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Association Between Initial QRS Duration and No-Reflow Phenomenon in Patients With Acute Left Main Coronary Artery Obstruction

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The 12-lead electrocardiogram (ECG) on admission is the established first step to define acute myocardial infarction (AMI), and it provides information to predict outcomes in patients with ST-segment elevation AMI.^{1–3} The ECG in the setting of left main coronary artery (LMCA) obstruction displays various patterns.⁴ The present investigation evaluates the admission ECG as an initial marker to identify the probability of no-reflow phenomenon for acute LMCA obstruction.

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Of the 538 consecutive patients admitted to our hospital from January 1999 through January 2002 who underwent coronary angioplasty for AMI, a total of 16 patients (13 men and 3 women) with acute LMCA obstruction were identified. Using a 7Fr guiding catheter, LMCA obstruction was successfully eliminated with stent implantation in all 16 patients. Two patients had other lesions in right coronary arteries. After eliminating LMCA obstruction, 3 patients showed distal lesions in the middle of the left anterior descending (n = 2) or left circumflex coronary artery (n = 1), and so these patients additionally underwent coronary angioplasty for those lesions. Only 1 patient received intravenous thrombolysis before proceeding with angioplasty, and 14 patients had a concomitant intra-aortic balloon pump intervention. This study was approved by the Institutional Review Board of Ehime Prefectural Central Hospital.

Patients' admission records, including vital signs, echocardiographically calculated left ventricular ejection fraction, and laboratory data, were evaluated. The admission ECG using standard gain (10 mm/mV) and speed (25 mm/s) were analyzed. Initial QRS duration was measured to evaluate the conduction intervals. The sum of ST-segment elevation in leads I, aVL, and V₁ through V₆ was calculated as an index of broad anterior wall myocardial ischemia.^{1,2} The sums of the absolute ST-segment deviation (both ST elevation and ST depression) for all leads³ and

for ST-segment elevation in lead aVR⁵ were also evaluated. All angiograms were filmed at 30 frames/s after the administration of intracoronary nitrates 0.3 to 0.4 mg. Thrombolysis In Myocardial Infarction (TIMI) flow grade was examined as previously defined.⁶ No-reflow phenomenon was defined when TIMI flow grade ≤ 2 was observed in the final postprocedural angiogram of the left anterior descending coronary artery in the absence of a mechanical obstruction.⁷ TIMI frame count was used to assess coronary blood flow as a continuous quantitative variable.⁸ The TIMI frame count of the right coronary artery was assessed before coronary angioplasty, and the corrected TIMI frame count of the left anterior descending coronary artery was analyzed by a final coronary angiogram after revascularization. Collateral circulation was evaluated by the grading system of Rentrop et al.⁹

All data are presented as mean $\pm$ SD. Patients were divided into 2 groups based on the incidence of no reflow. Quantitative variables were compared with an unpaired *t* or a Mann-Whitney U test, in accordance with the data distribution. Categorical variables were compared with the chi-square test. A univariate and/or multivariate linear regression analysis was performed to identify the association between the admission electrocardiographic variables and the reperfused coronary blood flow. Statistical significance was set as *p* < 0.05.

Total in-hospital mortality was 44%, and mean survival time of patients who died was 27 hours after admission to our hospital. As listed in Table 1, except in-hospital mortality, baseline clinical characteristics were not different between patients with and without no-reflow phenomenon. Adjunctive coronary bypass surgery after emergency coronary angioplasty was performed in 4 patients with no reflow and in 2 patients with normal reflow (67% vs 20%, *p* = 0.182). On the admission ECG, only QRS duration was different between patients with no or normal reflow (Table 2). The corrected TIMI frame count of the reperfused left anterior descending coronary artery was also different between the 2 groups. Initial QRS duration showed a clear relation with the corrected TIMI frame count of the reperfused left anterior descending coronary artery (Figure 1). In a multivariate

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TABLE 1 Patient Characteristics on Hospital Admission			
	No-reflow Phenomenon		p Value
	+	0	
Age (yrs)	65 ± 13	70 ± 9	0.288
Men	6	7	0.408
Body surface area (m ²)	1.7 ± 0.1	1.6 ± 0.1	0.129
Time from symptom to treatment (h)	2.3 ± 1.5	2.2 ± 1.3	0.939
In-hospital mortality	5	2	0.013
Heart rate (beats/min)	84 ± 39	87 ± 26	0.829
Systolic blood pressure (mm Hg)	98 ± 26	115 ± 9	0.085
Diastolic blood pressure (mm Hg)	59 ± 16	76 ± 15	0.050
Killip class ≥III	4	4	0.606
Left ventricular ejection fraction (%)	31 ± 9	36 ± 7	0.229
White blood cell count (per μL)	13,133 ± 5,657	9,920 ± 4,613	0.235
Creatine kinase (IU/L)	244 ± 239	310 ± 308	0.660
Creatine kinase-MB (IU/L)	22 ± 24	49 ± 50	0.245

Values expressed as mean ± SD or as number of patients.

TABLE 2 Analysis of Admission Electrocardiogram (ECG) and Coronary Angiogram			
	No-reflow Phenomenon		p Value
	+	0	
QRS duration (msec)	134 ± 22	96 ± 22	0.004
ST-segment elevation in lead aVR (mV)	0.20 ± 0.07	0.13 ± 0.10	0.175
Sum of ST-segment elevation (mV)	1.64 ± 1.53	0.84 ± 0.90	0.278
Sum of ST-segment deviation (mV)	3.04 ± 1.95	1.58 ± 1.09	0.127
Right bundle branch block	1	0	0.789
Left bundle branch block	0	0	>0.999
Ventricular tachycardia or ventricular fibrillation	4	2	0.182
Other lesions	2	3	>0.999
Initial TIMI flow grade 0	5	4	0.242
Rentrop et al's ⁹ collateral flow grade 2 or 3	0	2	0.696
TIMI frame count of right coronary artery (frames)	21 ± 2	20 ± 6	0.909
Corrected TIMI frame count of reperfused left anterior descending coronary artery (frames)	58 ± 20	33 ± 8	0.004

Values are expressed as mean ± SD or as number of patients.

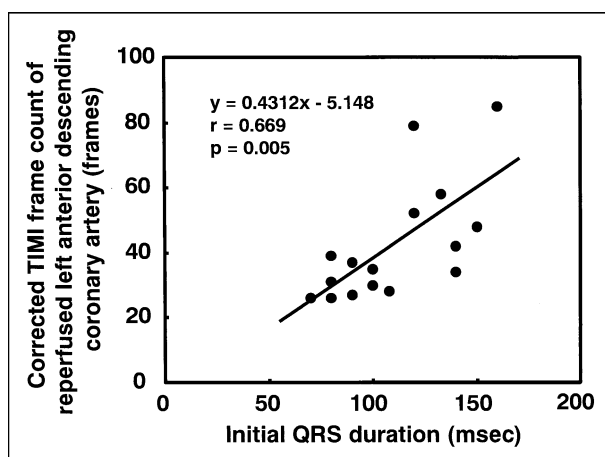


FIGURE 1. Relation between initial QRS duration on the admission ECG and corrected TIMI frame count of the reperfused left anterior descending coronary artery.

regression analysis, only initial QRS duration ($p = 0.006$)—but not the sum of ST-segment elevations ($p = 0.955$)—sum of the ST-segment deviation ($p = 0.983$), and ST-segment elevation in lead aVR ($p = 0.088$) correlated with the corrected TIMI frame count of the reperfused left anterior descending coronary artery.

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The present report demonstrates that QRS duration during the admission ECG is a powerful marker to identify the risk of no-reflow phenomenon, which was a fatal finding for patients who underwent coronary angioplasty for acute LMCA obstruction. We found a strong association between no-reflow phenomenon and in-hospital mortality in patients who underwent coronary angioplasty for acute LMCA obstruction, which suggests that restoring normal coronary blood flow may play the pivotal role in determining the survival benefit in patients with acute LMCA obstruction. Furthermore, adjunctive coronary bypass grafting in the absence of normal reflow by coronary angioplasty in patients with acute LMCA obstruction is less advantageous. Thus, to take drastic steps to avoid subsequent no-reflow phenomenon, initial QRS duration on the admission ECG is helpful to identify high-risk patients.

Our investigation suggests that initial QRS duration may serve as an independent marker for subsequent occurrence of no reflow in patients with acute LMCA obstruction. This is another variable to be considered before making the critical decision to perform an acute intervention in such patients.

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Prognostic Significance of Heart Rate Turbulence in Patients Undergoing Coronary Artery Bypass Grafting

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Coronary artery bypass grafting (CABG) has been documented to decrease the risk of cardiac and sudden death by improving the blood supply and thus decreasing myocardial ischemia and the arrhythmogenic substrate.^{1–3} Noninvasive parameters including late potentials and heart rate variability have been used to predict cardiac events in coronary patients. There are limited data regarding the prognostic significance of these parameters when evaluated before CABG.^{4,5} Heart rate turbulence (HRT), which reflects a response of heart rate to a premature ventricular beat, is a new, noninvasive electrocardiographic predictor of cardiac death.^{6–8} There are no data concerning the prognostic value of HRT parameters in patients undergoing CABG. This study evaluates the prognostic significance of HRT parameters for predicting cardiac death in patients undergoing CABG.

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The study population consisted of 146 consecutive patients (117 men and 29 women; aged 38 to 78 years, mean 62) with angiographically documented multivessel coronary artery disease who were qualified for elective CABG surgery. Exclusion criteria were: non-sinus rhythm (atrial fibrillation, paced rhythm), coexisting valvular heart disease, unstable angina, myocardial infarction <3 months before CABG, and heart failure symptoms of New York Heart Association class >III. The study protocol was approved by the local human investigation committee, and all patients signed informed consent.

At enrollment, which took place a few days before CABG, data on demographics (age and gender), clinical characteristics (past myocardial infarction, ejection fraction, diabetes, hypertension, obesity, smoking, family history of coronary disease), and medication were obtained. All patients underwent complete coronary revascularization in extracorporeal circulation.

Patients were followed for ≥ 1 year through a clinic visit or a phone call. Cardiac death was considered to be the end point of the study. Information regarding the nature of death was obtained from patients' relatives or hospital case history.

Twenty-four-hour Holter electrocardiographic monitoring was performed 2 to 7 days before cardiac surgery. Recordings, performed using 3-channel analogue recorders and analyzed using the Oxford Medilog System (Oxford, United Kingdom), were used to determine the presence of ventricular arrhythmias and calculate mean heart rate, heart rate variability parameters, and HRT parameters (the latter took place only in patients with ventricular arrhythmias).

The heart rate variability analysis was assessed over a 24-hour period and was performed both in time and frequency domains according to European Society of Cardiology/North American Society of Pacing and Electrophysiology guidelines.⁹ The following time-domain parameters were calculated: SD of all NN intervals (SDNN); mean of the SDs of all NN intervals for all 5-minute segments of the entire recording (SDNNI); SD of the averages of NN intervals in all 5-minute segments of the entire recording (SDANN); the square root of the mean of the sum of the squares of differences between adjacent NN intervals (rMSSD); and NN50 count divided by the total number of all NN interval (pNN50). Frequency-domain heart rate variability parameters (computed with fast-Fourier transformation) included total power, ultra low-frequency power, very low-frequency power, low-frequency power, high-frequency power, and the low frequency/high frequency ratio.

HRT parameters were calculated using an algorithm adapted from the web page popularizing the noncommercial use of HRT (www.h-r-t.org).⁶ In HRT analysis, 2 numerical descriptors were estimated: turbulence onset (TO), which reflects the initial phase of sinus rhythm acceleration, and turbulence slope (TS), which describes the deceleration phase. TO was defined as the percentage difference between the mean of first 2 RR intervals after a ventricular premature beat and the 2 last sinus RR intervals before a ventricular premature beat. TS was described as a maximum positive slope of a regression line assessed over any of 5 consecutive RR intervals within the first 20 sinus RR intervals after a ventricular

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