Left Ventricular Strain in Chronic Ischemic Mitral Regurgitation in Relation to Mitral Tethering Pattern

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Background: The aim of this retrospective study was to explore whether different tethering patterns in chronic ischemic mitral regurgitation have different distributions of left ventricular (LV) systolic longitudinal, circumferential, and radial strain before and after mitral valve repair.

Methods: Sixty-one patients with chronic ischemic mitral regurgitation who underwent mitral repair were divided on the basis of the preoperative anterior/posterior tethering angle ratio (cutoff value, 0.76). There were 29 patients with symmetric (group 1) and 32 with asymmetric (group 2) preoperative tethering patterns. Assessment of longitudinal peak systolic strain was performed offline by applying speckle-tracking imaging to the apical two-chamber, three-chamber, and four-chamber views of the left ventricle. Peak systolic radial and circumferential strain was obtained from short-axis views at the basal, middle, and apical levels. Twenty healthy subjects served as controls.

Results: In group 1, baseline LV strain was impaired in all LV segments, with the worst values in the anterolateral, anterior, and inferolateral segments at the midventricular and basal levels. In contrast, asymmetric patients showed higher values in the inferior and inferoseptal walls and values closer to normal in the other segments. After surgery, all strain measurements showed significant improvements in all LV segments in group 2, whereas in Group 1, strain worsened in the inferoseptal, inferior, and anteroseptal walls and did not change in the other segments

Conclusions: Patients with baseline symmetric tethering patterns showed more extensive abnormal strain, which was observed in all LV segments and was not reverted by surgery. These findings require confirmation in additional larger studies. (J Am Soc Echocardiogr 2013;■:■-■.)

Keywords: Mitral valve, Ischemic mitral regurgitation, Strain

Myocardial strain echocardiography has been introduced as a clinical index of regional[1,2] and global[3,4] left ventricular (LV) function. Two-dimensional speckle-tracking echocardiography measures strain by tracing tissue scatter in grayscale images and enables the angle-independent assessment of myocardial deformation indices.[5] As it is noninvasive and reproducible, strain might be well suited for follow-up and to guide the timing of surgical intervention.[6-9]

In our previous experiences, measures of leaflet tethering resulted in fundamental findings to identify patients with chronic ischemic mitral regurgitation (CIMR) who can benefit from restrictive annuloplasty. Specifically, preoperative symmetric tethering with anterior mitral leaflet predominance was strongly associated with recurrence of mitral regurgitation (MR) and lack of reverse remodeling.[10-12]

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0894-7317/$36.00

http://dx.doi.org/10.1016/j.echo.2013.01.011

In the present study, we tested the hypothesis that different tethering patterns in CIMR exhibit different distributions of LV systolic longitudinal, circumferential, and radial strain before and after mitral valve repair.

METHODS

Subjects

Patients with CIMR who survived combined coronary artery bypass grafting and undersized mitral ring annuloplasty performed at our institution (Academic Hospital, Maastricht, The Netherlands) between May 2010 and March 2012 were retrospectively included in the study. Inclusion and exclusion criteria are shown in Figure 1. The final study population consisted of 61 patients who were divided on the basis of the preoperative anterior/posterior tethering angle ratio (α/β). A cutoff value of 0.76 was chosen on the basis of our previous experience.[12] There were 29 patients with symmetric (group 1; mean α/β, 0.83 $\pm$ 0.5) and 32 with asymmetric (group 2; mean α/β, 0.63 $\pm$ 0.3) preoperative tethering patterns.

Finally, strain data of patients with CIMR were compared with data obtained from 20 healthy controls. The group of healthy controls comprised individuals matched for age, gender, body surface area, and body mass index who were volunteers recruited through general

Abbreviations

ALPM = Anterolateral papillary muscle

CIMR = Chronic ischemic mitral regurgitation

IQR = Interquartile range

LV = Left ventricular

MR = Mitral regurgitation

PISA = Proximal isovelocity surface area

PMPM = Posteromedial papillary muscle

WMSI = Wall motion score index

practitioners or subjects referred for echocardiography as part of a routine checkup during the study period. Those individuals who showed LV dilatation, had known hypertension, or were referred for echocardiographic evaluation of known valvular disease, murmur, or heart failure were excluded. Accordingly, all individuals included in the control group had normal echocardiographic results.

Surgery

All patients underwent complete revascularization. The ring size was determined by standard measurements of the intertrigonal distance and anterior leaflet height. Downsizing by two ring sizes was performed in all patients. A successful repair was assessed as leaflet coaptation ≥ 0.8 cm, MR grade ≤ 1, and diastolic mitral valve area > 2 cm^2 on intraoperative transesophageal echocardiography.

Echocardiography

Transthoracic echocardiography was carried out according to a standard protocol before surgery (<1 week before), at 1-year follow-up, and yearly thereafter. Echocardiographic examinations were performed using a commercially available ultrasound system (iE33; Philips Medical Systems, Best, The Netherlands). All patients reached 1-year follow-up. The median follow-up duration was 16.6 months (interquartile range [IQR], 14.1–20.5 months).

Images were acquired by experienced echocardiographers (F.L. and C.M.R.) blinded to the aims of the study, stored in Digital Imaging and Communications in Medicine format, and transferred to a workstation for further offline analysis (TomTec Imaging Systems, Unterschleissheim, Germany).

Standard Echocardiography. Quantitation of MR was carried out as previously described,[10] and the thresholds for mild, moderate, and severe MR followed American Society of Echocardiography recommendations.[13] Recurrent MR at latest follow-up was defined as insufficiency ≥ 2+ in patients with no or trivial MR at discharge.

The anterior mitral leaflet tethering angle, α (between the annular plane and the basal part of the anterior mitral leaflet), and the posterior mitral leaflet tethering angle, β (between the annular plane and the basal part of the posterior mitral leaflet), were directly measured using specific software (Philips DICOM Viewer; Philips Medical Systems).[10]

The ratio of α to β was a quantitative measurement of tethering: the closer the ratio to 1, the more symmetric the tethering.

Tenting area was measured as the area enclosed between the annular plane and mitral leaflets from the parasternal long-axis view at midsystole. Coaptation height was measured as the perpendicular distance between the coaptation point of the mitral leaflets and the line connecting the annular hinge points in the long-axis view at end-systole.

LV volumes and LV ejection fraction were assessed using the apical biplane method of disks.[14] The wall motion score index (WMSI) was

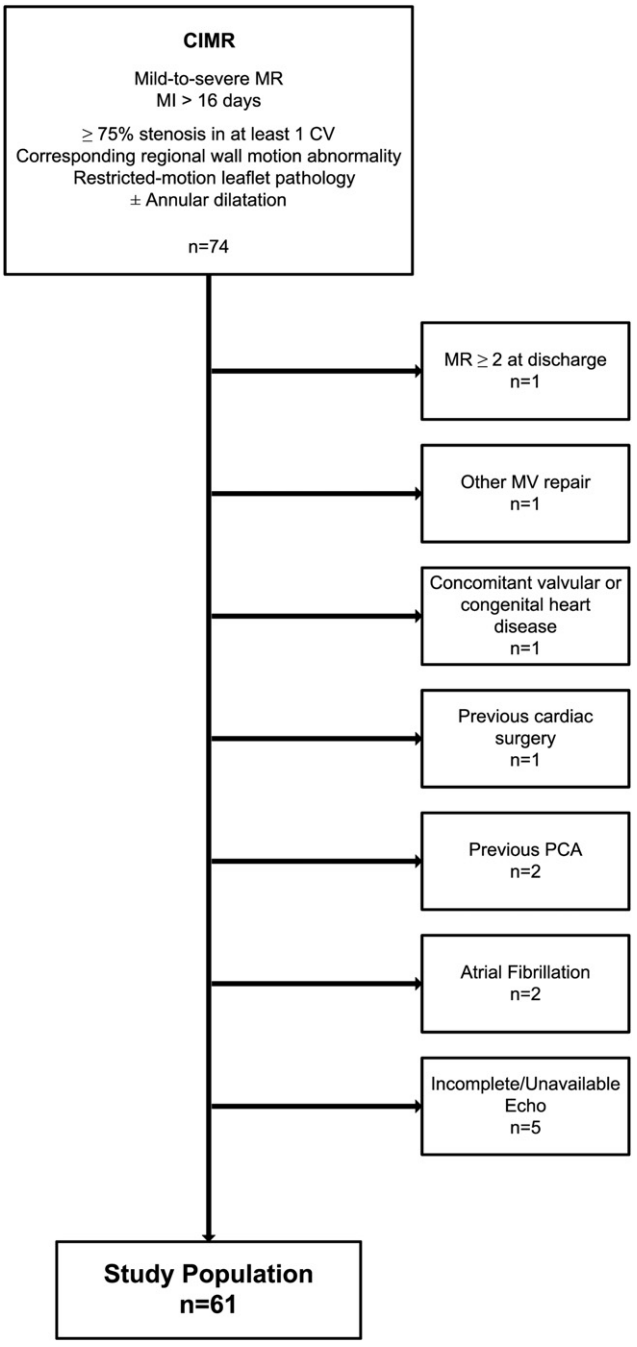

Figure 1 Patient selection. Patients were included on the basis of the following criteria: (1) mild to severe MR with prior myocardial infarction (>16 days), (2) ≥75% stenosis of at least one coronary vessel (CV), (3) a corresponding regional wall motion abnormality, and (4) restricted motion type leaflet dysfunction with or without annular dilatation. Exclusion criteria were (1) persistent or residual MR (≥2+ at discharge), (2) other concomitant mitral valve repair procedures performed, (3) degenerative or other nonischemic etiology or concomitant valvular or congenital heart diseases, (4) previous cardiac surgery or percutaneous transluminal coronary angioplasty, (5) atrial fibrillation, and (5) echocardiograms not available or incomplete or images not appropriate for two-dimensional speckle-tracking echocardiographic analysis. *PCA*, Percutaneous coronary angioplasty.