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# Is the epicardial adipose tissue area on non-ECG gated low-dose chest CT useful for predicting coronary atherosclerosis in an asymptomatic population considered for lung cancer screening?

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## Abstract

**Objects** The purpose was to determine whether the epicardial adipose tissue (EAT) area on low-dose chest CT (LDCT) could be used to predict coronary atherosclerosis in an asymptomatic population considered for lung cancer screening.

**Methods** Subjects aged 55-80 years with smoking history who underwent both LDCT and coronary CT angiography (CCTA) were retrospectively enrolled. Correlation between the EAT volume in CCTA and EAT area in LDCT was evaluated. Coronary risk factors including the body surface area (BSA) indexed EAT area were compared between coronary plaque negative and positive groups. Significant factors for predicting coronary atherosclerosis were analyzed with logistic regression analysis. Receiver-operating characteristic curve analysis was performed to determine the cutoff value.

**Results** A total of 438 subjects were enrolled, including 299 subjects with coronary atherosclerosis. There was a good correlation between the EAT volume in CCTA and EAT area in LDCT ($\rho = 0.712$, $p < 0.001$). There were significant differences in age, systolic blood pressure, all BSA indexed EAT area, sex, and hypertension between plaque negative and positive groups. In multivariate logistic regression for the BSA indexed EAT area in LDCT at the RCA level, sex (OR: 11.168, 95% CI: 2.107-59.201, $p = 0.005$), systolic blood pressure (OR: 1.021, 95% CI: 1.005-1.036, $p = 0.009$), hypertension (OR: 1.723, 95% CI: 1.103-2.753, $p = 0.017$), and EAT area (OR: 1.273, 95% CI: 1.154-1.405, $p < 0.001$) were significant. The area under the curve of the BSA indexed EAT area in LDCT at the RCA level for coronary atherosclerosis was 0.657, and the cut-off value was 7.66 $cm^2/m^2$.

**Conclusion** The EAT area in LDCT could be used to predict coronary atherosclerosis in an asymptomatic population considered for lung cancer screening.

**Key Points**

- *To quantify EAT, the EAT area in LDCT can be used instead of the EAT volume in CCTA.*
- *The EAT area measured in LDCT can be used as a predictor of coronary artery disease.*
- *The extensive CAD group tended to have a greater EAT area than the non-extensive CAD group.*

**Keywords** Coronary artery disease · Pericardium · Adipose tissue · Computed tomography angiography · Multidetector computed tomography

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**Abbreviations and acronyms**

| | |
|---|---|
| A_CCTA | EAT area in CCTA |
| A_LDCT | EAT area in LDCT |
| $A^{LM}$_LDCT | EAT area in LDCT at LM |
| $A^{RCA}$_LDCT | EAT area in LDCT at RCA |
| AUC | Area under the curve |
| BMI | Body mass index |
| BSA | Body surface area |
| CAD | Coronary artery disease |
| CCTA | Coronary CT angiography |
| CIs | Confidence intervals |

| | |
|---|---|
| CT | Computed tomography |
| DBP | Diastolic blood pressure |
| EAT | Epicardial adipose tissue |
| HDL | High-density lipoprotein |
| HU | Hounsfield units |
| IRB | Institutional Review Board |
| LDCT | Low-dose chest computed tomography |
| LDL | Low-density lipoprotein |
| LM | Left main coronary artery |
| MI | Myocardial infarction |
| MRI | Magnetic resonance imaging |
| NLST | National Lung Screening Trial |
| OR | Odds ratios (ORs) |
| RCA | Right coronary artery |
| ROC | Receiver-operating characteristic |
| SBP | Systolic blood pressure |
| USPSTF | US Preventive Services Task Force |
| V_CCTA | EAT volume in CCTA |

## Introduction

Epicardial adipose tissue (EAT) is a visceral thoracic fat located within the pericardium [1]. EAT originating from the splanchnopleuric mesoderm has higher lipolysis and lipogenesis rates than other adipose tissues of the body [2]. It exerts an inflammatory effect on the coronary arteries by releasing cytokines such as tumor necrosis factor-alpha and interleukin-6 [3]. As EAT surrounds the coronary arteries, it is presumed to play a key role in the development of coronary artery disease (CAD). Previous studies have suggested that EAT could be used to predict CAD [4–9].

Several methods can be used to quantify EAT, including measurement of its thickness, area, or volume using echocardiography, computed tomography (CT), or magnetic resonance imaging (MRI). Echocardiography can be used to measure EAT thickness at the right ventricular free wall or left ventricular lateral wall [10–12]. This method is easily accessible and cost-effective. However, it is dependent on the operator. In addition, it has lower accuracy than other methods such as area or volume measurement by CT or MRI [6, 7, 13]. EAT volume measurement is regarded as the most accurate method [13]. However, it takes a long time to measure EAT compared with other methods. ECG-gated cardiac CT has been widely used for EAT volume measurement. However, radiation hazard and contrast media usage are its limitations. Although MRI is a radiation-free modality, it is relatively expensive. It also takes a long time to scan.

According to the National Lung Screening Trial (NLST), low-dose chest CT (LDCT) screening can lower the lung cancer-specific and all-cause mortality rate [14]. Therefore, using LDCT for lung cancer screening has been increasing in frequency recently. According to the U.S. Preventive Services Task Force (USPSTF) recommendation for lung cancer screening [15], subjects aged 55 to 80 years with 30 pack-year smoking history, those who currently smoke, or those who have quit smoking within the past 15 years have to be included in lung cancer screening. Old age and smoking are also classic risk factors for cardiovascular diseases [16]. Thus, those who undergo LDCT for lung cancer screening share risk factors for cardiovascular diseases. LDCT has more merits than cardiac CT because of the lower radiation dose and non-usage of contrast media. Recently, incorporation of coronary artery calcium scoring into LDCT has been recommended because of its potential benefit for the early detection and treatment of CAD [17]. It might be meaningful if LDCT could be used to evaluate CAD risk by measuring EAT as well as lung cancer screening.

Therefore, the objective of this study was to determine whether non-ECG gated LDCT could be used to predict coronary atherosclerosis by measuring the EAT area in an asymptomatic population considered for lung cancer screening.

## Materials and methods

### Ethics statement

This study was approved by the Institutional Review Board (IRB) and Ethics Committee of our institution. Analyses were performed retrospectively. Informed consent was waived because the data were analyzed anonymously in accordance with the guidelines of the IRB. This study was conducted in compliance with the ethical principles of the Helsinki Declaration of 1964, revised by World Medical Organization in Edinburgh in 2000.

### Study participants

Asymptomatic self-referred subjects who underwent both LDCT for lung cancer screening and coronary CT angiography (CCTA) for evaluation of CAD in our health promotion center from June 2010 to December 2015 were retrospectively enrolled. Among 2,036 subjects, those aged 55 to 80 years who had a smoking history were included according to the USPSTF recommendation for lung cancer screening [15]. Subjects who had history of myocardial infarction and those whose CCTA image quality was poor for coronary artery evaluation were excluded. Finally, 438 subjects were enrolled for this study (Fig. 1).

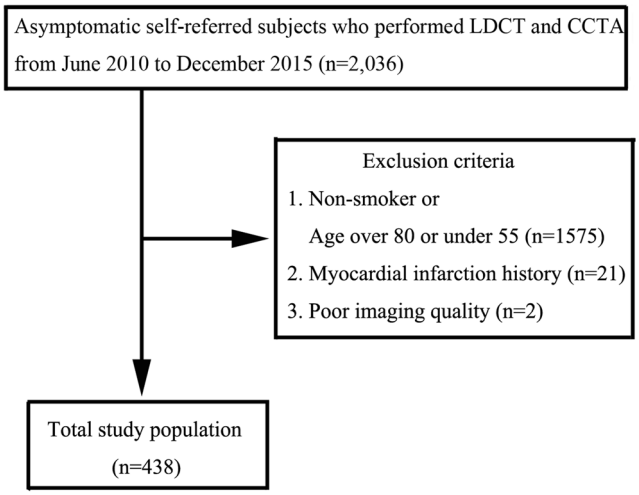


**Fig. 1** Flow chart showing the selection process for the study population. LDCT: Low-dose chest CT; CCTA: coronary CT angiography

## CT image acquisition

Both LDCT and ECG-gated CCTA were performed with a 64-detector-row CT scanner (Brilliance 64, Philips Medical Systems) in one session without changing the body position. Subjects whose heart rates were > 65 beats/min were given an oral beta-blocker (Betaloc 0.5T, metoprolol, Yuhan). Before the examination, all subjects were given nitroglycerin (nitroglycerin tab 0.6 mg, glyceryl trinitrate, Myungmoon). Non-ECG gated LDCT was performed at 120 kV, 40 mAs, 64 × 0.625-mm detector collimation, and 0.5-s gantry rotation time. The entire lung from the lung apex to the costophrenic angle was covered. The standard CCTA protocol was then applied. A bolus of 80 ml contrast agent (Ultravist 370, Schering) was injected intravenously at a rate of 5 ml/s followed by subsequent injection of a 40-ml mixture of saline and contrast agent chase (at a ratio of 7:3). As soon as the density in the ascending aorta reached a predefined threshold of 100 Hounsfield units (HU), the scan was started automatically with a 6-s scan delay. The entire volume of the heart was scanned during one breath-hold (8–10 s) with simultaneous recording of the ECG trace. For CCTA, imaging parameters were as follows: 120 kV, 800-1,000 mAs/slice, 64 × 0.625-mm detector collimation, and 420-ms gantry rotation time.

## Data acquisition

Electronic medical records of subjects were retrospectively analyzed to collect data about age, sex, hypertension, diabetes mellitus, dyslipidemia, history of myocardial infarction (MI), family history of myocardial infarction, systolic blood pressure (SBP), diastolic blood pressure (DBP), body mass index (BMI), hemoglobin, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglyceride levels. Body surface area (BSA) was calculated with the Mosteller formula based on the subject's weight (kg) and height (cm). The CCTA was reviewed on a dedicated workstation (Extended Brilliance Workspace, Philips Medical Systems). Atherosclerotic plaques were evaluated for all coronary arteries in CCTA. Structure clearly assignable to the vessel wall with density less than the lumen contrast was classified as a non-calcified plaque. Any structure in the enhanced coronary lumen with a density of ≥ 130 HU was defined as a calcified plaque [18, 19]. If subjects had any calcified, mixed, or non-calcified plaque anywhere in the coronary artery on CCTA, he/she was allocated to the atherosclerosis group. We divided the coronary arteries based on the 17-segment model defined by the American Heart Association (AHA), which is widely used in clinical practice. [20, 21] Additionally, ramus intermedius (RI) artery is added in our segmentation system. Then, we measured the number of coronary arteries with plaque among 18 coronary arteries. According to the number of involved coronary artery segments, severity was categorized as non-extensive (≤ 4 segments) or extensive CAD (> 4 segments) [22].

## Epicardial adipose tissue quantification

EAT was quantified using a commercially available software tool (Xelis Cardiac, INFINITT Healthcare). The EAT area was measured manually by tracing the pericardium in both the LDCT and CCTA at the left main coronary artery (LM) and right coronary artery (RCA) ostium levels. EAT with fat density of -250 to -50 HU was analyzed digitally (Fig. 2). The EAT area was then corrected against the BSA. The BSA indexed EAT area ($cm^2/m^2$) was calculated by dividing the EAT area by the BSA [23, 24]. EAT volume was calculated as the summation of EAT volume of each 1-cm thick axial

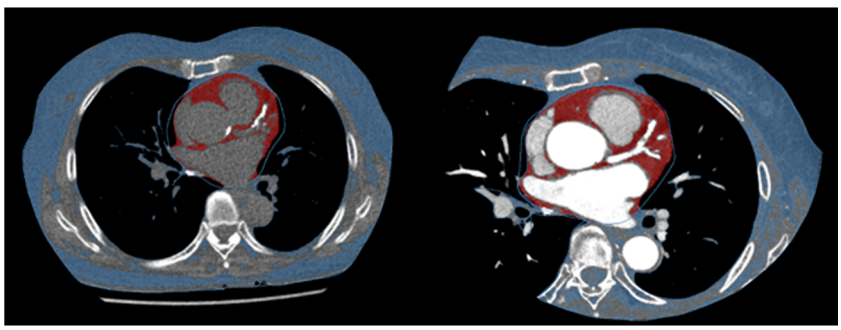

**Fig. 2** Pericardium is manually traced at the left main coronary artery level in both (a) LDCT and (b) CCTA. Epicardial adipose tissue with fat density of -250 to -50 HU is analyzed digitally

slice slab from the bifurcation level of the pulmonary trunk to the cardiac apex (Fig. 3).

### Statistical analyses

Continuous variables are presented as mean ± standard deviation while categorical variables are presented as percentages. Correlation between the EAT volume in CCTA (V_CCTA) and EAT area in LDCT at LM ($A^{LM}$_LDCT) and RCA ($A^{RCA}$_LDCT) levels were evaluated using Pearson's correlation coefficient. The correlation between the EAT area in CCTA and EAT area in LDCT at LM and the RCA levels was also evaluated using Pearson's correlation coefficient. To analyze the difference according to the presence or absence of coronary atherosclerosis, Student's t-test was used for continuous variables, while the chi-squared test was used for categorical variables. Both univariate and multivariate logistic regression analyses were performed to determine whether the EAT area and other variables were significant factors for predicting coronary atherosclerosis. Odds ratios (ORs) and 95% confidence intervals (CIs) for atherosclerosis were calculated. The relationship between the extent of CAD and the EAT area was compared using ANOVA. Additionally, receiver-operating characteristic (ROC) curve analysis was performed to evaluate the cutoff value, sensitivity, and specificity. All analyses were conducted using SPSS version 22.0 (SPSS Inc.). A $p$ value < 0.05 was considered statistically significant.

## Results

### General characteristics

A total of 438 subjects were enrolled (Fig. 1). General characteristics of these enrolled subjects are summarized in Table 1. Their mean age was 60.61 ± 5.07 years. There were 430 male subjects. A total of 299 subjects had plaque in the coronary artery on CCTA.

### The relationship between EAT volume in CCTA and EAT area in LDCT

The relationship between EAT volume in CCTA (V_CCTA) with EAT area in LDCT at the LM and RCA ostium levels in 50 subjects is shown in Fig. 4. V_CCTA had good correlation with the EAT area in LDCT at LM ($A^{LM}$_LDCT) and EAT area in LDCT at the RCA ($A^{RCA}$_LDCT) ($\rho$ = 0.725 and $\rho$ = 0.712, respectively, both $p$ < 0.001). Excellent correlation was found between the EAT area in LDCT and EAT area in CCTA at the LM and RCA ostium levels in all 438 subjects ($\rho$ = 0.97 and $\rho$ = 0.95, respectively, both $p$ < 0.001, Fig. 5).

### Different risk factors between the plaque-negative and -positive group

Differences in risk factors including the BSA indexed EAT area between the plaque-negative and -positive groups are summarized in Table 2. There were significant differences in age (59.59 ± 4.86 years vs. 61.08 ± 5.09 years, $p$ = 0.004), SBP (119.60 ± 14.89 mmHg vs. 124.78 ± 14.69 mmHg, $p$ = 0.001), all BSA indexed EAT areas (BSA indexed $A^{LM}$_LDCT: 7.53 ± 3.09 $cm^2$ vs. 8.98 ± 3.27 $cm^2$; BSA indexed $A^{RCA}$_LDCT: 7.27 ± 2.37 $cm^2$ vs. 8.61 ± 2.55 $cm^2$; BSA indexed $A^{LM}$_CCTA: 7.76 ± 2.96 $cm^2$ vs. 9.51 ± 3.30 $cm^2$; BSA indexed $A^{RCA}$_CCTA: 7.31 ± 2.34 $cm^2$ vs. 8.77 ± 2.50 $cm^2$, all $p$ < 0.001), sex (95.7% vs. 99.3%, $p$ = 0.014), and hypertension (32.4% vs. 49.5%, $p$ = 0.001) between the plaque-negative and -positive groups. Therefore, age, sex, hypertension, SBP, and EAT area were included in the univariate and multiple logistic regression analyses.

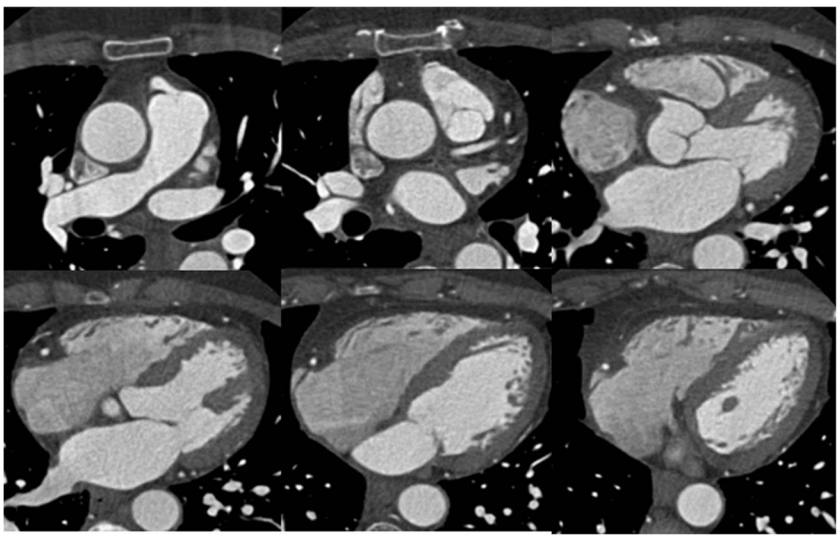

**Fig. 3** EAT volume is calculated by the summation of the EAT volume of each 1-cm-thick slice in coronary CT angiography from the bifurcation level of the pulmonary trunk to the cardiac apex

**Table 1** General characteristics of patients ($n$ = 438)

| Characteristics | *N*=438 |
|---|---|
| Gender (Male) | 430 (98.20%) |
| Age (years) | 60.61 ± 5.07 |
| SBP (mmHg) | 123.14 ± 14.94 |
| DBP (mmHg) | 80.76 ± 10.22 |
| BMI | 24.96 ± 2.67 |
| Hemoglobin (g/dL) | 14.95 ± 1.16 |
| Total cholesterol (mg/dL) | 189.89 ± 36.77 |
| HDL (mg/dL) | 49.72 ± 12.68 |
| LDL (mg/dL) | 119.05 ± 32.83 |
| Triglyceride (mg/dL) | 140.29 ± 81.93 |
| Hypertension (yes) | 193 (44.1%) |
| Diabetes mellitus (yes) | 59 (13.5%) |
| Dyslipidemia (yes) | 83 (18.9%) |
| Family history of MI (yes) | 48 (11.0%) |
| Plaque (+) | 299 (69.53%) |
| - Calcified plaque only | 98 (32.78%) |
| - Non-calcified plaque only | 43 (14.38%) |
| - Extensive CAD | 126 (42.14%) |
| - Non-extensive CAD | 173 (57.86%) |
| $A^{LM}$_LDCT ($cm^2$) | 15.48 ± 6.19 |
| $A^{RCA}$_LDCT ($cm^2$) | 14.83 ± 4.88 |
| $A^{LM}$_CCTA ($cm^2$) | 16.26 ± 6.25 |
| $A^{RCA}$_CCTA ($cm^2$) | 15.05 ± 4.83 |
| BSA i $A^{LM}$_LDCT ($cm^2/m^2$) | 8.52 ± 3.28 |
| BSA i $A^{RCA}$_LDCT ($cm^2/m^2$) | 8.19 ± 2.57 |
| BSA i $A^{LM}$_CCTA ($cm^2/m^2$) | 8.96 ± 3.28 |
| BSA i $A^{RCA}$_CCTA ($cm^2/m^2$) | 8.30 ± 2.54 |

Characteristics are presented as mean ± standard deviation for continuous variables and numbers with percentages for categorical variables

*SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *BMI* Body mass index, *HDL* High density lipoprotein, *LDL* Low density lipoprotein, *MI* Myocardial infarction, *BSA i* BSA indexed, $A^{LM}$_*LDCT* EAT area in LDCT at LM level, $A^{RCA}$_*LDCT* EAT area in LDCT at RCA level, $A^{LM}$_*CCTA* EAT area in CCTA at LM level, $A^{RCA}$_*CCTA* EAT area in CCTA at RCA level

### Result of logistic regression analysis

Results of logistic regression analysis are summarized in Table 3, including the odds ratio (OR), 95% confidence interval (95% CI), and $p$ value for coronary atherosclerosis in CCTA. In multivariate logistic regression for BSA indexed $A^{LM}$_LDCT to predict coronary atherosclerosis, sex (OR: 11.721, 95% CI: 2.109-65.124, $p$ = 0.005), systolic blood pressure (OR: 1.019, 95% CI: 1.004-1.034, $p$ = 0.014), hypertension (OR: 1.665, 95% CI: 1.057-2.623, $p$ = 0.035), and BSA indexed EAT area (OR: 1.155, 95% CI: 1.073-1.245, $p$ < 0.001) were statistically significant. For BSA indexed $A^{RCA}$_LDCT, sex (OR: 11.168, 95% CI: 2.107-59.201, $p$ = 0.005), systolic blood pressure (OR: 1.021, 95% CI: 1.005-1.036, $p$ = 0.009), hypertension (OR: 1.723, 95% CI: 1.103-2.753, $p$ = 0.017), and BSA indexed EAT area (OR: 1.273, 95% CI: 1.154-1.405, $p$ < 0.001) were significant.

### Result of ANOVA

Results of ANOVA are shown in Fig. 6. In the plaque-negative group, the EAT area was significantly lower than in the positive group including both the non-extensive and extensive CAD groups. In the extensive CAD group, the EAT area was higher than in the non-extensive CAD group (BSA indexed $A^{LM}$_LDCT: 9.19 ± 3.22 vs. 8.83 ± 3.30 $cm^2$; BSA indexed $A^{RCA}$_LDCT: 8.93 ± 2.72 vs. 8.38 ± 2.39 $cm^2$; BSA indexed $A^{LM}$_CCTA: 9.76 ± 3.19 vs. 9.33 ± 3.38 $cm^2$; BSA indexed $A^{RCA}$_CCTA: 9.07 ± 2.66 vs. 8.55 ± 2.36 $cm^2$). However, it was not statistically significant.

### Result of ROC curve analysis

Area under the curve (AUC) values of BSA indexed $A^{LM}$_LDCT and BSA indexed $A^{RCA}$_LDCT for coronary atherosclerosis were 0.635 and 0.657, respectively. Their cutoff values were 7.74 and 7.66 $cm^2/m^2$, respectively. Sensitivity and specificity of $A^{RCA}$_LDCT to predict atherosclerosis were 61.2% and 61.9%, respectively.

## Discussion

Our study showed that the EAT area in LDCT could be used to quantify EAT instead of the EAT volume in CCTA and could be used to predict coronary atherosclerosis.

In our study, the BSA indexed EAT area in both CCTA and LDCT was a significant independent factor for coronary atherosclerosis in an asymptomatic population considered for lung cancer screening. This result is consistent with previous studies suggesting that EAT might be related to coronary artery disease [4–9]. In a previous study, an EAT thickness of 5.2 mm has been reported to have a sensitivity of 85% and specificity of 81% for predicting CAD [10]. Another study using a cutoff EAT volume of 75 ml has shown that its sensitivity and specificity for the presence of atherosclerosis are 72% and 70%, respectively [25]. According to ROC curve analysis in this study, subjects whose BSA indexed EAT area at the RCA ostium level in LDCT > 7.76 $cm^2$ were expected to have coronary atherosclerosis with sensitivity of 61.2%. To our knowledge, only one previous study has shown that the EAT area in LDCT is associated with metabolic syndrome [26]. Therefore, our study might be the first study suggesting that the EAT area in LDCT can be used to predict coronary atherosclerosis. In the extensive CAD group, the EAT area

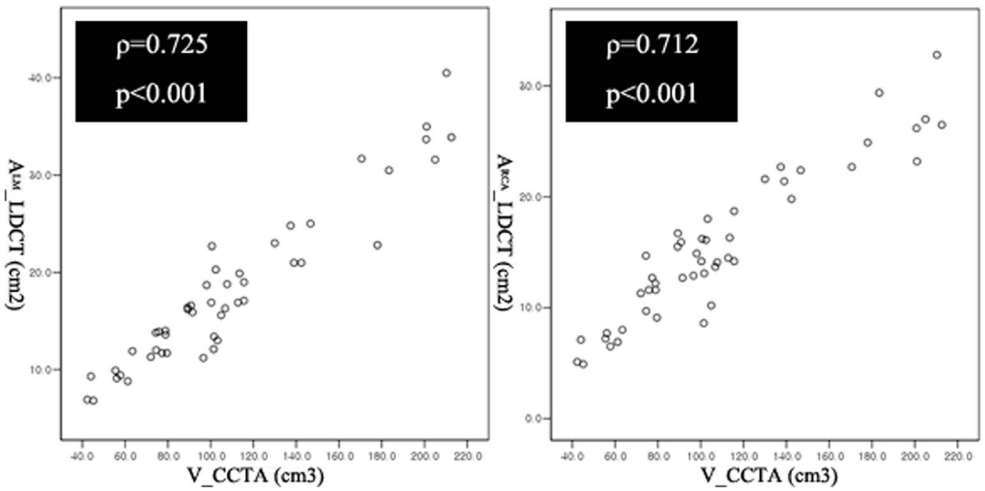


**Fig. 4** Graphs showing the relationship between the EAT volume in CCTA (V_CCTA) and EAT area in LDCT (A_LDCT) at (a) the left main coronary artery level and (b) right coronary artery ostium level ($n$ = 50)

was higher than in the non-extensive CAD group, however, there was no statistical significance.

Old age and smoking history are well-known risk factors for CAD and lung cancer [16]. Our results also showed that 68.3% (299 out of 438) of subjects had coronary atherosclerosis based on CCTA.

The Framingham Heart Study and other population-based cohorts have demonstrated that age, sex, smoking, LDL, total cholesterol, diabetes, and blood pressure can be combined in predictive models to estimate the risk of cardiac events [16, 27]. In our study, the EAT area, sex, SBP, and hypertension were significant factors for predicting coronary atherosclerosis in CCTA in multivariate regression model.

The feasibility of EAT quantification was verified by area measurement in LDCT. Although volume measurement is considered the most accurate method to quantify EAT, it takes approximately 8.5 min to measure the total EAT volume, which is time-consuming in the clinical setting [28]. Therefore, whether the EAT area instead of EAT volume could be used to quantify EAT was determined in this study. Our previous study showed that the EAT volume and EAT area are highly correlated in CCTA [19].

LDCT does not use contrast media. It has the advantage of using a lower radiation dose than CCTA. Therefore, LDCT instead of CCTA was used in this study to quantify EAT. A previous study has suggested that non-ECG gated LDCT could be used to quantify EAT with almost the same concordance and reliability as prospective ECG-gated cardiac CT [29]. To verify these results, the EAT area in LDCT and volume in CCTA were measured for 50 subjects. They showed good correlations. This result supports that the EAT area in LDCT can be used instead of the EAT volume in CCTA to quantify EAT. Furthermore, EAT areas in CCTA and LDCT for 438 patients showed excellent correlations. Therefore, it is feasible to use the EAT area in LDCT as an easily applicable method to quantify EAT.

This study has some limitations. First, it was a single-center and retrospective study. Second, only eight females were enrolled in our study. According to the recent Korea National Health and Nutrition Examination Survey (KNHANES) VI from 2013 to 2015, smoking rates in males and females are

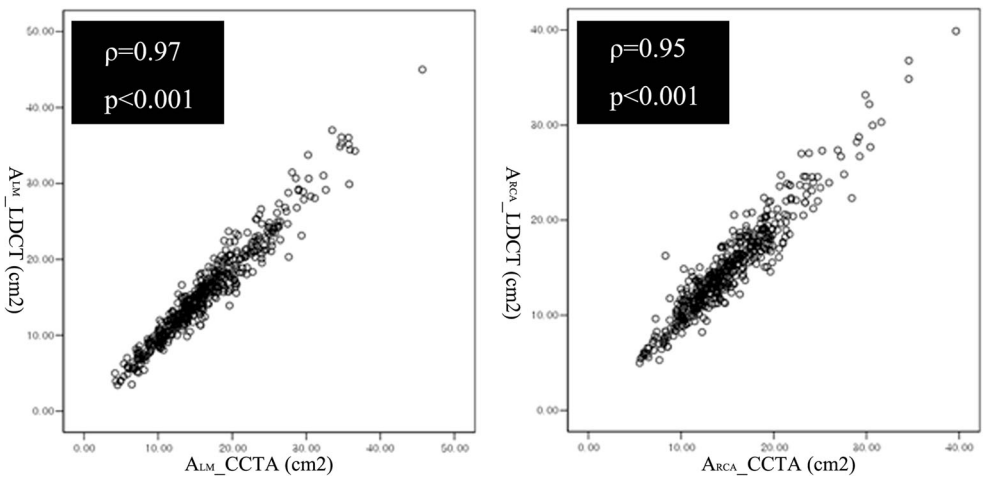


**Fig. 5** Graphs showing the relationship of epicardial adipose tissue area between CCTA (A_CCTA) and LDCT (A_LDCT) at (A) the left main coronary artery level and (B) right coronary artery ostium level ($n$ = 459)

**Table 2** Patient characteristics according to the presence or absence of coronary atherosclerosis

| Characteristics | Plaque | | *p*-value |
|---|---|---|---|
| | Negative (*n*=139) | Positive (*n*=299) | |
| Age | 59.59 ± 4.86 | 61.08 ± 5.09 | 0.004* |
| SBP (mmHg) | 119.60 ± 14.89 | 124.78 ± 14.69 | 0.001* |
| DBP (mmHg) | 79.73 ± 10.78 | 81.24 ± 9.94 | 0.150 |
| BMI | 24.75 ± 2.86 | 25.05 ± 2.57 | 0.273 |
| Hemoglobin (g/dL) | 15.10 ± 1.10 | 14.89 ± 1.18 | 0.084 |
| Total cholesterol (mg/dL) | 190.24 ± 32.41 | 189.73 ± 38.68 | 0.891 |
| HDL (mg/dL) | 49.92 ± 13.57 | 49.63 ± 12.26 | 0.825 |
| LDL (mg/dL) | 119.78 ± 28.33 | 118.72 ± 34.76 | 0.754 |
| Triglyceride (mg/dL) | 134.84 ± 75.11 | 142.82 ± 84.92 | 0.343 |
| Sex (male) | 133 (95.7%) | 297 (99.3%) | 0.014* |
| Hypertension (yes) | 45 (32.4%) | 148 (49.5%) | 0.001* |
| Diabetes mellitus (yes) | 12 (8.6%) | 47 (15.7%) | 0.050 |
| Dyslipidemia (yes) | 24 (17.3%) | 59 (19.7%) | 0.601 |
| Family history of MI (yes) | 14 (10.1%) | 34 (11.4%) | 0.745 |
| $A^{LM}$_LDCT ($cm^2$) | 13.64 ± 5.89 | 16.34 ± 6.15 | <0.001* |
| $A^{RCA}$_LDCT ($cm^2$) | 13.12 ± 4.48 | 15.63 ± 4.86 | <0.001* |
| $A^{LM}$_CCTA ($cm^2$) | 14.03 ± 5.67 | 17.30 ± 6.25 | <0.001* |
| $A^{RCA}$_CCTA ($cm^2$) | 13.18 ± 4.40 | 15.92 ± 4.78 | <0.001* |
| BSA i $A^{LM}$_LDCT ($cm^2/m^2$) | 7.53 ±3.09 | 8.98 ± 3.27 | <0.001* |
| BSA i $A^{RCA}$_LDCT ($cm^2/m^2$) | 7.27 ± 2.37 | 8.61 ± 2.55 | <0.001* |
| BSA i $A^{LM}$_CCTA ($cm^2/m^2$) | 7.76 ± 2.96 | 9.51 ± 3.30 | <0.001* |
| BSA i $A^{RCA}$_CCTA ($cm^2/m^2$) | 7.31 ± 2.34 | 8.77 ± 2.50 | <0.001* |

*$p < 0.05$

*SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *BMI* Body mass index, *HDL* High density lipoprotein, *LDL* Low density lipoprotein, *MI* Myocardial infarction, *BSA i* BSA indexed, $A^{LM}$_*LDCT* EAT area in LDCT at LM level, $A^{RCA}$_*LDCT* EAT area in LDCT at RCA level, $A^{LM}$_*CCTA* EAT area in CCTA at LM level, $A^{RCA}$_*CCTA* EAT area in CCTA at RCA level

43.1% and 5.7%, respectively. Considering the survey, it can be presumed that women did not respond even if they smoked therefore that the proportion of women in this study was much lower than it really was. Third, our study showed that using the EAT area in LDCT to predict coronary atherosclerosis had moderate sensitivity and specificity compared with those

**Table 3** Results of univariate and multivariate logistic analysis

| Characteristics | Univariate analysis | | Multivariate logistic analysis 1 | | Multivariate logistic analysis 2 | |
|---|---|---|---|---|---|---|
| | OR (95% C.I.) | *p*-value | OR (95% C.I.) | *p*-value | OR (95% C.I.) | *p*-value |
| Age | 1.065 (1.019-1.112) | 0.005* | | | | |
| Sex (male) | 6.699 (1.335-33.626) | 0.021* | 11.721 (2.109-65.124) | 0.005* | 11.168 (2.107-59.201) | 0.005* |
| BSA i $A^{LM}$_LDCT ($cm^2/m^2$) | 1.167 (1.086-1.254) | <0.001* | 1.155 (1.073-1.245) | <0.001* | | |
| BSA i $A^{RCA}$_LDCT ($cm^2/m^2$) | 1.271 (1.156-1.397) | <0.001* | | | 1.273 (1.154-1.405) | <0.001* |
| SBP (mmHg) | 1.025 (1.010-1.039) | 0.001* | 1.019 (1.004-1.034) | 0.014* | 1.021 (1.005-1.036) | 0.009* |
| Hypertension (yes) | 2.047 (1.343-3.121) | 0.001* | 1.665 (1.057-2.623) | 0.035* | 1.743 (1.103-2.753) | 0.017* |

*$p < 0.05$

Multivariate logistic regression 1; BSA indexed $LDCT_{area}{}^{LM}$; Multivariate logistic regression 2: BSA indexed $LDCT_{area}{}^{RCA}$ SBP: Systolic blood pressure; BSA i: BSA indexed; $A^{LM}$_LDCT: EAT area in LDCT at LM level; $A^{RCA}$_LDCT: EAT area in LDCT at RCA level

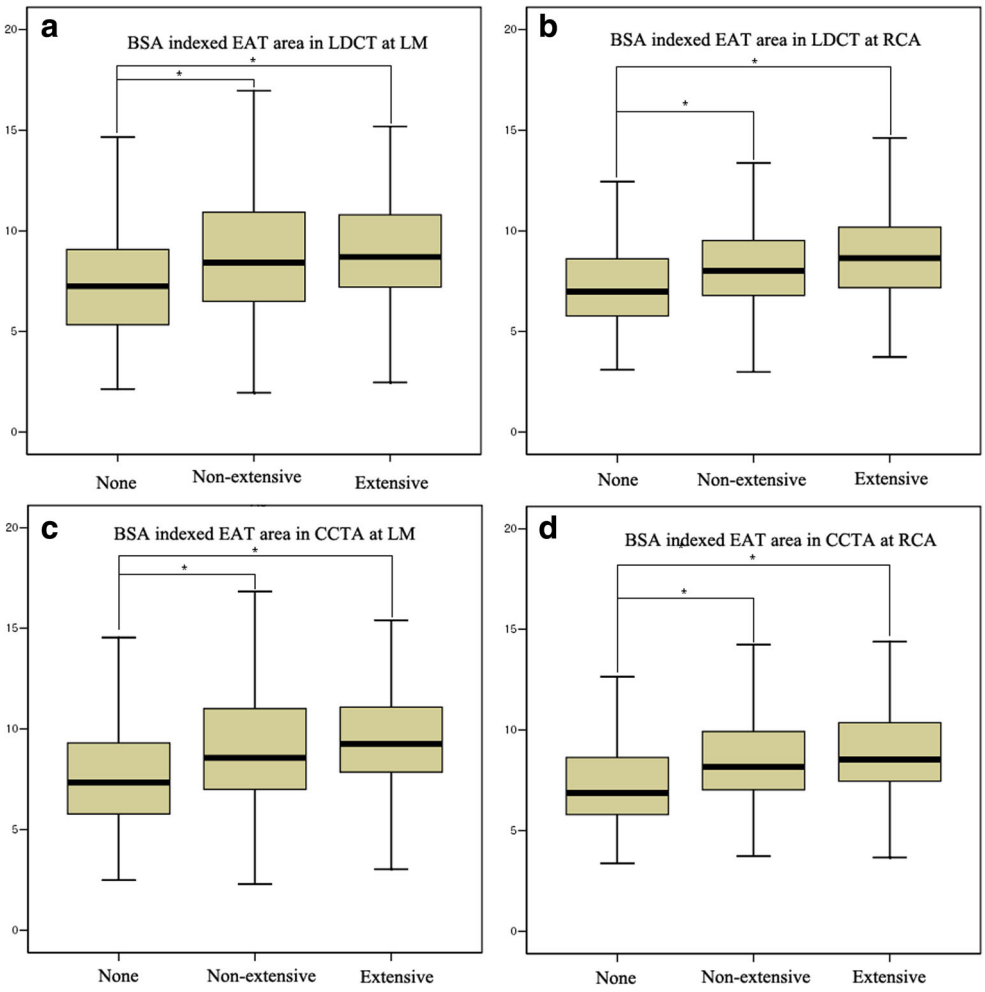


**Fig. 6** Graphs showing the results of ANOVA including (A) BSA indexed $A^{LM}$_LDCT, (B) BSA indexed $A^{RCA}$_LDCT, (C) BSA indexed $A^{LM}$_CCTA, and, (D) BSA indexed $A^{RCA}$_CCTA

values reported in previous studies [10, 25]. This means that the power of EAT quantification for predicting CAD is still limited. According to Tanami et a [30], the clinical significance of quantifying EAT remains uncertain but might be related to the pathophysiology of acute coronary events rather than the presence of atherosclerotic disease. Finally, although the feasibility of using the EAT area for predicting coronary atherosclerosis in CCTA was evaluated, its feasibility for predicting cardiac events was not determined. Although the coronary artery calcium score was reported to be the strongest factor correlated with cardiac events [31], calcified plaque was regarded as coronary atherosclerosis in this study. A few studies have suggested that EAT measurement can be used to predict cardiac events [8, 32]. Further studies are needed to determine whether the EAT area coupled with CAC could be used to predict future cardiac events.

In conclusion, the EAT area in LDCT instead of EAT volume in CCTA can be used to predict coronary atherosclerosis in an asymptomatic population considered for lung cancer screening.

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## Compliance with ethical standards

**Guarantor** The scientific guarantor of this publication is Hwan Seok Yong.

**Conflict of interest** The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

**Statistics and biometry** One of the authors has significant statistical expertise.

**Informed consent** Written informed consent was waived by the Institutional Review Board.

**Ethical approval** Institutional Review Board approval was obtained.

**Methodology**
- Retrospective
- Case-control study
- Performed at one institution

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