Coronary Computed Tomographic Angiography in Clinical Practice: State of the Art

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KEYWORDS

- Coronary CT angiography • Cardiac CT • Coronary artery disease • Chest pain
- Diagnostic accuracy • Prognostic value

KEY POINTS

- Coronary computed tomographic (CT) angiography (CCTA) has high diagnostic accuracy for the noninvasive assessment of coronary artery disease (CAD), and findings at CCTA hold strong prognostic significance.
- CCTA thus plays an important role in the evaluation and management of patients with known or suspected ischemic heart disease.
- The use of CCTA should be informed by established guidelines and appropriate use criteria, which are likely to further evolve and be refined.
- Novel, investigational developments in CCTA are aimed at characterizing and quantifying coronary artery plaque and assessing its hemodynamic significance.

INTRODUCTION

Within the past decade, CCTA has left the early stages of technical development and accuracy assessment and developed into a robust, well-established imaging test with an important role in the evaluation and management of patients with known or suspected ischemic heart disease.[1] The specific indications for CCTA continue to be the subject of debate, and guidelines on its appropriate use are likely to be modified and developed over the years to come. The controversies surrounding CCTA have led to uncertainties on the part of both radiologists and clinicians regarding its appropriate use. This article discusses established and emerging applications for CCTA in light of the available evidence on its accuracy, prognostic value, cost-effectiveness, risks, and benefits. Building on this evidence, the authors provide a practical overview of the appropriate use of CCTA in state-of-the-art clinical practice.

STABLE CHEST PAIN SYNDROME
Diagnostic Accuracy

A multitude of studies have investigated the accuracy of CCTA for detecting anatomically significant stenosis with 50% or more luminal narrowing with invasive angiography as the reference standard. Across all published meta-analyses on the accuracy of CCTA using at least 64-slice multidetector CT systems, the median sensitivity on a per-patient level was 97.8% with 89.6% sensitivity.[2] The high sensitivity reported across most studies translates into a negative predictive value of 95% to 100%. A fully diagnostic CCTA that demonstrates no significant stenosis can thus exclude obstructive CAD with a high degree of certainty.

These accuracy data were chiefly generated with retrospectively electrocardiography (ECG)-gated CCTA and 64-slice CT. The accuracy of CCTA using more dose-efficient techniques and more advanced CT systems has also been analyzed. Two meta-analyses specifically analyzing studies on prospectively ECG-triggered CCTA revealed a pooled sensitivity of 99% to 100% and specificity of 89% to 91% on the per-patient level.[2,3] Other meta-analyses have investigated the performance of CCTA with specific state-of-the-art CT systems. For 320-slice CCTA, a pooled per-patient sensitivity of 93% and specificity of 86% were reported, translating into a negative predictive value of 90%.[4] For dual-source CT, pooled sensitivity was 98% to 99% and specificity was 88% to 89%, with a negative predictive value of 98% to 99%.[5,6] Thus, there is overall good evidence that the accuracy of CCTA with state-of-the-art equipment and dose-saving techniques is at least equivalent to the more traditional retrospectively ECG-gated CCTA with 64-slice CT.

Prognostic Value

In a meta-analysis analyzing 11 studies including a total of 7335 mostly symptomatic patients with suspected CAD followed for a median of 20 months, the presence of any greater than 50% stenosis at CCTA was associated with a 10-fold higher risk for cardiovascular events, the finding of any CAD inferred a 4.5-fold risk, and each coronary segment involved increased the risk for adverse outcomes by 23%.[7] In a more recent analysis of 17,793 patients from the CONFIRM (Coronary CT Angiography Evaluation for Clinical Outcomes: An International Multicenter) registry, the majority of whom had chronic chest pain, the number of proximal segments with mixed or calcified plaques and the number of proximal segments with 50% or more stenosis were the CCTA parameters with the strongest predictive value for all-cause mortality at a median follow-up of 2.3 years.[8]

Evidence on the more long-term prognostic value of CCTA is beginning to accumulate. Hadamitzky and colleagues[9] followed up 1584 patients for a median of 5.6 years and described annual rates of major adverse cardiac events (MACE) of 0.2% for patients with no CAD and 1.1% in patients with obstructive CAD. In a 2014 study reporting on a median 6.9-year follow-up period in 218 patients, annual MACE rates were 0.3%, 2.7%, and 6.0% in patients with normal CCTA, nonobstructive CAD, and obstructive CAD, respectively.[10] Thus, the available data suggest that (1) the warranty period with an excellent prognosis after a CCTA study negative for any CAD extends beyond 5 years and (2) the presence of any CAD, obstructive CAD, and the burden of atherosclerotic changes at CCTA is strongly predictive for cardiac outcomes in patients with chronic chest pain.

Cost-Effectiveness

A decision analysis model comparing the cost-effectiveness of CCTA and single-photon emission computed tomography (SPECT) in patients with chest pain and no known CAD determined that CCTA is more cost-effective in this setting than SPECT for populations with an intermediate (30%–50%) prevalence of CAD.[11] A 2013 decision analysis performed on a prospective cohort of 471 outpatients with stable chest pain concluded that a CT-based diagnostic strategy is equally effective and less expensive than a stress-ECG–based strategy in all women and in men with low to intermediate (<70%) pretest probability.[12] A systematic review on this topic concluded that coronary CTA for the initial diagnostic evaluation of patients with stable chest pain has superior cost-effectiveness compared with alternative strategies in patients with a low to intermediate likelihood of CAD without adverse effects on clinical outcomes.[13]

Appropriate Use

Current Appropriate Use Criteria rate CCTA as an appropriate test for the initial evaluation of patients with stable symptoms and an intermediate CAD likelihood, especially in the setting of an uninterpretable ECG or inability to exercise.[14] In symptomatic patients with a high pretest probability of CAD, CCTA may be an appropriate initial test as an alternative to invasive coronary angiography and/or functional testing.[14] In patients with a low pretest probability of CAD, CCTA may be appropriate only in the setting of an uninterpretable ECG or inability to exercise.[14] Patients with prior testing with abnormal results represent a different