

Determinants and Prognostic Implications of Terminal QRS Complex Distortion in Patients Treated With Primary Angioplasty for Acute Myocardial Infarction

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Terminal QRS complex distortion on admission has an impact on a patient's prognosis after primary angioplasty for acute myocardial infarction (AMI). We evaluated the determinants and prognostic significance of terminal QRS complex distortion in 153 consecutive patients with AMI after primary angioplasty. The study population was divided into 2 groups according to the presence (group I, $n = 41$) or absence (group II, $n = 112$) of terminal QRS complex distortion. The primary end points were the occurrence, within 6 weeks after AMI, of death, nonfatal reinfarction, or congestive heart failure. Baseline characteristics were similar between the 2 groups. However, patients in group I had higher peak levels of serum creatine kinase than those in group II ($5,100 \pm 3,100$ vs $3,000 \pm 1,800$ U/L, respectively, $p < 0.01$). The rate of angiographic no-reflow (Thrombolysis In Myocardial Infarction flow grade ≤ 2) was 31.7% in group I and 10.7% in group II ($p < 0.01$). The predischARGE left ventricular ejection fraction was $45.0 \pm$

12.0% in group I and $54.0 \pm 8.0\%$ in group II ($p < 0.01$). Multivariate analysis identified the pressure-derived fractional collateral flow index and the culprit lesion in the left anterior descending coronary artery as independent determinants of the terminal QRS complex distortion. No patients died during 6 weeks of follow-up. The 2 groups were similar for life-threatening arrhythmia or reinfarction. However, there were more patients in group I than in group II with congestive heart failure (26.8% vs 5.4%, respectively, $p < 0.01$) or who reached the primary end points (29.3% vs 5.4%, respectively, $p < 0.01$). In conclusion, terminal QRS complex distortion on admission is associated with poor clinical outcome after primary angioplasty for AMI, and collateral flow may have a major influence on terminal QRS complex distortion during AMI. ©2001 by Excerpta Medica, Inc.

(Am J Cardiol 2001;88:210–213)

PPrimary angioplasty in acute myocardial infarction (AMI) has been shown to limit infarct size and improve prognosis.^{1–4} However, a significant proportion of patients fail to achieve the benefits of primary angioplasty and remain in a high-risk category.^{5–7} Therefore, early identification of patients who may benefit most from primary angioplasty is important. Distortion of the terminal portion of the QRS complex on the admission electrocardiogram has been reported to reflect profound myocardial ischemia⁸ and has been associated with poor clinical outcome in patients with AMI who are given thrombolytic therapy.^{9–12} It seems likely that terminal QRS complex distortion on admission would also have an impact on a patient's prognosis after primary angioplasty for AMI.¹³ However,

the determinants and prognostic significance of terminal QRS complex distortion in this situation remain uncertain. Collateral flow may attenuate the severity of myocardial ischemia during the occlusion of an epicardial coronary artery, and thereby reduce distortion of the terminal portion of the QRS complex in AMI. Intracoronary pressure measurement has been used as a promising method for quantitative assessment of collateral flow.^{14–17} In the present study, we tested the hypothesis that distortion of the terminal portion of the QRS complex on admission would be related to collateral flow by intracoronary pressure measurement and might predict clinical outcome in patients treated with primary angioplasty for AMI.

METHODS

Study patients: The study population consisted of 153 consecutive patients with first AMI who were treated with primary angioplasty at our institution from January 1998 to October 2000. The inclusion criteria were typical chest pain lasting >30 minutes, presentation within 12 hours after the onset of symptoms, and ST-segment elevation ≥ 0.1 mV in ≥ 2 limb leads or ≥ 0.2 mV in ≥ 2 consecutive precordial leads.

From the Department of Medicine, Asan Medical Center, University of Ulsan, Seoul, Korea. This study was supported by a grant from the Asan Institute for Life Science (#2000–217), Seoul, Korea. Manuscript received January 8, 2001; revised manuscript received and accepted February 21, 2001.

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Exclusion criteria were previous administration of thrombolytic agents for the index infarction, previous bypass surgery, cardiogenic shock, the culprit lesion in the left main coronary artery, chronic left bundle branch block, ventricular rhythm, or negative T waves in the leads with ST elevation. All patients received conventional drug therapy in accordance with standard clinical practice.

Primary angioplasty and collateral flow: Coronary angiography followed by primary angioplasty was performed according to the study protocol at our institution. A 0.014-in fiberoptic pressure monitoring guidewire (RADI Medical Systems, Uppsala, Sweden) was set at 0, calibrated, advanced through the guiding catheter, and positioned distal to the occlusion site to be dilated, and then balloon inflation was performed at the occlusion site to measure the collateral flow. Pressure-derived fractional collateral flow (PD-FCF) was determined by simultaneous measurement of aortic pressure (Pao [in mm Hg] obtained from the guiding catheter), distal coronary pressure during the balloon occlusion (Pocc), and right atrial pressure (RA): PDFCF index = (Pocc – RA)/(Pao – RA) × 100. Angiographic collateral vessels (0 to 3) were graded according to Rentrop's classification.¹⁸ All patients received aspirin and intravenous heparin before angioplasty. Abciximab therapy was administered at the discretion of the operator. Patients who received a stent were treated with aspirin plus ticlopidine for 1 month.

Data collection and analysis: Clinical data were collected prospectively while patients were in the hospital and entered in the database. Clinical follow-up was obtained by review of patient charts or by telephone contact. Electrocardiograms were carefully analyzed by 2 experienced cardiologists who were unaware of the study's purpose. Coronary angiograms were reviewed by 2 angiographers who were blinded to clinical information. The initial and final flow in the infarct-related artery was assessed according to the classification of the standard Thrombolysis In Myocardial Infarction (TIMI) trial.¹⁹ All patients underwent complete echocardiographic examination before discharge. Cardiac enzymes were measured at 4-hour intervals up to 24 hours after intervention and the maximum level was used as an enzymatic marker of infarct size.

Definitions and primary end points: The primary end points in this trial were the occurrence, within 6 weeks after AMI, of death, nonfatal reinfarction, or severe congestive heart failure (defined as the presence of congestive symptoms after discharge that required use of digitalis and diuretics). Distortion of the terminal portion of the QRS complex was defined as the presence of the following in ≥2 adjacent leads^{10–12} (Figure 1): (1) in leads with initial QR configuration, emergence of the J point at ≥50% of the R-wave amplitude, or (2) in leads without Q waves (RS configuration), absence of S waves. Angiographic no-reflow was defined as TIMI flow grade ≤2 in cine angiograms obtained at the end of angioplasty. Prein-

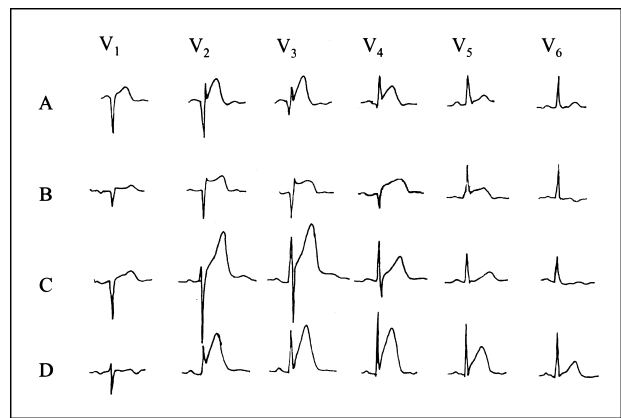


FIGURE 1. Representative electrocardiograms of 4 patients with anterior wall AMI (paper speed 25 mm/s, 1 mV = 10 mm). Lines A and C show negative QRS distortion patterns. Lines B and D show positive QRS distortion patterns.

TABLE 1 Baseline Characteristics

	Group I (n = 41)	Group II (n = 112)
Age (yrs)	59 ± 10	57 ± 11
Men/women	34/7	87/25
Killip class 2, 3	18 (43.9%)	45 (45.2%)
Location of infarct-related coronary artery		
Left anterior descending	26 (63.4%)	46 (41.1%)
Left circumflex	2 (4.8%)	10 (8.9%)
Right	13 (32%)	56 (50.0%)
Diabetes mellitus	6 (14.6%)	20 (17.8%)
Cholesterol >200 mg/dl	6 (36.6%)	48 (42.9%)
Systemic hypertension	14 (34.1%)	39 (34.8%)
Smoking	18 (43.9%)	60 (53.6%)
Symptom onset-to-balloon time (h)	4.7 ± 2.4	4.1 ± 2.4
Preinfarct angina	16 (40.2%)	48 (42.9%)
Mean blood pressure (mm Hg)	100.4 ± 19.5	99.5 ± 18.1
Mean heart rate (beats/min)	92.8 ± 17.4	87.8 ± 16.9
Use of abciximab	13 (31.7%)	35 (31.3%)

farct angina was defined as antecedent angina within 24 hours before the onset of AMI.²⁰

Statistical analysis: Data were expressed as mean ± SD for continuous variables, and frequencies for categorical variables. Continuous variables were compared by unpaired Student's *t* test, and categorical variables by chi-square test. Logistic regression analysis was performed to identify determinants of terminal QRS complex distortion, and variables that were *p* < 0.1 by univariate analysis were entered into a stepwise multiple regression analysis. A *p* value of < 0.05 was considered statistically significant.

RESULTS

Patients characteristics: The study population was divided into 2 groups according to the presence (group I, *n* = 41) or absence (group II, *n* = 112) of terminal QRS complex distortion. As shown in Table 1, baseline characteristics were similar between the 2 groups.

Angiographic results: Procedural success rate (defined as ≤30% diameter stenosis and TIMI flow grade ≥2) was 97.6% in group I and 95.6% in group II (*p* =

TABLE 2 Angiographic Characteristics

	Group I (n = 41)	Group II (n = 112)
Stent placement	28 (68.3%)	82 (73.2%)
Multivessel disease	16 (39.0%)	45 (40.2%)
Culprit lesion in left anterior descending coronary artery	26 (63.4%)	46 (41.1%)*
Reference artery diameter (mm)	3.3 ± 1.6	3.3 ± 0.5
Minimal lumen diameter after angioplasty (mm)	3.0 ± 0.6	3.0 ± 0.6
Diameter stenosis after angioplasty (%)	8.6 ± 10.0	7.4 ± 12.3
TIMI grade flow 2, 3 before angioplasty	7 (17.1%)	23 (20.5%)
Angiographic no-reflow	13 (31.7%)	12 (10.7%)†
Angiographic collaterals (≥grade 2)	4 (9.8%)	18 (16.1%)
PDFCF index	16.1 ± 9.1	20.7 ± 10.5*
PDFCF index (>24%)	8 (19.5%)	42 (37.5%)*

*p < 0.05; †p < 0.01.

NS). Angiographic characteristics were not different between the 2 groups, with the exception of the culprit lesion in the left anterior descending coronary artery, angiographic no-reflow, and PDFCF index (Table 2).

Infarct size and determinants of terminal QRS complex distortion: Patients in group I had higher peak levels of serum creatine kinase than those in group II ($5,100 \pm 3,100$ vs $3,000 \pm 1,800$ U/L, respectively, $p < 0.01$). The predischARGE left ventricular ejection fraction was significantly lower in group I than in group II ($45.0 \pm 12.0\%$ vs $54.0 \pm 8.0\%$, respectively, $p < 0.01$). From a variety of baseline characteristics, multivariate regression analysis identified the PDFCF index ($p < 0.05$) and occlusion that occurred in the left anterior descending coronary artery ($p < 0.05$) as independent determinants of the terminal QRS complex distortion (Table 2). Preinfarct angina, angiographic collaterals, and symptom-onset-to-balloon time were not related to terminal QRS complex distortion. However, in patients with insufficient collaterals (defined as PDFCF index $\leq 24\%$),^{14,17} symptom-onset-to-balloon time was significantly longer in group I than in group II (4.8 ± 2.4 vs 3.8 ± 2.1 hours, respectively, $p < 0.05$).

Clinical outcomes during the 6-week follow-up: No patients died during 6 weeks of follow-up. Three patients had nonfatal reinfarction, 17 patients had chronic congestive heart failure, and 4 patients experienced life-threatening arrhythmias (ventricular fibrillation or sustained ventricular tachycardia). There was no difference in the rate of life-threatening arrhythmia (2.4% vs 6.8%, respectively, $p = \text{NS}$) or reinfarction (7.3% vs 0%, respectively, $p = \text{NS}$). However, there were more patients in group I than in group II with congestive heart failure (26.8% vs 5.4%, respectively, $p < 0.01$) or who reached the primary end points (29.3% vs 5.4%, respectively, $p < 0.01$).

DISCUSSION

This study showed that distortion of the terminal portion of the QRS complex on the admission elec-

trocardiogram is associated with angiographic no-reflow, larger infarct size, and poor clinical outcome in patients treated with primary angioplasty for AMI. Furthermore, this study revealed that the PDFCF index is a major determinant of the terminal QRS complex distortion, suggesting that collateral flow may reduce myocardial ischemia with prevention of the terminal QRS complex distortion during AMI.

Prognostic significance: Primary angioplasty has been reported to be the preferred reperfusion strategy in patients with AMI.¹⁻³ However, the extent of myocardial salvage after primary angioplasty is highly variable,⁵⁻⁷ and there is a need for a method to predict potential myocardial salvage with this therapy. The admission electrocardiogram is simple and may provide useful information about clinical outcome after reperfusion therapy.⁸⁻¹³ It is known that the delayed conduction in the local Purkinje fibers during regional myocardial ischemia reduces the degree of cancellation, resulting in an increase in R-wave and a decrease in the S-wave amplitude on the surface electrocardiogram.^{21,22} The Purkinje system is less sensitive to ischemia than the contracting myocytes, and distortion of the terminal portion of the QRS complex reflects profound ischemia that would affect the Purkinje fibers.^{8,23,24} Recent studies suggest that in patients with AMI given thrombolytic therapy, the terminal QRS complex distortion on admission is associated with greater mortality rates, larger infarct size, and greater prevalence of left ventricular dysfunction.⁹⁻¹² The present study extends this observation to patients who undergo primary angioplasty. It is well known that the angiographic no-reflow phenomenon is associated with extensive microvascular damage within the jeopardized myocardium, predicting poor left ventricular functional recovery and a high risk of cardiac mortality after reperfused AMI.²⁵⁻²⁷ In our study, terminal QRS complex distortion was an independent predictor of the slow flow in the infarct-related artery despite successful dilation of the culprit lesion, suggesting that terminal QRS complex distortion appears to reflect extensive microvascular damage as a consequence of more severe ischemia.

Collateral circulation: Factors that determine the terminal QRS complex distortion in patients with AMI have been poorly described. In this study, we revealed that the PDFCF index is a major determinant of terminal QRS complex distortion during AMI, suggesting that collateral flow appears to play a crucial role in preventing terminal QRS complex distortion. The benefit of collateral flow in the jeopardized myocardium has been demonstrated in AMI.^{28,29} After sudden occlusion of a major artery, the residual blood flow to the perfusion field of the occluded vessel arrives only by way of coronary collaterals, guaranteeing the survival of ischemic myocardium after reperfusion therapy. Coronary angiography is commonly used for studying collateral circulation, but its limitations need to be recognized because most collateral vessels in humans may not be angiographically detectable. Intracoronary pressure measurement was reported to be more accurate in assessing the func-

tional significance of collateral circulation in AMI.^{16,17} As expected, we confirmed that terminal QRS complex distortion is significantly related to the PDFCF index. In addition, the occlusion occurring in the left anterior descending coronary artery is also significantly related to terminal QRS complex distortion, which may reflect more extensive necrosis as a result of the larger myocardial mass subtended by the longer arteries.

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