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Association Between Bicuspid Aortic Valve Phenotype and Patterns of Valvular Dysfunction and Bicuspid Aortopathy

Comprehensive Evaluation Using MDCT and Echocardiography

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OBJECTIVES We sought to define the clinical importance of an integrated classification of bicuspid aortic valve (BAV) phenotypes and aortopathy using multidetector computed tomography (MDCT).

BACKGROUND An association between BAV phenotypes and the pattern of valvular dysfunction or bicuspid aortopathy has yet to be definitely established.

METHODS The study cohort included 167 subjects (116 men, age 54.6 ± 14.4 years) who underwent both MDCT and transthoracic echocardiography from 2003 to 2010. Two BAV phenotypes—fusion of the right and left coronary cusps (BAV-AP) and fusion of the right or left coronary cusp and noncoronary cusp (BAV-RL)—were identified. Forty-five patients showed normal aortic dimensions and were classified as type 0. In the remaining patients, hierarchic cluster analysis showed 3 different types of bicuspid aortopathy according to the pattern of aortic dilation: type 1 (aortic enlargement confined to the sinus of Valsalva [n = 34]), type 2 (aortic enlargement involving the tubular portion of the ascending aorta [n = 49]), and type 3 (aortic enlargement extending to the transverse aortic arch [n = 39]).

RESULTS The prevalence of BAV-AP and BAV-RL was 55.7% and 44.3%, respectively. Comparing BAV-AP and BAV-RL, no differences in age or in the prevalence of male sex were determined. However, significant differences in the valvular dysfunction pattern were noted, with moderate-to-severe aortic stenosis predominating in patients with BAV-RL (66.2% vs. 46.2% in BAV-AP; $p = 0.01$), and moderate-to-severe aortic regurgitation in BAV-AP (32.3% vs. 6.8% in BAV-RL; $p < 0.0001$). A normal aorta was the most common phenotype in BAV-AP patients (33.3% vs. 18.9% in BAV-RL; $p = 0.037$), and type 3 aortopathy was the most common phenotype in BAV-RL patients (40.5% vs. 9.7% in BAV-AP; $p < 0.0001$).

CONCLUSIONS The patterns of valvular dysfunction and bicuspid aortopathy differed significantly between the 2 BAV phenotypes, suggesting the possibility of etiologically different entities. (J Am Coll Cardiol Img 2013;6:150–61) © 2013 by the American College of Cardiology Foundation

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Bicuspid aortic valve (BAV) is the most common congenital malformation, and it is responsible for a significant proportion of aortic valve replacements in adults (1–3). In addition to the marked phenotypic heterogeneity of BAV, there is a strong association with dilation of the ascending aorta (4–7). Indeed, aortopathy in BAV is a challenging clinical issue, and both pathogenesis and treatment are controversial. Moreover, not only is there marked variability in the phenotype of bicuspid aortopathy, but the presence and severity of the aortic dilation appear to be independent of the degree of valvular dysfunction (8–11). A sophisticated morphogenetic study showed that BAVs with different phenotypes develop at different embryonic stages and can, therefore, be viewed as etiologically distinct entities (12). It also has been suggested that the same etiological factors giving rise to the different BAV phenotypes are involved in the occurrence and progression of the associated valvular dysfunction or bicuspid aortopathy (12). However, although an integrated phenotypic classification that takes into account both BAV and the bicuspid aortopathy seems to be a logical approach to better understanding these pathologies, only a few clinical reports are available, and their therapeutic impact has not been fully explored (5,13–18).

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Echocardiography is the main imaging modality used to evaluate aortic valve and aortic pathology in patients with BAV, but this modality suffers from inherent flaws in terms of limited resolution and its inability to assess the entire aorta. Recently, excellent images of both the aortic valve and the aorta along its complete length have been obtained with computed tomography and magnetic resonance imaging in routine clinical practice. Accordingly, these techniques are being used with increasing frequency to better assess BAV and bicuspid aortopathy (17,18). Nonetheless, most studies published thus far have focused on pathology of either the aortic valve or the aorta itself, seldom considering the possible occurrence in both (5,13–15,17,18). Furthermore, those studies failed to thoroughly evaluate hemodynamic data obtained by echocardiography. Consequently, a potential association between BAV phenotypes and valvular dysfunction has not been seriously considered in the literature. Therefore, the aims of the present study were to: 1) evaluate bicuspid aortopathy phenotypes in patients with different types of BAV; and 2) assess the potential association between these 2 disease entities and clinical parameters, including hemodynamic variables. In this comprehensive evaluation, both echocardiography (to assess valvular dysfunction) and multidetector computed tomography (MDCT) (to phenotypically classify BAV and bicuspid aortopathy) were used.

METHODS

Subjects. From April 2003 to August 2010, 198 patients with BAV underwent MDCT to evaluate the coronary artery anatomy, aortic valve morphology including calcification, and aorta dilation for pre-operative evaluation. All patients were symptomatic or showed marked mediastinal widening and were referred for consultation of the timing of surgical intervention. From 2003 to 2006, 55 patients underwent MDCT examination with a 16-detector MDCT; from 2007 to 2010, 143 patients were evaluated with a dual-source MDCT scanner. Of these 198 patients, 31 were excluded from the study because the MDCT datasets did not cover the entire aortic arch and descending thoracic aorta. Thus, the study population consisted of 167 patients (mean age, 54.6 ± 14.4 years), of which 116 were men (69.0%). This retrospective study was approved by our institutional review board.

MDCT technique. No patients needed pharmacological agents to control heart rate during the MDCT examinations, as their heart rates were <85 beats/min; however, all patients received 0.6-mg nitroglycerin sublingually 1 min before the examination to dilate the coronary arteries if the patients had no contraindication. Contrast agent was administered using a bolus-tracking technique. For all computed tomography (CT) studies, a dual-head power injector (Stellant D, Medrad, Indianola, Pennsylvania) was used to administer the 2-phase bolus at a rate of 3.5 to 4.0 ml/s, with a total volume of 100 ml of iomeprol that has the iodine concentration of 400 mg/ml (Iomeron 400, Bracco Imaging, Milan, Italy), followed by 40 ml of saline chaser. The bolus tracking method was used for the start of the scan; CT image acquisition was started 7 s after the signal density reached a pre-defined threshold of 120 Hounsfield units at the region of interest on the ascending aorta.

ABBREVIATIONS AND ACRONYMS

AR = aortic regurgitation
AS = aortic stenosis
BAV = bicuspid aortic valve
BAV-AP = bicuspid aortic valve with fusion of the right and left coronary cusps
BAV-RL = bicuspid aortic valve with fusion of the right or left coronary cusp and noncoronary cusp
CT = computed tomography
ECG = electrocardiogram
MDCT = multidetector computed tomography
Vmax = peak systolic velocity