Mitral Annular Calcium and Mitral Stenosis Determined by Multidetector Computed Tomography in Patients Referred for Aortic Stenosis

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Mitral annular calcium (MAC) is a common finding in older patients referred for transcatheter aortic valve implantation (TAVI). Multidetector computed tomography (MDCT) allows fine quantification of the calcific deposits. Our objective was to estimate the prevalence of MAC and associated mitral stenosis (MS) in patients referred for TAVI using MDCT. A cohort of 346 consecutive patients referred for TAVI evaluation was screened by MDCT for MAC: 174 had MAC (50%). Of these patients, 165 patients (95%) had mitral valve area (MVA) assessable by MDCT planimetry (age 83.8 ± 5.9 years). Median mitral calcium volume and MVA were 545 mm^3 (193 to 1,253 mm^3) and 234 mm^2 (187 to 297 mm^2), respectively. The MS was very severe, severe, and moderate in 2%, 22%, and 10% patients, respectively. By multivariate analysis, MVA was independently correlated to mitral calcium volume, aortic annular area, and some specific patterns of mitral leaflet calcium. Based on these findings, a formula was elaborated to predict the presence of a significant MS. In conclusion, MDCT allows detailed assessment of MAC in TAVI populations, demonstrating a high prevalence. Mitral analysis should become routine during MDCT screening before TAVI as it may alter therapeutic strategy. © 2016 Elsevier Inc. All rights reserved. **(Am J Cardiol 2016;■:■−■)**

In patients referred for transcatheter aortic valve implantation (TAVI), mitral annular calcium (MAC) appears to have a relatively high prevalence. MAC may lead to mitral stenosis (MS).[1] Grading of MAC and MS remain a challenge by echocardiography.[2,3] Cardiac multidetector computed tomography (MDCT), however, allows a reliable study of calcium because of the specific x-ray absorption and the possibilities of 3-dimensional (3D) analysis. In degenerative aortic stenosis (AS), previous studies demonstrated the correlation between valve calcium volume and stenosis severity.[4] It was also demonstrated that MDCT can provide an accurate and reproducible planimetry of the mitral valve orifice in patients with MS in comparison with transthoracic echocardiography (TTE).[5] This study evaluates the characteristics of MAC and MS by cardiac MDCT in a pre-TAVI population and their relations with demographic data and defines criteria that might predict significant MS.

Methods

Pre-therapeutic evaluation for TAVI was performed in 346 consecutive high-risk patients with symptomatic severe AS from April 2010 to September 2012 in Hôpital Privé Jacques Cartier, Massy, France. All patients underwent routine cardiac MDCT and TTE. Therapeutic decisions were made by the Heart Team.

All MDCT examinations were performed using a Brilliance 64-slice MDCT scanner (Philips Medical, Amsterdam, Netherlands), with standard parameters including 120 kV tube voltage and retrospective ECG gating. Contrast enhancement was achieved with 50 to 80 ml of iomeprol 400 mg/ml. Beta blockade was not administered because of potential hemodynamic hazard in severe AS. Radiation dose was estimated by the dose-length product. Data were analyzed on a post-processing workstation (EBW; Philips Medical).

Mitral valves were studied retrospectively after patient discharge. The diastolic phase of the cardiac cycle with maximal mitral valve opening was selected. As previously described,[5] the mitral valve plane was selected using 4-chamber and 2-chamber views. Slice thickness was increased (10 to 20 mm) in average or minimal intensity projections to include mitral leaflets without papillary muscles, allowing delineation of the mitral orifice to evaluate mitral valve area (MVA). This assessment was done in all patients by the senior cardiac MDCT reader (E.B., American College of Cardiology/American Heart Association [ACC/AHA] level of proficiency 3) and in 152 randomly selected

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See page 6 for disclosure information.

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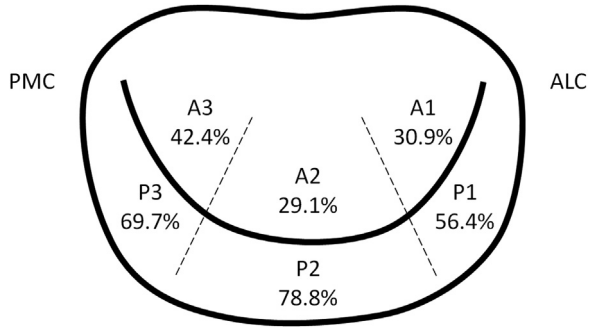

Figure 1. Incidence of mitral calcific deposits by segment in the study population of patients referred for TAVI workup. ALC = anterolateral commissure; PMC = posteromedial commissure.

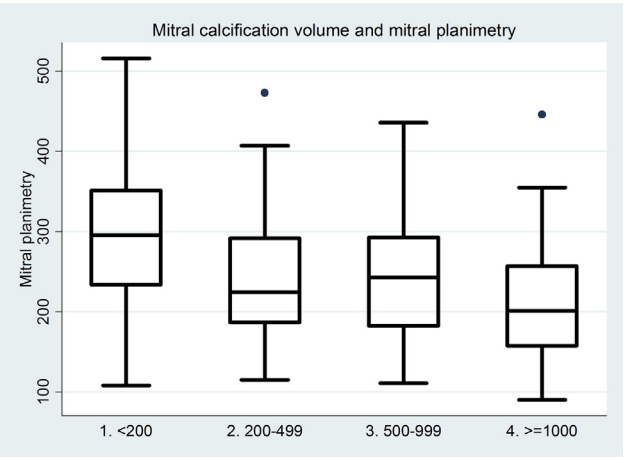

Figure 2. Box plots of MDCT mitral planimetry depending on classes of mitral valve calcium volume.

patients by a junior reader (S.M, level of proficiency 0) in a blinded fashion to evaluate interobserver agreement. Calcific deposits status of each segment of the mitral valve or annulus was noted. Similarly to a method previously described for aortic valve calcium,[6] mitral calcium volume was computed using a 3D threshold selecting voxels with a density >600 Hounsfield units inside the mitral valve volume (leaflet and annulus), with optional manual editing to exclude aortic or coronary calcium.

Contemporary to MDCT, all patients had standard 2-dimensional (2D) TTE examination using IE33 or CX50 ultrasound system with S3 probe (Philips Medical). Data were collected retrospectively. Planimetry measurements of the mitral orifice using 2D TTE were performed on a case-by-case basis by operators when morphology and mitral Doppler indexes were suggestive of MS. Four MS severity classes were defined similarly to ACC/AHA stages: class A or no significant MS, class B or moderate MS (TTE MVA 151 to 200 mm^2 and mean transmitral gradient <5 mm Hg), class C or severe MS (MVA 100 to 150 mm^2 or transmitral mean gradient 5 to 10 mm Hg), and class D or very severe MS (TTE MVA <100 mm^2 or transmitral mean gradient >10 mm Hg). Cardiologists performing these measurements were all highly experienced (ACC/AHA level of proficiency 3).

Categorical data are expressed as percentages and continuous data are expressed as median and interquartile range or mean ± SD. For unadjusted analyses, differences between groups were tested using chi-square tests for categorical data and Mann-Whitney nonparametric tests for continuous data. All variables corresponding to $p < 0.20$ in unadjusted analyses were retained for multivariate analysis, using stepwise descending logistic regression. A logit-based formula was elaborated to predict significant mitral valve stenosis.[7] Kappa coefficients (k) were used to approach interobserver reproducibility. All statistical analyses were performed using Stata (Release 10; StataCorp LP, College Station, Texas). The study was approved by our institutional review board.

Results

Of the 346 patients with severe AS screened for a TAVI procedure, MAC were found on MDCT in 174 patients (50%), mean age 83.8 ± 5.9 years, including 89 men. All examinations were suitable to topographic and volumetric analysis of mitral valvular calcium, MVA was not assessable in 9 patients (5%) because of a low signal/noise ratio or arrhythmia-related artifacts. During the CT examination, mean heart rate was 74 ± 15 beats/min and mean dose-length product was 1,165.2 ± 387.8 mGy·cm. Maximum mitral valve opening was found at phase 60% or 70% in most patients. Frequencies of mitral annulus calcium by segment are presented in Figure 1. Calcific deposits on the posterior mitral annulus were more frequent than on the anterior. Median mitral calcium volume was 545 mm^3 (193 to 1253 mm^3) and median MVA was 234 mm^2 (187 to 297 mm^2). According to planimetry, 4 patients (2%) had very severe MS (class D, MVA <100 mm^2), 16 patients (10%) had severe MS (class C, 100 $mm^2 \leq$ MVA < 150 mm^2), 36 patients (22%) had moderate MS (class B, 150 $mm^2 \leq$ MVA < 200 mm^2), and 109 patients (66%) had no significant MS (class A, MVA ≥ 200 mm^2). Comparison of mitral calcium volume and MVA by MDCT demonstrates significant but moderate correlation when studying linear regression (Pearson $r = -0.433$, $p < 0.001$) or quartiles (Figure 2).

Using a threshold of 200 mm^2 for significant MS in MDCT planimetry,[8] baseline characteristics are presented in Table 1. In the group with degenerative MS, women were more frequent and body surface areas smaller, whereas no difference was found in terms of cardiovascular risk factors or biologic characteristics. Calcific deposit patterns of mitral valve segments and calcium volumes of aortic and mitral valves are presented in Table 2. No difference between the 2 groups was found in terms of AS severity.

By multivariate analysis (Table 3), 3 parameters were independently correlated with the risk of presenting a significant degenerative MS: aortic annular area, some specific patterns of mitral leaflet calcium, and the mitral calcium volume. MVA was more closely correlated to the aortic annular area than to the body surface. Using these factors identified by multivariate analysis, a formula was built to estimate the risk of presenting a significant MS ≤200 mm^2, presented in the Supplementary Material. The estimated risk is expressed as a percentage and determined 3 groups according to the likelihood of having a significant MS: low