CHAPTER 5

Left ventricular dyssynchrony acutely after myocardial infarction predicts left ventricular remodeling

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ABSTRACT

Objectives
We sought to identify predictors of left ventricular (LV) remodeling after acute myocardial infarction.

Background
LV remodeling after myocardial infarction is associated with adverse long-term prognosis. Early identification of patients prone to LV remodeling is needed to optimize therapeutic management.

Methods
A total of 178 consecutive patients presenting with acute myocardial infarction who underwent primary percutaneous coronary intervention were included. Within 48 hours of intervention, two-dimensional echocardiography was performed to assess LV volumes, LV ejection fraction (LVEF), wall motion score index (WMSI), left atrial (LA) dimension, E/E’ ratio and severity of mitral regurgitation. LV dyssynchrony was determined using speckle-tracking radial strain analysis. At 6 months follow-up, LV volumes, LVEF and severity of mitral regurgitation were reassessed.

Results
Patients showing LV remodeling at 6 months follow-up (20%) had comparable baseline characteristics to patients without LV remodeling (80%), except for higher peak troponin T levels (p < 0.001), peak creatine phosphokinase levels (p < 0.001), WMSI (p < 0.05), E/E’ ratio (p < 0.05) and a larger extent of LV dyssynchrony (p < 0.001). Multivariable analysis demonstrated that LV dyssynchrony was superior in predicting LV remodeling. Receiver-operating characteristic (ROC) curve analysis demonstrated that a cutoff value of 130 ms for LV dyssynchrony yields a sensitivity of 82% and a specificity of 95% to predict LV remodeling at 6 months follow-up.

Conclusions
LV dyssynchrony immediately after acute myocardial infarction predicts LV remodeling at 6 months follow-up.
INTRODUCTION

The occurrence of left ventricular (LV) dilatation after acute myocardial infarction is not uncommon. Giannuzzi et al. noted severe LV remodeling 6 months after infarction in 16% of the patients. The clinical importance of LV remodeling was emphasized by White et al., who demonstrated that patients who died during follow-up after myocardial infarction had significantly higher LV volumes and lower LV ejection fractions (LVEF) than survivors. Furthermore, they indicated LV end-systolic volume (LVESV) as the primary predictor of survival after myocardial infarction. As a consequence, early identification of patients with LV remodeling after acute myocardial infarction is of vital importance.

Previous studies demonstrated relations between preexisting hypertension, infarct size and anterior location of the infarct, and the occurrence of LV remodeling after myocardial infarction. Recently, Zhang et al. demonstrated that myocardial infarction has a significant impact on LV synchronicity and that the degree of LV dyssynchrony is mainly determined by the infarct size.

In this work, we hypothesize that LV dyssynchrony occurring early after myocardial infarction may predict LV remodeling at 6 months follow-up. In the current study, the relation between LV dyssynchrony, as assessed by speckle-tracking radial strain analysis, occurring early after myocardial infarction and LV remodeling at 6 months follow-up was evaluated.

METHODS

Patients

A total of 194 consecutive patients, admitted with an acute myocardial infarction, were evaluated. To acquire a homogenous study population, patients who were treated conservatively (n = 6) or who underwent thrombolysis (n = 4) or coronary artery bypass grafting (n = 2) in the acute setting were excluded from the study. Four patients died during follow-up and therefore did not have the follow-up assessment. These patients were excluded from the study. The final study population comprised 178 patients who all underwent primary percutaneous coronary intervention.

Study protocol

Two-dimensional (2D) echocardiography was performed within 48 hours of admission (baseline) and at 6 months follow-up. At baseline, 2D echocardiography was used to
assess LV volumes, LVEF, wall motion score index (WMSI), left atrial (LA) dimension, the mitral inflow peak early velocity (E)/mitral annular peak early velocity (E’), or E/E’ ratio, and severity of mitral regurgitation. LV dyssynchrony was quantified using speckle-tracking radial strain analysis. At 6 months follow-up, LV volumes, LVEF and severity of mitral regurgitation were reassessed.(8) The study was approved by the institutional ethics committee, and informed consent was obtained from all patients.

Echocardiography

Patients were imaged in the left lateral decubitus position using a commercially available system (Vivid Seven, General Electric-Vingmed, Milwaukee, Wisconsin, USA). Standard images were obtained using a 3.5-MHz transducer, at a depth of 16 cm in the parasternal (long- and short-axis images) and apical (2- and 4-chamber images) views. Standard 2D and color Doppler data, triggered to the QRS complex, were saved in cine-loop format. LV volumes (end-systolic and end-diastolic) and LVEF were calculated from the conventional apical 2- and 4-chamber images, using the biplane Simpson’s technique.(9) LA dimension was measured at end-systole using M-mode. (10)

Pulsed-wave mitral inflow Doppler was obtained by placing the Doppler sample volume between the tips of the mitral leaflets. The E/E’ ratio was obtained by dividing E by E’ at the basal septal segment.(11)

Severity of mitral regurgitation was graded semiquantitatively from color-flow Doppler data in the conventional parasternal long-axis and apical views. Mitral regurgitation was characterized as: mild = 1+ (jet area/left atrial area < 10%), moderate = 2+ (jet area/left atrial area 10% to 20%), moderately severe = 3+ (jet area/left atrial area 20% to 45%), and severe = 4+ (jet area/left atrial area > 45%).(12)

The LV was divided into 16 segments. A semiquantitative scoring system (1, normal; 2, hypokinesia; 3, akinesia; 4, dyskinesia) was used to analyze each study. Global WMSI was calculated by the standard formula: sum of the segment scores divided by the number of segments scored.(13,14)

All echocardiographic measurements were obtained by 2 independent observers without knowledge of the clinical status of the patient. Inter- and intra-observer agreement for assessment of LV volumes were 90% and 93% for LVESV, and 92% and 93% for left ventricular end-diastolic volume (LVEDV), respectively.
Speckle-tracking radial strain analysis

Radial strain was assessed on LV short-axis images at the papillary muscle level, using speckle-tracking analysis. (15, 16) This novel technique tracks frame-to-frame movement of natural acoustic markers on standard gray scale images of the myocardium. Off-line analysis of radial strain was performed on digitally stored images.

The speckle-tracking software makes use of natural acoustic markers, or speckles, that are present on standard ultrasound tissue images. The software automatically subdivides the short-axis images of the LV into blocks of approximately 20 to 40 pixels containing stable patterns of speckles. These speckles move together with the myocardium, and can be followed accurately from frame-to-frame (frame rate varied from 40 to 80 frames/s). A dedicated algorithm tracks the location of the speckles throughout the cardiac cycle, using correlation criteria and sum of absolute differences. (15) Local 2D tissue velocity vectors are then derived from the spatial and temporal data of each speckle. Myocardial strain can then be assessed from temporal differences in the mutual distance of neighboring speckles. The change in length / initial length of the speckle pattern over the cardiac cycle can be used to calculate radial strain, with myocardial thickening represented as positive strain, and myocardial thinning as negative strain.

To assess regional LV strain, a region of interest was manually drawn at the endocardial-cavity boundary on a single frame at end-systole. The speckle-tracking software then automatically created a second larger circle at the epicardial level, such that the region of interest spans the LV myocardium. The automatically created circle width could be adjusted manually by the operator, depending on the LV wall thickness. Starting at the selected frame at end-systole, the speckle-tracking algorithm automatically tracked the region of interest and calculated radial strain throughout the cardiac cycle. Ultimately, the user-defined region of interest covered the entire myocardial wall during the entire cardiac cycle.

Finally, the traced endocardium was automatically divided into 6 standard segments: septal, anteroseptal, anterior, lateral, posterior, and inferior, respectively. The software provided a score for all 6 segments marked in green for good quality and in red for poor quality. Signals from all 6 segments had to be of good quality in order to be able to adequately determine radial strain. Time-strain curves for all 6 segments were then constructed and time from QRS onset to peak radial strain was obtained. Consequently, the location of the earliest and latest activated segments was determined. Inter- and intra-observer agreement for assessment of the absolute difference in time-to-peak radial strain for the earliest versus the latest activated segments was 87% both.
Statistical analysis

Most continuous variables were not normally distributed (as evaluated by Kolmogorov-Smirnov tests). For reasons of uniformity, summary statistics for all continuous variables are therefore presented as medians together with the 25th and 75th percentiles. Categorical data are summarized as frequencies and percentages. LV remodeling at 6 months follow-up was defined as an absolute increase in LVESV of at least 15%. Differences in baseline characteristics between patients who developed LV remodeling versus those who did not were analyzed using Wilcoxon-Mann-Whitney tests, Chi-square tests with Yates’ correction or Fisher’s exact tests, as appropriate. Echocardiographic changes that occurred over time (LVESV, LVEDV and LVEF) were studied by subtracting the baseline values from the values at 6 months follow-up for each individual patient. These changes were then summarized as median values together with 25th and 75th percentiles. Differences in changes between patients with and without LV remodeling were studied by applying the Wilcoxon-Mann-Whitney test.

LV dyssynchrony was defined as the absolute difference in time-to-peak radial strain for the earliest versus the latest activated segments. Univariable and multivariable linear regression analyses were performed to evaluate the relation between LV dyssynchrony at baseline and LVESV at 6 months follow-up, as well as the change in LVESV (indicating the magnitude of LV remodeling) after 6 months follow-up compared to the baseline value. The number of covariates in the final multivariable regression models was limited via a backward selection procedure, and all variables with a p value < 0.15 were maintained.

Additionally, univariable and multivariable logistic regression analyses were applied (with a similar model-building process), relating LV dyssynchrony (continuous variable) to LV remodeling (dichotomous outcome). We realize that dichotomization of a continuous variable (LVESV) will result in loss of statistical power to reveal relevant relations. Still, these analyses are useful from clinical point of view, as patients with a change in LVESV ≥ 15% constitute a cohort at increased risk of adverse events. Crude and adjusted odds ratios with their corresponding 95% confidence intervals are reported.

LV dyssynchrony was associated with LV remodeling. To determine the ‘optimal’ threshold of LV dyssynchrony for the prediction of LV remodeling, receiver operating characteristic (ROC) curve analysis was applied. This optimum was defined as the value for which the sum of sensitivity and specificity was maximized. As a result of the cut off p value (< 0.15) based on which covariates were included in the final multivariable regression model, the absoluteness of the obtained cut off value for LV
dyssynchrony can be discussed. All statistical tests were 2-sided. For all tests, a p value < 0.05 was considered statistically significant.

RESULTS

Baseline data of the study population
The study sample consisted of 178 patients (140 men, median age 61 (25th, 75th percentiles: 53, 70) years). During primary percutaneous coronary intervention, Thrombolysis In Myocardial Infarction flow grade III flow was obtained in all but 7 (4%) patients. The infarct-related artery was the left anterior descending coronary artery (LAD) in 92 (52%) patients, the left circumflex coronary artery (LCX) in 40 (22%) and the right coronary artery (RCA) in 44 (25%) patients. Multi-vessel disease was present in 95 (53%) patients.

At baseline, median WMSI was 1.50 (1.31, 1.63). Median peak cardiac troponin T and creatine phosphokinase levels were 6.5 μg/L (2.3, 10.3 μg/L) and 2133 U/L (1006, 3570 U/L), respectively. Eight (4%) patients had a previous myocardial infarction.

Median LVESV and LVEDV were 66 ml (54, 83 ml) and 128 ml (106, 150 ml), respectively, whereas median LVEF was 47% (42%, 52%). Median LA dimension was 38 mm (35, 42 mm). The median E/E’ ratio at baseline was 12.4 (9.8, 16.2). In 8 (4%) patients moderate to severe mitral regurgitation (≥ grade 2+) was observed.

Median LV dyssynchrony, as measured by speckle-tracking radial strain analysis, was 47 ms (13, 106 ms). In 14 (8%) of patients assessment of LV dyssynchrony using speckle-tracking radial strain analysis was not feasible due to poor quality of the 2D echocardiographic images.

LV remodeling at 6 months follow-up
In the entire patient population, median LVESV at 6 months follow-up was 63 ml (48, 80 ml), median LVEDV was 128 ml (104, 152 ml), whereas median LVEF was 49% (43%, 56%). The number of patients with moderate to severe mitral regurgitation (≥ grade 2+) was 13 (7%) at 6 months follow-up.

Patients were then divided into patients with LV remodeling (n = 36, 20%) and without LV remodeling (n = 142, 80 %) at 6 months follow-up. Baseline patient characteristics of these 2 groups are summarized in Table 1. At baseline, no significant differences were observed between the patients with and without LV remodeling except for the fact that peak levels of cardiac enzymes (reflecting enzymatic infarct size) were higher in the patients with LV remodeling.
The echocardiographic data of the patients with and without LV remodeling are shown in Table 2. At baseline, no significant differences in LV volumes and LVEF were observed. At 6 months follow-up however, the LVESV (according to the definition of LV remodeling) and LVEDV were significantly larger in the patients with LV remodeling. Moreover, the LVEF was significantly lower in the patients with LV remodeling.
Moderate to severe mitral regurgitation (≥ grade 2+) was more often present in the patients with LV remodeling.

At baseline, WMSI, E/E’ ratio and LV dyssynchrony (Figure 1) were the only baseline echocardiographic variables that were significantly different between patients with and without LV remodeling. In the patients with LV remodeling median WMSI was 1.56 (1.38, 1.69), whereas median WMSI in patients without LV remodeling was 1.50 (1.25, 1.63; p < 0.05). The median value for E/E’ ratio in patients with LV remodeling measured 14.8 (12.3, 18.4) and the patients without LV remodeling had a median E/E’ ratio of 11.7 (9.7, 15.7; p < 0.05).

Median LV dyssynchrony was 148 ms (134, 180 ms) in the patients with LV remodeling, compared with 31 ms (12, 77 ms) in the patients without LV remodeling (p < 0.001). The individual data are demonstrated in Figure 2.

Figure 3 shows the prevalence for each LV segment as being the latest activated segment in the patients with LV remodeling after 6 months of follow-up. According to the high prevalence of the LAD as infarct-related artery, the anteroseptal and
Figure 1.
Extent of LV dyssynchrony was significantly larger in patients with LV remodeling during follow-up versus those without LV remodeling.

Left panel demonstrates time-strain curves of a patient without dyssynchrony at baseline. This patient did not show left ventricular (LV) remodeling during follow-up (left ventricular end-systolic volume (LVESV) was 84 vs. 73 ml, baseline vs. 6-month follow-up). Right panel demonstrates time-strain curves of a patient with LV dyssynchrony at baseline (earliest activated segments: purple, green, and dark-blue; latest activated segments: light-blue, yellow, and red). This patient showed LV remodeling during follow-up (LVESV was 77 vs. 122 ml, baseline vs. 6-month follow-up).

Figure 2.
LV dyssynchrony in patients without versus with LV remodeling at 6-Month follow-up.
Box-whisker plot indicates median, first quartile, third quartile, and range. Median left ventricular (LV) dyssynchrony was significantly higher (p < 0.001) in the patients with LV remodeling versus without LV remodeling (148 ms (134, 180 ms) vs. 31 ms (12, 77 ms), respectively).
septal LV segments are activated late in a considerable proportion of the patients with LV remodeling.

**Determinants of LV remodeling**

Patients with more extensive LV dyssynchrony at baseline had a higher LVESV at 6 months follow-up (Figure 4, left panel). This relation remained after adjustment for the baseline LVESV, peak level of cardiac troponin T and history of hypertension (these variables had a p value < 0.15 in the final model; the R² value of the final model was 0.73). Each 10 ms increase in LV dyssynchrony is associated with a 1.2 ml (95% confidence interval (CI) 0.8 to 1.6 ml; p < 0.001) larger LVESV at 6 months.

Patients with more extensive LV dyssynchrony at baseline also had a higher change in LVESV in the 6 months period of follow-up (Figure 4, right panel). Of note, the extent of LV dyssynchrony was largest in patients with significant LV remodeling (increase in LVESV ≥15%) (Figure 5). After adjustment for the baseline LVESV, peak level of cardiac troponin T and history of hypertension, each 10 ms increase in LV dyssynchrony is associated with an 1.2 ml (95% CI 0.8 to 1.6 ml) higher change in
LVESV (note that the ‘change model’ had similar covariables as the ‘absolute value’ model; the $R^2$ value of the final ‘change model’ was 0.41).

LV dyssynchrony at baseline was also associated with an increased risk of LV remodeling at 6 months follow-up. Table 3 presents the univariable relations between a range of clinical and echocardiographic variables, and the incidence of LV remodeling at 6 months follow-up. Among the variables studied, LV dyssynchrony showed the strongest relation. This relation remained after adjustment for the peak level of cardiac troponin T ($p = 0.015$ in the final model), hypertension ($p = 0.10$), baseline LVESV ($p = 0.14$), and baseline LVEDV ($p = 0.14$). Each millisecond increase in LV

<table>
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<tr>
<th>Baseline Variable</th>
<th>Odds ratio</th>
<th>95% Confidence interval</th>
<th>p Value</th>
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<tr>
<td>LV dyssynchrony (per ms)</td>
<td>1.03</td>
<td>1.02 – 1.05</td>
<td>&lt; 0.001</td>
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<td>Peak cTnT level (per µg/L)</td>
<td>1.14</td>
<td>1.07 – 1.22</td>
<td>&lt; 0.001</td>
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<tr>
<td>Peak CPK level (per U/L)</td>
<td>1.44</td>
<td>1.20 – 1.72</td>
<td>&lt; 0.001</td>
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<tr>
<td>E/E’ ratio</td>
<td>1.09</td>
<td>1.01 – 1.17</td>
<td>0.019</td>
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<td>WMSI</td>
<td>8.11</td>
<td>1.39 – 47.0</td>
<td>0.020</td>
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<td>Age (per year)</td>
<td>1.03</td>
<td>1.00 – 1.07</td>
<td>0.073</td>
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<tr>
<td>LA dimension (per mm)</td>
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<td>0.99 – 1.15</td>
<td>0.081</td>
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<tr>
<td>LVESV (per ml)</td>
<td>1.02</td>
<td>1.00 – 1.03</td>
<td>0.090</td>
</tr>
<tr>
<td>LVEDV (per ml)</td>
<td>1.01</td>
<td>1.00 – 1.02</td>
<td>0.094</td>
</tr>
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<td>Positive family history</td>
<td>0.54</td>
<td>0.25 – 1.17</td>
<td>0.12</td>
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<td>Culprit vessel LAD</td>
<td>1.96</td>
<td>0.73 – 5.26</td>
<td>0.18</td>
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<td>QRS duration (per ms)</td>
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<td>0.99 – 1.04</td>
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<td>Gender</td>
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<td>Number of diseased vessels</td>
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<td>0.78 – 1.97</td>
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<td>MR</td>
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<td>0.57</td>
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<td>Culprit vessel LCX</td>
<td>1.34</td>
<td>0.41 – 4.40</td>
<td>0.63</td>
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<tr>
<td>LVEF (per %)</td>
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<td>0.94 – 1.04</td>
<td>0.72</td>
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<td>Diabetes</td>
<td>1.24</td>
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<td>Hypertension</td>
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<td>Previous MI</td>
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<td>Hyperlipidemia</td>
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<td>Smoking</td>
<td>0.94</td>
<td>0.44 – 1.98</td>
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**Table 3.** Relation between clinical and echocardiographic parameters and LV remodeling. Abbreviations as in Tables 1 and 2.
dyssynchrony was associated with a 3% increased risk of LV remodeling (adjusted odds ratio 1.03 per ms; 95% CI 1.02 to 1.05; \( p < 0.001 \)).

To identify the optimal extent of LV dyssynchrony that was predictive for LV remodeling at 6 months follow-up, ROC curve analysis was performed (Figure 6). At a cutoff value of 130 ms for LV dyssynchrony, ROC curve analysis revealed a sensitivity of 82% with a specificity of 95% to predict LV remodeling at 6 months follow-up.
DISCUSSION

The main findings of the present study can be summarized as follows: 1) 20% of the patients exhibited LV remodeling at 6 months after acute myocardial infarction, 2) patients in which LV remodeling occurred had higher baseline peak levels of cardiac enzymes, WMSI, E/E' ratio and a larger extent of LV dyssynchrony, 3) baseline LV dyssynchrony of 130 ms or more, as assessed by speckle-tracking radial strain analysis, had a sensitivity of 82% and a specificity of 95% to predict LV remodeling at 6 months after acute infarction.

Prediction of LV remodeling

During follow-up, 20% of the study group showed remodeling of the left ventricle. Accordingly, in these patients LVESV and LVEDV increased, while LVEF declined. In the GISSI (Gruppo Italiano per lo Studio della Sopravvivenza nell’Infarto Miocardico)-3 Echo Substudy, Giannuzzi et al. showed comparable results. Using the end-diastolic volume index as a marker of remodeling, the authors noted severe LV remodeling at 6 months after infarction in 16% of the patients. (1)
Cardiac remodeling is recognized as an important trigger for the progression of cardiovascular disease. Increasing LVESV (index) and declining LVEF post-infarction are important predictors of mortality.\textsuperscript{(2,19,20)} White et al. measured LV volumes, LV ejection fractions, and severity of coronary occlusions and stenoses in 605 male patients under 60 years of age at 1 to 2 months after a first (n = 443) or recurrent (n = 162) myocardial infarction. During a follow-up period of 78 months there were 101 cardiac deaths. Multivariable analysis showed that LVESV had greater predictive value for survival than LVEDV or LVEF. LVESV was significantly higher in patients who died from a cardiac cause (122 ± 65 ml) than in survivors (72 ± 36 ml).\textsuperscript{(2)} Therefore, early identification of patients with LV remodeling after acute myocardial infarction is of vital importance. In order to identify patients at high risk, parameters with adequate predictive values are needed.

In the current study, it was shown that patients with LV remodeling had significantly higher peak levels of cardiac enzymes, WMSI, E/E’ ratio and a significantly larger extent of LV dyssynchrony, compared with the patients without LV remodeling.

Significant relations have been described between cardiac troponin T levels after myocardial infarction and scintigraphic estimate of myocardial infarct size.\textsuperscript{(21,22)} The importance of the infarct size as determinant of LV remodeling was previously noted by McKay et al.\textsuperscript{(3)} The authors demonstrated that infarct size, as assessed by the extent of wall motion abnormalities, was directly proportional to the magnitude of LV remodeling during the acute phase of infarction. The predictive value of infarct size was further confirmed by Popovi \textit{et al}, who described initial infarct size after anterior wall acute myocardial infarction as a major determinant of infarct expansion and ventricular remodeling. Furthermore, the importance of the infarct-related artery patency as predictor for infarct expansion after anterior wall myocardial infarction was emphasized.\textsuperscript{(5)} Unfortunately, systematic information on vessel patency was not available in the current study.

The variables LA dimension and E/E’ ratio were evaluated for their relation with long-term LV remodeling. In previous studies, both variables demonstrated to be of clinical importance.\textsuperscript{(10,11)} In the present study, the influence of these variables on LV remodeling was limited, and LV dyssynchrony at baseline appeared superior for prediction of LV remodeling.

Recently, Zhang \textit{et al} emphasized the significant impact of acute myocardial infarction on regional myocardial contractility and systolic LV synchronicity early in the course, even in the absence of QRS widening or bundle-branch block. The authors concluded that the degree of LV systolic dyssynchrony was mainly determined by the infarct size. The infarct size was assessed by contrast-enhanced magnetic reso-
nance imaging and was significantly larger in patients with anterior infarction (n = 24) compared to inferior infarction (21.3 ± 12.1% vs. 13.3 ± 6.1%, respectively). Of note, a greater extent of LV dyssynchrony was demonstrated in patients with anterior than inferior myocardial infarction (46.8 ± 13.9 vs. 34.6 ± 8.5 ms, p = 0.002).(7)

LV dyssynchrony predicts long-term LV remodeling
A novel finding in the current study is that the extent of LV dyssynchrony was demonstrated to be an independent predictor of LV remodeling at 6 months follow-up. Moreover, multivariable analysis showed that LV dyssynchrony, measured at baseline after myocardial infarction, was superior to other variables in the prediction of LV remodeling. To identify a cutoff value to predict LV remodeling, we performed an ROC curve analysis and identified an optimal cutoff value of 130 ms. This cutoff value yielded a sensitivity and specificity of 82% and 95% to predict LV remodeling at 6 months follow-up. These findings suggest that assessment of LV dyssynchrony immediately after acute myocardial infarction may provide incremental predictive value for the identification of patients prone to the development of LV remodeling.

Speckle-tracking radial strain analysis to assess LV dyssynchrony
In the present study, the location of the earliest and latest activated segments was determined using speckle-tracking software applied to standard short-axis images. The definition of LV dyssynchrony was based on the absolute difference in time-to-peak radial strain for the earliest versus the latest activated segments. Speckle-tracking radial strain analysis is a novel technique that allows angle-independent measurement of regional strain and time-to-peak radial strain of different LV segments.(15,16) Recently, this technique has been validated against magnetic resonance imaging. (23) Furthermore, Suffoletto et al. demonstrated that speckle-tracking radial strain analysis can quantify LV dyssynchrony, and can accurately predict response to cardiac resynchronization therapy. (24) In contrast to tissue velocity imaging-derived strain, speckle-tracking radial strain is angle-independent and not limited by tethering.(25) Therefore, speckle-tracking radial strain analysis permits an accurate quantification of regional wall strain, with a high reproducibility.(23,25)

Clinical implications
Recently, numerous reports have been published on LV dyssynchrony, mainly in relation to prediction of response to cardiac resynchronization therapy.(17) In these studies, the presence of LV dyssynchrony in severely dilated left ventricles is predictive for response to cardiac resynchronization therapy.
According to the present study, a significant degree of dyssynchrony is highly predictive for the long-term development of LV remodeling after acute myocardial infarction. This finding offers a unique possibility to identify patients at risk for LV remodeling early after infarction and to subsequently intensify treatment of these patients.

There is an important role for medical therapy in the prevention of LV remodeling after myocardial infarction, especially for angiotensin-converting enzyme inhibitors and beta-blockers.\(^{(26-33)}\) The SOLVD (Studies of Left Ventricular Dysfunction) prevention trial for instance demonstrated that enalapril (partially) reversed LV dilatation in patients with LV dysfunction.\(^{(27)}\) Moreover, beta-blocker therapy has been shown to reduce LVEDV and LVESV indexes in patients with LV dysfunction.\(^{(32,33)}\)

In addition to further optimization of medical therapy, early cardiac resynchronization therapy could be considered in patients with severe LV dyssynchrony early after acute myocardial infarction. However, it is currently unclear whether large infarction results in LV dilatation, or whether LV dyssynchrony is most important for LV dilatation. Only when LV dyssynchrony is the main determinant of LV dilatation, cardiac resynchronization may be beneficial. Further studies are needed to explore these issues.

**CONCLUSIONS**

Patients with LV remodeling after acute myocardial infarction show significant LV dyssynchrony at baseline, as compared to patients without LV remodeling. Using a cutoff value of 130 ms, a sensitivity of 82% and a specificity of 95% were obtained to predict the LV remodeling at 6 months follow-up. LV dyssynchrony may be used to identify patients at high risk for development of LV remodeling after infarction.
REFERENCES


