

Association Between Bicuspid Aortic Valve and Ascending Aorta Morphology

Asociación entre la morfología de la válvula aórtica bicúspide y de la aorta ascendente

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ABSTRACT

Background: Bicuspid aortic valve (BAV) occurs in 2% of the population, and is divided into 3 morphological groups: right and left coronary cusp (RL), right coronary and non-coronary cusp (RN), and left coronary and non-coronary cusp (LN) fusion patterns.

Objective: The aim of the study was to evaluate the association between bicuspid aortic valve morphology and ascending aorta morphology.

Methods: This was a descriptive-analytical study carried out in 200 patients. A questionnaire collected echocardiographic findings and variables. SPSS 22 was used for statistical analysis.

Results: The study enrolled 139 men (69.5%) and 61 women (30.5%). Right and left coronary cusp fusion (69%) and total dilation of the ascending aorta (44.5%) were the most common morphologies.

Conclusion: Right and left coronary cusp fusion was the most prevalent morphology and total dilation of the aorta and abnormal aortic valve function were more frequent in RL cusp fusion.

Key words: Aorta - Aortic Valve, Bicuspid - Aortic Valve/abnormalities - Aortic Valve Stenosis - Aortic Valve Insufficiency

RESUMEN

Introducción: La válvula aórtica bicúspide (VAB) aparece en el 2% de la población y se divide en 3 grupos morfológicos: fusión de cúspide coronaria derecha e izquierda (DI), fusión de cúspide coronaria derecha y no coronaria (DN) y fusión de cúspide izquierda y no coronaria (NI).

Objetivo: Evaluar la asociación entre la morfología de la válvula aórtica bicúspide con la morfología de la aorta ascendente.

Material y métodos: Estudio descriptivo-analítico realizado en 200 pacientes. Las variables y los hallazgos ecocardiográficos se recogieron en un cuestionario. SPSS.22 se usó para el análisis estadístico.

Resultados: Este estudio incluyó 139 (69,5%) hombres y 61 (30,5%) mujeres. La fusión de cúspide coronaria derecha e izquierda (69%) fue la morfología más habitual. La dilatación total de la aorta ascendente fue la morfología más común (44,5%).

Conclusión: La morfología de fusión de cúspide coronaria derecha e izquierda fue la más común. La dilatación total de la aorta y la afectación funcional de la válvula aórtica fueron más comunes en la DI.

Palabras clave: Aorta - Válvula aórtica, bicúspide - Válvula aórtica / anomalías - Estenosis de la válvula aórtica - Insuficiencia de la válvula aórtica

Abbreviations

AR	Aortic regurgitation	LN	Left coronary and non-coronary cusp fusion
AS	Aortic stenosis	OR	Odds ratio
BAV	Bicuspid aortic valve	RL	Right and left coronary cusp fusion
DM	Diabetes mellitus	RN	Right coronary and non-coronary cusp fusion
HTN	Hypertension		

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INTRODUCTION

The aortic valve is normally a tricuspid valve, but it can be congenitally bicuspid in 1.3% of patients. (1) Bicuspid aortic valve (BAV) is a congenital heart defect associated with NOTCH1 mutation, (2) which affects 1%-2% of the general population. The incidence rate has been reported to be up to 10% in families with valve disease and it is the most common congenital heart defect in the Turner syndrome. Its prevalence is twice as high in men than in women. (3) Bicuspid aortic valve is classified into three types. The most common type is right and left coronary cusp fusion (RL) (80%). The second most common type is right coronary and non-coronary cusp fusion (RN) (17%) and the least common type involves left coronary and non-coronary cusp fusion (LN) (2%). (4)

Compared with the other types of cusp fusion, RN is associated with additional severe complications such as aortic regurgitation and aortic stenosis. Complications related with all types of BAV include aortic root, ascending aortic, and transverse aortic arch dilation. Over 35 % of affected individuals will develop severe complications from BAV, such as restricted valve opening, backward blood flow in the aortic valve, ascending aortic dilation, ascending aortic aneurysm, aortic coarctation and dissection, and infective endocarditis. (5)

Considering that BAV defect is affected by race, sex and geographical factors, and can cause severe complications at an early age, the aim of this study was to evaluate the association between BAV and ascending aorta morphology in an Iranian population.

METHODS

This was a cross-sectional descriptive-analytical study conducted on 200 consecutive patients with BAV referred to the Afshar Heart Center, Yazd, Iran, between 2015 and 2018.

All patients with BAV referred to the Afshar Heart Center were enrolled in the study, and patients who were not accessible and whose medical records were unavailable were excluded. The study was designed in accordance with the latest Declaration of Helsinki and all enrolled patients signed an informed consent form authorizing the use of their medical records for this investigation.

Patient data were collected on a questionnaire, including age, sex, diabetes mellitus (DM), hypertension (HTN), BAV morphology, ascending aorta morphology (sinus of Valsalva or ascending aortic root dilation, dilation of the tubular portion of the ascending aorta, total ascending aortic dilation and normal morphology), aortic valve function (aortic stenosis, aortic regurgitation), severity of aortic valve stenosis or regurgitation (mild, moderate, severe), mitral valve function (mitral stenosis, mitral regurgitation, mitral valve prolapse), aortic coarctation, blood pressure, ejection fraction, body mass index, smoking habit, and family history.

Statistical analysis

All patient data were entered into the SPSS 22 software for statistical analysis. Results were expressed as frequency, percentage, and mean and standard deviation.

Ethical considerations

The study was evaluated and approved by the Institution-

al Review Board under the registry code IR.IAU.YAZD.REC.1397.089.

RESULTS

This study was designed to evaluate the association between BAV and ascending aorta morphology and aortic valve involvement in BAV patients referred to the Afshar Heart Center, Yazd, Iran, between 2015 and 2018.

A total of 200 patients with mean age of 47.7 ± 16.9 (range 13-83) were enrolled in the study, including 139 men (69.5%) and 61 women (30.5%). Mean systolic blood pressure was 118.3 ± 12.8 mmHg, and mean diastolic blood pressure 73.1 ± 6.5 mmHg. Average body mass index was 24.4 ± 3.2 , and the ejection fraction was $52.0 \pm 9.3\%$. Thirty-four (17%) patients had diabetes; 60 (30%) HTN; 28 (14%) were smokers; and 58 (29%) had a family history of cardiovascular disease.

In the study population, 5 (2.5%) patients had aortic stenosis (AS), 66 (33%) aortic regurgitation (AR), 128 (64%) had both AS and AR, and only 1 (0.5%) patient had no functional valve disorder.

Among AS patients, 22.5% were mildly affected, 14.3% were moderately affected and 63.2% were severely affected. Among AR patients, 41.7% were mildly affected, 32.5% were moderately affected, and 25.8% were severely affected.

In this study, 7 (3.5%) patients had mitral stenosis, 177 (88.5%) mitral regurgitation and 16 (8%) mitral valve prolapse. Ten patients (5%) were associated with coarctation of the aorta.

Regarding BAV morphology, the RL type was observed in 69% of cases, RN in 26%, and LN in 5%. The most common ascending aorta morphologies in our study were total dilation of the ascending aorta (44.5%), dilation of the tubular portion of the ascending aorta (25.5%), normal morphology (20.5%) and sinus of Valsalva or aortic root dilation (9.5%), which means that 79.5% of the study population with BAV had ascending aorta involvement.

Table 1 summarizes the morphology of the ascending aorta based on BAV morphology

Table 2 summarizes the association between BAV morphology and the severity of stenosis or aortic regurgitation.

DISCUSSION

Biventricular aortic valve is the most common congenital heart defect and structural abnormality of the aortic valve, occurring in 1%-2% of the general population. It presents 3 different echocardiographic morphologies: RL, RN, and LN. (4) About 30% of BAV patients develop complications, and some of them can be very serious and life threatening. These complications include aortic aneurysm, aortic dissection, coarctation of the aorta, sudden cardiac death due to severe stenosis obstructing blood outflow, infective endocarditis leading to severe aortic regurgitation, and aortic regurgitation. (6)

In previous studies, the men-women ratio varied between 2 and 3, which was similar to our study. In general, BAV is more common in men than in women. (3, 7, 8) The same applies to most common BAV morphologies. (9)

In a study carried out by Schaefer et al. on the morphology of ascending aorta dilation, this was classified into 3 groups: ascending aorta dilation, sinus effacement, and normal shape. (9) In this study, they observed that the normal aortic shape was more common in RL than in RN morphology (60% vs. 32%) and that ascending aorta dilation was more common in RN than in RL morphology (35% vs. 54%). The researchers stated that sinus effacement was very rare among all groups.

Another study conducted by Nistri et al. (10) reported that the aortic diameter in BAV patients was significantly larger at the sinuses, the supra-aortic ridge and at the level of the proximal ascending aorta compared with the control group. The prevalence of aortic root dilation was 7.5% at the annulus, 19.6% at the sinuses, 15% at the supra-aortic ridge, and 43.9% at the ascending aorta.

A study conducted on 133 adult outpatients in 2013 revealed that in BAV patients aortic root dilation is associated with more severe aortopathy, and that ascending aorta dilation indicates a slower progression, more persistent disease. (11)

The study carried out by Fernandes et al. (7) showed that moderate to severe AS and AR are associated with RN morphology. They also reported that aortic coarctation was more common in patients with

RL morphology (89%), and that this type of morphology was associated with lower levels of AS or AR.

A study conducted by Kong et al. in 2017 reported that moderate/severe AR was more frequent in men, whereas women more often presented with moderate/severe AS. (12) They also reported that AR is not associated with any BAV morphotypes. A study by Della Corte et al. in 2014 stated that 36% of BAV patients had normal valve function, 35% had AS, and 28% of the study population had AR. (8)

In an updated study performed by X Ren et al. in 2019, (13) researchers analyzed age-related aortic valve dysfunction, as well as age differences between sexes. Finally, they reported a statistically significant relationship between aortic valve dysfunction and age, which is consistent with our results. Our evidence also shows that there is a statistically significant association between BAV morphology and age, and that RL morphology is more common in patients aged between 13 and 29 years. However, no significant association was found between BAV and sex.

Della Corte et al. found a significant correlation between RN morphology and sex. They reported that RN morphology is associated with older age, female sex, AS, and mitral valve prolapse. We have also found that RN is more common in women, but the difference was not statistically significant. (8)

We suggest future studies to investigate the incidence odds ratio (OR) of any BAV complication based on different BAV morphologies using regression analysis, as it may be very useful to explain the risk of incidence of each complication in the different BAV morphologies.

Table 1. Association between BAV and ascending aorta morphology. RL: Right and left coronary cusp fusion. RN: Right coronary and non-coronary cusp fusion. LN: Left coronary and non coronary cusp fusion.

BAV morphology	Aortic root dilation	Ascending aorta morphology			Total
		Dilation of the tubular portion	Total dilation of the ascending aorta	Normal ascending aorta	
RL	13 (9.4%)	39 (28.3%)	59 (42.7%)	27 (19.6%)	138 (100%)
RN	4 (7.7%)	11 (21.2%)	27 (51.9%)	10 (19.2%)	52 (100%)
LN	2 (20%)	1 (10%)	3 (30%)	4 (40%)	10 (100%)
Total	19 (9.5%)	51 (25.5%)	89 (44.5%)	41 (20.5%)	200 (100%)

Table 2. Association between BAV morphology and the severity of stenosis or aortic regurgitation. Abbreviations as in Table 1.

Aortic valve morphology	Severity of aortic stenosis			Total
	Mild	Moderate	Severe	
RL	17 (19.1%)	12 (13.5%)	60 (67.4%)	89 (100%)
RN	11 (29%)	6 (15.8%)	21 (55.2%)	38 (100%)
LN	2 (33.3%)	1 (16.7%)	3 (50%)	6 (100%)
Total	30 (22.5%)	19 (14.3%)	84 (63.2%)	133 (100%)
Aortic valve morphology	Severity of aortic regurgitation			Total
	Mild	Moderate	Severe	
RL	57 (43.2%)	43 (32.6%)	32 (24.2%)	132 (100%)
RN	20 (38.5%)	17 (32.7%)	15 (28.8%)	52 (100%)
LN	4 (40%)	3 (30%)	3 (30%)	10 (100%)
Total	81 (41.7%)	63 (32.5%)	50 (25.8%)	194 (100%)

CONCLUSIONS

Based on our study results, we can conclude that the RL morphology is the most common BAV morphology. Total dilation of the ascending aorta is the most prevalent morphology of the ascending aorta. Both severe AS and AR occurred more often in RL morphology.

Conflicts of interest

None declared.

(See authors' conflicts of interest forms on the website/ Supplementary material)

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