Cardiac computed tomography in the elderly: windows into a lifetime of exposure to cardiac risk

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Abstract

Cardiac computed tomography (CT) can non-invasively determine coronary calcium score, the extent and severity of coronary artery disease, and left ventricular function. These three elements have diagnostic and prognostic utility in the assessment of patients with suspected coronary artery disease. However cardiac CT requires high spatial and temporal resolution for an accurate assessment of these variables. The acquisition requirements of cardiac CT can be difficult to fulfil in the elderly with a higher prevalence of coronary calcification, atrial fibrillation, co-morbidities and impaired cognitive function. These potential challenges are to be weighed against the advantages of cardiac CT as a non-invasive test providing reliable anatomical data in a difficult to assess population.

Keywords: cardiac CT; coronary calcification; risk stratification; elderly

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Introduction

Cardiac computed tomography (CT) can determine the degree, location and extent of coronary artery disease non-invasively in patients with suspected ischemic heart disease. In the elderly, therefore cardiac CT may evaluate the cumulative impact of a lifetime of exposure to cardiac risk factors. However the utility of cardiac CT in this population has been questioned. The accumulative effects of risk factors over several decades may lead to coronary calcification with subsequent degradation of spatial resolution.

As a window on the coronary arteries, cardiac CT in the elderly may be as a white washed pane, opaque and not evaluable. Whereas for others, the “windows” may be clear, transparent and diagnostic (Fig. 1). With diagnostic scans, cardiac CT angiographic definition of high-risk coronary anatomy may be crucial for clinical decision-making. This is an important advantage in elderly patients with multiple comorbidities who are more susceptible to complications from invasive procedures.

In this review, we will consider the rationale for cardiac CT as part of a risk stratification tool in the elderly (>70 years) and examine the diagnostic and prognostic data available in these individuals.

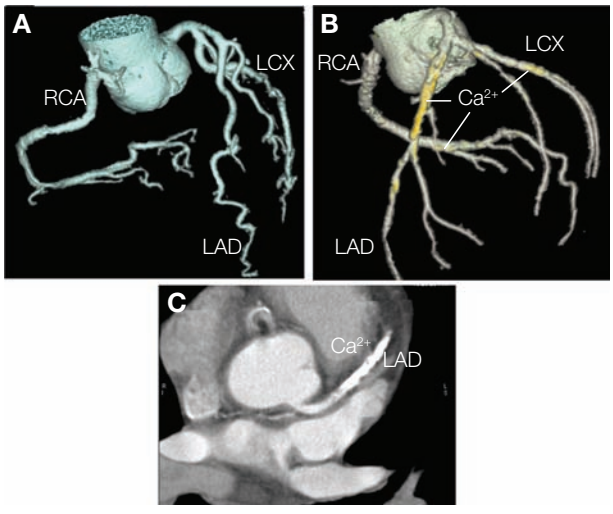

Fig. 1 Computed tomography coronary angiography in the elderly. A+B volume rendered 3D images of coronary arteries. A) 87-year-old female with a history of exertional dyspnea. There is no coronary calcification; CT coronary angiography was normal. B) 93-year-old male with chest pain. There is extensive calcification (Ca^{2+}) of the proximal and mid left anterior descending artery (LAD) with circumferential calcium (highlighted in yellow). Calcium was also noted in the circumflex (LCX) and right (RCA) coronary arteries. C) 2D axial slice demonstrating extensive calcium in the LAD rendering this segment of the coronary circulation non evaluable.

Evaluation of coronary artery disease in the aged

Assessment of coronary artery disease in the elderly population (>70 years old) can be problematic. A sedentary lifestyle may mask exertional symptoms. Cognitive dysfunction and impaired hearing may hinder accurate history taking. Despite these challenges, aging of the population indicates that coronary artery disease evaluation in the elderly will become an increasingly common problem.

Clinical risk stratification

Clinical risk stratification of patients with suspected coronary disease can be performed using risk factor scoring systems such as the Framingham Points Score (FPS) [1]. FPS however may be less accurate in the middle aged and elderly [2]. Other potential clinical risk stratifiers have not been well validated in an elderly population [3, 4]. The poor performance of clinical risk stratification in the elderly underscores the need for further non-invasive assessment in these individuals. Consideration could be given to exercise treadmill testing, stress testing with imaging or cardiac CT. There are however limitations in the operating characteristics of these alternatives, particularly in the elderly.

Non-invasive functional testing

Treadmill testing may be difficult in deconditioned individuals or those with limited mobility. Functional imaging tests with pharmacological stressors such as echocardiography, magnetic resonance imaging or nuclear perfusion studies are potential alternatives to treadmill testing. Although stress echocardiography is often readily available and inexpensive, adequate imaging requires good acoustic windows and patient compliance. Similarly, nuclear perfusion studies are usually accessible. However, elderly patients may not tolerate long nuclear imaging times and have poor images due to patient motion. Magnetic resonance imaging (MRI) may be contra-indicated in the elderly as a result of joint prostheses, renal failure, poor compliance or claustrophobia.

Cardiac CT

In contrast to these functional tests, cardiac CT defines coronary calcium and coronary anatomy.

Coronary calcium and prognosis

A coronary calcium score is often performed using a low dose non-contrast CT prior to CT coronary angiography. Coronary artery calcium (CAC) scores are usually measured as an Agatston score which identifies lesions greater than 130 Hounsfield units and an area $\geq 1mm^2$ [5].

In the elderly, the additional data provided by a CAC score can provide incremental prognostic value to clinical risk predictors [2, 6]. CAC may significantly increase the ability to predict cardiac events (non fatal MI and cardiac death) and appears incremental to clinical risk prediction with FPS. CAC calculation has been associated with a 14% net reclassification improvement in risk following clinical hazard prediction ($p<0.01$). The largest proportion of individuals reclassified as a consequence of CAC assessment was from the moderate Framingham risk group. Fifty-one percent of this group were reclassified by CAC with 30% moving down in risk and 21% moving to a high-risk group [6].

As many elderly patients fall within the moderate risk category of FPS system due to their age (age 70–74 scores 14 points projecting to a calculated 10-year risk

of 18.4% by Framingham risk) [1], the utility of CAC to reclassify approximately 50% of these patients in high or low risk strata may help to determine medical management goals and assist in deciding whether further clinical testing is required.

The utility of coronary calcium to predict prognosis in an elderly population was noted in a large prospective observational study of 35,388 patients of whom 3,570 were ≥70 years of age [7]. Mortality rates in patients with Agatston scores <10 were less than those predicted by age alone (3.4% cumulative event rate for mean follow up of 5.8+/-3 years for males, versus age predicted death rates of 5.8% in 75–84 years olds (Office for National Statistics, UK). Whereas those with calcium scores ≥400 had mortality rates in excess of those expected as a results of their age alone. Individuals without coronary calcification ≥70 years of age had a low annualized mortality rate (2.2%) [8].

CT coronary angiography and diagnostic accuracy

Coronary calcium, although a useful risk stratification tool and prognosticator, can hinder the accurate evaluation of luminal stenoses at CT coronary angiography (CTA). Assessment of the influence CAC on CTA accuracy was investigated in 134 suspected coronary artery disease patients with a mean age of 54 +/-9 years [9]. In comparison to patients with low calcium scores, those with higher Agatston scores (<142) had more unevaluable segments. In addition, evaluable segments in those individuals with higher Agatston scores (>142) showed less correlation with invasive angiography than evaluable segments from patients with low Agatston scores.

Thus the accuracy of CTA in patients with moderate or higher Agatston scores is likely to be less than that of patients with low or zero scores [9]. It remains unclear whether the diagnostic discrepancies between CTA and invasive coronary angiography in patients with elevated calcium scores would affect the prognostic utility of CTA in the elderly.

CT coronary angiography and prognosis

In a large prognostic study of 2,172 patients with a mean age of 58 +/-11 years, normal CT coronary angiography without evidence of coronary atherosclerotic plaque was associated with an excellent prognosis of 0.1% annualized risk of cardiac events [10]. Mild non-obstructive disease was associated with a slightly higher rate of 0.5% annualized risk. This study and others have indicated that moderate (≥50%) disease in any coronary artery, severe proximal obstructive disease (≥70%) or obstructive left main stem disease (>50%) portended a poorer prognosis [10, 11]. An incremental effect of left ventricle (LV) functional data, in addition to coronary anatomy in predicting outcomes, was also demonstrated [10].

The influence of age on outcomes was noted in these papers and increasing age was an important risk factor for predicting adverse events. The results were not stratified according to age and therefore the effect of high risk anatomy on mortality rates for different age groups was not given. Consistently however proximal coronary disease and multi-vessel coronary disease has been associated with poorer outcomes and it is likely such high risk anatomy would be important in determining outcomes in the elderly.

Cardiac CT angiography and radiation

Initially images were obtained using helical, ECG-gated imaging which was associated with relatively high radiation exposures (15mSv). Newer techniques using ECG gated/triggered axial step and shoot acquisition have considerably reduced x-ray exposure (7mSv) [12]. It should be noted that the sensitivity of tissues to radiation does diminish with age and although dose reduction principles should always be pursued, the necessity to limit radiation exposure is perhaps less essential in an elderly population [13].

Perspective

The role for cardiac CT in evaluating elderly patients (≥70 years) remains ill defined. Further long-term prognostic studies are required in addition to diagnostic feasibility studies to confirm the potential of CT coronary angiography in this population.

In the absence of guidelines for the use of cardiac CT in the elderly, a strategy (Fig. 2) in symptomatic individuals could be to perform a calcium score assessment in patients with no prior history of coronary revascularization, as initial risk stratification. Following CAC imaging it may become clearer whether CT coronary angiography is likely to be non-evaluable due to the presence of circumferential coronary calcium.

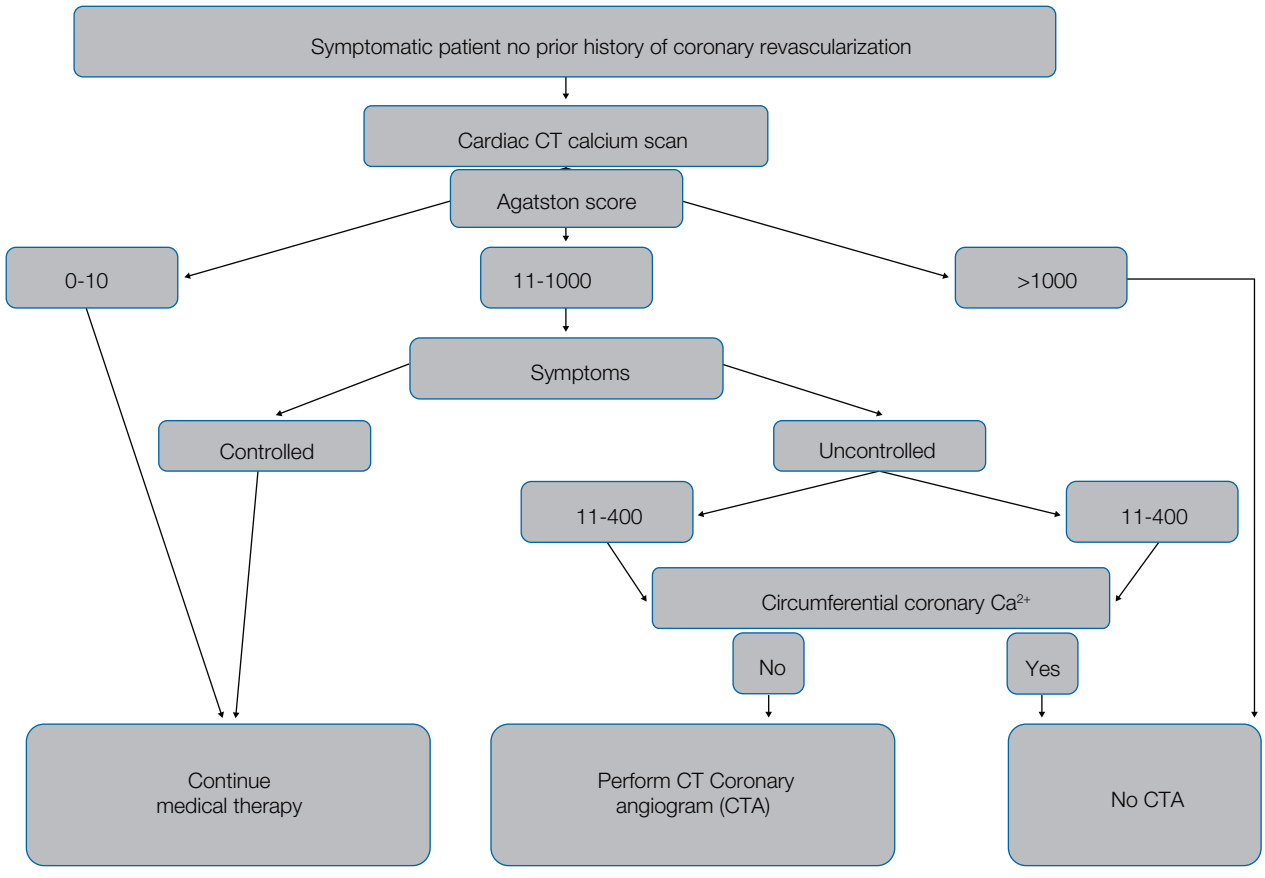

Fig. 2 *Proposed strategy for investigating suspected coronary artery disease in the elderly. CT computed tomography, Ca^{2+} calcium [6,7].*

In patients with uncontrolled symptoms and calcium scores 11–400, without circumferential calcium it may be useful to perform CT angiography to identify patients with high-risk coronary artery disease suitable for invasive management. In those with calcium scores 0–10 with controlled symptoms a more conservative approach with initial medical management could be pursued (Fig. 2).

Summary

Cardiac CT has been enthusiastically welcomed as a non-invasive test to investigate suspected coronary artery disease. Although used in the elderly, the increased prevalence of coronary calcification in this age group can predispose to non-diagnostic scans. Yet, in an era post COURAGE with greater acceptance of medical therapy in coronary artery disease management, further risk stratification by cardiac CT may be a useful gatekeeper for invasive testing [14]. Identification of patients with high-risk coronary anatomy for revascularization would be an important step prior to commitment to medical therapy. In light of this and especially in the elderly patient with suspected coronary artery disease, CT coronary angiography may provide a useful non-invasive window on coronary anatomy. •

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