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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.

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

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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

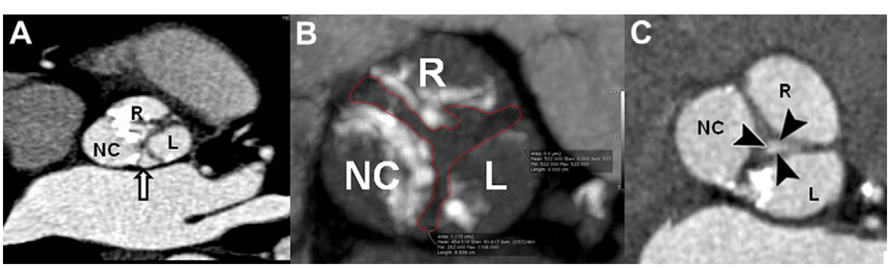

Figure 1 Multidetector computed tomography aortic valve short-axis views show various forms of trileaflet aortic valve pathology. (**A**) Mixed aortic stenosis and regurgitation with malcoaptation of the aortic leaflets in diastole (*arrow*). Heavy calcification is seen in the right and noncoronary cusps. (**B**) Planimetry assessment of an aortic valve in mid-systole with an aortic valve area of 1.1 cm^2. (**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.