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Mitral Annular Dimensions and Geometry in Patients With Functional Mitral Regurgitation and Mitral Valve Prolapse

Implications for Transcatheter Mitral Valve Implantation

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ABSTRACT

OBJECTIVES The aims of this study were to determine D-shaped mitral annulus (MA) dimensions in control subjects without significant cardiac disease and in patients with moderate to severe mitral regurgitation (MR) being considered for transcatheter mitral therapy and to determine predictors of annular size, using cardiac computed tomography.

BACKGROUND The recently introduced D-shaped method of MA segmentation represents a biomechanically appropriate approach for annular sizing prior to transcatheter mitral valve implantation.

METHODS Patients who had retrospectively gated cardiac computed tomography performed at our institution (2012 to 2014) and were free of significant cardiac disease were included as controls ($n = 88$; 56 ± 11 years of age; 47% female) and were compared with patients with moderate or severe MR due to functional mitral regurgitation (FMR) ($n = 27$) or mitral valve prolapse (MVP) ($n = 32$). MA dimensions (projected area, perimeter, intercommissural, and septal-to-lateral distance), maximal left atrial (LA) volumes, and phasic left ventricular volumes were measured.

RESULTS MA dimensions were larger in patients with FMR or MVP compared with controls (area index 4.7 ± 0.6 cm^2/m^2, 6.0 ± 1.3 cm^2/m^2, and 7.3 ± 1.7 cm^2/m^2; perimeter index 59 ± 5 mm/m^2, 67 ± 9 mm/m^2, and 75 ± 10 mm/m^2; intercommissural distance index 20.2 ± 1.9 mm/m^2, 21.2 ± 3.1 mm/m^2, and 24.7 ± 3.2 mm/m^2; septal-to-lateral distance index 14.8 ± 1.6, 18.1 ± 3.3, and 19.5 ± 3.4 mm/m^2 in controls and patients with FMR and MVP, respectively; $p < 0.05$ between controls and MR subgroups). Absolute MA area was 18% larger in patients with MVP than patients with FMR (13.0 ± 2.9 cm^2 vs. 11.0 ± 2.3 cm^2; $p = 0.006$). Although LA and left ventricular volumes were both independently associated with MA area index in controls and patients with MVP, only LA volume was associated with annular size in patients with FMR.

CONCLUSIONS Moderate to severe MR was associated with increased MA dimensions, especially among patients with MVP compared with control subjects without cardiac disease. Moreover, unlike in controls and patients with MVP, annular enlargement in FMR was more closely associated with LA dilation. (J Am Coll Cardiol Img 2016;9:269–80) © 2016 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

BMI = body mass index

BSA = body surface area

CT = computed tomography

FMR = functional mitral regurgitation

IC = intercommissural

LA = left atrial/atrium

LV = left ventricle/ventricular

MA = mitral annular/annulus

MR = mitral regurgitation

MVP = mitral valve prolapse

SL = septal-to-lateral

TMVI = transcatheter mitral valve implantation

TT = trigone-to-trigone

With the rapid innovation and growing clinical adoption of transcatheter mitral therapies, including transcatheter mitral valve implantation (TMVI), an accurate understanding of mitral annular (MA) dimensions and geometry is becoming increasingly important. Given the saddle-shaped, nonplanar configuration of the MA, 3-dimensional (3D) imaging is required for comprehensive assessment. Although this can be achieved using computed tomography (CT), with its excellent spatial resolution (1-4), limited data exist describing CT values for MA dimensions in patients with significant mitral regurgitation (MR) in whom TMVI may be a potential therapeutic option.

We recently proposed a D-shaped concept of MA geometry, in which the annulus is truncated along a virtual line connecting both fibrous trigones, as a standardized, reproducible, and more biomechanically appropriate method for MA sizing prior to TMVI (5). An important characteristic of the D-shaped segmentation method is that it yields a more planar annulus that closely resembles the cross-sectional area of current TMVI devices, which is not achieved by conventional (saddle-shaped) analyses. Annular size and geometry and the determinants of MA size in patients with moderate to severe MR have not been studied using the D-shaped method. Moreover, the range of D-shaped MA dimensions in patients without significant cardiac disease is unknown.

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Accordingly, we sought to determine annular dimensions, geometry, and drivers of annular size in patients with moderate to severe MR and compare these findings with those of control subjects without significant cardiac disease using retrospectively electrocardiographically (ECG) gated cardiac CT.

METHODS

STUDY POPULATION. The Institutional Review Board approved this retrospective study with a waiver for informed consent. Two study cohorts were identified. Consecutive patients who underwent clinically indicated, retrospectively gated cardiac CT at our institution between August 2012 and February 2014 and were identified as being free of significant cardiac disease on the basis of CT findings and review of available clinical information were included as controls. Only scans performed with retrospective ECG gating were included so that multiphasic data could be analyzed. Exclusion criteria included: 1) known significant mitral valve disease and/or greater than mild MA calcification seen on cardiac CT; 2) clinical history of congestive heart failure and/or reduced measured left ventricular (LV) ejection fraction <50%; 3) obstructive coronary artery disease on cardiac CT (≥70% in any coronary vessel or >50% in the left main) or prior coronary revascularization; 4) history of atrial fibrillation; 5) prior cardiac surgery; 6) complex congenital heart disease; 7) obesity (body mass index [BMI] >35 kg/m^2); 8) increased maximal left atrial (LA) volume index (>78 ml/m^2, a cutoff representing 2 SDs from the mean value previously reported in healthy subjects [6]); and/or increased LV mass index (>103 g/m^2 for men and >89 g/m^2 for women [7]). Consecutive patients with moderate to severe MR referred for cardiac CT between November 2013 and June 2015 for workup prior to potential TMVI were included. Patients with MR were divided into 2 groups based on MR mechanism (mitral valve prolapse [MVP] or functional mitral regurgitation [FMR]). Patients with a prior aortic and/or mitral valve prosthesis were excluded from the MR group.

CARDIAC CT DATA ACQUISITION. Cardiac CT was performed using a 64-slice helical CT scanner (Discovery high-definition 750 or VCT, GE Healthcare, Milwaukee, Wisconsin). For controls, CT acquisition was undertaken according to the institutional protocol for performing retrospectively gated clinical cardiac CT. For patients with MR, a pre-specified clinical cardiac CT protocol was used. Imaging was performed during a single breath-hold following injection of 80 to 110 ml of intravenous contrast media (Visipaque 320, GE Healthcare) with a triphasic injection (contrast, contrast/saline mix, and saline) for controls and a biphasic injection (contrast and saline) for patients with MR. Tube voltage and current were manually determined (on the basis of BMI) with subsequent ECG modulation of tube current for controls to minimize radiation dose (median [interquartile range] effective dose 9.6 mSv [5.7 to 11.8 mSv] in controls and 14.1 mSv [11.3 to 20.2 mSv] in patients with MR). Scan range extended from the carina to just below the inferior cardiac surface. Axial images were reconstructed at 10% intervals of the cardiac cycle with a slice thickness of 0.625 mm.

CT DATA ANALYSIS. CT measurements were performed offline by batch analysis using dedicated software for MA segmentation (3mensio Structural Heart V7.0, Pie Medical Imaging, Maastricht, the Netherlands) and volumetric analyses (Aquarius iNtuition v4.4, TeraRecon, Foster City, California). Different observers separately assessed MA parameters and cardiac volumes (P.B. and C.N. performed