5		0.975

Data are expressed as number (%), mean±SD or median (interquartile range). CAD: Coronary artery disease; AMI: Acute myocardial infarction; PCI: Percutaneous coronary intervention; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; LDL: Low-density lipoprotein; HDL: High-density lipoprotein; ACE-I: Angiotensin converting enzyme inhibitor.

compared to patients without AVDE. Final TIMI flow grade 3 (67.4% *vs.* 92.1%), MBG 3 (10.9% *vs.* 46.0%) and complete STR (30.5% *vs.* 62.5%) were all less frequent in patients with AVDE compared to those

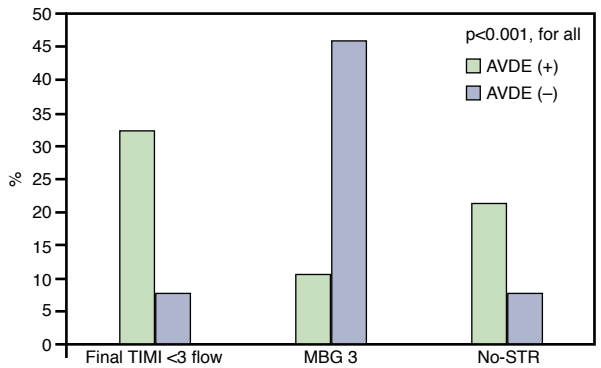

Figure 1. Comparison of the incidences of final thrombolysis in myocardial infarction (TIMI) flow grade <3, no-STR (ST segment resolution) and MBG 3 (myocardial blush grade) in patients with and without angiographically visible distal embolization (AVDE).

without AVDE (p<0.001 for all, Figure 1). Other angiographic characteristics are shown in Table 2.

Postprocedural LVEF [45% (40-50) *vs.* 48% (42-55), p=0.002] was lower and duration of hospitalization [5 (4-7) *vs.* 4 (3-6) days, p<0.001] was higher in patients with AVDE. In multivariate analysis, age [for each 10-year increase, Odds Ratio (OR) 1.34, 95% Confidence Interval (CI) 1.16–1.52, p<0.001], treatment of RCA (OR 2.52, 95% CI 1.30-4.87, p=0.034), repeated balloon dilatation (OR 1.84 95% CI 1.16-2.94, p=0.009), cut-off occlusion pattern (OR 2.17, 95% CI 1.38-3.42, p=0.001), lesion length >15 mm (OR 1.67, 95% CI 1.09-2.58, p=0.019), and RVD >3.5 mm (OR 5.08, 95% CI 3.32-7.65, p<0.001) were independent predictors of AVDE (Table 3). ROC analysis showed an area under the curve (AUC) of 0.68 for lesion length and AVDE. Lesion length >15 mm showed a sensitivity of 67.4% and a specificity of 71.6% for predicting AVDE (95% CI 0.63-0.73, p<0.001). In ROC analysis, AUC for RVD and AVDE was 0.77 and RVD >3.5 mm showed a sensitivity of 70.4% and a specificity of 76.1% for predicting AVDE (95% CI 0.72-0.81, p<0.001) (Figure 2).

In-hospital (8.1% *vs.* 3.8%, p=0.014) and one-month (10.8% *vs.* 4.9%, p=0.004) all- cause mortality rates were higher in patients with AVDE than in patients without AVDE. At the long-term follow-up (median: 42 months, IQR 37-53), both all-cause (21.5% *vs.* 10.4%, p<0.001) and cardiac mortality rates (18.4% *vs.* 8.0%, p<0.001) were higher in patients with AVDE. However, there was no significant difference between the two groups with respect to non-cardiac mortality. In-hospital reinfarction rates of the groups were not different. However, reinfarction rates at one-month (5.8% *vs.* 2.3%, p=0.017) and long-term follow-up (12.4% *vs.* 7.1%, p=0.03) were higher in patients with AVDE (Table 4). Survival curves of the two groups were significantly different (log-rank p=0.002, Figure 3).

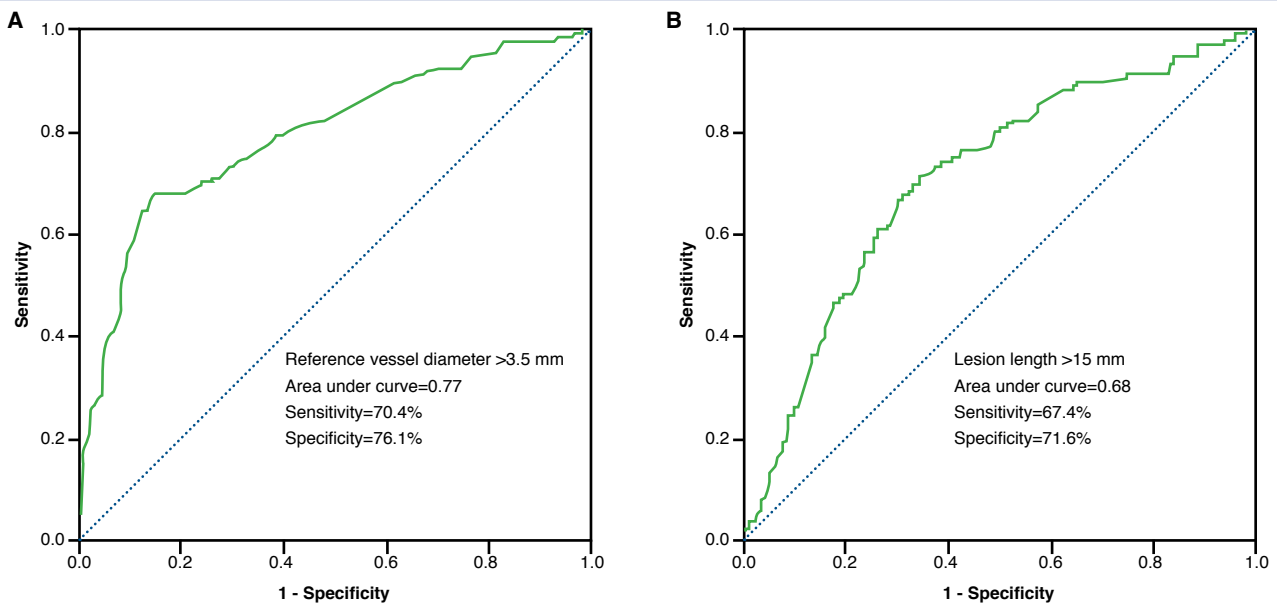

Figure 2. **(A, B)** ROC curves with optimal cut-off values of lesion length and reference vessel diameter for predicting AVDE.

Table 2. Angiographic and procedural characteristics

	Distal embolization (+)			Distal embolization (–)			*p*
	n	%	Mean±SD	n	%	Mean±SD	
Multivessel disease	57	42.2		758	40.5		0.692
Infarct- related artery							
LAD	40	29.6		946	50.5		**<0.001**
Cx	11	8.1		267	14.3		0.050
RCA	83	61.5		620	33.1		**<0.001**
LMCA/saphenous/diagonal	1	0.7		40	2.1		0.521
TIMI thrombus score ≥4	106	78.5		1232	65.8		**0.002**
Proximal lesion location	93	68.9		1004	53.6		**<0.001**
Baseline TIMI 2/3 flow	13	9.6		459	24.5		**<0.001**
Occlusion pattern							
Cut-off	72	53.3		620	33.1		**<0.001**
Tapered	50	37.0		734	39.2		0.617
Quantitative coronary analysis							
Lesion length (mm)			18.7±8.1			15.1±5.9	**<0.001**
Baseline RVD (mm)			3.49±0.49			3.08±0.36	**<0.001**
Final RVD (mm)			3.51±0.54			3.14±0.38	**<0.001**
Baseline DS (%)			99.1±3.4			96.9±6.5	**<0.001**
Final DS (%)			7.3±6.3			7.7±5.9	0.408
Tirofiban use before procedure	55	40.7		804	42.9		0.617
Aspiration catheter used	6	4.4		110	5.9		0.491
Maximal balloon inflation pressure			15.6±2.6			14.7±2.1	**<0.001**
Repeated balloon dilatations	82	60.7		665	35.5		**<0.001**
Stent use	123	91.1		1773	94.8		0.072
Direct stenting	18	13.3		405	21.6		0.022
Total stent length (mm)			26.3±13.2			21.4±8.5	**<0.001**
Final TIMI flow							
0/1	11	8.1		43	2.3		**<0.001**
2	33	24.4		105	5.6		**<0.001**
3	91	67.4		1724	92.1		**<0.001**
Myocardial blush grade							
0/1	72	56.3		372	23.8		**<0.001**
2	42	32.8		473	30.2		0.544
3	14	10.9		719	46.0		**<0.001**
ST segment recovery							
<30	28	21.4		147	8.2		**<0.001**
30-70	63	48.1		528	29.3		**<0.001**
>70	40	30.5		1126	62.5		**<0.001**
Peak troponin I	110	46-213		77.0	35-167		**0.001**
LVEF (%)	45	40-50		48	42-55		**<0.001**
Hospitalization duration	5	4-7		4	3-6		**<0.001**

Data are expressed as number (%), mean±SD or median (interquartile range). LAD: Left anterior descending; Cx: Circumflex; RCA: Right coronary artery; LMCA: Left main coronary artery; RVD: Reference vessel diameter; DS: Diameter stenosis; LVEF: Left ventricular ejection fraction.

Table 3. Independent predictors of angiographically visible distal embolization

	χ^2	OR	95% CI	*p*
Age (for each 10-year increment)	14.14	1.34	1.16 – 1.52	**<0.001**
Right coronary artery	7.56	2.52	1.30 – 4.87	**0.006**
Cut-off occlusion pattern	11.10	2.17	1.38 – 3.42	**0.001**
Lesion length >15 mm	5.46	1.67	1.09 – 2.58	0.019
RVD >3.5 mm	56.11	5.08	3.32 – 7.65	**<0.001**
Repeated balloon dilatation	6.79	1.84	1.16 – 2.94	**0.009**

χ^2= Wald chi-square; OR: Odds ratio; CI: Confidence interval; RVD: Reference vessel diameter.

Table 4. In-hospital and long-term outcomes

	DE (+)		DE (–)		*p*
	n	%	n	%	
In-hospital					
Death	11	8.1	71	3.8	0.014
Reinfarction	3	2.3	19	1.0	0.175
Revascularization	3	2.3	27	1.4	0.446
One-month					
Death	14	10.8	89	4.9	**0.004**
Reinfarction	7	5.8	40	2.3	0.017
Revascularization	7	5.8	50	2.8	0.069
Long-term†					
Death	28	21.5	190	10.4	**<0.001**
Cardiac	24	18.4	146	8.0	**<0.001**
Non-cardiac	4	3.1	44	2.4	0.557
Reinfarction	15	12.4	124	7.1	0.030
Revascularization	33	27.3	401	22.8	0.263

†Median follow-up time: 42 months.

DISCUSSION

This retrospective study demonstrated that AVDE had an incidence of 6.7% after p-PCI in patients with STEMI. Age, treatment of RCA, recurrent balloon dilatation, cut-off occlusion pattern, RVD >3.5 mm, and lesion length >15 mm were all independent predictors of DE. The presence of DE was associated with worse TIMI flow and MBG, less STR, and accordingly lower postprocedural LVEF. In-hospital, one-month and long-term mortality rates were higher in patients with DE. Although the reinfarction rates were higher at both short- and long-term follow-up in patients with DE, revascularization rates were not different from those without DE.

In a significant proportion of patients with STEMI, successful restoration of epicardial coronary artery patency does not lead to adequate reperfusion at the microvascular level. This phenomenon is called no-reflow or microvascular obstruction (MVO). DE of thrombi and atherosclerotic debris is one of the main pathogenetic mechanisms of no-reflow. Although microembolization is present in the vast majority of patients,[3] AVDE is evident in a smaller proportion of patients. Henriques et al. previously reported the rate of AVDE as 15%.[5] However, the rate has ranged between 2-8% in later trials.[4,6,14] The prognostic significance of the presence and the extent of MVO has been well documented by previous studies.[15-17] In patients with AVDE, impairment in microvascular flow

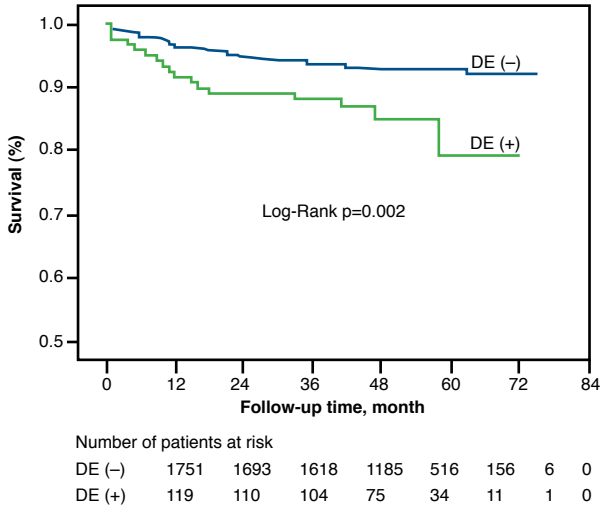

Figure 3. Kaplan-Meier survival analysis demonstrating the survival rates at the long-term follow-up (median: 42 months).

seems to be more prominent. In a study by Fokkema et al., the rates of MBG 3 and complete STR in patients with AVDE were 3.6% and 22%, respectively. In our study, the rates of MBG 3 and complete STR were 10.9% and 30.5%, respectively.

Thus, it is logical to expect that prevention of AVDE should be associated with lower enzymatic infarct size, less remodeling and better prognosis. However, early randomized trials of thrombectomy catheters and distal embolic protection devices have demonstrated neutral or even negative impacts on reduction of infarct size or improvement in prognosis.[7,8] In contrast, the REMEDIA, DEAR-MI and TAPAS trials demonstrated that thrombectomy improved microvascular perfusion.[4,6-18] A meta-analysis by Burzotta et al.[19] analyzing trials of different thrombectomy devices showed that thrombectomy improved survival in patients treated with glycoprotein IIb/IIIa inhibitors. This discrepancy may be related with the enrollment of patients regardless of their angiographic and clinical characteristics.

Identification of predictors of AVDE might be important for the selection of patients that would benefit more from these adjunctive devices. We found that age, treatment of RCA, recurrent balloon dilatation, cut-off occlusion pattern, RVD >3.5 mm, and lesion length >15 mm were all independent predictors of AVDE. TIMI thrombus score was not associated with AVDE. However, parameters defined by Yip et al.,[13] such as cut-off occlusion pattern and large IRA diameter, were found to be independent predictors of AVDE. The association of RCA with AVDE was previously explained by its structure with only a few side branches, leading to stasis and more thrombus formation during occlusion.[20] As the emboli are composed of not only thrombus but also atherosclerotic debris, larger IRA diameter may result in increased plaque burden, leading to increased incidence of AVDE.[21] Trauma caused by recurrent balloon dilatation may lead to embolization of both thrombus and debris.

The benefit of protection against AVDE may vary according to not only the thrombus burden, plaque volume and the device used, but also the contribution of embolization in the pathogenesis of no-reflow in each patient.[22] The predominant pathogenetic mechanism of no-reflow may vary in each individual. Napodano et al.[21] demonstrated that while the occurrence of AVDE was not time-dependent, its impact on epicardial reflow and tissue level reperfusion was time-dependent. They showed that AVDE had no effect on microvascular damage beyond the first 6 hours (h) after symptom onset. Furthermore, they showed that the enzymatic infarct area and in-hospital mortality was affected by only AVDE within the first 3 h. In our study, AVDE was associated with increased in-hospital, one-month and long-term mortality rates. Thus, this may be related with the short pain-to-balloon time in most of our patients. The incidence of reinfarction was also higher in patients with AVDE, and this may have contributed to the increased mortality. These findings suggest that AVDE is an important mechanism in the development of MVO in STEMI patients treated early with p-PCI and affects not only the short-term, but also the long-term clinical outcomes in these patients.

Some limitations of our study should be taken into consideration. First, this study has a single-center and retrospective design. In order to prevent bias, the in-hospital and long-term data were collected by different investigators. Second, the incidence of DE may have been underestimated because we evaluated only the angiographically visible macro-emboli. Finally, we measured enzymatic infarct size by peak troponin I, and evaluated microvascular perfusion by STR and MBG. Future prospective studies using optical coherence tomography for evaluating intraluminal thrombi and magnetic resonance imaging for detecting MVO and infarct size would be more valuable.

In conclusion, age, treatment of RCA, recurrent balloon dilatation, cut-off occlusion pattern, RVD >3.5 mm, and lesion length >15 mm were all independent predictors of AVDE. These predictors may help in the selection of appropriate patients for use of mechanical adjunctive devices during p-PCI. Angiographically evident DE is associated with poor clinical outcome at both the short- and long-term follow-up of STEMI patients treated early with p-PCI.

Conflict-of-interest issues regarding the authorship or article: None declared

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Key words: Embolization, therapeutic; coronary angiography; coronary thrombosis / diagnosis; myocardial infarction.

Anahtar sözcükler: Embolizasyon / terapötik; koroner anjiyografi; coroner tromboz/tanı; miyokart enfarktüsü.