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Quantity and Location of Aortic Valve Complex Calcification Predicts Severity and Location of Paravalvular Regurgitation and Frequency of Post-Dilation After Balloon-Expandable Transcatheter Aortic Valve Replacement

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ABSTRACT

OBJECTIVES This study sought to determine the impact of quantity and location of aortic valve calcification (AVC) on paravalvular regurgitation (PVR) and rates of post-dilation (PD) immediately after transcatheter aortic valve replacement (TAVR).

BACKGROUND The impact of AVC in different locations within the aortic valve complex is incompletely understood.

METHODS This study analyzed 150 patients with severe, symptomatic aortic stenosis who underwent TAVR. Total AVC volume scores were calculated from contrast-enhanced multidetector row computed tomography imaging. AVC was divided by leaflet sector and region (Leaflet, Annulus, left ventricular outflow tract [LVOT]), and a combination of LVOT and Annulus (AnnulusLVOT). Asymmetry was assessed. Receiver-operating characteristic analysis was performed with greater than or equal to mild PVR and PD as classification variables. Logistic regression was performed.

RESULTS Quantity of and asymmetry of AVC for all regions of the aortic valve complex predicted greater than or equal to mild PVR by receiver-operating characteristic analysis (area under the curve = 0.635 to 0.689), except Leaflet asymmetry. Receiver-operating characteristic analysis for PD was significant for quantity and asymmetry of AVC in all regions, with higher area under the curve values than for PVR (area under the curve = 0.648 to 0.741). On multivariable analysis, Leaflet and AnnulusLVOT calcification were independent predictors of both PVR and PD regardless of multidetector row computed tomography area cover index.

CONCLUSIONS Quantity and asymmetry of AVC in all regions of the aortic valve complex predict greater than or equal to mild PVR and performance of PD, with the exception of Leaflet asymmetry. Quantity of AnnulusLVOT and Leaflet calcification independently predict PVR and PD when taking into account multidetector row computed tomography area cover index. (J Am Coll Cardiol Intv 2014;7:885–94) © 2014 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

AnnulusLVOT = annulus and left ventricular outflow tract

AUC = area under the curve

AVC = aortic valve calcification

Ca = calcification

CT = computed tomography

HU = Hounsfield units

LVOT = left ventricular outflow tract

MDCT = multidetector row computed tomography

PD = post-dilation

PVR = paravalvular regurgitation

ROC = receiver-operating characteristic

TAVR = transcatheter aortic valve replacement

TEE = transesophageal echocardiography

THV = transcatheter heart valve

Transcatheter aortic valve replacement (TAVR) is an expanding alternative to surgical replacement for patients with high operative risk (1-3). Paravalvular regurgitation (PVR) is an important complication of TAVR that has been shown to be associated with increased mortality (4-8). Thus, there is a growing body of literature regarding the determinants of PVR (4,9-18). Aortic valve calcification (AVC) has been proposed as one of these determinants; however, the location and pattern of calcification differ significantly between patients. The impact of calcification in various regions of the aortic valve complex (leaflets, annulus, and left ventricular outflow tract [LVOT]) is incompletely understood. In theory, calcification impairs the seal of the transcatheter heart valve (THV) to the aortic annulus and LVOT, resulting in PVR.

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In the present study, our aim was to identify the impact of calcification of different locations of the aortic valve complex on the severity of PVR and to determine whether quantification of AVC by location accurately predicts the location of PVR. Additionally, we sought to determine whether calcification predicts the need for balloon post-dilation (PD), an important surrogate for PVR.

METHODS

PATIENT POPULATION AND PROCEDURE. This analysis included patients who underwent TAVR with a balloon-expandable Edwards Sapien or Sapien XT THV (Edwards Lifesciences, Irvine, California) in a single academic medical center from October 1, 2011 to July 31, 2013. All patients entering the analysis were required to have undergone both pre-procedural multidetector row computed tomography (MDCT) and intraprocedural transesophageal echocardiography (TEE) and were therefore nonconsecutive. After review of 218 charts, 150 patients were included in the final analysis on this basis. No patients were excluded from the analysis on the basis of imaging quality. The procedural access route was determined by the treating physicians. THV sizing was determined at the discretion of the treating physicians with the use of all available imaging modalities (MDCT and 3-dimensional TEE). All patients gave informed consent and the study was approved by the institutional review board for human research. The need for PD was decided by the treating physicians and was typically on the basis of the immediate post-deployment TEE imaging of more than mild PVR.

IMAGE ACQUISITION. Echocardiography. Patients underwent intraprocedural TEE using commercially available equipment (iE33, Philips Medical Imaging, Andover, Massachusetts). A complete 2-dimensional and 3-dimensional TEE was performed pre- and post-THV implantation as recommended by the American Society of Echocardiography guidelines (19).

MDCT. Our methodology for MDCT acquisition with a 320-slice scanner (Aquilion ONE, Toshiba Medical Systems, Otawara, Japan) has been previously described (18). Prior to April 27, 2013, iodixanol 320 mg I/ml (124 patients) was used; thereafter, iohexol 350 mg I/ml (26 patients) was used. Intravenous contrast was injected at a rate of 3.5 ml/s. Datasets were transmitted to a dedicated workstation and analyzed using 3mensio Valves software (version 5.1, Pie Medical Imaging, Maastricht, the Netherlands).

MDCT AORTIC ANNULUS MEASUREMENTS. The aortic annulus was defined as a virtual plane containing the basal attachment points of the 3 aortic valve leaflets in the LVOT. Annular area was planimetered directly in the short-axis plane. The area cover index representing the percentage of oversizing of the THV as compared with the measured annulus size was calculated using the formula ([nominal THV area - measured area]/nominal THV area) $\times$ 100%. All annulus measurements were performed in mid-systole.

MDCT QUANTIFICATION OF AORTIC VALVE CALCIFICATION. AVC was quantified using calcium volume scoring on contrast-enhanced images in keeping with recent investigations (9,14) and in light of the increased reproducibility compared with Agatston scoring (20,21). Contrast imaging allows for higher spatial resolution than do noncontrast images to delineate different leaflets and regions within the aortic valve complex. Quantification was performed by a cardiologist board-certified in cardiac CT who had previously reviewed at least 300 TAVR cases (O.K.K.). The late-diastolic phase with the best visually assessed image quality was used. An empiric CT number cutoff of 550 Hounsfield units (HU) was used for AVC quantification for most patients. However, given the variability of luminal enhancement in contrast-enhanced images, for patients with luminal attenuation <200 HU (11 patients), a cutoff of 300 HU was used for AVC quantification; for patients with luminal attenuation >500 HU (36 patients), a cutoff of 50 HU greater than the luminal attenuation