Asian Journal of Advances in Medical Science

4(1): 54-65, 2022

PATHOPHYSIOLOGY, INVESTIGATIONS, AND TREATMENT OF PATIENTS WITH BICUSPID AORTIC VALVE

OMAR ELSAKA [a*], MONEER AYMAN NOURELDEAN [a], MOHAMED ADEL GAMIL [a], MOSTAFA TAREK GHAZALI [a], ASHRAF HAMADA ABD AL-RAZIK [a] AND DALIA HISHAM [a]

[a] Department of Cardiology, Faculty of Medicine, Mansoura University, Mansoura Manchester Medical Program (MMMP), Mansoura, Egypt.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Received: 10 November 2021
Accepted: 24 January 2022
Published: 27 January 2022

Review Article

ABSTRACT

Bicuspid aortic valve is a congenital anomaly of the heart in which the aortic valve has two loops instead of the normal three. It causes valve degeneration and is associated with dilation of the aorta. This exercise discusses the role of inter-professional team in improving the management of patients with bicuspid aortic valves and describes the diagnosis and management of this problem. The purpose of this review article is to describe the epidemiology of bicuspid aortic valve, describe the presentation of patients with bicuspid aortic valve, summarize the use of electrocardiogram and echocardiogram in bicuspid aortic valve evaluation, and explain the importance of collaboration and communication. Interprofessional team to improve care coordination for patients with bicuspid aortic valve.

Keywords: *Bicuspid; congenital; aorta; aortic valve; heart defects; valvulopathy.*

1. INTRODUCTION

Adults with bicuspid aortic valves are more likely to develop aortic valve dysfunction and ascending aortic disease, requiring close monitoring and treatment of these disorders. Surveillance, timely intervention for aortic valve disease and aortic aneurysm, treatment of hypertension, measures to reduce the risk of infective endocarditis, counseling of patients on physical activity and management before and during pregnancy, all which can lead to bicuspid in adults. Part of disease management. This article reviews general nontraditional care for adults with a bicuspid aortic valve [1].

2. ETIOLOGY

Bicuspid aortic valves can occur sporadically or in families. The mode of inheritance of familial bicuspid aortic valve has been reported to be variable, but may be autosomal dominant. The bicuspid aortic valve affects about 20–30% of the other members of the family. The exact mechanism of the bicuspid aortic valve is still unknown. There are many hypotheses about how it develops. According to one view, incomplete separation of the valve occurs as a result of uneven blood flow through the valve during development. Another possibility is that valve cushion fusion occurs as a result of abnormal neural crest

**Corresponding author: Email: omarelsaka0808@gmail.com;*

migration. Bicuspid aortic valve is caused by a deficiency of endothelial nitric oxide synthase [2].

3. PATHOPHYSIOLOGY

Sclerosis and calcification can develop when the aging valves degenerate. The changes are similar to those found in coronary arteries with atherosclerosis. The bicuspid valve is likely to be fully functional, resulting in no regenerative flow. On the other hand, regeneration and enlargement of valve tissue can lead to valve regeneration. Complications are life-long in one-third of patients; As a result, the disease requires regular monitoring and medical intervention. Valve morphology may predict stenosis, regurgitation, or both. In children, stenosis or regurgitation is less commonly associated with fusion along the right or left leaflets. This configuration is more common in patients with aortic stenosis, whose valves are in good condition. In the pediatric population, fusion along the right and non-coronary leaflets is often associated with pathological changes in stenosis or deficiency [3].

4. MORPHOLOGY: DIFFERENT CLASSIFICATION ENDOW DIFFERENT EFFECTS

The aortic valve has three semilunar leaflets in its normal configuration. BAV usually has two uneven cusps and a central raphe due to the fusion of two out of three cusps. The Sievers classification system was frequently utilized in surgical procedures. BAV is classified into three types based on the number of raphes in the valve: type 0 (no raphe in the valve), type 1 (only one raphe in the valve), and type 2 (two raphes in the valve) (two raphes in the valve). The most frequent kind is type 1, which accounts for almost 90% of all patients. Types 1 and 2 were classified as left (L), right (R), and none (N) based on the raphe location with coronary sinuses. The right and left coronary leaflets (RL) were the most prevalent, accounting for about 80% of the total, followed by the right and non-coronary leaflet (RN) at about 17%, and the left and non-coronary leaflet (LN) at 2%. Europeans had a larger incidence of type 0 BAV than Asians, whereas Asians had a higher incidence of RN-BAV with a raphe. Pulse wave velocity (PWV) was used to quantify aortic stiffness using velocity-encoded magnetic resonance imaging (VENC-MRI), and patients with R-NC fusion had higher PWV than those with R-L fusion. This evaluation could be a novel criterion for assessing surgical risk (Fig. 1) [4].

A bilingual classification approach was established to demonstrate the association between the morphological type of BAV and valvulopathy or aeropotype. Coronary cusp fusion (CCF) is defined as a fusion of right and left coronary leaflet cups, while mixed capsule fusion is defined as a fusion of all other types of coronary leaflet cups (MCF). The MCF type of BAV has been identified as a risk factor for aortic stenosis and associated aeropathy, both of which cause severe hemodynamic changes. This classification is useful in routine because imaging by transthoracic echocardiography (TTE) has the qualities of accuracy and probability [6].

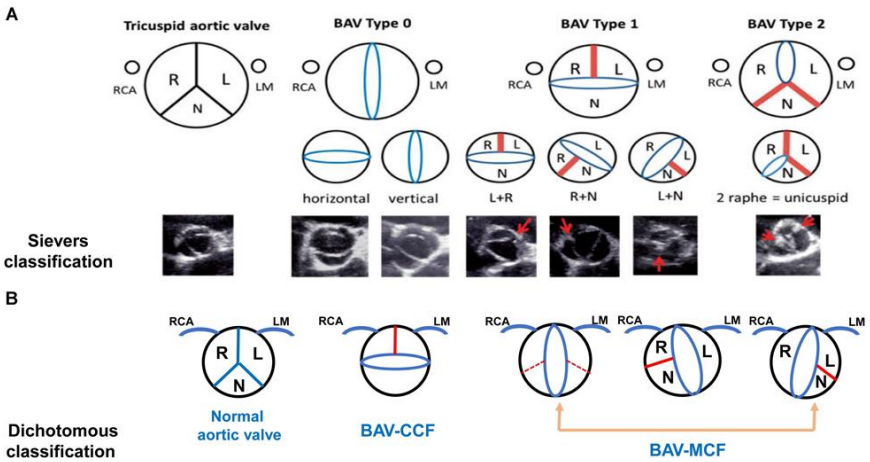

Fig. 1. Different bicuspid aortic valve morphologies are depicted in a schematic design and photographs. The Sievers classification and echocardiographic pictures are displayed in this diagram (A). In this diagram, dichotomous classification is presented (B). The raphe or commissural fusion is represented by red bands and arrows. The fusion of the non-coronary cusp with the right coronary cusp of the left coronary cusp occurs in patients with BAV, although it is difficult to exhibit raphe to fully define the subtype. On the left, the ostium of the right coronary artery (RCA) is seen, and on the right, the left main (LM) [5]

The primary method of determining valve status in BAV patients was transthoracic echocardiography. When the valve was placed in the systole, the typical shape of the "fish mouth" was shown in the short-axis view. In addition, the long axis view may indicate the appearance of some abnormal bixed valve in the systole. TTE alone, on the other hand, makes it difficult to determine the presence or absence of raphe or coronary artery perforation. TTE can detect valvular phenotype in 47.4% of patients, while 2D TEE can detect it in 90.1% of patients. However, in 9.9% of BAV patients, where 3D TEE was helpful, it was difficult to identify specific phenotypes for 2D TEE images. In an inexperienced hand, 3D TEE may specialize in providing important features about the structure of the valve in patients with small refractories or raphe is missing due to calcification in aortic leaflets. Another method of imaging, Color Doppler, is a useful tool that can be used to identify the immobilized trellis aortic valve or bicuspid valve [7].

The architecture of the aortic root, particularly the three-dimensional anatomy, must be fully understood in order to assess the aortic valve. The sinotubular junction (STJ), aortic sinus, and annulus are three separate structures that make up the aortic root. The aortic sinus contains the aortic valve cusps, leaflet attachments, sinuses of Valsalva, and intervalvular triangles. The basal annulus, the surgical annulus and the anatomical ventriculo-aortic junction are included in the annulus (VAJ). The basal ring, an elliptical ring, is characterized as a ring with three anchors at the bottom of each aortic cusp attachment, and its shape is inhomogeneous due to calcification. The surgical annulus is a complex three-dimensional crown-like structure that runs the full length of the aortic root from the basal annulus to the STJ, with the lower parts being the nadirs of the sinuses of Valsalva and the lower parts higher being the commissures. The ventriculo-aortic junction (VAJ) is a ring between the wall of the aorta and the myocardium of the left ventricle, located slightly above the basal ring. Relative track widening is defined as a mean tricuspid track diameter greater than 26 mm and a mean bicuspid track diameter greater than 28 mm after aortic valve replacement [8].

At the aortic root, the elliptical functional aortic annulus (FAA) became encircled through VAJ and STJ. The category of FAA, which aimed to understand unique styles of aortic regurgitation, became suggested to give an explanation for the various dilatation in all FAA. El Khoury sorts Ib and II, that are primarily based totally on Sievers kind 1 L-R BAV, are the maximum regularly occurring phenotypes in BAV restore in scientific practice. Type-IB AR is due to dilatation of the sinuses of Valsalva, that's resected and restored the use of reimplantation or reworking techniques. Excessive cusp or commissural disruption reasons Type-II AR, which may be dealt with with interrupted sub-commissural annuloplasty plication sutures. Three-dimensional transesophageal echocardiography (three-D TEE) and multidetector computed axial tomography (MDCT) have been determined to be beneficial in assessing FAA, and MDCT is usually recommended as a standards imaging approach for tool sizing withinside the TAVR procedure. The CT region had the satisfactory correlation and settlement with intraoperative sizing, ensuing in 84.6 and 74.zero percentage of BAVs agreeing on theoretical surgical and TAVR prosthesis selection, respectively. Although 3DTEE may be used alternatively for CT in BAVs sufferers who aren't applicants for CT, it nonetheless calls for extra care, in particular in sufferers with aortic annulus calcification, due to the fact partial acoustic shadowing can purpose inaccuracies [9].

In the age of TAVR, a complete understanding of the anatomy of the base of the aorta is essential. This is because the aortic root is the basis for device development, selection, and implantation. The annulus, Valsalva sinus, and ascending aorta were all dilated in BAV patients. Due to the non-uniform aortic annulus, the diagnosis of exclusion has been the traditional diagnostic approach to BAV in the past. Due to the asymmetrical deformation and dilation of the rounded bioprosthesis, this anatomical feature can cause leaflet deformity and potentially perivalvular leakage. The larger BAV ring, on the other hand, is circular and looks probably acceptable for existing off-the-shelf valved stents [10].

According to anatomy, shaping the aortic valve annulus, which represents the narrowest area of the aortic root, is a useful way to determine the size of the transcatheter heart valve (THV). When bicuspid AS is combined with severe calcification in leaflets, the morphological features of the supra-annulus, ranging from annulus to STJ, become much more complex. Since the annulus is defined by two capture points on the plane, the CT measurement of the annulus may be incorrect. The supernatural structure can have a significant effect on THV anchoring. BAV patients show morphological changes in their valves, such as convoluted eccentricity, asymmetric calcified leaflets, different droplets of leaflets, and aorta, which are deep implantation, PVL, TAV-in-TAV, annulus rupture. And associated with aortic disseses. Possibility. The mechanical properties of the annulus or supra-annular structures for THV anchoring cannot

be fully demonstrated with CT, despite its advantages in providing anatomical aortic root information. The shape of the balloon, which has never been described before, can provide information about the supernatural mechanical properties, combined with the diagnosis of contrast aortic and AR [11].

After TAVI, it is important to choose the right valve size, as this will help with rehabilitation. Balloon size qualifies as a good adjunct to multimodality imaging. Despite the low estimated size ratio, the incidence of PAR does not increase after valve placement and short-term follow-up after conversion to small THV with balloon size. According to MSCT, there was a trend toward better frame geometry in terms of better stent frame extension and flow circulation in patients with smaller valves than patients with the same size or larger valves. Although MSCT has a significant influence on the choice of THV size, balloon size can be used to complement and evaluate BAV morphology [12].

Failure to address the functional aortic ring during the BAV repair process is associated with early repair failure. The deep anterior dissection technique avoids complications and achieves other goals, such as enclosing the anuloplasty ring with the basal ring, allowing for symmetrical insertion, thinning the anterior root tissue, creating less muscle bands, improving implant size, and adjusting accuracy. And preventing recurrence of enlargement in the same area and enlargement of cusps combined with IVS [13].

Eccentricity of the aortic valve annulus, on the other hand, is probably inherited in infants and young children. Balloon aortic valvuloplasty, rather than transcatheter AV replacement, is often used to treat children with severe or severe aortic stenosis. Currently, 2D parasternal long-axis angiographic examination can be used to determine the size of the aortic valve annulus in adolescent patients. When the size of the eccentric ring is incorrect, the incidence of aortic insufficiency increases, as well as residual stenosis. When different annulus sizes are taken into account, we believe that balloon aortic valvuloplasty can help in therapeutic results [14].

5. HISTORY AND PHYSICAL PRESENTATION

Bicuspid valves are represented differently depending on the degree of stenosis and / or valve deficiency. The most mild valve malfunction in children is when there are no symptoms. Physical examination in this situation involves a low-pitch systolic ejection murmur and ejection click. Early ejection sounds are often heard in young populations, followed by systolic ejection rumble. The ejection noise is determined by the valve dynamics so that the more stable the valve cups, the lower the ejection noise. The severity of the valve defect affects the test. The ejection sound is mild to moderate aortic regurgitation, but is usually missing in acute aortic regurgitation (Fig. 2) [15].

6. COMPLICATIONS

Patients with bicuspid aortic valves have a wide range of complication rates. In general, a bicuspid aortic valve is thought to be a common cause of accelerated aging (eg, valve sclerosis, calcification). The congenitally bicuspid aortic valve has four unique problems [17].

6.1 Aortic Stenosis

Bicuspid aortic sclerosis usually appears in the first 20 years of life and calcification becomes more severe in the 40th year. Coronary artery risk factors (such as smoking and high cholesterol) can accelerate these processes. Congenital bicuspid valves are found in about half of adults with severe aortic stenosis. Rheumatic fever was the most common cause of aortic stenosis in the past. Due to the reduced incidence of rheumatic fever in developed countries, the most common cause of aortic stenosis in adults is the bicuspid aortic valve, which is also the most common cause of valve dysfunction. In developing countries, rheumatic fever and recurrence have always been a serious problem, and the long-term effects of rheumatic fever are always more important than bicuspid valves in the development of aortic stenosis and dysfunction. Only the presence of Ashoff can indicate rheumatic aortic valve injury during surgery or autopsy [18].

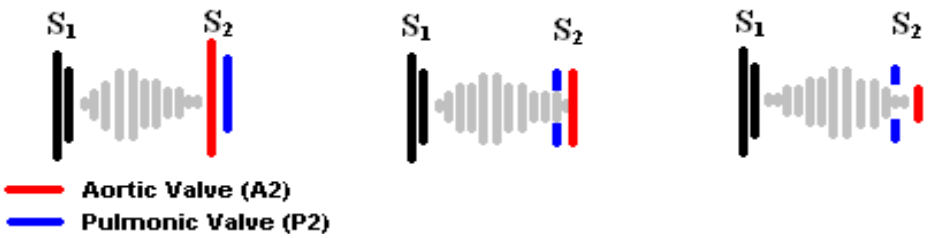

Fig. 2. Mild, moderate, and sever aortic stenosis (Bicuspid aortic valve) [16]

6.2 Aortic Insufficiency

A congenitally bicuspid valve is linked to the majority of cases of severe aortic insufficiency, either directly or indirectly. A variety of factors may play a role in the development of aortic valve insufficiency. Cusp prolapse, erosion of uneven commissure lines, aortic root dilatation (especially at the sinotubular junction or supra-aortic ridge), infective endocarditis, and systemic hypertension are some of the symptoms (particularly with coarctation) [19].

6.3 Bacterial (eg, Infective) Endocarditis

Throughout a lifetime, a bicuspid aortic valve has a 10-30% chance of developing infective endocarditis. The bicuspid aortic valve is the second most prevalent congenital etiology of infective endocarditis in infants and children, accounting for about 25% of all endocarditis infections [20].

6.4 Aortic Root Dissection

Histological examination of the aortic root in a person with a swollen aortic valve has shown different results. Post-stenosis dilation is often attributed to root growth. On the other hand, the roots can spread without significant valve stenosis, and some studies have found abnormal histology with rupture of elastic fibers and other features of Marfan syndrome. People with Marfan syndrome have a significantly higher risk of aortic root dissection (about 40%) than people with bicuspid aortic valves (about 5%). Bicuspid aortic valves are often associated with aortic root dissection because bicuspid aortic valves are more common in the general population [21].

A population-based retrospective cohort investigation in Olmsted County, Minnesota examined the problems of patients with bicuspid aortic valves. The reported incidence of aortic dissection in the 416 people studied over 16 years was modest (2 of 416), but was significantly higher than in the general population [22].

7. INVESTIGATIONS

7.1 Laboratory Studies

Baseline cholesterol levels can help recommend dietary changes for children with a family history of bicuspid aortic flap and hypercholesterolemia or early coronary artery disease. Children older than 3 years should have total and high-density lipoprotein (HDL) cholesterol tests, and fasting lipid panels. Increased Low-Density Lipoprotein (LDL) Cholesterol May Accelerate Bicuspid Aortic Valve Sclerosis [23].

7.2 Chest X-Ray

A posterior anterior image along the upper edge of the right heart may show a moderate protrusion of the ascending aorta on a chest x-ray. Progressive aortic valve dysfunction is indicated by left ventricular hypertrophy. In most cases, chest x-rays are not an effective screening method for bicuspid aortic valves [24].

8. ECHOCARDIOGRAPHY

The presence of a bicuspid aortic valve can be confirmed via two-dimensional echocardiography (Fig. 3) [25].

The bicuspid aortic valve can be seen through imaging in many planes. Parasternal long axis and short axis views provide highly relevant information. Due to the limited valve opening, normal systolic doming can be seen in the long axis image. At the peak systole, the diameter of the valve hole can be estimated. Valsalva's sinuses, sinotubular junction and ascending aorta are all sized (Fig. 4) [27].

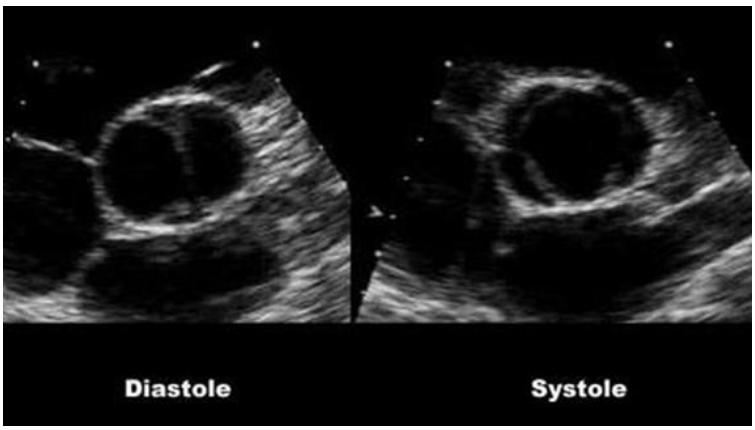

Fig. 3. Two-dimensional echocardiogram of the typical bicuspid aortic valve in diastole and systole, Valve margins are thin and pliable and open widely, creating the fishmouth appearance [26]

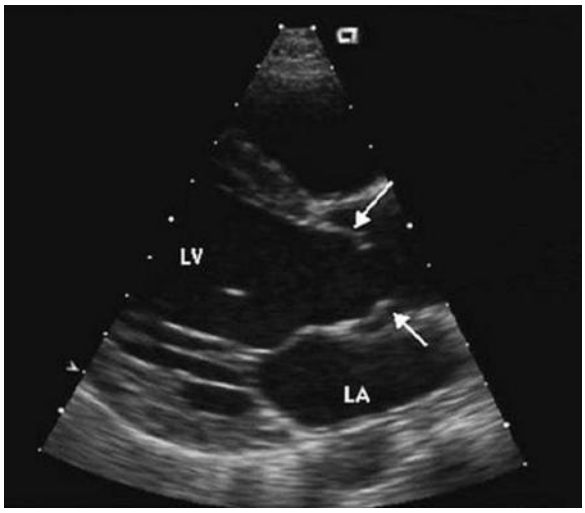

Fig. 4. Parasternal long-axis echocardiogram showing doming of a bicuspid aortic valve [28]

Commissures, leaflet shape, motility, and the presence or absence of a low raphe are all examined using the short-axis view. Because the true orifice is usually above this plane, the diameter or area of the valve opening is commonly exaggerated in this view. When the bicuspid valve opens, it resembles the mouth of a fish (Fig. 5) [29].

The apical 5-chamber, suprasternal, or upper right parasternal view can be used to take Doppler measurements of peak and average systolic velocities and gradients. To obtain reliable estimates of current speeds, the Doppler signal must be coupled to the jet as much as possible. Moving the transducer more centrally toward the sternum can sometimes improve the flow velocity estimates from the apical point of view. The color Doppler test for assessing aortic regurgitation can also be performed using long and short axis parasternal views. Several methods can be used to determine the severity of aortic valve regeneration. One of the simplest and most reliable methods is to measure the deficient jet diameter in the aortic annulus and compare it with the annual diameter. Incomplete visualization of all three valve closure lines may lead to false-positive diagnosis of the bicuspid aortic valve. Finally, the most common (trileaflet) aortic valve shows a rotating Mercedes sign. If excess raft is detected with valve closure, premolar valve cannot be detected [31].

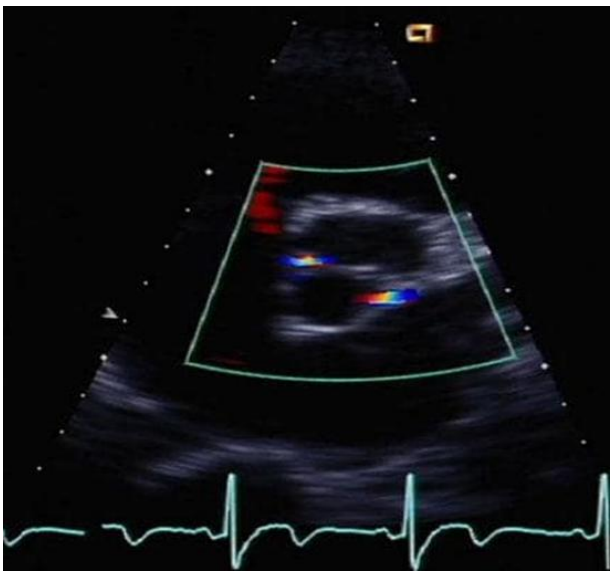

Fig. 5. Parasternal short-axis echocardiographic view in diastole, showing bicuspid aortic valve with nearly equal cusp size and right-left orientation of the commissure, Note the 2 color signals showing minimal aortic insufficiency [30]

When a bicuspid aortic valve is suspected on clinical grounds in adolescents or young adults, transesophageal echocardiography may be required to characterize valve commissures and vegetations (particularly those with symptoms or findings that suggest infective endocarditis) [32].

9. ANGIOGRAPHY

In the 30 ° anteroposterior right anterior oblique (RAO) projection, the bicuspid aortic valve is best seen. Both the left ventricle and the aortic root are injected. Angiography is the primary diagnostic method of bicuspid aortic valve. Systolic swelling of the valve margins due to incomplete opening is a common observation. Aortic root injections may detect aortic insufficiency (Fig. 6) [33].

10. MRI

Although MRI is not usually useful for diagnosing bicuspid aortic valves on its own, it can be useful for a thorough examination of the thoracic aorta, especially in situations of coarctation, Turner syndrome, or Williams syndrome [35].

11. ELECTROCARDIOGRAPHY

For an isolated bicuspid aortic valve with no stenosis or insufficiency, ECG results are usually normal.Left atrial enlargement and left ventricular hypertrophy occur as stenosis or insufficiency progresses (Fig. 7) [36].

12. TESTING IN FAMILY MEMBERS

Because a significant recurrence rate (as much as 12-17 percent) has been reported in various families, two-dimensional echocardiography is advised as a screening tool for the offspring and first-degree relatives (particularly males) of patients diagnosed with a bicuspid aortic valve [38].

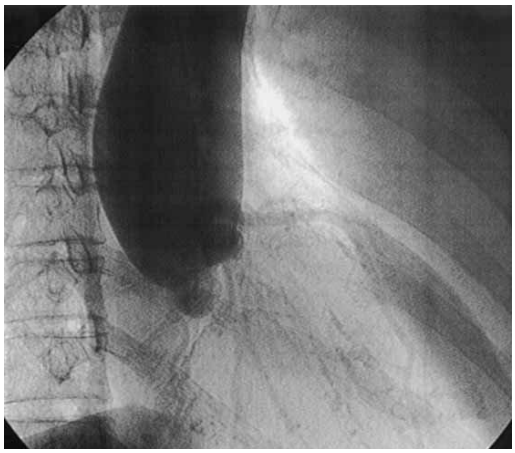

Fig. 6. Aortic root angiography shows grade 2 regurgitation, bicuspid aortic valve and dilatation of ascending aorta [34]

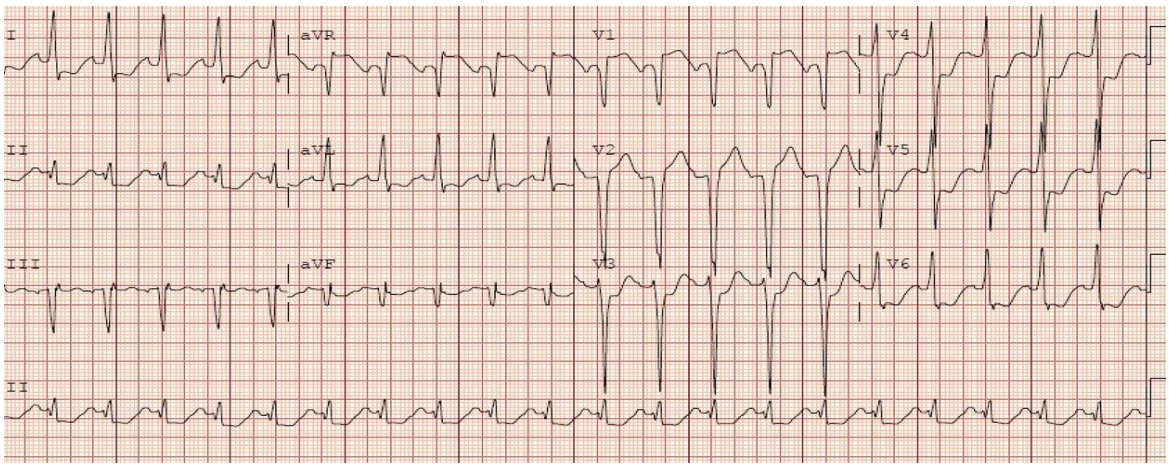

Fig. 7. ECG of bicuspid aortic valve [37]

13. TREATMENT

A healthy bicuspid aortic valve requires regular outpatient compliance. Families should be informed that bicuspid aortic valves inevitably deteriorate over time. Currently, there is no clinical intervention to reduce the evolution of bicuspid aortic valve stenosis or regurgitation into aortic stenosis or regurgitation. All first-line relatives of individuals with bicuspid aortic valve aorta should be evaluated. There are no other recommendations for examining all family members. In a patient with a bicuspid aortic valve, a single transthoracic echocardiogram is needed to assess the morphology of the valve, the severity of aortic stenosis or aortic regurgitation, and the size of the aortic sinuses and ascending aorta [39].

With a 4 cm diameter ascending aorta, bicuspid aortic valve requires regular echocardiographic monitoring (if it is not visible, aortic magnetic resonance angiography or CT angiography). Annual echocardiography is recommended by the American Heart Association if the size is more than 4.5 cm. Peak-to-peak gradients greater than 50 mmHg with ECG changes (ST or T-wave changes) with rest or activity or interest in participating in athletics are the cause of surgical intervention in the pediatric population, while children without symptoms have peak gradients greater than 60 mm Hg. Valvuloplasty is the gold standard of surgical procedures in pediatric populations [40].

Indications for bicuspid aortic valve replacement are similar to tricuspid aortic valve replacement in people over 18 years of age, but with aortic valve replacement the bicuspid aortic valve replacement population is much smaller, resulting in mechanical and bioprosthetic valve replacement. Changes make little difference. it is difficult. 30% of patients with bicuspid aortic valve require aortic valve replacement for aortic sinus or ascending aortic surgery. According to the current AHA guidelines, if the size of the aortic root is more than 4.5 cm and the surgeon is replacing the aortic valve, the aortic origin must also be replaced [40].

14. GUIDELINES

According to the latest ESC guidelines for the treatment of valvular heart disease, any patient with aortic root diameter less than 55 mm should be evaluated for surgery. However, in patients with BAV, surgery of aortic diameter less than 50 mm should be based on the patient's age, body size, concomitant diseases, type of surgery and presence of additional risk factors such as family history, systemic hypertension, aortic correction. Or an increase of aortic diameter greater than 2 mm per year is confirmed on repeated examinations with the same technique and by a different technique. If the aortic root diameter is less than 5.5 cm, the current ACC / AHA guidelines recommend surgical repair (Class I). The previous proposal with a cutoff value of 5 cm in 2006 was replaced in 2014 [41].

It should also be noted that the ACC/AHA recommendations have taken into account evidence of rapid progress from the maximum aortic cross-section: body-to-height ratio of 10 cm2/m as an additional criterion for deciding this. What has been proposed is not. Having aortic root. surgery, and it was associated with an increased risk of aortic dissection in several studies (Table 1) [42].

15. EPIDEMIOLOGY

Only 1-2% of the population has a biceps aortic valve. Its incidence has increased since the introduction of echocardiography. In 50 to 75% of patients with atrial fibrillation, there is a biceps aortic valve. It can also be found in other syndromes, such as Turner syndrome (30% of cases). Similarly, it is associated with 30% of cases of William syndrome and ventricular septal dysfunction. Some rare syndromes, such as shon syndrome, are also affected [43].

Table 1. Indications of aortic root surgery in patients with BAV according to measured aortic root diameter [42]

Aortic Root Diameter	Indication for Elective Aortic Root Surgery
≥55 mm	All - class I in ACC/AHA guidelines and IIa in ESC guidelines
50-54 mm	If associated with any of: Family history of dissection or unexplained sudden death, Rapid growth progression of aortic dilatation, and Others (systemic hypertension, associated coarctation, female patient seeking pregnancy)
≥45 mm	If concomitant valve surgery is indicated

16. PROGNOSIS

Individuals with bicuspid aortic valves have a fair overall prognosis. Patients with bicuspid valves have a rather benign history, according to previous reviews and findings. Recent findings on the natural history of these valves, on the other hand, show a slew of newer, more significant issues as well as an acceleration of typical valvular wear and tear. These issues may not appear till later in life. It is advised that a kid or adolescent with a bicuspid aortic valve receive routine and frequent follow-up [44].

17. DISCUSSION

The bicuspid aortic valve is a type of congenital heart disease (congenital heart disease). The aortic valve is the valve that connects the lower left ventricle (left ventricle) to the body's main artery (the aorta). With each heartbeat, valve tissue flaps (cusps) open and close, making sure the blood flows in the right direction. The aortic valve usually has three valves. Only two valves form the bicuspid valve. Some people are born with a single cusp (unicuspid) or four cusps (bicuspid) aortic valve (quadricuspid) [45].

The bicuspid aortic valve can cause a variety of heart problems, including aortic stenosis (narrowing of the aortic valve): As a result, the valve may not open completely. The flow of blood from the heart to the rest of the body is slowed or stopped. Backflow of blood (aortic regurgitation): The bicuspid aortic valve is not always completely sealed, allowing blood to flow back. and aorta (enlargement of the aorta): Some people with bicuspid aortic valves have an enlarged aorta. An enlarged aorta increases the likelihood of a tear in the lining of the aorta (aortic dissection) [45].

Bicuspid aortic valve, a type of heart disease that is passed down from generation to generation, has gained worldwide attention. Although most patients with bicuspid aortic valve (BAV) develop problems such as aortic stenosis, aortic regurgitation, endocarditis, and cardiac dysfunction in the later stages of the disease, there are no symptoms in childhood, leading to the diagnosis and treatment of BAV. It becomes difficult [45].

BAV-related aortic disease is characterized by chronic hemodynamic problems caused by valve abnormalities in BAV patients, including progressive aortic enlargement, aneurysm, dissection and rupture, cardiac arrhythmia, and sudden death. Preventive surgery is the only effective treatment used in this condition today, and the main criterion for surgery is aortic diameter. And treatment results are never enough for patients or professionals. Therefore, by combining basic research and clinical treatment, we need more ways to assess the BAV's progression, the value of surgery, and the timing of appropriate intervention (Fig. 8) [46].

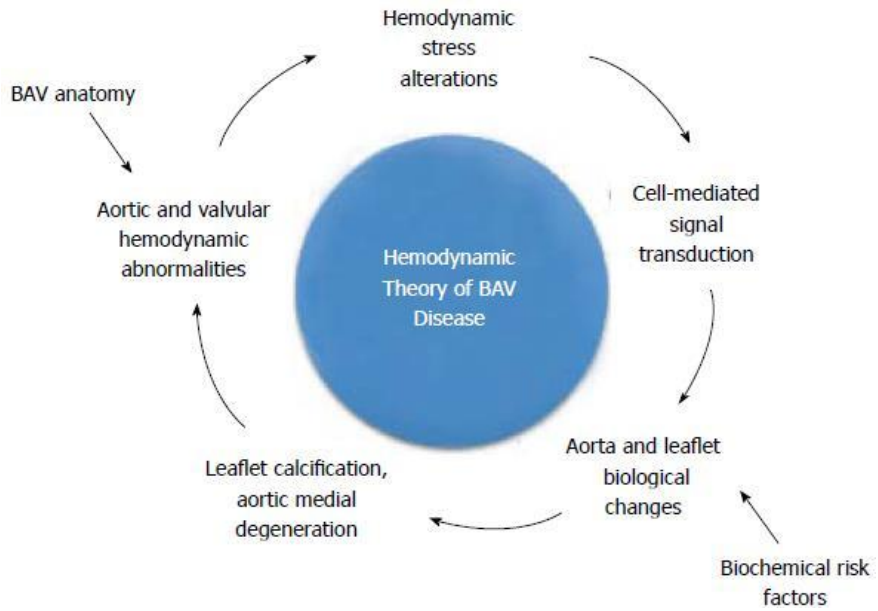

Fig. 8. The hemodynamic theory of bicuspid aortic valve (BAV) disease can be visualized as an irreversible feedback loop in which the apex and ascending aortic wall are exposed to local stress overload due to BAV morphology. Certain endothelial receptors may detect stress irregularities, which are then transformed into various biological responses, eventually forming calcified lesions on the leaflets or progressing the aortic medium. It leads to degeneration [46]

18. SUMMARY AND CONCLUSION

Primary care physicians, internists, and nurse practitioners often encounter the bicuspid aortic valve in clinical practice. The most important step is to consult a cardiologist to determine the severity of heart disease, the presence of symptoms and the age of the patient. Balloon valvoplasty or observation are two treatment options for children. Valve replacement is the only treatment option for symptomatic patients. After valve replacement, most patients have a good prognosis. Recurrence of symptoms after valvoplasty is common.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Beaton AZ, Nguyen T, Lai WW, et al. Relation of coarctation of the aorta to the occurrence of ascending aortic dilation in children and young adults with bicuspid aortic valves. Am J Cardiol. 2009 Jan 15;103(2):266-70.
2. Beppu S, Suzuki S, Matsuda H, et al. Rapidity of progression of aortic stenosis in patients with congenital bicuspid aortic valves. Am J Cardiol. 1993 Feb 1;71(4):322-7.
3. Bolling SF, Iannettoni MD, Dick M, Rosenthal A, Bove EL. Shone's anomaly: operative results and late outcome. Ann Thorac Surg. 1990 Jun;49(6):887-93.
4. Bonow RO. Bicuspid aortic valves and dilated aortas: A critical review of the ACC/AHA practice guidelines recommendations. Am J Cardiol. 2008 Jul 1;102(1):111-4.
5. Brandenburg RO Jr, Tajik AJ, Edwards WD, et al. Accuracy of 2-dimensional echocardiographic diagnosis of congenitally bicuspid aortic valve: Echocardiographic-anatomic correlation in 115 patients. Am J Cardiol. 1983 May 15;51(9):1469-73.
6. Brook MM. Pediatric bacterial endocarditis. Treatment and prophylaxis. Pediatr Clin North Am. 1999 Apr;46(2):275-87.
7. Chui MC, Newby DE, Panarelli M, Bloomfield P, Boon NA. Association between calcific aortic stenosis and hypercholesterolemia: Is there a need for a randomized controlled trial of cholesterol-lowering therapy?. Clin Cardiol. 2001 Jan;24(1):52-5.
8. Cripe L, Andelfinger G, Martin LJ, et al. Bicuspid aortic valve is heritable. J Am Coll Cardiol. 2004 Jul 7;44(1):138-43.
9. Davies RR, Kaple RK, Mandapati D, Gallo A, Botta DM, Elefteriades JA, Coady MA. Natural history of ascending aortic aneurysms in the setting of an unreplaced bicuspid aortic valve. Ann Thorac Surg. 2007 Apr;83(4):1338-44.
10. de Sa M, Moshkovitz Y, Butany J, David TE. Histologic abnormalities of the ascending aorta and pulmonary trunk in patients with bicuspid aortic valve disease: clinical relevance to the ross procedure. J Thorac Cardiovasc Surg. 1999 Oct;118(4):588-94.
11. Della Corte A, Bancone C, Quarto C, et al. Predictors of ascending aortic dilatation with bicuspid aortic valve: A wide spectrum of disease expression. Eur J Cardiothorac Surg. 2007 Mar;31(3):397-404.
12. Duran AC, Frescura C, Sans-Coma V, et al. Bicuspid aortic valves in hearts with other congenital heart disease. J Heart Valve Dis. 1995 Nov;4(6):581-90.
13. Ellison JW, Yagubyan M, Majumdar R, et al. Evidence of genetic locus heterogeneity for familial bicuspid aortic valve. J Surg Res. 2007 Sep;142(1):28-31.
14. Fazel SS, Mallidi HR, Lee RS, Sheehan MP, Liang D, Fleischman D, et al. The aortopathy of bicuspid aortic valve disease has distinctive patterns and usually involves the transverse aortic arch. J Thorac Cardiovasc Surg. 2008 Apr;135(4):901-7, 907.e1-2.
15. Fowles RE, Martin RP, Abrams JM, Schapira JN, French JW, Popp RL. Two-dimensional echocardiographic features of bicuspid aortic valve. Chest. 1979 Apr;75(4):434-40.
16. Gelb BD, Zhang J, Sommer RJ, Wasserman JM, Reitman MJ, Willner JP. Familial patent ductus arteriosus and bicuspid aortic valve with hand anomalies: A novel heart-hand syndrome. Am J Med Genet. 1999 Nov 19; 87(2):175-9.
17. Hallidie-Smith KA, Karas S. Cardiac anomalies in Williams-Beuren syndrome. Arch Dis Child. 1988 Jul. 63(7):809-13.
18. Harris C, Croce B, Munkholm-Larsen S. Bicuspid aortic valve. Ann Cardiothorac Surg. 2017 Nov;6(6):721.
19. Kang JW, Song HG, Yang DH, Baek S, Kim DH, Song JM, Kang DH, Lim TH, Song JK. Association between bicuspid aortic valve phenotype and patterns of valvular dysfunction and bicuspid aortopathy: Comprehensive

evaluation using MDCT and echocardiography. JACC Cardiovasc Imaging. 2013 Feb;6(2):150-61.
20. Kappetein AP, Gittenberger-de Groot AC, Zwinderman AH, Rohmer J, Poelmann RE, Huysmans HA. The neural crest as a possible pathogenetic factor in coarctation of the aorta and bicuspid aortic valve. J Thorac Cardiovasc Surg. 1991 Dec;102(6):830-6.
21. Khan W, Milsevic M, Salciccioli L, Lazar J. Low prevalence of bicuspid aortic valve in African Americans. Am Heart J. 2008 Sep;156(3):e25.
22. Kitchiner D, Jackson M, Walsh K, et al. The progression of mild congenital aortic valve stenosis from childhood into adult life. Int J Cardiol. 1993 Dec 31;42(3):217-23.
23. Lamas CC, Eykyn SJ. Bicuspid aortic valve--A silent danger: Analysis of 50 cases of infective endocarditis. Clin Infect Dis. 2000 Feb; 30(2):336-41.
24. Lee TC, Zhao YD, Courtman DW, Stewart DJ. Abnormal aortic valve development in mice lacking endothelial nitric oxide synthase. Circulation. 2000 May 23;101(20):2345-8.
25. Michelena HI, Khanna AD, Mahoney D, et al. Incidence of aortic complications in patients with bicuspid aortic valves. JAMA. 2011 Sep 14;306(10):1104-12.
26. Nanda NC, Gramiak R, Manning J, Mahoney EB, Lipchik EO, DeWeese JA. Echocardiographic recognition of the congenital bicuspid aortic valve. Circulation. 1974 May;49(5):870-5.
27. Pachulski RT, Weinberg AL, Chan KL. Aortic aneurysm in patients with functionally normal or minimally stenotic bicuspid aortic valve. Am J Cardiol. 1991 Apr 01;67(8):781-2.
28. Panayotova R, Macnab A, Waterworth PD. A pilot project of familial screening in patients with bicuspid aortic valve disease. J Heart Valve Dis. 2013 Mar;22(2): 150-5.
29. Parai JL, Masters RG, Walley VM, et al. Aortic medial changes associated with bicuspid aortic valve: myth or reality?. Can J Cardiol. 1999 Nov;15(11):1233-8.
30. Pomerance A. Pathogenesis of aortic stenosis and its relation to age. Br Heart J. 1972 Jun;34(6):569-74.
31. Roberts WC. Morphologic aspects of cardiac valve dysfunction. Am Heart J. 1992 Jun;123(6):1610-32.
32. Roberts WC. The congenitally bicuspid aortic valve. A study of 85 autopsy cases. Am J Cardiol. 1970 Jul;26(1):72-83.
33. Roos-Hesselink JW, Schölzel BE, Heijdra RJ, Spitaels SE, Meijboom FJ, Boersma E, Bogers AJ, Simoons ML. Aortic valve and aortic arch pathology after coarctation repair. Heart. 2003 Sep;89(9):1074-7.
34. Sabet HY, Edwards WD, Tazelaar HD, Daly RC. Congenitally bicuspid aortic valves: A surgical pathology study of 542 cases (1991 through 1996) and a literature review of 2,715 additional cases. Mayo Clin Proc. 1999 Jan;74(1):14-26.
35. Sachdev V, Matura LA, Sidenko S, et al. Aortic valve disease in Turner syndrome. J Am Coll Cardiol. 2008 May 13;51(19):1904-9.
36. Sadee AS, Becker AE, Verheul HA, et al. Aortic valve regurgitation and the congenitally bicuspid aortic valve: a clinico-pathological correlation. Br Heart J. 1992 Jun;67(6):439-41.
37. Sans-Coma V, Fernández B, Durán AC, Thiene G, Arqué JM, Muñoz-Chápuli R, Cardo M. Fusion of valve cushions as a key factor in the formation of congenital bicuspid aortic valves in Syrian hamsters. Anat Rec. 1996 Apr;244(4):490-8.
38. Siu SC, Silversides CK. Bicuspid aortic valve disease. J Am Coll Cardiol. 2010 Jun 22;55(25):2789-800.
39. Stefani L, Galanti G, Toncelli L, et al. Bicuspid aortic valve in competitive athletes. Br J Sports Med. 2008 Jan;42(1):31-5.
40. Sybert VP. Cardiovascular malformations and complications in Turner syndrome. Pediatrics. 1998 Jan;101(1):E11.
41. Tripathi A, Wang Y, Jerrell JM. Population-based treated prevalence, risk factors, and outcomes of bicuspid aortic valve in a pediatric Medicaid cohort. Ann Pediatr Cardiol. 2018 May-Aug;11(2):119-124.
42. Tutar E, Ekici F, Atalay S, Nacar N. The prevalence of bicuspid aortic valve in newborns by echocardiographic screening. Am Heart J. 2005 Sep;150(3):513-5.
43. Tzemos N, Therrien J, Yip J, Thanassoulis G, Tremblay S, Jamorski MT, Webb GD, Siu SC. Outcomes in adults with bicuspid aortic valves. JAMA. 2008 Sep 17;300(11):1317-25.
44. Ward C. Clinical significance of the bicuspid aortic valve. Heart. 2000 Jan;83(1):81-5.
45. Wessels MW, Berger RM, Frohn-Mulder IM, et al. Autosomal dominant inheritance of left ventricular outflow tract obstruction. Am J Med Genet A. 2005 Apr 15;134(2):171-9.
46. Wilson W, Taubert KA, Gewitz M, et al. Prevention of infective endocarditis: guidelines from the American Heart Association: a guideline from the American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki

Disease Committee, Council on Cardiovascular Disease in the Young, and the Council on Clinical Cardiology, Council on Cardiovascular Surgery and Anesthesia, and the Quality of Care and Outcomes Research Interdisciplinary Working Group. Circulation. 2007 Oct 9; 116(15):1736-54.

© Copyright MB International Media and Publishing House. All rights reserved.