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Sixty-four–slice multidetector computed tomography: the future of ED cardiac care

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Abstract

Multidetector computed tomography (MDCT) imaging, a technological advance over traditional CT, is a promising possible alternative to cardiac catheterization for evaluating patients with chest pain in the emergency department (ED). In comparison with traditional CT, MDCT offers increased spatial and temporal resolution that allows reliable visualization of the coronary arteries. In addition, a “triple scan,” which includes evaluation for pulmonary embolism and thoracic aortic dissection, can be incorporated into a single study. This test will enable emergency physicians to rapidly evaluate patients for life-threatening illnesses and may allow safer and earlier discharges of many patients with chest pain in comparison with a traditional rule-out protocol. In this article, we will highlight the technological advances of MDCT imaging, review the literature on coronary angiography via MDCT, and discuss the future of this technology as it relates to the ED.

1. Introduction

Evaluation for acute coronary syndrome accounts for more than 5 million emergency department (ED) visits [1]. Symptom presentation varies widely, and initial workup is often nondiagnostic [2-7]. However, cardiac disease remains a leading cause of morbidity, mortality, and medicolegal burden [8]. Thus, emergency physicians are required to have a low threshold to admit patients to an inpatient setting or observation unit for additional testing to “rule out” coronary artery disease [9,10], at great cost to the health care system and inconvenience to the patient.

Cardiac catheterization is currently the gold standard test for identifying coronary artery disease. In 2003, at least 1.4 million of these procedures were performed in the inpatient setting alone [8,11]. Approximately one fourth of patients undergoing the test will have normal coronary vessels and will not require percutaneous intervention [12,13]. Although relatively safe, the procedure carries the risk of complications such as bleeding, infection, stroke, and coronary vessel damage or clotting. According to recent American Heart Association statistics [8], cardiac catheterization carried an inhospital mortality rate of 1.0%, with an average length of stay of 3.7 days. In addition, the test requires an interventional cardiologist and specialized space and equipment. The mean charge for patients hospitalized for diagnostic cardiac catheterization was $24,893 [8]. Because of limitations of time, cost, risk, and availability, most ED patients with chest pain do not currently receive cardiac catheterization [1,8].

Multidetector computed tomography (MDCT) has emerged as a promising test for diagnosing coronary artery disease. This new technique may prove to be the new diagnostic gold standard. In addition to coronary artery disease, MDCT can diagnose other life-threatening diseases in an undifferentiated ED chest pain population. In this article, we seek to provide the emergency physician an overview of this technology and discuss future applications.

2. Methods

We reviewed all articles published from 1995 to present regarding MDCT for coronary angiography. A PubMed search was performed using the terms “multi-detector CT,” ”noninvasive coronary angiography,” “multi-slice,” “angiography,” “coronary,” and “MDCT.” We focused our review to articles reporting sensitivity and specificity values in reference to cardiac catheterization.

3. Background

3.1. Technical Aspects of CT/MDCT

Sir Godfrey Hounsfield introduced medical imaging by CT scanning in the 1970s [14]. A CT scanner consists of an x-ray source that emits radiation, a detector unit that detects the emitted radiation and converts it into an electric signal, and a computer that transforms the raw x-ray data into an image (Fig. 1). The x-ray source and the detectors are positioned opposite of each other within a ring-shaped housing called the *gantry*. X-ray radiation is tightly collimated along a thin plane within the gantry termed the *xy-imaging plane*. The patient, centered within the bore of the gantry, is moved in a direction perpendicular to the xy-imaging plane, along what is termed the *z-axis*. Image detail within the xy-imaging plane is quantified by spatial resolution and contrast resolution and is determined to a large extent by the detector array. The time to acquire a single image in the xy-imaging plane is generally equal to the time required to rotate the detector array 1808 and is termed temporal resolution [15,16].

The single detector row CT scanner created 2-dimensional planar images, or “slices,” one at a time as the patient was advanced through the gantry. Single row CT scanners require approximately 1.0 to 2.0 seconds per slice. The first helical scanner was introduced in 1988 with slip-ring technology that allowed continuous rotation of the x-ray tube along with continuous patient motion. However, single row helical detector CT scanner still required 0.5 to 1.0 second for acquisition of each slice. Inasmuch as the craniocaudal length of the heart approaches 10 cm, a single detector row scanner requires 50 to 100 seconds to scan through a heart. Motion artifact, from continuous beating of the heart, prevents adequate visualization of coronary vessels using single row CT [15,16].

In the 1990s, CT scanners with multiple detector rings were introduced, allowing simultaneous acquisition of multiple slices. The first double detector row scanner was introduced in 1992. With MDCT, the patient is moved continuously through the gantry as the x-ray source and detectors rotate within the gantry. The rate at which the table is advanced for each rotation of the detector array is termed the pitch. For cardiac imaging, spatial resolution is typically 0.5 mm in the xy-imaging plane. Image resolution along the z-axis, also known as slice thickness, is related to detector thickness and pitch. Thinner slices are obtained at the expense of increased radiation exposure by reducing the pitch. A typical pitch for imaging of the coronary arteries is 0.2 with a slice thickness of 0.5 to 0.67 mm. The data from these scans can be reconstructed in any plane because the resolution is isotropic; that is, individual point resolution is equal in the x-, y-, and z-

axes.

Early-generation 2-, 4-, and 8-slice CT scans created images that were not of sufficient quality to reliably identify or exclude coronary artery disease [17].The current decade has witnessed a rapid increase in the number of detector rows used in MDCT. Sixteen-slice CT scanners provided a marked improvement in both spatial and temporal resolution needed to visualize the coronary artery lumen. Initial studies reported sensitivity and specificity rates of 59% to 95% and 79% to 98%, respectively, primarily in patients with stable angina pectoris referred for cardiac catheterization (Table 1). The rate of adequate visualization of coronary vessels in these studies ranged from 68% to 96% [18-28]. These results have compared favorably with other modalities such as intravascular ultrasound and cardiac magnetic resonance imaging [29,30] but are still inadequate. In the largest multicenter study to date, Garcia and colleagues have confirmed some of the problems with 16-slice scans. In 238 outpatients, almost 30% of the scans had images of insufficient quality to determine coronary vessel disease, and sensitivity and specificity were poor [31].

Sixty-four–slice MDCT increases spatial and temporal resolution further and reduces overall scan time to as short as 8 seconds. Newer scanners in development use 256 detector rows or flat-panel technology that actually eliminates the need for individual rows of detectors.

Temporal resolution has been a major obstacle to cardiac CT imaging. Most cardiac imaging must be performed within the quiescent period of the heartbeat during diastole. At a heart rate of 60 beats per minute, the quiescent period is no more than 200 milliseconds. Multidetector CT provided increased z-axis coverage in a shorter time interval, but it did not address the issue of cardiac motion until the introduction of electrocardiogram gating. Electrocardiogram gating is the coordination of image acquisition with the cardiac cycle to address cyclical changes in the position of the heart with each heartbeat. Because the length of diastole is closely related to the heart rate, β-blockers are given to lower the heart rate for coronary CT.

Temporal resolution of MDCT in this decade has been further improved by faster gantry rotation speeds. More recently, one manufacturer has introduced a scanner with 2 x-ray sources that may double the temporal resolution and eliminate the need for the use of β-blockers. Improvements in temporal resolution reduce motion artifact by allowing scans to acquire data at the same quiescent phase of the cardiac cycle over multiple beats of the heart [18].

4. The present

4.1. Sixty-four–slice MDCT in outpatients

Five studies comparing 64-slice CT with cardiac catheterization in outpatients suspected of having coronary artery disease have been published (Table 2) [32-36]. Leschka et al reported their experience on 67 consecutive patients who were referred for suspected coronary artery disease or before coronary artery bypass graft [32]. Patients with prior stents or coronary artery bypass grafts were excluded. Vessels >1.5 mm were evaluated, and all vessels imaged were of adequate image quality. Based on individual vessels, sensitivity and specificity for >50% stenosis were 94% and 97%, respectively; and on a patient level, no false-negative or false-positive results were reported.

Mollet et al studied 70 patients who were scheduled for cardiac catheterization for atypical chest pain, stable or unstable angina, or non-ST elevation myocardial infarction [33]. They excluded those with previous stents or coronary artery bypass grafts. In addition, 18 patients were

excluded from analysis because of logistical issues such as scheduling of the study, arrhythmias, renal insufficiency, or contrast allergy. All vessel sizes were imaged, with 97% of vessels adequately imaged to allow interpretation. They reported patient-based sensitivity and specificity of 100% and 92%, respectively, for >50% vessel stenosis, misidentifying only one patient with normal coronaries by cardiac catheterization. They used 2 observers for MDCT, with an interobserver κ of 0.73.

Ropers et al reported use of 64-slice MDCT in 84 stable patients referred for cardiac catheterization for suspected coronary artery disease, excluding patients with contraindications to contrast and radiation or with previously documented coronary artery disease [34]. Vessels >1.5 mm were analyzed, with 96% of the vessels being adequately imaged. They found patient-based sensitivity and specificity of 96% and 91%, respectively, compared with cardiac catheterization, with only 4% of vessels inadequately visualized.

Raff et al studied 84 consecutive patients being referred for cardiac catheterization for suspected coronary artery disease, excluding 14 patients with arrhythmias or contra-indications to contrast and *β*-adrenergic blocking medication [35]. They reported sensitivity and specificity of 95% and 90%, respectively, for >50% stenosis. They imaged all vessel sizes and found that only 88% of vessels were imaged with high quality, but no patients needed to be excluded because of image quality.

Furthermore, Leber et al imaged 59 patients scheduled for cardiac catheterization, excluding those with atrial fibrillation, contraindications to contrast, previous coronary artery bypass graft, or more than one coronary stent [36].In addition, 4 patients were excluded because of inadequate CT imaging. They included patients with only one stent and those whose heart rates were >60 and found sensitivity of only 88% for vessels with >50% stenosis. Their limited accuracy was largely due to inclusion of patients with stents: in such patients, 6 of 13 vessels were incorrectly identified.

These studies demonstrate the technical capability of 64slice MDCT to accurately identify patients with >50% coronary stenosis. Although follow-up for adverse effects was not routinely or systematically performed, in the 332 patients studied, there were no reported adverse effects from the test, indicating its safety in a selectively screened population. The high negative predictive values reported suggest a role for MDCT as a noninvasive screening test for coronary artery disease.

However, several limitations apply to these results as a group. First, the study populations were stable outpatients who were being referred for cardiac catheterization. There was a high prevalence of coronary artery disease in these populations. Therefore, it is uncertain whether these results will translate to an ED population that is acutely symptomatic and has a different prevalence of coronary artery disease.

A second limitation is the use of 50% stenosis as the criterion for detecting a coronary lesion. This is a lower threshold than what is considered clinically significant based on angiography. It has been shown that lesions <50% portend a slight risk for myocardial infarction at 3 years [37]. Although this may increase specificity of the test, it comes at a cost of decreased sensitivity. Of the aforementioned studies, only two examined MDCT's ability to quantify lesion severity, finding a correlation coefficient of 0.54 and 0.76 compared with cardiac catheterization [34,36]. It remains to be seen whether MDCT can accurately quantify the percentage of coronary vessel stenosis, information that is valuable in guiding treatment.

A final limitation of some MDCT studies has been the exclusion of some segments or scans from analysis [38,39]. Although somewhat limited in research settings, the number of “nondiagnostic” or technically inadequate studies may be substantial in real-life settings. Nonetheless, the existing studies demonstrate the promise of this technology and indicate that this is fertile ground for emergency medicine research.

4.2. Emergency medicine literature

The literature on MDCT in ED patients is rapidly emerging. Gallagher and colleagues prospectively compared the accuracy of 64-slice MDCT with that of traditional stress tests in 92 low-risk ED observation patients with symptoms suggestive of coronary artery disease [40]. Patients with ischemic electrocardiographic findings; positive cardiac markers; existing cardiomyopathy, coronary artery disease, or heart failure; irregular heart rhythm; renal insufficiency; or a contraindication to contrast or *ß*-blockade medication were excluded. Seven patients’ MDCT images were of insufficient quality to evaluate. All patients received both nuclear imaging stress tests and MDCT. The results of all studies were available to the treating physicians, who determined which patients subsequently underwent cardiac catheterization. Outcomes were defined as 30-day adverse cardiac events or cardiac catheterization showing N70% stenosis. A total of 7 patients in the study group were found to have coronary artery disease, all by cardiac catheterization. Multidetector CT identified 6 of these patients. Eleven patients’ MDCT results showed >50% stenosis; 6 were ultimately found to have >70% stenosis on catheterization. They failed to find significant differences between MDCT and nuclear stress testing in terms of sensitivity (86% vs 71%, respectively), specificity (92% vs 90%), or negative (99% vs 97%) and positive (50% vs 38%) predictive values. Among patients with discordant results between MDCT and nuclear stress tests, there was 1 patient with a negative MDCT but positive stress test and 2 patients with a positive MDCT but negative stress test who ultimately were determined to have acute coronary syndrome.

The Departments of Radiology, Emergency Medicine, and Cardiology of Massachusetts General Hospital reported their experience using 64-slice MDCT in ED patients with chest pain who were being admitted despite an initially normal or nondiagnostic workup [41,42]. Patients were excluded if they had pain for >24 hours, evidence of hemodynamic instability or definite acute coronary syndrome, an arrhythmia, or a contraindication to iodinated contrast. All eligible patients received an MDCT, then standard clinical care throughout hospital admission. Two reviewers, blinded to the MDCT results, assigned the diagnosis of acute coronary syndrome to study patients based on evidence for myocardial infarction or unstable angina after the patient’s index hospitalization workup. In an initial trial of 40 patients using this protocol, MDCT identified all 5 patients with acute coronary syndrome, without any false-negative results [41]. At the same time, the MDCT results indicated or could not exclude stenosis on 9 patients who were determined not to be having acute coronary syndrome. In a second, more recent trial of 103 patients, they identified all 14 patients with acute coronary syndrome without any false-negative results in the 72 patients without MDCT findings. However, a significant stenosis was detected or could not be excluded in 30 patients, providing an overall positive predictive value of 47%. Fifteen of the 17 inconclusive studies were attributed to either previous stent placement or severe vessel calcification. Follow-up was completed in 81 of the 89 patients without acute coronary syndrome on an average of 5 months after the index hospitalization, and there were no subsequent adverse outcomes. Logistic regression analysis indicated that information on plaque severity enhanced risk stratification using traditional risk factors or a clinical gestalt estimate [42].

White et al studied 78 ED patients with acute chest pain, excluding those who were clinically unstable, had definite myocardial infarction, or deemed unlikely to have a significant cause of chest pain [43]. Patients consented to the 16-slice MDCT as an additional study. Nine patients were excluded because of loss of data or patient being unavailable for the MDCT after consenting. Approximately 1 month after each patient's ED visit, the final diagnosis was determined by consensus of a group consisting of an emergency physician, a cardiologist, and a radiologist. Diagnoses were based on clinical data (49%), radionuclide testing (22%), cardiac catheterization (16%), and stress echo (9%), depending on which tests the patient ultimately received. Multidetector CT diagnosed 4% of patients with noncardiac diseases for which CT is the standard reference technique of diagnosis. They noted high sensitivity (83%) and specificity (96%) for >50% stenosis using a 16-slice CT scanner, with only 2 false-positive and 2 false-negative results in the 69 patients.

Another study evaluated 66 consecutive patients admitted to the hospital for "acute chest pain syndrome" with a 16-slice CT scanner [44]. Vessels >2 mm were analyzed, with 3.1% of vessels inadequately imaged. After excluding 7 patients with inadequate studies, they found a vessel-based sensitivity and specificity of 80% and 89% for >50% stenosis compared with cardiac catheterization, respectively. The rate of coronary artery disease in this group was high (88.8% had acute myocardial infarction or unstable angina), and the average time between cardiac catheterization and MDCT was 4 days.

Chase et al [45] reported their experience with 64-slice MDCT in 41 patients at low risk for ischemia with a Thrombolysis In Myocardial Infarction (TIMI) risk score of 0 to 2 in abstract form only. Patients with negative MDCT results (<50% stenosis) were immediately discharged home instead of being placed in an observation unit. Thirty-three patients from this group were discharged, and none had any adverse events within 30 days. Although analysis of this study is limited in the absence of more detailed information on their methods and results, they are suggestive of the possibilities of MDCT in ED patients.

Savino and colleagues reported their initial experience on 23 ED patients with chest pain with nondiagnostic electrocardiograms and cardiac markers, finding moderate to severe coronary artery disease in 8 patients, all of which were later confirmed angiographically. Two patients with pulmonary embolism were diagnosed on the basis of the CT scan and treated with fibrinolytics. They note that 9 patients with normal scans were discharged from the ED, but no follow-up was reported. Whether this experience can be replicated in a population with lower prevalence of disease remains to be seen [46].

Moloo et al [47] compared MDCT with myocardial perfusion imaging via single photon emission CT and found a slightly lower rate of diagnostic abnormality using the MDCT. However, the rate of agreement was high (93%) when both studies were diagnostic; and only 1 of 63 patients had single photon emission CT perfusion defects with a negative MDCT, whereas there were 2 patients with abnormal MDCT examinations and normal single photon emission CT studies. Currently, there is not enough data to determine whether MDCT is better at identifying high-risk ED patients than proven modalities such as stress testing [48]; but if so, it would represent an advance in diagnosis, as MDCT can be more readily available than stress testing.

Although it was not the primary focus of some studies of ED patients, the ability of MDCT to detect noncardiac disease processes in patients with chest pain seems promising. White et al diagnosed 3 patients with non-coronary diseases: one patient each with pulmonary embolism, pericardial effusion, and pneumonia [43]. One study of 151 low-risk patients with chest pain

found that 11.9% of patients had significant noncardiac findings, including hiatal hernias, esophageal inflammation, pulmonary infiltrate, and pericardial effusion. An additional 6.6% had findings requiring follow-up such as enlarged lymph nodes or noncalcified masses [49].

Two investigators have estimated the financial impact of using MDCT in ED patients with chest pain. Nagurney et al [50] performed an analysis that showed that MDCT significantly changed the posttest probability of low-risk ED patients with chest pain with and without coronary artery disease. This would have resulted in 13 of 35 fewer admissions using MDCT. Khare [51] found that an MDCT-only strategy was less costly yet more effective than 3 other strategies (electrocardiogram stress observation unit, echocardiogram stress observation unit, or enzyme testing without observation unit) based on marginal cost-effectiveness.

4.3. MDCT technical limitations

Use of MDCT requires knowledge of its technical considerations to optimize results. As with other contrast-enhanced CT scans, the timing of dye injection is critical to highlight the areas of interest. The study is contraindicated in patients with contrast dye allergy or renal insufficiency. Patients need to be able to lie still and hold their breath for the duration of the study. An additional limitation to the technology is that the patient must have a regular cardiac rhythm. Patients with irregular rhythms have been excluded from studies on MDCT [32-36].

4.3.1. Radiation exposure

One of the majors concerns regarding MDCT is radiation exposure. Because of the low pitch and thin slice thickness, the amount of radiation to which the patient is exposed is greater than that with conventional CT scanning. Doses of radiation exposure range from 3.9 to 10.1 mSv, which is approximately equal to the radiation of a sestamibi scan (approximately 8-10 mSv) [16,25,52,53]. One method for limiting dose is using an electrocardiogram-dependent tube current modulation in which the tube pulses radiation triggered by R waves detected by electrocardiogram [54]. This method was used by Ropers and colleagues and resulted in radiation doses averaging 7.45 mSv for men and 10.24 mSv for women [55]. However, this technique does not allow retrospective reconstruction of images in additional phases of the cardiac cycle and will result in suboptimal image quality whenever there is a slight arrhythmia. In our experience, retrospective reconstruction in systolic phases is useful in approximately 20% of patients.

4.3.2. Heart rate

The first studies of MDCT recognized that heart rate had significant impact on the quality of vessel imaging. Faster heart rates were associated with more motion artifact, which was consistently the leading cause of inadequate images. In studies aimed specifically at evaluating this effect, a statistically significant inverse correlation between heart rate and vessel visibility was found [23,53,56]. For this reason, it has become standard protocol to administer *β*-blocker medication to patients whose heart rates are >60 beats per minute. This premedication significantly decreases heart rates and improves images [34].

In all of the 64-slice scan studies except that of Leschka and colleagues, patients were premedicated with *β*-blockers. Leschka et al noted that 2 significant lesions were missed because of motion artifact associated with increased heart rate [32]. Mollet et al premedicated patients with a heart rate >70, but motion artifacts still accounted for 60% of the images rated as poor [33]. Raff et al noted that sensitivity and specificity dropped to 88% and 71%, respectively,

for patients with a heart rate >70 [35].

However, although motion artifact and increased heart rate accounted for a high proportion of unevaluable images, these represent a minority of the total number of studies. In one study, 6 of 9 patients with heart rates >70 could still be imaged without deleterious effect [36]. Thus, although it seems prudent to premedicate patients without contra-indications before 64-slice MDCT, increased heart rate is not an absolute contraindication to MDCT.

4.3.3. Obesity

Because of greater tissue radiation interference, obese patients are more likely to have lower-quality CT scan images. One study found that although patients in the lowest body mass index (BMI) category had significantly higher-quality images, there were no differences in sensitivity and specificity among groups [20].Fifty percent of patients in the study of Raff et al had a BMI ≥30 kg/m^2. For these patients, sensitivity and specificity dropped to 90% and 86%, respectively. These patients accounted for all but one of their inaccurate results [35]. Other studies failed to systematically report the effect of obesity on image quality.

4.3.4. Coronary calcification

Heavily calcified coronary vessels can present a problem for CT scan images by creating blooming and beam hardening artifact. *Blooming* refers to the appearance that the calcified plaque is larger than its true size. Circumferential calcified plaque, for example, may appear to occlude the lumen of a patent vessel. *Beam hardening* refers to artifacts in the CT image adjacent to dense materials. There is often a dark area adjacent to calcified plaque that is related to beam hardening, and that mimics the appearance of soft plaque. The amount of calcification a patient demonstrates on CT scan can be quantified using a system called the Agatston score [57,58]. Calcifications accounted for 32% of unevaluable images in one series. This study found that by limiting analysis to patients with Agatston score equivalents <1000, the sensitivity increased from 72% to 98% [21]. Another study increased sensitivity from 59% to 93% in similar fashion [51].

The presence of calcium within the coronary circulation remains problematic despite advances in 64-slice CT scanners. Ropers et al found that 64% of unevaluable segments were due to calcifications [34]. Leschka and colleagues reported that half of the vessels segments they imaged had calcifications, 18% severe enough to cause artifacts. This resulted in 8 false-negative and all 24 of their false-positive readings [32]. Mollet et al found a 5.8% false-positive reading rate in vessels of patients with a calcium score >400 Agatston units compared with 3.2% in other patients [33]. Raff et al noted that specificity dropped to 67% for patients with a calcium score >400 Agatston units [35]. New techniques are under development that use dual-energy CT to differentiate calcium from true vessel lumen and to limit the artifact resulting from coronary calcium. However, until these new technologies are implemented, CT images of patients with a high level of calcifications should be interpreted with caution despite the increased visualization accomplished with 64-slice CT scans.

5. Conclusions

We believe MDCT will be a vital tool to the emergency physician. The current generation of MDCT scanners has been able to visualize coronary vessel luminal stenosis at a level comparable with cardiac catheterization. Given its high negative predictive value for coronary

artery disease and the rapidity with which it can be performed, it will likely become a part of the standard workup of ED patients with acute chest pain, possibly allowing immediate discharge of patients found to be free of stenosis. In addition, important prognostic information such as the level of plaque calcification, the degree of stenosis, and the ejection fraction can be determined [11,15,16].

Unlike cardiac catheterization, other intrathoracic diseases causing chest pain in the undifferentiated ED patient can be identified [40,46]. The cost of the study (approximately $2000) is considerably less than cardiac catheterization [8,11]. Furthermore, MDCT adapts familiar technology that is more widely available in EDs than modalities such as stress testing. It is possible that MDCT may prove to be more sensitive for detecting coronary artery disease lesions than cardiac catheterization and may become the new gold standard for detection of coronary artery disease.

Before this occurs, more ED-based MDCT scan studies are needed to determine the feasibility and utility of this technology (Table 3). As more EDs upgrade their CT technology and more radiologists become trained to read the studies, more data will emerge. Many studies on the use of MDCT in ED populations are currently under way. Ideal studies would include a representative ED population of symptomatic patients and follow them for a period of time to correlate MDCT results with patient outcomes. They would also report the rates of inaccurate results due to increased heart rates, obesity, and coronary calcifications. Cost analysis is an additional, important area for future investigation. If these studies continue to show such promising results, then MDCT will truly become the future of ED cardiac care.

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FIGURES & TABLES

Fig. 1 An example of an MDCT scanner. Image courtesy of Philips Medical Systems.

Table 1 Sixteen-slice MDCT scan studies

Authors	Year	N	Patient-based unit of analysis	Sensitivity	Specificity	PPV	NPV	Calcium scores reported	Premedication used	Inadequate images excluded	Adequate visualization rate
Achenbach et al	2001	64	Y	91	84	59	98	N	N	Y	68
Kopp et al	2002	102	N	93	97	81	99	N	N	N	nr
Nieman et al	2002	59	Y	95	86	80	97	Y	Y	N	93
Ropers et al	2003	77	N	92	93	79	97	N	Y	N	88
Achenbach et al	2004	22	N	82	88	91	76	Y	Y	N	NR
Hoffman et al	2004	33	Y	90	75	86	81	N	Y	N	83
Kuettner et al	2004	60	Y	72	97	72	97	Y	Y	N	79
Achenbach et al	2005	50	Y	94	96	69	99	N	Y	Y	96
Burgstahler et al	2005	117	N	83	97	88	95	N	Y	Y	NR
Heuscmid et al	2005	37	Y	59	87	61	87	Y	Y	N	88
Hoffman et al	2005	103	Y	95	98	87	99	N	Y	Y	94
Kefer et al	2005	52	Y	82	79	46	95	Y	N	N	NR
Kuettner et al	2005	124	N	85	98	91	96	Y	Y	N	94
Kuettner et al JACC	2005	72	Y	82	98	87	97	Y	Y	N	93

Results patient-based where available.
PPV indicates positive predictive value; NPV, negative predictive value; NR, not reported.

Table 2 Sixty-four–slice MDCT scan studies

Authors	Year	N	Patient-based unit of analysis	Sensitivity	Specificity	PPV	NPV	CAD prevalence	Calcium scores	Premedication	Inadequate images excluded	Adequate visualization rate
Mollet et al	2005	52	Y	100	92	97	100	73%	Y	Y	N	97
Leschka et al	2005	67	Y	100	100	100	100	70%	Y	N	N	100
Ropers et al	2006	84	Y	96	91	83	98	31%	N	Y	Y	96
Leber et al	2005	59	Y	88	85	88	85	42%	N	Y	Y	93
Raff et al	2005	70	Y	95	90	93	93	57%	Y	Y	Y	88

Results patient-based where available.
CAD indicates coronary artery disease.

Table 3 Reporting criteria for future MDCT scan studies

Population
% CAD
BMI/rates of obesity
Heart rate
Calcium score
Inpatient vs outpatient vs ED
Traditional cardiac risk factors
Inclusion criteria
Stents/CABG excluded?
Size of vessels evaluated
Premedication regimen
Vessel-based vs patient-based unit of analysis
What is comparison reference standard?
When was reference standard performed relative to MDCT?
Was MDCT reader blinded to reference standard?
Interobserver κ reported?
How are unevaluable segments handled?
What constitutes a positive rating for CAD on MDCT?

CABG indicates coronary artery bypass grafts.