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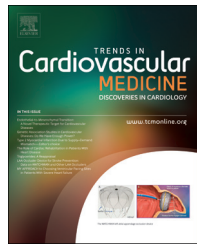

Incidental coronary calcifications on routine chest CT: Clinical implications

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ABSTRACT

Coronary artery calcification (CAC) is a marker of atherosclerosis and an independent risk factor for cardiac-related mortality, with much of the 50% decline in mortality over the past 30 years being attributed to early detection of coronary disease and intervention of modifiable risk factors. With over 10 million computed tomography (CT) examinations of the chest performed in the United States yearly, CAC can be identified in a very large number of patients. In this review, we discuss the clinical evidence underlying the relationship between radiologic identification of CAC, atherosclerosis, and cardiac outcomes and the implications of its assessment on standard chest CT. We conclude that reporting of incidental coronary calcification found on non-gated chest CT would have a great impact on both management and mortality and thus, in the appropriate setting, should be noted in the impression of the radiologic report when identified.

Key words: CAC, Coronary artery calcification, Atherosclerosis, Computed tomography, Coronary artery disease.

Introduction

Computed tomography (CT) of the chest is a critical tool in the evaluation of thoracic disease, with over 10 million chest CT examinations performed yearly [1]. Frequent clinical indications for chest CT include evaluation of pulmonary embolism, lung cancer screening and staging, and pulmonary fibrosis [2]. Recent advancements in multidetector CT technology and improved image resolution allow for easier detection of both pathology and incidental findings. A very common incidental finding on routine, or non-gated, chest CT protocols is coronary artery calcification (CAC), with rates ranging from 40% to 80% [3,4]. The strong relationship between the amount of CAC and future cardiovascular events is widely known. Reporting of the presence and extent of CAC has been shown to be associated with greater use of statins as well as with beneficial lifestyle changes [5], thus identification of coronary calcification during routine non-gated chest imaging is of clear importance. We aim to focus on the clinical importance and impact of identifying incidental coronary calcification on non-gated CT of the chest on cardiac outcomes.

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Coronary artery calcifications: An independent marker of cardiac disease and cardiovascular risk

Coronary artery disease (CAD) is the most common form of cardiovascular disease (CVD) and the leading cause of death worldwide, causing approximately one in every seven deaths in the United States in 2013 [6]. Even among individuals at high risk for lung cancer, death from CVD was found to be more common than death from lung cancer; 24.8% of deaths were due to CVD versus 24.1% from lung cancer in the National Lung Screening Trial [7]. Early detection of CAD allows for early intervention on modifiable risk factors and has resulted in a nearly 50% decline in U.S. deaths from cardiovascular disease from 1980 to 2000 [8,9]. The findings underlie the importance of early detection of coronary artery disease in reducing the risk of major cardiovascular events.

CAC is a highly specific marker for the presence of underlying atherosclerosis, representing the integration of the effects of all risk factors over a lifetime in an individual patient. As such, it overcomes the limitations of population-based global risk scores based on populations. A vast literature has documented a consistent strong relationship between the extent of CAC and risk of cardiovascular events [10–12]. CAC is often present in low-risk populations based on risk factor assessment in patients with no cardiovascular risk factors and absent in patients with multiple risk factors [13].

CAC is conventionally assessed on ECG-gated scans acquired for the purpose of CAC scanning, with which a CAC score is most commonly calculated according to the Agatston scoring system [14,15]. The CAC score calculation is based on the total number of voxels that measure above a specified density in Hounsfield Units (HU) (typically 130 HU) within a specified region of interest [14,15]. Score ranges are typically categorized as 1–9, 10–99, 100–399, 400, or more. Scores of zero have been associated with very low risk of coronary artery disease [16]. Increasing mortality risk has been found to be linked with each increase in the CAC score, with calcium scores above 400 associated with an over fivefold increased all-cause mortality [12,17]. Even asymptomatic individuals with CAC scores 1–10 have been shown to have a threefold increased risk for coronary disease compared with those with CAC = 0 [18,19].

Coronary calcification: Impact on management and patient lifestyle changes

The strong link between coronary calcification and CVD outcomes has led to recommendations regarding the use of calcium scanning among asymptomatic patients [20]. CAC scanning has been shown to lead to improvements in a healthy lifestyle, to increased prescription of statins and aspirin in patients with elevated risk based on the CAC findings, and to increased patient adherence to taking statin medication [21,22]. The authors found that the group receiving the calcium scan had superior control of risk factors including systolic blood pressure, low-density lipoprotein cholesterol, and waist circumference over a 4-year period. The authors concluded that coronary calcium scoring could improve management of cardiac risk factors without significant increased cost, further supporting the importance of early detection of CAC.

Detection of CAC on routine chest CT

It is estimated that in 2007, over 13 million chest CT examinations were performed, with less than 1 million being electrocardiogram-gated [23]. Since CAC is often observed on standard non-contrast chest CT examinations performed without ECG gating, there is an opportunity to use this CAC information to implement preventive management in a large number of patients not known to have coronary atherosclerosis.

Accuracy of visual coronary calcium assessment: Non-gated versus ECG-gated CT

Wu et al. [24] published a study comparing coronary artery CAC scores among 483 patients who underwent both low-dose routine non-gated chest CT and retrospective cardiac-gated multidetector CT. Inter-observer variability was 9.6% with low-dose non-gated CT versus 3.6% for ECG-gated CT. Concordance between the two techniques was high when categorizing the score into four major score ranges of 0, 1–100, 101–400, and >400. A similar study prospectively compared Agatston scores based on ECG-gated CT with visual ranking of CAC (1–10, 11–100, 101–400, and ≥401) based on non-gated CT and found 71.6% concordance and 98.9% correct within one category [25].

Of note, a true CAC score of 0 can only be reliably determined with gated studies, as studies using routine non-gated chest CT may show 0 among patients with CAC 0–9 on gated studies. Hutt et al. [26] used ECG-gated CT as the gold standard to investigate the reliability of non-gated CT in detecting coronary calcification. They found a sensitivity of 96.4% and specificity of 100% for the detection of CAC. A review of four studies comprising 1153 subjects found a false-negative rate of 8.3% [27]. Based on these findings, while non-gated low-dose CT scores are more variable compared with ECG-gated CT, it remains a useful tool for coronary risk stratification. Since even scores as low as 1–9 are associated with increased cardiac events and any coronary calcium could change management, this limitation should be recognized [18,19]. A comparison of EKG-gated and non-gated CT in patients with low and high CAC scores is demonstrated in the Fig. and Table 2.

Relationship between CAC on routine chest CT and cardiovascular events

The Agatston scoring system and other approaches to semi-quantitative analysis of CAC on non-gated chest CT have been assessed in quantifying the degree of coronary calcification on low-dose, non-contrast CT [28,29]. An ancillary study of the Dutch–Belgian Randomized Lung Cancer Screening Trial (NELSON study) found that Agatston scores derived