Original Article

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대한영상의학회지

Utility of the 16-cm Axial Volume Scan Technique for Coronary Artery Calcium Scoring on Non-Enhanced Chest CT: A Prospective Pilot Study

비 조영증강 흉부 CT에서 관상동맥 칼슘스코어 측정을 위한 16 cm 축상 촬영 기법의 유용성: 전향적 탐색적 연구

So Jung Ki, MD[1], Chul Hwan Park, MD[1], Kyunghwa Han, MD[2], Jae Min Shin, MD[1], Ji Young Kim, MD[1], Tae Hoon Kim, MD[1]*

[1]Department of Radiology and the Research Institute of Radiological Science, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea
[2]Department of Radiology and the Research Institute of Radiological Science, Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

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***Corresponding author**
Tae Hoon Kim, MD
Department of Radiology and the Research Institute of Radiological Science, Gangnam Severance Hospital, Yonsei University College of Medicine, 211 Eonju-ro, Gangnam-gu, Seoul 06273, Korea.

Tel 82-2-2019-3510
Fax 82-2-3462-5472
E-mail thkim1@yuhs.ac

ORCID iDs
So Jung Ki
https://orcid.org/0000-0002-5007-6527
Chul Hwan Park
https://orcid.org/0000-0002-0004-9475
Kyunghwa Han
https://orcid.org/0000-0002-5687-7237
Jae Min Shin
https://orcid.org/0000-0003-4549-3518
Ji Young Kim
https://orcid.org/0000-0002-3727-6436
Tae Hoon Kim
https://orcid.org/0000-0002-4032-1285

Purpose This study aimed to evaluate the utility of the 16-cm axial volume scan technique for calculating the coronary artery calcium score (CACS) using non-enhanced chest CT.

Materials and Methods This study prospectively enrolled 20 participants who underwent both, non-enhanced chest CT (16-cm-coverage axial volume scan technique) and calcium-score CT, with the same parameters, differing only in slice thickness (in non-enhanced chest CT = 0.625, 1.25, 2.5 mm; in calcium score CT = 2.5 mm). The CACS was calculated using the conventional Agatston method. The difference between the CACS obtained from the two CT scans was compared, and the degree of agreement for the clinical significance of the CACS was confirmed through sectional analysis. Each calcified lesion was classified by location and size, and a one-to-one comparison of non-contrast-enhanced chest CT and calcium score CT was performed.

Results The correlation coefficients of the CACS obtained from the two CT scans for slice thickness of 2.5, 1.25, and 0.625 mm were 0.9850, 0.9688, and 0.9834, respectively. The mean differences between the CACS were -21.4% at 0.625 mm, -39.4% at 1.25 mm, and -76.2% at 2.5 mm slice thicknesses. Sectional analysis revealed that 16 (80%), 16 (80%), and 13 (65%) patients showed agreement for the degree of coronary artery disease at each slice interval, respectively. Inter-reader agreement was high for each slice interval. The 0.625 mm CT showed the highest sensitivity for detecting calcified lesions.

Conclusion The values in the non-contrast-enhanced chest CT, using the 16-cm axial volume scan technique, were similar to those obtained using the CACS in the calcium score CT, at 0.625 mm slice thickness without electrocardiogram gating. This can ultimately help predict cardiovascular risk without additional radiation exposure.

Index terms Calcium; Coronary Vessels; Tomography, X-Ray Computed; Coronary Artery Disease

INTRODUCTION

The coronary artery calcium score (CACS) is a quantitative measure of coronary artery calcification, which has a high correlation with the total amount of atherosclerotic plaque and is an independent predictor of coronary artery disease (CAD), and subsequent ischemic heart disease (1-3). There are several methods for calculating the calcium scores, including volume scores and the derived calcium mass; among these, the Agatston score is most widely used (4-6). In this scoring method, calcifications are defined as lesions with attenuation > 130 Hounsfield unit (HU) and size > 1 mm^3, and scores are calculated by multiplying the area and weight of calcification.

The calcium score is generally measured using electrocardiogram (ECG)-gated CT. However, recent studies have shown that calcium scores can also be obtained from non-ECG-gated, conventional chest CT (7-9). These studies have shown a high correlation between the CACS obtained from non-ECG-gated non-enhanced chest CT and that obtained from ECG-gated CT scans. The 2016 Society of Cardiovascular Computed Tomography and Society of Thoracic Radiology guidelines issued recommendations for the qualitative assessment of CACS using non-enhanced chest CT (10). However, there may be certain limitations associated with CACS calculated from non-ECG-gated chest CT owing to cardiac motion. Nonetheless, recent advancements in CT technology can potentially minimize cardiac motion artifacts on chest CT by using a reduced gantry rotation time, and increased detector coverage (11, 12). Therefore, the purpose of this study was to evaluate the feasibility of using the 16-cm axial volume scanning technique to calculate the CACS from non-ECG-gated non-enhanced chest CT imaging.

MATERIALS AND METHODS

This study was reviewed and approved by the Institutional Review Board of our institution (IRB No. 3-2017-0237). Informed consent was obtained from all participants. Twenty-eight patients aged ≥ 50 years who required a chest CT scan for various clinical reasons were prospectively enrolled in this study from December 2017 to April 2018.

First, all 28 patients underwent a non-ECG-gated non-enhanced chest CT. Patients without coronary calcification on visual assessment were excluded from the study. Subsequently, 20 patients underwent an ECG-gated CT, and the CACS was calculated. These 20 patients underwent chest CT for investigating a solitary pulmonary nodule (n = 6, 30%), lung metastasis (n = 6, 30%), primary lung cancer (n = 5, 25%), other pulmonary diseases (n = 2, 10%), and health examination (n = 1, 5%). Finally, the results of the 20 patients were analyzed in this study.

CT PROTOCOLS

All non-ECG gated and ECG-gated CT scans were performed with a 256-slice CT scanner (Revolution CT, GE Healthcare, Chalfont St., Giles, UK). First, non-contrast chest CT without EGC-gating was performed for the 28 patients at the end of inspiration in the supine position. The scan parameters were as follows: 120 kVp; 50-100 mAs (AEC, fixed noise index: 20); 0.625-mm slice thickness; wide detector, 16-cm coverage, and fast gantry rotation time (0.28 sec). A chest CT scan of the region from the thyroid gland level to the adrenal gland level was performed using 2 or 3 axial scanning with a maximal Z-axis coverage of 16 cm. The ECG-gated calcium score CT was immediately performed with the same parameters for 20 patients, (excluding the 8 patients with calcium scores of 0); 120 kVp; 50 mAs; 2.5-mm slice thickness. The chest CT images were reconstructed at 0.625-, 1.25-, and 2.5-mm slice intervals during acquisition. Three sets of chest CT images were stored in the picture archiving and communication system (Centricity 4.0, GE Medical Systems, Mt Prospect, IL, USA) (Table 1).

IMAGE QUALITY ANALYSIS FOR CHEST CT

Two radiologists with more than 10 years of experience in the field of chest radiology evaluated the image quality of the chest CT images (slice thickness: 2.5 mm) with a three-point grading system. The grading system was as follows:

Grade 1: severe artifacts caused by cardiac motion: the CACS cannot be calculated.

Grade 2: some artifacts due to cardiac motion, but the CACS can be calculated.

Grade 3: minimal artifacts and the CACS can be accurately calculated.

CORONARY ARTERY CALCIFICATION SCORE ANALYSIS

The three sets of non-enhanced chest CT images (0.625-/1.25-/2.5-mm slice thickness) and the calcium score CT images were exported to a commercially available analysis software (Aquarius iNtuition TM Ver.4.4.6 TeraRecon, Foster City, CA, USA). Two readers analyzed the CACS. As per the Agatston scoring method, a lesion with attenuation > 130 HU was defined as a calcification, and the calcification area was established using the semi-automated method. Calcium deposition observed in the three coronary arteries was manually selected by the reader, and the area of calcification (mm^2) and weight number of the lesion (1 = 130–199 HU, 2 = 200–299 HU, 3 = 300–399 HU, and 4 = > 400 HU) were automatically multiplied by the program (Fig. 1). The total CACS was calculated by adding the CACS obtained from each artery (4).

Table 1. Acquisition Parameters for Chest CT and Calcium Score CT

	Chest CT	Calcium Score CT
Tube voltage, kVp	120	120
Tube currents, mAs	50–100 (AEC, fixed noise index: 20)	50
Slice thickness, mm	0.625/1.25/2.5	2.5
Coverage length, cm	16	16
Scan mode	Axial	Axial
Rotation time, sec	0.28	0.28
ECG-gating	None	Done

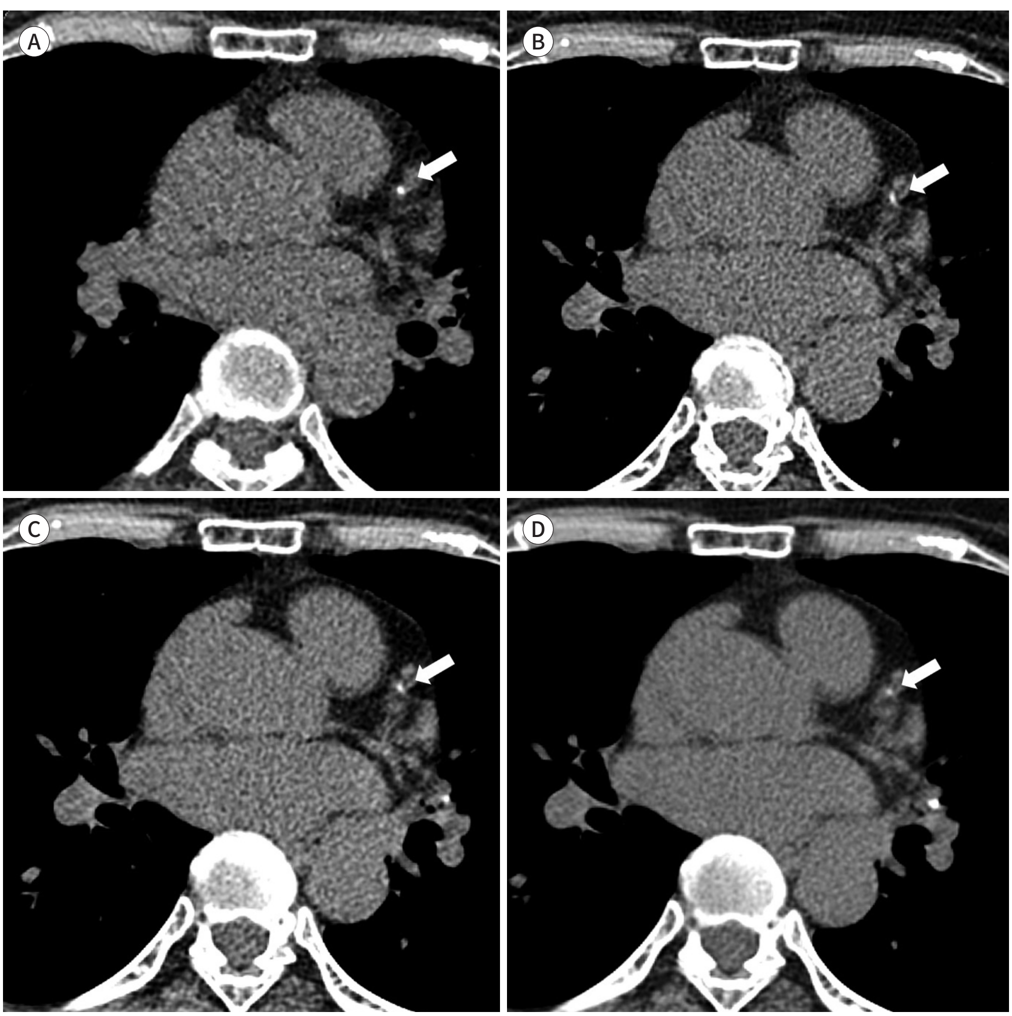
AEC = automatic exposure control, ECG = electrocardiogram

In addition, each calcified plaque's location and length were recorded according to the previously reported guidelines on calcium score CT. Each calcified plaque was additionally checked to determine and compare its visibility on chest CT and calcium score CT.

The CACS was classified into four grades to stratify the risk of CAD for each slice thickness for sectional analysis: minimum, < 10; mild, 10 to < 100; moderate, 100 to < 400; and severe, ≥ 400 (1). The grades from each slice thickness were compared with those obtained from calcium score CT. By comparing the grades obtained from the non-enhanced chest CT and the calcium score CT, the degree of agreement for the clinical significance of CACS was confirmed.

To analyze the effective radiation dose, the volume CT dose index and dose-length product (DLP) were obtained from the patient's dose report. The effective radiation dose was calculated by multiplying the DLP by a conversion factor (chest CT: 0.017 mSv/mGy, calcium score

Fig. 1. Representative image of well visualized calcium on calcium score CT scan and chest CT scan. Discrete calcified plaques (arrows) are observed at mid left anterior descending artery, and each coronary artery calcium score is as follows.
A. Calcium score CT: 7.72.
B. 0.625 mm slice thickness non-enhanced chest CT: 4.18.
C. 1.25 mm slice thickness non-enhanced chest CT: 4.04.
D. 2.5 mm slice thickness non-enhanced chest CT: 0 (not exceeding 130 Hounsfield unit), respectively.



CT: 0.014 mSv/mGy).

STATISTICAL ANALYSIS

Categorical variables were represented as numerical values of frequencies and/or percentages, while continuous variables were denoted as mean ± standard deviation or median (Q1, Q3). The normality of data distribution was evaluated using the Shapiro–Wilk test. Wilcoxon signed-rank test with post-hoc analysis using the Bonferroni method was used to compare the CACS obtained for the calcium score CT and non-enhanced chest CT. Spearman's correlation analyses were performed to compare the CACS obtained from the calcium score CT and the non-enhanced chest CT, and the Bland–Altman analyses were used to determine the limits of agreement between the CACS obtained from the two types of CT. The mean difference was calculated as a percentage value: the difference in the CACS between the calcium score CT and chest CT was divided by the average of the two values and multiplied by 100. Cohen's kappa test was used to evaluate the inter-reader reproducibility of chest CT image quality assessment. One proportion test was used to compare the differences in calcium scoring according to the slice thickness of the chest CT. Generalized estimated equations were used to compare the visualization differences in calcium by plaque length and location. Inter-reader reproducibility of the CACS measurements was verified using the intraclass correlation coefficient (ICC). ICCs values < 0.20, 0.21–0.40, 0.41–0.60, 0.61–0.80, and 0.81–1.00 indicated slight, fair, moderate, substantial, and almost perfect agreement, respectively. R, version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria) was used for all statistical analyses. p values < 0.05 were considered statistically significant.

RESULTS

PARTICIPANT CHARACTERISTICS

The demographic data of the 20 participants (male:female = 13:7, mean age = 67.7 ± 2.1 years) are summarized in Table 2. The mean height, body weight, and heart rate during the scan were 162.8 ± 11.7 cm, 64.2 ± 13.2 kg, and 75.7 ± 13.1 beats per minute, respectively. The mean DLP was 264.2 ± 72.73 mGycm for the non-enhanced chest CT scans and 34.15 ± 23.52 mGycm for the calcium score CT scans. No complications occurred after the CT scan. The CACS and the characteristics of the calcium plaques measured using the calcium score CT and non-enhanced chest CT are summarized in Table 3.

IMAGE QUALITY OF CHEST CT WITH THE 16 CM AXIAL VOLUME SCAN TECHNIQUE

Among the 20 chest CT images of 2.5-mm slice thickness, 13 were graded as 2 and 7 were graded as 3. The inter-reader kappa value for chest CT image quality was 0.780.

CORRELATION OF CORONARY ARTERY CALCIFICATION SCORE ON CALCIUM SCORE CT AND NON-ENHANCED CHEST CT

The median CACS score derived from calcium score CT was 110.4 (15.4, 537.2) for 20 patients. The median CACS in the non-enhanced chest CT with 2.5-, 1.25-, and 0.625-mm slice

Table 2. Demographic Data and Baseline Characteristics of 20 Patients Who Underwent Chest CT Scan and Calcium Score CT Scan

Variables	Values
Age, years	67.7 ± 2.1
Sex, male/female, *n* (%)	13 (65)/7 (35)
Hypertension, *n* (%)	11 (55)
Diabetes, *n* (%)	6 (30)
Dyslipidemia, *n* (%)	4 (20)
Height, cm	162.8 ± 11.7
Weight, kg	64.2 ± 13.5
Heart rate, beats/min	75.7 ± 13.1
Body mass index, kg/m^2	24.2 ± 3.1
DLP of chest CT scan, mGycm, mean ± SD (range)	264.20 ± 72.73, (97.86–481.87)
DLP of calcium score CT scan, mGycm, mean ± SD (range)	34.15 ± 23.52, (13.26–90.40)

DLP = dose-length product, SD = standard deviation

thickness was 59.9 (10.8, 421.1), 81.8 (14.8, 515.2), and 89.9 (15.6, 566.9) respectively. The median CACS for the unenhanced chest CT was significantly lower than that for the calcium score CT for only the 2.5-mm slice thickness (p = 0.039). The p values for the 1.25-mm and 0.625–mm slice thicknesses were 0.103 and 0.529, respectively, which did not show a statistically significant difference. The CACSs obtained from the different slice intervals of non-enhanced chest CT differed significantly from each other (p < 0.05). The CACS exhibited high correlation coefficients of 0.985, 0.969, and 0.983 between calcium score CT and non-enhanced chest CT with slice intervals of 0.625-, 1.25-, and 2.5 mm, respectively (Fig. 2).

BIAS OF CACS BETWEEN CALCIUM SCORE CT AND CHEST CT

The mean differences (%) between the CACS obtained from the calcium score CT and chest CT were -21.4% (95% limit of agreement: -131.0% and 88.2%) for the 0.625-mm slice thickness, -39.4% (95% limit of agreement: -165.8% and 87.0%) for the 1.25-mm slice thickness, and -76.2% (95% limit of agreement, -220.4% and 68.1%) for the 2.5-mm slice thickness (Fig. 3).

SECTIONAL ANALYSIS

The CACS values obtained from the calcium score and non-enhanced chest CT scans were compared. The results of the calcium score CT results showed that 4, 6, 4, and 6 patients had a minimum (1–10), mild (11–100), moderate (101–400) and severe (> 400) risk of CAD, respectively. There were four cases of severity inconsistencies on the 1.25- and 0.625-mm slice thickness chest CT: one case was overestimated and three were underestimated in each slice interval, respectively. The calcium score was underestimated for all three severity inconsistencies on 2.5-mm slice thickness CT (Table 4).

DETECTION RATE OF CHEST CT AND DIFFERENCE IN CALCIUM SCORE ACCORDING TO LOCATION AND LENGTHS

The number of calcium plaques in the 20 subjects in this study was 89. The detection rate of chest CT with a 0.625-mm slice thickness was 96.6 (92.9–100.4), which was significantly higher than those of chest CTs with 1.25-mm (88.8 [82.2–95.3]) and 2.5-mm (67.4 [57.7–77.2]) slice thicknesses (p = 0.016 and p < 0.001, respectively). Regarding the effects of plaque length

Table 3. CACS and Characteristics of Calcium Plaques Measured Using Calcium Score CT and Non-Enhanced Chest CT

Patient	Plaque Count	Each Location (Length)	CACS (Calcium Score CT)	CACS (0.625 mm Chest CT)	CACS (1.25 mm Chest CT)	CACS (2.5 mm Chest CT
1	6	p-RCA (D), m-RCA (D), d-RCA (D) p-LAD (D), p-LAD (D), p-LCx (D)	97.16	74.56	26.46	20.62
2	1	p-LAD (D)	12.32	2.84	0	0
3	9	p-RCA (D), m-RCA (D), d-RCA (T) p-LAD (T), p-LAD (D), p-LAD (D) m-LAD (D), m-LAD (D), p-LCx (D)	547.37	524.16	504.70	463.03
4	4	p-RCA (D), d-RCA (D) p-LAD (Di), m-LAD (Di)	527.00	609.56	575.48	504.50
5	8	p-RCA (D), m-RCA (D), d-RCA (D) p-LAD (T), m-LAD (D), DG (D) p-LCx (D), OM (D)	571.00	661.02	525.68	379.24
6	1	LM (D)	8.70	13.50	12.86	9.92
7	3	p-RCA (D), d-RCA (D), OM (D)	18.48	18.12	16.72	11.76
8	8	p-RCA (Di), m-RCA (Di) d-RCA (Di), p-LAD (Di) m-LAD (Di), d-LAD (Di) p-LCx (Di), OM (Di)	2242.30	1654.40	1698.50	1295.00
9	4	p-LAD (D), p-LAD (D) m-LAD (T), p-LCx (D)	315.31	353.77	313.65	254.67
10	4	p-RCA (D), p-LAD (D) p-LAD (D), m-LAD (D)	66.20	82.19	81.90	59.90
11	1	LM (D)	30.60	29.84	20.40	14.33
12	9	LM (D), m-LAD (D), DG (D) DG (D), p-LCx (D), p-LCx (D) p-LCx (D), p-LCx (D). d-LCx (D)	290.06	398.00	283.70	216.81
13	5	p-LAD (Di), m-LAD (Di), d-LAD (Di) p-RCA (Di), DG (Di)	719.50	722.70	699.14	621.40
14	1	m-LAD (D)	4.83	0	0	0
15	10	p-RCA (D), m-RCA (D), d-RCA (D) d-RCA (d), p-LAD (T), m-LAD (T) m-LAD (D), DG (D), p-LCx (D) d-LCx (D)	1066.50	1005.40	959.50	863.59
16	5	p-RCA (D), d-RCA (D), p-LAD (D) m-LAD (D), DG (D)	197.68	175.51	151.77	84.52
17	5	p-RCA (D), d-RCA (D), p-LAD (D) m-LAD (D), DG (D)	123.60	97.52	81.76	59.90
18	3	m-RCA (D), d-RCA (D), m-LAD (D)	72.76	42.90	34.91	15.80
19	1	m-LAD (D)	7.72	4.18	4.04	0
20	1	p-LAD (D)	6.00	4.71	4.41	0

CACS = coronary artery calcium score, D = discrete, d = distal, Di = diffuse, LAD = left anterior descending artery, LCx = left circumflex artery, m = mid, p = proximal, RCA = right coronary artery, T = tubular

Fig. 2. Correlation of CACS between calcium score CT scan and chest CT scan.
A-C. The correlation coefficient of CACS between calcium score CT and non-enhanced chest CT with slice intervals of 0.625 mm (A), 1.25 mm (B), and 2.5 mm (C) are 0.9850, 0.9688, and 0.9834, respectively.
CACS = coronary artery calcium score

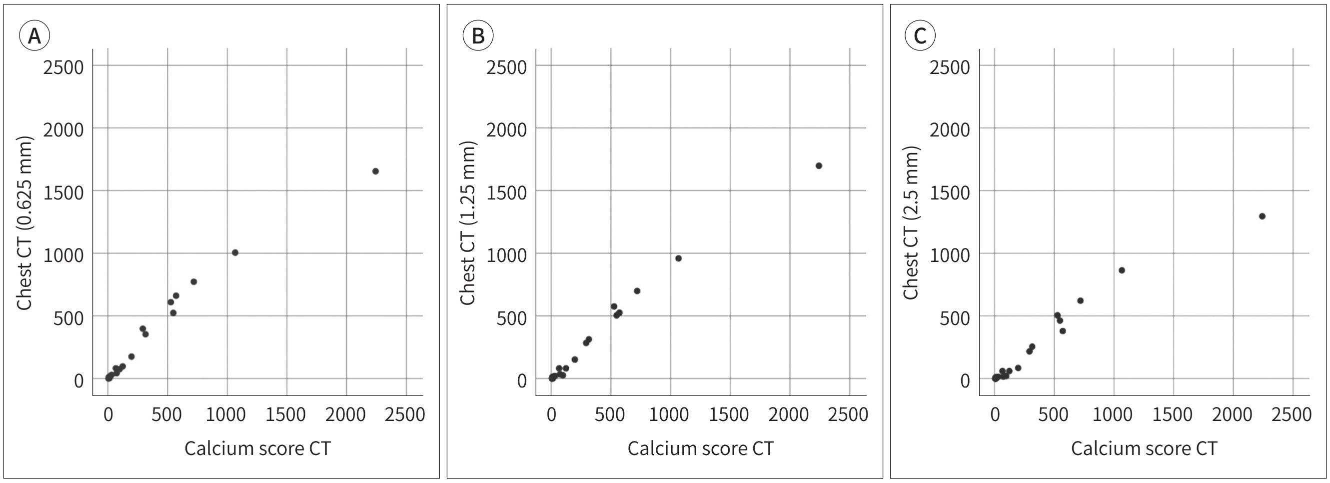
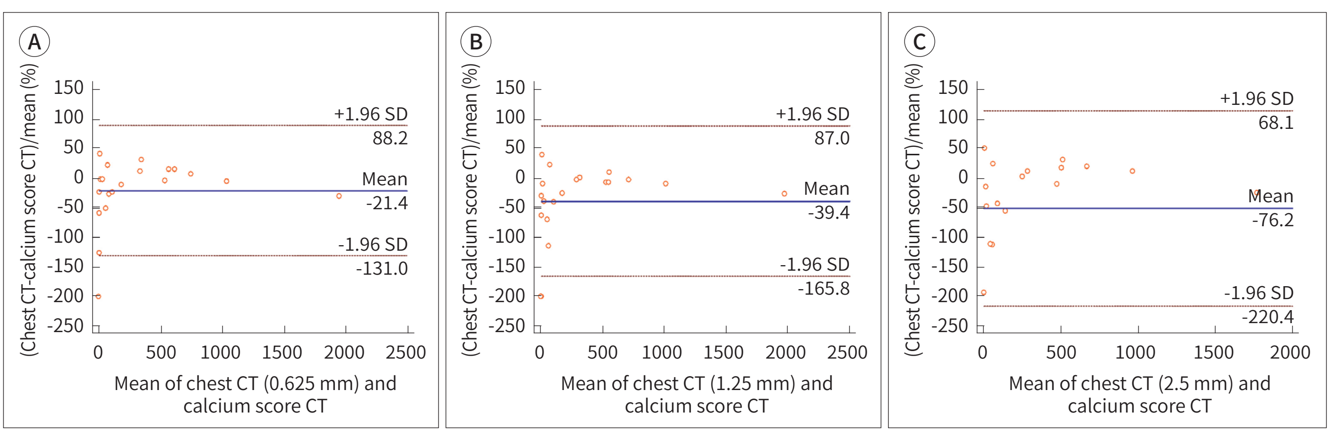


Fig. 3. Bland-Altman plot of coronary artery calcium score obtained from calcium score CT and chest CT.
A-C. The mean bias between calcium score CT and non-enhanced chest CT with slice intervals of 0.625 mm (A), 1.25 mm (B), and 2.5 mm (C) are -21.4%, -39.4%, and -76.2%.
SD = standard deviation



and location, the marginal logistic model based on generalized estimated equations showed that no factors affected the detection of calcium plaques on non-enhanced CT, regardless of slice thickness ($p = 0.139$ and $p = 0.408$, respectively).

REPRODUCIBILITY OF CACS MEASUREMENTS

There was a high inter-reader agreement for the CACS measured from the non-enhanced chest CT. The ICC obtained from the CACS calculated by the two readers was 0.987, 0.998 and 0.993 with 0.625-, 1.25-, and 2.5-mm slice intervals, respectively.

Table 4. Sectional Analysis according to Coronary Artery Disease Risk Stratification

	Chest CT 0.625 mm					
	0	< 10	10– < 100	100– < 400	400-	
Calcium scoring CT 2.5 mm						
0						
< 10	1	2	1			4
10– < 100		1	5			6
100– < 400			1	3		4
400-					6	6
	Chest CT 1.25 mm					
	0	< 10	10– < 100	100– < 400	400-	
Calcium scoring CT 2.5 mm						
0						
< 10	1	2	1			4
10– < 100	1		5			6
100– < 400			1	3		4
400-					6	6
	Chest CT 2.5 mm					
	0	< 10	10– < 100	100– < 400	400-	
Calcium scoring CT 2.5 mm						
0						
< 10	3	1				4
10– < 100	1		5			6
100– < 400			2	2		4
400-				1	5	6

DISCUSSION

This study showed that the value of the CACS obtained with a 16-cm axial volume scan was highly correlated to that obtained from the calcium score CT. The CT protocol and scan type for the 16-cm axial volume technique were similar to that of the conventional calcium score CT, with the exception of ECG-gating.

Since the discovery that CACS could be measured using chest CT, several attempts have been made to calculate the calcium score using various protocols and scan methods. Visual estimation of CACS from non-gated chest CT and calcium score CT has shown high agreement in previous studies (13-15). The ability to ascertain the presence of calcium plaques in the coronary artery quickly and easily is a great advantage for visual assessment; however, the lack of accuracy is a limitation of this method (16). Several previous studies have attempted to measure CACS quantitatively using chest CT, in addition to qualitative measurements through visual assessment (14, 15). However, a specific chest CT protocol for quantitatively evaluating the CACS has not been established, despite various studies on the subject. Kim et al. (8) have shown that CACS with a high correlation can be obtained from a low-dose CT for lung screening. Another study (7) has shown a higher correlation with the CACS obtained using the conventional chest CT protocol. Chen et al. (17) have recently shown an even higher correlation with the CACS obtained using a high-speed helical scan. This series of studies demonstrated the possibility of estimating CACS qualitatively and quantitatively using non-gated chest CT with high relevance. However, most studies used a helical scan, while the original calcium score CT uses an axial scan. The advantage of our study was that it used the exact same protocol as the calcium score CT, including the axial-scan mode. The only difference was that ECG-gating was not performed. The axial scan enables imaging of the heart with one scan without ECG-gating. The 16-cm axial volume scanning technique can detect a greater length than previous methods, which rendered cardiac scanning possible within 1 breath-hold and reduced cardiac motion artifact. In our study, CACS values were calculated using a 16-cm axial volume scan at three slice intervals (0.625, 1.25, and 2.5 mm). Among these, the 0.625-mm slice interval showed the highest correlation between the CACS obtained from the non-enhanced chest and calcium score CT scans. We assumed that the largest difference between in the conventional and calcium score CT was observed with the 2.5-mm slice thickness because the effect of motion artifact and partial volume artifact was maximized at the 2.5-mm thickness, compared with the 0.625-mm thickness, resulting in CACS underestimation. Previous studies have shown that motion artifacts occur during the cardiac systolic phase and that the partial volume effect decreases as the slice thickness decreases. (7, 18, 19). The section analysis revealed the overestimated and underestimated portions for each slice thickness. All portions were underestimated at the 2.5-mm slice interval, resulting in the loss of small solitary lesions as the slice thickness increased. The values in the calcium score CT were 2242.3, and the values measured on the 0.625-, 1.2-, and 2.5-mm slice intervals of the non-enhanced chest CT were 1654.4, 1698.5, and 1295.0, respectively, for this outlier. Although these values were different, they belonged to the same stratification level, i.e., the severe grade with scores of ≥ 400; therefore, there was no significant change in their clinical relevance. Several studies have shown that cardiac events can be predicted more accurately by the stratification of the CACS (20-22). Therefore, we think that the measurement of CACS using non-enhanced chest CT, which showed a high consistency, can be a good screening tool for the risk assessment of CAD. Moreover, all slice thicknesses showed very high ICC values, which is evidence of good reproducibility. Although the scan was not ECG-gated, using a high-rotation time enabled the acquisition of images of good quality.

Our study has some limitations. First, this was a single-center study with a small sample. Second, the number of calcified plaques was not high, and the analysis was performed based on the location and length of each plaque, and not calcium scoring. Third, because ECG gating was not performed, the artifacts caused by cardiac motion cannot be ignored. However, we attempted to minimize these artifacts by using a fast gantry rotation time.

In conclusion, the 16-cm axial volume scan technique is feasible for assessing the CACS using non-enhanced chest CT. This technique facilitates the quantitative evaluation of the CACS in patients who have undergone chest CT for any clinical requirement. The ability to detect CACS values in all patients without additional radiation exposure can also help in the risk stratification of cardiovascular disease.

Author Contributions

Conceptualization, K.S.J., K.T.H., P.C.H.; data curation, K.S.J., K.J.Y., P.C.H.; formal analysis, K.S.J., H.K., P.C.H.; investigation, K.T.H., S.J.M., H.K., K.J.Y.; methodology, K.S.J., S.J.M., H.K., K.J.Y., P.C.H.; supervision, K.T.H., P.C.H.; and writing—original draft, K.S.J., P.C.H.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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비 조영증강 흉부 CT에서 관상동맥 칼슘스코어 측정을 위한 16 cm 축상 촬영 기법의 유용성: 전향적 탐색적 연구

기소정[1] · 박철환[1] · 한경화[2] · 신재민[1] · 김지영[1] · 김태훈[1]*

목적 관상동맥 칼슘스코어(coronary artery calcium score; 이하 CACS)를 측정하는 데 있어 비 조영증강 흉부 CT에서 16 cm 축상 촬영 기법의 유용성을 알아보고자 하였다.

대상과 방법 20명의 환자를 대상으로 16 cm 축상 촬영 기법을 이용한 비 조영증강 흉부 CT와 칼슘 스코어 CT를 전향적으로 시행하였다. 흉부 CT는 세 가지 절편 두께(0.625, 1.25, 2.5 mm)로 재구성하여, Agatston 방법을 통해 관상동맥 칼슘스코어를 측정하였다. 다양한 절편 두께의 비 조영증강 흉부 CT와 칼슘스코어 CT의 관상동맥 칼슘스코어를 비교하고, 단면 분석을 통해 CACS의 임상적 중요성에 대한 일치를 확인하였다. 또한 각각의 석회화 병변들을 위치와 크기로 나누어 비 조영증강 흉부 CT와 칼슘스코어 CT에서 일대일 비교를 시행하였다.

결과 2.5, 1.25, 0.625 mm 절편 두께의 흉부 CT와 칼슘스코어 CT의 CACS 상관 계수는 각각 0.9850, 0.9688, 0.9834였다. 흉부 CT와 칼슘스코어 CT 간의 CACS 차이는 0.625 mm에서 -21.4%, 1.25 mm에서 -39.4%, 2.5 mm 절편 두께에서 -76.2%였다. CACS 구간별 분석에서 절편 두께별로 16명(80%, 0.625 mm), 16명(80%, 1.25 mm), 13명(65%, 2.5 mm)의 환자가 관상 동맥 질환의 위험도 구간이 일치하였다. 관찰자 간 일치도는 모든 절편 간격에서 높게 나타났다. 세 절편 두께 중에서는 0.625 mm CT에서 석회화 병변에 대한 민감도가 가장 높았다.

결론 16 cm 축상 촬영 기법을 이용한 비 조영증강 흉부 CT에서 electrocardiogram 동기화 없이도, 0.625 mm 절편 간격에서 칼슘스코어 CT에서의 CACS와의 유사한 값을 얻을 수 있었다. 이를 통해 추가 방사선 노출 없이, 심혈관 질환 위험을 예측하는 데 도움이 될 수 있다.

[1]연세대학교 의과대학 강남세브란스병원 영상의학과,
[2]연세대학교 의과대학 세브란스병원 영상의학과