Clinical Policy Bulletin: Cardiac CT, Coronary CT Angiography and Calcium Scoring

Policy History

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Definitions

Additional Information

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Policy

I. Aetna considers cardiac computed tomography (CT) angiography of the coronary arteries using 64 slices or greater medically necessary for the following indications:

A. Rule out significant coronary stenosis in persons with a low or very low pre-test probability of coronary artery disease by Framingham risk scoring or by American College of Cardiology criteria (see appendix), with any of the following indications:

1. Evaluation of persons with chest pain who cannot perform or have contraindications to exercise and pharmacologic stress testing (see appendix); *or*
2. Evaluation of persons with a positive (i.e., greater than or equal to 1 mm ST segment depression) exercise stress test; *or*
3. Evaluation of persons with chest pain presenting to the emergency department when an imaging stress test or coronary angiography are being deferred as the initial imaging study.

B. Evaluation of asymptomatic persons at low pretest probability of coronary heart disease by Framingham risk scoring (see appendix) who have an equivocal exercise or pharmacological stress test. Note: Current guidelines from the American Heart Association recommend against routine stress testing for screening asymptomatic adults.

C. Preoperative assessment of persons scheduled to undergo 'high-risk" noncardiac surgery, where an imaging stress test or invasive coronary angiography is being deferred unless absolutely necessary. The American College of Cardiology defines high-risk surgery as emergent operations, especially in the elderly, aortic and other major vascular surgeries, peripheral vascular surgeries, and anticipated prolonged surgical procedures with large fluid shifts and/or blood loss involving the abdomen and thorax.

D. Preoperative assessment for planned noncoronary cardiac surgeries including valvular heart disease, congenital heart disease, and pericardial disease, in lieu of cardiac catheterization as the initial imaging study.

E. Detection and delineation of suspected coronary anomalies in young persons (less than 30 years of age) with suggestive symptoms (e.g., angina, syncope, arrhythmia,

and exertional dyspnea without other known etiology of these symptoms in children and adults; dyspnea, tachypnea, wheezing, periods of pallor, irritability (episodic crying), diaphoresis, poor feeding and failure to thrive in infants).

II. Aetna considers CT angiography of cardiac morphology for pulmonary vein mapping medically necessary for the following indications:

A. Evaluation of persons needing biventricular pacemakers to accurately identify the coronary veins for lead placement.

B. Evaluation of the pulmonary veins in persons undergoing pulmonary vein isolation procedures for atrial fibrillation (pre- and post-ablation procedure).

III. Aetna considers cardiac CT for evaluating cardiac structure and morphology in congenital heart disease medically necessary for the following indications:

A. Anomalous pulmonary venous drainage;
B. Evaluation of other complex congenital heart diseases;
C. Evaluation of sinus venosum atrial-septal defect;
D. Kawasaki's disease;
E. Person scheduled or being evaluated for surgical repair of tetralogy of Fallot or other congenital heart disease;
F. Pulmonary outflow tract obstruction;

G. Suspected or known Marfan's syndrome.

IV. Aetna considers cardiac CT angiography experimental and investigational for persons with any of the following contraindications to the procedure:

A. Body mass index (BMI) greater than 40.
B. Inability to image at desired heart rate (under 80 beats per minute), despite beta blocker administration.
C. Person with allergy or intolerance to iodinated contrast material
D. Persons in atrial fibrillation or with other significant arrhythmia.

E. Persons with extensive coronary calcification by plain film or with prior Angston score greater than 1700.

V. Aetna considers coronary CT angiography experimental and investigational for screening of asymptomatic persons, evaluation of persons at intermediate or high pretest probability of coronary artery disease, evaluation of stent occlusion or in-stent restenosis, evaluation of persons with an equivocal PET rubidium study, and for all other indications.

Aetna considrs cardiac CT angiography using less than 64-slice scanners experimental and investigational.

VI. Aetna considers calcium scoring medically necessary for diagnostic cardiac CT angiography to assess whether an adequate image of the coronary arteries can be obtained.

Aetna considers calcium scoring (e.g., with ultrafast (electron beam) CT, spiral (helical) CT, and multislice CT) experimental and investigational for all other indications because the definitive value of calcium scoring for assessing coronary heart disease risk has not been established in the peer-reviewed published medical literature.

Background

Cardiac CT Angiography

Contrast-enhanced cardiac CT angiography involves the use of multislice CT and intravenously administered contrast material to obtain detailed images of the blood vessels of the heart. It has been used as an alternative to conventional invasive coronary angiography for evaluating coronary artery disease and coronary artery anomalies.

The performance of cardiac CT angiography has been improved by increasing the number of slices that can be acquired simultaneously by increasing the number of detector rows (AHTA, 2006). As the number of slices that can be acquired simultaneously increases, the scanning time is shortened and the spatial resolution is increased. Initial cardiac CT imaging was conducted with four-slice detector CT. Scanning times were reduced from 40 seconds down to 20 seconds with 16-slice detector CT and with the advent of 64-slice detector CT, scanning times have been reduced to a 10 second breath-hold .

Cardiac CT angiography using 64-slices has been shown in studies to have a high negative predictive value (93 to 100 percent), using conventional coronary angiography as the reference standard. Given its high negative predictive value, cardiac CT angiography has been shown to be most useful for evaluating persons at low risk of coronary artery disease where invasive coronary angiography may otherwise be indicated. This would include evaluation of low risk persons with a positive exercise stress test, evaluation of asymptomatic low risk persons with an equivocal exercise or pharmacologic stress test, and evaluation of low-risk persons with chest pain who have a contraindication to exercise and pharmacological stress testing. Cardiac CT angiography is also a useful alternative to invasive coronary angiography for preoperative evaluation of persons undergoing noncoronary cardiac surgery or high-risk noncardiac surgery, where invasive coronary angiography would otherwise be indicated.

Substantial controversy over the appropriate indications for cardiac CT angiography is due, in part, to the relatively poor quality of available evidence. An assessment of cardiac CT angiography by the Duke Evidence-Based Practice Center (EPC) for the Agency for Healthcare Research and Quality (AHRQ) (Matchar, et al., 2006) found that published studies of cardiac CT angiography were generally small, performed at single centers, and often did not include information that would serve to provide confident assessments of key questions of effectiveness. The reported noted: “In particular, we did not identify any studies evaluating the clinical impact of diagnostic strategies including NITs [noninvasive tests] of coronary anatomy compared with strategies that did not include these techniques.”

The BlueCross BlueShield Association’s Medical Advisory Panel (BCBSA, 2006) concluded that contrast-enhanced cardiac CT angiography as a substitute for invasive coronary angiography in the diagnosis of coronary artery stenosis does not meet the TEC criteria. The assessment found that “[t]he studies evaluating the use of CTA in comparison to angiography are relatively small studies from single centers. Their major failing is that they enrolled convenience samples of patients being referred for angiography. The results from these studies may not generalize to lower-risk populations.” The assessment explained that “in order to demonstrate improved patient outcomes, valid prognostication tied to improved management and outcomes must be demonstrated. Clinical trials comparing patients undergoing CTA as part of their diagnostic work up compared to patients not undergoing CTA may be required to demonstrate improved patient outcomes.”

An assessment by the California Technology Assessment Forum (CTAF) found that cardiac CT angiography has generally not been compared with the established alternatives (Walsh, 2007). The assesment explained that cardiac CT angiography has relatively high sensitivity but a lower specificity than invasive coronary angiography. Thus, the negative predictive value of cardiac CT angiography is high, but there is a high false positive rate, which then leads to additional testing. The assessment also found that, in several studies a high proportion of cardiac CT angiographies were unevaluable, which further limits the utility of this technology. The assessment reported that a precise estimate of the proportion of tests that are unevaluable is difficult to ascertain, because the absolute numbers of patients in each of the studies is small.

CTAF also found only one study that compared cardiac CT angiography to the standard of care for the evaluation of chest pain. In that study, although cardiac CT angiography was accurate for ruling in or ruling out significant coronary artery disease in three quarters of subjects, about one quarter of subjects required additional diagnostic testing to clarify the diagnosis. The CTAF report noted, in addition, that important clinical outcomes that should be evaluated, such as the number of patients with acute coronary syndrome and the number of patients safely discharged from the emergency room, have not been evaluated in most of the studies. The CTAF assessment stated that, ideally, studies should demonstate that cardiac CT angiography reduced the need for invasive procedures, accurately identified patients with acute coronary syndromes, and correctly identifed patients who could safely be sent home from the emergency room.

An assessment by the Ontario Ministry of Long-Term Care Medical Advisory Secretariat (MAS, 2007) found insuffient evidence for the use of coronary CTA as a screening test for coronary artery disease (CAD) in asymptomatic individuals. The assessment found that coronary CTA exhibits only moderately high sensitivity and specificity for detection of CAD in an asymptomatic population. If population-based screening were implemented, a high rate of false positives would result in increased downstream costs and interventions. Additionally, some cases of CAD would be missed, as they may not be developed, or not yet have progressed to detectable levels. The assessment noted that there is no evidence for the impact of screening on patient management. Cardiovascular risk factors are positively associated with the presence of coronary artery calcification and cardiovascular events; however, risk factor stratification to identify high-risk asymptomatic individuals is unclear given the current evidence-base. The assessment noted that the safety of coronary CTA screening is also an issue because of the introduction of increased radiation doses for the initial screening scan and possible follow-up interventions. The assessment found that no large randomized controlled trials of coronary CTA screening have been published. The assessment also found no evidence on the long-term implications of screening.

A decision memorandum from the Centers for Medicare & Medicaid Services (CMS, 2008) has concluded that there is uncertainty regarding any potential health benefits or patient management alterations from including coronary CTA in the diagnostic workup of patients who may have CAD. The memorandum stated that no adequately powered study has established that improved health outcomes can be causally attributed to coronary CTA for any well-defined clinical indication, and the body of evidence is of overall limited quality and limited applicability to Medicare patients with typical comorbidities in community practice. The memorandum noted that the primary safety concerns with cardiac CTA are the exposure to radiation and the use of contrast and ß blocker medications. .

The CMS decision memorandum (CMS, 2008) explained that cardiac CT angiography is unlikely to benefit persons at high risk for CAD, as these persons will likely need to have invasive coronary angiography regardless of the results of this test. The CMS decision memorandum also stated that there is no evidence that CT angiography will benefit persons with chest pain at low risk of CAD In support of that conclusion, the decision memorandum cited a randomized clinical trial by Goldstein, et al. (2007) of low risk patients presenting to the emergency room with chest pain. Study subjects were randomized to evaluation with cardiac CT angiography versus standard of care. At 6 months, there was no significant difference in the number of cumulative cardiac catheterizations (12 percent in persons assigned to cardiac CT angiography versus 7 percent in persons assigned to standard of care; p = 0.24). There were no significant differences between groups in cumulative angioplasty or coronary artery bypass surgery at 6 months. There were also no deaths or myocardial infarctions in either group at 6 months.

The decision memorandum observed that, in systematic reviews of coronary CT angiography, the overall reported sensitivity, specificity and predictive values are generally above 80 to 90 percent (CMS, 2008). The decision memorandum stated, however, that these estimates have limitations in applicability and generalizability due to patient selection and potential bias. The decision memorandum found no published studies of the sensitity and specificity of coronary CT angiography in persons at low or intermediate pretest probability of CAD. Although available

studies have not consistently reported the participants' pretest probability of CAD, almost all persons enrolled in these studies are likely to be at relatively high risk for CAD, since they were already scheduled for invasive coronary angiography. The decision memorandum noted that, in general, test sensitivity and specificity will be higher in patients with more severe disease. Thus, the sensitivity and specificity estimates for high risk patients are not directly applicable to patients at low or intermediate risk. The sensitivity and specificity of coronary CT angiography for persons at intermediate or low risk are likely to be lower given the reduced severity of disease.

The CMS decision memorandum also explained that the reported positive and negative predictive values of coronary CT angiography based on high risk patients are not directly applicable to low or intermediate risk patients because the prevalence of disease is different (CMS, 2008). The predictive values would very likely be lower if calculated using data from low or intermediate risk patients since these populations have a lower prevalence of CAD.

The Institute for Clinical and Economic Review (ICER, 2008) completed a health technology assessment and cost-effectiveness analysis of CCTA for coronary artery disease. ICER evaluated the cost-effectiveness of CCTA in the emergency department to evaluate persons with chest pain, and found, at base case, with costs based upon Medicare data, that CCTA is cost-saving, with about $296 in savings per patient in comparison with standard of care. The ICER assessment also evaluated the cost-effectiveness of the use of CCTA in the outpatient setting to evaluate persons at intermediate risk of CAD with stable chest pain. A number of strategies were evaluated involving CCTA, stress echocardioraphy, and myocardial perfusion imaging, used alone or in combination. Based on base case assumptions, the analysis found that all strategies were dominated except for CCTA alone and stress ECHO alone. Stress echocardiography was the least expensive strategy, and the incremental cost-effectiveness ratio of CCTA alone versus stress echocardiography was $178,000 per quality adjusted life year.

In the outpatient setting, where the interest in the use of CCTA has been focused on the evaluation of patients with stable chest pain symptoms who are at low-to intermediate risk of significant CAD, there are no published studies to date that have directly measured the impact of CCTA on clinical decision-making or on patient outcomes. The majority of available literature on 64-slice CCTA is limited to small, single-center studies of diagnostic accuracy compared to ICA, typically among consecutive patients at relatively high risk of CAD who are already scheduled to undergo ICA.

The American College of Cardiology has published appropriateness criteria for cardiac CT angiography (Hendel, et al., 2006). These criteria are based upon consensus of a technical panel, and not upon an explicit assessment of the available evidence.

Cardiac CT angiography requires high doses of ionizing radiation, with an average dose of 8.1 milliSieverts for patients weighing 75 kgs. This dose is approximately 2-3 times higher than the average radiation dose administered to patients during conventional coronary angiography (AHTA, 2006). Although the risk associated with a dose of this size is minimal, it may raise concerns about repeated doses, or in children and women of child-bearing age. In addition, a greater volume of contrast media is required for coronary CT angiography (150 milliliters) compared to conventional coronary angiography (approximately 20 milliliters).

Einstein and colleagues (2007) ascertained the lifetime attributable risk (LAR) of cancer incidence associated with radiation exposure from a 64-slice computed tomography coronary angiography (CTCA) study and evaluated the influence of age, sex, and scan protocol on cancer risk. Organ doses from 64-slice CTCA to standardized phantom (computational model) male and female patients were estimated using Monte Carlo simulation methods, using standard spiral CT protocols. Age- and sex-specific LARs of individual cancers were estimated using the approach of BEIR VII and summed to obtain whole-body LARs. Main outcome measures were whole-body and organ LARs of cancer incidence. Organ doses ranged from 42 to 91 mSv for the lungs and 50 to 80 mSv for the female breast. Lifetime cancer risk estimates for standard cardiac scans varied from 1 in 143 for a 20-year-old woman to 1 in 3261 for an 80-year-old man. Use of simulated electrocardiographically controlled tube current modulation (ECTCM) decreased these risk

estimates to 1 in 219 and 1 in 5017, respectively. Estimated cancer risks using ECTCM for a 60-year-old woman and a 60-year-old man were 1 in 715 and 1 in 1911, respectively. A combined scan of the heart and aorta had higher LARs, up to 1 in 114 for a 20-year-old woman. The highest organ LARs were for lung cancer and, in younger women, breast cancer. The authors concluded that these estimates derived from simulation models suggested that use of 64-slice CTCA is associated with a non-negligible LAR of cancer. This risk varies markedly and is considerably greater for women, younger patients, and for combined cardiac and aortic scans.

In a study published in the *New England Journal of Medicine*, Miller and co-workers (2008) stated that the accuracy of multi-detector CTA involving 64 detectors has not been well-established. These investigators conducted a multi-center study to examine the accuracy of 64-row, 0.5-mm multi-detector CTA as compared with conventional coronary angiography in patients with suspected coronary artery disease. Nine centers enrolled patients who underwent calcium scoring and multi-detector CT angiography before conventional coronary angiography. In 291 patients with calcium scores of 600 or less, segments 1.5 mm or more in diameter were analyzed by means of CT and conventional angiography at independent core laboratories. Stenoses of 50 % or more were considered obstructive. The area under the receiver-operating-characteristic curve (AUC) was used to evaluate diagnostic accuracy relative to that of conventional angiography and subsequent revascularization status, whereas disease severity was assessed with the use of the modified Duke Coronary Artery Disease Index. A total of 56 % of patients had obstructive coronary artery disease. The patient-based diagnostic accuracy of quantitative CT angiography for detecting or ruling out stenoses of 50 % or more according to conventional angiography revealed an AUC of 0.93 (95 % confidence interval [CI], 0.90 to 0.96), with a sensitivity of 85 % (95 % CI, 79 to 90), a specificity of 90 % (95 % CI, 83 to 94), a positive predictive value of 91 % (95 % CI, 86 to 95), and a negative predictive value of 83 % (95 % CI, 75 to 89). Computed tomographic angiography was similar to conventional angiography in its ability to identify patients who subsequently underwent re-vascularization: the AUC was 0.84 (95 % CI, 0.79 to 0.88) for multi-detector CTA and 0.82 (95 % CI, 0.77 to 0.86) for conventional angiography. A per-vessel analysis of 866 vessels yielded an AUC of 0.91 (95 % CI, 0.88 to 0.93). Disease severity ascertained by CT and conventional angiography was well-correlated (r= 0.81; 95 % CI, 0.76 to 0.84). Two patients had important reactions to contrast medium after CT angiography. The authors concluded that multi-detector CTA accurately identifies the presence and severity of obstructive coronary artery disease and subsequent re-vascularization in symptomatic patients. However, the negative and positive predictive values indicate that multi-detector CTA can not replace conventional coronary angiography at present.

An accompanying editorial commenting on the study by Miller et al. stated that this study exemplifies current research in the field (Redberg & Walsh, 2008). The editorialists stated that, although this study was carefully done and provides more data on diagnostic accuracy, it does not advance our knowledge of the appropriate use and possible benefits of the technology. The editorialists explained that Miller et al. sought to identify "patients with suspected coronary artery disease who should be referred for conventional coronary angiography." However, because all patients received both cardiac CT angiography and conventional coronary angiography and no data on outcomes are reported, the study does not answer this important question. The editorialists commented that, with respect to risks, Miller, et al. claimed that the new technology compares favorably to conventional coronary angiography, even though in their study the radiation exposure with cardiac CT angiography was significantly greater than that with conventional coronary angiography. The editorialists noted, in any event, that Miller, et al. concluded that cardiac CT angiography is not accurate enough to replace the older technology for patients with chest pain, adding to the body of research failing to prove a benefit of the new procedure.

The editorialists noted that the use of cardiac imaging has been increasing despite a lack of evidence of outcome benefit (Redberg & Walsh, 2008). The editorialists said that there is some evidence that cardiac imaging leads to additional unnecessary procedures, such as additional diagnostic testing, revascularizations, or biopsies for "incidental findings." The editorialists also noted that cardiac CT angiographic equipment exposes patients with radiation many orders of

magnitude greater than that of traditional radiographs — posing a risk that has never been studied in depth. The editorialists cited evidence that estimates that 1.5 to 2.0% of all cases of cancers in the United States may be attributable to CT radiation.

Cardiac CT angiography often produces noncardiac incidental findings. To evaluate the incidence, clinical importance, and costs of these incidental findings, MacHaalany, et al. (2009) studied 966 consecutive patients who underwent CTA. Incidental findings were noted in 401 patients (41.5%); of these, 12 were deemed to be clinically significant (e.g., 5 thrombi, 1 aortic dissection that was not clinically suspected, 1 ruptured breast implant), and 68 were deemed to be indeterminate (e.g., 34 noncalcified pulmonary nodules <1 cm, 11 larger lung nodules, 9 liver nodules/cysts). After a mean 18-month followup, no indeterminate finding became clinically significant, although three malignancies were diagnosed after subsequent diagnostic tests. Noncardiac and cancer death rates were not significantly different between patients with and without incidental findings. In all, 164 additional diagnostic tests and procedures were performed in the 80 patients with indeterminate or clinically significant incidental findings, including 1 patient who suffered empyema and abdominal abscesses as a complication of transthoracic biopsy.

Calcium Scoring

Ultrafast computed tomography (also known as electron beam computed tomography) has been shown to be able to quantify the amount of calcium in the coronary arteries, and thus has been primarily investigated as a tool to predict risk of CAD. In ultrafast CT, an electron beam is magnetically steered along stationary tungsten rings to produce a rotating X-ray beam.

Research has indicated that EBCT is highly sensitive in detecting coronary artery calcification in comparison to other types of CT. Moreover, various studies have shown a strong correlation between EBCT calcium scores and quantities of atherosclerotic plaque. However, there is skepticism about the relationship between EBCT calcium scores and the likelihood of coronary events because of the following factors:

- Calcium does not collect exclusively at sites with severe stenosis
- EBCT calcium scores do not identify the location of specific vulnerable lesions
- Substantial non-calcified plaque is frequently present in the absence of coronary artery calcification
- There are no proven relationships between coronary artery calcification and the probability of plaque rupture.

Some advocates have argued that EBCT scores could be an effective substitute for standard risk factors in predicting the risk of coronary artery disease. However, citing evidence that shows that only a small proportion of asymptomatic individuals with calcified coronary arteries ultimately develop symptomatic coronary artery disease, a 1996 American Heart Association (AHA) scientific statement on coronary artery calcification concludes that the presence of coronary artery calcium is a poor predictor of coronary artery disease risk, and that there is no role for ultrafast CT as a general screening tool to detect atherosclerosis in people who have no symptoms of the disease and no risk factors. More importantly, although a negative scan may mean a low probability of significant artery blockage in asymptomatic people with or without a previous cardiac event (e.g., myocardial infarction, bypass surgery, angioplasty, etc.), an unstable or vulnerable plaque may go undetected by ultrafast CT, and may rupture and cause thrombosis and obstruction of the coronary artery. Detrano (1999) demonstrated that the addition of EBCT data provided no added value to the risk of coronary artery disease risk determined by the Framingham and National Cholesterol Education Program risk models.

Several investigators have examined the potential role of ultrafast CT measurements of coronary artery calcium in ruling out coronary artery disease in patients with atypical anginal symptoms. The AHA report estimates that the negative predictive value of an ultrafast CT scan in these patients ranges from 90-95%, and suggests that a negative study may be useful in determining the need for further work-up with exercise stress testing and/or angiography. It must be realized, however, that

ultrafast CT provides only anatomic and not physiologic information. Although ultrafast CT can be used to determine whether calcium is present in the coronary arteries, it cannot replace stress testing and angiography in determining whether lesions result in significant coronary artery obstruction and ischemia. Ultrafast CT is being investigated for this proposed use.

The AHA does not recommend ultrafast CT as a replacement for stress testing and/or angiography in patients with conventional risk factors and in patients with typical anginal chest pain. The increased predictive value of ultrafast CT of the coronary arteries relative to traditional risk factor assessment is not yet defined. Although a greater amount of calcium may indicate a greater likelihood of obstructive disease, studies have shown that site-specificity and exact 1:1 correlations are not well predicted, that is, ultrafast CT cannot define the location or amount of obstruction with sufficient accuracy to be of use in predicting risk of coronary artery disease, in diagnosing coronary artery disease, or in planning surgical treatment.

Several studies have shown a variability in repeated measures of coronary calcium by ultrafast CT; therefore, use of serial ultrafast CT scans in individual patients to track the progression or regression of calcium is problematic. Although there is emerging evidence that ultrafast CT may help in identifying the presence of early coronary artery disease in people with known heart disease risk factors, there is no definitive evidence that ultrafast CT can substitute for coronary angiography because the absence of calcific deposits on an ultrafast CT scan does not imply the absence of atherosclerosis. Conversely, the presence of calcium does not secure a diagnosis of significant angiographic narrowing. There is still a need for further clarification regarding the relationship between calcification, atherosclerosis, and risk of plaque rupture.

The critical issue that defines the utility (or lack thereof) of ultrafast CT is its prognostic value. The evidence in the peer reviewed medical literature linking detectable coronary calcium to event outcomes such as future coronary bypass surgery, angioplasty, myocardial infarction, and coronary death is limited. Large-scale prospective studies are still needed to define a role for ultrafast CT.

In a review on coronary artery calcium scoring using EBCT, Thomson and Hachamovitch (2002) stated that studies have indicated that the very early detection of a coronary artery burden is possible with EBCT. However, both the Prevention Conference V and the ACC/AHA Expert Consensus Document on EBCT have recommended against the routine use of EBCT for screening for CAD in asymptomatic individuals. Moreover, there is no evidence so far to support using the results of EBCT in an asymptomatic patient to select a therapy or to guide referral to invasive investigations. The clinical role of EBCT is yet to be established in terms of screening for disease or risk assessment. Electron beam computed tomography is highly sensitive, but its specificity is low. In fact, when referral to angiography is based on the results of EBCT, referrals will be made for very few patients with normal results while many referrals will be made for those with abnormal results. The outcome will be that, in clinical practice, the observed sensitivity of EBCT will be increased, and the observed specificity will be reduced. To date, there are no well-conducted studies that clearly demonstrate the incremental value of calcium scoring over traditional assessments of risk factors, and the clinical role of EBCT is yet to be established in terms of screening for disease or risk assessment. The authors' view is shared by Redberg and Shaw (2002) who stated that widespread use of EBCT is not recommended. More research is needed to establish the effectiveness of EBCT in the role of risk factor reduction and prevention of cardiovascular disease. Furthermore, Greenland (2003) stated that "To date, most research on EBT [electron-beam computed tomography] has been observational in nature, based entirely on self-referred patients" and that the "role of EBT remains uncertain" and that "additional randomized trials to define specific roles for EBT in risk prediction" are needed.

These conclusions are consistent with those of the U.S. Preventive Services Task Force (2004), which stated that there is "insufficient evidence to recommend for or against routine screening with ... EBCT [electron beam CT] scanning for coronary calcium for either the presence of severe [coronary artery stenosis] or the prediction of [coronary heart disease] events in adults at increased risk for coronary heart disease." The USPSTF reaffirmed their position in 2009, stating that the evidence is insufficient to assess the balance of benefits and harms of using coronary artery

calcification (CAC) score on electron-beam computed tomography (EBCT) to screen asymptomatic men and women with no history of CHD to prevent CHD events.

Multislice (or multirow detector) CT and spiral (or helical) CT has also been used to quantify calcium in the coronary arteries. Spiral or helical CT differs from conventional CT in that the patient is continuously rotated as he is moved. Multislice CT is a technical advance over spiral CT, and uses multiple rows of detector arrays to rapidly obtain multiple slices with one pass. Multislice CT differs from ultrafast CT in that the latter has no moving parts, and ultrafast CT scans are faster than with multisclice CT. One study examined the accuracy of spiral CT in evaluating coronary calcification, using ultrafast CT as the gold standard for comparison, in 33 asymptomatic individuals who were referred for calcium scans. Spiral CT was reported to have a sensitivity of 74% and a specificity of 70% compared to ultrafast CT. An assessment of spiral CT and multislice CT in screening persons with coronary artery disease by the Canadian Coordinating Office for Health Technology Assessment (2003) found no adequate long-term studies on clinical outcomes of people screened with multislice CT or spiral CT. In addition, the assessment failed to identify studies that compared spiral CT and multislice CT with established screening modalities like risk factor algorithms. The authors noted that the low specificity of spiral CT and multislice CT gives rise to concern over false positive results, and that false positives may cause harm and expense due to inappropriate and invasive follow-up. The assessment concluded that “[t]here is insufficient evidence at this time to suggest that asymptomatic people derive clinical benefit from undergoing coronary calcification screening using MSCT [multislice CT] or spiral CT scanning."

In an editorial accompanying a meta-analysis of electron-beam CT for CAD by Pletcher et al (2004), Ewy (2004) explained that "the clinical utility of fast computed tomography (CT) scanners (i.e., the electron beam [EB] and double helical CT scanner) is still limited. Electron beam CT is not ready for prime time."

An assessment of the literature on calcium scoring by the German Agency for Health Technology Assessment (DAHTA, 2006) concluded that measuring coronary calcium is a "promising" tool for risk stratification, but that many questions remain unanswered about the targeted use in medical practice, including which patient groups should be screened, which calcium score threshold should be applied, and which scoring method should be used.

An assessment prepared for the National Coordinating Centre for Health Technology Assessment (Waugh, et al., 2006) found: "CT examination of the coronary arteries can detect calcification indicative of arterial disease in asymptomatic people, many of whom would be at low risk when assessed by traditional risk factors. The higher the CAC score, the higher the risk. Treatment with statins can reduce that risk. However, CT screening would miss many of the most dangerous patches of arterial disease, because they are not yet calcified, and so there would be false-negative results: normal CT followed by a heart attack. There would also be false-positive results in that many calcified arteries will have normal blood flow and will not be affected by clinically apparent thrombosis: abnormal CT not followed by a heart attack." The NCCHTA assessment concluded: "For CT screening to be cost-effective, it has to add value over risk factor scoring, by producing sufficient extra information to change treatment and hence cardiac outcomes, at an affordable cost per quality-adjusted life-year. There was insufficient evidence to support this. Most of the NSC [National Screening Committee] criteria were either not met or only partially met."

An assessment by the Institute for Clinical Effectiveness and Health Policy (Bardach, 2005) concluded: "Most consensus consider EBCT, SCT and MSCT still at their investigational stage for the following: a) detection of coronary artery calcifications as a screening method for asymptomatic subjects with coronary disease; b) detection of coronary artery calcifications in symptomatic patients; and c) assessment of coronary graft viability. No study reported that calcification measuring (plaque characterization) reduces the incidence of coronary events or death."

Detrano and associates (2008) noted that in white populations, computed tomographic measurements of coronary artery calcium (CAC) predict coronary heart disease independently of traditional coronary risk factors. However, it is unclear if CAC predicts coronary heart disease in

other racial or ethnic groups. These researchers collected data on risk factors and performed scanning for CAC in a population-based sample of 6722 men and women, of whom 38.6 % were white, 27.6 % were black, 21.9 % were Hispanic, and 11.9 % were Chinese. The study subjects had no clinical cardiovascular disease at entry and were followed for a median of 3.8 years. There were 162 coronary events, of which 89 were major events (myocardial infarction or death from coronary heart disease). In comparison with participants with no CAC, the adjusted risk of a coronary event was increased by a factor of 7.73 among participants with coronary calcium scores between 101 and 300 and by a factor of 9.67 among participants with scores above 300 ($p < 0.001$ for both comparisons). Among the 4 racial and ethnic groups, a doubling of the calcium score increased the risk of a major coronary event by 15 to 35 % and the risk of any coronary event by 18 to 39 %. The AUCs for the prediction of both major coronary events and any coronary event were higher when the calcium score was added to the standard risk factors. The authors concluded that the coronary calcium score is a strong predictor of incident coronary heart disease and provides predictive information beyond that provided by standard risk factors in 4 major racial and ethnic groups in the United States. No major differences among racial and ethnic groups in the predictive value of calcium scores were detected. While there were some interesting differences in the prevalence of CAC among the 4 racial and ethnic groups, what remains unclear is how this test should best be employed, or if it should be used at all, to attain better health outcomes for patients.

Calcium scoring may be useful when performed with an otherwise indicated mutislice cardiac CT angiography to assess the calcium burden of the coronary arteries to determine whether an adequate scan can be obtained. The calcium score may be estimated with a scout scan, and the injection of contrast withheld if it appears that the patient has a prohibitively high calcium score. This allows one to avoid exposing the patient to unnecessary radiation from contrast if it is clear that the patient's calcium score is so high that an adequate image of the coronary vessels cannot be obtained. In such cases, the patient may need invasive angiography to adequately assess the coronary vessels.

Baig and colleagues (2009) stated that CAD is present in 38 % to 40 % of patients starting dialysis. Both traditional and chronic kidney disease-related cardiovascular risk factors contribute to this high prevalence rate. In patients with end-stage renal disease, CAD, especially acute myocardial infarction, is under-diagnosed. Dobutamine stress echocardiography and, to a lesser extent, stress myocardial perfusion imaging have proved useful in screening for CAD in such patients. Coronary artery calcium scoring is less useful. Acute myocardial infarction is associated with high short- and long-term mortality in dialysis patients. Cardiac troponin I appears to be more specific than cardiac troponin T or creatine kinase MB subunits in the diagnosis of acute myocardial infarction.

Appendix

Table 1 can be used to assess whether a person has a low or very low pretest probability of coronary artery disease (CAD). Alternatively, pretest probability of CAD can be assessed using the Framingham Risk Scoring Tool available at the following website, with low risk defined as a 10-year risk of less than 10 %: http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof. (For details on Framingham Risk Scoring, see appendix to CPB 381 - Cardiac Disease Risk Tests.)

Table 1: ACC Criteria for Pretest Probability of CAD by Age, Gender and Symptoms:†

Age (yrs)	Gender	Typical / Definite Angina Pectoris	Atypical / Probable Angina Pectoris	Nonanginal Chest Pain	Asymptomatic
30-39	Men	Intermediate	Intermediate	Low	Very Low

	Women	Intermediate	Very Low	Very Low	Very Low
40-49	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Low	Very Low	Very Low
50-59	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Intermediate	Low	Very Low
60-69	Men	High	Intermediate	Intermediate	Low
	Women	High	Intermediate	Intermediate	Low

Key: High: greater than 90% pretest probability; Intermediate: between 10% and 90% pretest probability; Low: between 5% and 10% pretest probability; Very low: less than 5% pretest probability.

†No data exist for patients less than 30 years or greater than 69 years, but it can be assumed that prevalence of CAD increases with age. In a few cases, patients with ages at the extremes of the decades listed may have probabilities slightly outside the high or low range.

Source: Adapted from Hendel, et al., 2006.

Table 2: Clinical Classification of Chest Pain:

Typical angina (definite):

> 1) Substernal chest discomfort with a characteristic quality and duration that is 2) provoked by exertion or emotional stress and 3) relieved by rest or nitroglycerin

Atypical angina (probable):

> Meets 2 of the above criteria.

Noncardiac chest pain:

> Meets 1 or none of the above criteria.

Source: Snow, et al., 2004.

Table 3: Contraindications to Exercise Stress Testing:

The following contraindications to exercise stress testing are from the AHA/ACC guidelines:

- Acute aortic dissection
- Acute myocardial infarction (within 2 days)
- Acute myocarditis or pericarditis
- Acute pulmonary embolus or pulmonary infarction
- Symptomatic severe aortic stenosis
- Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise
- Uncontrolled symptomatic heart failure

- Unstable angina not previously stabilized by medical therapy.

In addition, exercise stress testing is not useful in persons who are unable to exercise, persons on digoxin, persons who have a cardiac conduction abnormality that prevents achievement of an adequate heart rate response, persons on a medication (e.g., beta blockers, other negative

chronotropic agents) that cannot be stopped which prevent achievement of an adequate heart rate response, and persons with an uninterpretable electrocardiogram. The American College of Cardiology defines an uninterpretable electrocardiogram as a ventricular paced rhythm, complete left bundle branch block, ventricular preexcitation arrhythmia (Wolfe Parkinson White syndrome), or greater than 1 mm ST segment depression at rest.

Table 4: Contraindications to Pharmacologic Stress Testing:

The following are contraindications to adenosine or dipyridamole (Persantine) stress testing:

- Active bronchospasm or reactive airway disease;
- Patients taking Persantine (contraindication to adenosine stress testing);
- Patients using methylxanthines (eg, caffeine and aminophylline) (In general, patients should refrain from ingesting caffeine for at least 24 hours prior to adenosineor dipyridamole administration);
- Severe bradycardia (heart rate less than 40 beats per minute);
- Sick sinus syndrome or greater than than first-degree heart block (in persons without a ventricular-demand pacemaker);
- Systolic blood pressure (SBP) less than 90 mm Hg.

The following are contraindications to *dobutamine* stress testing:

- Atrial tachyarrhythmias with uncontrolled ventricular response;
- History of ventricular tachycardia;
- Left bundle branch block;
- Recent (within the past week) myocardial infarction;
- Significant aortic stenosis or obstructive cardiomyopathy;
- Thoracic aortic aneurysm;
- Uncontrolled hypertension;
- Unstable angina.

CPT Codes / HCPCS Codes / ICD-9 Codes	
CPT codes covered if selection criteria is met:	
75571	
75572	
75573	
75574	
Other CPT codes related to the CPB:	
33250 - 33266	
93015 - 93024	
93556	
93650 - 93652	
HCPCS codes not covered for indications listed in the CPB:	
S8092	Electron beam computed tomography (also known as ultrafast CT, cine CT)

ICD-9 codes covered if selection criteria is met (not all-inclusive):	
424.3	Pulmonary valve disorders [pulmonary outflow obstruction]
446.1	Acute febrile mucocutaneous lymph node syndrome [Kawasaki disease]
745.2	Tetrology of Fallot
747.40 - 747.42	Anomaly of great veins, unspecified, total anomalous pulmonary venous connection, or partial anomalous pulmonary venous connection [anomalous pulmonary venous drainage]
759.82	Marfan syndrome
Other ICD-9 codes related to the CPB:	
391.1	Acute rheumatic endocarditis
394.0 - 394.9	Diseases of mitral valve
395.0 - 395.9	Diseases of aortic valve
396.0 - 396.9	Diseases of mitral and aortic valves
397.0 - 397.9	Diseases of other endocardial structures
414.00 - 414.01, 414.06	Coronary atherosclerosis of unspecified type of vessel, native or graft, of native coronary artery, or native artery of transplanted heart [in persons with low or very low pretest probability of CAD- see criteria] [not covered for extensive calcification by plain film, prior Angston score greater than 1700, or evaluation of stent occlusion, or instent restenosis]
420.90 - 420.99	Other and unspecified acute pericarditis
421.0	Acute and subacute bacterial endocarditis
424.0 - 424.99	Other diseases of endocardium
427.31	Atrial fibrillation [evaluation of pulmonary veins pre- and post ablation] [not covered for persons in atrial fibrillation]
428.0 - 428.9	Heart failure [only for lead placement in persons needing biventricular pacemakers]
745.0 - 747. 9	Congenital heart disease codes [745.8 Other specified defect of septal closure is reported for sinus venosum atrial-septal defect]
786.50 - 786.59	Chest pain [if cannot perform or have contraindications to exercise and pharmacologic stress testing]
794.39	Nonspecific abnormal results of cardiovascular function studies [positive exercise test]
V72.81	Pre-operative cardiovascular examination [for "high-risk" noncardiac surgery where an imaging stress test or invasive coronary angiography is being deferred unless absolutely necessary - see criteria] or [noncoronary cardiac surgeries in lieu of cardiac catheterization as the initial imaging study] [not covered for persons at intermediate or high pretest probability of coronary artery disease, evaluation of stent occlusion, or instent restenosis]

V81.0	Special screening for ischemic heart disease [covered for asymptomatic persons at low pretest probability with equivocal exercise or pharmacological stress test] [not covered for persons at intermediate or high pretest probability of coronary artery disease, evaluation of stent occlusion, or instent restenosis]
V81.2	Special screening for other and unspecified cardiovascular conditions
Other ICD-9 codes related to the CPB (suggestive symptoms for suspected coronary anomalies without other known etiology):	
413.0 - 413.9	Angina pectoris
427.0 - 427.9	Cardiac dysrhythmias [except significant]
779.3	Feeding problems in newborn
780.2	Syncope and collapse
780.8	Hyperhidrosis [diaphoresis]
780.92	Excessive crying of infant (baby)
780.95	Excessive crying of child, adolescent, or adult
782.61	Pallor
783.3	Feeding difficulties and mismanagement
783.41	Failure to thrive
786.06	Tachypnea
786.07	Wheezing
786.09	Other dyspnea and respiratory abnormalities [exertional dyspnea]
799.2	Nervousness [irritability]
ICD-9 codes contraindicated for this CPB (not all-inclusive):	
414.02 - 414.05, 414.07	Coronary atherosclerosis of bypass graft [stent occlusion or instent restenosis]
427.0 - 427.2	Paroxysmal supraventricular tachycardia, paroxysmal ventricular tachycardia, paroxysmal tachycardia, unspecified
427.32	Atrial flutter
427.5	Cardiac arrest
996.72	Other complications due to other cardiac device, implant, and graft [stent occlusion or instent restenosis]
V15.08	Personal history of allergy to radiographic dye [iodinated contrast material]
V85.4	Body mass index 40 and over, adult

The above policy is based on the following references:

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