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Agatston Calcium Score as a Predictor of Obstructive Coronary Artery Disease: A Cross-Sectional CCTA-Based Study

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Abstract

Background: Agatston calculated coronary artery calcium scoring (CAC) has been firmly in place as a means of finding and measuring the burden of calcified atherosclerosis. Although zero calcium score is typically indicative of a reduced possibility of major coronary artery disease (CAD), it is less efficient in ruling out the occurrence of obstruction lesions. It has been demonstrated that calcium score has a robust association with the degree and severity of coronary stenosis on CT angiography (CCTA).

Objectives: To assess the usefulness of the Agatston calcium score in ruling out or ruling in clinically significant stenosis (of the coronary arteries) (>50%) in symptomatic individuals.

Methodology: The investigations of 183 patients referred to receive CCTA at the Iraqi Center of Heart Disease are carried out in the form of a cross-sectional study. Patients are grouped by calcium score (0, 100, 200 99, 100, 200 or greater), age bracket and extent of coronary stenosis. There are standardized preparations and CCTA protocols used with calcium scoring done through non contrasted CT.

Results: Within patients with zero CAC, zero stenosis was located in 78.5 percent of patients, non-significant stenosis in 15.4 percent of patients and significant stenosis in 6.1 percent of patients. Among the patients with CAC 100 or more, 75 percent of them presented with significant stenosis. There is a significant positive correlation between the rise of calcium score and severity of stenosis (P=0.001). There is also a relation between older age, calcium scores and stenosis rates (P=0.01 and P=0.02 respectively). Significant stenosis is more often found in male patients compared to female ones (P=0.02).

Conclusion: Agatston calcium score is also a good indicator of coronary artery stenosis. Calcium scores above 100 are very strong indicators of a good CCTA, whereas zero scores lower risks of CAD seriousness, but do not extinguish it.

Keywords: Calcium score, coronary artery disease, CT angiography, Agatston score, coronary stenosis.

Introduction

Coronary artery calcium (CAC) is an established marker of coronary atherosclerosis and has the core importance in governing the development, destabilization and stabilization of coronary plaques. CAC occurrence and severity have a strong relationship with cardiovascular incidents in the future. The CAC scoring in clinical assessments has been proven to improve cardiovascular risk reclassification and stratification over the traditional scoring systems. Besides, the CAC burden is a general indicator of atherosclerotic disease composed of calcified as well as non-calcified plaques. Agatston is the most popular algorithm to quantify CAC whereby the area of lesions together with its density is used to initiate a total calcium score. Despite being extremely accurate metrics in the prediction of the disease burden as well as the coronary artery involvement, the Agatston score fails to incorporate the geographical distribution of calcifications in the coronary arteries. Use of coronary computed tomography (CT) angiography has demonstrated that diffuse atherosclerosis with non-calcified plaque is associated with poor outcomes independent of presence of obstructive stenosis (1). Coronary computed tomography angiography (CCTA) is a highly sensitive and specific non-invasive method of imaging that can detect both important and unimportant coronary artery stenosis. High diagnostic sensitivity of it and an excellent negative predictive value are characteristic properties that makes CTA fit to exclude coronary artery disease (CAD) and detect early or subclinical lesion (2). This is because a proper determination of the coronary artery anatomy is necessary in the interpretation of CCTA results. Right coronary artery (RCA) and left main coronary artery (LMCA) originate in the respective aortic sinuses with non-coronary sinus not having an arterial branch (3). The RCA provides various cardiac structures and originates other structures such as conus artery, acute marginal artery, and posterior interventricular artery (4). The LMCA bifurcates to form the left anterior descending (LAD) and the left circumflex (LCX) arteries that provide the blood supply to the anterior and lateral walls of the heart. The dominance in Coronary depends on the source of the posterior descending artery, which is different among people (5). The presence of myocardial bridging most commonly located in mid LAD may possess valuable clinical consequences like dysrhythmia and ischemia (6). Innovation in the technology of cardiac CT scans- more so 16 and 64 slices- has advanced the quality of imaging and allowed abidance of the full cardiac scan being captured in one breath hold (7). Use of cardiac gating improves the reduction of the motion artifacts, where prospective andretrospective ECG gating is used, and the latter provides the possibility of functional assessment at the expense of increased radiation doses (8). Agatston score is the total quantity of lesion scores in all the coronary arteries with the threshold of 130 Hounsfield units (HU) and the density-weighting system that is on the basis of the peak attenuation values (9).

Improper patient preparation is one of the main reasons of inaccurate diagnosis due to the inability to capture proper images and that must entail heart rate stabilization, breath holding exercise, nitrates, and diligent contrast index. Allergy patients, patients with chronic renal disease, or arrhythmias, need special precautions (10-12). However, CCTA has certain limitations, especially on those situations when there is too much calcification of the coronary arteries or conditions where heart rates cannot be stabilized (7).

The major cause of coronary artery diseases is the problem of Atherosclerosis which manifests as the formation of plaques, decrease in the size of the lumen and possibly rupture causing thrombi conditions. Advancement to symptomatic illness is tailored by an array of factors such as the customary, and controllable cardiovascular risk factors (13,14). As such, the objective of the study was to establish the usefulness of the Agatston score as a predictor or exclusion of the presence of significant coronary artery disease (CAD) in symptoms patients

Research Methodology

2.1 Study Design and Setting

This cross-sectional study was conducted at *Al-Shahid Ghazi Al-Hariri Hospital* the *Iraqi Center of Heart Disease* in Baghdad, Iraq, from June 2024 to February 2025. The study population consisted of patients referred for coronary computed tomography angiography (CCTA) primarily to evaluate chest pain and suspected coronary artery disease (CAD).

2.2 Study Population

A total of 220 patients were initially screened. Of these, 37 patients (16.8%) were excluded due to excessive heart rate, arrhythmia, history of coronary stenting or coronary artery bypass grafting (CABG), allergy to contrast agents, impaired renal function (*serum creatinine > 1.2 mg/dL*), or extensive coronary calcification that precluded accurate imaging. The final cohort comprised 183 participants—103 males (83.2%) and 80 females (16.8%)—aged 21 to 74 years.

2.3 Patient Preparation

All patients underwent standardized preparation prior to scanning:

- Fasting: Solid foods were discontinued at least 4 hours before imaging.
- Hydration: Adequate hydration was ensured to optimize contrast excretion.
- Caffeine restriction: Patients refrained from caffeine consumption for 12 hours prior to scanning.
- Renal assessment: Serum creatinine was measured to confirm adequate renal function.

If the heart rate exceeded 65 beats per minute, oral beta-blockers were administered, when not contraindicated, to achieve a rate between 50–60 bpm. Immediately before scanning, sublingual nitrates were given to improve coronary artery visualization.

2.4 Imaging Protocol

All scans were performed using a 64-slice multidetector computed tomography (MDCT) scanner (*Philips Brilliance 64*, Philips Medical Systems, The Netherlands)

1. Non-contrast Calcium Scoring Scan:
- o Tube voltage: 120 kV
- o Tube current: 140 mAs
- o Slice thickness: 2.5 mm

The coronary artery calcium (CAC) score was calculated using the Agatston method.

2. Contrast-enhanced CCTA Scan:
- o Contrast agent: *Iopromide (Ultravist 370 mg/mL)*
- o Injection rate: 5.5–6.0 mL/s via power injector
- o Bolus tracking: Triggered at 110 HU in the descending aorta
- o Reconstruction: Retrospective ECG-gating at 40%, 75%, and 80% of the R-R interval

Post-processing included multiplanar reformation (MPR), maximum intensity projection (MIP), and volume-rendered (VR) reconstructions to evaluate coronary anatomy and stenosis severity.

2.5 Classification and Analysis

Patients were stratified based on:

- Agatston CAC Score: 0, 1–99, 100–299, and ≥300
- Coronary Stenosis Level: <50% (non-significant) or ≥50% (significant)
- Age Categories: 21–40, 41–60, and ≥61 years

All quantitative and qualitative image analyses were performed by experienced radiologists blinded to clinical data. Statistical analyses were conducted using SPSS version 25 (IBM Corp., Armonk, NY, USA). Associations between CAC score, stenosis severity, and demographic variables were tested using the chi-square test, with a significance threshold of $P < 0.05$.

3. Results

3.1 Study Population

Out of 220 patients initially screened, 37 patients (16.8%) were excluded due to motion artifacts, arrhythmia, coronary stent or CABG history, renal impairment, or contrast allergy. The final study cohort included 183 patients (83.2%), comprising 103 males (56.3%) and 80 females (43.7%), aged 21–74 years (mean ± SD: 51.7 ± 10.2 years).

3.2 Age Distribution

The largest age group was 41–60 years (113 patients, 61.7%), followed by ≥61 years (40 patients, 21.9%) and 21–40 years (30 patients, 16.4%).

Table 1: Distribution of study sample according to age and sex

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	21–40	30	16.4
	41–60	113	61.7
	≥61	40	21.9
Sex	Male	103	56.3
	Female	80	43.7

3.3 Distribution of Coronary Artery Calcium (CAC) Scores

The distribution of Agatston calcium scores revealed that 71% of the cohort had a CAC = 0, 20.2% had scores between 1–99, and 8.8% had scores of ≥100. This indicates that the majority of symptomatic patients undergoing CCTA had low or absent coronary calcification.
The distribution pattern is illustrated in *Figure 2*.

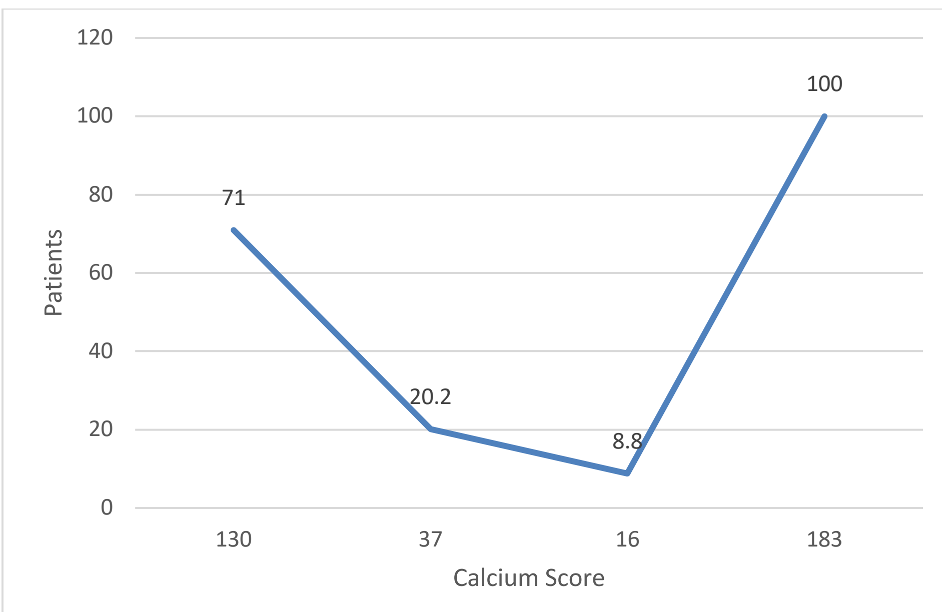

Figure 2: *Distribution of the study sample according to calcium score categories.* Bar chart demonstrating that most patients (71%) had zero CAC, followed by 20.2% with mild (1–99) and 8.8% with high (≥100) calcium scores.

3.4 Distribution According to Degree of Coronary Stenosis

Analysis of stenosis severity on CCTA demonstrated that 114 patients (62.3%) had no stenosis, 40 patients (21.9%) exhibited non-significant stenosis (< 50%), and 29 patients (15.8%) had significant stenosis (≥ 50%).

The distribution of stenosis categories across the study population is shown in *Figure 3*

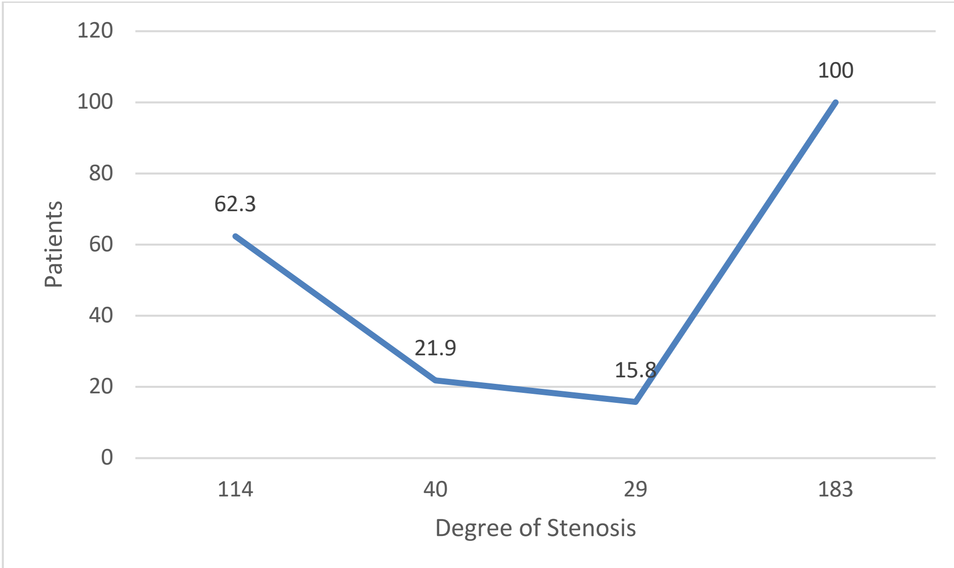

Figure 3: *Distribution of the study sample according to degree of stenosis.* Histogram illustrating the relative proportions of patients with no, mild (< 50%), and significant (≥ 50%) stenosis on CCTA.

3.5 Relationship Between Calcium Score and Coronary Stenosis

A strong, statistically significant association was observed between Agatston calcium score and stenosis severity (*P = 0.001*).

Patients with CAC = 0 were largely free of obstructive disease 78.5% had no stenosis and only 6.1% demonstrated ≥ 50% stenosis.
Conversely, 75% of patients with CAC ≥ 100 exhibited significant stenosis (≥ 50%).
The distribution across all CAC categories is summarized in *Table 2*.

Table 2: ***Relationship between calcium-score categories and coronary artery stenosis.***

CAC Category	No stenosis n (%)	< 50 % n (%)	≥ 50 % n (%)	Total n (%)
0	102 (78.5)	20 (15.4)	8 (6.1)	130 (100)
< 100	11 (29.8)	17 (45.9)	9 (24.3)	37 (100)
≥ 100	1 (6.2)	3 (18.8)	12 (75.0)	16 (100)
Total	**114 (62.3)**	**40 (21.9)**	**29 (15.8)**	**183 (100)**

A progressive increase in the prevalence of significant stenosis was observed with higher CAC categories, confirming that elevated calcium scores strongly predict obstructive coronary artery disease.

3.6 Association Between Calcium Score, Age, and Sex

Calcium scores increased consistently with age. Among participants aged 21–40 years, 93.4% had a CAC = 0, and only 3.3% had scores ≥ 100. In contrast, within the ≥61 years age group, 52.5% had CAC = 0, whereas 22.5% exhibited scores ≥ 100. This age-related rise in calcium burden was statistically significant (*P = 0.01*).Male patients demonstrated a higher frequency of elevated CAC scores and greater stenosis severity compared with females (*P = 0.02*).

3.7 Representative Imaging Findings

Curved multiplanar reconstruction of CCTA demonstrated the presence of non-calcified plaque in the left anterior descending (LAD) artery producing approximately 90% luminal narrowing, as shown in ***Figure 4*** This case illustrates that even patients with low or absent calcification may still harbor obstructive non-calcified plaques

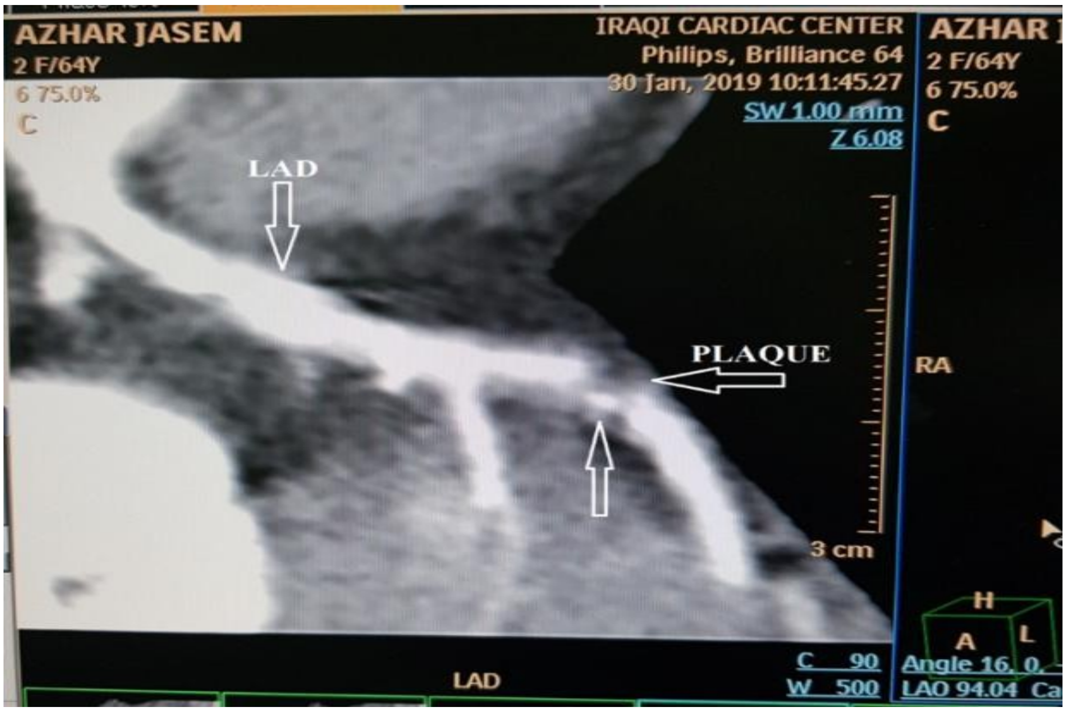

Figure 4: *Curved multiplanar reformation of CCTA showing non-calcified plaque in the LAD causing approximately 90% stenosis.*

Discussion

This study evaluated the correlation between coronary artery calcium (CAC) scores and coronary artery stenosis determined by coronary computed tomography angiography (CCTA) in 183 symptomatic patients after excluding 37 cases with motion artifacts, excessive calcification, prior revascularization, or contraindications.

The results demonstrate a strong positive relationship between increasing CAC score and the severity of coronary stenosis (*P = 0.001*). Among patients with a CAC = 0, 78.5% exhibited no stenosis, 15.4% had non-significant stenosis, and 6.1% had significant stenosis. These findings are consistent with those of Villines et al. (15), VenkateshVenkatesh et al. (16), and Rubinshtein et al. (17).

The presence of significant stenosis in a small subset (6.1%) of patients with CAC = 0 agrees with reports by Rubinshtein et al. (17), Kamran et al. (18), Tay et al. (19), and Shabestari et al. (20).

This reinforces the understanding that a zero calcium score significantly lowers, but does not eliminate, the probability of obstructive coronary artery disease (CAD). The explanation lies in the inability of non-contrast CT to visualize non-calcified fibrous or lipid-rich plaques, which may still lead to significant luminal narrowing and ischemia.

In the low CAC group (1–99), 24.3% of patients showed significant stenosis. These findings align with those of Rubinshtein et al. (17), Shabestari et al. (20), and Henneman et al. (21), who reported that even a small detectable calcium burden is associated with an increased likelihood of obstructive CAD.

Similarly, in the high CAC category (≥100), 75% of patients had significant stenosis, a result comparable to Shabestari et al. (20) (94%), Henneman et al. (21) (82.9%), and Nizar et al. (22) (100%). These consistent observations from multiple studies confirm that increasing Agatston score parallels the progression of luminal obstruction and overall atherosclerotic burden.Furthermore, the positive association between CAC and stenosis has also been reported by Schuhbaeck et al. (23), Iwasaki et al. (24), and Nizar et al. (22), though Leschka et al. (25) noted that the anatomical location of calcification may not always correspond directly to stenotic sites, highlighting the complex interplay between plaque morphology and distribution

The influence of age was also significant in the present study. CAC scores increased progressively with age (*P = 0.01*), consistent with results from Rajesh et al. (26), Nizar et al. (22), and Loria et al. (27).

Older individuals exhibited a higher frequency of critical stenosis (*P = 0.02*), supporting findings by Zhong-Hua et al. (28), who observed that patients above 65 years have a markedly higher prevalence of coronary abnormalities. This relationship reflects the cumulative nature of atherosclerotic calcification and plaque maturation over time.

Although the current analysis found no statistically significant difference in mean CAC score between sexes (*P = 0.5*), male patients demonstrated a higher incidence of significant stenosis (*P = 0.02*). This agrees with Nakao et al. (33), who reported that males exhibit more advanced atherosclerotic changes, likely influenced by hormonal and lifestyle factors. Earlier studies by McClelland et al. (30), Haberl et al. (31), and Nørgaard et al. (32) have shown a more pronounced sex-related difference in CAC distribution than was evident in our sample, possibly due to demographic or ethnic variations.

One limitation of this study is the reliance on CCTA instead of invasive coronary angiography as the reference standard. Although invasive angiography remains the definitive diagnostic tool, CCTA is a validated, highly sensitive, and less invasive technique that reliably quantifies both calcified and non-calcified plaque burden. Its non-invasive nature and excellent reproducibility make it a practical alternative for large-scale clinical evaluation of CAD severity and plaque characteristics

Conclusion

This study demonstrates a strong, statistically significant correlation between the Agatston coronary artery calcium (CAC) score and the severity of coronary artery stenosis detected by CCTA.

Patients with higher CAC values were significantly more likely to have obstructive coronary artery disease, while those with zero CAC had a markedly reduced, but not negligible, risk of significant stenosis. Specifically, 6.1% of patients with CAC = 0 exhibited ≥50% stenosis, emphasizing that the absence of calcification does not entirely exclude coronary pathology, particularly in the presence of non-calcified, fibrofatty, or mixed plaques.

A CAC score ≥100 was strongly associated with the presence of clinically significant stenosis (≥50%), confirming its role as a reliable predictive marker for obstructive CAD.

Age was a significant determinant of both CAC and stenosis severity, and male patients were more likely to demonstrate advanced disease patterns. These findings reinforce that CAC scoring provides a simple, non-invasive, and cost-effective approach for early CAD risk assessment and can serve as a valuable adjunct to CCTA in guiding diagnostic and therapeutic decisions

Clinical Implications

- Risk stratification: CAC scoring allows clinicians to better categorize symptomatic patients into low- and high-risk groups before performing invasive or high-cost procedures.
- Zero CAC caveat: Even patients with a score of zero should not be dismissed outright; further evaluation is warranted when symptoms or risk factors persist.
- High CAC guidance: Scores above 100 should prompt more aggressive diagnostic work-up, lifestyle modification, and preventive pharmacotherapy.
- Integration in protocols: Combining CAC with CCTA findings provides a comprehensive non-invasive framework for diagnosing and managing coronary artery disease in routine clinical practice.

Limitations and Future Work

The main limitation of this study is its single-center, cross-sectional design and reliance on CCTA rather than invasive angiography. Future research should incorporate larger multicenter populations, longitudinal follow-up, and functional outcome analysis to validate the predictive accuracy of CAC across diverse patient groups and ethnicities

Reference

1. 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. *Circ Cardiovasc Imaging.* 2017;10:e006592. doi:10.1161/CIRCIMAGING.117.006592.
2. Cademartiri F, Maffei E, Palumbo A, et al. Coronary calcium score and computed tomography coronary angiography in high-risk asymptomatic subjects: assessment of diagnostic accuracy and prevalence of non-obstructive coronary artery disease. Eur Radiol. 2010;20:846–854.
3. Gerber TC, Kantor B, Williamson EE. Computed Tomography of the Cardiovascular System. 1st ed. United Kingdom: Informa Healthcare; 2007:67.
4. Villa AD, Sammut E, Nair A, Rajani R, Bonamini R, Chiribiri A. Coronary artery anomalies overview: the normal and the abnormal. World J Radiol. 2016;8(6):537–555.
5. Yan B, Yang J, Fan Y, et al. Association of coronary dominance with the severity of coronary artery disease: a cross-sectional study in Shaanxi Province, China. BMJ Open. 2018;8:e021292. doi:10.1136/bmjopen-2017-021292.
6. Ripa C, Melatini MC, Olivieri F, Antonicelli R. Myocardial bridging: a "forgotten" cause of acute coronary syndrome – a case report. Int J Angiol. 2007;16:115–118.
7. Ho KT, Han KB, Chen K, et al. Guidelines on cardiac CT in Singapore. Ann Acad Med Singap. 2006;35:287–296.
8. Desjardins B, Kazerooni EA. ECG-gated cardiac CT. AJR Am J Roentgenol. 2004;182:993–1010.
9. Blaha MJ, Mortensen MB, Kianoush S, Tota-Maharaj R, Cainzos-Achirica M. Coronary artery calcium scoring: is it time for a change in methodology? JACC Cardiovasc Imaging. 2017;10(8):923–937.
10. Coronary CT Angiography. Available from: https://emedicine.medscape.com/article/1603072-overview#a8
11. Prat-Gonzalez S, Sanz J, Garcia M. Cardiac CT: indications and limitations. J Nucl Med Technol. 2008;36:18–24.
12. Schoepf UJ, Zwerner PL, Savino G, Herzog C, Kerl JM, Costello P. Coronary CT angiography. Radiology. 2007;244:48–63.

13. Grech ED. Pathophysiology and investigation of coronary artery disease. BMJ. 2003;326(7397):1027–1030.
14. Risk Factors for Coronary Artery Disease. Available from: https://emedicine.medscape.com/article/164163-overview
15. Villines TC, Hulten EA, Shaw LJ, et al. Prevalence and severity of coronary artery disease and adverse events among symptomatic patients with coronary artery calcification scores of zero undergoing coronary computed tomography angiography: results from the CONFIRM registry. J Am Coll Cardiol. 2011;58:2540–2548.
16. Venkatesh V, Ellins ML, Yang S, et al. Incremental detection of coronary artery disease by assessment of non-calcified plaque on coronary CT angiography. Clin Radiol. 2009;64(3):250–255
17. Rubinshtein R, Gaspar T, Halon DA, et al. Prevalence and extent of obstructive coronary artery disease in patients with zero or low calcium score undergoing 64-slice cardiac multidetector CT for chest pain evaluation. Am J Cardiol. 2007;99:472–475.
18. Akram K, O'Donnell RE, King S, Superko HR, Agaston A, Voros S. Influence of symptomatic status on the prevalence of obstructive coronary artery disease in patients with zero calcium score. Atherosclerosis. 2009;203(2):533–537.
19. Tay SY, Chang PY, Lao WT, Lin YC, Chung YH, Chan WP. Proper use of coronary calcium score and coronary CT angiography for screening asymptomatic patients with cardiovascular risk factors. Sci Rep. 2017;7(1):17653. doi:10.1038/s41598-017-17655-w.
20. Shabestari AA, Akhlaghpour SH, Shadmani M, Abrahimi M, Majid S, Moghadam MS. Agreement determination between coronary calcium scoring and coronary stenosis significance on CT angiography. Iran J Radiol. 2006;3(2):85–90.
21. Henneman MM, Schuijf JD, Pundziute G, et al. Noninvasive evaluation with multislice CT in suspected acute coronary syndrome: plaque morphology versus calcium score. J Am Coll Cardiol. 2008;52:216–222.
22. Bhulani N, Khawaja A, Jafferani A, et al. Coronary calcium scoring: are results comparable to CT coronary angiography for screening coronary artery disease in a South Asian population? BMC Res Notes. 2013;6:279.
23. Schuhbaeck A, Schmid J, Zimmer T, et al. Influence of the coronary calcium score on the ability to rule out coronary stenoses by coronary CT angiography in suspected CAD. J Cardiovasc Comput Tomogr. 2016;10(5):421–427.
24. Iwasaki K, Matsumoto T. The relationship between coronary calcium score and high-risk plaque/significant stenosis. World J Cardiol. 2016;8(8):481–487.
25. Leschka S, Scheffel H, Desbiolles L, et al. Combining dual-source CT coronary angiography and calcium scoring: added value for assessment of CAD. Heart. 2008;94:1154–1161.
26. Tota-Maharaj R, Blaha MJ, McEvoy JW, Blumenthal RS, et al. Coronary artery calcium for prediction of mortality in young (<45 y) and elderly (>75 y) adults. Eur Heart J. 2012;33(23):2955–2962.
27. Loria CM, Liu K, Lewis CE, Hulley SB, et al. Early adult risk factor levels and subsequent coronary artery calcification: the CARDIA Study. J Am Coll Cardiol. 2007;49(20):2007–2013.
28. Sun ZH, Liu YP, Zhou DJ, Qi Y. Use of coronary CT angiography in the diagnosis of suspected coronary artery disease: findings and clinical indications. J Geriatr Cardiol. 2012;9(2):115–122.

29. Jalowiel DA, Hill JA. Myocardial infarction in the young and in women. Cardiovasc Clin. 1989;20:197–206.
30. McClelland RL, Chung H, Detrano R, Post W, Kronmal R. Distribution of coronary artery calcium by race, gender, and age: results from the Multi-Ethnic Study of Atherosclerosis (MESA). Circulation. 2006;113:30–37.
31. Haberl R, Becker A, Leber A, et al. Correlation of coronary calcification and angiographically documented stenoses in patients with suspected CAD: results of 1,764 patients. J Am Coll Cardiol. 2001;37(2):451–457.
32. Nørgaard KS, Isaksen C, Buhl JS, et al. Gender influence in coronary CT angiography in patients with low-to-intermediate pretest probability of coronary heart disease: a single-center cohort. *Open Heart.* 2015;2:e000233. doi:10.1136/openhrt-2014-000233.
33. Nakao M, Miyamoto Y, et al. Sex differences in the impact of coronary artery calcification to predict coronary artery disease. *Heart.* 2018;104:10.1136/heartjnl-2017-312151