Regence

Medical Policy Manual Radiology, Policy No. 06

Computed Tomography to Detect Coronary Artery Calcification

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IMPORTANT REMINDER

Medical Policies are developed to provide guidance for members and providers regarding coverage in accordance with contract terms. Benefit determinations are based in all cases on the applicable contract language. To the extent there may be any conflict between the Medical Policy and contract language, the contract language takes precedence.

PLEASE NOTE: Contracts exclude from coverage, among other things, services or procedures that are considered investigational or cosmetic. Providers may bill members for services or procedures that are considered investigational or cosmetic. Providers are encouraged to inform members before rendering such services that the members are likely to be financially responsible for the cost of these services.

DESCRIPTION

CT scan-derived coronary artery calcium (CAC) measures allow the quantification of calcium in coronary arteries and have been used to evaluate coronary atherosclerosis.

MEDICAL POLICY CRITERIA

The use of computed tomography to detect and quantify coronary artery calcification is considered **investigational**.

NOTE: A summary of the supporting rationale for the policy criteria is at the end of the policy.

CROSS REFERENCES

1. Ultrasonographic Measurement of Carotid Artery Intima-Media Thickness as an Assessment of Atherosclerosis, Radiology, Policy No. 37
2. Whole Body CT Screening, Radiology, Policy No. 40
3. Cone Beam Breast Computed Tomography for Breast Cancer Diagnosis, Radiology, Policy No. 59

BACKGROUND

Several types of fast computed tomography (CT) imaging, including but not limited to, electron

beam computed tomography (EBCT), spiral computed tomography, and multi-detector computed tomography (MDCT) have been used to quantify calcium in coronary arteries. A fast CT study for coronary artery calcium is a noninvasive measurement which generally takes 10 to 15 minutes and requires only a few seconds of scanning time.

Coronary calcium is present in coronary atherosclerosis, but the atherosclerosis detected may or may not be causing ischemia or symptoms. Coronary calcium measures may be correlated with the presence of critical coronary stenoses or serve as a measure of the patient's proclivity toward atherosclerosis and future coronary disease. Thus, it could serve as a variable to be used in a risk assessment calculation for the purposes of determining appropriate preventive treatment in asymptomatic patients. Alternatively, in other clinical scenarios, it might help determine whether there is atherosclerotic etiology or a component to the presenting clinical problem in symptomatic patients, thus helping to direct further workup for the clinical problem. In this second scenario, a calcium score of zero usually indicates that the patient's clinical problem is unlikely to be due to atherosclerosis and that other etiologies should be more strongly considered. CAC testing does not determine a specific diagnosis. Most clinical studies have examined the use of coronary calcium for its potential use in estimating the risk of future coronary heart disease (CHD) events.

Coronary calcium levels can be expressed in many ways. The most common method is the Agatston score, which is a weighted summed total of calcified coronary artery area observed on CT. This value can be expressed as an absolute number, commonly ranging from 0 to 400. These values can be translated into age and sex-specific percentile values. Different imaging methods and protocols will produce different values based on the specific algorithm used to create the score.

REGULATORY STATUS

Many models of CT devices have been cleared for marketing by the U.S. Food and Drug Administration (FDA) through the 510(k) process. Marketing clearance via the 510(k) process does not require evidence of clinical efficacy. FDA product code: JAK.

NOTE: This policy does not address the use of contrast-enhanced computed tomography angiography (CCTA) for coronary artery evaluation.

EVIDENCE SUMMARY

This policy addresses the use of CT for CAC scoring in asymptomatic individuals and CAC for evaluating atherosclerotic etiology of disease in symptomatic patients.

Assessment of the proposed uses of CT must fulfill three parameters:

1. Establish technical feasibility, typically assessed with two types of studies, those that compare test measurements with a gold standard and those that compare results taken with the same device on different occasions (test-retest). Normally conducted in the pre-clinical setting, the focus of this parameter is on test reproducibility and establishment of the test protocol.
2. Demonstrate diagnostic performance (sensitivity, specificity, positive and negative predictive values) of the test compared with the gold standard.
3. Evaluate clinical outcomes based on the performance of the test versus the standard of care. While in some cases, new diagnostic tests can be adequately evaluated using

technical and diagnostic performance, when a test identifies a new or different group of patients with a disease, randomized trials are needed to demonstrate the impact of the test on net health outcomes (balance of benefits and harms).

For the evaluation of clinical validity and utility of CAC scoring using CT, this evidence review is focused on large studies that reported on the accuracy of the marketed version of the technology, included a suitable reference standard, and described participant selection criteria and clinical characteristics.

CORONARY ARTERY CALCIUM SCORING IN ASYMPTOMATIC INDIVIDUALS

Clinical Validity

Systematic Reviews

Bell (2022) evaluated the incremental gain of CAC scoring in addition to traditional cardiovascular risk assessments for primary prevention in a systematic review and meta-analysis of cohort studies.[1] Six studies (n=17,961) were included. Mean patient age ranged from 50 to 75.1 years; 38.4% to 59.4% of patients in each study were women and 38% to 100% were white. The C statistic for the traditional CVD risk assessments ranged from 0.693 (95% confidence interval [CI] 0.661 to 0.726) to 0.80. The addition of CAC scoring resulted in a gain of 0.036 (95% CI 0.020 to 0.052). When CAC score reclassified low risk patients to intermediate or high risk, 85.5% to 96.4% of patients did not have a CVD event during follow-up (range 5.1 to 10 years). Of those originally classified as high risk and reclassified as low risk after CAC scoring, 91.4% to 99.2% did not have a CVD event during follow-up. Although the CAC score did add some additional discrimination to traditional CVD risk assessment, the authors cautioned that costs, rates of incidental findings, and radiation risks may offset the benefit.

Sarwar (2009) conducted a systematic review and meta-analysis to examine the prognostic utility of CAC scoring in categorizing asymptomatic patients according to their risk for adverse events.[2] Thirteen studies assessing the relation between CAC and adverse cardiovascular outcomes (n=71,595 asymptomatic patients; 65% men) were included in the analysis. Among the participants, 29,312 (41%) did not have any evidence of CAC (range, 22% to 80% of patients per study). During a mean follow-up of 50 months (range, 32 to 102 months), 154 (0.47%) of 29,312 patients without CAC and 1,749 (4.14%) of 42,283 patients with CAC had cardiovascular events. The pooled relative risk was 0.15 (95% CI 0.11 to 0.21, p<0.001).

Observational Studies

A study published by Blaha (2019) evaluated the risk of all-cause and cardiovascular mortality in the subset of patients from the Coronary Artery Calcium Consortium that had CAC score of 0 (45% of the total 66,363 individuals in the study, mean age 45).[3] After a mean follow-up of 12 years, these patients had very low rates of both all-cause, and CVD mortality (1.38 to 1.62 and 0.32 to 0.43 per 1,000 person-years, respectively). The authors suggested that patients with CAC scores of 0 may be candidates for more flexible treatment goals related to primary prevention.

Takamura (2017) retrospectively evaluated the incremental prognostic value of adding CCTA to plaque findings in 339 asymptomatic patients.[4] Framingham Risk Score (FRS), CAC score, and CT-verified high-risk plaque were the standard predictors of cardiac events investigated; CT-verified high-risk plaque results were based on CCTA findings. Using multivariate Cox

proportional hazard analysis, the authors determined that both CAC score (hazard ratio [HR] 13.23, 95% CI 1.62 to 107.78, p<0.016) and CT-verified high-risk plaque (HR 11.27, 95% CI 1.24 to 102.12, p<0.032) independently predicted cardiac events. Using net reclassification indices (NRI) and integrated discrimination improvement (IDI) reclassification, the authors calculated the improvement in predictive accuracy by adding CT-verified high-risk plaque findings. The NRI was 0.9556 (p<0.001) and IDI was 0.2582 (p<0.020), which suggested that the addition of CT-verified high-risk plaque improved the diagnostic performance of the CAC score and FRS. The retrospective design, inability to follow all patients, inability to clarify patient use of oral medications, small number of cases, and paucity of cardiac events are the limitations of this study.

Ferencik (2017) evaluated whether the distribution of CAC in individual coronary arteries and segments, as well as CAC in the proximal dominant coronary artery, as detected by cardiac CT predicts incident major CHD events independent of traditional CAC score in 1,268 asymptomatic subjects without prevalent major CHD from the offspring and third generation cohorts of the Framingham Heart Study.[5] Results revealed a total of 42 major CHD events occurring during a median follow-up period of 7.4 years. Both the number of coronary arteries with CAC (HR 1.68 per artery, 95% CI 1.10 to 2.57, p=0.02) and the presence of CAC in the proximal dominant coronary artery (HR 2.59, 95% CI 1.15 to 5.83, p=0.02) were associated with major CHD events after multivariable adjustment.

Numerous observational studies have used data available from the Multi-Ethnic Study of Atherosclerosis (MESA) cohort to evaluate CAC in patients asymptomatic for CVD. The MESA cohort of 6,814 asymptomatic men and women 45 to 84 years of age is designed to study the characteristics of subclinical CVD and the risk factors that predict progression to symptomatic CVD. Approximately 38% of the patients in MESA were white, 28% African American, 22% Hispanic, and 12% Asian. Cainzos-Achirica (2020) assessed whether use of CAC improved appropriate aspirin use for primary prevention compared with other risk calculators. In multivariable regression analysis, a CAC score ≥100 was independently associated with an increased risk of CVD events compared with those with a CAC score of 0 (HR 3.9, 95% CI 2.5 to 6.1]. The pooled cohort equations and an estimated cardiovascular risk threshold of >20% failed to identify optimal candidates for aspirin; however, a CAC score of at least 100 was able to identify subgroups of patients where aspirin would yield benefit. Gepner (2017) evaluated CVD, CHD, and stroke or transient ischemic attack (TIA) events to compare the use of CAC with carotid plaque scores to predict CVD events.[6] After 11.3 years of follow-up among 4,955 participants (mean age 61.6 years), 709 CVD, 498 CHD, and 262 stroke/TIA events had occurred. CAC score significantly reclassified non-CVD events (3%, 95% CI 2% to 5%) and CHD events (13%, 95% CI 5% to 18%). Carotid plaque score did not consistently reclassify CVD or CHD events or nonevents. The authors noted that there were limitations in the MESA study and that carotid ultrasound continues to be a noninvasive, inexpensive, radiation free diagnostic tool and therefore potentially more suitable in children and young adults.

Additional analysis of data from the MESA study found that CAC is associated with CHD events among individuals at either high or low CHD risk on the basis of traditional risk factors.[7, 8] Blaha (2016) used data from MESA to demonstrate that CAC scores of 0 were associated with the highest reclassification in cardiovascular risk, compared with other risk markers (e.g., high-sensitivity C-reactive protein [hs-CRP]).[9] Gibson (2014) used data from the MESA study to evaluate the association between CAC and incidence of cerebrovascular events, including all strokes and transient ischemic attacks (TIAs).[10] Over an average of 9.5 years of follow-up, 234 cerebrovascular events occurred (3.5%). Having an elevated CAC was

independently predictive of both cerebrovascular events and stroke (HR 1.70, 95% CI 1.24 to 2.35, p=0.001; HR 1.59, 95% CI 1.11 to 2.07, p=0.01, respectively). Arps (2019) published a modeling study that used data from the MESA study to explore the potential for CAC scoring to identify individuals at high risk for a cardiovascular event that might benefit from prophylactic rivaroxaban treatment.[11] The predicted five-year number needed to treat to avoid such an event was 75 for those with a CAC of 100 to 299 and 45 for those with a CAC above 300.

Nakanishi (2016) conducted a study among 13,092 consecutive asymptomatic individuals without known CAD (mean age 58 years) clinically referred for a CAC scan between 1997 and 2011 at a university medical center; the study examined the predictive value of CAC for five- and 15-year mortality rates among men and women.[12] CAC showed an incremental prognostic value over traditional risk factors among men at five years (area under curve [AUC], 0.702 vs 0.655, p=0.002) as well as at 15 years (AUC 0.723 vs 0.656, p<0.001). In women, the incremental prognostic value of CAC was not statistically significant at five years (AUC 0.650 vs 0.612, p=0.065) but was statistically significant at 15 years (AUC 0.690 vs 0.624, p<0.001). The authors noted study limitations including the fact it was single center and risk factors being self-reported.

Kavousi (2016) reported on the use of CAC for CVD risk stratification among low-risk women.[13] The meta-analysis included data from 6,739 women in five large cohort studies: the Dallas Heart Study, the Framingham Heart Study, the Heinz Nixdorf Recall Study, the Multi-Ethnic Study of Atherosclerosis, and the Rotterdam Study. These women had a 10-year risk of atherosclerotic CVD (ASCVD) below 7.5% and a mean age range of 44 to 63 years. CAC was present in 36.1% of the participants and was associated with an increased risk of ASCVD (4.33 events per 1000 person-years, vs 1.41 events per 1000 person-years in those without CAC). Adding CAC to the traditional risk factors resulted in a small improvement to the C statistic (from 0.73, 95% CI 0.69 to 0.77; to 0.77, 95% CI 0.74 to 0.81) and a net reclassification index of 0.20 (95% CI 0.09 to 0.31). This study did not assess the clinical utility of using CAC for risk stratification.

Many additional studies have reported that CAC scoring is associated with CHD events[14-24] and adds predictive information among asymptomatic subjects, including those with type 2 diabetes.[25-38] Pursnani (2015) used data from the offspring and third-generation cohorts of the Framingham Heart Study, including 2,435 statin-naïve individuals, to evaluate the association of CAC as a predictive factor (beyond typical risk factors) with incident cardiovascular disease (CVD).[39] CAC scores of greater than 100 and greater than 300 were associated with increased risk of cardiac events in both statin eligible and noneligible subjects. Similarly, a study of 1,029 asymptomatic adults with at least one coronary risk factor, Greenland (2004) showed that a calcium score of greater than 300 predicted increased risk of cardiac events within Framingham risk categories.[34] A study by Taylor (2005) examined the association of the FRS and calcium scores in a young military population (mean age 43 years).[25] Although only nine acute coronary events occurred, calcium scores were associated with risk of events while controlling for the risk score. LaMonte (2005) also analyzed the association of calcium scores and CHD events in 10,746 adults.[40] In this study, coronary risk factors were self-reported. During a mean follow-up of 3.5 years, 81 CHD events occurred. Similar to the other studies, the relationship between calcium scores and CHD events remained after adjustment for other risk factors.

The U.S Preventative Services Task Forced (USPSTF) conducted a systematic review and found wide variation was reported in the estimates of the risk ratio for higher calcium scores.[41]

Higher quality studies had lower relative risks for a given difference in calcium score. Limitations of the five studies were the use of proxy measures to control for Framingham risk factors, or recruitment of self-selected participants. USPSTF concluded the following: "Although the eight included studies consistently reported statistically significant relative risks for coronary events with increasing CAC scores, no study uniformly met all three of the following conditions: addressed an intermediate-risk cohort, was population-based or free of selection bias, and appropriately measured or controlled for traditional risk factors."

Clinical Utility

Patel (2021) used data from the MESA study to evaluate the potential clinical utility of CAC scoring to guide the allocation of statin therapy in patients with risk-enhancing factors, but no clinical ASCVD.[42] Risk-enhancing factors in this study included chronic kidney disease, chronic inflammatory conditions, lipid and inflammatory biomarkers, low ankle-brachial index, premature menopause, preeclampsia, and family history of premature ASCVD, as defined by the 2018 AHA/ACC Cholesterol Guideline on the Management of Blood Cholesterol.[43] A total of 1,688 adults at intermediate risk for ASCVD were included in the evaluation, of whom 722 (42.8%) had a CAC score of 0, 532 (31.5%) had a score between 1 and 99, and 434 (25.7%) had a score above 99. The prevalence of CAC among risk-enhancing factor categories did not differ substantially after adjusting for age, with a 45.7% of patients with one to two risk-enhancing factors and 40.3% of patients with three or more factors having a CAC=0. After a median follow-up of 12 years, the unadjusted incidence rate for ASCVD events for all factors or combinations of factors except for ankle-brachial index was less than 7.5 events per 1000 person-years. Low ankle-brachial index was associated with an incidence rate of 10.4 events per 1000 person-years. The authors suggest that CAC scoring in addition to these risk-enhancing factors could have utility in helping to classify which patients should statin therapy.

Ajufo (2020) used data from the Dallas Heart Study to evaluate the potential use of CAC to guide use of aspirin therapy for primary prevention.[44] The Dallas Heart Study is a multi-ethnic population-based cohort study, with deliberate oversampling of African American individuals, that includes 6,101 adults between age 18 and 65. The primary outcomes in the study were first bleeding events or first ASCVD events leading to hospitalization or death. Participant CAC scores were grouped into three categories (0, 1-99, and ≥100) and the effect of aspirin therapy was modeled based on data from a 2019 aspirin meta-analysis[45]. Overall, both bleeding and ASCVD risks increased with CAC scores. For those with CAC scores <100, the risk of bleeding with aspirin outweighed the reduction in risk of ASCVD. There was a potential net benefit of aspirin therapy for individuals with CAC ≥100 with an intermediate 10-year risk of ASCVD (5-20%), or for individuals at high (>20%) 10-year risk of ASCVD regardless of CAC score.

Shreibati (2014) used Medicare claims data to compare clinical outcomes and cardiac testing utilization for patients who had CAC scoring with patients who had high-sensitivity C-reactive protein (hsCRP) testing or lipid screening.[46] The study included 4,184 patients who had CAC who were propensity-score matched to 261,356 patients who had hsCRP and 118,093 patients who had lipid screening. CAC testing was associated with increased rates of noninvasive cardiac testing within 180 days (HR 2.22, 95% CI 1.68 to 2.93, p<0.001 vs hsCRP; HR 4.30, 95% CI 3.04 to 6.06, p<0.001 vs lipid screening). It was also associated with increased rates of coronary angiography (HR 3.54, 95% CI 1.91 to 6.55, p<0.001 vs. hsCRP; HR 4.23, 95% CI 2.31 to 7.74, p<0.001). Overall rates of the composite outcome of death, myocardial infarction, or stroke were low, but event-free survival was higher in patients who underwent CAC compared with those who had hsCRP (94.4% vs 92.7%, p=0.008).

A number of studies have evaluated whether the use of CAC in asymptomatic patients is associated with subsequent behavioral change; particularly related to risk factor reduction or medication adherence. Gupta (2017) performed a systematic review and meta-analysis evaluating the odds of initiating or continuing pharmacological (i.e., aspirin, lipid-lowering, and blood pressure lowering medications) and lifestyle preventive therapies in asymptomatic CAD patients with nonzero versus 0 CAC scores as detected on cardiac CT.[47] Results revealed that the odds of aspirin, lipid-lowering, and blood pressure lowering medication initiation, lipid-lowering medication continuation, an increase in exercise, and dietary changes were significantly higher in patients with nonzero CAC versus 0 CAC scores. However, the odds of aspirin or blood pressure-lowering medication continuation were not significantly increased in the nonzero CAC group. Statistical heterogeneity was present across studies for many of the outcomes; potential sources of heterogeneity included variations in sample size and the proportion of patients with 0 versus nonzero CAC, whether patients were shown their CAC scan, and differences in clinical characteristics of study populations.

Mamudu (2014) conducted a systematic review of studies evaluating the effects of CAC screening on behavioral modification, risk perception, and medication adherence in asymptomatic adults, which included 15 studies, three RCTs, and 12 observational studies.[48] The review primarily provided descriptive results of the studies given the lack of standardization across studies in terms of CAC measures and outcome variables. Thirteen of the 15 studies, including two of the RCTs, reported increased medication adherence in CAC-screened patients. An example of one of the observational studies included in the Mamudu (2014) review was reported by Johnson (2014), who assessed the association between CAC score and subsequent health behavior change.[49] The study included a convenience sample of 174 adults with CHD risk factors who underwent CAC scoring. The authors found no significant change in risk perception measured by the Perception of Risk of Heart Disease Scale scores between groups (CAC score, 0, 1 to 10, 11 to 100, 101 to 400, and greater than 400), with the exception of a small increase in the moderate-risk group (CAC score 101-400) from 55.5 to 58.7 ($p=0.004$). All groups demonstrated increases in health-promoting behavior over time.

Wheaton (2012) published a meta-analysis of RCTs that evaluated the impact of coronary calcium scores on cardiac risk profiles and cardiac procedures.[50] There were four trials identified with a total of 2,490 participants; the individual trials ranged in size from 50 to 1934 patients. The authors pooled data from four trials on the impact of calcium scores on blood pressure, three on the impact on low-density lipoprotein, and two on the impact on high-density lipoprotein. Pooled analysis did not show a significant change in any of these parameters as a result of calcium scores. Similarly, in four studies that looked at the rates of smoking cessation following calcium scores, there was not significant change found. There were two studies that included rates of coronary angiography and two studies that included rates of revascularization. Pooled analysis of these studies did not show a significant change following measurement of coronary calcium. One of these studies, by O'Malley (2003), randomized 450 subjects to receive EBCT, or not, and assessed outcomes one year later for change in FRS.[51] Thus, EBCT was used as a guide to refine risk in patients and possibly provide motivation for behavioral change. The study was not powered for clinical end points. EBCT did not produce any benefits in terms of a difference in Framingham risk score at one year.

Whelton (2012) evaluated the impact of CT scanning for CAC on cardiac risk factors.[50] A total of 2,137 healthy subjects were randomized to CT scanning or no CT scanning and followed for four years. At baseline, both groups received one session of risk factor counseling by a nurse practitioner. The primary outcome was change in 12 different cardiac risk profile measures,

including blood pressure, lipid and glucose levels, weight, exercise, and FRS. At the four-year follow-up, there was differential dropout among the groups, with 88.2% of follow-up in the scan group versus 81.9% in the no-scan group. Results demonstrated differences in four of the 12 risk factor measurements between groups: systolic blood pressure, low-density lipoprotein, waist circumference, and mean FRS. This trial highlights the potential benefit of CAC screening in modifying cardiac risk profile but is not definitive in demonstrating improved outcomes. Limitations of this study include different intensity of interventions between groups and differential dropout rates. It is possible that the small differences reported in the trial were the result of bias from these methodologic limitations. In addition, this trial does not compare the impact of other types of risk factor intervention, most notably more intensive risk factor counseling. Finally, the generalizability of the findings is uncertain given that this was a volunteer population that may have been highly motivated for change.

Section Summary

For individuals who are asymptomatic with risk of CAD who receive CAC scoring, the evidence includes systematic reviews, RCTs, and nonrandomized studies. There is evidence on the predictive value of CAC score screening for cardiovascular disease among asymptomatic patients that demonstrates scanning can predict risk of CAD. However, evidence from high quality studies that demonstrate the use of CAC score measurement in clinical practice leads to changes in patient management or changes in individual risk behaviors that improve cardiac outcomes is lacking. The evidence is insufficient to determine the effects of the technology on health outcomes.

CORONARY ARTERY CALCIUM FOR EVALUATING ATHEROSCLEROTIC ETIOLOGY OF DISEASE IN SYMPTOMATIC PATIENTS

In certain clinical situations, such as patients presenting with chest pain or other symptoms, it is uncertain whether the symptoms are potentially due to CHD. Coronary calcium measurement has been proposed as a method that can rule out CHD in certain patients if the coronary calcium value is zero. Because coronary disease can only very rarely occur in the absence of coronary calcium, the presence of any coronary calcium can be a sensitive, but not specific, test for coronary disease. False positives occur because the calcium may not be causing ischemia or symptoms. The absence of any coronary calcium can be a specific test for the absence of coronary disease and direct the diagnostic workup toward other causes of the patient’s symptoms. In this context, coronary calcium measurement is not used to make a positive diagnosis of any kind but as a diagnostic tool to rule out an atherosclerotic cause for the patient’s symptoms.

Lo-Kioeng-Shioe (2019) conducted a systematic review and meta-analysis of 19 observational studies (n=34,041) to assess the ability of CAC to predict risk of MACE, defined as the composite of late cardiac revascularization, hospitalization for unstable angina pectoris or heart failure, nonfatal myocardial infarction, and cardiac death or all-cause mortality) in stable patients with suspected CAD.[52] Of 1,601 cardiovascular events, 158 occurred in patients with a CAC score of 0. The pooled risk ratio for MACE in patients with CAC >0 was 5.71 (95% CI 3.98 to 8.19), and risk increased with increasing levels of CAC. The pooled relative risk for incidence of all-cause mortality or nonfatal myocardial infarction was 3.64 (95% CI 2.68 to 4.96).

Chaikriangkrai (2016) published a systematic review that evaluated the use of CAC scoring in patients without known CAD presenting in the emergency department with acute chest pain.[53]

The review included eight longitudinal studies with a total of 3,556 patients and a median follow-up of 10.5 months. After pooling the studies for meta-analysis, the authors found that the prevalence of CACS of 0 was 60%, and that major adverse cardiovascular event (MACE) rates for individuals with CACS of 0 were significantly lower than for those with CACS greater than 0 (MACE 0.8% per year and death or myocardial infarction 0.5% per year, vs MACE 14.6% per year; death or myocardial infarction 3.5% per year, respectively. The authors conclude that initial testing with CACS could prevent further cardiac testing and unnecessary hospitalizations in those with a CACS of 0. A limitation of this meta-analysis is that the included populations do not represent all patients with acute chest pain presenting to the emergency department, as the studies all enrolled hemodynamically stable patients without ischemic ECG changes or increased cardiac markers. Additionally, several included studies were performed more than 15 years ago, and likely reflect temporal differences in treatment standards.

Studies that were not reported in the reviews above include a study by Mortensen (2021) that used data from the Western Denmark Heart Registry to evaluate the diagnostic value of a CAD score of 0.[54] Out of a total of 23,759 symptomatic patients who underwent computed tomography angiography (CTA), 12,771 (54%) had a CAC score of 0 and were included in the analysis. The median age of these patients was 58 (49-65) years, and 55% were women. The prevalence of obstructive CAD ranged from 3% in patients below age 40 to 8% in those older than 70. The added diagnostic value of a CAC score of 0 increased with age.

A prospective study by Yerramasu (2014) assessed an evaluation algorithm including CAC scoring for patients presenting to a rapid access chest pain clinic with stable chest pain possibly consistent with CHD.[55] Three hundred patients presenting with acute chest pain to one of three chest pain clinics underwent CAC scoring. If the CAC score was 1000 or more Agatston units, invasive coronary angiography (ICA) was performed, and if the CAC score was less than 1000, CTA was performed. All patients with a CAC of zero and low pretest likelihood of CHD had no obstructive CHD on CTA and were event-free during follow-up. Of the 18 patients with CAC score from 400 to 1000, 17 (94%) had greater than 50% obstruction on subsequent CTA and were referred for further evaluation, 14 (78%) of whom had obstructive CHD. Of 15 patients with CAC score 1000 or more and who were referred for coronary angiography, obstructive CHD was present in 13 (87%). This study suggests that CAC can be used in the acute chest pain setting to stratify decision making for further testing.

Williams (2015) assessed results from 210 CCTA from the Scottish Computed Tomography of the Heart (SCOT-HEART) trial to examine intraobserver and interobserver variability in determining CAC score.[56] Patients in the SCOT-HEART trial were attending the rapid access chest pain clinic. There were no differences in Agatston calcium score on intraobserver assessment (373, 95% CI 224 to 505 Agatston units vs 278, 95% CI 202 to 354 Agatston units, p=0.138) or interobserver assessment (290, 95% CI 210 to 370] Agatston units; p=0.191). The authors used Bland-Altman plots to examine intraobserver and interobserver agreement. Excellent intraobserver and interobserver agreement was identified for CAC scores below 1000.

Korley (2015) reported a pilot study describing a diagnostic strategy of low high-sensitivity troponin I (hsTnI) and CAC to identify individuals at low risk of CAD presenting with suspected ACS, and in whom CCTA could be avoided.[57] The authors report on 314 patients presented to an ED with suspected ACS. A strategy of avoiding any further testing in patients with an undetectable hsTnI but obtaining CAC in patients with detectable but non-increased hsTnI and

CCTA in subjects with Agatston greater than 0 has NPV of 100.0% (95% CI 98.2% to 100%) for significant CAD.

Lubbers (2016) compared CAC scoring to functional testing in the CRESCENT trial, which randomized 350 patients with suspected coronary artery disease at four Dutch hospitals.[58] There were 242 patients randomized to a tiered cardiac CT approach, and 108 patients randomized to standard care based on functional testing. The CT approach began with determination of a CAC score. Patients with a score of 1 to 400 then underwent CT angiography, while patients with a CAC score greater than 400 or an indeterminant CT angiogram underwent functional testing or invasive angiography. The functional test strategy involved exercise ECG testing and/or myocardial perfusion or stress echocardiography. After one year, fewer patients in the CT group reported angina than in the functional testing group (25% vs 39%), but the proportion of patients with similar or worsened symptoms were not significantly different. Event-free survival at 1.2 years was greater in the CT group as well. Interpretation of these results is limited by differing loss to follow-up between the two groups (22% for those in the functional testing group vs 14% in the CT group) and lack of long-term follow-up.

Ten Kate (2013) conducted a prospective study to evaluate the accuracy of cardiac CT, including CAC scoring with or without CTA, in distinguishing heart failure due to CAD from heart failure due to non-CAD causes.[59] Data on the predictive ability of a negative CAC in ruling out CAD was also included. The study included 93 symptomatic patients with newly diagnosed heart failure of unknown etiology, all of whom underwent CAC scoring. Those with a CAC score of greater than zero underwent CCTA, and if the CCTA was positive for CAD (>20% luminal diameter narrowing), ICA was recommended. Forty-six percent of patients had a CAC score of zero. At follow-up of mean duration 20 months, no patient with a CAC score of zero had a myocardial infarction, underwent percutaneous coronary intervention, had a coronary artery bypass graft, or had signs of CAD.

Dharampal (2013) retrospectively evaluated a cohort of 1,975 symptomatic patients who underwent clinical evaluation and CAC scoring and CCTA or ICA.[60] The primary outcome was obstructive CAD (≥50% stenosis) on ICA or CCTA (if ICA was not done). The authors evaluated the net reclassification improvement with the addition of CAC score to a clinical prediction model for patients who had an intermediate probability of CHD (10%to 90%) after clinical evaluation based on chest pain characteristic, age, sex, risk factors, and electrocardiogram. Discrimination of CAD was significantly improved by adding the CAC score to the clinical evaluation (area under the curve, 0.80 vs 0.89, p<0.001).

Section Summary

A number of studies suggest that CAC scoring could be used to rule in or rule out CHD, particularly regarding decisions about further invasive imaging. However, relatively few studies have employed a prospective design. Moreover, studies need to be conducted to address some of the potential barriers to such an approach, including whether performing CAC scoring in symptomatic patients delays diagnosis or intervention and whether the net effect of CAC scoring is to increase or decrease invasive testing.

PRACTICE GUIDELINE SUMMARY

U.S. PREVENTIVE SERVICES TASK FORCE (USPSTF)

The U.S. Preventive Services Task Force (2018) updated its recommendations on the use of nontraditional or novel risk factors in assessing coronary heart disease risk in asymptomatic persons.[61] Calcium score was one of three nontraditional risk factors considered. Reviewers concluded that the current evidence was insufficient to assess the balance of benefits and harms of adding any of the nontraditional risk factors studied to traditional risk assessment for cardiovascular disease in asymptomatic persons.

AMERICAN COLLEGE OF CARDIOLOGY (ACC) AND THE AMERICAN HEART ASSOCIATION (AHA)

The AHA/ACC (2019) issued a special report on the use of risk assessment tools to guide decision-making in the primary prevention of atherosclerotic CVD (ASCVD).[62] The guidelines include an algorithm of clinical approaches to incorporate CAC measurement in risk assessment for borderline- and intermediate-risk patients:

> "For borderline-risk (10-year risk 5% to <7.5%) and intermediate-risk (7.5% to <20%) patients who are undecided regarding statin therapy, or when there is clinical uncertainty regarding the net benefit, consider the value of additional testing with measurement of CAC. If CAC is measured, interpret results as follows:
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> a. CAC score of 0 indicates that a borderline- or intermediate-risk individual is reclassified to a 10-y event rate lower than predicted, and below the threshold for benefit from a statin. Consider avoiding or postponing statin therapy unless there is a strong family history of premature ASCVD, history of diabetes mellitus, or heavy cigarette smoking. Consider repeat CAC measurement in 5 years if patient remains at borderline or intermediate risk.
>
> b. CAC score 1 to 99 and <75th percentile for age/sex/race/ethnicity indicates that there is subclinical atherosclerosis present. This may be sufficient information to consider initiating statin therapy, especially in younger individuals, but does not indicate substantial reclassification of the 10-y risk estimate. Consider patient preferences and, if statin decision is postponed, consider repeat CAC scoring in 5 years.
>
> c. CAC score 100 or >75th percentile for age/sex/race/ethnicity indicates that the individual is reclassified to a higher event rate than predicted, that is above the threshold for statin benefit. Statin therapy is more likely to provide benefit for such patients."

The ACC/AHA (2018) Clinical Practice Guidelines on the Management of Blood Cholesterol state, "When risk status is uncertain, a CAC score is an option to facilitate decision-making in adults 40 to 75 years of age."[43] The guidelines further note, "One purpose of CAC scoring is to reclassify risk identification of patients who will potentially benefit from statin therapy. This is especially useful when the clinician and patient are uncertain whether to start a statin. Indeed, the most important recent observation has been the finding that a CAC score of 0 indicates a low ASCVD risk for the subsequent 10 years. Thus, measurement of CAC potentially allows a clinician to withhold statin therapy in patients showing 0 CAC."

With regard to the prognostic significance of CAC, the guideline "makes use of the available data to predict the risk associated with CAC."[43] The guideline notes that "these data need to be amplified by new and ongoing studies to guide treatment decisions" and that "particular uncertainty exists about the predictive value of intermediate CAC scores." Additionally, there

are concerns regarding the predictive significance of a CAC score of 0, which must be further verified in follow-up studies. For patients with a 0 score, "it is currently uncertain when and if follow-up CAC measurements should be done to reassess risk status."

The ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease (2019) is in line with the blood cholesterol guideline stating that adults (40 to 75 years of age) who are being evaluated for cardiovascular disease prevention should initially undergo 10-year atherosclerotic cardiovascular disease (ASCVD) risk estimation with a clinician-patient risk discussion before starting pharmacological therapy.4[63] The guideline also notes that assessing for other risk-enhancing factors can help guide decision making "about preventive interventions in select individuals, as can CAC scanning." The guideline specifically states the following recommendation regarding assessment of cardiovascular risk and CAC:

> "In adults at intermediate risk (≥7.5% to < 20% 10-year ASCVD risk) or selected adults at borderline risk (5% to <7.5% 10-year ASCVD risk), if risk-based decisions for preventive interventions remain uncertain, it is reasonable to measure a CAC score to guide clinician-patient risk discussion [Class (Strength) of Recommendation: IIa; Level (Quality) of Evidence: B-NR]. A IIa class of recommendation is of moderate strength based on moderate quality nonrandomized studies."

The AHA/ACC (2021) Guideline on Evaluation and Diagnosis of Chest Pain includes a recommendation for CAC as first-line testing in patients with stable chest pain with no known coronary artery disease and low likelihood of obstruction.[64] The guidelines recommend the addition of CAC may also be useful for intermediate-high risk patients with stable chest pain and no known coronary artery disease undergoing stress testing.

ACC/AHA/AATS/PCNA/SCAI/STS

In 2012, ACC/AHA/AATS/PCNA/SCAI/STS published guidelines for the diagnosis and management of patients with stable ischemic heart disease that include some recommendations related to CAC scoring[65]:

- Class IIb recommendation: For patients with a low to intermediate pretest probability of obstructive IHD, noncontrast cardiac computed tomography to determine the coronary artery calcium score may be considered. (Level of Evidence: C)

Level C evidence is defined as: For certain conditions for which inadequate data are available, recommendations are based on expert consensus and clinical experience.

In 2014 ACC/AHA/AATS/PCNA/SCAI/STS issued a focused update to the 2012 guideline on the diagnosis and management of patients with stable ischemic heart disease with no additional recommendations related to CAC scoring.[66]

AMERICAN COLLEGE OF PREVENTIVE MEDICINE (ACPM)

The 2011 ACPM position statement on ASCVD screening in adults states that the ACPM does not recommend routine screening, including EBCT, of the general adult population.[67] The statement also notes a lack of evidence that coronary calcium scores improve the prediction of CHD in populations at intermediate risk, stating that more population-based studies are needed in the intermediate risk population.

SUMMARY

It appears that coronary artery calcium (CAC) score may improve cardiovascular disease risk prediction for some people. More research is needed to know for sure. Therefore, the use of computed tomography to detect and quantify coronary artery calcification is considered investigational.

REFERENCES

1. Bell KJL, White S, Hassan O, et al. Evaluation of the Incremental Value of a Coronary Artery Calcium Score Beyond Traditional Cardiovascular Risk Assessment: A Systematic Review and Meta-analysis. *JAMA Intern Med.* 2022;182(6):634-42. PMID: 35467692
2. Sarwar A, Shaw LJ, Shapiro MD, et al. Diagnostic and prognostic value of absence of coronary artery calcification. *JACC Cardiovascular imaging.* 2009;2(6):675-88. PMID: 19520336
3. Blaha MJ, Cainzos-Achirica M, Dardari Z, et al. All-cause and cause-specific mortality in individuals with zero and minimal coronary artery calcium: A long-term, competing risk analysis in the Coronary Artery Calcium Consortium. *Atherosclerosis.* 2019. PMID: 31784032
4. Takamura K, Fujimoto S, Kondo T, et al. Incremental Prognostic Value of Coronary Computed Tomography Angiography: High-Risk Plaque Characteristics in Asymptomatic Patients. *Journal of atherosclerosis and thrombosis.* 2017;24(11):1174-85. PMID: 28674321
5. Ferencik M, Pencina KM, Liu T, et al. Coronary Artery Calcium Distribution Is an Independent Predictor of Incident Major Coronary Heart Disease Events: Results From the Framingham Heart Study. *Circulation Cardiovascular imaging.* 2017;10(10). PMID: 28956774
6. Gepner AD, Young R, Delaney JA, et al. Comparison of carotid plaque score and coronary artery calcium score for predicting cardiovascular disease events: the multi-ethnic study of atherosclerosis. *Journal of the American Heart Association.* 2017;6(2). PMID: 28196817
7. Silverman MG, Blaha MJ, Krumholz HM, et al. Impact of coronary artery calcium on coronary heart disease events in individuals at the extremes of traditional risk factor burden: the Multi-Ethnic Study of Atherosclerosis. *Eur Heart J.* 2014;35:2232-41. PMID: 24366919
8. Budoff MJ, Mohlenkamp S, McClelland R, et al. A comparison of outcomes with coronary artery calcium scanning in unselected populations: the Multi-Ethnic Study of Atherosclerosis (MESA) and Heinz Nixdorf RECALL study (HNR). *Journal of cardiovascular computed tomography.* 2013;7(3):182-91. PMID: 23849491
9. Blaha MJ, Cainzos-Achirica M, Greenland P, et al. Role of Coronary Artery Calcium Score of Zero and Other Negative Risk Markers for Cardiovascular Disease: The Multi-Ethnic Study of Atherosclerosis (MESA). *Circulation.* 2016;133(9):849-58. PMID: 26801055
10. Gibson AO, Blaha MJ, Arnan MK, et al. Coronary artery calcium and incident cerebrovascular events in an asymptomatic cohort. The MESA Study. *JACC Cardiovascular imaging.* 2014;7(11):1108-15. PMID: 25459592

11. Arps K, Rifai MA, Blaha MJ, et al. Usefulness of Coronary Artery Calcium to Identify Adults of Sufficiently High Risk for Atherothrombotic Cardiovascular Events to Consider Low-Dose Rivaroxaban Thromboprophylaxis (from MESA). *The American journal of cardiology.* 2019;124(8):1198-206. PMID: 31416591
12. Nakanishi R, Li D, Blaha MJ, et al. All-cause mortality by age and gender based on coronary artery calcium scores. *European heart journal cardiovascular Imaging.* 2016;17(11):1305-14. PMID: 26705490
13. Kavousi M, Desai CS, Ayers C, et al. Prevalence and Prognostic Implications of Coronary Artery Calcification in Low-Risk Women: A Meta-analysis. *JAMA.* 2016. PMID: 27846641
14. Elkeles RS, Godsland IF, Feher MD, et al. Coronary calcium measurement improves prediction of cardiovascular events in asymptomatic patients with type 2 diabetes: the PREDICT study. *Eur Heart J.* 2008;29(18):2244-51. PMID: 18573867
15. Lakoski SG, Greenland P, Wong ND, et al. Coronary artery calcium scores and risk for cardiovascular events in women classified as "low risk" based on Framingham risk score: the multi-ethnic study of atherosclerosis (MESA). *Arch Intern Med.* 2007;167(22):2437-42. PMID: 18071165
16. Martin SS, Blaha MJ, Blankstein R, et al. Dyslipidemia, coronary artery calcium, and incident atherosclerotic cardiovascular disease: implications for statin therapy from the multi-ethnic study of atherosclerosis. *Circulation.* 2014;129:77-86. PMID: 24141324
17. Miedema MD, Duprez DA, Misialek JR, et al. Use of coronary artery calcium testing to guide aspirin utilization for primary prevention: estimates from the multi-ethnic study of atherosclerosis. *Circulation Cardiovascular quality and outcomes.* 2014;7:453-60. PMID: 24803472
18. Hou ZH, Lu B, Gao Y, et al. Prognostic value of coronary CT angiography and calcium score for major adverse cardiac events in outpatients. *JACC Cardiovascular imaging.* 2012;5(10):990-9. PMID: 23058065
19. Bischoff B, Kantert C, Meyer T, et al. Cardiovascular risk assessment based on the quantification of coronary calcium in contrast-enhanced coronary computed tomography angiography. *European heart journal cardiovascular Imaging.* 2012;13:468-75. PMID: 22166591
20. Meyer M, Henzler T, Fink C, et al. Impact of coronary calcium score on the prevalence of coronary artery stenosis on dual source CT coronary angiography in caucasian patients with an intermediate risk. *Academic radiology.* 2012;19(11):1316-23. PMID: 22897947
21. Petretta M, Daniele S, Acampa W, et al. Prognostic value of coronary artery calcium score and coronary CT angiography in patients with intermediate risk of coronary artery disease. *The international journal of cardiovascular imaging.* 2012;28(6):1547-56. PMID: 21922205
22. Kim KH, Jeon KN, Kang MG, et al. Prognostic value of computed tomographic coronary angiography and exercise electrocardiography for cardiovascular events. *The Korean journal of internal medicine.* 2016;31(5):880-90. PMID: 27017387
23. Halon DA, Azencot M, Rubinshtein R, et al. Coronary Computed Tomography (CT) Angiography as a Predictor of Cardiac and Noncardiac Vascular Events in Asymptomatic Type 2 Diabetics: A 7-Year Population-Based Cohort Study. *Journal of the American Heart Association.* 2016;5(6). PMID: 27412899
24. Lei MH, Wu YL, Chung SL, et al. Coronary Artery Calcium Score Predicts Long-Term Cardiovascular Outcomes in Asymptomatic Patients with Type 2 Diabetes. *Journal of atherosclerosis and thrombosis.* 2021;28(10):1052-62. PMID: 33162430

25. Taylor AJ, Bindeman J, Feuerstein I, et al. Coronary calcium independently predicts incident premature coronary heart disease over measured cardiovascular risk factors: mean three-year outcomes in the Prospective Army Coronary Calcium (PACC) project. *J Am Coll Cardiol.* 2005;46(5):807-14. PMID: 16139129
26. Erbel R, Mohlenkamp S, Moebus S, et al. Coronary risk stratification, discrimination, and reclassification improvement based on quantification of subclinical coronary atherosclerosis: the Heinz Nixdorf Recall study. *J Am Coll Cardiol.* 2010;56:1397-406. PMID: 20946997
27. Detrano R, Guerci AD, Carr JJ, et al. Coronary calcium as a predictor of coronary events in four racial or ethnic groups. *N Engl J Med.* 2008;358:1336-45. PMID: 18367736
28. Polonsky TS, McClelland RL, Jorgensen NW, et al. Coronary artery calcium score and risk classification for coronary heart disease prediction. *JAMA.* 2010;303(16):1610-6. PMID: 20424251
29. Yeboah J, McClelland RL, Polonsky TS, et al. Comparison of novel risk markers for improvement in cardiovascular risk assessment in intermediate-risk individuals. *JAMA.* 2012;308:788-95. PMID: 22910756
30. Budoff MJ, Shaw LJ, Liu ST, et al. Long-term prognosis associated with coronary calcification: observations from a registry of 25,253 patients. *J Am Coll Cardiol.* 2007;49(18):1860-70. PMID: 17481445
31. Paixao AR, Ayers CR, El Sabbagh A, et al. Coronary Artery Calcium Improves Risk Classification in Younger Populations. *JACC Cardiovascular imaging.* 2015;8(11):1285-93. PMID: 26476504
32. Elias-Smale SE, Proenca RV, Koller MT, et al. Coronary calcium score improves classification of coronary heart disease risk in the elderly: the Rotterdam study. *J Am Coll Cardiol.* 2010;56:1407-14. PMID: 20946998
33. McClelland RL, Jorgensen NW, Budoff M, et al. 10-Year Coronary Heart Disease Risk Prediction Using Coronary Artery Calcium and Traditional Risk Factors: Derivation in the MESA (Multi-Ethnic Study of Atherosclerosis) With Validation in the HNR (Heinz Nixdorf Recall) Study and the DHS (Dallas Heart Study). *J Am Coll Cardiol.* 2015;66(15):1643-53. PMID: 26449133
34. Greenland P, LaBree L, Azen SP, et al. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals. *JAMA.* 2004;291(2):210-5. PMID: 14722147
35. Arad Y, Goodman KJ, Roth M, et al. Coronary calcification, coronary disease risk factors, C-reactive protein, and atherosclerotic cardiovascular disease events: the St. Francis Heart Study. *J Am Coll Cardiol.* 2005;46(1):158-65. PMID: 15992651
36. Grandhi GR, Mirbolouk M, Dardari ZA, et al. Interplay of Coronary Artery Calcium and Risk Factors for Predicting CVD/CHD Mortality: The CAC Consortium. *JACC Cardiovascular imaging.* 2019. PMID: 31734198
37. Chang SM, Nabi F, Xu J, et al. Value of CACS compared with ETT and myocardial perfusion imaging for predicting long-term cardiac outcome in asymptomatic and symptomatic patients at low risk for coronary disease: clinical implications in a multimodality imaging world. *JACC Cardiovascular imaging.* 2015;8(2):134-44. PMID: 25677886
38. Lee KY, Hwang BH, Kim TH, et al. Computed Tomography Angiography Images of Coronary Artery Stenosis Provide a Better Prediction of Risk Than Traditional Risk Factors in Asymptomatic Individuals With Type 2 Diabetes: A Long-term Study of Clinical Outcomes. *Diabetes care.* 2017;40(9):1241-48. PMID: 28663384

39. Pursnani A, Massaro JM, D'Agostino RB, Sr., et al. Guideline-Based Statin Eligibility, Coronary Artery Calcification, and Cardiovascular Events. *JAMA.* 2015;314(2):134-41. PMID: 26172893
40. LaMonte MJ, FitzGerald SJ, Church TS, et al. Coronary artery calcium score and coronary heart disease events in a large cohort of asymptomatic men and women. *Am J Epidemiol.* 2005;162(5):421-9. PMID: 16076829
41. Helfand M, Buckley DI, Freeman M, et al. Emerging risk factors for coronary heart disease: a summary of systematic reviews conducted for the U.S. Preventive Services Task Force. *Ann Intern Med.* 2009;151(7):496-507. PMID: 19805772
42. Patel J, Pallazola VA, Dudum R, et al. Assessment of Coronary Artery Calcium Scoring to Guide Statin Therapy Allocation According to Risk-Enhancing Factors: The Multi-Ethnic Study of Atherosclerosis. *JAMA cardiology.* 2021;6(10):1161-70. PMID: 34259820
43. Grundy SM, Stone NJ, Bailey AL, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA Guideline on the Management of Blood Cholesterol: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation.* 2019;139(25):e1082-e143. PMID: 30586774
44. Ajufo E, Ayers CR, Vigen R, et al. Value of Coronary Artery Calcium Scanning in Association With the Net Benefit of Aspirin in Primary Prevention of Atherosclerotic Cardiovascular Disease. *JAMA cardiology.* 2020. PMID: 33112372
45. Zheng SL, Roddick AJ. Association of Aspirin Use for Primary Prevention With Cardiovascular Events and Bleeding Events: A Systematic Review and Meta-analysis. *JAMA.* 2019;321(3):277-87. PMID: 30667501
46. Shreibati JB, Baker LC, McConnell MV, et al. Outcomes after coronary artery calcium and other cardiovascular biomarker testing among asymptomatic medicare beneficiaries. *Circulation Cardiovascular imaging.* 2014;7:655-62. PMID: 24777939
47. Gupta A, Lau E, Varshney R, et al. The Identification of Calcified Coronary Plaque Is Associated With Initiation and Continuation of Pharmacological and Lifestyle Preventive Therapies: A Systematic Review and Meta-Analysis. *JACC Cardiovascular imaging.* 2017;10(8):833-42. PMID: 28797402
48. Mamudu HM, Paul TK, Veeranki SP, et al. The effects of coronary artery calcium screening on behavioral modification, risk perception, and medication adherence among asymptomatic adults: a systematic review. *Atherosclerosis.* 2014;236(2):338-50. PMID: 25128971
49. Johnson JE, Gulanick M, Penckofer S, et al. Does Knowledge of Coronary Artery Calcium Affect Cardiovascular Risk Perception, Likelihood of Taking Action, and Health-Promoting Behavior Change? *The Journal of cardiovascular nursing.* 2014. PMID: 24434820
50. Whelton SP, Nasir K, Blaha MJ, et al. Coronary artery calcium and primary prevention risk assessment: what is the evidence? An updated meta-analysis on patient and physician behavior. *Circulation Cardiovascular quality and outcomes.* 2012;5(4):601-7. PMID: 22811506
51. O'Malley PG, Feuerstein IM, Taylor AJ. Impact of electron beam tomography, with or without case management, on motivation, behavioral change, and cardiovascular risk profile: a randomized controlled trial. *JAMA.* 2003;289(17):2215-23. PMID: 12734132
52. Lo-Kioeng-Shioe MS, Rijlaarsdam-Hermsen D, van Domburg RT, et al. Prognostic value of coronary artery calcium score in symptomatic individuals: A meta-analysis of 34,000 subjects. *International journal of cardiology.* 2020;299:56-62. PMID: 31229262

53. Chaikriangkrai K, Palamaner Subash Shantha G, Jhun HY, et al. Prognostic Value of Coronary Artery Calcium Score in Acute Chest Pain Patients Without Known Coronary Artery Disease: Systematic Review and Meta-analysis. *Annals of emergency medicine.* 2016. PMID: 27765299
54. Mortensen MB, Gaur S, Frimmer A, et al. Association of Age With the Diagnostic Value of Coronary Artery Calcium Score for Ruling Out Coronary Stenosis in Symptomatic Patients. *JAMA cardiology.* 2021. PMID: 34705022
55. Yerramasu A, Lahiri A, Venuraju S, et al. Diagnostic role of coronary calcium scoring in the rapid access chest pain clinic: prospective evaluation of NICE guidance. *European heart journal cardiovascular Imaging.* 2014;15:886-92. PMID: 24513880
56. Williams MC, Golay SK, Hunter A, et al. Observer variability in the assessment of CT coronary angiography and coronary artery calcium score: substudy of the Scottish COmputed Tomography of the HEART (SCOT-HEART) trial. *Open Heart.* 2015;2(1):e000234. PMID: 26019881
57. Korley FK, George RT, Jaffe AS, et al. Low high-sensitivity troponin I and zero coronary artery calcium score identifies coronary CT angiography candidates in whom further testing could be avoided. *Academic radiology.* 2015;22(8):1060-7. PMID: 26049777
58. Lubbers M, Dedic A, Coenen A, et al. Calcium imaging and selective computed tomography angiography in comparison to functional testing for suspected coronary artery disease: the multicentre, randomized CRESCENT trial. *Eur Heart J.* 2016;37(15):1232-43. PMID: 26746631
59. ten Kate GJ, Caliskan K, Dedic A, et al. Computed tomography coronary imaging as a gatekeeper for invasive coronary angiography in patients with newly diagnosed heart failure of unknown aetiology. *Eur J Heart Fail.* 2013;15:1028-34. PMID: 23759285
60. Dharampal AS, Rossi A, Dedic A, et al. Restriction of the referral of patients with stable angina for CT coronary angiography by clinical evaluation and calcium score: impact on clinical decision making. *European radiology.* 2013;23(10):2676-86. PMID: 23774892
61. U.S. Preventive Services Task Force. Cardiovascular Disease: Risk Assessment With Nontraditional Risk Factors. 2018. [cited 12/27/2024]. 'Available from:' https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/cardiovascular-disease-screening-using-nontraditional-risk-assessment.
62. Lloyd-Jones DM, Braun LT, Ndumele CE, et al. Use of Risk Assessment Tools to Guide Decision-Making in the Primary Prevention of Atherosclerotic Cardiovascular Disease: A Special Report From the American Heart Association and American College of Cardiology. *Circulation.* 2019;139(25):e1162-e77. PMID: 30586766
63. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation.* 2019;140(11):e596-e646. PMID: 30879355
64. Gulati M, Levy PD, Mukherjee D, et al. 2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation.* 2021;144(22):e368-e454. PMID: 34709879
65. Fihn SD, Gardin JM, Abrams J, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease: executive summary: a report of the American College of Cardiology Foundation/American Heart Association task force on practice guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive

Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Circulation.* 2012;126:3097-137. PMID: 23166210
66. Fihn SD, Blankenship JC, Alexander KP, et al. 2014 ACC/AHA/AATS/PCNA/SCAI/STS focused update of the guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines, and the American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *The Journal of thoracic and cardiovascular surgery.* 2015;149(3):e5-23. PMID: 25827388
67. Lim LS, Haq N, Mahmood S, et al. Atherosclerotic cardiovascular disease screening in adults: American College Of Preventive Medicine position statement on preventive practice. *Am J Prev Med.* 2011;40:381 e1-10. PMID: 21335273

CODES

Codes	Number	Description
CPT	75571	Computed tomography, heart, without contrast material, with quantitative evaluation of coronary calcium
HCPCS	S8092	Electron beam computed tomography (also known as ultrafast CT, cine CT)

Date of Origin: *January 1996*