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EXPEDITED REVIEW

Diagnostic Performance of Multislice Spiral Computed Tomography of Coronary Arteries as Compared With Conventional Invasive Coronary Angiography

A Meta-Analysis

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OBJECTIVES This study was designed to define the current role of multislice spiral computed tomography (MSCT) for the diagnosis of coronary artery disease (CAD) using a meta-analytic process.

BACKGROUND Multislice spiral computed tomography has recently been proposed as an alternative to conventional coronary angiography (CA) for the diagnosis of CAD.

METHODS Using Medline, we identified 29 studies (2,024 patients) evaluating CAD by means of both MSCT (≥16 slices) and conventional CA before July 2006. After data extraction the analysis was performed according to a random-effects model.

RESULTS The per-segment analysis pooled the results from 27 studies corresponding to a cumulative number of 22,798 segments. Among unassessable segments, 4.2% were excluded from the analysis and 6.4% were classified at the discretion of the investigators, underscoring the shortcomings of MSCT. With this major limitation, the per-segment sensitivity and specificity were 81% (95% confidence interval [CI] 72% to 89%) and 93% (95% CI 90% to 97%), respectively, with positive and negative likelihood ratios of 21.5 (95% CI 13.1 to 35.5) and 0.11 (95% CI 0.06 to 0.21), respectively, and positive and negative predictive values of 67.8% (95% CI 57.6% to 78.0%) and 96.5% (95% CI 94.7% to 98.3%), respectively. As expected, the per-patient analysis has shown an increased sensitivity of 96% (95% CI 94% to 98%) but a decreased specificity of 74% (95% CI 65% to 84%).

CONCLUSIONS Multislice spiral computed tomography has shortcomings difficult to overcome in daily practice and, at the more clinically relevant per-patient analysis, continues to have moderate specificity in patients with high prevalence of CAD. Studies evaluating the diagnostic performance of the newest generation of MSCT, including patients with low to moderate CAD prevalence, will be critical in establishing the clinical role of this emerging technology as an alternative to CA. (J Am Coll Cardiol 2006;48:1896–1910) © 2006 by the American College of Cardiology Foundation

Coronary artery disease (CAD) is the leading cause of death and disability in the U.S. and other Western countries. Conventional coronary angiography (CA) is currently the reference test for coronary artery lumen assessment, and its use has been steadily increasing over the last decade (1). The CA test comes at a considerable cost and, although complications may be infrequent, cardiac catheterizations account for well known procedure-related morbidity (2). Recent advances in multislice computed tomography (MSCT) seem to respond adequately to the need for a noninvasive and reliable assessment of the coronary artery lumen. Several studies have compared CA and MSCT; however, each of these studies was based on a particularly limited sample size, meaning that a reliable and unbiased estimate of the performance of MSCT compared with CA in a reasonably large data set is lacking. To overcome this issue and to provide an evidence-based evaluation of the clinical utility of MSCT, we performed a comprehensive meta-analysis of all currently available studies comparing MSCT and CA for the detection of CAD in native coronary arteries.

METHODS

Search strategy. Database searches for English-language articles published from January 2002 to July 2006 were performed in Medline. We combined the medical subject headings for computed tomography, multislice computed tomography, and coronary angiography with the exploded term coronary artery disease and scanned references in retrieved articles and reviews. The retrieved studies were carefully examined to exclude potentially duplicate or overlapping data. Meetings abstracts were excluded because they could not provide adequately detailed data and their results may not have been final. Only papers evaluating the

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Abbreviations and Acronyms

AUC = area under the curve
CA = coronary angiography
FN = false negative
FP = false positive
MSCT = multislice computed tomography
NPV = negative predictive value
PPV = positive predictive value
TN = true negative
TP = true positive

presence of significant obstructive CAD in native coronary arteries by both conventional invasive CA and MSCT in the same subjects were included. Studies were eligible regardless of whether they referred to subjects with suspected or proven CAD.

Study eligibility. We included a study if: 1) it used MSCT as a diagnostic test for obstructive CAD, with >50% diameter stenosis selected as the cut-off criterion for significant CAD, using conventional invasive angiography as the reference standard; 2) it used the newest generation of MSCT (≥16 slices); and 3) it reported cases in absolute numbers of true positive (TP), false positive (FP), true negative (TN), and false negative (FN) results or presented sufficiently detailed data for deriving these figures. Studies were excluded if they were performed: 1) only in patients after coronary artery bypass graft surgery; 2) after percutaneous coronary intervention for long-term stent patency assessment; 3) in a subset of patients with prior heart transplant; or 4) with fewer than 30 enrolled patients.

Data extraction. The following information was extracted from each study: first author, year of publication, and journal; study population characteristics including sample size (number of subjects evaluated with both tests, number of patients excluded); number of patients with documented CAD; gender; mean age (and standard deviation); mean heart rate (and standard deviation); relative timing of the 2 imaging procedures and whether or not evaluation of one test was blind to the result of the other and to the clinical condition of the tested subject; technical characteristics of the MSCT, including type and brand of machine used; and rate of beta-blocker usage. Data were recorded separately, whenever available, at the level of segments, vessels, and subjects. Two investigators performed the data extraction independently. Discrepancies were solved by a third investigator and global consensus. The study quality conformed to the Quadas guidelines (3).

Data synthesis and statistical analysis. Categoric variables from individual studies are presented as n/N (%) and continuous variables are presented as median values. Measures of diagnostic accuracy are reported as point estimates (with 95% confidence intervals [CI]). The main analysis was performed at the coronary artery segment level, because most studies focused on this level of information. Secondary analyses combined the available vessel-level data, considering 4 coronary arteries per patient (left main coronary artery, left anterior descending artery, circumflex artery, and right coronary artery) and patient-level data.

By means of TP, TN, FP, and FN rates we computed sensitivity, specificity, positive and negative likelihood ratios, and diagnostic odds ratios (4). Although sensitivity and specificity are well known as measures of diagnostic accuracy, their results may be influenced by the prevalence of disease in tested subjects. The positive likelihood ratio (the ratio between sensitivity and 1 − specificity) provides an estimate of the probability of a positive test in a patient with disease, and the negative likelihood ratio (the ratio between 1 − sensitivity and specificity) gives an estimate of the probability of a negative test among diseased subjects. Both likelihood ratios are roughly independent from prevalence rates, and there is consensus that a positive likelihood ratio of >10 and a negative likelihood ratio of <0.1 provide reliable evidence of satisfactory diagnostic performance (5). Finally, the information from both positive and negative likelihood ratios can be combined in a single parameter, the diagnostic odds ratio, which is computed as the ratio of positive to negative likelihood ratios and provides an estimate of how much greater the odds of having the disease are for the people with a positive test result than for the people with a negative test result. Although likelihood ratios are the recommended summary statistics for systematic reviews of diagnostic studies, predictive values may also be of interest for clinicians, even if these values vary widely in their dependence on disease prevalence. Such limitations of predictive values notwithstanding, these figures were also computed and reported as exploratory data in this review.

We computed all statistics for individual studies, and then combined them using a random-effects model, weighting each point estimate by the inverse of the sum of its variance and the between-study variance. Between-study statistical heterogeneity was also assessed using the Cochran Q chi-square tests. Because diagnostic parameters are by definition interdependent, independent weighting may

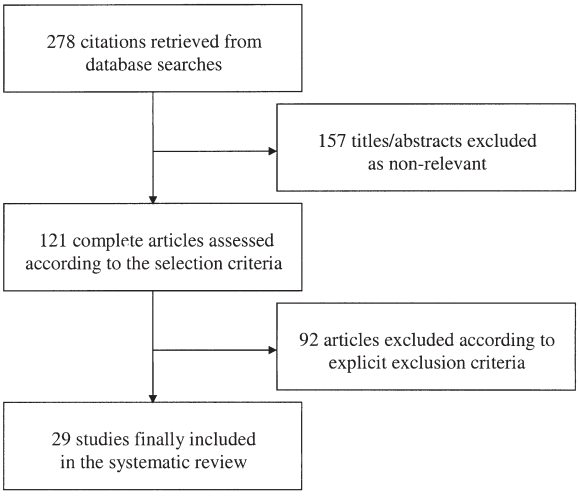

Figure 1. Flow diagram of the reviewing process.