Chronic Mitral Regurgitation: A Pilot Study to Assess Preoperative Left Ventricular Contractile Function Using Speckle-Tracking Echocardiography

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Background: The development of postoperative left ventricular (LV) dysfunction is a frequent complication in patients with chronic severe mitral regurgitation (MR) and implies a poor prognosis. The aim of this study was to evaluate the predictive value of preoperative regional LV contractile function assessment using two-dimensional echocardiography–based speckle-tracking analysis in patients with chronic severe MR.

Methods: Thirty-eight consecutive patients with chronic severe MR scheduled for mitral valve replacement were prospectively enrolled. Preoperative two-dimensional echocardiography–based speckle-tracking analysis at the level of the interventricular septum (IVS) was carried out, and strain and strain rate values were obtained. LV dP/dt and Doppler tissue imaging–derived strain and strain rate measurements were also obtained. LV volumes and LV ejection fraction (LVEF) were defined using three-dimensional echocardiography.

Results: Preoperative speckle tracking–derived longitudinal strain and strain rate values at the level of the IVS strongly predicted a postoperative LVEF decrease of >10%. Their predictive values were greater than those obtained for preoperative LV volumes and LVEF, LV dP/dt, and Doppler tissue imaging–derived strain and strain rate. The best discriminant parameter to detect a postoperative LVEF reduction of >10% with speckle tracking was a longitudinal strain rate at the level of the mid IVS $< -0.80\ s^{-1}$ (area under the receiver operating characteristic curve, 0.88; sensitivity, 60%; specificity, 96.5%; positive predictive value, 90%; negative predictive value, 82.35%).

Conclusions: IVS longitudinal speckle tracking–derived strain rate allows the accurate detection of early abnormalities in LV contractile function. It is a powerful predictor of early postoperative LVEF decreases in patients with chronic severe MR. Furthermore, speckle-tracking technology is more accurate than other methods. This new tool might assist clinicians in the optimal timing of surgery in patients with chronic severe MR. (J Am Soc Echocardiogr 2009;22:831-838.)

Keywords: Mitral regurgitation, Speckle tracking, Ventricular dysfunction

The optimal timing of surgery in patients with chronic severe mitral regurgitation (MR) remains controversial.[1,2] Progressive left ventricular (LV) remodeling occurs, and LV dysfunction may insidiously develop in asymptomatic patients. Delaying surgical correction may result in irreversible myocardial damage and carries an increased risk for postoperative mortality, LV dysfunction, and heart failure.[1,3-6] Current guidelines recommend careful clinical follow-up until symptoms, LV dilatation, decreasing LV ejection fraction (LVEF), pulmonary hypertension, or atrial fibrillation appears.[7] However, symptoms may be masked because of their insidious appearance and progression, and interpretation of LVEF in the presence of significant MR may be difficult.[3,4,8-11]

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Recently, strain and strain rate analysis have been used as quantitative variables to accurately estimate regional myocardial contractility. Speckle tracking is a newer non-Doppler-based method for the angle-independent quantification of myocardial deformation from standard bidimensional data sets. This new tool may overcome some of the limitations of Doppler tissue imaging (DTI).[12,13]

In this study, the usefulness of preoperative regional LV systolic functional assessment was evaluated by means of speckle tracking–derived strain and strain rate in patients with chronic severe MR. We sought to assess the hypothesis that speckle tracking–derived strain and strain rate might detect those patients with significant postoperative decreases in LVEF. Our second aim was to compare the diagnostic accuracy of this new method with those of other traditional methods.

METHODS

Study Population

For this pilot study, 38 consecutive patients with chronic severe MR due to chronic organic mitral valve disease, scheduled for mitral valve

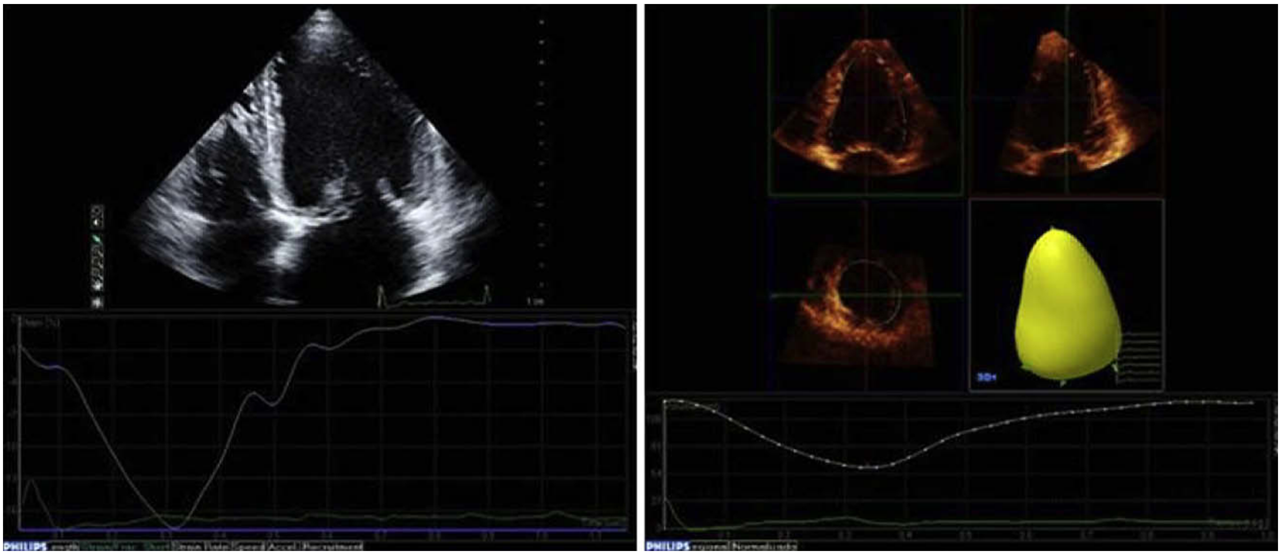

Figure 1 Two-dimensional strain of the IVS obtained by speckle-tracking *(left)* and three-dimensional *(right)* analysis of LV volumes and LVEF.

replacement between December 2006 and October 2007, were prospectively enrolled and followed up. Exclusion criteria were the presence of significant coronary artery disease, more than mild aortic valvular disease, more than mild mitral stenosis, congenital heart disease, and the presence of cardiomyopathies. None of the enrolled patients had prior myocardial infarctions or any wall motion abnormalities on preoperative echocardiographic evaluation. Clinical management was determined independently by the patients' personal physicians. Measurements were obtained by an investigator blinded to the clinical status and echocardiographic measurements of the patients. Every patient was given verbal and written information about the techniques they would undergo. They were also informed and gave consent for the anonymous use of their data for research purposes. The study was supervised by the institution's ethics committee, and all work was in compliance with the declaration of Helsinki.

The study population was divided into two groups, according to postoperative decrease in LVEF: group 1, with postoperative LVEF decreases < 10%, and group 2, with postoperative LVEF decreases > 10%. The reason for this cutoff point was the fact that interobserver and intraobserver variability were relatively high, and variations in LVEF of < 10% are often found in the absence of any real modification.[14]

Doppler Echocardiographic Studies

Preoperative examinations were performed < 48 hours before surgery and postoperative ones < 6 days after surgery. Every patient underwent a complete standard Doppler echocardiographic study using an iE33 ultrasound system and a S5-1 probe (Philips Medical Systems, Andover, MA). Data sets were stored for offline analysis using Q-Lab (Philips Medical Systems). MR severity was quantified by using the proximal isovelocity surface area method, and the effective regurgitant orifice (ERO) was estimated. LV dP/dt was obtained from the continuous-wave Doppler signal of the mitral regurgitant jet. Longitudinal strain and strain rate measurements of the interventricular septum (IVS) by DTI were also obtained, according to previously described methods.[11-14] Three-dimensional LV volumes and LVEFs were obtained using an iE33 ultrasound system and a X3-1 probe (Figure 1, right). This system uses a fully sampled matrix-array transducer, which uses 3000 active elements to obtain a pyramidal data set from an apical window that contains the entire LV cavity. The 3-dimensional images were optimized by modifying the different settings. Data sets were then acquired using the wide-angle acquisition mode, in which 4 to 7 wedge-shaped subvolumes were obtained. The acquisition of each subvolume was triggered to the electrocardiographic R-wave. The 3DQ Advanced software (Philips Medical Systems) was used for the analysis of 3-dimensional data. Nonforeshortened, anatomically correct apical 2-chamber and 4-chamber views were extracted from the pyramidal data set on the first frame in the loop, which corresponded to end-diastole. Then, 5 anatomic landmarks were manually initialized, including 2 points to identify the mitral valve annulus in each of the two apical views and 1 point to identify the apex in either view. Following the manual identification of these points, the program automatically identified the 3-dimensional endocardial surface using a deformable shell model. Adjustments to the automatic surface detection could be performed at this time, if necessary. End-diastolic volume was then automatically computed directly from voxel counts. Then, end-systole was selected by identifying the frame with the smallest LV cavity cross-sectional area in both apical views. Surface detection, including initialization, was then repeated on this frame to obtain end-systolic volume. The LVEF was then calculated. The average values of 2 beats for patients in sinus rhythm and 3 beats for patients in atrial fibrillation were used for analysis.

Two-Dimensional Speckle-Tracking Analysis

Preoperative longitudinal and radial peak systolic strain and strain rate were obtained in the basal and mid segments of the IVS from the apical 4-chamber view using an iE33 ultrasound system and an S5-1 probe. Data sets were stored for offline analysis using Q-Lab. Two regions of interest were placed at the level of the basal and mid IVS, and speckle tracking–derived longitudinal strain and strain rate were calculated (Figure 1, left). The average values of 2 beats for patients in sinus rhythm and 3 beats for patients in atrial fibrillation were used for analysis.