Journal of Cardiovascular Computed Tomography 8 (2014) 299–306

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofCardiovascularCT.com

Original Research Article

Aortic valve and aortic root features in CT angiography in patients considered for aortic valve repair

*Madelien V. Regeer MD, Vasileios Kamperidis MD, MSc, Michel I.M. Versteegh MD, Robert J.M. Klautz MD, PhD, Arthur J.H.A. Scholte MD, PhD, Jeroen J. Bax MD, PhD, Martin J. Schalij MD, PhD, Nina Ajmone Marsan MD, PhD, Victoria Delgado MD, PhD**

Department of Cardiology, Heart Center Leiden, Leiden University Medical Center, Albinusdreef 2, 2333 ZA Leiden, The Netherlands

ARTICLE INFO

Article history:
Received 3 April 2014
Received in revised form
19 June 2014
Accepted 23 June 2014

Keywords:
Aortic root pathology
Aortic regurgitation
Computed tomography
Aortic valve repair
Aortic root replacement

ABSTRACT

Background: The underlying mechanism of aortic regurgitation and aortic valve and root characteristics are associated with the durability of surgical repair.

Objective: We investigated whether multidetector CT (MDCT) identifies the characteristics of the aortic valve and root that may be associated with the ability to perform successful surgical repair.

Methods: Sixty-one patients with aortic regurgitation and/or aortic root pathology who were evaluated for aortic valve or root repair and underwent clinically indicated gated or non-gated MDCT of the aortic valve and aortic root were included in the present analysis. Patients with endocarditis were excluded. MDCT data of aortic valve anatomy and calcification and thoracic aorta dimensions were analyzed.

Results: The aortic valve and root was successfully repaired in 36 patients (55 ± 13 years; 61% male; median EuroSCORE II, 3.8%) whereas in 25 patients (56 ± 15 years; 52% male; median EuroSCORE II, 2.5%) repair was not attempted (n = 20) or valve repair was converted to aortic valve replacement during surgery (n = 5). In patients in whom repair was considered not possible or failed, there was a higher percentage of bicuspid aortic valves (48% vs 17%; P = .019), more severe commissural calcification, and more severe annular calcification.

Conclusion: The degree of commissural and annular calcification of the aortic valve determined by MDCT is inversely related to the ability to perform surgical valve repair instead of replacement. Similarly, bicuspid valve anatomy predicts failure to perform repair.

Conflicts of interest: V.D. received consulting fees from St. Jude Medical and Medtronic. V.K. received a European Society of Cardiology training grant and a Hellenic Society of Cardiology training grant. The remaining authors declare no conflicts of interest.

The Department of Cardiology received grants from Biotronik, Medtronic, Boston Scientific Corporation, St. Jude Medical, Sandra Lotus, and GE Healthcare.

Dr M.V. Regeer and Dr V. Kamperidis contributed equally to this study.

* Corresponding author.
E-mail address: v.delgado@lumc.nl (V. Delgado).

1934-5925/$ – see front matter
http://dx.doi.org/10.1016/j.jcct.2014.06.008

1. Introduction

Valve-sparing aortic root replacement techniques are successfully performed in selected patients with aortic regurgitation (AR) and/or aortic root pathology.[1–4] The underlying mechanism of AR and several morphologic characteristics of the aortic valve and root have been associated with durable aortic valve repair.[5] Based on direct surgical inspection, a classification of AR mechanisms has been developed to guide the decision and feasibility of surgical aortic valve repair.[6] In AR type 1 (functional aortic annulus dilation) and AR type 2 (cusp prolapse), different aortic root and valve repair techniques may be applied unless the valve is heavily calcified. In contrast, in AR type 3 (cusp restriction), repair techniques are not recommended as the risk of failed repair and recurrent significant AR is high.[6] In addition, wide preoperative aortoventricular junction (AVJ) is associated with recurrence of AR after aortic valve repair.[7]

Two-dimensional transesophageal echocardiography (TEE) has been applied (1) to identify the underlying mechanism of AR, (2) to characterize the anatomy and morphology of the aortic valve, (3) to assess geometry of the aortic root, and (4) to predict surgical reparability.[5] However, 2-dimensional TEE underestimates the diameters of the functional aortic annulus as compared with multidetector CT (MDCT).[8,9] MDCT provides high spatial resolution data of the aortic valve and root characteristics and permits qualitative (morphology of aortic valve and root, extent of annulus, cusps, and commissural calcification) and quantitative (dimensions) evaluation of the aortic valve and root that may be relevant for decision making.[10] The aim of the present study was to investigate whether MDCT provides preoperative insight into characteristics of the aortic valve and root that may be associated with feasible and successful aortic valve repair.

2. Methods

2.1. Patients

The institutional ethical committee approved this retrospective evaluation of clinically acquired data and waived the need for individual written patient consent. A total of 168 patients with AR and/or aortic root pathology were evaluated for surgical valve-sparing aortic root repair at the Leiden University Medical Center between 2003 and 2013. Patients with available preoperative MDCT data of the aortic valve and root were considered eligible for the present study. Patients with endocarditis were excluded. The study population consisted of 61 patients with AR and/or aortic root pathology. MDCT data of aortic valve anatomy and calcification and aortic root dimensions were analyzed and compared between patients who underwent successful valve-sparing aortic root repair (defined as postoperative AR <grade 2) and patients in whom repair was not successful or not feasible and who eventually underwent aortic root replacement using the Freestyle stentless bioprosthesis (Medtronic, Minneapolis, MN). Clinical and surgical data were collected in the departmental cardiology information system (EPD-Vision; Leiden University Medical Center, Leiden, the Netherlands) and retrospectively analyzed.

2.2. Multidetector computed tomography

MDCT studies were performed to evaluate the presence and extent of aortic root pathology within the Leiden University Medical Center in 40 patients with a 320-slice, 64-slice, or 16-slice MDCT scanner (Aquilion; Toshiba Medical Systems, Tokyo, Japan). In the remaining 21 patients, the MDCT studies were performed at the referral hospitals. MDCT angiography data acquisition extended from above the aortic arch to the diaphragm, including the entire thoracic aorta. MDCT data were acquired during breathhold in deep inspiration, with tube potential of 100 or 120 kV and tube current adapted to body habitus, with intravenous contrast enhancement and no electrocardiographic triggering in 77% of patients. In 14 patients (23%), the scans were electrocardiographically triggered at 45% or 75% of the R-R interval. Data were reconstructed with a slice thickness of 0.5 to 5 mm. All the MDCT data sets were loaded for off-line analysis to a dedicated remote workstation (Vitrea fX 1.0; Vital Images, Minnetonka, MN). MDCT angiography was not performed in patients with chronic kidney disease stage 4 or 5. Chronic kidney disease stage 3 (estimated glomerular filtration rate, 30–59 mL/min) was present in 8 patients. These patients were hydrated orally or intravenously before and after MDCT to prevent contrast-induced nephropathy.

Data analysis was performed by 2 experienced observers blinded to the reparability of the valve. Anatomy of the aortic valve (tricuspid or bicuspid), the degree of calcification of aortic valve, and AVJ[10,11] and the diameter of thoracic aorta at 10 different levels were evaluated.[12,13]

Three orthogonal multiplanar reformation (MPR) planes were oriented to obtain the cross-sectional plane parallel to the AVJ, just below the hinge points of the coronary cusps.[11] By orienting the reconstructed single-oblique sagittal and coronal views across the aortic annulus, the true short-axis of the AVJ was displayed on the reconstructed double-oblique transverse view.[11] On this view, the anatomy of aortic valve (tricuspid or bicuspid) was identified, and the grade of commissural calcification was qualitatively assessed based on a scale from 0 to 3 (0 = no calcification, 1 = small calcium spots <5 mm, 2 = several calcium lesions >5 mm, and 3 = heavy calcification of all cusps; Fig. 1).[10,11] In addition, annular calcification was also visually assessed on a scale from 0 to 3 (0 = no calcification, 1 = 1 or multiple spots <5 mm or 1 spot >5 mm, 2 = 2–3 spots >5 mm, and 3 = >3 spots of >5 mm diameter; Fig. 1).[10] From the double-oblique view, the centerline was determined and on the orthogonal coronal and the single-oblique sagittal views, the coronal, and sagittal AVJ diameters were measured[11] (Fig. 2) and the average diameter was calculated. The AVJ shape was evaluated by calculating the eccentricity index = 1 − (sagittal or coronal diameter); when the result of the equation was ≥ 0.1, the aortic annulus was considered ellipsoid.[14] Next, the diameter of the sinus of Valsalva (SOV) and sinotubular junction (STJ) at the single-oblique sagittal view, orthogonal to the double-oblique transverse view, were measured.[13]

The diameters of the different levels of the thoracic aorta (at the level of the tubular ascending aorta, proximal and distal to the innominate trunk, proximal and distal to the left subclavian artery, proximal descending aorta, and at the level