Relation of Terminal QRS Distortion to Left Ventricular Functional Recovery and Remodeling in Acute Myocardial Infarction Treated With Primary Angioplasty

Riccardo Bigi, MDa,b,*, Antonio Mafrici, MDa, Paola Colombo, MDa, Dario Gregori, MA, PhDc, Elena Corrada, MDa, Antonia Alberti, MDa, Annamaria De Biase, MDa, Pedro Silva Orrego, MDa, Cesare Fiorentini, MDb, and Silvio Klugmann, MDa

The association between admission electrocardiogram and 6-month change in left ventricular function and volume was assessed in 200 patients who had acute myocardial infarction that was treated with primary percutaneous coronary intervention. Logistic regression analysis indicated peak creatine phosphokinase-MB, number of Q-wave leads, QRS interval distortion, wall motion score index, and angiographic Thrombolysis In Myocardial Infarction flow grade as predictors of no functional recovery and QRS interval distortion and Thrombolysis In Myocardial Infarction flow grade as predictors of left ventricular remodeling. © 2005 Elsevier Inc. All rights reserved. (Am J Cardiol 2005;96:1233–1236)

Despite the known association between initial ST-segment alterations and final size of an acute myocardial infarction (AMI), the value of the admission electrocardiogram in predicting the evolution of left ventricular (LV) function remains undefined. We sought to clarify the association between admission electrocardiogram and evolutionary changes of LV function in patients who had extensive AMI that was treated with percutaneous coronary intervention (PCI).

The study population consisted of 200 patients who underwent primary PCI because of first ST-segment elevation AMI at Niguarda Hospital (Milan, Italy) and were consecutively selected on the basis of the following criteria: (1) ST-segment elevation ≥0.2 mV in ≥4 contiguous leads; (2) achievement of Thrombolysis in Myocardial Infarction trial flow grade 3 within 12 hours of symptom onset; (3) no left bundle branch block or paced rhythm; (4) Thrombolysis In Myocardial Infarction grade flow <3 before PCI; and (5) no major cardiovascular complications and/or further revascularization procedures within 6 months of the index PCI. Infarction was anterior in 130 patients (65%), inferior in 40 (20%), and lateral in 30 (15%); the right ventricle was involved in 14 patients (7%). All patients received unfractionated heparin and aspirin, and 30 (12%) were treated with platelet glycoprotein IIb/IIIa inhibitors before PCI. In case of stenting, which was applied in 190 patients (95%), aspirin plus ticlopidine or clopidogrel was administered for ≥1 month after hospital discharge. Standard post-discharge therapy included β blockers, angiotensin-converting enzyme inhibitors, and aspirin. Statins were used to achieve low-density lipoprotein cholesterol levels <2.6 mmol/L.

Angiograms were analyzed by 2 experienced observers; discrepancies were resolved by consensus. Percent luminal diameter stenosis was determined according to the caliper technique. Multivessel disease was defined as the presence of >70% luminal diameter obstruction in >1 major epicardial vessel. Contrast flow through the epicardial vessel was graded according to the standard Thrombolysis In Myocardial Infarction trial flow scale.1

Echocardiographic measurements were obtained 24 hours after PCI, at hospital discharge, and at 6-month follow-up. LV volumes were echocardiographically assessed using the modified Simpson’s rule and used to derive the ejection fraction according to standard calculations. Wall motion was semi-quantitatively evaluated with a 16-segment 4-point scoring modality.2 A wall motion score index was calculated by adding the numeric value that was assigned to each segment and divided by the number of visualized segments.

Admission electrocardiograms were analyzed by the same physician (PC) who was unaware of the study aim. The following electrocardiographic variables were considered: (1) number of leads with ≥0.2-mm ST-segment elevation; (2) number of pathologic Q waves; (3) maximal ST-segment elevation; and (4) QRS interval distortion, defined as the emergence of the J point at ≥50% of the R-wave amplitude that was measured from the isoelectric line in case of an initial QR pattern or as absence of S waves in case of an Rs pattern, as previously described.3 Intraobserver agreement in diagnosing QRS interval distortion was 98%.

Functional recovery and remodeling of the left ventricle

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*Corresponding author: Tel: 390-2-6444-2605; fax: 390-2-6611-6990.
E-mail address: riccardo.bigi@unimi.it (R. Bigi).

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were defined as an ejection fraction increase $\geq 10\%$ and an end-diastolic LV volume increase $\geq 15\%$, respectively, at follow-up compared with predischarge evaluation.

Continuous variables are presented as medians with corresponding interquartile differences. Categorical variables are presented as absolute numbers with corresponding percentages. Univariate odds ratios refer to the effect of an interquartile difference for continuous variables and to the category with the highest observed frequency for categorical variables. The patient effect of clinical, electrocardio-

graphic, echocardiographic, and angiographic variables to predict LV functional recovery and remodeling was assessed by univariate and multivariate analyses using a stepwise logistic regression model. At each step, a significance of 0.1 was required for a variable to be entered into the model. Nonlinearity was formally assessed by Wald's test to compare higher order models with those that included only linear terms. In case of nonlinearity, a restricted cubic spline was used to model a nonlinear effect of the covariate. The selection criterion was the Akaike Information Criterion that was applied backward for each model. Models were cross-validated by bootstrap technique. Multivariate odds ratios are presented with 95% confidence intervals. Accuracy of the probability function as defined by the multivariate predictors in each subject was evaluated by the area under the receiver-operating characteristic curve method. Statistical significance was indicated by $p < 0.05$. S-plus (release 2000, Insightful Corporation, Seattle, Washington) statistical package and Harrell's Design and Hmisc libraries (http://biostat.mc.vanderbilt.edu/twiki/bin/view/Main/Hmisc) were used for analysis.

Follow-up echocardiographic evaluation was not available in 6 patients (3%); thus the analysis refers to 194 patients. Of these, 103 (54%) showed recovery of LV function, whereas 91 (46%) did not. There was no significant

Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No recovery (n = 91)</th>
<th>Recovery (n = 103)</th>
<th>Combined (n = 194)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>59 (53, 68)</td>
<td>57 (47, 66)</td>
<td>59 (50, 67)</td>
<td>1.49 (0.99–2.27)</td>
</tr>
<tr>
<td>Women</td>
<td>18 (20%)</td>
<td>18 (17%)</td>
<td>36 (19%)</td>
<td>1.16 (0.56–2.38)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>42 (46%)</td>
<td>37 (36%)</td>
<td>79 (41%)</td>
<td>1.53 (0.86–2.70)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>13 (14%)</td>
<td>15 (15%)</td>
<td>28 (14%)</td>
<td>0.99 (0.43–2.17)</td>
</tr>
<tr>
<td>Symptom-to-balloon time (min)</td>
<td>222 (163–336)</td>
<td>210 (151–296)</td>
<td>220 (160–308)</td>
<td>1.07 (0.88–1.31)</td>
</tr>
<tr>
<td>Peak creatine phosphokinase (µg/ml)</td>
<td>3,432 (1,718–5,467)</td>
<td>2,297 (1,393–3,485)</td>
<td>2,776 (1,461–4,868)</td>
<td>1.31 (0.88–2.00)</td>
</tr>
<tr>
<td>Killip’s class</td>
<td>67 (74%)</td>
<td>79 (77%)</td>
<td>146 (76%)</td>
<td>0.97 (0.47–2.12)</td>
</tr>
<tr>
<td>ST-elevation lead number</td>
<td>6 (5–7.75)</td>
<td>5 (4–7)</td>
<td>5.5 (4–7)</td>
<td>1.69 (1.06–2.70)</td>
</tr>
<tr>
<td>Maximal ST elevation (mV)</td>
<td>0.8 (0.6–1.0)</td>
<td>0.7 (0.5–0.9)</td>
<td>0.7 (0.5–0.9)</td>
<td>1.23 (0.88–1.72)</td>
</tr>
<tr>
<td>Q-wave number</td>
<td>2 (0–3)</td>
<td>1 (0–2)</td>
<td>1 (0–3)</td>
<td>1.69 (1.06–2.70)</td>
</tr>
<tr>
<td>QRS interval distortion</td>
<td>58 (64%)</td>
<td>32 (31%)</td>
<td>90 (46%)</td>
<td>3.84 (2.12–7.14)</td>
</tr>
<tr>
<td>24-h echocardiogram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End-diastolic volume</td>
<td>111 (102–120)</td>
<td>106 (99–113)</td>
<td>108 (103–114)</td>
<td>1.44 (0.90–2.17)</td>
</tr>
<tr>
<td>End-systolic volume</td>
<td>65 (37–87)</td>
<td>62 (35–84)</td>
<td>63 (36–85)</td>
<td>1.11 (0.89–1.33)</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>45 (38–55)</td>
<td>52 (46–57)</td>
<td>49 (42–57)</td>
<td>1.04 (0.73–1.47)</td>
</tr>
<tr>
<td>Wall motion score index</td>
<td>1.87 (1.7–2.0)</td>
<td>1.75 (1.5–2.0)</td>
<td>1.81 (1.62–2.0)</td>
<td>1.75 (0.25–2.43)</td>
</tr>
<tr>
<td>Admission coronary angiogram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multivessel disease</td>
<td>5 (5%)</td>
<td>15 (15%)</td>
<td>20 (11%)</td>
<td>0.95 (0.47–1.92)</td>
</tr>
<tr>
<td>TIMI flow grade 0</td>
<td>74 (82%)</td>
<td>63 (62%)</td>
<td>137 (71%)</td>
<td>2.56 (1.16–5.88)</td>
</tr>
</tbody>
</table>

Continuous variables are presented as medians (first and third quartiles). Categorical variables are presented as absolute numbers (percentages). Univariate OR (95% CIs): Values refer to the effect of an interquartile difference for continuous variables and to the category with the highest observed frequency for categorical variables.

CI = confidence interval; OR = odds ratio; TIMI = Thrombolysis In Myocardial Infarction.

Table 2

<table>
<thead>
<tr>
<th>Multivariate predictors of no functional recovery and left ventricular remodeling</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No functional recovery</td>
<td>0.80 (0.74–0.96)*</td>
</tr>
<tr>
<td>Q-wave number</td>
<td>1.96 (1.06–3.57)</td>
</tr>
<tr>
<td>QRS interval distortion</td>
<td>3.70 (1.81–7.70)</td>
</tr>
<tr>
<td>Peak creatine phosphokinase-MB</td>
<td>1.72 (1.15–2.56)</td>
</tr>
<tr>
<td>Wall motion score index</td>
<td>3.03 (1.66–6.25)</td>
</tr>
<tr>
<td>TIMI flow grade 0</td>
<td>1.88 (1.69–5.00)</td>
</tr>
<tr>
<td>Remodeling</td>
<td>0.73 (0.62–0.85)</td>
</tr>
<tr>
<td>QRS distortion</td>
<td>2.84 (1.10–7.44)</td>
</tr>
<tr>
<td>TIMI flow grade $&gt;0$</td>
<td>0.23 (0.06–0.88)</td>
</tr>
</tbody>
</table>

* Area under the receiver operating characteristic curve of probability function.

Abbreviations as in Table 1.
difference in the use of β blockers (78% vs 80%), angiotensin-converting enzyme inhibitors (77% vs 75%), aspirin (87% vs 89%), and statins (49% vs 46%) between groups. Characteristics of the study population according to the occurrence of functional recovery are presented in Table 1. Among electrocardiographic variables, number of leads with ST-segment elevation and/or pathologic Q wave and presence of QRS interval distortion were inversely and significantly associated with failure to improve LV function. After adjusting for clinical, echocardiographic, and angiographic covariates, peak creatine phosphokinase-MB, number of pathologic Q waves, QRS interval distortion, wall motion score index, and angiographic Thrombolysis In Myocardial Infarction flow grade independently predicted the absence of functional recovery (Table 2). The correlation between QRS interval distortion and functional recovery is shown in Figure 1. At predischARGE evaluation, functional recovery was similar in patients who had QRS interval distortion and those who did not; conversely, the absence of QRS interval distortion was associated with significantly greater improvement of ejection fraction and wall motion score index at 6-month evaluation.

QRS interval distortion and Thrombolysis In Myocardial Infarction flow grade were multivariate predictors of LV remodeling. Patients who had QRS interval distortion showed a significant increase in end-diastolic volume, indicating unfavorable LV remodeling at 6-month evaluation compared with those who did not have QRS interval distortion (Figure 2).

The results of the present study demonstrate that the admission electrocardiogram retains independent value in predicting LV functional recovery and remodeling in patients who have extensive AMI that is treated with primary PCI. Among electrocardiographic variables, the terminal QRS interval distortion is the most powerful predictor of persistent LV dysfunction. Infarct size, LV filling pattern, heart failure on admission, and blood flow in the culprit vessel have been identified as major predictors of LV dysfunction and unfavorable remodeling after primary PCI. The electrocardiogram has been used to estimate infarct size, evaluate the patency of the infarct-related artery after reperfusion therapy, and assess prognosis. Moreover, it has been correlated with the presence and location of wall motion abnormalities and myocardial perfusion. Evolutionary changes in the T wave were found to predict postinfarct ventricular remodeling in the Third Groupo Italiano per lo Studio della Sopravvivenza nell’Infarto Miocardico (GISSI-3) Echo Substudy that included low-risk patients who had only a 72% incidence of reperfusion therapy. Recently, QRS interval distortion has been suggested as a marker of increased in-hospital mortality and long-term prognosis in patients who have AMI that is treated with thrombolytic therapy or short-term outcome after primary PCI. Our results expand these observations by demonstrating a strong association between QRS interval distortion and persistence of LV dysfunction in patients who undergo primary PCI. This association is independent of established prognostic determinants and may represent the pathophysiologic substrate of the unfavorable prognostic significance of QRS interval distortion that has been reported in previous studies. The presence of QRS interval distortion has been demonstrated to correlate with a larger infarct, likely indicating profound ischemia, in the absence of myocardial...
protection at the time of coronary occlusion. This hypo-
thesis is supported by the finding of a greater incidence of
no-reflow phenomenon after emergency PCI in patients who
have QRS interval distortion compared with those who do
not. In addition, collateral flow may decrease myocardial
damage and in turn prevent QRS interval distortion
during AMI, as suggested by the major role of pressure-
derived fractional collateral flow index in the occurrence of
QRS interval distortion. Thus, a larger infarct and an inability
to achieve a complete reperfusion of the ischemic tissue
despite successful recanalization of the culprit vessel can
provide a pathophysiologic basis to explain remodeling and
persistent dysfunction of the left ventricle.

Patients who presented with major complications or un-
derwent further revascularization during the 6-month fol-
low-up were excluded; thus, this study deals with a selective
group of patients that is not representative of the general
postinfarction population. In addition, because corrected
Thrombolyis In Myocardial Infarction frame count and
myocardial blush grade were not available in all patients, no
causal correlation was possible between QRS interval dis-
tortion and status of coronary microcirculation.

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