

Original article

Incidental CAC on non-gated chest CT: prognostic value for cardiovascular events in patients without prior cardiovascular disease

Jitanart Tantisirivitt*

Bangkok Metropolitan Administration General Hospital, Thailand

Abstract

Background: Non-gated chest computed tomography (CT) is routinely performed for the evaluation of thoracic conditions. Although the heart is not the primary focus of this examination, coronary artery calcification (CAC) is frequently encountered as an incidental finding and reflects underlying atherosclerotic burden.

Objective: The study aimed to assess whether incidentally detected CAC on non-gated chest CT is associated with five-year cardiovascular outcomes in patients without prior cardiovascular disease (CVD).

Methods: We conducted a retrospective cohort study of adults aged 40-70 years who underwent non-gated chest CT at Bangkok Metropolitan Administration (BMA) General Hospital between July 2019 and June 2020. CAC was assessed using a visual coronary artery calcium (vCAC) scoring system. Demographic characteristics, cardiovascular risk factors, and cardiovascular events occurring within five years after the index CT were obtained from electronic medical records.

Results: Incidental CAC ($vCAC \geq 1$) was present in 54.3% of patients. Individuals with CAC were significantly older and had a higher burden of cardiometabolic risk factors. Cardiovascular events occurred more frequently in patients with CAC than in those without CAC (14.6% vs. 3.3%), corresponding to an approximately fourfold higher event rate. Event rates also increased with CAC severity ($P < 0.001$ for trend), with a notable increase observed among patients with vCAC scores ≥ 2 .

Conclusion: Incidental CAC on routine non-gated chest CT is associated with future cardiovascular events in patients without known CVD. Visual CAC assessment may provide clinically useful prognostic information and support opportunistic cardiovascular risk stratification in routine radiology practice.

Keywords: CAC severity, cardiovascular events, coronary artery calcification, non-gated chest CT.

*Correspondence to: Jitanart Tantisirivitt, Bangkok Metropolitan Administration General Hospital, Thailand.

E-mail: jitanartt@gmail.com

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Non-gated chest computed tomography (CT) is widely used in routine clinical practice to evaluate pulmonary, airway, pleural, and mediastinal abnormalities. Although the primary purpose of this examination is not cardiac assessment, coronary artery calcification (CAC) is frequently detected incidentally. CAC is a marker of underlying atherosclerosis and is strongly associated with the risk of future cardiovascular disease (CVD).⁽¹⁾

Reporting incidental CAC from chest CT offers an opportunity to use existing imaging data more efficiently, without additional radiation exposure or cost, particularly among individuals without known CVD.⁽¹⁾ Several international studies have demonstrated that CAC identified on routine non-gated chest CT is associated with an increased risk of myocardial infarction, stroke, heart failure, and cardiovascular mortality.⁽¹⁻⁴⁾

However, in many healthcare systems, including Thailand, standardized guidelines or routine systems for reporting incidental CAC are not yet established. As a result, clinically valuable information may be overlooked, and patients at elevated cardiovascular risk may miss opportunities for timely risk assessment and preventive care.^(3, 4) Prior international studies have reported that incidental CAC is detected in approximately 26.0% - 68.0% of patients without a history of CVD, depending on the characteristics of the study population.^(1, 2, 4, 5) To date, there are no published data from Thai public hospitals examining the prognostic value of incidental CAC on non-gated chest CT for future cardiovascular events. This study was therefore conducted to evaluate the association between incidentally detected CAC and five-year cardiovascular outcomes in Thai patients without prior CVD, aiming to provide local evidence to support the use of incidental CAC in cardiovascular risk prediction and to inform future radiology reporting practices and preventive health policies in Thailand.

Materials and methods

Ethical considerations

The study has been approved by the Bangkok Metropolitan Administration Human Research Ethics Committee (BMAHREC) (Certificate no. 145; Project Code: S023hc/68_EXP). The study was conducted retrospectively using anonymized imaging and electronic medical records, without direct patient contact.

Study design and setting

This investigation was conducted as a retrospective cohort study at the Department of Radiology, BMA General Hospital, Bangkok, Thailand. All eligible patients who underwent non-gated chest CT between July 2019 and June 2020 were identified from the hospital database. All data were obtained from existing clinical records and imaging archives, without direct patient contact.

Study population and eligibility criteria

Patients aged 40-70 years at the time of chest CT examination were considered eligible. Individuals were included if they had no documented history of CVD-defined as ischemic heart disease, prior myocardial infarction, stroke, heart failure, or prior coronary revascularization-and had at least five years of follow-up information in the electronic medical records after the index CT or until the occurrence of a cardiovascular event. Patients were excluded if non-contrast chest CT images were unavailable or non-diagnostic, or if cardiovascular events were attributable to non-atherosclerotic causes, such as valvular heart disease, infective endocarditis, severe arrhythmia, or stroke from non-atherosclerotic etiologies.

Data collection

Clinical and demographic data were retrieved from electronic medical records, including age, sex, body mass index (BMI), smoking status, diabetes mellitus, hypertension, and dyslipidemia. These comorbidities were identified using physician documentation and International Classification of Diseases, Tenth Revision (ICD-10) codes: F17 for smoking, E11 for diabetes, I10 for hypertension, and E78 for dyslipidemia. Cardiovascular events within five years after the index CT were identified using ICD-10 codes: I21-I25 for ischemic heart disease, I63 for ischemic stroke, I50 for heart failure, and Z95.1 or Z95.5 for coronary revascularization performed during follow-up (bypass surgery or stent placement). All cardiovascular events including cardiovascular death were confirmed by review of discharge summaries and physician notes. Only ischemic stroke events were included in the analysis; patients with stroke attributable to non-atherosclerotic etiologies were excluded according to the study criteria.

CT image review and vCAC scoring

All chest CT examinations were reviewed using the hospital Picture Archiving and Communication System (PACS) by a radiologist with more than eight years of experience in thoracic imaging, who was blinded to clinical outcomes to minimize observer bias. CAC was evaluated on axial images, using soft tissue window settings (window level 40, window width 400) with a 2.5-mm slice thickness. The CAC severity was classified using the visual coronary artery calcium (vCAC) scoring method^(6, 7), which categorizes CAC into four severity levels: 0 (none) for no visible CAC, 1 (mild) for punctate calcifications (**Figure 1A**), 2 (moderate) for linear or segmental calcifications involving less than one-third of the length of the affected coronary artery (**Figure 1B**), and 3 (severe) for calcifications extending along at least one-third of the vessel length (**Figure 1C**). As for primary analyses, patients were grouped as vCAC=0 or vCAC $\geq$ 1.

Statistical analysis

Statistical analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables, such as age and BMI, were summarized as means with standard deviations (SD) or as medians with interquartile ranges (IQR), depending on data distribution. Categorical variables, including sex and comorbidities, were summarized as counts and percentages. Comparisons between patients with and without incidental CAC (vCAC $\geq$ 1 vs. vCAC = 0) were conducted using the unpaired student *t* - test or Mann-Whitney U test for continuous variables, and the Chi-square test for categorical variables. A *P* < 0.05 was considered statistically significant.

Logistic regression analysis was performed to evaluate associations between potential risk factors-age, sex, BMI $\geq$ 23 kg/m², diabetes, hypertension, dyslipidemia, and smoking-and the presence of incidental CAC (vCAC $\geq$ 1). Results were expressed as odds ratios (ORs) with 95%

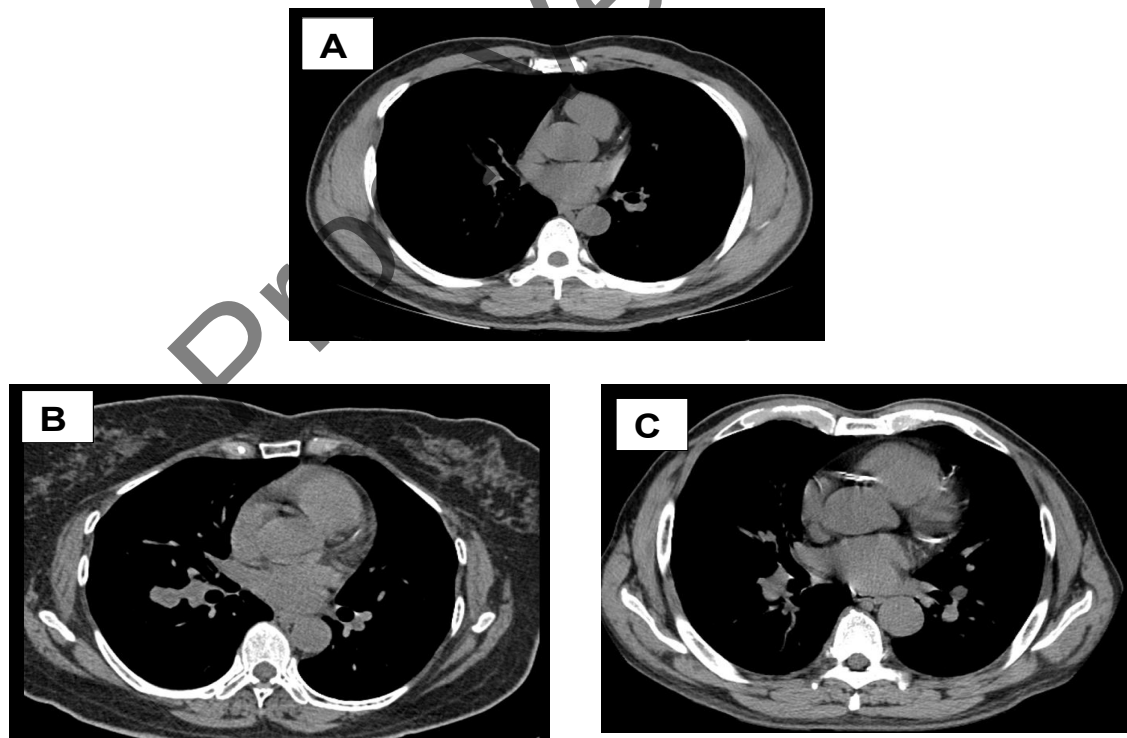


Figure 1. (A) Visual coronary artery calcium (vCAC) score 1 (mild). Axial non-gated chest CT image demonstrates punctate calcification within a coronary artery, consistent with mild CAC. ;(B) Visual coronary artery calcium (vCAC) score 2 (moderate). Axial non-gated chest CT image shows linear or segmental calcification involving less than one-third of the length of the affected coronary artery; (C) Visual coronary artery calcium (vCAC) score 3 (severe). Axial non-gated chest CT image demonstrates extensive calcification extending along at least one-third of the coronary artery length.

confidence intervals (CIs). Both univariate and multivariable models were constructed to assess the significant contribution of each factor.

For analyses examining the relationship between vCAC severity (scores 0-3) and cardiovascular risk factors or cardiovascular events, categorical variables were analyzed using the Chi-square test for trend to evaluate linear associations across ordered CAC categories. Post-hoc pairwise comparisons were performed where appropriate.

Additional analyses were conducted for BMI categories according to the World Health Organization (WHO) Asia-Pacific criteria for Asian populations: < 18.5, 18.5-22.9, 23.0-24.9, 25.0-29.9, and ≥ 30.0 kg/m².⁽⁸⁾ Logistic regression was used to assess the association between each BMI category and the presence of CAC, using the normal BMI group (18.5-22.9 kg/m²) as the reference.

Results

A total of 265 patients met the eligibility criteria and were included in the analysis. The mean age was 59.1 ± 7.5 years (median 60 years, interquartile range [IQR] 55-65 years), and 52.8% were women. The mean BMI was 22.7 ± 4.5 kg/m² (median 22.8 kg/m², IQR 19.4-26.6). Incidental CAC (vCAC ≥ 1) was detected in 144 patients (54.3%). Patients with CAC were significantly older and had higher BMI than those without CAC (Table 1).

Comparisons of cardiovascular risk factors between groups showed that patients with CAC (vCAC ≥ 1) had a higher proportion of male sex, BMI ≥ 23 kg/m², diabetes, hypertension, dyslipidemia, and smoking than those without CAC (vCAC = 0). All differences were statistically significant (all $P < 0.05$; Table 2).

Table 1. Baseline characteristics by vCAC group.

Variable	vCAC = 0	vCAC ≥ 1	P-value
Age, years (mean $\pm$ SD)	56.2 $\pm$ 7.4	61.6 $\pm$ 6.8	<0.001
Age, years (median, IQR)	58 (51–62)	63 (59–67)	<0.001
BMI, kg/m ² (mean $\pm$ SD)	21.8 $\pm$ 4.5	23.9 $\pm$ 3.9	<0.001
BMI, kg/m ² (median, IQR)	21.5 (17.9–25.8)	23.8 (20.8–28.4)	<0.001

Baseline demographic and clinical characteristics stratified by the presence of incidental coronary artery calcification (vCAC). Values are presented as mean $\pm$ standard deviation (SD) or median (interquartile range [IQR]).

Table 2. Cardiovascular risk factors by vCAC group

Risk factor	vCAC = 0 n (%)	vCAC ≥ 1 n (%)	P-value
Male sex	45 (37.2)	80 (55.6)	0.003
BMI ≥ 23 kg/m ²	27 (22.3)	48 (33.3)	0.047
Diabetes mellitus	11 (9.1)	36 (25.0)	0.001
Hypertension	16 (13.2)	47 (32.6)	<0.001
Dyslipidemia	20 (16.5)	51 (35.4)	<0.001
Smoking	3 (2.5)	22 (15.3)	<0.001

Comparison of cardiovascular risk factors between patients with and without incidental coronary artery calcification. Values are presented as number of patients (%). Percentages are calculated within each vCAC group.

Table 3. Logistic regression analysis for presence of incidental CAC (vCAC ≥ 1).

Variable	Univariate OR	P-value	Adjusted OR	95% CI	P-value
Age (per year)	1.11	<0.001	1.10	1.06–1.15	<0.001
Male sex	2.11	0.003	1.93	1.07–3.43	0.021
BMI ≥ 23 kg/m ²	1.74	0.047	1.92	1.02–3.55	0.024
Diabetes mellitus	3.33	0.001	1.95	1.15–3.77	0.003
Hypertension	3.18	<0.001	2.12	1.08–4.87	0.028
Dyslipidemia	2.77	<0.001	1.44	1.07–2.92	0.024
Smoking	7.09	0.002	4.65	1.12–16.45	0.003

Univariate and multivariable logistic regression analyses evaluating factors associated with the presence of incidental coronary artery calcification (vCAC ≥ 1). Adjusted odds ratios (ORs) were derived from a multivariable model including age, sex, BMI ≥ 23 kg/m², diabetes mellitus, hypertension, dyslipidemia, and smoking. OR = odds ratio; CI = confidence interval.

Table 4. Cardiovascular risk factors stratified by vCAC score

Variable	vCAC 0 (n = 121)	vCAC 1 (n = 56)	vCAC 2 (n = 60)	vCAC 3 (n = 28)	P for trend
Age, mean (years)	56.2	59.1	62.4	65.0	<0.001
BMI ≥ 23 kg/m ²	27 (22.3)	17 (30.4)	22 (36.7)	9 (32.1)	0.012
Male sex	45 (37.2)	26 (46.4)	29 (48.3)	25 (89.3)	<0.001
Hypertension	16 (13.2)	14 (25.0)	20 (33.3)	13 (46.4)	<0.001
Diabetes mellitus	11 (9.1)	11 (19.6)	12 (20.0)	13 (46.4)	<0.001
Dyslipidemia	20 (16.5)	18 (32.1)	22 (36.7)	11 (39.3)	<0.001
Smoking	3 (2.5)	5 (8.9)	9 (15.0)	8 (28.6)	<0.001

Distribution of cardiovascular risk factors according to visual coronary artery calcium (vCAC) score. Values are presented as number of patients (%) unless otherwise specified. *P* for trend was calculated using appropriate trend tests according to variable type.

Table 5. Types of cardiovascular events according to vCAC group

Cardiovascular event	vCAC = 0 (n = 121)	vCAC ≥ 1 (n = 144)
Any cardiovascular event	4 (3.3)	21 (14.6)
Myocardial infarction	0	7
Stroke	3	9
Heart failure	2	10
Coronary revascularization	0	6
Cardiovascular death	0	2

Distribution of cardiovascular events in patients with and without incidental coronary artery calcification. Values are presented as the number of patients. Percentages are shown only for the overall cardiovascular event rate. Some patients experienced more than one cardiovascular event during follow-up; therefore, the total number of events exceeds the total number of patients with events.

Table 6. Cardiovascular event rates by vCAC score.

vCAC score	No CVD n (%)	CVD n (%)
0	117 (96.7)	4 (3.3)
1	54 (96.4)	2 (3.6)
2	48 (80.0)	12 (20.0)
3	21 (75.0)	7 (25.0)
P for trend		<0.001

Cardiovascular event rates during five-year follow-up according to visual coronary artery calcification (vCAC) score. Values are presented as number of patients (%). *P* for trend was calculated using the chi-square test for trend.

Logistic regression analysis demonstrated that age, male sex, BMI ≥ 23 kg/m², diabetes, hypertension, dyslipidemia, and smoking were significantly associated with the presence of CAC (vCAC ≥ 1) in univariate analysis. In the multivariable model, older age, male sex, BMI ≥ 23 kg/m², diabetes, hypertension, dyslipidemia, and smoking remained significantly associated with CAC, with smoking showing the highest adjusted OR of 4.65 (95% CI 1.12–16.45) (**Table 3**).

When patients were further stratified according to vCAC severity (scores 0-3), an overall increasing trend in age and cardiovascular risk factors was observed with increasing vCAC scores. The prevalence of BMI ≥ 23 kg/m², male sex, diabetes, hypertension, dyslipidemia, and smoking showed a significant increasing trend across higher vCAC categories (all *P* for trend < 0.05; **Table 4**).

During the five-year follow-up period, 25 patients experienced at least one cardiovascular event, with a total of 39 cardiovascular events recorded. Cardiovascular events were observed in both patients with and without CAC, with stroke and heart failure being the most common events. Myocardial infarction, coronary revascularization, and cardiovascular death occurred exclusively in patients with CAC (**Table 5**). Cardiovascular events were significantly more frequent in patients with CAC than in those without CAC (14.6% vs. 3.3%), corresponding to an approximately fourfold higher event rate. A significant increasing trend in cardiovascular event rates across vCAC categories was observed, with event rates of 3.3% for score 0, 3.6% for score 1, 20.0% for score 2, and 25.0% for score 3 (*P* for trend < 0.001; **Table 6**).

Table 7. Pairwise comparisons of cardiovascular events by vCAC score

Comparison	P-value	Interpretation
0 vs 1	1.000	Not significant
0 vs 2	0.001	Significant
0 vs 3	<0.001	Significant
1 vs 2	0.015	Significant
1 vs 3	0.009	Significant
2 vs 3	0.800	Not significant

Post-hoc pairwise comparisons of cardiovascular event rates between vCAC score categories. *P*-values were calculated using pairwise comparisons following the overall trend analysis.

Table 8. Association between BMI categories and presence of incidental CAC

BMI category (kg/m ²)	vCAC = 0 n	vCAC ≥ 1 n	Total n	% with CAC	OR	95% CI	P-value
<18.5	7	3	10	30.0	0.40	0.10–1.60	0.20
18.5–22.9	87	93	180	51.7	Reference	–	–
23.0–24.9	22	18	40	45.0	0.77	0.38–1.52	0.45
25.0–29.9	5	28	33	84.8	5.24	1.94–14.18	0.001
≥ 30.0	0	2	2	100	Unstable	–	–

Association between body mass index (BMI) categories and the presence of incidental coronary artery calcification (vCAC ≥ 1). Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using univariate logistic regression, with BMI 18.5–22.9 kg/m² as the reference category. BMI categories were defined according to the World Health Organization Asia-Pacific classification. Estimates for the BMI ≥ 30.0 kg/m² category should be interpreted with caution due to the very small sample size.

Pairwise comparisons confirmed that cardiovascular risk became significantly elevated beginning at vCAC ≥ 2, whereas the difference in event rates between vCAC = 0 and vCAC = 1 was not statistically significant (**Table 7**).

Additional analysis of BMI categories showed that individuals with BMI 25.0–29.9 kg/m² had a notable association with presence of CAC (vCAC ≥ 1) (**Table 8**). Although all patients with BMI ≥ 30 kg/m² exhibited detectable CAC, the group consisted of only two individuals (n = 2), limiting statistical interpretability.

Discussion

This study demonstrates that incidental coronary artery calcification (CAC) detected on non-gated chest CT is associated with an increased risk of future cardiovascular events among Thai adults without known cardiovascular disease. More than half of the patients in this cohort had detectable CAC, and those with CAC experienced an approximately fourfold higher cardiovascular event rate over five years compared with patients without CAC. The findings emphasize the clinical relevance of incidental CAC identified on routine chest CT.

The observed association between incidental CAC and cardiovascular events in our study is consistent with prior international studies. Kirsch et al. reported that patients in whom CAC was documented on chest CT had higher rates of cardiovascular events than those without reported CAC, underscoring the prognostic relevance of this finding.⁽³⁾ Silva et al. observed cardiovascular event rates of approximately 12–15% among patients with CAC over a similar follow-up period, compared with less than 5% in those without CAC.⁽²⁾ Wetscherek et al. also found that incidental CAC on non-gated CT thorax was associated with a markedly higher incidence of cardiovascular events and death, with event rates of about 14% versus 3% in patients with and without CAC, respectively.⁽¹⁾ A systematic review and meta-analysis by Osborne-Grinter et al. confirmed that incidental CAC on non-gated thoracic CT is associated with a two- to fourfold increase in cardiovascular risk compared with the absence of CAC.⁽⁴⁾ The magnitude of risk observed in our study, in which patients with vCAC ≥ 1 had a cardiovascular event rate of 14.6% compared with 3.3% in those with vCAC = 0, aligns well with these prior findings. Although CAC primarily reflects coronary atherosclerosis, it is increasingly recognized

as a marker of overall atherosclerotic burden and future cardiovascular risk.^(5,6) In the present study, all stroke events included in the composite cardiovascular outcome were ischemic strokes. Previous studies evaluating incidental CAC on non-gated chest CT have demonstrated associations with a broad range of cardiovascular outcomes, including myocardial infarction, stroke, heart failure, cardiovascular mortality, and composite cardiovascular events.^(1,2,4) Therefore, ischemic stroke was retained in the outcome definition of this study to reflect the broader atherosclerotic cardiovascular risk associated with CAC.

This study also shows that traditional cardiovascular risk factors-including age, male sex, elevated BMI, diabetes, hypertension, dyslipidemia, and smoking-are associated with both the presence and severity of CAC. These factors are well-established cardiovascular risk factors and are commonly incorporated into cardiovascular risk prediction models used in clinical practice. The associations between clinical risk factors and CAC severity support the concept that CAC may serve as an imaging marker of cumulative atherosclerotic burden.

Among BMI categories based on the WHO Asia-Pacific classification, individuals with BMI 25.0-29.9 kg/m² (obesity class I) demonstrated the relatively notable association with incidental CAC. This observation is consistent with prior evidence indicating that Asian populations experience elevated cardiovascular risk at lower BMI thresholds compared with Western populations.⁽⁸⁾ Although all patients with BMI ≥ 30 kg/m² in our study had detectable CAC, the very small sample size in this subgroup (n = 2) limits the interpretability of these results. Nonetheless, the association observed in individuals with BMI 25.0-29.9 kg/m² highlights the importance of recognizing increased cardiovascular risk in Asian patients who may not be classified as obese under conventional Western BMI criteria.

Patients with vCAC score 1 did not exhibit a significantly higher risk of cardiovascular events compared with those with score 0, suggesting that small punctate calcifications may have limited prognostic value. In contrast, the sharp increase in event rates observed at vCAC ≥ 2 suggests that this category may represent a relevant prognostic threshold for cardiovascular risk. These findings are consistent with the work of Urzua Fresno et al., who emphasized that CAC severity-not merely its presence-is the key determinant of risk.⁽⁷⁾

Incidental CAC including its severity has demonstrated prognostic utility in multiple studies^(1-4, 6-7) and provides a practical approach to cardiovascular risk assessment during routine chest CT interpretation. This method enables opportunistic risk stratification using standard non-gated chest CT, without additional radiation exposure or the need for ECG-gated acquisition or specialized Agatston scoring software.

In Thai healthcare settings, incorporating incidental CAC assessment into structured radiology reports may allow radiologists to play a more active role in early cardiovascular risk detection. This approach may also support timely preventive evaluation in patients without known cardiovascular disease.

A major strength of this study is the use of real-world clinical data from a large urban public hospital, together with a five-year follow-up period that allowed the assessment of clinically relevant cardiovascular outcomes.

However, several limitations should be acknowledged. First, the retrospective single-center design may introduce selection bias and limit generalizability to other populations. Second, outcome ascertainment relied on electronic medical records, which may be incomplete or subject to misclassification. Third, because all CT images were interpreted by a single radiologist, inter-observer variability could not be assessed. Fourth, although the association between higher BMI and CAC was statistically significant, the very small number of individuals with BMI ≥ 30 kg/m² (n = 2) limits interpretation in this subgroup. Finally, although visual CAC scoring does not provide quantitative measurements such as Agatston scores, it demonstrated prognostic stratification in this cohort, with higher cardiovascular event rates observed across increasing vCAC categories.

Patients with incidental CAC demonstrated a higher risk of cardiovascular events. CAC severity (vCAC score) provided more informative prognostic stratification than CAC presence alone. Routine assessment and reporting of incidental CAC on non-gated chest CT may provide a practical approach to enhance cardiovascular risk stratification in routine radiology practice.

Conclusion

Incidental coronary artery calcification detected on non-gated chest CT is associated with future cardiovascular events in Thai adults without prior cardiovascular disease. Both the presence and severity

of CAC provide valuable prognostic information in addition to conventional clinical risk factors. Patients with $vCAC \geq 1$ experienced a significantly higher risk of cardiovascular events, and individuals with $vCAC \geq 2$ demonstrated higher event rates. These findings support the routine assessment and reporting of incidental CAC on non-gated chest CT to facilitate early cardiovascular risk stratification and contribute to improved cardiovascular disease prevention efforts in Thailand.

Author contributions

Jitanart Tantisirivit contributed substantially to the conception and design of the study, data acquisition, literature review, data analysis, interpretation of data, and drafting and critical revision of the manuscript.

The author approved the final version submitted for publication and takes responsibility for the integrity and accuracy of the work.

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Conflict of interest statement

The author declares no conflicts of interest, either academic or financial, and did not receive external funding for this study.

Data sharing statement

The datasets generated and/or analyzed during the current study are not publicly available due to patient confidentiality and institutional regulations but are available from the corresponding author on reasonable request and with permission from BMA General Hospital and the relevant ethics committee.

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