BRIEF ARTICLE

Evaluation of Coronary Artery and Aortic Valve Calcium Score Using Low Radiation Dose Non-Gated Chest Computed Tomography

Evaluación del score de calcio coronario y valvular aórtico mediante TC de tórax no gatillada de baja dosis

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ABSTRACT

Background: Coronary artery calcium (CAC) score is a prevention tool scarcely used, in part due to its high cost which should not be higher than that of chest computed tomography (CT). Conventional chest CT scan has a predictive value similar to that of gated CT to evaluate CAC using visual or semi-quantitative scales.
Methods: In this retrospective and observational study we included patients (n = 35) undergoing low dose radiation non-gated chest CT and gated CT with evaluation of CAC score within the same hospital stay.
Results: We identified good agreement between the methods for both the qualitative and quantitative assessment, with a mean of 3.86 ± 0.7 segments with coronary artery calcifications identified by gated chest CT, and 3.79 ± 0.6 segments using low radiation dose non-gated chest CT (concordance correlation coefficient 0.98 [95% CI 0.95-0.99]); CAC score assessed by Agatston units was underestimated by 9.8%.
Conclusion: In this study, we demonstrated that low radiation dose CT could accurately provide qualitative and quantitative assessment of CAC score.

RESUMEN

Introducción: El *score* de calcio coronario (SCC) es una herramienta de prevención subutilizada, en parte debido a su elevado costo, que no debería diferir del de una tomografía computarizada (TC) de tórax. El *score* de calcio coronario puede ser evaluado mediante una TC de tórax convencional, generalmente utilizando escalas visuales o semicuantitativas, y con valor pronóstico similar al gatillado.
Material y métodos: En este estudio observacional retrospectivo, incluimos pacientes (n = 35) en quienes se realizó dentro de la misma internación una TC de tórax no gatillada de baja dosis y un score de calcio coronario gatillado.
Resultados: Identificamos una buena concordancia entre los métodos tanto en su valoración cualitativa como cuantitativa, con una media de 3,86 ± 0,7 segmentos con calcificaciones arteriales coronarias mediante *score* de calcio coronario gatillado, comparado con 3,79 ± 0,6 segmentos mediante TC de tórax no gatillada de baja dosis (coeficiente de correlación de concordancia 0,98 [IC 95% 0,95-0,99]) y una subestimación del score de calcio coronario evaluado mediante unidades Agatston del 9,8%.
Conclusión: En este estudio, demostramos que el score de calcio coronario podría ser evaluado con precisión de forma tanto cualitativa como cuantitativa mediante estudios de TC de tórax no gatillada de baja dosis.

Palabras clave: Tomografía computarizada - Prevención - Imágenes

Abbreviations

CAC	Coronary artery calcification	**CT**	Computed tomography
CCC	Concordance correlation coefficient	**LRD**	Low radiation dose

INTRODUCTION

The evaluation of coronary artery calcium (CAC) score by computed tomography (CT) scan as a tool for the stratification of cardiovascular risk in asymptomatic subjects at intermediate risk is probably the cardiovascular screening tool equivalent to mammography for the early detection of breast cancer. Paradoxically, despite being a rapid, effective and safe (~1 mSv) non-

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invasive tool, its use in the local setting is almost negligible despite the recommendations of several scientific societies (class IIa in intermediate risk patients). (1, 2) In particular, the absence of calcifications (CAC score = 0) allows reclassification of a non-negligible percentage of intermediate risk patients into the low-risk category who would not benefit from statin therapy. (3)

One of the main difficulties preventing the implementation of CAC scoring in our environment is perhaps its high cost, which, in fact, should not differ from the cost of a conventional chest CT scan, since X ray tube consumption is lower, and the process of analysis and reporting is even simpler. In addition, CAC score can also be evaluated with non-gated non-contrast chest CT examinations including low radiation dose CT examinations (used for lung cancer screening and, nowadays, in the setting of the COVID-19 pandemic), generally using visual or semi-quantitative scales. (4) Whatever the strategy chosen, many studies have demonstrated the predictive value of the evaluation of CAC by chest CT scan, with results comparable to the one obtained by gated chest CT and with good agreement between both methods. (5, 6) With the intention of increasing the visibility of this problem in our environment (underutilization of a good prevention tool and underreporting of CAC evaluation in chest CT), and the likelihood of having a cheaper and more universally available option, we evaluated the agreement between these methods using qualitative and quantitative strategies.

METHODS

We conducted a retrospective and observational study of patients undergoing low radiation dose (LRD) and non-gated chest CT on admission in the context of the COVID-19 pandemic and gated cardiac computed tomography angiography with estimation of CAC score within the same hospital stay (Figure 1). Images were acquired with the same multidetector CT equipment (IQon Spectral CT, Philips Healthcare, Best, Netherlands). Patients with a history of myocardial revascularization surgery and stents implanted were excluded from the analysis. The presence and extent of CAC was evaluated using ordinal variables (number of segments with CAC, and qualitative assessment: absent, mild, moderate or severe) and continuous variables (Agatston units). (4) Aortic valve calcification (Agatston units) was also evaluated. The quantitative analysis of CAC score was made with a dedicated software (HeartBeat-CS, Philips Healthcare, Best, Netherlands). Low radiation dose CT, associated with an effective radiation dose < 3 mSv, was acquired using the following parameters: collimation, 64 × 0,625 mm; tube voltage, 120 kV; tube current, 70-140 mAs; rotation time, 270 ms; pitch, 1.23; slice thickness 2.0 mm (1 mm-increase). Thicker reconstructions were not generated (gated CT for CAC scoring uses 2.5-mm slice thickness) to evaluate agreement using the LRD CT standard protocol, without modifying the workflow. All the procedures were conducted following the recommendations of the 1975 Declaration of Helsinki and subsequent addenda, and all the patients signed an informed consent.

Statistical analysis

Agreement between the methods was assessed using Cohen's kappa coefficient for ordinal and categorical variables, and concordance correlation coefficient (CCC) and Bland-Altman plots for continuous variables. Statistical analysis was performed using SPSS 22.0 statistical package (Armonk, NY, USA) and MedCalc Software 13.3.3 (MedCalc Software bvba, Ostend, Belgium).

RESULTS

A total of 35 patients (17 men) with mean age of 65.9 ± 12.8 years underwent LRD CT and gated CT angiography for evaluation of CAC score between June and December 2020. Coronary artery calcium was identified in 25 patients (71%) using gated CT angiography and in 26 patients (74%) with LRD CT (kappa 0.93; 95% CI, 0.79-1). We identified good agreement between both methods for the ordinal qualitative assessment of CAC, with a weighted kappa of 0.85 (95% CI 0.73-0.97) (Table 1).

Gated CT angiography identified a mean of 3.86 ± 0.7 segments with CAC compared with 3.79 ± 0.6

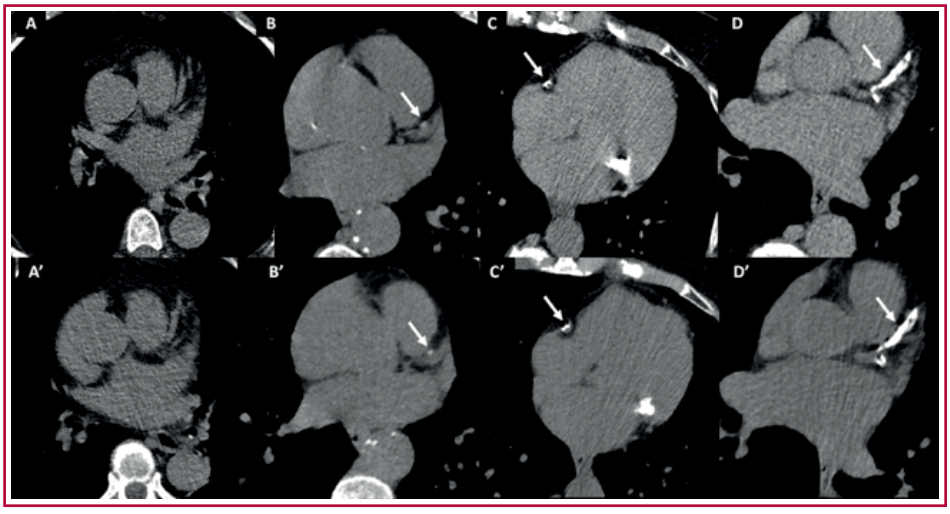

Fig. 1. Examples of agreement between gated cardiac computed tomography (coronary artery calcium, panels A-D) and low radiation dose chest computed tomography (panels A'-D') in patients without calcification (A-A'). minimal calcification (B-B'), mild calcification (C-C') and diffuse calcification (D-D').

Table 1. Evaluation of coronary artery calcium (CAC) score by gated computed tomography (CT) and low radiation dose (LRD) chest computed tomography

Variable	CAC score (gated)	LRD CT	Agreement
Qualitative evaluation:			
Absence	10 (29%)	9 (26%)	0.85 (95% CI, 0.73-0.97)
Mild	11 (31%)	13 (37%)	
Moderate	8 (23%)	7 (20%)	
Severe	6 (17%)	6 (17%)	
Quantitative evaluation:			
CAC (n segments)	3.86 ± 0.7	3.79 ± 0.6	0.98 (95% CI, 0.95-0.99)
CAC (Agatston, median)	180 (0-759)	164 (0-702)	0.98 (95% CI, 0.96-0.99)
CAC (Agatston) ≥ 400	15 (43%)	13 (37%)	0.88 (95% CI, 0.72-1)

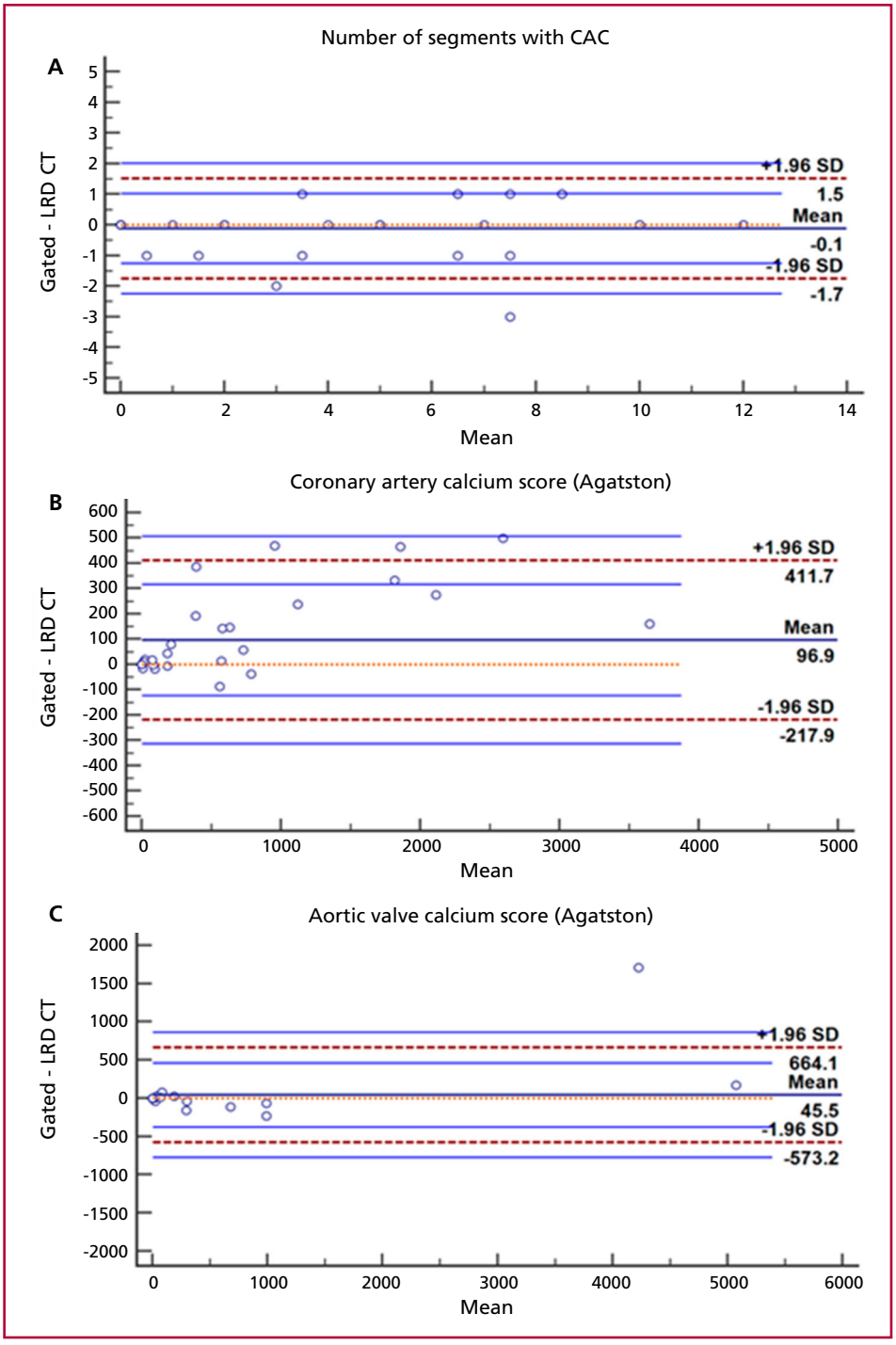

Fig. 2. Bland-Altman plots (mean of two assessment methods in the x-axis and difference between both methods in the y-axis) showing agreement between coronary artery calcium (CAC) score evaluated by gated cardiac computed tomography and low radiation dose (LRD) chest computed tomography (CT) for the evaluation of the number of segments with CAC (panel A), estimation of CAC score (Agatston units, panel B), and aortic valve calcium score (Agatston units, panel C). The plots demonstrate that the greater dispersion occurs in patients with extensive calcification.

segments using LRD CT, with a CCC of 0.98 (95% CI, 0.95 -0.99). The Bland-Altman plots also demonstrated good agreement between both methods in the assessment of the number of segments with CAC (Figure 2). Both methods also had good agreement for the quantitative evaluation of CAC (Agatston units), with a median of 180 (interquartile range 0-759) Agatston units for gated CT and 164 (0-702) for LRD CT, with a CCC of 0.98 (95% CI 0.96 - 0.99) and an underestimation of 9.8 % for the latter strategy. The Bland-Altman analysis demonstrated good agreement for the quantification of CAC (Agatston) in patients with CAC score < 400 Agatston units, with greater dispersion in those with extensive calcification (CAC score > 1000 Agatston units). Agreement was good for the identification of patients with CAC score > 400, kappa 0.88 (95% CI, 0.72-1). Finally, we evaluated the aortic valve calcium score by both methods, and observed good agreement, with CCC of 0.96 (95% CI 0.94-0.98), also shown in the Bland-Altman plot (Figure 2).

DISCUSSION

The main finding of our study was the good agreement for qualitative and quantitative estimation of CAC and aortic valve calcification using LRD CT.

There are many large studies with a maximum follow-up of 15 years, demonstrating the incremental predictive value of CAC score over the traditional risk factors, with special emphasis on the absence of calcifications (CAC score = 0) to identify very low-risk (asymptomatic) patients, even in the presence of other risk factors. (7-9) In addition, CAC score has proved to improve the selection of patients who would benefit from statin therapy. (3, 10)

Despite the evidence supporting the use of CAC score, the implementation of this tool is scanty in our environment, probably because its cost is thought to be much higher (a wrong assumption, according to our perception) than that of chest CT, considering that X-ray tube consumption is significantly lower. Low radiation dose CT is a tool originally conceived for the early detection of lung cancer, and several international studies have demonstrated that its predictive value to detect CAC is similar to that of gated CT. (5)

Although previous and much larger studies have validated non-gated CT as a valid tool for the qualitative ordinal assessment of CAC score in incremental risk scales (absent, mild, moderate and severe), there is limited evidence in terms of agreement for quantitative assessment. (4) Moreover, the aim of our study is to raise visibility on the fact that CAC scoring as a prevention tool is underused, and bring into discussion the probability of evaluating CAC score directly in LRD CT examinations frequently requested as part of clinical health check-ups in asymptomatic patients who generally share a similar risk profile.

On the other hand, we demonstrated good agreement between methods for the assessment of the aortic valve calcium score, an emerging marker for the evaluation of the severity of aortic stenosis and the probability of complications in patients considered for percutaneous aortic valve replacement. (11)

CONCLUSION

This hypothesis-generating study demonstrated that low radiation dose CT could accurately provide qualitative and quantitative assessment of CAC score.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web/Additional material.)

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