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Review Article

Evaluation of valvular disease by cardiac computed tomography assessment

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Abstract. Cardiac multidetector computed tomography (MDCT) angiography is emerging as a technique to evaluate cardiac valve structure and function. MDCT can provide insights into cardiac valve anatomy and pathologic states, including comparable efficacy in valve area and regurgitant orifice area assessment compared with echocardiography and magnetic resonance imaging. MDCT can also be useful when initial evaluation of valvular disease with echocardiography yields suboptimal images. MDCT provides concurrent visualization of coronary anatomy which may avoid the need for further invasive preoperative testing. Overall, more studies have shown the utility of MDCT in imaging of left-sided valves (aortic and mitral), whereas its ability in assessing right-sided valves (tricuspid and pulmonary) is somewhat limited. MDCT has shown promise as a valuable adjunctive imaging tool to conventional imaging modalities in providing essential anatomic and physiologic data on the sequelae of valvular dysfunction, with the potential of guiding both surgical and percutaneous management. MDCT technology continues to evolve, and more studies are indicated to further refine its precise role in the evaluation of patients with valvular pathology.
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Introduction

Valvular heart disease encompasses a large variety of pathologic findings that result in abnormal cardiac valve structure or function. In the United States, valvular heart disease accounts for approximately 10%–20% of all cardiac surgical procedures.[1] Although transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) have been the noninvasive "gold standard" in the evaluation of cardiac valves, cardiac multidetector computed tomography (MDCT) is emerging as a powerful tool in cardiac valve assessment, displaying distinct advantages over imaging modalities such as TTE, TEE, and cardiac magnetic resonance imaging (MRI) in valve assessment. Datasets acquired from routine coronary CT angiography (CTA) also provide valuable information on valvular anatomy and function without the need for additional imaging protocols.[2] Moreover, the evolution of MDCT has resulted in marked improvement in temporal

and spatial resolution during image acquisition.[3] This article discusses the effectiveness of MDCT in evaluating the normal structure and function of the 4 major cardiac valves, as well as its diagnostic utility in analyzing valve pathology, primary valve tumors, and endocarditis.

Rationale for cardiac MDCT

The high degree of image quality and short acquisition time of MDCT have allowed for improved diagnostic and noninvasive method of analyzing cardiac valves. Contemporary MDCT provides true 3-dimensional (3D) datasets with high resolution submillimeter isotropic voxels that allow interactive evaluation of the coronary arteries, cardiac valves, and other cardiac and extracardiac structures of interest. Multiphase retrospectively gated MDCT is typically required for assessment of valvular structure and function, but it has the disadvantage of higher radiation doses compared with that of prospective imaging. MDCT has limited temporal resolution relative to cardiac MRI and echocardiography, although acquisition time and spatial resolution are specific advantages of MDCT. MDCT can visualize the anatomic structure of cardiac valves with similar accuracy as TEE without the limitations of varying acoustic windows and heavy calcification that can limit anatomic assessment.[2] In addition, MDCT can be used in patient populations that are unable to undergo MRI studies, such as patients with claustrophobia, pacemakers, and implantable defibrillators. Therefore, MDCT can be an extremely useful supplemental imaging technique in the noninvasive evaluation of cardiac valves. In addition, concurrent evaluation of coronary anatomy may potentially negate the need for invasive coronary angiography, and its accompanying radiation exposure, before cardiac valve surgery, given its high negative predictive value for excluding significant coronary artery disease (CAD). Currently, MDCT is considered an appropriate imaging modality to exclude CAD in patients with an intermediate pretest probability of CAD undergoing noncoronary cardiac surgery.[4]

Aortic valve

Normal anatomy and physiology

The normal aortic valve consists of 3 cusps (right, left, and noncoronary), an annulus, and commissures. Above the cusps, outpouchings of the aorta are present, the sinuses of Valsalva. Congenital variants of the aortic valve include bicuspid, quadricuspid, or unicuspid structures. Retrospectively gated multiphase coronary CTA can be used to evaluate the aortic valve throughout the cardiac cycle, providing for structural assessment of the leaflets, annulus, and adjacent aortic root structure.[5] There is also strong evidence for its accuracy in imaging the aortic root and in determining aortic valve area.[5,6] MDCT studies should be performed with electrocardiographic (ECG) gating to ensure significant motion artifacts of the aortic valve and aortic root are prevented.

Aortic stenosis

Aortic valve stenosis is an abnormal narrowing of the aortic valve opening associated with a high mortality once the stenosis is deemed severe and accompanied by symptoms. The leading cause of aortic stenosis in Western countries is degenerative or calcific-related causes. Other causes include congenital malformations or rheumatic heart disease. Fibrotic valvular thickening and calcification are common eventual endpoints in both nonrheumatic calcific and rheumatic aortic stenosis.

The severity of aortic stenosis can be evaluated effectively by MDCT with the use of planimetry of the anatomic aortic valve area during systolic phases. Studies have shown that the valve area is largest during mid-systole[7] with other studies suggesting that the optimal phases correspond to 10%–30% of the R-R interval.[8–10] Shah et al[7] concluded that MDCT can provide accurate assessment of aortic valve area compared with TEE and is valuable when the latter is inconclusive. MDCT can be considered an alternative to echocardiography for measuring aortic valve area because it is neither operator nor acoustic window dependent.[2] Figure 1 shows various
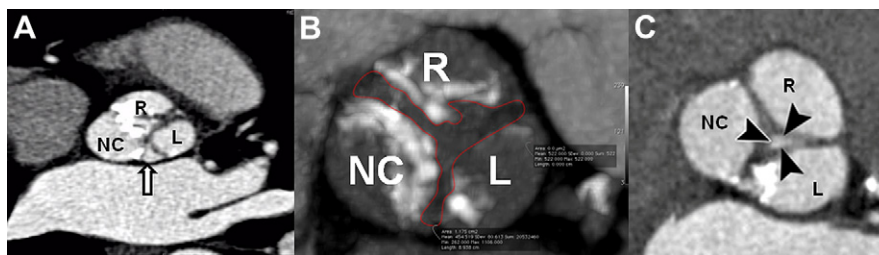

Figure 1   Multidetector computed tomography aortic valve short-axis views show various forms of trileaflet aortic valve pathology. (**A**) Mixed aortic stenosis and regurgitation with malcoaptation of the aortic leaflets in diastole (*arrow*). Heavy calcification is seen in the right and noncoronary cusps. (**B**) Planimetry assessment of an aortic valve in mid-systole with an aortic valve area of 1.1 cm². (**C**) Aortic regurgitation because of malcoaptation of the aortic leaflets (*arrowheads*) seen in mid-diastole. NC, noncoronary cusp; R, right coronary cusp; L, left coronary cusp.

MDCT trileaflet aortic valve abnormalities. A meta-analysis of 14 studies that involved 16, 40, and 64-slice MDCT showed a trend toward slight overestimation of the aortic valve area on planimetry by MDCT compared with TTE (bias $+0.08$ cm^2; 95% CI 0.04–0.13 cm^2; $P = 0.0001$), and good correlation when comparing MDCT with TEE planimetric assessment of the aortic valve (bias -0.02 cm^2; 95% CI 0.16–0.11 cm^2; $P = 0.71$).[11] However, there are potential limitations to planimetry assessment, given that the aortic valve orifice is a 3D structure, and the measurement of a 2-dimensional orifice at any given level may not reflect the true flow dynamics through the valve, which are typically assessed by echocardiography and MRI.

Congenital malformations include bicuspid, quadricuspid, and unicuspid aortic valves, although the latter 2 are relatively rare. These anatomic variants are prone to development of both premature aortic stenosis and regurgitation. This in turn can cause calcification, fibrosis, and rigidity of leaflets and subsequent reduction of the aortic valve area.[5] MDCT with ECG gating can be effective in detecting these structural abnormalities with the use of established protocols[12] (Figs. 2 and 3; Supplemental Movies 1 and 2).

Aortic valve calcification has a variety of causes, the most common of which is caused by age-related degeneration from hemodynamic stress that follows a classical
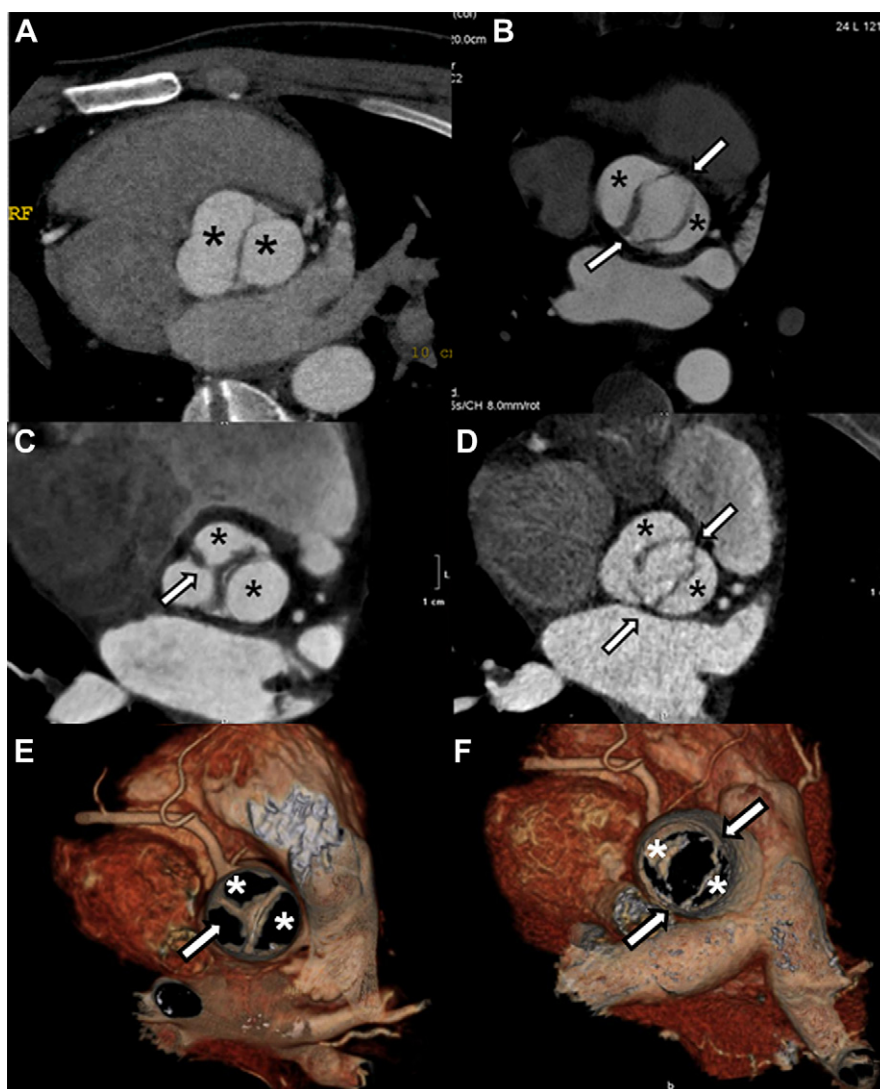

Figure 2   Multidetector computed tomography aortic valve short-axis views show congenital variants of bicuspid aortic valve morphologies. (**A**) Bicuspid aortic valve morphology with 2 aortic cusps seen (*asterisks*) in diastole. (**B**) Bicuspid aortic valve in systole, with 2 commissures defining the outline of the 2 cusps (*asterisks*). (**C**) Example of a bicuspid aortic valve with an initial trileaflet appearance in diastole, which reveals itself to be a bicuspid valve with a prominent raphe in systole. The 2 cusps are shown (*asterisks*) with the raphe (*arrow*) fusing the right and noncoronary cusps. (**D**) The bicuspid aortic valve in systole, with the 2 commissures (*arrows*) seen defining the 2 aortic cusps (*asterisks*). (**E**) Three-dimensional volume rendering of panel C, with the raphe (*arrow*) and 2 aortic cusps (*asterisks*) identified in diastole. (**F**) Three-dimensional volume rendering of panel D, with the 2 commissures (*arrows*) defining the 2 cusps (*asterisks*) in systole.

Figure 3   Multidetector computed tomography aortic valve short-axis view show congenital variants of aortic valve morphologies. Quadricuspid aortic valve morphology with 4 aortic cusps (*asterisks*).

Figure 4   Multidetector computed tomography left ventricular outflow tract view of the aortic valve and ascending aorta in mid-diastole show malcoaptation of the aortic valve leaflets (*arrow*) because of annuloaortic ectasia, resulting in central aortic regurgitation.

"response to injury" process similar to atherosclerosis. On MDCT, calcified leaflets are thicker and have a higher attenuation ("brighter") than surrounding tissue. The extent of calcification by MDCT strongly correlates with the hemodynamic severity of aortic stenosis by echocardiography, a useful tool in patients with low gradient severe aortic stenosis due to low left ventricular ejection fraction.[13–15] For the detection of severe aortic stenosis (by TTE), an aortic valve calcium threshold of >1650 arbitrary units by electron beam CT yielded a sensitivity of 82%, specificity of 80%, positive predictive value of 88%, and negative predictive value of 70%.[15] Aortic valve calcium has also been shown to be an independent predictor of mortality after adjusting for traditional risk factors and was associated with increased all-cause mortality (hazard ratio, 1.82; 95% CI 1.11–2.98).[16] On the basis of these data, MDCT can be considered the preferred imaging technique for both diagnosis and prognosis in patients with poor acoustic windows or left ventricular (LV) dysfunction.[17]

Aortic regurgitation

In developing countries, the most common cause of aortic regurgitation is rheumatic fever. In Western countries, however, aortic regurgitation is attributable largely to congenital causes (such as bicuspid aortic valve with associated aortopathy) and degenerative causes (such as annuloaortic ectasia; Fig. 4) which typically present in the fourth to sixth decades of life.[18] Endocarditis and aortic dissection can also lead to aortic regurgitation, and in the acute setting both of these conditions can be life threatening.
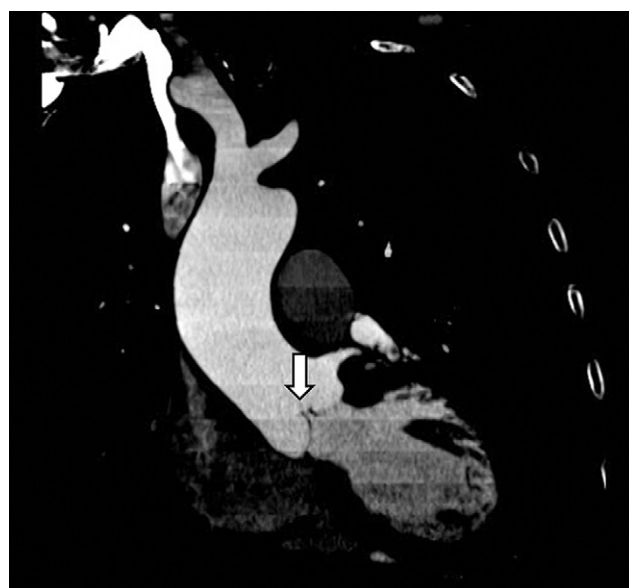
The ability of MDCT in identifying all grades of aortic regurgitation at a 75% phase of the R-R interval had a sensitivity, specificity, positive predictive value, and negative predictive value of 100%, 85.7%, 93.5%, and 100%, respectively.[19] Quantification of the anatomic regurgitant area by MDCT also significantly correlated with echocardiography in detecting mild, moderate, and severe aortic regurgitation (mean ± SD, 0.25 ± 0.34 cm^2; $P < 0.001$). MDCT missed mild aortic regurgitation in 26% of patients, most of whom had a heavily calcified or bicuspid aortic valve, or both.[20] These investigators extended this analysis to that of assessing aortic valve regurgitant volume and fraction from 3D ventricular segmentation on MDCT.[21] The sensitivity and specificity of CT-based regurgitant volume and fraction was 98% and 90%, respectively, and the specificity improved to 97% if the regurgitant area by CT was added as a diagnostic criterion.

Mitral valve

Normal anatomy and physiology

The mitral valve separates the structural left ventricle from the left atrium. It consists of 2 leaflets, -the anterior and posterior leaflets, each of which consist of 3 scallops. The leaflets are stabilized by the support of the cord-like structures known as the chordae tendinae that insert into papillary muscles in the left ventricle. The mitral valve annulus is considered part of the cardiac skeleton and is part the myocardium. The cardiac fibrous skeleton extends
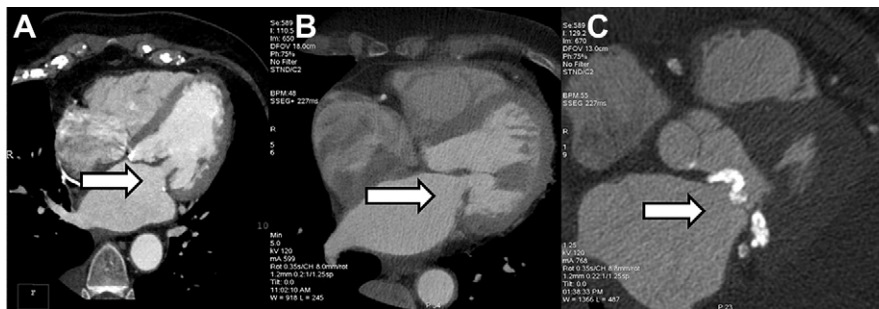
Figure 5   Multidetector computed tomography axial 4-chamber angiography shows various forms of mitral stenosis. Dilated left atria are seen in all panels. (**A**) Rheumatic mitral stenosis in mid-diastole shows a "hockey-stick" appearance of the mitral leaflets (*arrow*). Restricted posterior leaflet motion was also seen. (**B**) Rheumatic mitral stenosis in mid-diastole shows thickening of the mitral leaflet tips (*arrow*). (**C**) Calcific mitral stenosis shows heavy calcification of the mitral annulus and anterior mitral valve leaflet (*arrow*).

to a fibrous continuity between the aortic and mitral valve. MDCT has the ability to analyze normal mitral valve leaflets, the mitral valve annulus, and leaflet commissures with high image quality, requiring perpendicular long-axis reconstructions.[22] Disease states of the left ventricle can lead to secondary dysfunction of the mitral valve, and primary mitral valve disease can gradually lead to LV remodeling and decreased systolic function as a result of the attempt to maintain forward stroke volume in the face of significant regurgitant flow.

Mitral stenosis

Mitral valve stenosis is the narrowing of the mitral valve, causing an obstruction of blood flow between the left atrium and left ventricle. The most common cause of mitral stenosis is rheumatic mitral valve disease, which can cause leaflet thickening, commissural fusion, and chordal fusion that result in a progressive narrowing of the mitral orifice which becomes tubular in appearance. MDCT can be useful for determining mitral stenosis severity as an alternative to echocardiography, especially with patients with poor acoustic windows (Fig. 5). When MDCT mitral valve orifice planimetry is obtained at the 75% phase, accurate mitral valve area (MVA) quantification can be achieved compared with echocardiography, with low interobserver variability.[23] It has been noted that the MDCT-derived anatomic MVA is larger than that obtained by TTE; however, MDCT yields good correlation with TTE for the detection of moderate-to-severe mitral stenosis ($r = 0.90$; $P < 0.001$; limits of agreement, ± 0.65 cm^2).[24]

Mitral regurgitation

Mitral valve regurgitation is caused by the improper closure of the mitral valve, resulting in abnormal backflow or regurgitation. There are a variety of pathologic origins of mitral regurgitation, including mitral valve prolapse usually caused by myxomatous degeneration. Torn or damaged chordae tendinae, endocarditis, uncontrolled hypertension,

previous myocardial infarction, and less frequently congenital defects can also cause mitral regurgitation. In addition, pathologic states of the left ventricle (ie, ischemia, cardiomyopathy) can have deleterious effects on mitral valve function, causing mitral annular deformation, papillary muscle displacement, and LV remodeling, resulting in tethering of the mitral valve and lack of coaptation of the leaflets.[25,26] This can result in functional mitral regurgitation.

Several studies have highlighted the benefits of MDCT in assessing mitral regurgitation. ROA, an important parameter in estimating regurgitant severity, can be difficult to estimate accurately with echocardiography, whereas MDCT can directly image and provide planimetered ROA. It has also been reported that MDCT is able to detect structural abnormalities such as mitral valve prolapse, flail leaflet, annular calcification, and leaflet thickening which could elucidate the underlying pathologic mechanism[27] (Fig. 6). Another study
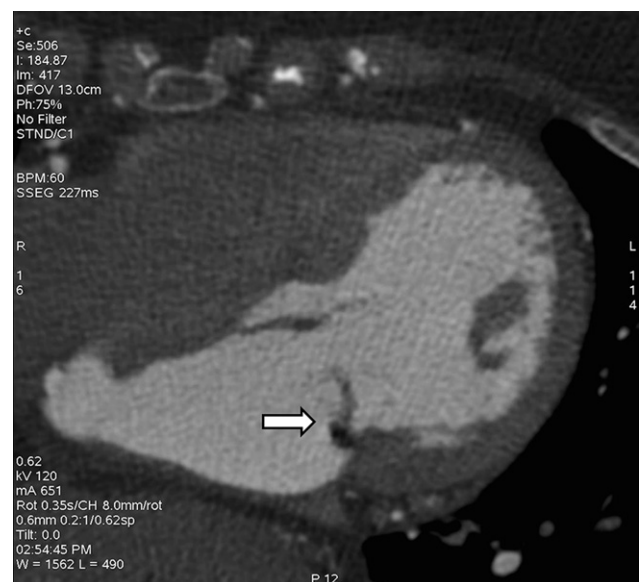

Figure 6   Multidetector computed tomography axial 4-chamber angiography shows a flail posterior mitral valve leaflet (*arrow*), causing severe mitral regurgitation.

of patients with documented isolated mitral regurgitation by echocardiography found that MDCT regurgitant volume and regurgitant fraction measurements correlated well with MRI, whereas MR grading correlated with TTE assessment of regurgitant severity.[28] MDCT can also provide anatomic and geometric information on the mitral valve apparatus in the setting of significant functional mitral regurgitation, and it has shown increased posterior leaflet angles, more outward displacement of the papillary muscles, and increased tethering of the mitral leaflets at the central and posteromedial levels.[26] MDCT has also been shown to assist in determining the presence of papillary displacement and resultant leaflet tethering in dilated and ischemic cardiomyopathy with functional mitral regurgitation. MDCT was able to accurately visualize a spectrum of anatomic variations of symmetric and asymmetric leaflet tethering, which can have an effect on regurgitant severity, and can potentially guide surgical therapies with mitral valve repair and papillary muscle repositioning.[29]

Tricuspid valve

Normal anatomy and physiology

The tricuspid valve is the right-sided atrioventricular valve, is typically a trileaflet structure (the septal, anterior, and posterior cusps) and consists of 3 papillary muscles. Similar to the pulmonic valve, it is generally much more difficult to visualize with MDCT because of relatively thin leaflet structure and contrast mixing artifacts, but this can be overcome by novel protocols for contrast infusion. Despite the limitations mentioned, MDCT compared with cardiac MRI, has superior spatial resolution for evaluating structural morphology of right-sided valves.[30]

Tricuspid stenosis

Tricuspid valve stenosis, although relatively rare, can be caused by rheumatic fever, systemic lupus erythematosus, carcinoid syndrome, and cardiac tumors (ie, myxoma). Tricuspid stenosis often results in an enlarged right atrium, thickened cusps, and thickened chordae tendinae. As mentioned earlier, MDCT has the advantage of elucidating structural malformations of the tricuspid valve.[30] For example, tricuspid stenosis is most often seen on MDCT as a marked thickening of cusps. Normal cusps are often thin and faint, making the appearance of clear and thick cusps a strong indication of tricuspid stenosis. In addition, an enlarged right atrium and thick chordae tendinae in the right ventricle can be clearly seen on MDCT and are characteristic of tricuspid stenosis. Nevertheless, echocardiography will likely remain the primary imaging modality over both MDCT and MRI in the evaluation of the tricuspid stenosis because of its diagnostic correlation to invasive cardiac catheterization techniques.[31]

Figure 7 Multidetector computed tomography axial 4-chamber view of a patient with Ebstein anomaly. Significant right-sided enlargement and "atrialization" of the right ventricle is seen, with significant apical displacement of the tricuspid septal leaflet (*arrow*).

Tricuspid regurgitation

Tricuspid regurgitation can result from a structurally compromised valvular apparatus, such as chordae tendinae,
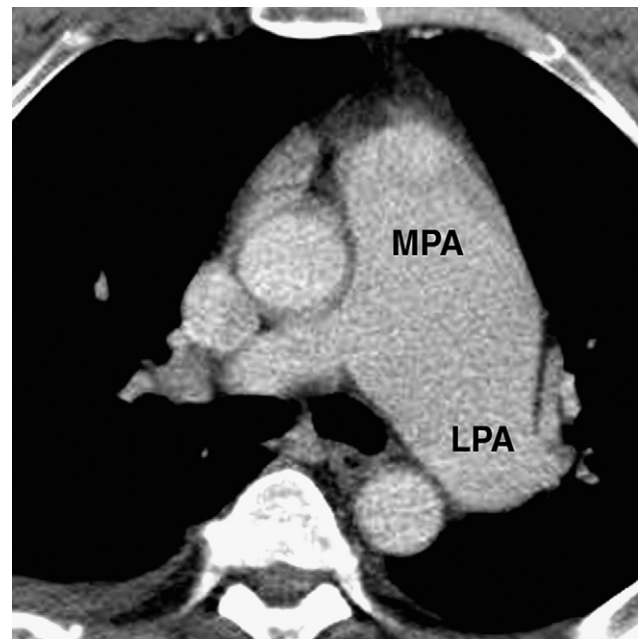

Figure 8 Axial multidetector computed tomography of the chest shows poststenotic dilatation of the main pulmonary artery (MPA) and left pulmonary artery (LPA), with sparing of the right pulmonary artery. Used with permission.[36]

leaflets, and papillary muscles. Pathologic structural morphology can in many instances be acquired from rheumatic fever and endocarditis or can be a result of Ebstein anomaly, a congenital malformation that comprises apical displacement of the sepal and posterior leaflets with "atrialization" of the right ventricle (Fig. 7). Most commonly, tricuspid regurgitation results from dilatation of the tricuspid annulus and right ventricle, which can result from any cause that leads to right-heart congestive heart failure.

Limited data exist on the utility of MDCT in the systematic evaluation of tricuspid valve pathology. MDCT can highlight important structural diagnostic clues in tricuspid regurgitation that have strong correlation to echocardiography and provide supplemental information in clinical management. Semiquantitation from first-pass contrast reflux present in the inferior vena cava (IVC) or hepatic veins has traditionally been considered a reliable sign of tricuspid regurgitation with moderate agreement to echocardiography (κ weighted coefficient was 0.56).[32] More recently, several superior vena cava and IVC contrast characteristics were found to have good correlation with echo-derived right atrial and ventricular pressures.[33]

Pulmonary valve

Normal anatomy and physiology

The method of evaluating the trileaflet pulmonary valve is similar to that of the aortic valve. However, the pulmonary valve, as with the tricuspid valve, generally has thin leaflets, as well as being susceptible to contrast artifact limitations, making it complex to evaluate with MDCT.[34] Accurate visualization with echocardiography can also prove difficult for the above-mentioned reasons, as well as the distance from the esophagus (in the case of TEE imaging). Nonetheless, it is still useful to consider MDCT as a viable option, because it can provide useful evidence of underlying pathology, especially after suboptimal visualization from other modalities.

Pulmonary valve stenosis

Pulmonary valve stenosis is the obstructive restriction of blood from the right ventricle to the pulmonary artery, which frequently results in a domed appearance of the valve

Figure 9   Multidetector computed tomography imaging of various tumors. (**A**) Axial 4-chamber view of a rhabomyoma (*arrows*) with calcification that involves the right atrium and right ventricle. (**B**) Axial 4-chamber view of a myxoma (*arrows*) prolapsing into the left ventricle during mid-diastole. (**C**) Axial 4-chamber view of a lipoma (*arrow*) with involvement of the right atrium. (**D**) Oblique 3-chamber view shows both a myxoma attached to the interatrial septum (*vertical arrow*) and papillary fibroelastoma (*horizontal arrow*) attached to the aortic valve leaflets.

during systole, and can lead to right ventricular hypertrophy over time. Several causes of pulmonary valve stenosis are known, with the most common resulting from a congenital defect, such as tetralogy of Fallot. In addition, complications of rheumatic fever and carcinoid syndrome are also known to cause pulmonary valve stenosis.

Similar to left-sided valves, MDCT permits evaluation of the pulmonary valve planimetered area, and this can be computed to supplement and confirm clinical findings. Pulmonary valve stenosis severity is traditionally determined by peak transvalvular pressure gradients on echocardiography, and a normal pulmonary valve area measures approximately 2 cm^2. Grading severity of pulmonary valve stenosis on the basis of valve area is not recommended because, although the echo-derived continuity equation is feasible, it has not been widely validated. Patients with pulmonary valve stenosis often may have other associated congenital malformations, and MDCT can be especially helpful because it allows visualization of great vessels and pulmonary trunk dilation when associated with pulmonary valve stenosis[35] (Fig. 8).

Pulmonary valve regurgitation

The most common causes of pulmonary valve regurgitation include pulmonary hypertension, carcinoid heart disease, bacterial endocarditis, and Tetralogy of Fallot.[37] The ability of MDCT to evaluate other structural consequences of valvular heart disease, such as right atrial and right ventricular dilation in the setting of pulmonary valve regurgitation, provides important supplementary information to assist in clinical decision making. In MDCT, pulmonary valve regurgitation, as with aortic regurgitation, can be appreciated by evaluating for incomplete coaptation of cusps during diastole, as well as leaflet thickening and structural pathology. Indirect evidence for pulmonary valve regurgitation with the use of MDCT can be elicited by looking for right ventricular hypertrophy. However, because MRI and echocardiography are the standard bearers for evaluating both the causal mechanism and severity of pulmonary valve regurgitation, they remain the diagnostic methods of choice.[38,39]

Cardiac valve tumors

MDCT can also be a useful diagnostic tool in evaluating cardiac valve tumors. Cardiac valve tumors, which include lesions such as papillary fibroelastomas, myxomas, fibromas, sarcomas, and hamartomas, represent <10% of all primary cardiac tumors, with papillary fibroelastomas accounting for most valvular neoplastic lesions.[40] In the past, MDCT was not used to diagnose papillary fibroelastomas because of their small and mobile nature.[40] However, recent evidence has shown that MDCT can be a potentially important diagnostic tool in the evaluation of papillary

fibroelastomas and other valvular tumors. For example, MDCT can help distinguish between a pedunculated papillary fibroelastoma and a thrombus by elucidating the tumor's lobulated contour and thin stalk.[41] Moreover, it appears that even with small and mobile papillary fibroelastomas, visualization is possible with MDCT.[41–43] Although echocardiography may still be a first-line diagnostic tool, MDCT can be an important adjunct imaging tool in evaluating valvular and cardiac tumors, with its ability to visualize the extent of tumor infiltration to optimize surgical resection strategies (Fig. 9; Supplemental Movie 3).

Prosthetic valve evaluation

Prosthetic cardiac valves may be mechanical or bioprosthetic. Tissue valve repair can also be performed with annuloplasty ring placement. Although TTE, TEE, and fluoroscopy are the most common imaging techniques used to evaluate for prosthetic valve dysfunction, mechanical valve evaluation can be limited by significant acoustic shadowing on echocardiography. Although fluoroscopy can accurately evaluate leaflet motion and dynamics, it is difficult to determine the mechanism of dysfunction (ie,
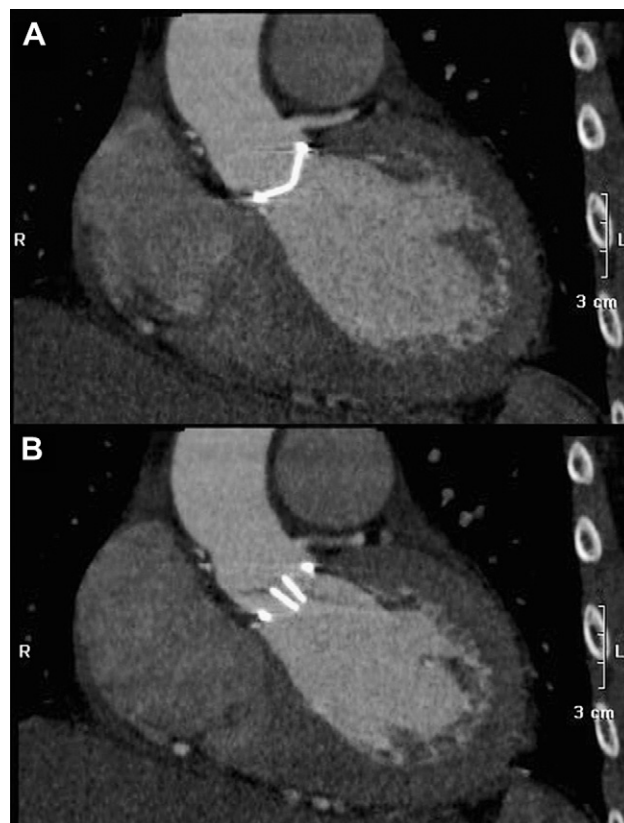

Figure 10 Multidetector computed tomography coronal angiography shows a normally functioning mechanical St. Jude bileaflet aortic valve (St. Jude Medical, St. Paul, MN, USA) in diastole (**A**) and systole (**B**). Minimal artifact allows for accurate opening and closing angle measurements.
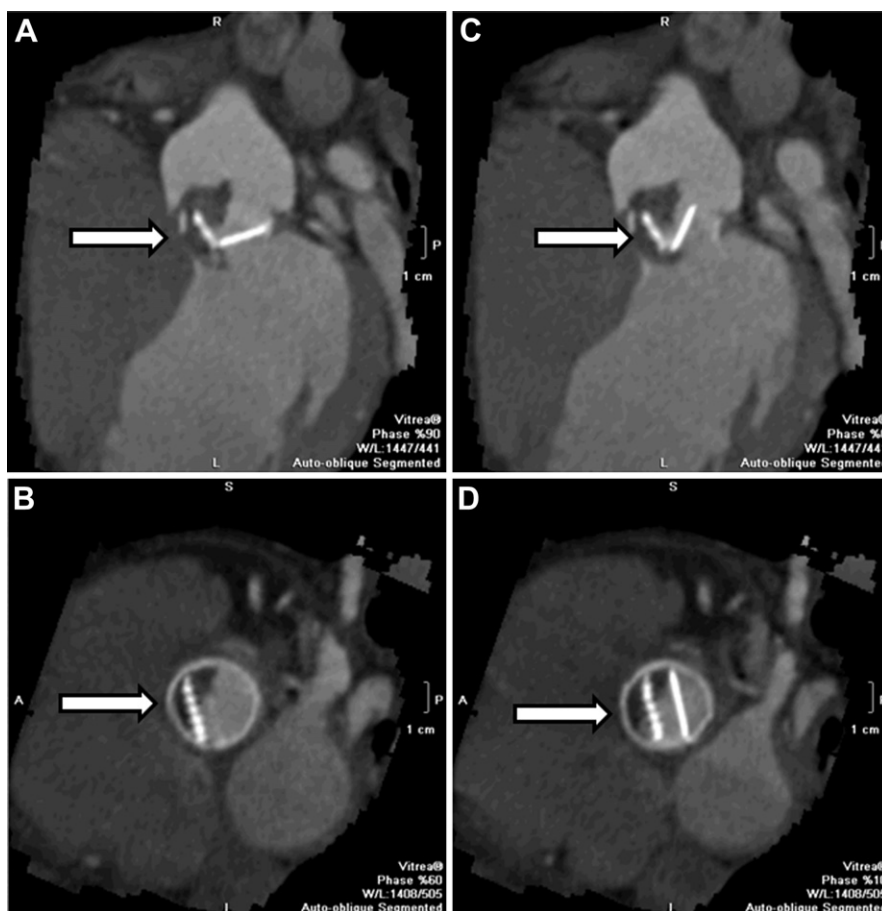
Figure 11   Multidetector computed tomography angiography shows a malfunctioning St. Jude mechanical aortic valve because of thrombus on the right leaflet (*arrow*), interfering with leaflet closure with minimal movement in diastole (**A** and **B**) and systole (**C** and **D**).

pannus, vegetation, thrombus formation, or dehiscence). MDCT has shown promise in evaluating prosthetic heart valve pathology. Although initial data have been limited with small numbers of valves studied, retrospective ECG-gated MDCT can visualize most mechanical and tissue prosthetic valves accurately with opening and closing angle measurements comparable with fluoroscopy[44] (Fig. 10; Supplemental Movie 4). In addition, MDCT planimetry can measure the effective prosthetic orifice area in bioprosthetic valves with similar efficacy as TTE, as well as evaluating for leaflet abnormalities. It can also potentially provide insight into causes of restricted leaflet motion, such as pannus and thrombus[45,46] (Fig. 11; Supplemental Movie 5). Although further studies are warranted, MDCT may be a potentially invaluable tool in evaluating prosthetic valve function and causes of dysfunction and assisting in surgical management.

Endocarditis

Although TEE remains the "gold standard" for the noninvasive assessment of valvular vegetations, preliminary

Figure 12   Multidetector computed tomography axial 5-chamber view demonstrating a large perivalvular abscess (*arrows*) surrounding a bileaflet mechanical aortic valve.

data indicate that MDCT is a potentially valuable tool in evaluating for infectious endocarditis[47] (Figs. 12 and 13). MDCT has been shown to be more accurate for assessing the extent of perivalvular involvement of endocarditis than TEE. Limitations of MDCT include inability to visualize small leaflet perforations (≤2 mm) and small vegetations (≤4 mm)[48] (Fig. 14; Supplemental Movie 6).

Conclusions

MDCT provides a valuable imaging tool for visualizing valvular anatomy and pathology. Although MDCT does have the limitations of reduced temporal resolution and the delivery of radiation in comparison with echocardiography and MRI, these issues will improve as CT technology continues to evolve. Studies showing the effectiveness of MDCT in evaluating left-sided valvular disease have shown good correlation compared with conventional imaging; however, the utility of MDCT is limited in right-sided valve assessment and warrants further study. MDCT has been shown to be useful in evaluating for prosthetic valve dysfunction, as well as assessing the extent of perivalvular abscesses in endocarditis and cardiac tumor infiltration, which would otherwise be difficult to visualize by echocardiography. Combined evaluation of the coronary arteries can be performed which may preclude the need for invasive coronary angiography before surgical valve intervention. Currently, MDCT provides primarily an adjunctive imaging modality in valve assessment. However, it has the potential
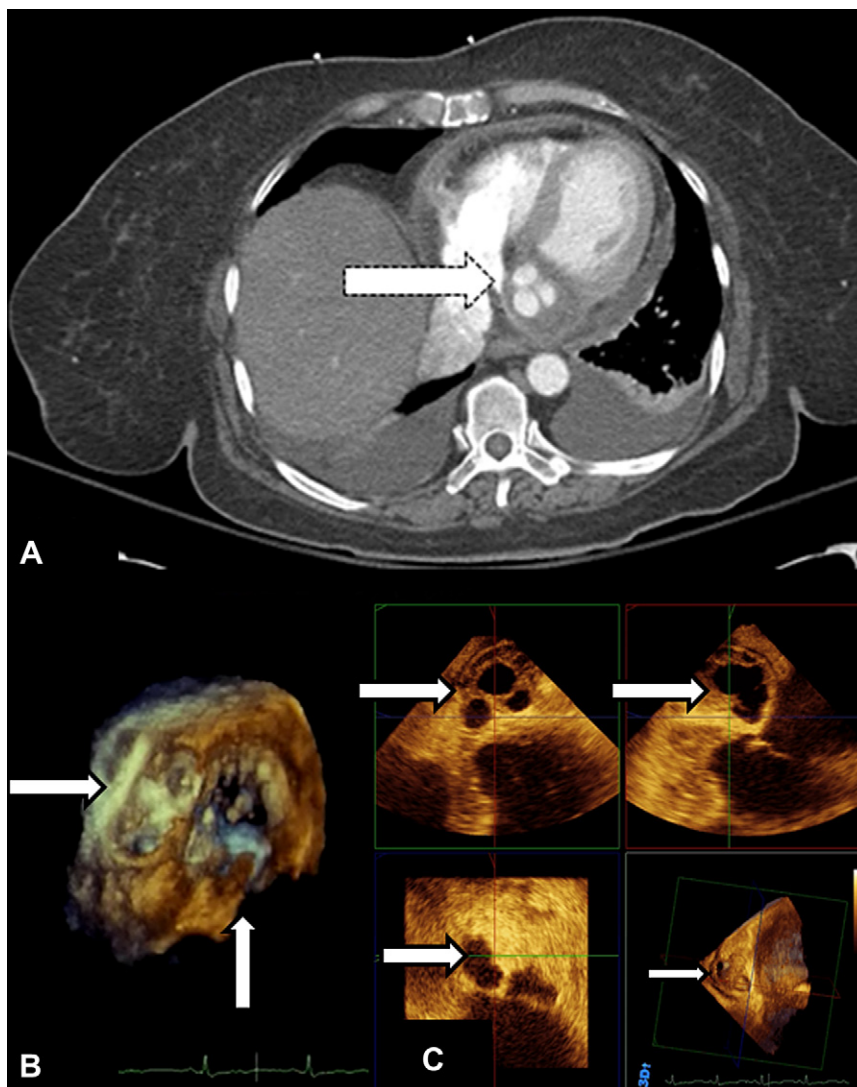

Figure 13 Correlation of a mitral valve perivalvular abscess with both multidetector computed tomography (MDCT) and transesophageal echocardiography (TEE). (**A**) MDCT axial angiography shows a loculated mitral perivalvular abscess in the inferior portion of the heart (*arrow*). Three chambers are seen in the abscess. (**B**) Three-dimensional TEE visualization of the abscess (*horizontal arrow*), adjacent to the mitral valve (*vertical arrow*). (**C**) Three-dimensional TEE, multiplanar views of the perivalvular abscess (*arrows*), shows 3 loculated chambers.
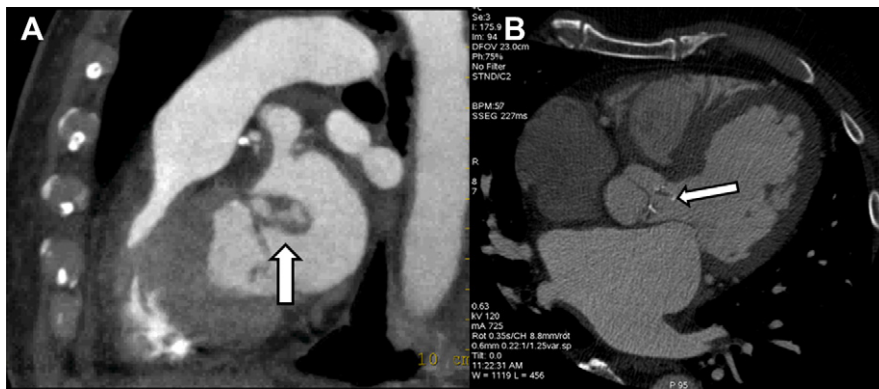
Figure 14   Multidetector computed tomography angiography shows various examples of endocarditis. (**A**) Oblique two-chamber view shows a vegetation attached to the anterior mitral valve leaflet (*arrow*). (**B**) Five-chamber view shows small vegetations attached to the aortic valve (*arrow*).

to refine both the assessment of valvular dysfunction and the resultant hemodynamic effects on surrounding cardiac structures.

Supplementary data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jcct.2012.10.007.

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