CORRELATION OF CORONARY CALCIUM SCORE AND ANGIOGRAPHIC FINDINGS IN PATIENTS WITH ISCHEMIC HEART DISEASE

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Submitted: 25/6/2022; Accepted: 20/12/2022; Published: 21/3/2023

ABSTRACT

Background

Acute myocardial infarction and sudden cardiac death was reported to be the initial presentation in 50% of patients with coronary artery disease (CAD); coronary artery calcium score can be regarded as one of the potential tools to improve risk stratification and predict coronary events in these patients.

Objectives

To find the correlation between coronary calsuim score calculated by CT scan and significant coronary stenosis by conventional coronary angiography.

Materials and Methods

A hundred patients who were referred for conventional coronary angiography having CAC score calculated by CT scan, 50 patients with CAC <400 and 50 patients with >400 were randomly selected to be involved.

Results

The age ranged from 32 to 70 years with a mean of 56.7 ±8.9. There were 59 males with 41 females. Chest pain was our study's main reason for undergoing imaging (67%). The mean coronary calcium score was 528.54 for total coronary vessels and 19,236.8, 115.45 and 157.98 for LMS, LAD, LCX and RCA, respectively. The mean of the calculated syntax score was 23.4. Stenosis of >50% was 9% for LMS, and stenosis of ≥75% was found in 41%, 27%, and 8% of LAD, LCX and RCA, respectively. A significant correlation between total coronary calcium score at a threshold of 400 and age, being diabetic, LAD stenosis, LCX stenosis, RCA stenosis, mean syntax score and syntax score categories. Also, the mean total coronary calcium score was significantly correlated to age, gender and syntax score. Moreover, the stenosis in LAD, LCX and RCA was significantly correlated to the mean of the calcium score of respective vessels.

Conclusion

Total CAC score was significantly associated with angiographic coronary stenosis, and the correlation is stronger at 400 and above. This study may support using calcium screening as an initial filter before further sophisticated imaging or invasive angiography. However, a zero or low CACS does not exclude CAD.

Keywords: *Total coronary calcium score, Coronary artery disease, Coronary artery stenosis.*

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https://doi.org/10.17656/jsmc.10393

INTRODUCTION

Along-term atherosclerotic process is the principal mechanism in the pathogenesis of coronary artery disease (CAD), leading to significant stenosis regarded as more than 50% of luminal narrowing of the coronary arteries. In addition, acute myocardial infarction and sudden cardiac death were reported to be the initial presentation in 50% of them [1] despite increased efforts to establish associated risk factors to detect patients at risk of future cardiac events. Unfortunately, the ability to predict the occurrence of coronary events through evaluating conventional risk factors, like Framingham Risk Score, physical examination, and stress testing, is limited, particularly among patients within the intermediate risk group [2].

Coronary artery calcium score (CACS) can improve risk stratification and predict coronary events. While it has other advantages, like direct visualization of plaques and precise localization by computed tomography (CT), it is also a recognized marker for determining atherosclerotic plaque burden[3]. In contrast to conventional risk factors, which can only provide a statistical probability of developing coronary events, Agatston calcium scoring [4] can quantify calcium in the coronary arteries and allow a direct assessment of each patient. The use of CACs has been supported by many reports in the assessment of coronary event risk stratification [3]. Although the gold standard diagnostic tool of CAD is conventional coronary angiography (CCA) because of its spatial and temporal resolution, leading to precise evaluation of the degree of stenosis of the coronary arteries. However, it is inconvenient for many patients due to the invasive nature of the procedure and its cost; on the other hand, CACS is quantified through a CT scan, which is a routine practice in non-invasive diagnostic modalities.

PATIENTS AND METHODS

A total number of 100 Patients who were referred to Sulaimani cardiac hospital and the cardiac unit of Shar hospital for invasive coronary angiography and having Computed tomography coronary angiography with calculated calcium score by the Agaston system [5] were involved prospectively in our study, from which 50 patients with calcium score more than 400 and 50 patients with a score of less than 400 randomly selected.

Patients with a prior history of coronary artery disease and who underwent coronary artery bypass grafting or stenting were excluded from the study.

Kurdistan Board approved ethical consideration through study protocol for Medical Specialties, Directorate of Training Affairs, and Ethical and Scientific Research Units.

After taking informed consent from each participant, demographic characteristics were obtained from their files, and cardiovascular risk factors were assessed through detailed history.

Coronary calcium scores were obtained by reviewing their CTCA reports and were divided into two categories below and above 400. Coronary lesion stenosis during invasive angiography was classified as non-significant luminal stenosis of less than 50%, significant luminal stenosis of more than 50%, and severe luminal stenosis of more than 75% stenosis. Using an online calculator (www.syntaxscore.com), the SYNTAX score, an anatomical measure of coronary lesion severity and complexity, was calculated for all patients with significant coronary luminal stenosis, 61 patients in our study group. Three categories of calculated SYNTAX score were set [6], less than 22 as low complexity, between 23 and 32 as an intermediate, and greater than 33 as high complexity score; the studied population was further categorized more broadly into two groups of low-intermediate risk of ≤ 32 and high-risk tertile of > 32.

Statistical analysis was performed through SPSS 25.0 software. Continuous variables were expressed as mean ± standard deviation (SD), and Categorical variables as percentages. Student's t-test or the Mann-Whitney U test was used for group means for continuous variables. Pearson's or Spearman's correlation analysis was used to assessing the correlation between the total CAC score and continuous variables. A p-value of ≤ 0.05 was set to be statistically significant.

RESULTS

All 100 participants completed the study with no missed cases. The age ranged from 32 to 70 years with a mean of 56.7 ±8.9. There were 59 males with 41 females; forty patients were active smokers. Among them, the percentage of hypertension, diabetes mellitus, dyslipidemia and family history of ischemic heart disease was 57%, 35%, 54% and 39%, respectively, Table 1.

Chest pain was our study's main reason for undergoing imaging (67%). The mean coronary calcium score was 528.54 for total coronary vessels and 19, 236.8, 115.45

and 157.98 for LMS, LAD, LCX and RCA, respectively.

Having no significant disease was 39% among them. Also, the percentage of single, two and three-vessel disease was 30%, 16%, and 15%, respectively. Stenosis of >50% was 9% for LMS, and stenosis of ≥75% was found in 41%, 27%, and 8% of LAD, LCX and RCA, respectively. The mean of the calculated syntax score was 23.4, and a score ≤ 32 was found in 80.3% of them, and 19.7% had a syntax score of ≥33, Table 2.

A significant correlation between having a total coronary calcium score at a threshold of 400 and age, being diabetic, LAD stenosis, LCX stenosis, RCA stenosis, mean syntax score and syntax score categories, Table 3.

The mean of total coronary calcium score was significantly correlated to age, gender and syntax score, and also, the stenosis in LAD, LCX and RCA was significantly correlated to the mean of the calcium score of respective vessels, Table 4.

Table 1. Demographic and cardiovascular risk Factors of the Participants.

Parameter (n=100)		Value
Mean age ± SD (years)		56.7 ± 8.9
Age range (years)	20-40	6
	41-60	61
	> 60	33
Gender	Male (%)	59
	Female (%)	41
Smoking status	Active smoker (%)	40
	Non-smoker (%)	60
Hypertension	hypertensive	57
	normotensive	43
Diabetes Mellitus	Diabetic	35
	Non-diabetic	65
Dyslipidemia	Dyslipidemia	54
	No Dyslipidemia	46
Family history of IHD	Positive	39
	Negative	61

Table 2. The calcium score and invasive angiographic findings.

Parameter		Value
Total calcium score (mean+SD)		528.54 ±425.66
CCA of LMS (mean+SD)		19 ± 60
CCA of LAD (mean+SD)		236.8 ± 260.35
CCA of LCX (mean+SD)		115.45 ± 126.97
CCA of RCA (mean+SD)		157.98 ± 165.15
Indication of coronary angiography	Chest pain (%)	67
	Perioperative evaluation (%)	29
	Heart failure (%)	4
Number of diseased vessels	No significant disease (%)	39
	Single vessel disease (%)	30
	Two vessels disease (%)	16
	Three vessels disease (%)	15
Coronary stenosis	No Significant stenosis	29
	Significant stenosis	71
	No lesion	85
LMS stenosis (%)	<50%	6
	≥50%	9
	No significant lesion	48
LAD stenosis (%)	50-74%	11
	≥75	41
	No significant lesion	67
LCX stenosis (%)	50-74%	6
	≥75%	27
	No significant lesion	62
RCA stenosis (%)	50-74%	8
	≥75	30
Syntax score (n=61) (mean+SD)		23.4 ± 9
Syntax score (n=61)	0-22	42.6 (%)
	23-32	37.7(%)
	≤ 32	80.3(%)
	≥33	19.7(%)

Table 3. Correlation of different variables with Coronary calcium score.

Parameter		CORONARY CALCIUM SCORE		P value.
		<400	>400	
Gender	Male (%)	26	33	0.15
	Female (%)	24	17	
Age (years)	20-40	6%	0%	
	41-60	36%	25%	<0.001
	61-80	8%	25%	
Smoking status	Smokers (%)	20	20	0.5
	Non-smokers (%)	30	30	
Hypertension	Hypertensive (%)	29	28	0.8
	Normotensive (%)	21	22	
DM	Diabetic (%)	22	13	0.05
	Non-diabetic (%)	28	37	
FH of IHD (%)	Yes	22	17	0.3
	No	28	33	
Dyslipidemia(%)	Yes	25	29	0.42
	No	25	21	
Coronary stenosis	Not significant	26	3	0.001
	Significant	25	46	
LMS stenosis	>50%	5	1	
	<50%	5	4	0.2
	No lesion	40	45	
LAD stenosis	>75%	2	39	
	50-74%	3	8	0.001
	no significant stenosis	45	3	
LCX stenosis	>75%	4	23	
	50-74%	3	3	0.001
	no significant stenosis	43	24	
RCA stenosis	>75%	5	25	
	50-74%	3	5	0.001
	no significant stenosis	42	20	
Syntax score	≤ 32	38.7%	61.22%	0.04
	> 33	8.3%	91.7%	
Syntax score	0-22	53.8%	46.2%	
	22-32	21.7%	78.3	0.008
	≥33	8.3	91.7	
syntax score (mean+ SD)		17.4 ± 8.4	26.3 ± 7.8	0.001

Table 4. Correlation of different variables with the mean of Coronary calcium score.

Parameter		(Mean SD)	P. value
Gender to total CCA	Male	636.8 ± 485	0.002
	Female	372.6 ± 257.9	
Age to total CCA.	20-40	244 ± 159.9	
	41-60	466.4 ± 441	0.01
	61-80	694.9 ± 374.7	
Number of diseased vessels to total CCA score.	No significant disease	417 ± 425	
	Single vessel disease	476 ± 205	0.09
	Two vessels disease	617.8 ± 290.5	
	Three vessels disease	828 ± 682.8	
Coronary stenosis to total CAC means	Not significant	204.6 ±207.5	0.001
	Significant	660.8 ±421.6	
Syntax score to CCA score	0-22	362.8 ± 255.9	
	23-32	644.6 ± 313.2	0.001
	≥33	1027.3 ± 501.8	
Syntax score to Total CCA score	≤ 32	495.1 ± 315	0.001
	> 32	1027.3 ± 501.8	
LMS stenosis % to LMS CA score	No stenosis	16.29 ± 47.1	
	<50%	70 ± 171.46	0.098
	≥50%	11.1 ± 33.3	
LAD stenosis % to LAD CA score	No significant stenosis	70.2 ± 69.78	
	50-74%	196.6 ± 152.7	0.001
	≥75%	442.6 ± 281	
LCX stenosis % to LCX CA score	No significant stenosis	99.8 ± 125.7	
	50-74%	110.3 ± 80	0.001
	≥75%	155.3 ± 133.1	
RCA stenosis % to RCA CA score	No significant stenosis	79.5 ± 83.5	
	50-74%	147.8 ± 122.4	0.001
	≥75%	322.7 ± 183.25	

DISCUSSION

Images with very high temporal and spatial resolution can be obtained from CTCA, which can be in a very short period. It is a non-invasive procedure with direct visualization and assessment of the coronary anatomy and associated atherosclerotic plaque [7]. However, due to a serious concern about the long-term effects of radiation on patients, especially in women and young patients, made CTCA is not to be used freely. While CCS is regarded as a marker for atherosclerosis, it is still inadequate to be used diagnostically [8]. Hence there are many efforts toward studying the efficacy of CCS and comparing it to CTCA and coronary catheterization.

In our study, CT scans and catheterization were performed by the different operators within a lag time of a few days of each other to avoid potential errors due to the progression of time the stenosis. However, it is reported that there was no significant difference between referring within a few days as compared to a mean of 18 months of delays [9].

In our study, the mean calcium scores for men were significantly higher than for women (p 0.002). This is shown in many other reports with a significant increase in CCA with the age of our participants (p 0.01), these relations were also confirmed in many other studies [10].

Many previous studies confirmed a close relationship between coronary calcium and the severity of coronary artery stenosis in the number of coronary arteries and the degree of stenosis found on coronary catheterization [11, 12].

In this study, when the severity of the stenotic segment was compared to the degree of calcification in an individual coronary, an incremental increase in the stenosis severity was noted increased calcium scores. The example of this significant relationship as observed for LAD, calcium scores were 70.2 ± 69.78, 196.6 ± 152.7 and 442.6 ± 281 in the presence of non-significant, 50–74% and ≥ 75% stenosis, respectively ($p<0.001$). Similar relationships were noted for the LCX, and RCA ($p<0.001$), and a similar ratio was noted for the LMS lesions but with less degree of significance (p 0.09), observing a similar result for these findings in other studies solidified these associations more [9,11,12]. Although statistically not significant, A positive association was also found between the mean calcium score and the number of vessels with significant stenosis, patients with no vessel involved, 1, 2 and 3-vessel disease, mean calcium scores of 417 ± 425, 476 ± 205, 617.8 ± 290.5 and 828 ± 682.8 recorded, respectively ($p<0.001$).

Finding these relationships support that the higher the calcium score, the higher the degree of coronary stenosis we get, but the reliability to set a cut point above which CAD should rule out or in is still under question since we found that 5%, 3% and 3% of our patients with significant stenosis in LAD, LCX and RCA respectively, having zero calcium score in respective vessels, making exclusion of CAD difficult even in zero calcium score, this made us to set a higher calcium score (less and more than 400) as a threshold point aiming in improving sensitivity and specificity for detecting CAD in our study. Even though we still found that 6% of our patients had no coronary lesions despite having a CCA of >400.

As previously reported [9, 11, 12], a statistically significant positive association was seen between CAC scores of more than 400 and significant lesions. Furthermore, a recent study made CAC scores of more than 400 more attractive by finding significantly higher perfusion defects among them [13]. Our study also confirmed that a CAC score of more than 400 was associated with significant coronary stenosis in comparison to those with a CAC of less than 400 (p0.001); looking deeper at our result, significant lesions were found in 25 patients with CAC less than 400, while it nearly doubled in patients more than 400 (46 patients), on the other hand, non-significant lesions were found in 3 patients with CAC of greater than 400 and 26 patients with a calcium score of less than 400, this makes sensitivity (64.8%), specificity(89.7%), positive predictive value (93.9%) and negative predictive value (51%) with (p0.001). Unfortunately, there were no previous reports evaluating the CAC of 400 as a cut point to check sensitivity, specificity, and negative and positive predictive value in the diagnosis of CAD with invasive coronary angiography, however comparing with CT coronary angiography, it was recorded to have a positive predictive value of 87% [14].

Although it was not a part of the primary analysis of the current study, we found a significant correlation between the mean of the CAC score and the degree of complexity calculated with a syntax score (p0.001) and a calcium score of more than 400 (p0.04). Although no report assessed the calcium score with a threshold of 400, very few reports used conventional angiography in their study with a ratio to the current study [15].

In conclusion, total CAC score was significantly associated with angiographic coronary artery stenosis. The correlation is more potent at a CAC of 400 and above. Although this study supports calcium screening as an initial filter before further sophisticated imaging and angiography, a zero or low CACS would not exclude CAD.

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