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Original Research Article

CARDIAC CT DIAGNOSTIC UTILITY IN THE ASSESSMENT OF BICUSPID AORTIC STENOSIS: A COMPARATIVE STUDY WITH ECHOCARDIOGRAPHY AND OPERATIONAL RESULTS

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Abstract: *The bicuspid aortic valve is the most prevalent congenital cardiac abnormality, often leading to symptoms in middle-aged individuals. It is a significant determinant of aortic valve dysfunction in the young population. This study aimed to assess the diagnostic utility of cardiac CT in evaluating individuals with bicuspid aortic valve disease. Thirty consecutive individuals with aortic stenosis who underwent surgical valve repair from January 2021 to July 2022 at Chaudhary Pervez Ellahi Institute of Cardiology Multan, Pakistan, were included in the study. ECG-gated CT and echocardiography were performed utilising a 64-MDCT scanner. Imaging findings regarding the number of aortic valve leaflets (bicuspid or tricuspid) were compared with intraoperative observations. Statistical analysis was conducted using one-way univariate analysis of variance. The aortic valve area (AVA) was assessed using CT and echocardiography, and the results were statistically analysed using a paired Student's t-test.***:** *Eleven 30 patients had bicuspid aortic valves, while nineteen had tricuspid aortic valves. Echocardiography failed to determine the type of aortic valve in five patients due to severe calcification. The sensitivity, specificity, positive predictive value, and negative predictive value for detecting a bicuspid aortic valve were 75.5%, 60.3%, 67.6%, and 93.5%, respectively, for echocardiography, and 93.7%, 100%, 100%, and 96.7%, respectively, for CT. CT findings were not significantly different from perioperative observations (p = 0.87), while echocardiographic results were (p < 0.05). CT and echocardiography yielded AVA measurements of 0.931 ± 0.42 cm2 and 0.649 ± 0.241 cm2, respectively, with a significant difference (p < 0.05). ECG-gated cardiac CT provides a reliable morphologic diagnosis of bicuspid aortic stenosis, especially in individuals with significant valve calcification.*

Keywords: Aortic Valve, Bicuspid Valve, Cardiac CT, Echocardiography

Introduction

The bicuspid aortic valve is among the most prevalent congenital heart abnormality (1). It is a primary cause of aortic valve dysfunction in young adults, and symptoms usually appear in middle age (2, 3). Aortic stenosis is among the most common consequences of a bicuspid aortic valve, which necessitates a replacement of the aortic valve in numerous individuals (4). Numerous BAV patients acquire aortic stenosis due to progressive calcification and reduced leaflet movement (5). In addition to aortic stenosis development, the likelihood of aortic dissection or rupture is more significant among individuals with a BAV than the rest of the population (6).

Since aortic valve replacement alone cannot prevent increasing dilatation of the ascending aorta in individuals with a bicuspid aortic valve, surgical valve replacement, valve repair, and ascending aortic replacement are all necessary (7) (8). CT is a noninvasive scan method that can provide precise morphologic details regarding the aortic valve. Previous studies have shown excellent diagnostic precision for the identification of BAV compared to transthoracic echocardiography (8, 9).

The specific kind of valve must be accurately identified prior to surgery to select the best surgical repair method. The current study aimed to determine the diagnostic utility of cardiac CT in evaluating individuals with bicuspid aortic valve dysfunction.

Methodology

CT and echocardiography were used to evaluate thirty sequential aortic stenosis patients who had surgical valve replacement between April 2021 and July 2022 at Chaudhary Pervez Ellahi Institute of Cardiology Multan, Pakistan. Due to the study's retrospective design, our institutional committee on medical ethics approved the waiver of patient informed consent. The accepted frame of reference for determining whether a bicuspid or tricuspid valve was present was thought to be the intraoperative results.

Upon obtaining oral informed consent, CT was used to calculate the ascending aorta's size, determine the extent of coronary artery disease, and determine the severity of atherosclerotic changes by looking for plaque and calcification of the ascending aortic wall. Utilising a 64-MDCT scanner, contrast-enhanced CT was carried out while breathing at the end of inhalation. 200 mm was the reconstructed field of view; 135 kV for tube voltage; 300–350 mA for tube current; 0.5 mm for slice thickness; and 0.35–0.4 s/rotation for gantry spin rate were the imaging settings. Using a 22-gauge peripheral IV line inserted into the right antecubital vein, 0.525 g of iodine per kg of body weight was given at an administration rate of 1.575 g/s for IV contrast material. After the contrast material injection, each patient received a 30-mL saline flush. Using an acceptable level of 200 HU in the left ventricle, the manually performed bolus-tracking approach managed the start time of the scan. Due to patient table motion and mechanical delays, there was a 5-second scan delay

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following the trigger. Aortic valve anatomy was assessed during the optimal cardiac phase using images taken from 15% to 35% at 5% intervals for the systolic cycle and 65% to 75% at 5% intervals for the diastolic cycle. Two radiologists blind to the surgical and echocardiographic results examined each reconstructed image independently. A radiologist also carefully traced the aortic valve area (AVA) toward the end-systolic stage, when the aortic valve was nearly fully open. The estimated AVA readings determined by Doppler echocardiography were analysed using the AVA measurements acquired by CT. The diagnostic features that determined the type of valve were the number and arrangement of leaflets, the existence of a raphe (which in turn was assessed based on its extension to the aortic annulus or the leaflet border), and the design of the opening (oval or triangular). The intraoperative findings and the morphologic details from the CT scan were compared.

Detailed echocardiographic investigations, including Doppler measures and 2D M-mode scanning, were carried out on all patients by skilled sonographers utilising various diagnostic ultrasound equipment. Expert cardiologists with over ten years of expertise evaluated the pictures while blind to the CT results.

The paired Student's t-test was utilised to examine and compare the AVA values acquired from CT and echocardiography. Results were deemed statistically significant when the two-tailed test produced p-values less than 0.05. The number of leaflets found by CT and echocardiography was correlated with the intraoperative results and subjected to a one-way univariate analysis of variance to evaluate the diagnostic accuracy. If the p-values obtained were less than 0.05, the differences in the results were deemed statistically significant. SPSS version 21 was used for all statistical analyses.

Results

Thirty patients were enrolled in our study. The mean age of the participants was 49.34 ± 10.6 years. Most of the patients were male, 70%, as compared to females, 30%. The mean body surface area was 1.5 ± 0.3 m2, and our study population's mean body mass index was 26.2 ± 2.6 kg/m2. Diabetes was found in 26.6% of the study population, hypertension in 43.3%, CAD in 30%, and dyslipidemia was present.

Table 1: Patients demographics

Variable	Result N=30 n,%
Age in years (Mean ± SD)	49.34 ± 10.6
Gender	
Male	21 (70)
Female	9 (30)
Body surface area (m2)	1.5 ± 0.3
Body mass index kg/m2	26.2 ± 2.6
Comorbidities	
Diabetes	8 (26.6)
Hypertension	13(43.3)
Coronary artery disease	9 (30)
Dyslipidemia	8 (26.6)

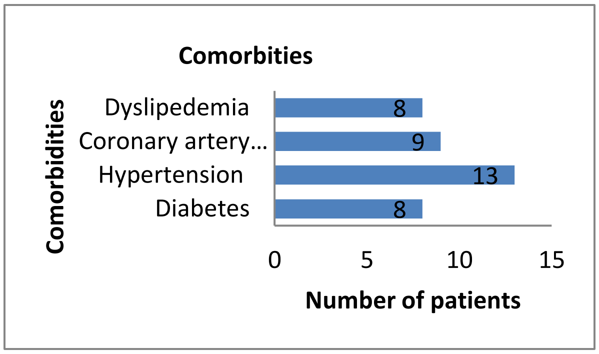

Fig 1 Showing comorbidities among the study population

On CT results, a bicuspid aortic valve was diagnosed in 10 individuals and a tricuspid aortic valve in 20 individuals. In comparison, operative findings revealed a bicuspid aortic valve in 11 individuals and a tricuspid aortic valve in 19 individuals. Table 2 shows the CT findings and their comparison with the operative findings. Regarding the two radiologists' analysis of the CT scans, their kappa score for interobserver agreement was 0.949. The sensitivity, specificity, positive predictive value, and negative predictive value of cardiac CT were 93.7%, 100%, 100%, and 96.7%, respectively. The diagnostic accuracy of CT was 96.6% (29/30).

Table 2: The efficacy of CT to diagnose the bicuspid aortic valve

Variable	Ct findings n,%	Operative findings n,%	P value
Bicuspid	10 (33.3)	11 (36.6)	0.87
Tricuspid	20 (67.7)	19 (63.4)	
Total	30	30	

On transthoracic echocardiography, a bicuspid aortic valve was found in 40.7%, while according to the operative findings, which were our reference point, 36.6% had a bicuspid aortic valve. A similarly tricuspid aortic valve was found in 43.3% of the cases on echo, but on operative findings, it was 63.4%. Five cases were not diagnosed as the radiologist could not count valve leaflets due to significant acoustic shadowing brought on by widespread calcification. Echocardiography's sensitivity, specificity, and positive and negative predictive values were 75.5%, 60.3%, 67.6%, and 93.5%, respectively. The diagnostic accuracy of the echo was 62%.

Based on echocardiographic evaluation, every patient in this research had aortic stenosis ranging from moderate to severe, accompanied by calcification. According to echocardiography, the transvalvar maximum pressure gradient was 101 ± 28 mm Hg, whereas the mean (± SD) pressure gradient was 58 ± 17 mm Hg. The Doppler echocardiography calculated AVA was 0.657 ± 0.229 cm2, while the CT traced AVA was 0.937 ± 0.42 cm2. Comparing Doppler echocardiography and CT, there was a significant difference ($p < 0.05$) and a decent correlation ($r = 0.43$). While the echocardiographic results were significantly different ($p < 0.05$), the CT results did not differ from the intraoperative results ($p = 0.87$).

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Table 3: The efficacy of trans thoracic echocardiography in diagnosing the bicuspid aortic valve.

Variable	Echo findings n,%	Operative findings n,%	P value
Bicuspid	12 (40.7)	11 (36.6)	< 0.05
Tricuspid	13 (43.3)	19 (63.4)	
Not diagnosed	5 (16.6)	0	
Total	30	30	

Table 4: Other findings of the investigation

Variable	Echo finding	Ct finding	P value
Aortic valve area (AVA)	0.657 ± 0.229 cm2	0.937 ± 0.42 cm2	p < 0.05
Trans valvar maximum pressure gradient	101 ± 28 mm Hg	---	--
mean (± SD) pressure gradient	58 ± 17 mm Hg	--	--

Discussion

Echocardiography is the gold standard for diagnosing and treating people with valvular disease (10). The ensuing acoustic shadows may induce a misdiagnosis of significant calcification, often linked to aortic valve dysfunction (11). While transesophageal echocardiography can be a helpful diagnostic tool, those suffering from severe aortic stenosis should not undergo such examinations since the stress of the procedure frequently makes hemodynamic instability worse (12).

Irrespective of the degree of aortic stenosis, intraoperative transesophageal echocardiography is also helpful (13). The valvular disease can be diagnosed, and its severity is assessed using Doppler measures, even in those with severe calcification. Determining the existence and severity of an aortic pathologic anomaly is crucial since enlargement and dissection of the ascending aorta are frequently seen in patients with aortic stenosis (14). Furthermore, patients with a bicuspid aortic valve and those with a tricuspid aortic valve have markedly different consequences, including increasing aortic dilatation, aneurysm development, and dissection in the distal part of the ascending aorta (15).

Heart disease can now be evaluated with MDCT with ECG-gated reconstruction (16), whereas aortic valve disease can also be diagnosed with CT. Since calcification of the valve or annulus is a strong indicator of severe valvular illness or ischemic heart disease, it has been the subject of numerous research involving individuals with valvular disease (17). However, a few papers have addressed the morphologic examination of the aortic valve utilising CT with ECG gating (18), and some of these findings relied on examination by traditional computed tomography without ECG-gated reconstruction. In this study, we evaluated the utility of MDCT with ECG-gated reconstruction in aortic stenosis and found a robust association with intraoperative results.

There was a considerable difference between the AVA measures derived by Doppler echocardiography and CT. Similar to previous studies, the AVA readings from CT were more significant than those from Doppler echocardiography (19) (20). Our investigation did not find a strong association between the AVA measures from Doppler echocardiography and CT scans. Due to constraints in the cardiac phase selection process, we employed 5% of the R-R interval for evaluation, and one reason for the variation in AVA values could have been suboptimal cardiac phase selection.

In several studies, Doppler echocardiography yielded estimated AVA measures greater than those in the present investigation (21). This result implies that this study's patient selection differed from that in previous investigations. Doppler echocardiography is believed to yield more accurate AVA readings than CT in patients who need surgery to treat their aortic stenosis (22).

A prior study found that CT had greater sensitivity and specificity than TTE (94.1% and 100% versus 76.5% and 60.6% in TTE, respectively) (23). CT was also more helpful, especially for patients with severe valvular calcification, as an extensively calcified aortic valve can be challenging to recognise on echocardiography due to severe acoustic shadowing (24). These results are in line with our findings.

Despite the drawbacks of radiation exposure and AVA calculation in patients having severe aortic stenosis, CT measurement of the aortic valve still offers advantages in evaluating aortic valve morphology while simultaneously assessing aortic and coronary artery disorders (25).

The current study contains several shortcomings. First, it was a retrospective study conducted by a single institution. Second, the majority of surgical records lacked information about valve subtypes.

Conclusion

ECG-gated cardiac CT provides a reliable morphologic diagnosis of bicuspid aortic stenosis, especially in individuals with significant valve calcification.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department Concerned.

Consent for publication
Approved

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Conflict of interest

The authors declared absence of conflict of interest.

Author Contribution

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Conception of Study, Development of Research Methodology Design, Study Design,, Review of manuscript, final approval of manuscript.
Conception of Study, Final approval of manuscript.
UMAIMA ZAFAR (PGR Radiology)
Manuscript revisions, critical input.
Coordination of collaborative efforts.
SHALMEEN TARIQ (PGR MD Radiology)
Data acquisition, analysis.
Manuscript drafting.
Data entry and Data analysis, drafting article.

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