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Coronary Artery Atherosclerosis Assessment Using Multi Detector Computed Tomography and its Correlation with Framingham Risk Score among Symptomatic Patients with Chest Pain

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Abstract

Purpose: A non-invasive assessment of coronary atherosclerosis by means of Framingham risk scoring and multi-slice computed tomography coronary angiography could improve patients' risk stratification. However, the data is still limited on the strong association between FRS and imaging modality in the form of MSCT coronary angiography, for this we designed this study to assess the relationship between FRS and MDCT coronary angiography in diagnosis of CAD.

Methods: This prospective cross sectional study which enrolled 150 patients presented to Kobry El-kobba military hospital with chest pain. All patients were subjected to clinical assessment with FRS, after which they had undergone MDCT coronary angiography owing to diagnosing the type of vessels affected, number of stenotic segments as well as the volume of plaques obstructing the vessels.

Results: Most of our studied patients were males (70.7%) with mean age 54.9 years. Clinical assessment of the subjects following application of FRS revealed that the mean score was 15.6 with median value of 13.2. The majority of the patients were classified as low risk score. Relationship between FRS grades and number of affected segments revealed that patients with higher risk grade showed more than 2 segments of stenosis. FRS had been correlated strongly with the number of affected segments as well as the volume of detected plaques. Subjects who were in the higher risk group were significantly older, had disturbed lipid profile and showed the highest systolic blood pressure compared to the low and intermediate risk groups.

Conclusion: Framingham risk score is a well validated clinical score being moderately correlated with number of affected segments and volume of plaques detected in MDCT coronary angiography. Higher group of FRS was significantly associated with male gender, older subjects and disturbed lipid profile.

Keywords: FRS; Coronary angiography

Introduction

Coronary artery disease (CAD) is considered one of the most serious causes of mortality and morbidity. It affects about 16.5 million American over the age of 20 years old. Vascular injury with cholesterol plaque had been established to be the most common cause of CAD, known atherosclerosis. Obstructing blood flow of the great coronary vessels could lead to group of diseases that includes stable and unstable angina, myocardial infarction and sudden cardiac arrest [1]. Patients with any of previously mentioned diseases are commonly presenting with chest pain and/or chest discomfort.

Identifying those patients with atherosclerosis who are at risk of acute cardiovascular events, including myocardial infarction (MI) and death, is crucial for the indication of treatment and measures for secondary prevention [2].

A widely used risk score, the Framingham risk score (FRS), which is a reliable tool for prediction of CAD severity, however it doesn't possess higher sensitivity and specificity that don't exceed 70% and 82% respectively [3]. Several predictors are included in the FRS: age, gender, TC, HDL-c, blood pressure, antihypertensive therapy, and cigarette smoking [3].

Computed tomography (CT) coronary angiography is a promising noninvasive imaging modality for diagnosis coronary artery stenosis which showed comparable results to conventional angiography. It has consistently showed to have a very high negative predictive value (well above 90%) in ruling out patients with significant CAD defined as coronary luminal stenosis of >50% [4]. Introducing the multi-slice computed tomography (MSCT) technology such as 64-slice, 128-slice, 256-slice, and 320-slice MSCT has gaining much popularity nowadays with better diagnostic accuracy of CT coronary angiography [5].

The present study was designed to assess the relationship between FRS and MDCT coronary angiography in diagnosis of CAD.

Patients and Methods

This work was accepted by the Ethical Committee of Al-Azhar University. After explaining the whole steps, aim and beneficial goals of the study as well as the inconvenience might be caused by our methodology, written informed consent was obtained from every subject who participated in this research.

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We had enrolled 150 patients presented with chest pain to Kobry El-kobba military hospital, Cairo, Egypt. All patients were subjected to clinical assessment with FRS, after which they had undergone MDCT coronary angiography owing to diagnosing the type of vessels affected, number of stenotic segments as well as the volume of plaques obstructing the vessels.

All studied group had been subjected to the following:

- Detailed history including socio-demographic data collection, and economic status were evaluated by questionnaire.
- Clinical general and cardiac examination.
- Laboratory investigations including lipid profile.
- FRS was calculated according to D'Agostino et al. [6].

Classification of patients according to their FRS grade:

- >10% is low.
- 10-20% intermediate.
- >20% high 10-year risk of CAD.
- MDCT coronary angiography using 128-slice-second-generation dual-source CT scanner: assessment for coronary vessels stenotic branches, plaque distribution, and plaque volume (Table 1) [7].

Patient preparation was done by instructing them to fast for about 8 h, received beta blocker dose and sublingual nitrates.

Patients were asked to hold breath during imaging maneuver with reassurance for any side effects of the contrast used.

Statistical analysis

Data were analyzed by the Statistical Package for Social Science (IBM SPSS) version 2.0. Qualitative variables were expressed as number and percentages while quantitative variables were presented as mean, standard deviations. Chi-square test and/or Fisher exact test was used to compare between two groups with qualitative data. The comparison between two groups with quantitative data was done by using student t-test for if variable was normally distributed and Mann Whitney test if not normally distributed. Correlation between two quantitative parameters was assessed by Pearson correlation while correlations between qualitative data were assessed by spearman's rho. The p-value was considered significant if $p<0.05$.

Results

Most of our studied patients were males (70.7%) with mean age 54.9 years. Hypertensive patients accounted for 55.3% of total studied cases with 46% of which were smokers. Clinical assessment of the subjects following application of FRS revealed that the mean score was 15.6 with median value of 13.2 and it was ranged between 1-66.6. The majority of the patients were classified as low risk score (Table2).

After patients had been subjected to MDCT coronary angiography, LAD showed to be the most affected vessel 93.3%, additionally most of our cases were complaining of 1 segment affection (70.7%). Mean volume of plaques detected among the patients was 47.8 mm with 430 mm being the highest detected value.

Relationship between FRS grades and number of affected segments revealed that patients with higher risk grade showed more than 2 segments of stenosis. FRS had been correlated strongly with the number of affected segments as well as the volume of detected plaques (Table 3).

Subjects who were in the higher risk group were significantly older, had disturbed lipid profile and showed the highest systolic blood pressure compared to the low and intermediate risk groups.

Plaques' volume showed significant positive correlation with cholesterol level and systolic blood pressure and negative association with HDL. Interestingly the patients with 3 and 4 segments affection showed the higher plaques' volume (Tables 4-9).

		Study group	
		N=150 patients	
Age (years)	Mean ± SD	54.93 ± 9.11	
	Median	56	
	Range	35	75
Gender	Male	106	70.70%
	Female	44	29.30%
HTN		83	55.30%
Smoking		69	46%
Type of vessel affected	LM	10	6.70%
	LAD	140	93.30%
	LCX	32	21.30%
	RCA	25	16.70%
Number of the affected segments	One	106	70.70%
	Two	31	20.70%
	Three	12	8.00%
	Four	1	0.70%

Table 1: Demographic data, history of comorbidities, type of vessel and number affected segments using MDCT coronary angiography among studied group.

	Study group N=150 patients				
	Mean	± SD	Median	Range	
Systolic blood pressure (mmHg)	121.86	12.56	122.5	100	155
HDL (mg/dl)	48.97	14,59	51	19	80
Total cholesterol (mg/dl)	215.34	67.82	190.5	127	393

Table 2: Clinical and laboratory characteristics among studied group.

	Study group N=150 patients					
FRS Grades	Mean	± SD	Median	Range		
	15.62	11.36	13.2	1	66.6	
	Low	54	36.00%	-	-	-
	Intermediate	47	31.30%	-	-	-
	High	49	32.70%	-	-	-

Table 3: Framingham risk score among studied group.

Study group N=150 patients					
	Mean	± SD	Median	Range	
Volume	47.86	59.24	30	10	430

Table 4: Volume of plagues among studied group.

	Low		Intermediate		High		p-value
	n	%	n	%	n	%	
One	45	42.5	31	29.2	30	28.3	0.049*
Two	8	25.8	12	38.7	11	35.5	
Three	1	8.3	3	25	8	66.7	
Four	0	0	1	100	0	0	

Table 5: Correlation between FRS grades and number of affected segments (Fischer exact test*: statistically significant difference).

	FRS value	
	r	p
Number of affected segments	0.251	0.002*
Volume of plagues	0.235	0.004*

Table 6: Correlation of FRS value with number of affected segments and volume of plagues (Pearson correlation - Spearman rank correlation*: statistically significant difference).

	Low		Moderate		High		p- value
	Mean	± SD	Mean	± SD	Mean	± SD	
Age (years)	52.53	9.19	54.19	8.51	58.28	8.75	0.010*
T. cholesterol (mg/dl)	182.07	52.94	217.27	64.32	250.16	68.79	0.000*
HDL (mg/dl)	55.79	12.05	49.87	15.42	40.59	12.17	0.000*
Systolic blood pressure (mmHg)	116.11	10.4	121.38	12.05	128.67	12.1	0.000*
Volume (mm)	38.518	42.17	44.25	41.27	61.63	83.62	0.012*

Table 7: Correlation of FRS grades with clinical, laboratory and volume of plaques (1 way Anova - Kruskal wallis test - *: statistically significant difference).

	Volume of plaques	
	r	p
Age	-0.006	0.943 NS
Cholesterol	0.335	0.000*
HDL	-0.232	0.004*
Systolic blood pressure	0.286	0.001*

Table 8: Correlation of volume of plaques with clinical, laboratory data (Pearson correlation- Spearman correlation-*: statistically significant difference, NS: no statistically significant difference).

	One		Two		Three		Four		
	N=106 patients		N=31 patients		N=12 patients		N=1 patient		p- value
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	
Volume (mm)	39.52	50.18	62.9	79.17	85.83	58.22	100	0	0,000*

Table 9: Correlation between volume of plaques and number of affected segments (Kruskal wallis test-*: statistically significant difference).

Discussion

Precise identification of patients who are risky for CAD is very crucial owing to reduce morbidity and mortality among those individuals. In order to accurately identify those patients; FRS, one of the most well-known clinical risk scores is being used in clinical practice. However, its moderate or limited predictive value highlights the potential utility of direct imaging modalities as MSCT coronary angiography for proper diagnosis of coronary atherosclerosis [8].

A Turkish report studied this association showed variable results compared to ours as the prevalence of hyperlipidemia, hypertension, and smoking was (66. 64, and 31%, respectively) [9], while other reports showed relatively lower prevalence (56.5, 51.2, and 28.2; and 56, 24, and 23%, respectively) [10,11].

Among our studied subjects, mean systolic blood pressure at presentation was within normal range (121 mmHg), mean cholesterol level was higher 215 mg/dl despite mean HDL being within protective range (48.9 mg/dl). This could be referred to that cholesterol level showed not too much higher value.

After presentation, FRS was calculated for all selected patients, which showed mean score of 15.6 with median level of 13.2. Patients were then classified according to grades of FRS and showed the low risk group (36%) being most common and followed in order by high risk group (32.7%).

All patients were subjected to MSCT CA which showed LAD being the most affected vessel 93.3%, 21.3% of the patients revealed LCX vessel affection. More than one hundred patients had one segment involved with plaques (70.7%), 20.7% had 2 segments that showed plaques, 8% showed three segments filled with plaques with only 1 patient who showed plaques in four segments.

MDCT coronary angiograph had measured volume of the plagues and revealed mean volume among studied patients of 47.8 mm, with higher volume presented in female compared to male patients however no significant difference was demonstrated (p=0.108). Mean volume of the plaques was compared among affected segments which revealed higher volume in the 4 segments compared with other number of segments (p=0.000).

Studying the association between grades of FRS and the type of vessel affected that showed no significant relationship between any of the vessels and those clinical grades. Unlike to our findings, Seaoud et al. showed that there was a significant difference between the three grades of FRS regarding left main (p-value=0.001), LAD (p-value 0.011) and RCA (p-value 0.013)[10].

Multivariate logistic regression was done for acquiring the predictors of volume of plaques; it was revealed that FRS, cholesterol level, HDL and systolic blood pressure were the predictors associated with higher volume. Those predictors showed also positive significant correlations of plaques' volume. Jong-Shiuan, et al. reported that only FRS and CACS were the only predictors of atherosclerotic plaque in the studied patients and neither cholesterol level nor body mass index were predictors of the plaques [12].

In the study by Uğur et al. which studied the association between cardiovascular (CV) risk factors and coronary atherosclerotic plaque (CAP) burden/subtypes shown by multidetector computed tomography in symptomatic patients free of known CAD. It had reported that male subjects, older age, hypertension, diabetes mellitus, smoking, and dyslipidemia had increased the likelihood of the presence of CAP in univariate analysis (P<0.001). it was demonstrated also that older age, male sex, dyslipidemia, and diabetes mellitus independently increased the likelihood of the presence of CAP in multivariate analysis (P<0.005). Patients with low FRS showed a large number of CAPs (33.8 and 40.4%), although CAP was more prevalent in the high-risk groups (67 and 78%, respectively) [11].

All numbers of affected segments were compared regarding different grades of Framingham risk score. This comparison showed that the more number of affected segments, the higher grade of FRS with significant difference. Most of patients who showed 1 segment affection showed were categorized as low FRS, while most of the patients with 3 segments had been categorized as higher FRS. The only patient who showed 4 segments affection was classified as intermediate risk. Therefore a significant positive correlation was revealed between FRS value and number of affected segments (p=0.002).This was in agreement with Seaoud et al. who showed that number of segments affected seen by CT was significantly related to Framingham risk score. Patients of low and intermediate grades had mostly one segment affection, while those of higher grade had mostly two segment affection with significant difference between the three grades (p = 0.002) [9].

Patients in the higher class of FRS showed the highest mean volume of plaques compared to other classes of FRS (p=0.012) in the study

by Pen et al. similar finding was reported as he noted that the mean atherosclerosis plaque burden increased with increasing the 10-year % risk as calculated by FRS [13]. Another study demonstrated the same results as they revealed that plaque volume increased with increasing FRS [14].

On the other hand patients categorized as low FRS class had been younger, with lowest cholesterol level, highest HDL and lowest level of systolic blood pressure compared to the other classes of FRS. Jong-Shiuan and his colleagues reported similar results as he showed that patients with atherosclerotic plaques were older, had higher systolic blood pressure and cholesterol level [12].

Comparing mean values of FRS among gender in the studied patients revealed that male patients had higher significant value compared with females, however male patients with higher FRS don't preclude that they would show higher volume of plaques. Hwang et al., reported that FRS was effective for predicting coronary artery disease only in symptomatic women [15].

A study in Taiwan demonstrated that the FRS is independent predictor of subclinical coronary atherosclerosis in asymptomatic subjects with low to intermediate cardiovascular risk [12].

Our report has some limitations. First, this is a cross-sectional study in a group of patients with suspected CAD, and the potential role of MDCT to detect CAP cannot be generalized to the whole population to optimize CV risk reduction strategies. Second, absence of comparative group prevents achieving powerful validity of FRS. Coronary atherosclerosis can be detected in patients with increasing age; therefore, large-scale follow-up studies are needed to clarify the clinical significance of those CAPs in the low-risk patient population. Finally, in contrast to other non-invasive methods, MDCT has a disadvantage in terms of radiation exposure and contrast administration. Although technologies aimed to reduce radiation exposure are evolving, long-term hazardous effects of radiation especially on young women patients should be kept in mind when MDCT-based non-invasive evaluation methods are being considered.

Conclusion

Framingham risk score is a well validated clinical score being moderately correlated with number of affected segments and volume of plagues detected in MDCT coronary angiography. Higher group of FRS was significantly associated with male gender, older subjects and disturbed lipid profile.

Conflict of Interest

Authors admitted no conflict of interest.

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