

Comparison of Agatston Score Calculation Between the Syngo.Via Automated Method and the Manual Method in Non-Contrast Cardiac CT

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Keywords:	Abstract
agatston score; coronary arterial calcium; cardiac ct; syngo.via; measurement deal, weasis	In clinical practice, the Agatston Score can be calculated manually or automatically using post-processing software such as Syngo.Via; However, the difference in absolute values between these methods can affect clinical interpretation. The study aimed to compare measurements of the Agatston Score obtained using the Syngo.Via automated method and manual calculations on non-contrast cardiac CT, with an emphasis on measurement differences, suitability, and reliability. A quantitative observational analytical study was conducted using retrospective no-contrast cardiac CT data from 20 subjects. The Agatston score is calculated automatically using Syngo.Via and manually using the Weasis software on the same image dataset. The difference in measurement was analyzed descriptively and tested for normality. Statistical differences were evaluated using the Wilcoxon Signed Rank Test, suitability was evaluated using Bland–Altman analysis, and reliability was evaluated using the Intraclass Correlation Coefficient (ICC) with a two-way mixed effect model and absolute suitability. Results showed that a difference between the method was not normally distributed and a statistically significant difference in the Agatston score was observed ($p < 0.05$). The Bland–Altman analysis showed that most of the differences were distributed around the zero line with a few outliers, while the ICC analysis revealed a very high reliability between the two methods (ICC = 1,000). In conclusion, the automatic and manual measurement of the Agatston Score showed excellent reliability and good agreement despite the statistically significant differences in absolute values, suggesting that the two methods could be compared.

INTRODUCTION

Cardiovascular disease is one of the main causes *Morbidity* and *Mortality* in the world, including in Indonesia, with coronary heart disease as the most significant clinical manifestation. The disease is closely related to the *Atherosclerosis* in the coronary arteries characterized by the accumulation of plaque composed of lipids, fibrous tissues, and calcium, and plays a role in increasing the risk of major cardiovascular events such as *myocardial infarction* and sudden death ((Benjamin *et al.*, 2019)(Virani *et al.*, 2020).

Calcification of the coronary arteries is the result of calcium deposition in plaque *atherosclerotic* and has been recognized as a quantitative marker of load *Atherosclerosis* Total(Wicaksono, 2024)(Santoso, A. H., 2021)(Mori *et al.*, 2018)(Shreya *et al.*, 2021). Various studies have shown that the degree of calcification of the coronary arteries has a strong correlation with the risk of future cardiovascular events and can be used as an independent predictor of coronary heart disease, both in the population *asymptomatic* or *Symptomatic* (Blaha *et al.*, 2017)(Budoff *et al.*, 2018). Therefore, the evaluation of coronary artery calcification plays an important role in risk stratification and clinical decision-making (Patel *et al.*, 2021) .

Non-contrast cardiac CT scan is an imaging modality *Non-invasive* widely recommended for assessing coronary artery calcification (Enys, 2014)(Wicaksono, 2024). This examination is performed without the administration of intravenous contrast media and generally uses the *electrocardiography (ECG) gating* to minimize artifacts due to heart movement. The advantages of non-contrast cardiac CT scans include short examination time, relatively low radiation dose, and good reproducibility, making it the standard of examination *Coronary artery calcium (CAC) scoring* in various international clinical guidelines (Budoff *et al.*, 2018)(Hecht, 2018).

Agatston Score is the most widely used method of quantifying coronary artery calcification globally (Czaja-Ziółkowska *et al.*, 2022). This method calculates the score based on the area of the calcified plaque with a density of ≥ 130 *Hounsfield Unit (HU)* which is multiplied by the weighting factor according to the maximum density of the plaque (Santoso, A. H., 2021). Although other quantification methods have been developed such as *Volume Score* and *Mass Score*, *Agatston Score* is maintained as a reference method due to its ease of implementation and its strong association with the risk of cardiovascular events (Budoff *et al.*, 2018).

In clinical practice, calculations *Agatston Score* Manual is still widely used, but this method is relatively time-consuming and susceptible to variation between examiners (*interobserver variability*) or repeated measurement variations by the same examiner (*intraobserver variability*), which can affect the consistency and accuracy of results (van Velzen *et al.*, 2017)(Lessmann *et al.*, 2018). Along with the development of medical imaging technology, post-processing software such as *Syngo.via* developed to provide calculations *Agatston Score* automatically with the aim of improving the efficiency and consistency of analysis (Chamberlin *et al.*, 2025)(Healthineers, 2021).

Several previous studies have reported a high correlation between automated methods and manual methods in calculations *Agatston Score*. However, most of these studies still focus on correlation analysis and have not comprehensively evaluated the level of conformity and accuracy of absolute values between methods, despite the differences in values *Agatston Score* may affect risk stratification and clinical decisions. In addition, the specific evaluation of *Syngo.Via*'s software on non-contrast cardiac CT scan examinations uses an agreement-based statistical approach, such as Bland–Altman and *Intraclass Correlation Coefficient (ICC)*, still relatively limited (Koo, T. K., & Li, 2016)(Kang *et al.*, 2022).

The urgency of this research is driven by several factors. First, the increasing clinical adoption of automated CAC scoring software requires validation against reference standard manual methods. Second, differences in absolute *Agatston Score* values between methods may affect cardiovascular risk stratification, particularly for patients near risk category thresholds (e.g., between scores of 99 and 100, or 399 and 400). A patient misclassified from moderate to severe risk (score 399 vs 400) might receive different statin therapy recommendations. Third, longitudinal assessment of CAC progression requires consistent measurement methods; a change from 100 to 130 (30% increase) might be clinically significant if real, but could represent measurement variability if method differences are substantial. Fourth, Indonesia's healthcare system increasingly adopts digital imaging and post-processing software, necessitating local validation studies. Fifth, the radiation dose optimization in modern CT protocols (using 90 kV and 33 mAs) requires confirmation that automated methods maintain accuracy at lower dose settings. Sixth, manual scoring remains time-consuming (15-30 minutes per patient), while

automated methods promise efficiency (1-2 minutes), but efficiency gains must not compromise accuracy.

The novelty of this research lies in: first, the specific comparison of Syngo.Via (Siemens Healthineers) automated method with Weasis software manual calculation, which has not been extensively reported in indexed literature. Second, the comprehensive statistical approach combining three analyses: (a) Wilcoxon Signed Rank Test for statistical difference; (b) Bland-Altman analysis for agreement including LoA calculation; and (c) ICC with two-way mixed effects model for reliability. Third, the explicit evaluation of proportional bias through regression analysis on Bland-Altman plots, assessing whether measurement differences vary across Agatston Score ranges. Fourth, the use of a locally relevant sample from Indonesia's healthcare setting with standardized acquisition parameters (90 kV, 33 mAs, 3 mm slice thickness). Fifth, the documentation of absolute difference values (mean difference -0.354 ± 6.682) and agreement limits (± 13 units) that provide clinically interpretable benchmarks for other institutions implementing similar automated systems. Sixth, the identification that even with ICC=1.000 (excellent reliability), statistically significant differences exist, highlighting the distinction between reliability and absolute agreement.

Therefore, this study aimed to compare the accuracy and suitability of the *Agatston Score* calculation between Syngo.Via's automated method and manual methods on non-contrast cardiac CT scans, focusing on clinically relevant absolute value agreement.

RESEARCH METHODS

This study applied a quantitative approach with an analytical observational design to compare the results of the Agatston Score calculation between the automated method using the Syngo.Via software and the manual method on non-contrast cardiac CT examination. This study was carried out at the Radiology Installation of Banyumas Hospital by utilizing multidetector CT that supports *coronary artery calcium* (CAC) scoring.

The data used in this study were retrospective, in the form of non-contrast cardiac CT images from 20 samples that met the inclusion criteria during the data collection period. The number of samples was obtained based on the availability of patient data with coronary artery calcification findings within the 7-day study period. The sample in this study ranged from 54 to 71 years old, with an average age of 61.7 years, reflecting a population with a relatively high risk of coronary heart disease. All data used is data that is stored and can be accessed on the system during the data collection process. Furthermore, the images were automatically analyzed using *Syngo.Via* software as part of routine clinical procedures, then the same dataset was re-evaluated by the researchers through manual *calculation of the Agatston Score* using *Weasis* software.

All inspections are carried out with uniform acquisition parameters. Details of non-contrast cardiac CT parameters for *coronary artery calcium* (CAC) scoring examination at the Radiology Installation of Banyumas Hospital are presented in Table 1.

Table 1. Parameters of non-contrast cardiac CT scan for *coronary artery calcium* (CAC) scoring at the Radiology Installation of Banyumas Hospital

Parameters	Value
Tube voltage (kV)	90 kV
Tube current (Eff. mAs)	33 mAs

CTDIvol	1.60 mGy
DLP	21.8 mGy·cm
Detector configuration	64 × 0.6 mm
Rotation time	0.33 seconds
Slice thickness	3 mm
Acquisition techniques	ECG-gated

In the manual analysis stage using *Weavis software*, the calculation process was carried out systematically by identifying coronary artery calcification lesions on each slice of CT image based on an attenuation threshold of ≥ 130 HU. Region of interest (ROI) determination is done manually on each calcified lesion with reference to the location pre-identified by *Syngo.Via*'s automated method, to ensure the suitability of the area analyzed. The ROI is drawn following the limits of the calcification contour precisely on each slice, then the area of the lesion is calculated automatically by the software. Furthermore, each lesion was classified based on the peak density value (*peak HU*) to determine the weighting factor according to the *Agatston Score* method. This process is carried out repeatedly in all calcified lesions found in the main coronary arteries, namely *left main (LM)*, *left anterior descending (LAD)*, *left circumflex (LCx)*, and *right coronary artery (RCA)*. The score of each lesion was then summed to obtain the total *Agatston Score* in each patient. This approach is carried out to ensure consistency of location, area, and score calculation between manual and automatic methods (Agatston *et al.*, 1990; Budoff *et al.*, 2018; Hecht, 2018).

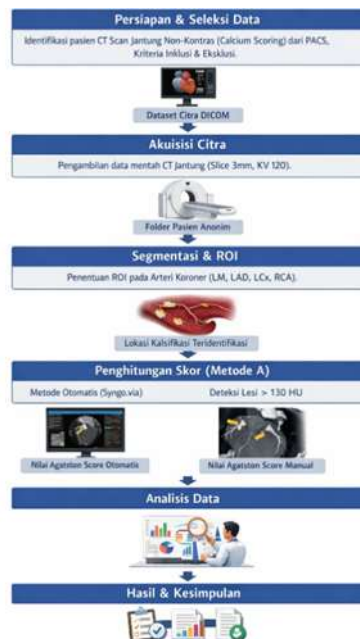


Figure 1. Research Flow

Calculation of the Agatston Score

The *Agatston Score* is calculated based on the area of the calcified lesion and the calcium density weighting factor determined from the maximum attenuation value (HU) on the CT scan. A lesion is classified as calcified if it has a value of ≥ 130 HU and an area of at least 1 mm². The *Agatston score* is calculated using the following formula:

$$\text{Agatston Score} = \sum(A_i \times W_i) \quad (1)$$

Where A_i is the area of calcification area (mm²) and W_i is the density weighting factor based on $A_i W_i$ the value of Hounsfield Unit (HU), namely:

1. 130–199 HU = 1
2. 200–299 HU = 2
3. 300–399 HU = 3
4. ≥ 400 HU = 4

(Agatston *et al.*, 1990).

The calculation is done automatically by *Syngo.Via* software and manually with the determination of ROI on each calcification lesion using *Weasis Software*

Data Analysis

The suitability of the Agatston Score measurement between *the Syngo.Via automatic method* and the manual method was analyzed using SPSS with a significance level of 0.05. The difference in measurement (*Diff Score*) was analyzed descriptively and tested for normality using *the Kolmogorov–Smirnov* and *Shapiro–Wilk tests*. Since the data is not normally distributed, the differences between the two methods are analyzed using *the Wilcoxon Signed Rank Test*.

The suitability between the methods was evaluated using *the Bland–Altman* analysis with an agreement limit of ± 1.96 standard deviation (Bland & Altman, 1986), while the reliability was assessed using *the Intraclass Correlation Coefficient (ICC)* of the two-way random effects model of the *absolute agreement* type with a 95% confidence interval (Koo & Li, 2016).

RESULTS AND DISCUSSION

The study included 20 subjects who each underwent two Agatston Score assessments, namely using an automated method through *the Syngo.Via* application and a manual method with *Weasis* software. All data obtained are complete without missing values, so that all subjects can be included in their entirety in each stage of statistical analysis.

As an illustration of the difference in measurement approaches, the *determination of the region of interest (ROI)* on the same dataset is carried out using an automated method through *Syngo.Via* and a manual method with *Weasis* software. The results of determining the ROI of the two methods are then compared and presented in Figure 2.

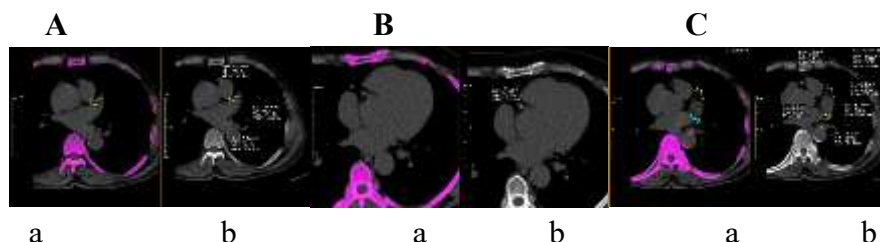


Figure 2. ROI comparison between *Syngo.Via's automated method* and manual method.

Furthermore, the difference in *the Agatston Score* between *Syngo.Via's automated method* and the manual method is defined as *Diff_Score (Total_Score_Syngo – Total_Score_Manual)*, while *Mean_Score* represents the average value of both measurement techniques. The distribution of individual Agatston Score scores along with the difference in measurement results is shown in Table 1.

Table 1. Agatston Score data manual method and Syngo.Via

Syngo	Manual	Diff Score
331,089±415,1558	331,443±416,7883	-0.354± 6.6822

In the initial stage, a descriptive analysis was carried out on the difference in measurement results (*Diff_Score*) between *the Syngo.Via method* and the manual method to describe the characteristics of the difference in *Agatston Score* values obtained from the two approaches.

Table 2. Descriptive statistics of the difference in Agatston Score (Diff_Score) between Syngo.Via and manual methods

Variable	N	Red	SD	Minimum	Maximum
Diff_Score	20	0.354	6.682	-27.70	5.70

The results of the descriptive analysis showed that *Diff_Score* had a relatively wide range of values, including the presence of extreme values towards negatives, reflecting the variation in measurement results between *the Syngo.Via method* and the manual method. The pattern of data distribution appears to be asymmetrical, so it is necessary to test normality first before determining the most appropriate inferential analysis method.

Table 3. Agatston Score (Diff_Score)

Statistics	df	Sig.(p)
0.474	20	< .001

The test results showed a significance value of $p < 0.05$ in both test methods, which indicates that the measurement difference data was not normally distributed. Therefore, further inferential analysis is carried out using a non-parametric approach.

The difference in measurement results between the manual method and the automatic method of Syngo.Via was then analyzed using *the Wilcoxon Signed Rank Test*. The results of *the Wilcoxon test* are presented in Table 4.

Table 4. Wilcoxon Signed Rank Test test results between Syngo.Via and manual methods

		N	Mean	P-Value
			Rank	Sum of Ranks
Total_Score_Syngo - Total_Score_Manual	Negative Ranks	5	8.00	40.00
	Positive Ranks	14	10.71	150.00
	Ties	1		
	Total	20		.027

The results of the Wilcoxon test showed that the number of *positive ranks* ($n = 14$) was greater than the *negative ranks* ($n = 5$), with 1 data *tie*. This shows that in most subjects, the *Agatston Score* obtained using *the Syngo.Via method* tends to be higher than the manual method. The significance value showed $p = 0.027$ ($p < 0.05$), so it can be concluded that there is a statistically significant difference between the *Agatston Score* obtained using *the Syngo.Via method* and the manual method.

The degree of *agreement* between the two measurement methods was evaluated through *Bland-Altman analysis* by plotting the difference between the measurement results and the

average value of the two methods. A visualization of *this Bland–Altman analysis* is presented in Figure 3.

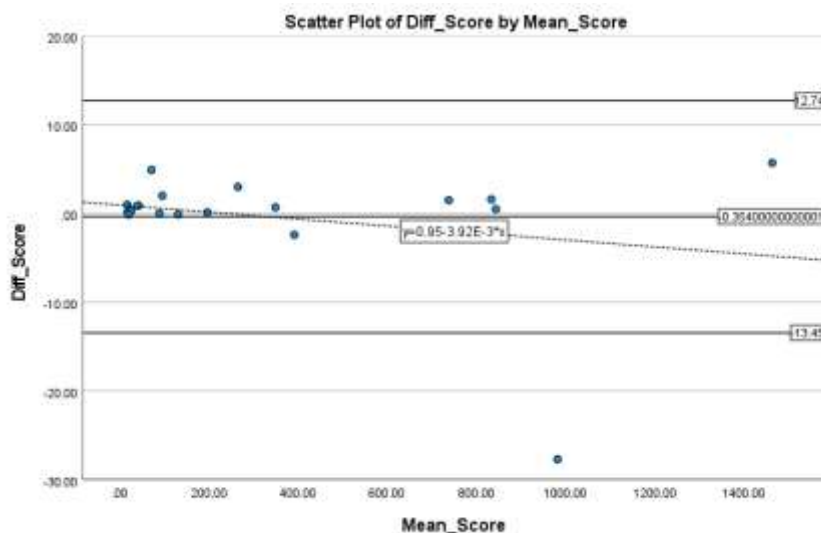


Figure 3. Bland–Altman plot of *Agatston Score* compatibility between *Syngo.Via* and manual methods

The *Bland–Altman plot* illustrates the relationship between the average value of the *Agatston Score* (*Mean_Score*) and the difference in measurement of the *Agatston Score* (*Diff_Score*) between *Syngo.Via's automated method* and the manual method. The center line represents the mean *difference*, while the upper and lower boundary lines show the *limit of agreement (LoA)* which is calculated as follows:

$$\text{LoA} = \text{mean difference} \pm 1.96 \times \text{SD_diff} \quad (1)$$

The results of the analysis showed a *mean difference* value of 0.35, with an upper *LoA limit* of 12.74 and a lower *LoA limit* of -13.45. The majority of the difference values are within the *range of the LoA*, which indicates a good degree of compatibility between the two measurement methods.

Nevertheless, an *LoA range* of around ± 13 units needs to be considered in a clinical context, particularly in patients with low *Agatston Scores*, where minor changes may affect cardiovascular risk categorization.

Table 5. Regression test results

Models	Unstandardized Coefficients		Standardized Coefficients		t	Sig.
	B	Std. Error	Beta			
1(Constant)	.946	1.922			.492	.629
Mean_Score	-.004	.004	-.244		-1.069	.299

In addition, in the *Bland–Altman plot*, a linear regression line between *Diff_Score* and *Mean_Score* is added to assess the presence of *proportional bias*. The resulting regression equation was $y = 0.95 - 3.92 \times 10^{-3} x$ with a significance value of $p = 0.299$, which shows that there is no significant relationship between the average value of the *Agatston Score* and the measurement difference. Thus, no significant proportional bias was found between the *Syngo.Via* method and the manual method across the various *ranges of Agatston Scores*.

Thus, the difference in measurement results between *the Syngo.Via* method and the manual method tends to be consistent across different ranges of *Agatston Scores*, so that no meaningful *proportional bias* is found .

As a final stage, the reliability between *Syngo.Via*'s manual method and automatic *method* was analyzed using the Intraclass Correlation Coefficient (ICC) with an absolute agreement type two-way mixed effects model. The results of the ICC test are presented in Table 6.

Table 6. Intraclass Correlation Coefficient (ICC) reliability test results between Syngo.Via and manual methods

Size Type	ICC	95%CI (Lower–Upper)	Sig.
Single Dimensions	1.000	[1.000 – 1.000]	0.000
Averages Measurese	1.000	[1.000 – 1.000]	0.000

The results of the Intraclass Correlation Coefficient (ICC) analysis showed an ICC value = 1,000 in both *the single measures* and *average measures* categories, which reflects the *very high agreement* between the *Syngo.Via* method and the manual method in the measurement of *the Agatston Score*.

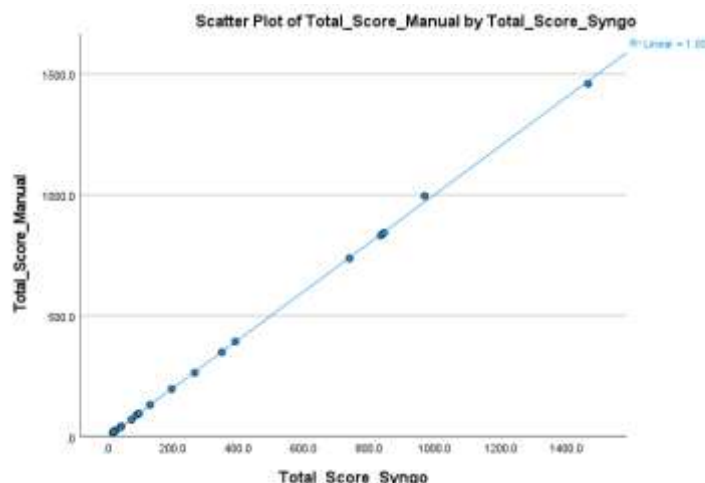


Figure 4. ICC graph of *Agatston Score* compatibility between *Syngo.Via* and manual methods

Figure 4. The graph of the compatibility of *the Agatston Score* between the *Syngo.Via* method and the manual method shows a very high level of agreement, in line with the results of the *Intraclass Correlation Coefficient (ICC)* reliability test in Table 6, which shows an ICC value = 1,000 on both *single measures* and *average measures*.

The results of the descriptive analysis showed that there was a variation in *the Agatston Score* value between the automated method using *the Syngo.Via software* and the manual method, with an average difference (*Diff_Score*) that was small and close to zero, but followed by a relatively large standard deviation. These findings suggest that in general the two methods produce comparable values, although there are variations at the individual level. The wide range of differences, reflected in the extreme minimum and maximum values, indicates that in a small percentage of subjects there is a fairly significant absolute difference between the two methods. This condition is mainly found in subjects with high calcification scores, where the distribution of coronary calcium tends to be more complex, involving many segments of vessels with varying densities. This complexity can affect the process of automatic segmentation and manual

delineation, thus contributing to variations in score calculation results. These findings are consistent with previous research that stated that at high calcification scores, variations in segmentation can increase absolute value differences even though correlations between methods remain high (Lessmann et al., 2018; van Velzen et al., 2017). In addition, the asymmetrical distribution of measurement differences and the presence of extreme values indicate that *the data Diff_Score* not normally distributed. This was confirmed by the *Kolmogorov–Smirnov* and *Shapiro–Wilk normality tests* which resulted in a significance value of $p < 0.05$, so that the nonparametric approach was considered more suitable for subsequent inferential analysis. This approach is in line with methodological recommendations in measurement method suitability evaluation studies, where the difference distribution is often abnormal due to calcification data characteristics that tend to *be skewed* (Koo & Li, 2016).

The distribution of measurement differences that show asymmetry and the presence of extreme values indicate that *the data Diff_Score* not normally distributed. This pattern reflects the characteristics of coronary calcification data that tend to *be skewed* (skewed), especially due to the striking differences between subjects with low and high scores. The findings are strengthened by the results of *the Kolmogorov–Smirnov* and *Shapiro–Wilk normality tests* which show a significance value of $p < 0.05$, so that the use of a nonparametric approach is considered more suitable for advanced inferential analysis. The selection of nonparametric tests in this context is not only based on the distribution of data, but also plays a role in increasing the validity of statistical interpretations at relatively small sample sizes ($n = 20$). This approach is in line with methodological recommendations in measurement method agreement evaluation studies, where the difference distribution is generally abnormal due to the heterogeneity of calcification data characteristics (Koo & Li, 2016).

The results of *the Wilcoxon Signed Rank Test* show that there is a statistically significant difference between the *Agatston Score* obtained through the automatic method and the manual method. The dominance of *positive rankings* indicates that in most subjects, the automated method tends to produce slightly higher values than the manual method. This condition is likely related to the software's sensitivity in identifying high-density pixels that meet the calcification threshold, so that small calcification lesions remain detected and accounted for. However, the direction and magnitude of these differences are inconsistent across subjects, reflecting individual variations in anatomical characteristics and image quality. Although this difference is statistically significant, the mean *difference* (mean difference 0.35) suggests that in practice the difference is relatively small. Therefore, the interpretation of statistical significance needs to be considered alongside its clinical relevance, given that *the Agatston Score* plays a role in the stratification of coronary heart disease risk, where small changes in the range of low scores can affect a patient's risk classification (Budoff et al., 2018; Blaha et al., 2017).

Conformity assessment using *Bland–Altman* analysis provides a more comprehensive picture of the relationship between the two measurement methods. Most of the difference values are within *the limit of agreement (LoA)*, which indicates a good level of agreement between the automated and manual methods. The mean *difference* of 0.35 indicates a very small systematic bias, so in general the two methods can be considered as mutually substitutive in clinical practice. From a methodological perspective, the *Bland–Altman approach* is considered more comprehensive than correlation analysis alone, because it is able to assess absolute differences between measurements while identifying the existence of systematic bias and random variation (Commandeur et al., 2021). Although the *LoA range* of about ± 13 units is relatively small

compared to the overall score variation, the clinical implications are still worth considering, particularly in low-scoring patients, where small changes may affect risk classification according to *coronary artery calcium scoring guidelines* (Hecht, 2018; Budoff *et al.*, 2018).

The absence of a consistent pattern of increasing the difference as the average *value of the Agatston Score* increased, as well as the result of the regression equation $y = 0.95 - 3.92 \times 10^{-3} x$ with a significance value of $p = 0.299$, indicated that the difference in measurement results was not directly influenced by the magnitude of the score. Thus, there is no *meaningful proportional bias* between the two methods. These findings show that automated software is able to maintain stable performance over a wide range of scores, both under minimal and extensive calcification conditions. Such consistency has an important role in longitudinal evaluation, where score changes over time are used to monitor disease progression. These results are also in line with previous research on the evaluation of auto-based coronary calcium quantification software that reported measurement stability at various calcification severity levels (Kang *et al.*, 2022).

Reliability analysis using *the Intraclass Correlation Coefficient (ICC)* showed an ICC value = 1,000 on both *single measures* and *average measures*, accompanied by a very narrow 95% confidence interval. These results reflect a very high level of consistency and reliability between the two measurement methods. However, the near-perfect interpretation of ICC values needs to be done with caution, as it is likely to be influenced by much greater variation between subjects than variation between methods, resulting in a very high reliability estimate. Thus, although the ICC shows excellent consistency, this parameter does not directly represent absolute similarity between the methods. Therefore, ICC analysis should be combined with a consensus approach such as *Bland–Altman* to provide a more comprehensive evaluation and avoid potential overestimation of method equivalence (Koo & Li, 2016).

Overall, the results of this study show that *Syngo.Via's* software-based automated method has a very high level of suitability and reliability compared to the manual method in calculating *the Agatston Score* on non-contrast cardiac CT. These findings indicate that the application of automated technology in the post-process stage of medical imaging has the potential to increase the efficiency of analysis time, reduce variability between operators, and improve the reproducibility of measurement results. Nevertheless, manual methods still play an important role, especially as a *reference standard* and under certain conditions such as complex calcification distributions, the presence of image artifacts, or extreme scores. Therefore, the most optimal approach in clinical practice is to make automated methods the primary tool equipped with manual verification when necessary, so that the balance between efficiency and accuracy can be maintained.

CONCLUSION

Based on the results of the study, it can be concluded that the automated method using *Syngo.Via* software has a very high level of suitability and reliability compared to the manual method in calculating *the Agatston Score* on non-contrast cardiac CT. Although statistically significant differences were found, the mean very small differences suggest that the differences are not clinically significant in most cases. Variation in values mainly occurred in subjects with high calcification scores due to the complexity of calcium distribution that affected the segmentation process, but in general no proportional bias was found so that measurement consistency was maintained across various score ranges. The results of *the Bland–Altman* analysis showed that the majority of the data were within acceptable agreement limits with

minimal bias, while the *very high Intraclass Correlation Coefficient* value confirmed consistency between methods, although it needed to be interpreted together with the agreement analysis to avoid *overestimation*. Overall, automated methods can be used as an efficient and consistent alternative in clinical practice, while maintaining the role of manual methods as a comparator, especially in cases with complex calcification characteristics or extreme score values.

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