Aortopathy in Congenital Heart Disease

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KEYWORDS

• Aortopathy • Congenital heart disease • Aortic dissection • Bicuspid aortic valve

KEY POINTS

- Normal values for aortic dimensions may vary by age and body size prompting the need to consult nomograms when evaluating individual patients.
- High-risk patients include those with the "aortic root phenotype" and those with syndromic or familial aortopathies including Marfan syndrome, Loeys-Dietz syndrome, and Turner syndrome.
- The most significant functional alteration in aortopathy is increased wall stiffness, which is seen in patients with Marfan syndrome and bicuspid aortic valves and patients with other familial thoracic aortic aneurysms and dissections.
- Aortic dilatation is common in patients with conotruncal congenital heart defects, and rarely results in aortic dissection.

Over the last few decades, an accumulating body of medical literature has documented the presence of aortic dilation in patients with congenital heart defects (CHD) and explored the clinical importance of this common radiographic finding.[1–9] The impetus of a clinical review published a decade ago was to alert cardiologists to the potential for progressive, clinically significant aortic dilation in patients with CHD, a disease entity that had previously received little attention.[1] As often is the case in clinical medicine, the pendulum swung toward intervention, perhaps too far, and only more recently has begun to right itself.[4–6] Although progressive aortic dilation is seen commonly in adults with congenital heart disease, aortic dissection is rare.[9] Progressive aortic dilation is seen most commonly in bicuspid aortic valve (BAV) and conotruncal defects, both of which are discussed in this article.[7,8,10]

THE NORMAL AORTA

The thoracic ascending aorta (TAA) is considered dilated or ectatic when its size measures more than 1.1 to 1.5 times normal and aneurysmal if greater.[6,11,12] The normal aorta is larger in older individuals and patients with greater body surface area and/or height, with an average increase of 1.2 mm for each decade in age and 1 mm for each 0.23 m^2 in body surface area.[8,11] In a large American population-based study of more than 5000 participants age 45 to 84 years, the upper limit of normal for the TAA luminal diameter for white women was 35.8 mm (22 mm/m^2) and 40.3 mm (20 mm/m^2) for white men as determined

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by MRI.[11] Aortic diameters were greater in Chinese Americans, smaller in African Americans, and not significantly different in Hispanic individuals.[11] Within the general population, gender is thought to have a significant impact on aortic size and the risk for, and outcome of, aortic dissection. Female gender has been associated with greater rates of TAA growth, higher rates of TAA dissection, and lower 5-year event-free survival.[13] In light of the normal variations in aortic size described previously, use of gender-specific nomograms that index aortic size for body size and age are recommended and readily available.[14–17] Gone are the days when an aortic diameter less than 4 cm is considered normal.

STRUCTURAL AND FUNCTIONAL ALTERATIONS OF THE DILATED AORTA

Structural Alterations

The same picture of maladaptive remodeling of the aortic media seen in Marfan syndrome is also noted in patients with BAV and conotruncal defects.[18–22] In contrast to degenerative ascending aortic aneurysms, there is extracellular matrix degradation associated with noninflammatory loss of vascular smooth muscle cells.[8] The vascular smooth muscle cell apoptosis is thought to occur secondary to excessive activity of a group of degradative enzymes known as matrix metalloproteinases (MMPs). The increase in MMP activity may arise because of an imbalance of these enzymes and their tissue inhibitors (TIMPs).[8] As with Marfan syndrome, the transforming growth factor-β superfamily of cytokines has also been implicated in aneurysm formation in patients with CHD.[20,22] The underlying impetus that triggers the maladaptive remodeling process in all of these disorders remains poorly understood. Either because of a fibrillin deficiency as documented in BAV, an altered fibrillin product as is the case in Marfan syndrome, or a hemodynamic stressor the MMP cascade is triggered resulting in the common pathologic appearance.[8,21] Despite the similarities in the pathophysiology, the frequency of aortic dilation, and more importantly, the risk of aortic dissection, differs considerably among the aortopathies of Marfan syndrome, BAV, and conotruncal defects.[3,6] In light of these differences, the criteria for surgical intervention differ.[1,4–6,23]

Functional Alterations

The most significant functional alteration in aortopathy is increased wall stiffness, which is seen in patients with Marfan syndrome and BAV and patients with other familial thoracic aortic aneurysms and dissections.[24–28] This increased stiffness is also seen with increasing age and with diabetes.[29,30] Stiffness is measured in many different ways depending on the modality used (ie, echo vs MRI), but in general is a measure of the relative change in vessel dimension compared with changes in pressure between systole and diastole.[24,25,31,32]

There has been historical debate as to whether increased stiffness leads to dilation or aneurysm formation. Stiffness is believed to predict more significant aortic dilation in patients with Marfan syndrome and BAV, even in the absence of significant valvular dysfunction.[24,32–35] More recent studies, however, have shown stiffness to be a consequence of the previously discussed cellular remodeling rather than a stimulus for said remodeling.[24,26] Two smaller recent studies have shown increased aortic stiffness to be associated with slowed arterial dilation and aneurysm formation, suggesting stiffness may be protective.[24,26] However, more work is needed to refine the understanding of the causal relationship between stiffness and dilation and to determine whether prospective monitoring of aortic stiffness by echocardiography or MRI can be used to predict change in aortic size or, more importantly, to provide useful input into medical and surgical decision-making.

BICUSPID AORTIC VALVE AORTOPATHY

BAV is the most common congenital cardiac defect with a prevalence of 1% to 2% of the general population, with males comprising approximately 70% of all BAV cases.[6,36] Although stenosis and insufficiency are the most common complications of BAV, aortic aneurysms occur in 40% to 50% of patients.[1–6] Aortic dilation often begins in early childhood and is progressive, increasing at a more rapid rate than age-matched healthy control subjects.[2] BAV aortopathy-related mortality estimates vary widely, which likely relates to the fact that BAV aortopathy is a heterogeneous disorder. In 1978, before the advent of modern-day echo, Edwards and colleagues[37] noted at 6.14% lifetime risk of aortic dissection in all-comers with BAV. With modern echo techniques and routine thoracic screening performed for a multitude of noncardiac disorders, many more patients with a normally functioning BAV are diagnosed. As the denominator has increased with inclusion of much milder forms of the disease, estimates of dissection risk have decreased. The incidence of aortic dissection was 0.1% per patient year of follow-up in a Toronto study involving more than 600 patients with a BAV.[9] Similarly, Michelena and colleagues[38] documented no increase in mortality or dissection over age-

matched control subjects over a period of 20 years in a young adult cohort with a normal functioning BAV receiving routine cardiac care. Despite the low mortality rate in this cohort, morbidity remained high with combined cardiovascular medical or surgical events (heart failure, stroke, endocarditis, valve or aortic surgery) occurring in 42% at 20 years after diagnosis.

Although the risk of aortic dissection has been shown to be lower than once thought, BAV aortopathy remains a common indication for surgical intervention with studies demonstrating significant regional variations in surgical practice and practice patterns that are not guideline-driven.[39] Efforts are being made to distinguish between high- and low-risk patients to provide timely surgery to only those at higher risk of dissection. Aortic size alone has been shown to be insufficient in predicting the risk of ascending aortic dissection because most patients experiencing dissection do so at less than the current surgical criteria of 5.5 cm.[40] Although this has been an impetus for some to operate at smaller diameters, the vast denominator of those with smaller aortas who do not dissect suggests the pitfall in relying in aortic size alone.[41] Substantial efforts are currently being made to improve risk prediction of aortic catastrophes in BAV patients. Circulating levels of MMPs, TIMPs, transforming growth factor-β1 levels, specific microRNA signatures, and levels of sRAGE, an immunoglobulin superfamily of surface molecules that bind proinflammatory mediators, have all shown promise correlating with the degree of aortic disease in different at-risk BAV populations.[42–45] Although none of these circulating biomarkers are yet ready for routine introduction into clinical practice, the hope is that serologic testing may soon offer complementary information to radiographic imaging. Additionally, imaging measurements of aortic stiffness may become more clinically useful in the future.

Genetics of Bicuspid Aortic Valve and Bicuspid Aortic Valve Aortopathy

The role of a genetic versus hemodynamic alteration as the source of BAV aortopathy remains controversial.[3,8] There are ample data to support a role for both and the weight of either may vary from patient to patient. Familial studies suggest an autosomal-dominant mode of inheritance with incomplete penetrance.[46,47] Loscalzo and colleagues[48] noted an increased incidence of aortic dilation and aortic dissection in family members of patients with BAV even in the absence of a BAV suggesting the aortopathy and valve abnormality were two different manifestations of a common developmental anomaly. Familial studies have documented a 9% to 20% chance of identifying BAV in first-degree relatives of an affected proband and form the basis for the guidelines recommending echocardiographic screening in all first-degree relatives.[3–6,8,31,46,49] Despite high heritability, only a few genes to date have been linked to isolated familial nonsyndromic BAV aortopathy, including *NOTCH-1*, *SMAD6*, and *MAT2A*.[47,50,51] Within patients with Turner syndrome, *TIMP3* and *TIMP1* (genes for the TIMPs) have been implicated in BAV aortopathy.[52]

Hemodynamic Perturbations and Bicuspid Aortic Valve Aortopathy

The hemodynamics of BAV aortopathy are relevant in that the altered flow patterns caused by the abnormal valve are related to aortic morphology.[53–57] Additionally, valve morphology, independent of valve function, correlates with the type of aortic dilation present, suggesting that there are predictable patterns of flow that lead to specific aortopathy patterns.[55,57] Different patterns of leaflet fusion (eg, right-left coronary cusp fusion vs right-noncoronary cusp fusion) lead to predictably different flow acceleration through and beyond the valve. These altered flows lead to focal increases in wall shear stress in characteristic locations in the ascending aorta, with right-left cusp fusion leading to an anteriorly directed jet and right-nonfusion leading to a more posteriorly directed jet.[58] The phenotypic patterns of dilation seen in these two different populations of patients correspond with their respective characteristic areas of maximum wall shear stress.[53–56,58] These flow patterns have been extensively studied using MRI, but to date this information has not been translated into routine clinical application.

Surveillance of Patients with Bicuspid Aortic Valve

The rationale for periodic visits for patients with BAV is not only to monitor the status of valve function but to monitor the rate of progression of aortic dilation, monitor and treat elevated blood pressure, reassess whether the patient falls into a high-risk category, use such information to determine the appropriate timing of surgery (**Table 1**), and provide and reinforce lifestyle recommendations aimed at mitigating disease progression.

Medical Therapy for Bicuspid Aortic Valve and Bicuspid Aortic Valve Aortopathy

There have been no randomized trials demonstrating improved outcomes for BAV aortopathy, either dilation or dissection, with the use of any

Table 1
Syndrome and nonsyndromic aortopathies with increased prevalence of bicuspid aortic valve

Gene	Disorder	History	Incidence of BAV	Examination Findings	Timing of Aortic Replacement
FBN-1	Marfan syndrome	Positive family history in 75%	5%	www.marfan.org/dx/score	<5.0 cm
TGFBRI/TGFBRII	Loeys-Dietz syndrome	Skin fragility, wide scars	6%	Bifid uvula, pectus, translucent skin, wide-set eyes, Marfan features, aortic tortuosity	4.0–4.5 cm
ELN	Autosomal-dominant cutis laxa	Hypermobility	25%	Pendulous cheeks, loose skin folds	5.0 cm
SMAD3	Osteoarthritis aortopathy syndrome	Early onset arthritis, disk degeneration, easy bruising	5%	Marfan features, wide-set eyes, dolichocephaly, MVP, aortic tortuosity	4.0–4.5 cm
ACTA2	Smooth muscle dysfunction syndrome	Bowel obstructions, peripartum dissections	4%	Fixed dilated pupils, livedo reticularis, moyamoya, vessel occlusive disease	4.5–5.0 cm
X chromosome	Turner syndrome	Short stature, delayed puberty, infertility	40%	Short stature, webbed neck, ↑carrying angle	Aorta/BSA >2.5 cm/m^2

Abbreviations: BSA, body surface area; MVP, mitral valve prolapse.
Data from Refs.[5,13,66–71]

specific medications. As a result, no specific medical therapy is recommended in the 2014 American College of Cardiology (ACC)/American Heart Association (AHA) guideline for management of patients with valvular heart disease or the 2018 guidelines on bicuspid aortopathy.[6,49] Blood pressure control and general cardiovascular risk reduction are recommended, as in nonheritable thoracic aortopathy.[59,60] Beta-blockers and renin-angiotensin system inhibitors are often used based on extrapolation from data in patients with Marfan syndrome, but there is no evidence that these classes of antihypertensives are superior.[61–63] Additionally, there is no evidence that blood pressure targets lower than the general population are indicated.[60]

THE HIGH-RISK BICUSPID AORTIC VALVE PATIENT

Patients with BAV at higher risk for aortic dissection have been identified and include those with (1) an aortic root phenotype, (2) a familial syndromic or nonsyndromic thoracic aortic aneurysm syndrome, and (3) Turner syndrome.[3,5,8,31,46,64]

Root Phenotype

Several classification schemes for BAV aortopathy have been proposed, but in general terms, two phenotypes exist: one where the aortic root is primarily involved, and one where the primary site of dilation is the ascending or tubular portion of the aorta.[3,5] The aortic root phenotype is the rarest and is associated with a younger age at diagnosis, male gender, and aortic insufficiency; more recent four-dimensional flow MRI has also shown an association with fusion of the right-coronary and noncoronary cusps.[3,7,58] This pattern is thought to carry a higher rate of aortic dilation and dissection, which may be explained by the fact that this pattern of BAV aortopathy is seen in association with several different systemic syndromic and nonsyndromic disorders.[65–71]

Syndromic or Nonsyndromic Aortopathy

One of the great clinical dilemmas when evaluating the patient with a nonstenotic BAV is determining whether the valve abnormality is an isolated problem or whether it is a feature of an underlying systemic disorder that carries significant risk of aortic dissection. Personal medical history, family history, and clinical examination should all be directed toward assessing for features that may suggest the presence of a syndrome associated with a higher risk of rapid aortic dilation and dissection. BAV has been documented to occur with increased frequency in several conditions independently associated with aortic dissection, such as Marfan syndrome, Loeys-Dietz syndrome, smooth muscle dysfunction syndrome, aortopathy-osteoarthritis syndrome, and in patients with autosomal-dominant cutis laxa depending on the exon involved.[66–71] Although the yield of routine genetic testing in patients with BAV is low, the presence of suggestive clinical signs or symptoms should trigger genetic testing for the suspected underlying disorder.[72] Timing of surgical intervention is dictated by the underlying genetic mutation in these cases (see **Table 1**).

Turner Syndrome

BAV is present either alone, or in combination with aortic coarctation in approximately 40% of patients with Turner syndrome.[73] The risk of aortic dissection is higher than that of the general population and often occurs at smaller aortic diameters even when accounting for the short stature of most patients; as such, surgical criteria differ (see **Table 1**). Given the strong male predilection of BAV, a diagnosis of Turner syndrome should be considered in a female without a family history of BAV disease.

Method of Surveillance

Although various imaging modalities are used to evaluate BAV disease, per AHA/ACC guidelines, transthoracic echocardiography (TTE) is the standard diagnostic tool.[5,49,74] The frequency of imaging depends on the degree of valvar dysfunction, the degree of aortic dilation, and the presence or absence of associated syndromic or nonsyndromic systemic aortopathies.[5,6,49] TTE provides a comprehensive evaluation of the aortic valve including identification of valve morphology and assessment of valve function, and the aorta. Valve morphology is determined based on visual assessment of the number of valve leaflets, leaflet motion, thickness, and presence of calcification. Identification of the valve morphology and pattern of dilation is important for reasons mentioned previously. The severity of aortic stenosis is evaluated with Doppler velocity and pressure measurements and quantitative measures, such as aortic valve area determined by the continuity equation. Assessment of aortic regurgitation focuses on color and Doppler parameters and measures of the left ventricle. Left ventricular volumes and systolic function, and in certain populations, global longitudinal strain measurements, can aid in prognosis and timing of an intervention.[75] Limitations of echocardiography mainly relate to poor acoustic windows, which can

lead to inadequate visualization or incomplete evaluation of cardiac structures. Evaluation for ascending aortic dilation is more difficult, but techniques are used to adequately image the mid or distal ascending aorta.[73] If, despite use of high parasternal and right parasternal imaging, TTE provides inadequate imaging, other modalities, such as transesophageal echocardiography, cardiac MRI (CMR), and computed tomography (CT), can complement and provide further assessment. Fig. 1 demonstrates diffuse aortic involvement in a patient with BAV and familial aortopathy.

The 2018 guidelines on bicuspid aortopathy recommend repeat TTE every 3 to 5 years if the initial aortic measurements are normal.[6] If any segment of the aorta measures 40 to 49 mm, confirmation should be obtained using CT or CMR, with repeat imaging in 12 months to determine rate of change.[6] If measurements are stable, repeat imaging every 2 to 3 years using the same modality (echo or cross-sectional imaging, depending on echo images) is appropriate.[6] These recommendations differ slightly from the 2014 ACC/AHA Guidelines for Management of Patients with Valvular Heart Disease, which state that repeat examination frequency is at the discretion of the clinician based on the previous rate of change of diameter and family history until the aorta measures greater than 4.5 cm, at which point annual cross-sectional imaging should be performed.[49]

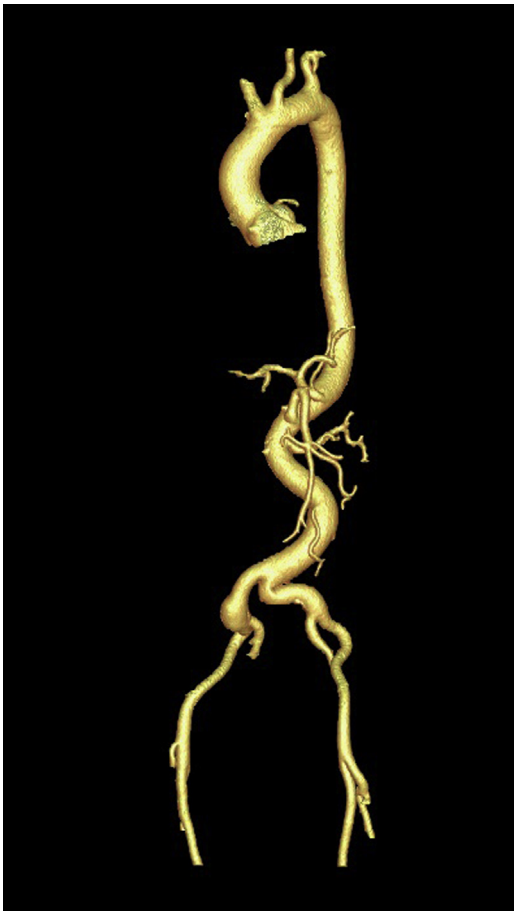

Fig. 1. Aortic CT scan of patient with bicuspid aortic valve and familial aortopathy. There is involvement of the proximal thoracic aorta and aortic tortuosity and iliac artery aneurysm.

CMR provides a comprehensive assessment of BAV disease and is used as a valuable adjunctive imaging modality to assess aortic disease specifically when TTE is inadequate.[76] Cine images of the aortic root depict aortic valve morphology and allow for measurement of its dimensions. Phase-contrast flow measurements accurately quantify the regurgitation fraction of the aortic valve. Left ventricular volumes, mass, and function are determined from short-axis cine images. Delayed enhancement imaging identifies regions of myocardial fibrosis, which may be present in a subset of patients. Contrast-enhanced magnetic resonance angiography provides a comprehensive evaluation of the thoracic aorta, demonstrating any evidence of dilation or aneurysm. Thoracic aorta diameters are accurately measured using multiplanar reconstruction in double-oblique cross-sectional planes. Currently, research with CMR using four-dimensional flow sequences and analysis of aortic wall stress in individuals with BAV aortopathy have demonstrated how different valve morphologies impact flow patterns, dilation, and wall stress in the aorta and contribute or cause aortopathy.[57,58,77] Limitations of CMR include availability, cost, and the need for patients to tolerate lying flat for longer examination times.

Cardiac CT provides high spatial resolution images of the thoracic aorta and is useful for the morphologic assessment of the bicuspid valve and evaluation of calcification. A CT of a patient with BAV and familial aortopathy is shown in Fig. 1. Additionally, if needed, coronary artery anatomy can be concurrently evaluated. Aortic measurements are obtained using multiplanar reconstruction in double-oblique cross-sectional planes. If candidacy for transcatheter aortic valve replacement is being considered, CT has a role for preoperative assessment, aiding in accurate annular dimensions for valve sizing. Limitations of CT include radiation dose, need for iodinated contrast, and a lack of functional information regarding severity of valve disease.

In addition to risk stratification, clinical visits should cover the following topics where appropriate:

1. Pregnancy: Female patients require timely counseling regarding the potential risks of pregnancy.

Such counseling should commence before the onset of sexual activity and be reinforced at regular intervals during the childbearing years. Pregnancy has been documented to have an effect on aortic size in healthy patients, with greater aortic size associated with greater parity.[78] Pregnancy in itself is recognized as an independent risk factor for aortic dissection.[79] However, provided that a woman does not have BAV as a feature of an underlying genetic aortopathy, the risk of aortic dissection associated with BAV in a woman with an aortic diameter greater than 5 cm is exceedingly small; the data do not substantiate a risk greater than that of the general peripartum population.[79] Most published peripartum aortic dissections have involved women with a trileaflet aortic valve.[80] Despite claims to the contrary, a higher risk of aortic dissection in the general population of woman with BAV and an aortic diameter less than 5 cm is not born out by the numbers, and there is no basis for recommendations to consider replacement of the aorta at a smaller size if a woman desires pregnancy.[81,82] Because the denominator of patients experiencing pregnancy with a normal-functioning BAV is exceedingly large, the overall risk quite small.

2. Avoidance of fluoroquinolones: There are accumulating data documenting the risk of aortic aneurysm ± dissection in patients using fluoroquinolones.[83–85] A propensity-matched study of patients receiving amoxicillin or a fluoroquinolone by Pasternak and colleagues[83] demonstrated a 66% increased risk of an aortic dissection in patients receiving the fluoroquinolone, with increased incidence most pronounced within the first 10 days of treatment. Other observational studies have documented a similar association.[84,85] Furthermore, administration of ciprofloxacin to an aneurysm-prone mouse model significantly increased the incidence of aortic dissection.[86] The mechanism of action has been purported to be increased activity of MMPs.[83–85] In December of 2018, the Food and Drug Administration issued a drug safety announcement advising that fluoroquinolones can increase the risk of aortic dissection. It is recommended that this class of antibiotics not be used in patients at risk for aortic aneurysm including those with aortic dilation, hypertension, genetic disorders associated with aneurysm, and the elderly.[87]
3. Athletics: More than a decade ago, Elefteriades[88] reported on the association of ascending aortic dissection and high-intensity weight lifting. These data, in combination with studies of healthy volunteers documenting blood pressures in excess of 300 to 400 mm Hg with weight lifting, form the basis of exercise recommendations for patients with BAV aortopathy.[89] Patients with moderate (45 mm) or greater aortic dilation should avoid heavy weight lifting and extreme sports.[3] Aerobic/endurance exercise, however, is recommended if concomitant valve disease does not preclude such.[3] The blood pressure lowering effect of routine aerobic exercise is thought to be beneficial.[5]

The recommendations of the ACC/AHA that follow are for patients with BAV and associated aortic root enlargement[49]:

1. Patients with BAV with no aortic root dilatation (less than 40 mm or the equivalent according to body surface area in children and adolescents) and no significant aortic stenosis or aortic regurgitation may participate in all competitive sports.
2. Patients with BAV and dilated aortic roots between 40 and 45 mm may participate in low and moderate static or low and moderate dynamic competitive sports (classes IA, IB, IIA, and IIB), but should avoid any sports in these categories that involve the potential for bodily collision or trauma.
3. Patients with BAV and dilated aortic root greater than 45 mm can participate only in low-intensity competitive sports (class IA).

If such patients also have significant valvar stenosis, insufficiency, or Marfan syndrome these recommendations should be considered in concert with those discussed in the document related to these valvular and connective tissue diseases.

Conotruncal Defects and Aortopathy

Although there is clear evidence of increased risk of dissection caused by BAV aortopathy, this is not the case for other types of complex congenital heart disease. Conotruncal defects including truncus arteriosus, transposition of the great arteries (TGA), tetralogy of Fallot, and double outlet right ventricle are frequently associated with thoracic aortic dilation.[19,90–96] A representative magnetic resonance angiography of an adult with tetralogy of Fallot and aortic dilatation is shown in **Fig. 2**. The mechanism of this dilation is thought to be related to hemodynamically significant right-to-left shunting before repair, because increased volume loading of the aorta has consistently been shown to be associated with increased diameter.[19,97] Additionally, histologic studies have shown cystic medial necrosis in the aortic wall in patients with tetralogy of Fallot, suggesting there

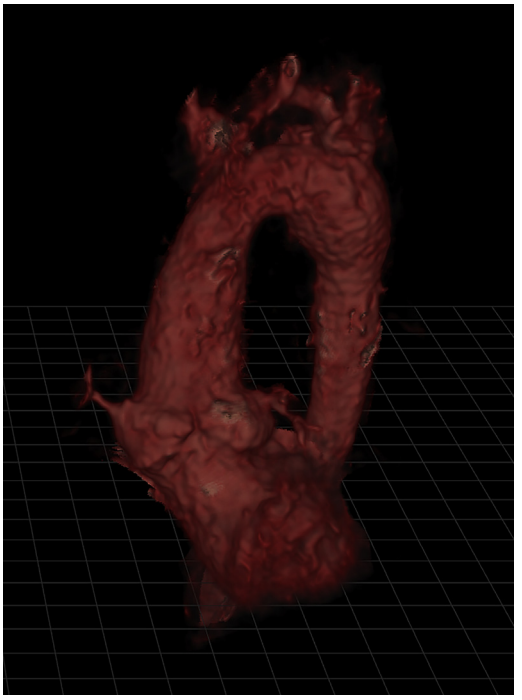

Fig. 2. Three-dimensional steady-state free precession MRI in a 39-year-old man with tetralogy of Fallot. Sagittal projection with the right heart removed demonstrates dilatation of the aortic root and ascending aorta, and focal dilatation of the proximal descending aorta. The maximal sinus-to-sinus measurement is 58 mm. (*Courtesy of* Jimmy Lu, MD, Ann Arbor, MI.)

is an additional cellular-level cause of decreased elasticity.[18,19,90,98]

Despite frequent dilation, dissection is rare. In a study of children and young adults with aortic dissection, patients with CHD were more likely than the general population to have aortic dissection, but the incidence of aortic dissection in children, with and without CHD, was extremely low and, unsurprisingly, well lower than that of the general adult population.[99] The discussion of this study postulated that some of these dissections were procedure-related because the diagnosis was not present on admission.

There is a single reported case of dissection in D-TGA occurring following Mustard procedure at maximum diameter of 70 mm. Aortic dilation is much more commonly seen following arterial switch operation compared with Mustard procedure and no case reports of dissection following arterial switch have been published, although two cases of dissection following unspecified D-TGA repair were included in a recent database study.[10,100] The same database study, examining dissection in all inpatients in the state of Texas, documented a single case of dissection in a patient with truncus arteriosus, but no other cases have been reported.[10] There have been no documented cases of dissection in patients with double outlet right ventricle.

The few existing case reports of dissection in patients with tetralogy of Fallot occurred in individuals with massive aortic dilation or older age: three cases in patients 30 years or younger had maximum aortic dimensions of 70 mm, 70 mm, and 93 mm, respectively.[101–103] An additional report described a dissection in a 60-year-old patient had maximum aortic dimension of 53 mm.[104] A recent review of thoracic aortic dissection in patients with tetralogy of Fallot was performed by Egbe and colleagues[105] using the National Inpatient Sample looking at all hospitalizations nationally over a 15-year period. They identified 11 total dissections in more than 18,000 admissions for patients with tetralogy of Fallot corresponding to 6 dissections per 10,000 admissions (0.06%), a number that is certainly even lower for the total tetralogy of Fallot population including nonhospitalized patients. When compared with the frequency of thoracic aortic aneurysm in patients with tetralogy of Fallot, with different studies suggesting prevalence of 28% to 69%, the rate of dissection is vanishingly small.[19,31,90,91,95–97,102,105,106]

Given limited data, neither the 2018 ACC/AHA Guideline for the Management of Adults with Congenital Heart Disease nor the 2010 European Society of Cardiology make specific recommendations regarding intervention for patients with conotruncal defects and aortic dilatation. The 2018 ACC/AHA guideline describes the identification of adults at risk for aortic dissection as a knowledge gap meriting further investigation. Dearani and colleagues[23] recommended surgery for aortic aneurysm in conotruncal congenital heart disease based on criteria similar to the general population (>55 mm) with consideration for earlier intervention if the patient was planning for cardiac surgery for another lesion. Based on the previously mentioned data about the low incidence of dissection despite larger aortic dimensions, more conservative management, particularly in those without additional risk factors (age, hypertension, genetic disorder), is likely warranted in conotruncal congenital heart disease. More data are needed, however, to determine the dimensions at which intervention is warranted.

DISCLOSURE

None of the authors have any disclosures to report.

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