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EDITORIAL COMMENT

Computed Tomography to Analyze Mitral Valve

An Answer in Search of a Question*

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Multidetector computed tomography (MDCT) presently has the highest image quality of all non-invasive imaging modalities to visualize cardiac morphology. There are 3 main reasons for this: spatial resolution, signal-to-noise ratio, and completeness of data. Actual spatial resolution in the heart is difficult to determine. The frequently cited spatial resolution measured in phantoms in an idealized, in vitro setup is below 0.5 mm for 64-slice MDCT (1). Signal-to-noise ratio is even more difficult to nail down, but colloquially it may be described as crispness and clarity of image. Comparison of a good MDCT image with a good corresponding echocardiographic image, for example of a 4-chamber view, will confirm that although the spatial resolution of echocardiography is only

See page 556

slightly worse than MDCT resolution, the abundance of artifacts, dropouts, noise, and clutter even on good echocardiographic images makes their interpretation more difficult. Moreover, even on good echocardiographic images there are frequently areas and structures poorly imaged, whereas MDCT image quality at least visually seems to be largely "isotropic" throughout the data set. Finally, MDCT acquires a full 3-dimensional (3D) set of morphologic data of the whole heart and surrounding structures, much more data than a routine echocardiography generates. Of course, this limitation of echocardiography can be conceptually overcome by 3D echocardiography, but the present image quality of 3D echocardiography is considerably inferior to 2D echocardiographic imaging, let alone MDCT.

In this issue of *iJACC*, Delgado et al. (2) report a detailed morphologic study of normal and functionally regurgitant mitral valves by 64-slice MDCT in 151 patients referred for noninvasive coronary angiography. The data were generated by retrospective analysis of data generated from MDCTs performed to assess coronary anatomy; thus, no extra procedure was performed. The main findings were:

- Assessment of the mitral valve was feasible in all patients, with excellent image quality and remarkable detail, as judged from the representative examples provided.
- In patients with systolic heart failure, functional mitral regurgitation was accompanied by characteristic changes in mitral valve morphology. The presence and degree of mitral regurgitation was diagnosed by echocardiography, using the proximal convergence zone method to calculate regurgitant orifice area. In the heart failure group, 29 patients (43%) had moderate or severe mitral regurgitation, whereas the majority (57%) had no or mild mitral regurgitation. Comparing patients with heart failure with moderate to severe mitral regurgitation to patients with heart failure without (or with mild) regurgitation, several parameters characteristic of the shape change of the functionally regurgitant mitral valve were significantly increased, in particular the distance between the papillary muscles, the angle of the posterior leaflet at the central and posteromedial segments with the mitral annulus level, and the tenting height. These parameters (loosely) correlated with regurgitant orifice area by echocardiography. They were also higher in the overall heart failure group in comparison with the patients without heart failure, who had normal

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systolic function and no (or mild) mitral regurgitation.

This paper represents one of the first detailed attempts to characterize and quantify morphologic aspects of the normal and functionally regurgitant mitral valve by MDCT. The number of patients included is the largest so far for this application. Earlier studies had qualitatively examined MDCT for mitral valve morphology (3) and had compared several features of the mitral valve by MDCT to nonquantitative transesophageal echocardiographic assessment in mitral regurgitation of different etiologies, finding good agreement (4). In another study, a direct quantitative comparison between echocardiography and MDCT in mitral stenosis revealed slight overestimation (0.20 ± 0.17 cm^2) of echocardiographic planimetry data for mitral orifice area (5). The findings of the study of Delgado et al. (2) are in line with previous echocardiographic reports on morphologic changes accompanying functional mitral regurgitation in heart failure. These are characterized by a displacement of the apposition zone of the mitral leaflets into the left ventricle ("tenting"), which can be measured by systolic tenting height (perpendicular distance of leaflet apposition zone to annulus level) as well as the systolic angle of the leaflets with the atrioventricular plane (6,7). In fact, current pathophysiologic understanding of functional mitral regurgitation and the typical parameters of mitral valve "tenting" associated with it have largely emanated from echocardiographic research (8).

There are several important drawbacks to this study. First and foremost, there is no independent standard, such as echocardiographic or surgical inspection. Not a single comparison of a descriptive parameter with another method was performed, and thus the findings of the study remain unvalidated, providing us in essence with a "feasibility study."

Further, the limited temporal resolution (200 ms) makes it likely that measurements would differ from imaging techniques with higher resolution, such as echocardiography (10 ms or better). Moreover, the point in time at which measurements were taken was fixed: the "diastolic phase" at 75% of the cardiac cycle for analysis of the subvalvular apparatus and the "systolic phase" at 30% of the cardiac cycle for mitral leaflet geometry. It might be preferable to adjust these time points by visually scrolling through the whole heart cycle and for example, selecting the moment of maximal mitral tenting.

Finally, although not explicitly stated in the paper, these patients most likely all were in sinus rhythm, which would constitute a considerable selection particularly for patients with heart failure and substantial mitral regurgitation.

Thus, this report essentially shows that MDCT can confirm—no doubt very often with superior image quality—findings that have been previously described using echocardiography. Some morphologic details analyzed in the present article, such as the anatomic variations of the subvalvular apparatus, in particular the papillary muscles, would be quite difficult to appreciate by echocardiography, because 2D echocardiography does not generate a comprehensive, well-ordered 3D data set and 3D echocardiography presently cannot match the spatial resolution of MDCT. Conceivably, such information might be of value in some reconstructive mitral valve procedures. Again, we have no independent confirmation of the findings, and their clinical utility remains speculative.

Where does this leave us concerning the role for MDCT in mitral valve disease? Delgado et al. (2) did not elaborate on why they chose MDCT for a task that is usually believed to be well performed by echocardiography. Apart from low temporal resolution, and lack of blood flow data, the fundamental weaknesses of MDCT lie in 2 characteristics:

- Different from echocardiography, MDCT needs expensive and immobile machinery.
- MDCT produces radiation and for most tasks requires intravenous X-ray contrast application. Weighing individual benefits and risks of a radiation-involving procedure in a given patient and scenario is quite difficult, but the issue cannot be ignored or trivialized as long as good imaging modalities devoid of radiation and the need for contrast are available. Importantly, in this study, spiral scanning with retrospective data reconstruction was used for coronary angiography, for which a radiation dose of 10 to 15 mSv has to be assumed (9). On the other hand, data acquisition algorithms with a narrow electrocardiography-pulsing window or prospective gating (step-and-shoot acquisition) that allow low-dose MDCT coronary angiography (1.2 to 4.3 mSv) use a predefined mid-to-end diastolic time instant for optimal imaging, whereas other cardiac cycle phases have lower signal-to-noise ratios; in prospective scanning, systolic images are not acquired at all (10).

Echocardiography therefore will beyond any doubt continue to be the routine and, with a few exceptions, only imaging modality to assess the mitral valve apparatus. Note that even in the present study, echocardiography was necessary to detect and grade mitral regurgitation. Nevertheless, a better understanding of mitral morphology and pathophysiology and the broadening surgical options for valve repair have increased the demands on the reliability of morphologic assessment of the mitral valve. As the study by Delgado et al. (2) nicely demonstrates, MDCT may be a good reserve option if echocardiography fails to unambiguously clarify mechanism or location of mitral valve pathology. This is important because in real life, mistakes are made with all imaging tools, conflicting findings are frequent, and the accuracy of any diagnostic method is considerably lower than under study conditions (which of course also applies to MDCT). This said, the additional expense and radiation exposure—if MDCT is not performed for other reasons anyway—must be weighed against the potential diagnostic benefit, and the availability of MDCT should be no excuse for poor echocardiography. In the end, the niche opened for MDCT by the article of Delgado et al. (2) will be a small one.

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Key Words: mitral valve ■ multislice computed tomography ■ mitral regurgitation.