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ORIGINAL ARTICLE

Coronary Calcification in Prediction of Short and Mid-Term Results of Coronary Intervention

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Abstract

Background: **After percutaneous coronary intervention (PCI), excessive coronary calcification might cause negative outcomes. We assessed how the coronary calcium score, determined by multidetector computed tomography (MDCT), affected the short and medium-term outcomes after PCI.**

Methods: **Before PCI, we analyzed 150 patients with coronary stenosis identified by MDCT. Total and single-artery coronary calcium score was calculated using the Agatston method. We divided them into three groups: (0.1−100), (100−400) and (>400).**

Results: **Statistical analysis (Chi squared) showed significant correlation between the patients' classifications according to all studied demographic data ($P < 0.05$). Classifying the groups with higher calcium score, they were found to have more difficult procedures, and higher syntax score than groups with lower calcium score. Statistical analysis (*T* tests) showed that all differences were significant. The relation between the three calcium groups showed that all the assessed complications had significant relation with higher calcium score groups. As regard to 6 months follow up, the total complications at 6 months were statistically significant (*P* value 0.01). The association between lesion type and single artery group in left anterior descending coronary artery, left circumflex artery and right coronary artery showed that the relation between groups was significant ($P < 0.0001$).**

Conclusions: **Coronary calcium score evaluated by Multidetector computed tomography can predict procedural difficulty, periprocedural complications, and complications from PCI at six months follow up after PCI. At the 30-day follow up, there were no reported complications found.**

Keywords: Calcium score, Coronary intervention, Periprocedural complications

1. Introduction

In some patients with symptomatic coronary artery disease, performing percutaneous coronary intervention (PCI) is regarded as a successful treatment. Numerous variables, including lesion anatomy, patient age, the existence of multivessel disease, the need for an urgent or emergency intervention, and the presence of congestive heart failure especially if class III or IV, are related to procedure outcomes[1]

An alternate diagnostic and prognostic tool would be the non-contrast CT scanning detection of coronary artery calcium (CAC). In contrast to previous testing methods, the calcium score offers a quantitative evaluation of the entire atherosclerotic burden. It has been demonstrated that the calcium score can accurately predict outcomes across a range of examined subject categories. Coronary artery calcium scanning enhanced prognostic categorization in asymptomatic participants. The absence of coronary artery calcium has been demonstrated to identify patients with low risk for cardiovascular disease and cardiovascular events in symptomatic individuals, negating the necessity for additional downstream testing.[2]

Uncertainty exists on how the coronary calcium score (CCS) derived from multidetector computed

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tomography (MDCT) may affect the outcomes of PCI with a drug-eluting stent. We anticipated that higher calcium score would lead to more PCI-related complications in the short- and mid-term. We aimed to investigate the impact of coronary artery calcifications (CAC), assessed by calcium score, on the short and mid-term results of percutaneous coronary interventions.

2. Patients and methods

150 patients who were referred for multidetector computed tomography MDCT and who had coronary calcium score measurement using the Agatston score method, followed by percutaneous coronary intervention, were included in the study. Patients with previous percutaneous coronary intervention (PCI), patients with previous coronary artery bypass grafting (CABG), and patients with chronic renal failure were excluded from the study.

After providing informed consent, patients were subjected to full history taking, complete physical examination, ECG, laboratory investigations including renal function test and lipid profile. Also, echocardiography was performed to all patients.

2.1. CT protocol

MDCT was performed using a 160 slice Toshiba Aquilion prime CT scanner. We used the best electrocardiographic diastolic phase to perform retrospective calcium score imaging. Then we performed reconstruction and analysis of the calcium score using the Agatston method.[3] The CAC score will be classified as 0.1–100 (group 1), 100–400 (group 2) and ≥400 Agatston units (group 3). Each single artery was divided into two groups: 1st group, including arteries with calcium score <250 and the 2nd group, including arteries with calcium score >250.

2.2. Coronary angiography and percutaneous coronary intervention

Using conventional coronary angiography techniques, standard coronary projections of the left and right coronary systems were assessed. Each patient received a drug-eluting stent during PCI. Coronary lesions were graded to (A, B or C) lesions according to the American College of Cardiology/American Heart Association (ACC/AHA) grading of lesions.[4] Angiographic calcium score (0, 1, 2, or 3) was assessed, SYNTAX score (synergy between PCI with TAXUS and cardiac surgery) was calculated, and percentage vascular stenosis were also calculated. the volume of contrast injection, the final TIMI flow grade (the grade of thrombolysis in myocardial infarction), the number of implanted stents and their lengths, Then we investigated the following procedural complications firstly; coronary artery dissection (defined as intimal tears in the arterial wall requiring either prolonged balloon inflation or applying another stent), Second; occurrence of no reflow (defined as no antegrade flow occur after stent deployment), Third; coronary perforation (defined as evidence of extravasation of dye or blood from the coronary artery during or following the interventional procedure), fourth; contrast-induced nephropathy (defined as an elevation of serum creatinine (Scr) of more than 25% or ≥0.5 mg/dl (44 μmol/l) from baseline within 48 h after procedure) or fifth; periprocedural myocardial infarction (more than 5 times rise in the cardiac troponin level) in the 24 h after procedure. The interventionist also reported the following parameters, including the operation categorization into easy (direct stenting, single balloon inflation) or difficult (multiple balloon inflations). The duration of the procedure and fluoroscopy duration were reported also. A final thrombolysis in myocardial infarction grade flow of 3 and less than 10% stenosis with no procedural problems were considered indicators of successful angiography.[5]

Regarding the occurrence of heart failure, hospitalization, recurrence of symptoms, myocardial infarction, stroke, target lesion revascularization, and mortality, patients were followed up at one month and six months, respectively.

2.3. Statistical analysis

Categorical variables are stated as a number and a percentage for continuous data, and mean and standard deviation are used for continuous data. The chi-square test was used to compare categorical variables, and the student *t*-test was employed to assess differences between continuous variables. IBM Corp., Armonk, New York, USA, SPSS for Windows, Version 23, was used for all statistical analysis. For all tests, a *P* value of 0.05 was regarded as statistically significant.

3. Results

The study sample composed of 150 patients, 63 (42%) of them were belonging to the first group with calcium score (0.1–100), 49 patients (32.6%) belonging to the second group with calcium group (100–400) and the last group 38 patients (25.3%)

Table 1. Distribution of studied patients' risk factors among the calcium score groups.

Risk factor	Group 1	Group 2	Group 3	Total	*P* value
Sex					
Male	28	35	27	90	**0.001**
	31.1%	38.9%	30%	60%	
Female	35	14	11	60	
	58.3%	23.3%	18.3%	40%	
Diabetes					
Non diabetic	49	28	14	91	**<0.0001**
	53.8%	30.8%	15.4%	61%	
Diabetic	14	21	24	59	
	23.7%	35.6%	40.7%	59%	
Hypertension					
Non hypertensive	17	28	3	48	**<0.0001**
	35.4%	58.3%	6.3%	32%	
Hypertensive	46	21	35	102	
	45.1%	20.6%	34.3%	68%	
Smoking					
Non smoker	35	35	11	81	**0.008**
	43.2%	43.2%	13.6%	54%	
Smoker	28	14	27	69	
	40.6%	20.3%	39.1%	46%	
Dyslipidemia					
Non dyslipidemic	49	14	7	70	**<0.0001**
	70%	20%	10%	47%	
Dyslipidemic	14	35	31	80	
	17.5%	43.8%	38.8%	53%	
Family History of premature cardiovascular disease					
No family history of ischemic heart disease	56	35	25	116	**0.002**
	48.3%	30.2%	21.6%	77%	
Positive family history for ischemic heart disease	7	14	13	34	
	20.6%	41.2%	38.2%	23%	
Total	63	49	38	150	
	42%	32.7%	25.3%	100%	

were belonging to the third group with calcium score (>400).

According to patients' sex; 90 patients (60%) were males. And as regard to diabetes 91 patients (61%) were nondiabetic. According to hypertension; 102 (68%) were hypertensive. And according to smoking, 81(54%) were smokers.

According to dyslipidemia, 80 (53%) were dyslipidemic. And as regard family history for ischemic heart disease 116 patients (77%) had no family history.

(Table 1) shows the distribution of risk factors in patients studied sample among the three groups.

Statistical analysis (Chi-squared) showed significant correlation between the patients' classifications according all studied demographic data ($P < 0.05$).

Classifying the groups with higher calcium score they were found to have more difficult procedures (procedure duration, fluoroscopy duration, number of stents, total stents length, and contrast volume) and higher syntax score than groups with lower calcium score were shown in (Table 2).

Statistical analysis (*T* tests) showed that all possible differences were significant.

The correlation between the three calcium groups in (Table 3) showed that most of the assessed

Table 2. Means, standard division and T tests between groups.

	Gr 1	Gr 2	Gr 3	*P* values		
				Gr 1 vs Gr 2	Gr 1 vs Gr 3	Gr 2 vs Gr 3
Syntax score	8.22 ± 2.72	17.43 ± 4.64	24.68 ± 8.38	<0.0001	<0.0001	<0.0001
Angiographic calcium score	0.89 ± 0.88	2.57 ± 0.50	3.00 ± 0.00	<0.0001	<0.0001	0.007
procedure Duration	35.08 ± 16.11	42.49 ± 14.47	79.71 ± 19.67	<0.01	<0.0001	0.03
Fluoroscopy duration	17.43 ± 8.07	20.73 ± 7.48	24.21 ± 4.73	<0.02	<0.0001	<0.014
Total Stents length	44.14 ± 25.90	61.92 ± 30.81	83.16 ± 38.65	<0.001	<0.0001	<0.005
Number of stents	1.56 ± 0.71	1.88 ± 0.94	2.39 ± 0.97	<0.04	<0.0001	<0.015
Contrast volume	108.65 ± 34.28	135 ± 44.76	163.95 ± 59.93	<0.001	<0.0001	<0.012

Table 3. Relation between calcium score groups and periprocedural and six months complications.

	Gr 1	Gr 2	Gr 3	*P* value	
No reflow					
No	63	48	34	145	0.014
	43.4%	33.1%	23.4%	100%	
Yes	0	1	4	5	
	0%	20%	80%	100%	
Dissection					
No	63	49	35	140	0.011
	42.9%	33.3%	23.8%	100%	
Yes	0	0	3	3	
	0%	0%	100%	100%	
Myocardial infarction					
No	63	49	36	148	0.05
	42.6%	33.1%	24.3%	100%	
Yes	0	0	2	2	
	0%	0%	100%	100%	
Contrast induced nephropathy					
No	63	49	35	147	0.011
	42.9%	33.3%	23.8%	100%	
Yes	0	0	3	3	
	0%	100%	0%	100%	
Six months					
No complications	63	48	32	143	0.01
	44.1%	33.6%	22.4%	100%	
Chest pain	0	1	3	4	
	0%	25.0%	75.0%	100%	
Revascularization	0	0	1	1	
	0%	0%	100%	100%	
Heart failure	0	0	2	2	
	0%	0%	100%	100%	
Total	63	49	38	150	
	42%	32.70%	25.30%	100%	

complications (e.g., no reflow, dissection, myocardial infarction, and contrast-induced nephropathy) recorded significant correlation with higher calcium score groups.

As regard to short-term complications at one month follow up there was no complications recorded in the three groups.

As regard to 6 months follow up four cases developed chest pain one of them was recorded in group 2 and the other three cases were recorded in group 3. Also, one case needed revascularization and was recorded in group 3. Two cases developed heart failure symptoms and they were belonging to group 3. The total complications at six months were statistically significant ***(P value 0.01)***.

Each single artery was divided into two groups regarding the calcium score with group A calcium score <250 and group B with calcium score >250. Then the association between these groups and type of coronary lesions (type A, B or C). was assessed.

The association between lesion type and single artery group in left anterior descending coronary artery (LAD) and also in left circumflex artery (LCX) and right coronary artery (RCA)showed that the correlation between groups was significant ($P < 0.0001$). In left main artery all studied patients had type A lesions.

4. Discussion

Our research supports the findings of Abazid, Kattea et al., 2017[1], which demonstrated a correlation between higher coronary calcification as determined by MDCT and an increase in acute PCI complications.

According to Kang et al., 2018,[6] high CACS (>113), measured by CTCA, has an effect on the likelihood of periprocedural myocardial infarction (PMI) in patients having PCI. They suggest that a high calcium score may be a useful surrogate marker for predicting PMI in patients with stable CAD. Our study supported their findings; however, their study was included only patients with chronic coronary syndrome.

In a large-scale study of individual patient data pooled of 18 randomized trials with 19,833 patients and 5-year follow-up Guedeney et al., 2020.[7] also found that target lesions with moderate and severe CAC were present in about one-third of the study group. the presence of those lesions was highly associated with long-term complications. Treatment those patients with second-generation drug eluting stents (DES) was associated with better long-term outcomes in both patients with and without moderate and severe coronary artery calcifications (CAC). However, even with second-generation DES, early and late complications rate following treatment of moderate or severe target lesion CAC was still considerable.

In a large Chinese study of patients undergoing PCI moderate/severe CAC was prevalent, and was an independent predictor of 2-year, but not 5-year unplanned target lesion revascularization and major adverse cardiac events.[8]

In the Liu et al., 2022.[9] study, it was discovered that patients with heavily calcified lesions (HCLs) still had higher risks of occurrence of procedural complications, procedural failure, and adverse events at 3 years follow up than patients without HCLs, despite using cutting balloons (CBs) in conjunction with non-compliant balloons for modification of coronary plaques.

Aoi et al., 2020 used angiographic coronary calcium score with high sensitivity C reactive protein (HsCRP) and found that the presence of both moderate and severe coronary calcifications and systemic inflammation confers a synergistic effect on risk for major adverse cardiac events following PCI.[10]

In 2016, Lee et al. discovered that calcium score and post6-procedural CK-MB were reliable

indicators of TLR. This suggests that a noninvasive method for predicting TLR might be utilised to use the CCS as assessed on MDCT before PCI.[11]

According to Cosgrove et al., 2021 research, calcium predisposes patients to CTO percutaneous coronary intervention complications and lower procedural success rates.[12]

Another study by Komaki et al., 2021 showed that stent expansion is predicted by pre-intervention evaluation of target vessel coronary artery calcium (TV-CAC) using MDCT. The TV-CAC score may be able to foretell complexity and aid in PCI operational strategy.[13]

Another study by Rong et al., 2021 found that the coronary calcium score model and the SYNTAX score had a good ability to predict clinical events. According to the study, a SYNTAX> 14 score along with moderate and severe calcium may possibly predict thrombotic outcomes following an acute coronary syndrome.[14]

In patients with drug-eluting stents (DES), Zheng et al., 2022 discovered that a high calcium score by Agatston score was linked to increased instances of in-stent restenosis (ISR).[15]

4.1. Conclusion

The higher calcium score using multislice compute tomography (MSCT) is associated with more severe coronary lesions, and associated with more difficult PCI (percutaneous coronary intervention) procedures, and is also associated with more procedural complications and mid-term complications at six months follow up but no difference was found between patients with low and high calcium scores at short term complications at one month follow up.

Conflicts of interest

Authors declare that there is no conflict of interest, no financial issues to be declared.

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