

Editorial

Cardiac Computed Tomography Angiography: A Versatile Technique

Angiografía mediante tomografía computarizada cardiaca: una técnica versátil

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Cardiac computed tomography angiography (CCTA) is a noninvasive anatomic imaging modality for coronary artery evaluation and atherosclerotic plaque characterization, and is a very promising technique for functional perfusion information.¹

This method has experienced rapid technological development in the last decade, from 4-slice scanners to 320-row and dual-source equipment. These advances have resulted in improvements in temporal and spatial resolution, improved volume coverage, and reduction in acquisition time and radiation exposure.²

The main application of CCTA is the diagnostic evaluation of obstructive coronary artery disease (CAD). Several studies have compared the diagnostic performance of CCTA, especially 64-slice technology, with that of invasive coronary angiography, with high per-patient sensitivity ranging from 91% to 99% and specificity from 74% to 96%.^{3–5} The most important value obtained by CCTA is the highest negative predictive value (NPV) (99%–100%) to exclude CAD, which is very helpful information in various clinical scenarios. Recent studies have also shown some relevance of CCTA in prognostic implications and risk stratification. However, not many studies have supported this value of CCTA use. This is due to the recent introduction of computed tomography (CT) scanners capable of performing routine CCTA, which has limited the time required to observe cardiac events after testing. These studies have focused on the relationship of obstructive CAD to true incidence of adverse CAD prognosis.^{6–8}

Cardiac CT imaging requires high spatial and temporal resolution due to the constant physiologic movement that takes place in every cardiac cycle. Since the introduction of electron beam computed tomography in the early 1990 s, followed by the development of multidetector CT scanners, the capability to image the heart with minor radiation exposure has improved. The

technical advances have not stopped, and we now have systems with higher temporal and spatial resolution, with 16, 64 and up to 320 slices as well as two tubes and detectors ("dual-source CT"), that has positive effects on image quality.²

The broad spectrum of clinical applications of cardiac CT has increased and is not limited to the detection of coronary stenosis. Its added value in the clinical setting is in coronary atherosclerotic plaque visualization, mainly for purposes of risk stratification and also cardiovascular anatomy and structure evaluation, left ventricular ejection fraction quantification as long as myocardial perfusion and viability estimation. Since data acquisition is performed with cardiac gating, the left and right ventricular function can be calculated along with valvular characterization.^{6–8}

Under certain prerequisites, most importantly a low and stable heart rate, cardiac CT allows robust visualization of the heart and coronary arteries.

Cardiac CT offers two ways of assessing coronary atherosclerosis. The first is performed without the injection of iodinated contrast agent, with the objective of detecting and measuring coronary artery calcium (calcium scoring). The second method, a scan performed with the injection of iodinated contrast media, uses more refined imaging protocols (CCTA) and is capable of detecting non-calcified plaque components and characterizing such plaque.^{1,8–10}

The main clinical application of this technology relies on CAD evaluation. The major value of this assessment is the exclusion of obstructive coronary artery plaque.^{1,6–8}

Recently, the clinical value of CCTA in the presurgical setting in patients with valve disease has been described.^{11,12}

Conventional coronary angiography (CCA) prior to surgery has traditionally been performed in a wide range of patients with valvular disease to detect the presence of significant concomitant CAD, according to the most recent guidelines.¹³ Knowledge of coronary anatomy improves risk stratification and determines whether coronary revascularization is indicated in association with valvular surgery. It is important to note that the measurement of pressures and cardiac output, or the performance of ventricular angiography, is restricted to situations where non-invasive

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evaluation is inconclusive or discordant with clinical findings. Given its potential risks, cardiac catheterization in patients with valvular heart disease waiting for cardiac surgery should be limited to those with an uncertain CCTA; unfortunately, CCA remains common in all of the cases in daily practice. The same guidelines also state that CCTA can be useful to exclude CAD in patients who are at low risk of atherosclerosis.¹³

In the article published in *Revista Española de Cardiología*, Rodríguez-Palomares et al¹⁴ compare CCTA results with those obtained using CCA to determine the capacity to provide comprehensive noninvasive data prior to valve replacement in patients with valvular heart disease. It is interesting to note that this study prospectively included 106 patients, of which 66 had aortic valve stenosis (higher probability of CAD), 15 had aortic regurgitation, 4 had mitral stenosis and 17 had mitral regurgitation; only 4 suffered from bivalve disease (aortic and mitral). Mean age was 67 years and 84% of the patients (89/106) were in sinus rhythm, 15.1% in atrial fibrillation and 0.9% in pacemaker rhythm. Patients with heart rate >65 bpm received repeated 1 mg doses of intravenous propranolol, up to a dose of 5 mg; sublingual nitroglycerin was administered to all patients except those with aortic stenosis. A 16-slice cardiac CT scanner was used to acquire non contrast CT for calcium scoring and CCTA in all patients, with retrospective gating. The mean calcium score was 558 AU (range 0-7572 AU).

In the per patient analysis, CCTA correctly identified 61 of 65 cases without obstructive CAD (in this article an obstructive lesion was considered $\geq 50\%$). The reported sensitivity was 94% with a specificity of 94%. In the per segment analysis the sensitivity was 76% and specificity 99%; positive predictive value (PPV) was 84% and NPV was 99%. In the per vessel analysis, the global NPV was 99%. The influence of coronary calcification, expected in older patients with aortic stenosis, revealed that >1000 UA was associated with a higher proportion of non-assessable segments ($n = 39$). It is important to mention that the prevalence of CAD in this population was 30%. According to the results, 66 CCA could have been avoided.

In this study, irregular rhythm, such as atrial fibrillation, did not reduce NPV, as has been previously described.¹¹⁻¹²

The results presented in the article by Rodríguez-Palomares et al¹⁴ are consistent with those from Gilard et al¹¹, who studied 55 consecutive patients with severe aortic valve stenosis with a 16-slice cardiac CT scanner and observed that the sensitivity of the CCTA-based strategy in detecting significant stenosis was 100%, with 80% specificity, PPV 55% and NPV 100%. For calcium scores < 1000 (77% of patients), CCTA detected all patients without CAD, enabling CCA to be avoided in 80% of the cases. For calcium scores > 1000, CCTA results enabled CCA to be avoided in only 6% of cases, either because significant stenosis was found with a possible indication of revascularization, or because the examination was not interpretable; therefore, they concluded that CCTA may serve as an alternative to CCA to rule out obstructive lesions (considered as >50%). However, the prevalence of obstructive CAD was 20%, less than in the present study. The mean calcium score was also lower, 609 ± 860 UA, which increased diagnostic accuracy in the Gilard et al study.

In the most recent study by Bettencourt et al¹², 237 consecutive patients with heart valve disease were included, most of them with aortic valve stenosis ($n = 161$); the second most frequent valve disease was mitral valve regurgitation ($n = 41$); the third, aortic valve regurgitation ($n = 33$); and the fourth, mitral stenosis ($n = 27$). In all cases, a 64-slice cardiac CT scanner was used. The mean calcium score was 443 ± 835 UA (range 0-6617). In a patient based analysis, the sensitivity was 95%, specificity 89%, PPV 66% and NPV 99% to detect an obstructive (considered as >50%) coronary lesion. Again, the results are highly similar to those of

Rodríguez-Palomares et al.¹⁴ Special attention must be paid to the older aortic valve patients with high calcium scores and to overestimating the grade of obstruction from densely calcified plaque.¹¹

According to the most recent published guidelines on appropriate use criteria for cardiac computed tomography,¹⁵ as part of the preoperative evaluation CT angiography was viewed as a potential option for patients undergoing heart surgery for noncoronary indications (e.g., valve replacement surgery or atrial septal defect closure) when the pretest CAD risk was either intermediate (appropriate) or low (uncertain). There were no appropriate indications for CCTA as part of the preoperative evaluation for noncardiac surgery.¹⁵

In conclusion, the convenient imaging capabilities of CCTA have made it a reliable tool, very comparable to CCA, to exclude CAD in presurgical patients with valvular heart disease and low-to-intermediate risk of CAD.

CONFLICTS OF INTEREST

None declared.

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