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FOCUS ISSUE: CARDIAC IMAGING

In Vivo Analysis of the Anatomical Relationship of Coronary Sinus to Mitral Annulus and Left Circumflex Coronary Artery Using Cardiac Multidetector Computed Tomography

Implications for Percutaneous Coronary Sinus Mitral Annuloplasty

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OBJECTIVES We sought to determine the in vivo anatomical relationships between mitral annulus (MA) and coronary sinus (CS) as well as CS and left circumflex coronary artery using cardiac computed tomography.

BACKGROUND Percutaneous treatment of mitral regurgitation (MR) by annuloplasty via CS is under development. Success of such treatment depends on the close anatomical proximity of the MA to the CS. The in vivo data regarding this anatomical relationship in humans are scant. We investigated this relationship using contrast multidetector computed tomography.

METHODS We studied 25 normal individuals and 11 patients with severe MR (3 to 4+) due to mitral valve prolapse. Separation between MA and CS was measured in standard planes, in 4-chamber (4C), 2-chamber (2C), and 3-chamber views. Distance from ostium of CS to the intersection with left circumflex (LCX), and anatomical relation of LCX and CS were determined using 3-dimensional mapping (Philips Brilliance, Philips Medical Systems, Amsterdam, the Netherlands).

RESULTS There was significant variance of CS to MA separation at all planes. Separation of CS and MA was increased in lateral location (4C) and decreased in posterior location (2C) in the MR group with increase in MA size. Left circumflex artery crossed between CS and MA in 80% of patients. The LCX crossed CS at a variable distance from the ostium of CS (86.5 ± 21 mm, range 37 to 123 mm)

CONCLUSIONS There is significant variability in the relation of CS to MA in humans. Coronary sinus to MA distance increases in patients with severe MR and annular dilation, mainly in the postero-lateral location. The left circumflex crosses under the CS the majority of times, but with a significant variability in the location where it crosses the CS. These anatomical features should be taken into consideration while selecting percutaneous treatment strategies for mitral valve repair. (J Am Coll Cardiol 2006;48:1938–45) © 2006 by the American College of Cardiology Foundation

According to the population-based Strong Heart Study, the prevalence of mitral regurgitation (MR) is reported to be as high as 21% (1–3). Current surgical options include either repair or replacement of mitral valve. Studies have suggested that mitral valve repair (MVR) is superior to valve replacement because the former is associated with lower operative mortality, improved late survival, reduced risk of endocarditis, fewer thromboembolic complications, and better preservation of left ventricular function (4–10). The number of MVRs performed each year has increased from 23% in 1990 to 32% in 1999 (11). There is some evidence that MVR with an annuloplasty ring in patients with cardiomyopathy from end-stage heart failure may help restore left ventricular function (12). However, due to concerns regarding significant surgical morbidity and mortality, use of surgical mitral annuloplasty for advanced heart failure is limited (13).

Percutaneous MVR techniques have, therefore, attracted significant attention in recent years. The possibility of minimally invasive correction of symptomatic valvular pathology has obvious attraction for patients. This may offer decreased recovery time and avoid surgical morbidity/mortality for the patients who are correctly selected for these procedures. Currently, several concepts for repair of MR from different etiologies are under various stages of development from bench testing to early clinical trials (14). One of them is to exploit the anatomical relationship of the coronary sinus (CS) with the mitral annulus (MA), to modulate shape and size of the annulus to allow proper coaptation of leaflets. Several animal studies have already been performed, and some human studies are under inves-

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Abbreviations and Acronyms

CS	= coronary sinus
CT	= computed tomography
LCX	= left circumflex coronary artery
MA	= mitral annulus
MDCT	= multidetector computed tomography
MR	= mitral regurgitation
MVP	= mitral valve prolapse
MVR	= mitral valve repair
2C	= 2 chamber
3C	= 3 chamber
4C	= 4 chamber

tigation with different CS devices to correct MR related to ischemia or cardiomyopathy. These animal studies have shown the feasibility of percutaneous CS-based mitral annuloplasty (15–18).

Little in vivo quantitative information is available, however, regarding the anatomical relationship between the CS and MA and whether it changes in various stages of MR. The precise anatomical relationship between the CS and left circumflex coronary artery (LCX) has also not been formally investigated. Some authors have suggested that CS devices may potentially impinge on the LCX during annuloplasty via the CS (19).

Multidetector computed tomography (MDCT) has high spatial resolution that allows precise non-invasive delineation of cardiac anatomy. We sought to study the anatomical relationship between the CS and MA and between the CS and LCX artery using cardiac, contrast-enhanced MDCT and the alteration that occurs in this anatomy from MR due to mitral valve prolapse (MVP).

METHODS

We retrospectively studied 27 normal patients and 14 consecutive patients with severe MR (3 to 4+ by echocardiographic criteria) due to MVP. All patients had undergone contrast-enhanced MDCT under an institutional-review-board-approved research protocol using Philips 16- or 40-slice MDCT (Philips Medical Systems, Amsterdam, the Netherlands) between January and April of 2005. All patients provided informed consent. The normal patients were those with no known history of coronary artery disease or valvular heart disease who underwent MDCT for purpose of CT angiography. The patients in the MVP group were scheduled to undergo either surgical valve repair or replacement and had agreed to enroll in CT angiography study. Two patients in the normal group and 3 in the MR group were excluded because the image quality was compromised due to motion artifacts to such an extent that an accurate interpretation could not be made.

Imaging protocol. We retrospectively reviewed the contrast-enhanced cardiac computed tomography (CT) scans that were already performed for purpose of CT angiography under an institutional review board–approved protocol. These gated contrast-enhanced spiral CT scans were performed using a 16-slice MDCT scanner (Mx8000, Philips Medical Systems) using the following protocol: 120 kVp, 300 mAs, 0.5 s rotation time, collimation of 4 × 1 mm, and

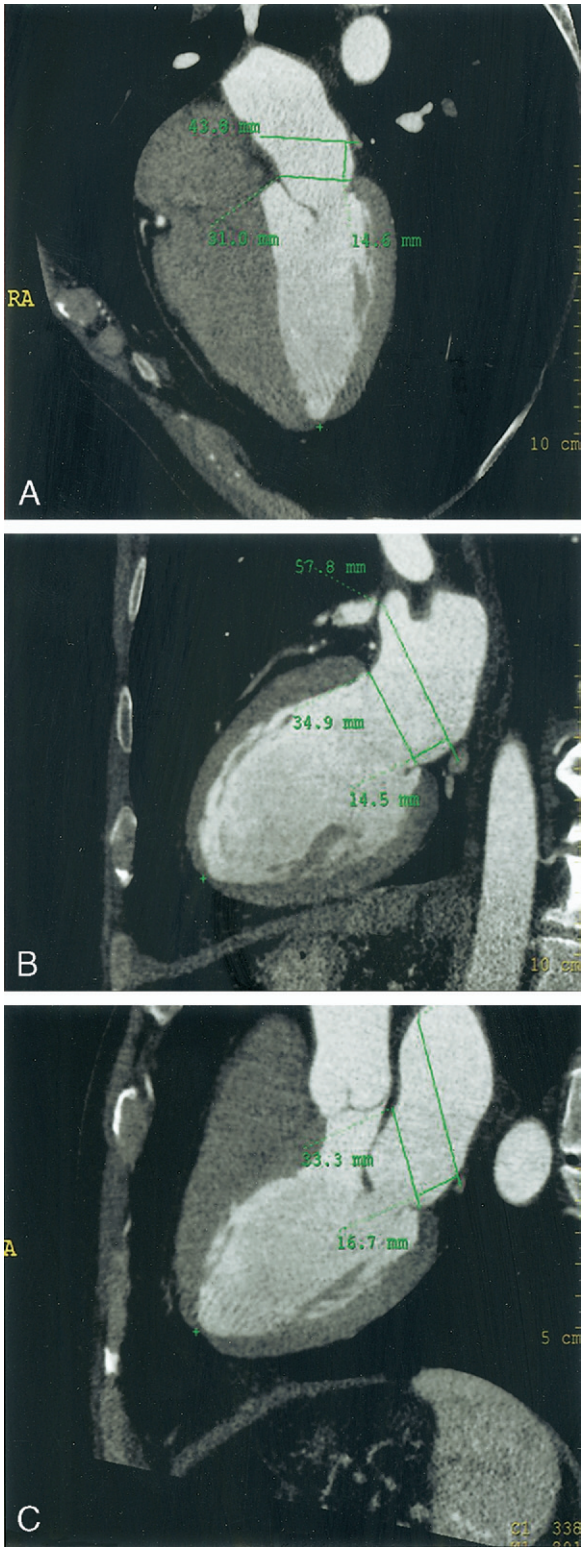

Figure 1. Measurement of the distance between the mitral annulus and coronary sinus in standard 2-dimensional planes in **(A)** 4-chamber view; **(B)** 2-chamber view; and **(C)** 3-chamber view. RA = right atrium.