ORIGINAL ARTICLE

Diagnosis of the diseased coronary vessel by calcium score in patients with chest pain

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ABSTRACT

Introduction: coronary artery disease is one of the leading causes of death worldwide. A valuable tool for its diagnosis is calcium score by cardiac tomography.
Objective: to describe the results of the use of calcium scoring in the diagnosis of coronary artery disease.
Methods: a cross-sectional descriptive study was carried out at the Cardiocentro "Ernesto Che Guevara" of Santa Clara in 2019. The population consisted of 820 patients with chest pain attended at the tomography service and the sample consisted of 246 patients selected by simple random sampling. A request for informed consent was made and anamnesis, physical examination and coronary calcium score were performed. In the statistical analysis, the Kruskal-Wallis test was used to compare the variables describing the calcium score in the four coronary vessels and the Mann-Whitney U test (penalized by the Bonferroni method).
Results: 61.4% of those investigated were over 60 years of age, 65.9% were male, 78.1% had some risk factor and arterial hypertension was the most frequent (68.7%). The most common diagnosis was multivessel disease (42.28%) and the anterior descending artery was the most affected (41.46%). There were significant differences between the mean ranges for the number of lesions in the vessels with a median of three for the anterior descending and right coronary arteries.
Conclusion: the calcium score was able to diagnose coronary vessel disease in the majority of patients with chest pain.
Key words: thoracic pain; coronary artery disease; soccer score; diagnosis

RESUMEN

Introducción: la enfermedad de vasos coronarios constituye una de las principales causas de muerte a nivel mundial. El calcio score por tomografía cardíaca es una valiosa herramienta para su diagnóstico.
Objetivo: describir el resultado del empleo del calcio score en el diagnóstico de los vasos coronarios enfermos.
Métodos: se realizó un estudio descriptivo transversal en el Hospital Provincial Universitario Cardiocentro "Ernesto Guevara" de Santa Clara en 2019. La población estuvo conformada por 820 pacientes con dolor torácico atendidos en el Servicio de

Tomografía y la muestra por 246 seleccionados por muestreo aleatorio simple. Se solicitó consentimiento informado y se realizaron anamnesis, examen físico y calcio score coronario. En el análisis estadístico se empleó la prueba de Kruskal-Wallis para comparar las variables descriptoras del calcio score en los cuatro vasos coronarios y la prueba de la U de Mann-Whitney (penalizada por el método de Bonferroni).
Resultados: el 61,4% de los investigados tuvieron edades superiores a los 60 años, el 65,9% eran masculinos, el 78,1% tuvo algún factor de riesgo y la hipertensión arterial fue la más frecuente (68,7%). Fue más usual el diagnóstico de enfermedad multivaso (42,28%) y la arteria descendente anterior la más afectada (41,46%). Hubo diferencias significativas entre los rangos medios para el número de lesiones en los vasos con una mediana de tres para la descendente anterior y para la coronaria derecha.
Conclusión: con el calcio score se pudo diagnosticar la enfermedad de vaso coronario en la mayoría de los pacientes con dolor torácico.
Palabras clave: dolor torácico; enfermedad de arterias coronarias; calcio score; diagnóstico

INTRODUCTION

In the early seventies of the last century Sir Godfrey Newbold Hounsfield and Allan MacLeod Cormack initiated the career of computed tomography. This brilliant idea, born from the studios of EMI record, the recording company of The Beatles, won the Nobel Prize in Physics and Medicine in 1979. This technology, novel for the time, was the forerunner of today's tomographs that facilitate the diagnosis and clinical and evolutionary interpretation of coronary artery disease and its most advanced stage, ischemic heart disease.[1]
The different generations of tomographs have added technological changes that guaranteed the usefulness of this technique; among its first applications in cardiology is the study published by Agatston and his group in 1990 entitled Quantification of Coronary Artery Calcium Using Ultrafast Computed Tomography, from which the calcium score, also called the Agatston score, emerged. The Agatston scale is based on the surface area of calcium and its density. The detection of three or more pixels with a density greater than 130 HU is multiplied by a conversion factor with preconceived values ranging from one to four, to which the following ranges correspond, 1 from 130 to 199 HU, 2 from 200 to 299 HU, 3 from 300 to 399 HU and 4 more than 400, successively.[2]
Many publications on the subject came out in multiple impact journals in the last 30 years with different results, but they confirmed the usefulness of this study as a stratifier of coronary artery disease together with its predictive capacity for future events. The modifications that the calcium score tomographic technique has undergone in the course of technological evolution have evidently improved its specificity and sensitivity in the diagnosis of coronary artery disease. Despite the efforts of researchers, classical methods are less effective than this test because it consists of volumetric measurement and quantification of calcium, which is a consequence of atherosclerosis or arterial wall disease. The possibility provided by this test guarantees an adequate management of this disease and leads it, on occasions, to a reversible stratum with only pharmacological treatment, which obviously improves the patient's quality of life and prognosis.

Calcium scoring is a tomographic study technique without contrast injection in which images are acquired during a short period of apnea, with prospective synchronization to the patient's electrocardiogram from the patient's carina to the apex, with a slice thickness of 3 mm and a tube power of 120 kVp. The approximate scan time is three to five seconds in multislice equipment.

The relationship between calcium load and coronary artery disease is well described; it is known that the most calcified plaques, with a beam attenuation above 1000 HU, are much more stable than those at or near the minimum, 130 HU, which worsens the patient's prognosis due to their high vulnerability.

To date, predictive models of cardiovascular events are based on invasive coronary angiography, which concentrates interest on occlusive lesions or lesions that cause ischemia based on functional examinations; however, it has been demonstrated by large studies that the most important predictor of cardiovascular events is the total burden of calcified plaque, which surpasses the presence of occlusive plaques alone.[3]

The epidemiological variables used in coronary risk stratification to date are less specific than direct measurements of their consequence on the vessel wall based on calcium scoring; however, despite the fact that the assessment and study of the coronary tree is mostly based on functional tests, the anatomical and volumetric details that are measured by calcium scoring have several advantages.[3]

Certain risk factors have been associated with epicardial coronary segments and the relationship of coronary artery wall disease with its geometry has been described, which justifies the presence of plaques in certain curvatures of the walls. If some chronic non-communicable diseases such as diabetes mellitus, arterial hypertension (AHT), hypercholesterolemia and smoking are associated with this geometric phenomenon, the probability of plaques in the arterial wall is very high.[4]

Cardiovascular morbidity and mortality is currently the main concern of physicians and public health officials worldwide. By the year 2025, cardiovascular mortality, worldwide, will possibly surpass all major groups of diseases, including infections, cancers and trauma. Cuba is not exempt from that reality, cardiovascular diseases as a whole caused 44 471 deaths between 2017 and 2018, for a mortality rate of 197.6 per 100 000 inhabitants, and were responsible for 80% of deaths and the loss of 10.7 years of potential life per 100 000 inhabitants because it occurs increasingly at younger ages of life and in stages of full work performance. Multiple studies have been carried out to determine the magnitude of the influence of coronary risk factors, which recognize their multiplicity and their association as a cause of cardiovascular disease, with a predominance of obesity, diabetes mellitus, smoking and inadequate diets.[5]

In Villa Clara Province, cardiovascular disease is the main cause of death, so several investigations related to causality and prediction are carried out to promote impact strategies.

It is important for the medical professional to know the cardiovascular condition of the patient who comes to the Health Service with chest pain, and the calcium score is a useful non-invasive instrument. The aim of this study is to describe the results of the use of calcium scoring in the diagnosis of diseased coronary vessels.

METHODS

Design and population

An analytical observational study was carried out at the "Ernesto Guevara" University Cardiocenter Provincial Hospital of Santa Clara City, Villa Clara Province, in 2019.

The study population consisted of 820 adults with chest pain who were seen at the Cardiac Tomography Service of the "Ernesto Guevara" Cardiocenter who underwent calcium score tomography in 2019.

The total population was sampled by simple random probability sampling, and the sample consisted of 246 patients.

Simple random sampling was used, for the calculation a reliability level of 95% was established, the prevalence of arterial hypertension (30%) as the theoretical factor recognized as having the greatest influence on the epidemiology of coronary disease and a precision of 2%.

Variables of the study

Age group: under 60 years old/60 years old and over.

Sex: male and female were considered. Qualitative nominal dichotomous

Coronary risk factor: yes and no.

It is defined as the condition (biological, lifestyle or acquired habits) that increases the probability of suffering coronary disease and to recognize the population group most exposed to suffer it.

- Arterial hypertension: patient with a history of AHT (elevated blood pressure -BT- on one or more occasions with pharmacological treatment). Systolic BP greater than 140 mmHg and diastolic BP greater than 90 mmHg.
- Diabetes mellitus: patient with a history of diabetes mellitus (glycemia ≥ 6.6 mmol/l, with dietary treatment, oral hypoglycemic agents or insulin).
- Dyslipidemia: patient with a history of hyperlipidemia (presence of cholesterol levels greater than 6.7 mmol/l and triglyceride levels greater than 1.8 mmol/l -or both-) with pharmacological treatment.
- Habit of smoking: patient with a history of being a smoker (or having been a smoker in the last 20 years).

Diseased vessel: yes and no, according to the presence of calcium plaques in the vessels, as a result of calcium score by tomography.

Coronary vessels. According to the anatomical location of each coronary vessel.

- Left main coronary artery (LMCA): the common beginning of the left coronary artery is called the left coronary trunk. It originates in the left aortic sinus and passes behind the pulmonary artery. It bifurcates into two branches, the anterior descending artery and the circumflex artery. The length of the left coronary trunk is highly variable and can be up to 20 mm.
- Anterior descending (AD): arises from the bifurcation of the left main coronary artery, passes to the left of the pulmonary artery and runs along the anterior interventricular groove to the apex. It is the artery that irrigates most of the territory of the left ventricle, supplying the entire anterior aspect and part of the lateral aspect of the left ventricle,

as well as the anterior two thirds of the septum, part of the right ventricular outflow tract and, in some patients, the mid-apical segments of the inferior aspect.

- Circumflex (CX): arises from the bifurcation of the left coronary trunk and runs along the left coronary sulcus, bordering the heart towards its posterior region, in the direction of the posterior interventricular sulcus. It supplies the lateral and posterolateral aspect of the left ventricle, the lateral and posterior aspect of the left atrium and, if there is left dominance, it also supplies the inferior aspect of the left ventricle. Along its course it gives branches to the left atrium and to the lateral wall of the left ventricle.
- Right coronary artery (RCA): it leaves the right coronary sinus of Valsalva, goes to the right and follows the right atrioventricular groove giving branches to the anterior aspect of the right ventricle. Subsequently, it continues backwards and gives rise to the posterior descending or posterior interventricular artery that irrigates the posterodiaphragmatic side of the heart and on which the artery that irrigates the atrioventricular node depends.

Descriptor variables of the calcium score:

- Number of lesions: is the sum of the number of pixels, always greater than 1, having a threshold greater than 130 HU.
- Mass: the equivalent mass is proportional to the number of plaques classified by lesion volume.
- Volume: is the summation of the area by the increment of the reconstruction of the acquired image that corresponds to 50% of the slice thickness; the slice is made at 3 mm, therefore, the 50% increment would correspond to 1.5, and is given in mm^3.
- Quantification: this is based on the attenuation of each individual lesion in which a score is calculated by multiplying the area of calcification in mm2 by a cofactor between 1 and 4 that depends on the maximum value of HU in that plaque. The cofactor is 1 if the atheroma plaque is between 130-199 HU, 2 between 200-299 HU, 3 between 300-399 HU and 4 if plaque attenuation is greater than 400 HU. This score can be obtained for each individual plaque or all scores can be summed to obtain the total amount of calcium per coronary artery or for the coronary tree: ΣA(n).cofactor (n).

Procedures/data collection and management

Each patient with chest pain who was seen in the cardiac tomography department was asked for informed consent to participate in the investigation, underwent ananmnesis and physical examination and underwent coronary calcium scoring with a Somatom Definition, Siemens, Forcheim, German dual-source tomograph, and complementary laboratory and cardiovascular examination. The data were stored in the medical records and then in the Service's statistical registry in a Microsoft Excell data file prepared for research purposes.

Statistical analysis

The data were processed in the Statical Package for the Social Sciences (SPSS®) 21.0 statistical software installed on the Windows 10® operating system, and were analyzed as follows:

Qualitative variables were expressed in absolute frequencies and by hundreds.

The normal distribution of the variables was tested using the Kolmogorov-Smirnov test with a significance level of α=0.05. The distribution was not normal; therefore, the Kruskal-Wallis nonparametric test was applied to compare each of the calcium score descriptor variables (number of lesions, volume, mass, and quantification) in four groups (the four coronary vessels). Once the null hypothesis of equality of medians was rejected to complete the analysis, the possible a posteriori comparisons (two to two) were performed using the Mann-Whitney U test, but penalizing it with the Bonferroni method. By combinatorial theory (four cups-in-two) resulted in six possible pairwise combinations.

RESULTS

Of the total number of patients studied in the sample, the most frequent were the group over 60 years of age (61.40%) and the male sex (65.90%). Coronary risk factors were identified in 192 patients (78.05%); arterial hypertension prevailed in 169 (68.70%) -Table 1-.

Table 1. Distribution of patients according to age group, sex and risk factors

Epidemiological variables (n=246)	No.	%
Age group		
Under 60 years old	95	38.60
60 years and over	151	61.40
Gender		
Male	162	65.90
Female	84	34.10
Risk Factors	**192**	**78.05**
High blood pressure	169	68.70
Smoking habit	73	29.67
Dyslipidemia	66	26.83
Diabetes mellitus	62	25.20

Source: Cardiology Registry

Multivessel disease (42.28%) and involvement of the LAD-LMCA-CX (15.45%) predominated in the study -Table 2-. Importantly, LAD was present in most patients with multivessel disease.

Comparison between groups was performed with the nonparametric Kruskal-Wallis test in all cases because the assumptions of normality were not met (Table 3).

Comparison of the number of lesions according to vessel showed that there were significant differences between the mean ranges. The highest values were observed in the RCA and the median for this vessel was three lesions, as was the coronary LAD.

In relation to the variables volume, mass and quantification, there were no significant differences in the values.

Table 2. Distribution of patients according to coronary vessel disease by calcium score

Coronary vessel disease	No.	%
No diseased vessels	97	39.43
Monovessel disease	45	18.29
Multi-vessel disease	104	42.28
LAD-LMCA-CX	38	15.45
LAD-LMCA	22	8.94
LAD-CX	17	6.91
LAD-LMCA-CX-RCA	15	6.10
LAD-CX-RCA	4	1.63
LAD-RCA	4	1.63
LAD-LMCA-RCA	2	0.81
LMCA-RCA	1	0.41
LMCA-CX	1	0.41

LAD: left anterior descending artery; LMCA: left main coronary artery; CX: circumflex artery; RCA: right coronary artery
Source: Cardiology Registry

Table 3. Comparison of diseased coronary vessels according to calcium score descriptor variables

Coronary vessel diseased	Median	Minimum	Maximum	Mean Range	P*
Number of injuries					
LMCA	1	1	6	124.19	0.000
LAD	3	1	16	220.16	
CX	2	1	11	185.52	
RCA	3	1	22	242.44	
Volume					
LMCA	44.3	1.25	1 447.70	194.65	0.099
LAD	63.5	0.50	945.80	198.75	
CX	36.1	0.30	1 381.20	175.15	
RCA	82.1	2.40	1 595.60	218.86	
Mass					
LMCA	11.1	0.54	366.50	198.54	0.087
LAD	14.5	0.13	257.84	200.46	
CX	7.6	0.08	338.62	171.28	
RCA	19.6	0.56	554.70	215.93	
Quantificatio					
LMCA	56.6	2.0	1 834.4	197.85	0.104
LAD	77.3	0.3	1 179.7	200.60	
CX	39.9	0.2	1 634.2	172.30	
RCA	96.1	2.2	2 038.5	215.49	

*Statistical significance of the Kruskal-Wallis nonparametric test
Source: Cardiology Registry

Due to the fact that in the comparison of the number of lesions according to vessel there were significant differences between the mean ranges, we proceeded to the comparison to identify the combinations of diseased coronary vessels.

The values of number of lesions showed significant differences between the groups, with the exception of the comparison between the LAD and RCA artery; these results are related to the similarity in the length of both arteries (Table 4).

Table 4. Paired combinations of diseased coronary vessels according to mean ranges of the number of lesions

Coronary vessel	Average ranges \ p*			
	1) LMCA	2) LAD	3) CX	4) RCA
1) LMCA		0.000	0.000	0.000
2) LAD	1)78.64 2)133.86		0.024	0.112
3) CX	1)68.94 3)95.37	2)115.93 3)96.40		0.000
4) RCA	1)62.61 4)114.07	2)111.36 4)125.48	3)71,75 4)96,89	

*Nonparametric Mann-Whitney U test (penalized by the Bonferroni method)
Source: Cardiology Registry

DISCUSSION

Table 2 shows the frequency of coronary vessel disease. Multivessel coronary artery disease predominated, without downplaying the importance of patients with disease accompanied by chest pain and simulating coronary vessel disease, which is ruled out by calcium scoring. In a published study, the authors found that 29.4% of patients with coronary lesions had a single lesion, while 70.6% had multiple lesions. In these combinations the anterior descending artery was present.[6]

Patients with a calcium score greater than or equal to 400 UA are frequently associated with multivessel disease; the higher the score, the greater the diagnostic specificity. The presence of coronary calcium is associated with a high risk of acute myocardial infarction even in asymptomatic patients.[7]

Identification of the coronary artery involved could also improve risk prediction. The presence of calcium at the level of the LMCA and LAD has been associated with increased risk.[8] Eighty percent of acute coronary events in young people are due to atherosclerotic disease mainly located in the LAD and RCA arteries.[9] In a recent study dedicated to the topographic characterization of coronary vessels, the LAD artery was most frequently affected (62.5%), followed by the RCA (60.9%) and the CX (57.8%). There were no associated coronary lesions in 54.7%. Only one vessel was affected in 44% and more than two vessels were involved in 56% of cases.[10]

Visual estimation of the extent of coronary calcium is simple and has been shown to be of significant prognostic value.[11,12]

The amount of coronary calcium is closely related to the total atherosclerotic plaque burden, but calcifications are only the tip of the iceberg. It is estimated that the volume of calcified plaque represents 20% of the total atherosclerotic burden. In other words, patients who have calcified plaque are also more likely to have noncalcified plaques or soft plaques, which are prone to rupture and acute coronary thrombosis; this is the basis for the calcium score classifications.[13]

Recent evidence suggests that calcium quantification may contribute to decision making in patients with intermediate Framighan probability, in whom a calcium score greater than 300 AU is associated with high probability of infarction and sudden death.[14,15]

In a meta-analysis of 49 studies, the objective was to determine the value of a coronary calcium score of zero AU in predicting cardiovascular events in symptomatic and asymptomatic patients.(16)
The MESA (Multi-Ethnic Study of Atherosclerosis) study showed that 8 of 3409 patients with zero UA calcium score had major cardiovascular events in the 3.8 years of follow-up. The prevalence of zero coronary calcium in the general population is 30 to 65%.(17)
In the literature consulted, no comparison was found of the variables describing the calcium score according to coronary vessel, only mention is made of calcium quantification.

CONCLUSIONS

The calcium score was able to diagnose coronary vessel disease in most patients with chest pain. Multivessel coronary artery disease was more frequent and the anterior descending artery was more affected.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHORS' CONTRIBUTION

MPD: conceptualization, formal analysis, methodology, data curation, project management, supervision, resourcing, validation, visualization, research, writing the original draft, writing (review and editing).
YHD, ITP: formal analysis, methodology, validation, supervision, writing original draft, writing (review and editing).
ECCF, NPR, BYM: conceptualization, formal analysis, methodology, data curation, visualization, research, project management, writing original draft.