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Relationship Between Epicardial Fat Measured by Multidetector Computed Tomography and Coronary Artery Disease assessed by CT angiography

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Abstract

Background:Epicardial fat (EF) is the visceral fat of the heart deposited under the visceral layer of the pericardium and has the same origin as abdominal visceral fat which is shown to be strongly related to the development of coronary artery disease (CAD). This study aimed to assess the relationship between epicardial fat measured by Multidetector Computed Tomography, coronary calcium score and coronary artery disease.Methods:The current study included 73 Patients with suspected coronary artery disease (Low-intermediate probability). The patients were divided into 3 groups: Group 1 (n=21): no atherosclerosis. Group 2 (n=26): no obstructive atherosclerosis (luminal narrowing less than50% in diameter). (26 patients). Group 3(n=26): obstructive atherosclerosis (luminal narrowing equal to or more than 50%). Results: EAT and PCFT showed statistical significance positive correlation with each other (p<0.001). EAT and Ca score showed statistical significance positive correlation with each other (p0.003). PCFT and Ca score showed statistical significance positive correlation with each other (p<0.001). Conclusion:There is a positive correlation between both epicardial fat and pericoronary fat thickness and the presence of obstructive coronary stenosis. Epicardial fat and pericoronary fat thickness can be used in predicting the severity of coronary artery disease.

Keywords: Epicardial Fat; Multidetector Computed Tomography; Coronary Artery Disease; CT angiography.

1.Introduction

Epicardial fat (EF) is the visceral fat of the heart deposited under the visceral layer of the pericardium and has the same origin as abdominal visceral fat, which is shown to be strongly related to the development of coronary artery disease (CAD). The accumulation of EF is known to be a rich source of free fatty acids and a number of inflammatory cytokines [1].

The physiological and beneficial roles of EF are immune barrier, myocardial and coronary artery protection, local fatty acid source for the myocardium, and predominate at normal quantities [2].

Epicardial fat thickness reflects visceral adiposity rather than general obesity. It correlates with metabolic syndrome, insulin resistance, CAD, and subclinical atherosclerosis, and could serve as a simple tool for cardiometabolic risk prediction [3].

The adverse cardiovascular effects of obesity are mainly due to systemic and local accumulation of visceral fat pad with metabolically releasing of chemokines and cytokines [4].

Previously, the association between epicardial fat thickness and CAD has been evaluated using echocardiography. Nowadays, the introduction of multidetector computed tomography (MDCT) provides more objective results and a better quantitation of EF compared to the echocardiographic assessment due to its high acquisition speed, improved spatial resolution, intravenously contrast material bolus timing and reduced motion artifacts [5].

Multi-detector computed tomography (MDCT) allows for simultaneous assessment of coronary artery calcium (CAC), coronary artery stenosis and presence coronary plaque, plaque composition and plaque vulnerability as well as epicardial fat volume (EFV) [6].

Previous studies have shown strong correlation between pericardial fat and coronary artery calcium score as well as cardiac events[7].

The purpose of this study was to assess the relationship between epicardial fat measured by Multidetector Computed Tomography, coronary calcium score and coronary artery disease.

2.Patients and methods

The current study included 73 Patients with suspected coronary artery disease (Low-intermediate probability). The study was performed between February 2023 and January 2024 in ministry of health, Kuwait.

Inclusion criteria were Patients presenting with chest pain with (Low - intermediate probability of coronary artery disease). The pretest probability was assessed.

Exclusion criteria were Patients with renal insufficiency (S. creatinine >1.5 mg/dl), with previous history of PCI or previous CABG, with dye allergy, have difficulties in performing CT, like inadequate breath holding and heart failure.

Grouping: The patients were divided into 3 groups:**Group 1:** no atherosclerosis. (20 patients). **Group 2:** no obstructive atherosclerosis (luminal narrowing less than50% in diameter). (25 patients). **Group 3:** obstructive atherosclerosis (luminal narrowing equal to or more than 50%). (25 patients).

All studied cases were subjected to the following: Detailed history taking, full Clinical examination and 12 leads ECG. Routine laboratory investigations [Fating Blood glucose level, serum creatinine, complete lipid profile].**CT coronary angiography.**

CT coronary angiography:

All CT scans were performed using GE Revolution 256 MULTIDETECTORS.

Patient preparation

Patients with a heart rate >70 beats per minute received oral metoprolol (25-50 mg) or ivabradine (2.5-5mg) before the study. All scans were preceded by non-contrast enhanced scan for coronary calcium score (sequential scan with 32 x 0.6 mm collimation, tube current 60 mAs at 120 kV), this was done to rule out patients with dense coronary calcification (total score above 1000). Five mg sublingual dose of nitroglycerin was administered just before the scan.

All included patients received intravenous nonionic iso-osmolar contrast medium (visipaque320 mg/mL) using the test bolus technique with a bolus of 10 ml of the contrast agent was injected intravenously visipaque 320 mg/mL at flow rate 6 ml/sec followed by 60 ml saline at flow rate 6 ml/sec using power injector or infusion syringe.

Image reconstruction:The CT scanning was performed at the following settings: retrospective ECG-gated acquisition spiral mode. A three-dimensional workstation was used to reconstruct axial images retrospectively at an optimal window. The image data sets were analyzed by means of Multiplanar reformatted images (vertical, long-axis, and short-axis views), curved Multiplanar reformatted images, thin-slab maximum- intensity projection images, and volume-rendered images.

Two-dimensional reconstructions (curved Multiplanar reformation) of the coronary arteries were (ADVANCED WORKSTATION) for image analysis.

Calcium Score.

Using Smart score. Presence of minimal three contiguous pixels with an attenuation of ≥ 130 Hounsfield unit (HU) was considered calcification; non-calcified were defined as structures clearly assignable to the vessel wall (in at least two views) with density lower than the lumen contrast; Plaques demonstrating calcification ≤50% of the plaque area were classified as mixed. Coronary artery calcification score were calculated using the method described by [8].

Measurement of epicardial fat thickness

Measurements were performed in the most motionless phase of the cardiac cycle, which was most frequently the mid-diastolic phase, with retrospective cardiac gating at70-80% of the R-R interval.

Epicardial fat thickness: Measurements were performed at the base (basal level) of the ventricles on short-axis views. The basal level was defined as the level at the base of the ventricles. Three measurements of epicardial fat thickness were made, namely, inferior, center, and superior, corresponding to measurements at the American College of Cardiology/American Heart Association **as ≥ 50%** narrowing of the lumen diameter in at least one major coronary artery**[10].**

at a rate of (5 ml/s). Then angiography was done by injecting 60 ml of the same contrast agent at a rate of 6 ml/s.

Tomogram: Taken from tracheal bifurcation to the diaphragm in a single breath-hold in the cranio-caudal direction.

Test bolus: Injection of 10 ml visipaque 320 mg/mL followed by 50 ml saline in antecubital vein and then acquisition of sequence of images at the level of the Aorta and Pulmonary arteries every two seconds.Calculation of the actual delay time from start of injection till maximum intensity of dye in the Aorta.

CT angiography:After accurate calculation of delay time and checking the ECG trigger, images acquisition is done after injection of 60 ml

performed on several planes to assess patency of the vessels. These 2-dimensional images show the vessel's wall and lumen and all the surrounding tissue. They are reconstructed on at least 2 orthogonal planes, and continuity of contrast material throughout the vessel serves as an indication of patency.

Assessment of the severity of lesions

Visual assessment:The degree of luminal reduction compared to the reference diameter in axial and oblique views.

Quantative assessment:Curved multiplane reconstruction. Computed tomography datasets were transferred to an offline workstation

the 25%, 50% and 75% level of the RV wall, espectively, from the visceral epicardium to the outside of the myocardium and perpendicular to the surface of the heart. The mean of the three measurements (referred to as 'EAT') was used for the analyses[9].

Pericoronary fat thickness: Pericoronary fat thickness (mm) was quantified on axial views. To avoid overestimating the pericoronary fat due to obliquity, thickness measurements were performed on images in which the axial sections were perpendicular to the surface of the heart. In each of the regions of the right coronaryartery (RCA), left coronary artery (LCA), and left circumflex (LCX), the maximum fat thickness, assessed as the largest distance from the myocardium to the visceral epicardium,was determined. The mean thickness of the pericoronary fat surrounding the three coronary arteries was used to analyze the pericoronary fat thicknesses[9]**.**

Coronary angiography

The angiography was performed to patients in group 3 (≥ **50%**stenosis by MDCT) in the cath-lab under local anesthesia by an expert cardiologist. Significant coronary stenosis is defined according to

The syntax score was calculated to all patients in group 3. The score was adopted in Syntax trial and include the following variables:

Each coronary lesion with diameter stenosis≥50% in vessels≥1.5mm

Dominance: Right dominance when the posterior descending artery arises from the RCA while left dominace when the PDA arises from the LCX

Total occlusion: TIMI flow 0.

Trifurcation lesions: Division of a main branch into three branches.

Bifurcation lesions: Division of a main parent branch into two daughter branches of at least 1.5mm.

Aorto-ostial: when it is located within 3 mm of the origin of coronary vessels from the aorta.

Severe tortousity: one or more bends of 90°or three or more bends of 45° to 90° proximal of the diseased segments. Length of lesions more than 20mm.

Heavy calcification.

The severity of coronary stenosis in group 3 was also estimated by the Gensini coronary score **.**The Gensini score is based on the number of stenotic coronary artery segments, including the degree of luminal narrowing and the localization of the stenosis**.**

The Gensini system scores the narrowing of the coronary artery lumen as follows: 1%–25% narrowing=1; 26%–50% narrowing=2; 51%–75% narrowing=4; 76%–90% narrowing=8; 91%–99% narrowing=16; and total occlusion=32. The score is then multiplied by a factor that incorporates the importance of the lesion position in the coronary arterial tree as follows: ×5 for the left main coronary artery; ×2.5 for the proximal left anterior descending or left circumflex coronary artery; ×1.5 for the mid-segment of the left anterior descending; ×1 for the distal left anterior descending, right coronary artery or mid-distal left circumflex; and ×0.5 for any other arteries.

Statistical analysis

Data were analyzed using IBM SPSS 23.0 for windows (SPSS Inc., Chicago, IL, USA) and NCSS 11 for windows (NCSS LCC., Kaysville, UT, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.A one-way analysis of variance (ANOVA) was used when comparing between more than two means if data is normally distributed.Kruskal-Wallis test used when the normality, homogeneity of variances, or outliers' assumptions for One-Way ANOVA are not met.

Chi-square (X2) test of significance was used in order to compare proportions between two qualitative parameters.Spearman's correlation coefficient (r) test was used for correlating data.Receiver operating characteristic (ROC) curve analysis was used to identify optimal cut-off values.A two tailed P value < 0.05 was considered statistically significant.

3.Results

There was no significant difference in the incidence of dyslipidemia, obesity, smoking and family history of premature coronary artery disease among the 3 groups.Ca score was significantly higher in group 3 than in group 2 and group 1.The average epicardial adipose tissues thickness (EAT) was significantly larger in group 3 than in group 2 and group 1.average pericoronary fat thickness (PCFT) was significantly larger in group 3 than in group 2 and group 1.**Table 1**

Table (1): Comparison between the studied groups regarding the demographic data.

Demographic data	All patients	Group 1 (Normal)	Group 2 (Non-obstructive)	Group 3 (Obstructive)	Test	p-value(Sig.)
Count (%)	73 (100%)	21 (28.7%)	26 (35.6%)	26 (35.6%)		
Sex						
Male	46 (63.3%)	9 (42.8%)	15 (57.6%)	22 (84.7%)	11.52‡	0.004(S)
Female	27 (36.7%)	12 (57.2%)	11 (42.4%)	4 (15.3%)		
Age (years)						
Mean ± SD	49.1 ± 8.9	44.6 ± 9.3 ●●	54.9 ± 7.5	51.2 ± 8.6	8.39 ᴬ	0.002(S)
Range	25 - 70	25 - 57	41 - 70	32 - 70		
HTN						
	29 (39.7%)	4 (13.8%)	11 (38%)	14 (48.2%)	4.92‡	0.075(NS)
DM						
	21 (28.7%)	2 (9.5%)	9 (42.8%)	10 (47.7%)	7.29‡	0.026(S)
Dyslipidemia						
	20 (27.3%)	3(14.2%)	5 (19.2%)	12 (46%)	3.03‡	0.219(NS)
Obesity						
	30 (40%)	9 (42.8%)	11 (42.3%)	8 (30.7%)	1.01‡	0.601(NS)
Smoking						
	15 (21.4%)	2 (10%)	5 (20%)	8 (32%)	3.24‡	0.198(NS)
Family history						
	3 (4.3%)	1 (5%)	1 (4%)	1 (4%)	0.035‡	0.983(NS)

EAT and PCFT showed statistical significance positive correlation with each other (p<0.001).EAT and Ca score showed statistical significance positive correlation with each other (p0.003).PCFT and Ca score showed statistical significance positive correlation with each other (p<0.001).**Table 2**

Table (1) correlation between age, Ca score, EAT and PCFT (Spearman's correlation).

			EAT	PCFT	Age	Ca score
Spearman's rho	**EAT**	**Correlation Coefficient**		**.450****	**.087**	**.330****
		Sig. (2-tailed)		**<0.001(HS)**	**.415**	**0.003 (S)**
		N		**73**	**73**	**73**
	PCFT	**Correlation Coefficient**	**.450****		**.142**	**.521****
		Sig. (2-tailed)	**<0.001 (HS)**		**.340**	**<0.001 (HS)**
		N	**73**		**73**	**73**
	Age	**Correlation Coefficient**	**.088**	**.142**		**.280***
		Sig. (2-tailed)	**.425**	**.340**		**0.03 (S)**
		N	**73**	**73**		**73**
	Ca score	**Correlation Coefficient**	**. 330****	**. 521****	**. 280***	
		Sig. (2-tailed)	**0.003 (S)**	**<0.001(HS)**	**0.03 (S)**	
		N	**73**	**73**	**73**	

Thereis statistically significant higher Ca score in patients with DM, hypertension and smoking compared to patients without these risk factor. On the other hand, there was no statistically significant difference in patients with other risk factors (dyslipidemia, obesity, positive family history of premature coronary artery disease) compared to patients without these risk factors. there was slight increase (statistically nonsignificant) in EAT in patients with risk factors (hypertension, DM, smoking, obesity, positive family history of premature coronary artery disease).there was slight increase (statistically nonsignificant) in PCFT in patients with risk factors (hypertension, DM, smoking, dyslipidemia, obesity).**Table 3**

Table (2) The relationship between risks factors and Ca score and between risks factors and EAT thickness (mm).

Risk factors	**Count (%)**	**Ca score**		
		Mean ± SD	**Z-value •**	**P-value**
HTN	29 (39.7%)	177.2 ± 349.9	-2.598	0.005*
DM	21 (28.8%)	250.4 ± 335	-2.698	0.006*
Smoking	15 (20.5%)	266.1 ± 491.6	-2.176	0.041*
Dyslipidemia	20 (27.3%)	138.9 ± 343.9	-0.29	0.620
Obesity	30 (41%)	76.6 ± 148.9	-0.189	0.786
Family history	3 (4.1%)	162.7 ± 281.7	-0.276	0.785
		EAT thickness (mm)		
HTN	3 (4.1%)	8.1 ± 2.7	-1.349	0.168
DM	21 (28.7%)	8.2 ± 2.4	-1.311	0.213
Smoking	15 (21.4%)	8.8 ± 3.4	-1.950	0.049
Dyslipidemia	20 (27.3%)	7.1 ± 1.5	-1.380	0.148
Obesity	28 (40%)	7.6 ± 2.1	-1.39	0.158
Family history	29 (39.7%)	7.6 ± 1.4	-0.961	0.289
		EAT thickness (mm)		
HTN	29 (39.7%)	12.6 ± 2.7	-0.678	0.451
DM	21 (28.7%)	8.1 ± 2.1	-1.153	0.251
Smoking	15 (21.4%)	13.2 ± 2.9	-1.092	0.311
Dyslipidemia	20 (27.3%)	13.3 ± 2.3	-1.041	0.298
Obesity	28 (40%)	12.9 ± 2.3	-0.899	0.370
Family history	3 (4.1%)	12.5 ± 1.0	0.061	0.864

***: statistically significant as P value <0.05**

There was a non-significant negative correlation between the gencini score and both EFT and PCFT in group 3. There was positive correlation between the EFT and PCF in group3. There was positive correlation between the PCF and age in group3.**Table 4**

Table (3) correlation between Gensini score, age, Ca score, EAT and PCFT within the obstructive group (Spearman's correlation).

			Gensini score	EAT	PCFT	Age	Ca score
Spearman's rho	**Gensisni score**	**Correlation Coefficient**		-.167	-.062	-.146	.234
		Sig. (2-tailed)		.426	.770	.486	.271
		N		25	25	25	25
	EAT	**Correlation Coefficient**	-.167		.570**	-.148	-.020
		Sig. (2-tailed)	.426		.003 (S)	.480	.926
		N	25		25	25	25
	PCFT	**Correlation Coefficient**	-.062	.570**		.074	.218
		Sig. (2-tailed)	.770	.003 (S)		.727	.306
		N	25	25		25	25
	Age	**Correlation Coefficient**	-.146	-.148	.074		.262
		Sig. (2-tailed)	.486	.480	.727		.215
		N	25	25	25		25
	Ca score	**Correlation Coefficient**	.214	-.001	.233	.165	
		Sig. (2-tailed)	.304	.996	.262	.432	
		N	25	25	25	25	

***: statistically significant as P value <0.05**

ROC curve was used to define the best cut off value of EAT and PCFT in predicting the obstructive CAD group [3] and it was ≥7.1 and 12.5 mm for EAT and PCFT respectively with sensitivity of 67%and 72% respectively, specificity of 67.4% and 62.2% respectively, positive predictive value (PPV) of 50%and 51.4% respectively, negative predictive value (NPV) of 76.3% and 80% respectively with diagnostic accuracy of 64.3% and 65.7% respectively.**Figure 1**

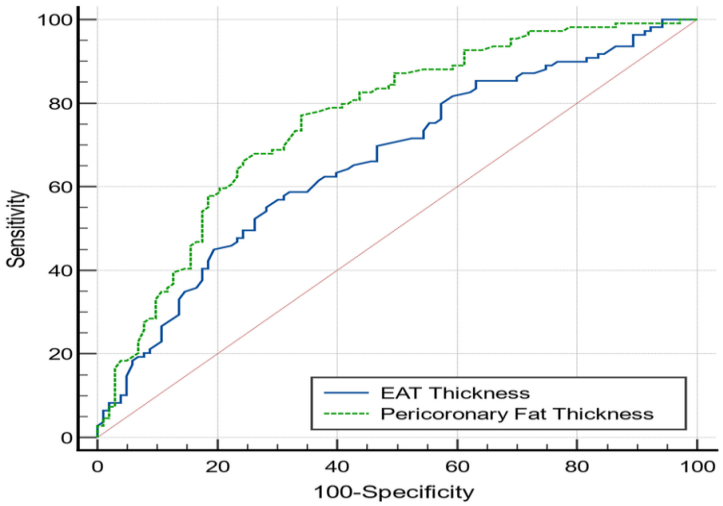

Figure (1): ROC curve for EAT and PCFT for the development of obstructive coronary artery disease**.**

There was a non-significant negative correlation between syntax score and both EAT and PCFT.**Table 5**

Table (4) correlation between Syntax score, age, Ca score, EAT and PCFT within the obstructive group (Spearman's correlation).

			Syntax score	EAT	PCFT	Ca score	Age
Spearman's rho	**Syntax score**	**Correlation Coefficient**		-0.070	-0.113	0.203	0.002
		Sig. (2-tailed)		0.741 (NS)	0.592 (NS)	0.331 (NS)	0.993
		N		25	25	25	25
	EAT	**Correlation Coefficient**	-0.070		0.570	-0.001	-0.148
		Sig. (2-tailed)	0.741 (NS)		.003 (S)	0.996	0.480
		N	25		25	25	25
	PCFT	**Correlation Coefficient**	-0.113	0.570		0.233	0.074
		Sig. (2-tailed)	0.592 (NS)	.003 (S)		0.262	0.727
		N	25	25		25	25
	Ca score	**Correlation Coefficient**	0.203	-0.001	0.233		0.262
		Sig. (2-tailed)	0.331 (NS)	0.996	.262		0.215
		N	25	25	25		25
	Age	**Correlation Coefficient**	0.002	-0.148	0.074	0.165	
		Sig. (2-tailed)	0.993	0.480	0.727	0.432	
		N	25	25	25	25	

There was higher Ca score (non-significant) in patients with three vessels disease compared to patients with single and two vessels disease, however there was no significant difference in PCFT and EAT among the 3 groups of patients with single, double and three vessels disease. **Table 6**

Table (5) Relation between the angiographic findings regarding the number of vessels affected and EAT, PCT, Ca score.

Coronary CT data	**Patients with obstructive CAD**	**One-vessel disease**	**Two-vessel disease**	**Multi-vessel disease**	**p-value (Sig.)**
Count (%)	26 (100%)	10 (38.4%)	7 (26.9%)	9 (34.6%)	
Ca score	319 ± 442.5	189.7 ± 333.3	380.5 ± 660	405.8 ± 419.7	0.350
EAT thickness (mm)	8.5 ± 3.1	9.2 ± 3.4	8.5 ± 4.3	8.0 ± 2.3	0.640
PCFT (mm)	14 ± 2.4	13.9 ± 3.0	13.9 ± 2.6	14.1 ± 2.1	0.890

4.Discussion

In the present study 63.3% of patients were males which was similar to the study conducted by Demircelik MB, et al. However, the mean age of the patients in our study was younger (50.6±9.3, 54±11 years)[11]. On the other hand,in the study conducted by Aydin et al the mean age of the study population was younger (49.30±12.60) and the number of males were less (51.3%)[12].

Regarding risk factors, there was a statistically significant higher Ca score in patients with DM, hypertension and smoking compared to patients without this risk factor. There was also slightly increased (statistically non-significant) EAT and PCFT in patients with risk factors (hypertension, DM, smoking, obesity, positive family history of premature coronary artery disease).

We found a significant relation between the thickness of both EF and PCF as well as the calcium score and the severity of coronary artery disease with higher values in group 3 with obstructive coronary artery disease compared to group1 and [2].

Aydin et al Studied also the relationship between pericoronary fat thickness and the severity of coronary artery disease. They concluded that the pericoronary fat thickness was higher in patients with coronary artery disease compared to patients without coronary artery disease[12].

Fabien A et al e measured epicardial fat thickness by computed tomography and assessed the presence and extent of CAD by coronary angiography in participants from the prospective EVASCAN study.They found that lateral wall EAT thickness correlated with the presence and extent of angiographic CAD[13].

We found a significant positive relation between EAT and PCFT with Ca score. Aydin et al also found that Pericoronary EAT was significantly thinner in patients with calcium scores of 0 compared with those having scores >0, in the present study. In addition, pericoronary EAT was thicker in cases with calcified plaque compared with those without. These findings suggest that epicardial adipose tissue could have a role in the development of calcified plaque in coronary arteries. DemircelikMB et al also had similar results regarding the correlation between EAT and PCFT with Ca score[11].

We found also that EAT and PFT can be used as a predictor of obstructive coronary artery disease with cut off value ≥7.1mm and 12.5 mm for EAT and PCFT respectively with sensitivity of 67%and 72% respectively, specificity of 67.4% and 62.2% respectively, positive predictive value (PPV) of 50%and 51.4% respectively, negative Predictive value (NPV) of 76.3% and 80% respectively with diagnostic accuracy of 64.3% and 65.7% respectively. The results of our study were similar to the results of the study done by Demircelik et al. A ROC curve for OCAD was assessed to verify the optimum cut-off point for PCFT, which was 13.8 mm with a sensitivity of 72.2% and a specificity of 68.1%. A ROC curve for OCAD was assessed to verify the optimum cut-off point for which EAT was 6.8 cm with a sensitivity of 73.5% and a specificity of 69.3%[11].

Fabien A et al found that left ventricle lateral wall (LVLW) EAT thickness ≥2.8 mm had a sensitivity of 46.1%, specificity of 66.5%, positive predictive value of 80%, and negative predictive value of 28.8%. The area under the curve was 0.58. The best cut-off for Right ventricle lateral wall (RVLW) was 5.3 mm. RVLW EAT thickness ≥5.3 mm predicted the presence of significant coronary stenosis, with sensitivity of 45.1%, specificity of 67.9%, positive predictive value of 81.1%, and negative predictive value of 28.9% [13].

In our study There was higher Ca score (but statistically non significant) in patients with three vessels disease compared to patients with single and two vessels disease, however there was no significant difference in PCFT and EAT among the patients in group 3 with single, double and three vessels disease. These results were similar to the results of the study conducted by Chaowalit N, et al in 139 patients who were referred for conventional coronary angiography which did not show a significant correlation between EAT thickness and number of atherosclerotic coronary segments(14). On the other hand, Demircelik MB et al found a positive association between EAT thickness and the number of coronary arteries with significant stenosis[11].

5.Conclusion

There is a positive correlation between both epicardial fat and pericoronary fat thickness and the presence of obstructive coronary stenosis.Epicardial fat and pericoronary fat thickness can be used in predicting the severity of coronary artery disease.

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Author contribution

Authors contributed equally in the study**.**

Conflicts of interest

No conflicts of interest

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