JACC: CARDIOVASCULAR INTERVENTIONS
VOL. 4, NO. 11, 2011

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER INC.
DOI: 10.1016/j.jcin.2011.07.014

Aortic Annulus Diameter Determination by Multidetector Computed Tomography

Reproducibility, Applicability, and Implications for Transcatheter Aortic Valve Implantation

Ronen Gurvitch, MBBS,* John G. Webb, MD,* Ren Yuan, MD,* Mark Johnson, MBBS,* Cameron Hague, MD,* Alexander B. Willson, MBBS,* Stefan Toggweiler, MD,* David A. Wood, MD,* Jian Ye, MD,* Robert Moss, MD,* Christopher R. Thompson, MD,* Stephan Achenbach, MD,† James K. Min, MD,‡ Troy M. LaBounty, MD,‡ Ricardo Cury, MD,§ Jonathon Leipsic, MD*

British Columbia, Vancouver, Canada; Erlangen, Germany; Los Angeles, California; and Miami, Florida

Objectives This study sought to determine the most reproducible multidetector computed tomography (MDCT) measurements of the aortic annulus and to determine methods to improve the applicability of these measurements for transcatheter aortic valve implantation.

Background The reproducibility and applicability of MDCT annular measurements to guide transcatheter aortic valve implantation remain unclear.

Methods Annular measurements were performed in 50 patients planed for transcatheter aortic valve implantation in multiple planes: basal ring (short- and long-axis, mean diameter, area-derived diameter), coronal, sagittal, and 3-chamber projections. A theoretical model was developed taking into account the differences between the most reproducible MDCT measurements and transesophageal echocardiography to guide valve size choice.

Results The most reproducible measurements were the area-derived diameter and basal ring average diameter (inter-reader intraclass correlation coefficient: 0.87 [95% confidence interval: 0.81 to 0.92] and 0.80 [95% confidence interval: 0.70 to 0.87]; respectively; intrareader >0.90 for all readers). These were generally larger than transesophageal echocardiography diameters (mean difference of 1.5 ± 1.6 mm and 1.1 ± 1.7 mm, respectively). When a strategy of valve-sizing is undertaken using these CT measurements using an echocardiographic sizing scale, a different THV size would be selected in 44% and 40% of cases, respectively. When adjusting the sizing cutoffs to account for the differences in observed diameters, this was reduced to 10% to 12% ($p < 0.01$ for both, respectively).

Conclusions The most reproducible MDCT measurements of the annulus are the area-derived diameter and basal ring average diameter, with derived values generally larger than those obtained with echocardiography. If MDCT is used for valve sizing, a strategy incorporating these differences may be important. MDCT using these easily derived measurements may be ideally suited to sizing transcatheter aortic valves as they account for the eccentricity of the aortic annulus, are reproducible, and are noninvasive. (J Am Coll Cardiol Intv 2011; 4:1235–45) © 2011 by the American College of Cardiology Foundation

From the *St. Paul's Hospital, University of British Columbia, Vancouver, Canada; †University of Erlangen, Erlangen, Germany; ‡Departments of Medicine, Imaging, and Biomedical Sciences, Cedars-Sinai Medical Center, Los Angeles, California; and the §Baptist Hospital of Miami, Miami, Florida. Dr. Webb is a consultant for Siemens and Edwards Lifesciences. Dr. Wood is a consultant for Edwards Lifesciences. Dr. Ye is a consultant to Edwards Lifesciences. Dr. Achenbach receives research support from Siemens Healthcare and Bayer Schering. Dr. Min is on the Speaker's Bureau of GE Healthcare; is a consultant for Edwards Lifesciences; and has equity interest in TC3. Dr. Leipsic is on the Speaker's Bureau and advisory board of Edwards Lifesciences; and he is on the Speaker's Bureau for GE Healthcare and Equity Stakeholder TC3 Corelab. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received April 1, 2011; revised manuscript received June 30, 2011, accepted July 21, 2011.

JACC: CARDIOVASCULAR INTERVENTIONS, VOL. 4, NO. 11, 2011
NOVEMBER 2011:1235–45

Transcatheter aortic valve implantation (TAVI) is becoming an accepted procedure for selected patients with severe aortic stenosis (1). Accurate evaluation of the native aortic valve annular dimensions is critical to optimize selection of the correct bioprosthetic valve size. In contrast to surgical aortic valve replacement where surgeons perform valve sizing under direct visualization and with the aid of annular sizing probes, noninvasive imaging methods are generally required in the setting of TAVI. Incorrect valve sizing may lead to paravalvular aortic regurgitation, which is a predictor of worse long-term outcome (2), valve embolization, patient prosthesis mismatch, or catastrophic annular rupture (3,4).

Given the complex shape of the aortic annulus, which includes a generally noncircular profile coupled with a conical form that is bounded at its nadir by the attachment of the 3 aortic leaflets (5), accurate evaluation by 2-dimensional imaging modalities, such as echocardiography, is intrinsically difficult. Recently, 3-dimensional multidetector computed tomography (MDCT), which is not limited by planar imaging, has been shown to provide fine anatomical detail and accurate assessment of the complex anatomical shape of the aortic valve and annulus (6–8). Whereas some have suggested that MDCT-derived measurements may better serve as a gold standard for aortic valve sizing, the reproducibility, reliability, and applicability of these measurements have not been well defined. Furthermore, the clinical utility of MDCT measures remains limited. Previous studies have also suggested that despite propitious clinical outcomes of patients undergoing TAVI with echo-based aortic valve sizing, an MDCT-based valve sizing strategy might result in up to 39% of cases requiring a different valve size or exclusion from candidacy for TAVI using currently available devices (9–11). However, these prior MDCT studies employed aortic annular measurements in limited planes and without systematic adjustment for discordance between MDCT and echocardiographic modalities.

Abbreviations and Acronym

CI = confidence interval

ICC = intraclass correlation coefficient

IQR = interquartile range

MDCT = multidetector computed tomography

TAVI = transcatheter aortic valve implantation

TEE = transesophageal echocardiography

TTE = transthoracic echocardiography

In the present study, we thus aimed to: 1) evaluate the aortic annular dimensions in patients undergoing TAVI using MDCT in multiple planes; 2) assess which measurements have the greatest interobserver and intraobserver reproducibility; and 3) determine the difference in valve sizing recommendations if MDCT measurements are used according to current (transesophageal echocardiography [TEE]–based) sizing cutoffs ("unadjusted criteria") versus a strategy of incorporating the observed differences between MDCT and echocardiography into the sizing criteria ("adjusted criteria").

Methods

Patient population. Fifty patients with severe symptomatic aortic stenosis being considered for TAVI underwent preprocedural evaluation using MDCT imaging. Forty-one of these patients underwent TAVI, and all these patients had matched transthoracic echocardiography (TTE) and TEE images. Patients with bicuspid aortic stenosis were excluded. MDCT was clinically indicated for evaluation before the procedure to assess the peripheral vasculature and determine the optimal angiographic projection angles for valve implantation (12,13). Following implantation, implantation height was angiographically defined as optimal or suboptimal, with optimal position defined as occurring when the native leaflet insertion point was within the middle third of the stent frame. All other valve positions were defined as suboptimal.

Patients were evaluated by a team of senior cardiologists and cardiothoracic surgeons to determine if they posed a prohibitively high surgical risk before being accepted for TAVI. Patients underwent transfemoral or transapical implants of Edward Sapien/Sapien XT balloon expandable bioprostheses (Edwards Lifesciences, Irvine, California) of 23-mm, 26-mm, or 29-mm diameter with valve size chosen based on annulus diameters as derived by TEE as previously described (14–18).

CT images acquisition. MDCT examinations were performed on a 64-slice Discovery HD 750 High Definition scanner (GE Healthcare, Milwaukee, Wisconsin), and 80 to 120 ml of iodixanol 320 (GE Healthcare, Princeton, New Jersey) were injected at 5 ml/s followed by 30 ml of normal saline. The timing delay of the scan was determined using a smart prep of the ascending aorta with a preset threshold of 150 Hounsfield units. The MDCT examinations were performed in the craniocaudal direction with retrospective gating from the aortic arch through to the diaphragm. Heart rate reduction with beta-blockade was avoided as interpretation of the coronary arteries was not required and because of clinical concern regarding severe aortic stenosis. MDCT scanner detector collimation width was 0.625 mm, detector coverage was 40 mm, reconstructed slice thickness was 1.25 mm, and the slice interval was 1.25 mm. Gantry rotation time was 0.35 s, and the scan pitch ranged between 0.16 and 0.20 (adjusted per heart rate). Depending on the patient size, the maximum tube current ranged between 450 and 700 mA with a fixed tube voltage of 100 kVp for patients with a body mass index <30 kg/m^2 and 120 kVp used in larger patients. Electrocardiography-gated dose modulation was used with tube current reduced to 60% of maximum tube current in systole. This provided adequate image