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Association between non-alcoholic fatty liver disease and epicardial adipose tissue volume with cardiometabolic risk in coronary heart disease

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Abstract

Background: Regional adiposity has a significant impact on the formation of adverse metabolic and cardiovascular risk profiles. While much of the attention was directed to the importance of intra-abdominal adipose tissue, there were several new investigations about mediastinal and epicardial regions' visceral adiposity. Our study aimed to determine the association between non-alcoholic fatty liver and increased epicardial adipose tissue mass with coronary artery disease severity.

Methods: This study was conducted on sixty patients who presented with symptoms of coronary artery disease and attended elective coronary angiography to rule out coronary artery disease. All patients have been subjected to full hepatic profile, noninvasive scoring system such as Fibrosis-4 and non-alcoholic fatty liver disease fibrosis score and abdominal ultrasound for diagnosis of non-alcoholic fatty liver disease and trans-thoracic echocardiography for measurement of average epicardial adipose tissue thickness. Student *T* test, analysis of variance test, chi-square test, and Fisher's exact test were used for statistical analysis.

Results: According to the severity of coronary artery disease, patients with significant coronary stenosis had statistically significant higher degree of hepatic steatosis in abdominal ultrasound (*P* value < 0.001) while regarding the non-alcoholic fatty liver disease fibrosis score and Fibrosis-4 for non-alcoholic fatty liver disease diagnosis, there was no significance between both groups. Also, the epicardial adipose tissue mean thickness was found to be statistically significantly higher among those with significant coronary stenosis than those without [7.859 ± 0.691 mm versus 5.600 ± 0.386 mm]. Moreover, statistically significant higher epicardial adipose tissue thickness values were found among grade 3 hepatic steatosis than in grades 2, 1, or 0 (*P* value < 0.001). At a cutoff > 6.1 mm, epicardial adipose tissue thickness was a valuable tool in discrimination between significant and non-significant coronary artery disease with specificity and sensitivity of 100%.

Conclusion: High epicardial adipose tissue thickness may represent a marker of severity of non-alcoholic fatty liver disease as well as an independent predictor of coronary artery disease risk.

Keywords: Visceral adiposity, Non-alcoholic fatty liver disease, Epicardial adipose tissue mass, Coronary artery disease

Introduction

Coronary artery diseases (CAD) have become a serious epidemic reason of morbidity and mortality. Numerous studies are investigating many parameters as a marker

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for coronary artery diseases. One of the main concerns of the cardiology studies is how to prevent coronary artery disease development and how to estimate the risk of the disease before it becomes clinically symptomatic [1].

Variation in the prevalence of non-alcoholic fatty liver disease (NAFLD) is found based on factors such as race, ethnicity, age, gender, geographical distribution, and the diagnostic modality used [2]. NAFLD has been firmly linked to insulin resistance, type 2 diabetes mellitus, dyslipidemia, and metabolic syndrome, especially in patients with sedentary lifestyles, changing dietary patterns, and increased obesity [3]. These factors also comprise the risk profile for CAD. Both CAD and NAFLD share the same underlying pathophysiological mechanism, risk factors, lifestyle modification, and treatment plans and were therefore hypothesized to be closely related [4]. NAFLD is recently suggested to be an independent risk for cardiovascular diseases and is also associated with higher cardiovascular mortality [4].

A result of the studies emphasized that there was some parallelism between visceral adiposity and ischemic heart disease [5]. As both progression of NAFLD and increasing epicardial adipose tissue (EAT) mass have the same risk factors, therefore these two conditions might be associated with each other [6].

The aim of our work was to determine the association between non-alcoholic fatty liver and increased epicardial adipose tissue mass and its relation to severity of CAD.

Methods

A cross-sectional study

The design of the study was approved by the ethical committee of the faculty of medicine, Ain Shams University, and was following the 1975 Helsinki declaration. All patients included in our study have given written informed consent after explaining the procedures and before they participated in the study.

This was a cross-sectional study including 60 patients who had signs and symptoms of coronary artery disease who attended elective coronary angiography to rule out coronary artery disease. Patients with any form of chronic liver disease as alcoholic or viral liver disease, Wilson's disease, and hereditary hemochromatosis and patients with poor echogenicity, pericardial effusion > 0.5 cm, calcified pericardium or pericardial thickness > 5 mm all had been excluded.

Full history, full clinical examination, and measuring of body mass index (BMI) were done to all patients. Laboratory investigations including alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase, gamma GT, fasting sugar, HbA1C, and lipid profile were obtained from all patients.

Calculation of NAFLD fibrosis scoring was also done in form

(1) NAFLD fibrosis scoring system (NFS)

$$1.675 + 0.037 \times \text{age (years)} + 0.094 \times \text{BMI (kg/m}^2\text{)} + 1.13 \times \text{IFG/diabetes (yes} = 1,\ \text{no} = 0\text{)} + 0.99 \times \text{AST/ALT ratio} - 0.013 \times \text{platelet (}\times 109/\text{l)} - 0.66 \times \text{albumin (g/dl)}$$

NFS is > -1.455 (proved to have no or mild fibrosis) or < 0.676 (proved to have advanced fibrosis).

(2) FIB-4 scoring

$$(\text{Age} \times \text{AST (IU/l)}/\text{platelets count (}\times 109/\text{litre)} \times \sqrt{\text{ALT (IU/l)}})$$

FIB-4 score is < 1.30 (proved to have no or mild fibrosis) or > 2.67 (proved to have advanced fibrosis).

Study procedures

Coronary angiography

Selective coronary angiography was performed by 6F or 7F catheters via standard Judkin's technique using the right or left femoral or radial approaches. Coronary artery lesions above 50% lesion were considered significant while those below 50% lesion were considered non-significant.

Abdominal ultrasound

Liver ultrasonography performed by experienced radiologists correlated to clinical details (Toshiba real-time device using a 3.5 MHz convex transducer). Diagnosis of NAFLD based on detection of the following findings; liver parenchyma hyperechogenicity, poor visualization of intra-hepatic vessel borders, and attenuation of ultrasound beam Semi-quantitative assessment of the severity of hepatic steatosis was also done as follows: 0 (none), grade 1 (mild), grade 2 (moderate), and grade 3 (severe), depending on the discrepancy degree of amplitude of echo between liver and kidney and echoes loss from the intrahepatic vessels walls and diaphragm.

Echocardiography

Trans-thoracic echocardiography was performed (GE Vivid 7 device using 3.5 MHz transducer) to measure EAT thickness using the long and short parasternal axes in the left lateral decubitus position. Pericardial fat thickness was measured on the right ventricle free wall and three measurements were taken and averaged.

Statistical analysis

Data were collected, tabulated, and entered into a PC using (SPSS 25). Descriptive statistics were done using

mean and standard deviation for numerical data, frequency, and percentage for non-numerical data. The statistical significance of the difference between two study group means was assessed using the Student *T* test while the statistical significance of the difference between more than two study group means was assessed using ANOVA Test. The relationship between two qualitative variables was examined using the chi-square test and Fisher's exact test. *P* value of ≤ 0.05 was considered significant while a *P* value of ≤ 0.01 was considered highly significant.

This study was approved by the ethical committee of the cardiology department, Ain Shams University under Federal Wide Assurance No.FWA 000,017585.

Results

Our study comprised of sixty patients. They were divided according to the coronary angiography into 2 groups; group A included those having a significant coronary artery disease (above 50% stenosis) and group B comprised of patients having a non-significant coronary artery disease (below 50% stenosis). Forty-four patients were found to be in group A (73.3%) while 16 patients were found to be in group B (26.7%).

Regarding group A, they were 36 (82%) males and 2 (18%) females with a mean age of 49.750 ± 10.607 while in group B, they were 14 (87.5%) males and 2 (12.5%) females with a mean age of 54.625 ± 8.717. Regarding age, sex, and BMI distribution, no statistically significant differences could be detected between both groups (Table 1).

In group A, 28 patients had DM (64%), 29 patients were hypertensive (66%), and 40 patients were smokers (91%) while in group B, 12 patients had DM (75%), 12 patients had HTN (75%), and 12 patients were smokers (75%). Regarding the distribution of risk factors of CAD, no statistically significant differences between both groups did exist (Table 2).

Regarding the hepatic and metabolic profile, a statistically significant higher liver enzyme [ALT, AST, GGT, ALP] among group A patients than in group B (*P* value 0.006, 0.001, < 0.001, < 0.001, respectively), while regarding the noninvasive scoring system [NFS and

Table 1 Demographics and anthropometric data of the patients

		Groups				*T* test	
		Group A		Group B		*t*	*P* value
Age	**Range**	30–74		38–67		-1.645	0.105
	Mean ± SD	49.750 ± 10.607		54.625 ± 8.717			
BMI	**Range**	25–34		26.1–29		1.361	0.179
	Mean ± SD	28.132 ± 2.045		27.413 ± 0.827			
Chi-square		***N***	**%**	***N***	**%**	X^2	***P* value**
Sex	**Male**	36	81.82	14	87.50	0.273	0.602
	Female	8	18.18	2	12.50		

BMI body mass index, *SD* standard deviation, *N* number, *%* percentage

Table 2 CAD risk factors distribution in group A versus group B

	Groups				Chi-square	
	Group A		Group B			
	N	**%**	***N***	**%**	X^2	***P* value**
DM						
Positive	28	63.64	12	75.00	0.682	0.409
Negative	16	36.36	4	25.00		
HTN						
Positive	29	65.91	12	75.00	0.448	0.503
Negative	15	34.09	4	25.00		
Smoking						
Positive	40	90.91	12	75.00	2.570	0.109
Negative	4	9.09	4	25.00		

DM diabetes mellitus, *HTN* hypertension, *N* Number, *%* percentage

FIB-4] for NAFLD diagnosis, there was no significance between both groups (Table 3).

Regarding the distribution and grading of NAFLD in our study population, it was as follows: 19 patients were described as having no hepatic steatosis (32%), 21 patients were with grade 1 disease (35%), 18 patients were with grade 2 (30%), and 2 patients had grade 3 (3%). A statistically significantly higher percentage of hepatic steatosis (grades 1 and 2) was found among group A patients in comparison to group B (*P* value < 0.001) (Table 4).

Table 3 Full hepatic and metabolic profile among group A versus group B

	Groups		*T* test	
	Group A	Group B	*t*	*P* value
ALT				
Range	11–67	11–27	2.868	0.006*
Mean ± SD	26.295 ± 12.676	16.875 ± 5.377		
AST				
Range	12–67	11–25	3.498	0.001*
Mean ± SD	26.773 ± 11.620	16.250 ± 4.837		
Alkaline phosphatase				
Range	45–134	35–65	4.264	< 0.001*
Mean ± SD	68.114 ± 17.276	48.375 ± 10.794		
Gamma GT				
Range	2–54	4–12	6.389	< 0.001*
Mean ± SD	28.250 ± 12.920	7.375 ± 2.419		
Fasting sugar				
Range	80–400	100–250	0.722	0.473
Mean ± SD	199.455 ± 81.494	183.750 ± 49.244		
HbA1C				
Range	5–7.5	4.9–7.1	− 0.163	0.871
Mean ± SD	6.277 ± 0.743	6.313 ± 0.737		
T. cholesterol				
Range	101–225	130–190	0.112	0.911
Mean ± SD	157.227 ± 27.606	156.375 ± 21.229		
LDL				
Range	45–147	90–105	− 1.547	0.127
Mean ± SD	87.182 ± 23.695	96.500 ± 6.022		
HDL				
Range	25–62	43–50	− 1.626	0.109
Mean ± SD	42.227 ± 10.046	46.375 ± 2.419		
TG				
Range	65–347	130–200	− 2.887	0.005*
Mean ± SD	132.636 ± 44.186	166.250 ± 23.488		
FIB-4				
Range	0.39–2.98	0.41–1.5	1.729	0.089
Mean ± SD	1.100 ± 0.529	0.850 ± 0.386		
NAFLD fibrosis scoring system				
Range	− 4.46–1.34	− 3.73–0.06	1.039	0.303
Mean ± SD	− 1.250 ± 1.290	− 1.665 ± 1.568		

* mean significant

No statistically significant relationship between the NAFLD fibrosis scoring system of the patients and their sex or their comorbidities could be detected (Table 5).

Average EAT thickness in Group A ranged between 6.7 and 9.7 mm while in group B, it ranged between 4.9 and 6.1 mm yielding statistically higher values among group A patients in comparison to those of group B (*P* value < 0.001) as shown in Table 6.

Regarding the risk factors, average EAT thickness was statistically significantly higher among patients with DM and HTN but not among smokers. No statistically significant relationship was found between the average EAT thickness of the patients and their sex (Table 7).

A statistically significant positive correlation was found between average EAT thickness on one side and BMI (*P* value = 0.011) and each of the following patients' metabolic parameters on the other side: alkaline phosphatase (*P* value = 0.003), gamma GT (*P* value < 0.001), fasting sugar (*P* value = 0.019*), HbA1C (*P* value = 0.032), and LDL (*P* value = 0.029) (Table 8).

Also, statistically significant higher EAT thickness values were found among grade 3 hepatic steatosis than in grades 2, 1, or 0 (*P* value < 0.001). These data are represented in Table 9.

Finally, our study demonstrated the best cutoff value of EAT thickness in the detection of significant CAD among all studied patients as > 6.1 mm, with 100% sensitivity, 100% specificity, 100% PPV, and 100% NPV with an overall accuracy of 100%. This was shown in Table 10 and Fig. 1.

NAFLD fibrosis scoring system cutoff value that shows discrimination between significant and non-significant CAD, at cutoff > − 2.18, sensitivity was 79.55, specificity was 50, PPV was 81.4, NPV was 47.1, and accuracy was 56%. These data are represented in Table 11 and Fig. 2.

Discussion

Cardiovascular diseases represent the largest cause of death in the world and the greatest proportion of those deaths are due to CAD. Therefore, more sensitive measures for risk stratification and prevention and treatment of coronary vascular disease are highly required [7].

Excess adiposity had been linked to increased cardiovascular risk. A growing amount of evidence suggests that regional adiposity has been associated with the development of adverse metabolic and cardiovascular risk profiles. The major site of fat accumulation is the subcutaneous tissue and this type of fat represents the "good" fat [7].

Recent increased awareness of the NAFLD is deemed essential as it has been shown to correlate with other

Table 4 NAFLD grading distribution in group A versus group B

NAFLD	Groups				Chi-square	
	Group A		Group B			
	N	%	*N*	%	X^2	*P* value
Grade 0	7	15.91	12	75.00	20.834	< 0.001*
Grade 1	17	38.64	4	25.00		
Grade 2	18	40.91	0	0.00		
Grade 3	2	4.55	0	0.00		

NAFLD non-alcoholic fatty liver disease, *N* number, *%* percentage

* Significant

Table 5 Relationship between NAFLD fibrosis scoring system and sex of the patients and their comorbidities

	NAFLD fibrosis scoring system		*T* test or ANOVA	
	N	Mean ± SD	*T* or *F*	*P* value
Sex				
Male	42	− 1.343 ± 1.408	− 0.685	0.497
Female	8	− 0.984 ± 1.026		
DM				
Positive	33	− 1.109 ± 1.293	1.295	0.202
Negative	17	− 1.628 ± 1.436		
HTN				
Positive	34	− 1.237 ± 1.345	0.366	0.716
Negative	16	− 1.388 ± 1.404		
Smoking				
Positive	44	− 1.376 ± 1.300	− 1.301	0.200
Negative	6	− 0.617 ± 1.658		

NAFLD non-alcoholic fatty liver disease, *DM* diabetes mellitus, *HTN* hypertension, *N* number

Table 6 Average EAT thickness in group A versus group B

	Groups		*T* test	
	Group A	Group B	*t*	*P* value
Average EAT thickness				
Range	6.7–9.7	4.9–6.1	12.351	< 0.001*
Mean ± SD	7.859 ± 0.691	5.600 ± 0.386		

EAT epicardial adipose tissue thickness, *SD* standard deviation

* Significant

Table 7 Relationship between average EAT thickness and sex of the patients and their comorbidities

	Average EAT thickness		*T* test or ANOVA	
	N	Mean ± SD	*T* or *F*	*P* value
Sex				
Male	50	7.228 ± 1.141	− 0.417	0.679
Female	10	7.400 ± 1.440		
DM				
Positive	40	7.488 ± 1.230	2.205	0.031*
Negative	20	6.795 ± 0.954		
HTN				
Positive	41	7.478 ± 1.219	2.196	0.032*
Negative	19	6.779 ± 0.968		
Smoking				
Positive	52	7.354 ± 1.148	1.645	0.105
Negative	8	6.625 ± 1.293		

EAT epicardial adipose tissue thickness, *N* number, *DM* diabetes mellitus, *HTN* hypertension, *SD* standard deviation

* Significant

diseases, in particular atherosclerotic CAD. It has been suggested that NAFLD induces a systemic inflammatory response, increased oxidative stress, insulin resistance, fatty acid toxicity, and endothelial dysfunction; all of which share the same pathophysiology for the development of atherosclerotic CAD [8]. The study aimed to investigate the association between NAFLD and increased EAT mass and their relationship with coronary artery disease severity.

Our study population consisted of sixty patients who presented with signs and symptoms of coronary artery disease eligible for elective coronary angiography to rule out CAD. In our study, 41 patients were with a history of hypertension (68%), 40 patients with a history of diabetes mellitus (66.7%), and 52 patients were smokers (86.7%). All patients were examined by abdominal ultrasound for the diagnosis of NAFLD. 41 patients were detected as having NAFLD (68%) and they were classified as follows: 21 patients were classified as grade 1 (35%), 18 patients with grade 2 (30%), while 2 patients were described as having grade 3 disease (3%). There were 19 patients with no steatosis (32%).

Table 8 Correlations between average EAT thickness and BMI of the patients and their metabolic parameters

Correlations		
	Average EAT thickness	
	R	***P* value**
FIB-4	0.161	0.219
NAFLD fibrosis scoring system	0.082	0.535
Age	−0.207	0.112
BMI	0.325	0.011*
ALT	0.187	0.153
AST	0.236	0.069
Alkaline phosphatase	0.377	0.003*
Gamma GT	0.461	< 0.001*
Fasting sugar	0.303	0.019*
HbA1C	0.277	0.032*
T. cholesterol	0.178	0.173
LDL	0.282	0.029*
HDL	−0.187	0.152
TG	−0.088	0.506

BMI body mass index, *ALT* alanine aminotransferase, *AST* aspartate transaminase, *GT* gamma glutamyl transpeptidase, *HBA1C* hemoglobin A1C, *T* total, *LDL* low-density lipoprotein, *HDL* high-density lipoprotein, *TG* triglyceride, *EAT* epicardial adipose tissue, *FIB-4* Fibrosis-4, *NAFLD* non-alcoholic fatty liver disease

* mean significant

Table 9 Correlation between average EAT thickness and grading of NAFLD among the study population

	Average EAT thickness		**ANOVA**	
	N	**Mean ± SD**	***F***	***P* value**
NAFLD				
Grade 0	19	6.100 ± 0.745	35.920	< 0.001*
Grade 1	21	7.224 ± 0.875		
Grade 2	18	8.256 ± 0.418		
Grade 3	2	9.600 ± 0.141		

EAT epicardial adipose tissue, *NAFLD* non-alcoholic fatty liver disease, *N* number, *SD* standard deviation

* Significant

Table 10 ROC curve of EAT thickness in prediction of significant coronary artery disease (above 50% stenosis)

ROC curve between group A and group B					
Cutoff	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
> 6.1	100.0	100.0	100.0	100.0	100%

PPV positive predictive value, *NPV* negative predictive value

Relation between NAFLD and cardiovascular risk

The present study showed that patients with significant coronary stenosis had statistically significantly higher liver enzymes [ALT, AST, ALP, GGT] than patients without significant coronary stenosis. While there was an insignificant higher NAFLD fibrosis scoring system and FIB-4 among patients with significant coronary stenosis.

Although reports have addressed the relationship between these liver enzymes and risk factors for CVD, there exists discordance in the relationships between specific liver enzymes and CVD. A meta-analysis performed by Fraser et al. [9] has shown that GGT but not ALT is associated with the incidence of coronary heart disease and stroke. Another stratified analysis has demonstrated that ALT is positively associated with stroke but negatively associated with coronary heart disease [10]. On the contrary, Lee et al. [11] showed that elevated ALT and AST are related to CVD mortality. These variations in previous findings may result from different ages, genders, ethnicities, and sample sizes of the studies and also from variable disease conditions.

Also in this study, patients with significant CAD have a statistically significantly higher percentage of NAFLD by

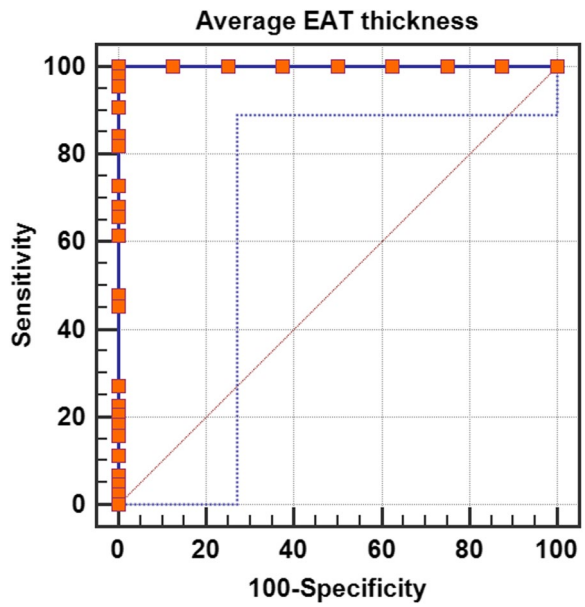

Fig. 1 The ROC (receiver operating characteristic) curve for the best cutoff value of epicardial fat volume to predict significant coronary stenosis

Table 11 ROC curve of NAFLD fibrosis score in prediction of significant coronary artery disease (above 50% stenosis)

ROC curve between group A and group B					
Cutoff	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
> -2.18	79.55	50.0	81.4	47.1	56%

PPV positive predictive value, *NPV* negative predictive value

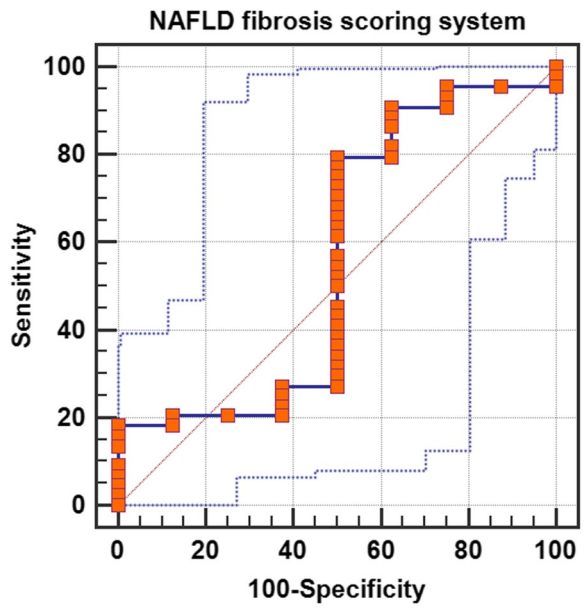

Fig. 2 The ROC (receiver operating characteristic) curve for the best cutoff value of the NAFLD fibrosis scoring system to predict significant coronary stenosis

ultrasound(grades 1 and 2) in comparison to those with non-significant CAD (P value = 0.005). The results of our study are concordant with Targher et al. in 2008 who reported that NAFLD per se is associated with accelerated Atherogenesis [12].

Moreover, on applying ROC curve analysis, the best discrimination between significant and non-significant CAD in relation to NAFLD fibrosis scoring was found at cutoff value of > -2.18, sensitivity was 79.55, specificity was 50, PPV was 81.4, NPV was 47.1, and accuracy was 56%.

Accumulation of liver fat and elevated liver enzymes are associated with type 2 diabetes and hypertension, both of which are representative risk factors for CVD. Furthermore, on using ^{18}F-fluorodeoxyglucose positron emission tomography (FDG-PET), it was found that NAFLD is associated with vascular inflammation, which may reflect rupture-prone vulnerable atherosclerotic plaques. Both visceral fat accumulation and risk of metabolic syndrome are significantly correlated with GGT and ALT levels [13].

Relation between EAT and cardiovascular risk

Visceral fat perhaps more than total fat is implicated in atherosclerosis. Epicardial adipose tissue (EAT), a non-traditional visceral fat depot modulates coronary arteries through paracrine or vasocrine secretion of bioactive adipokines [14].

In our study, hypertension, diabetes mellitus, and dyslipidemia (represented by LDL-c) were found to have statistically significant higher EAT thickness. These results are consistent with the findings of a study by Kim et al. in 2015 which investigated epicardial fat thickness measured by echocardiography and its relation to coronary artery calcification where they found that epicardial fat thickness has a statistically significant correlation to hypertension, diabetes mellitus, and LDL-C [15].

Also, the EAT mean thickness was found to be statistically significantly higher among those with significant coronary stenosis than those without [7.859 ± 0.691 mm versus 5.600 ± 0.386 mm] (P value < 0.001). This observation is supported by the study of Shambu et al. who measured EAT in 503 patients undergoing coronary angiogram and found that mean EAT was significantly higher in the CAD group than the control group (5.55 ± 1.21 mm vs 3.25 ± 1.15 mm, $p < 0.0001$) [14].

The results of our study are also concordant with Jeong et al. in 2007 who found that the EAT layer is significantly thicker in patients presenting with acute coronary syndrome compared to those having chronic stable angina and considered EAT as one of the risk factors of clinically significant CAD, along with other risk factors as age, diabetes mellitus, and smoking [16].

Moreover, on applying ROC curve analysis, the best discrimination between significant and non-significant CAD in relation to EAT thickness was found at cutoff value of > 6.1 mm, sensitivity was 100, specificity was 100, PPV was 100, NPV was 100 and accuracy was 100%. This result was supported by Eroglu et al. in 2009 who reported that the best cutoff value of EAT for CAD was 5.2 mm [5]. Also, Shambu et al. found that EAT at a cutoff ≥ 4.75 mm had 87% sensitivity and 63% specificity for the prediction of significant CAD [14].

All these findings could be attributed to and supported by Mazurek and collaborators who compared the expression of inflammatory factors in biopsy specimens of subcutaneous adipose tissue (SAT) and EAT in patients with severe coronary artery disease who did not have diabetes or obesity. The local expression of certain chemokines (MCP-1) and inflammatory cytokines (IL-1β, IL-6, and TNFα) was higher in EAT than in SAT, showing that EAT may contribute to the coronary local inflammatory potential. The author also observed a higher infiltration of macrophages in EAT than in SAT [17].

Relation between EAT and NAFLD

The current study showed a statistically significant relation between EAT thickness and degree of steatosis by ultrasound with higher values of EAT thickness measured among grade 3 hepatic steatosis than in grade 2 (9.600 ± 0.141 vs 8.256 ± 0.418 mm) (P value < 0.001).

These results were in agreement with Lacobellis et al. who conclude that epicardial fat thickness was significantly higher ($P<0.01$) in obese subjects with NAFLD when compared to those without NAFLD as well as in subjects with severe (ultrasound score 3) than those with moderate (score 2) liver steatosis (9.7 ± 0.2 vs. 8 ± 0.7 mm, $P<0.01$) [18]. Also, the results of our study come in concordance with the findings of Stramaglia et al. in 2010 who reported that EAT measured by echocardiography was related to the severity of hepatic steatosis as detected by ultrasonography [19].

Also, a significant positive correlation was noted between EAT thickness and both ALP and GGT levels. These results are matching with Iacobellis et al. in 2008 who found a statistically significant relation between EAT on one side and ALT and AST on the other side [20].

Hence, our data suggested that echocardiography-measured epicardial fat thickness is independently associated with NAFLD. Its measurement can be clinically feasible and represent an additional tool for the stratification of the cardiometabolic risk in coronary heart disease.

Conclusions

High EAT thickness may represent a marker of the severity of NAFLD as well as an independent predictor of coronary artery disease risk. EAT assessment by transthoracic echocardiography is a simple and non-invasive tool that can be used for cardiovascular risk stratification.

Limitation of the study

The study includes rather a small number of cases and represents a single-center study. More advanced and expanded studies are recommended on a larger number of patients to get a better evaluation and to clarify the pathogenesis of the local fat tissues' influence on systemic atherosclerosis.

Abbreviations

CAD: Coronary artery diseases; EAT: Epicardial adipose tissue; BMI: Body mass index; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; NFS: NAFLD fibrosis scoring system; FIB4: Fibrosis-4.

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Authors' contributions

In addition to being the corresponding author, HSR had proposed the idea for research and had conducted a final revision of the gathered data. SAA and ASH had collected the relevant data. HSR and SAA had prepared the manuscript. SED and HHZ had outlined the study design and revised the manuscript. The authors read and approved the final manuscript.

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Availability of data and materials

The datasets that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declarations

Ethics approval and consent to participate

This study was performed according to the ethical standards for human experimentation and in accordance with the ethical principles of the 1975 Declaration of Helsinki. Patients included in this study signed an informed written consent to participate and all the procedures were in accordance with the standards of the Research Ethics Committee (REC) of the Faculty of Medicine, Ain Shams University (FWA 000017585).

Consent for publication

Consent was taken from each author for publication.

Competing interests

The authors declare that they have no competing interests.

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