



HEALTH SCIENCES

Evaluation of Epicardial Adipose Tissue by Echocardiography and Its Correlation with Aortic Velocity Propagation and Carotid Intima-Media Thickness in Patients of Type 2 Diabetes Mellitus

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Abstract: Epicardial fat thickness (EFT) is associated with aortic stiffness in diabetic patients. In this study, we aimed to determine if there is an association among the parameters of EFT, aortic velocity propagation (AVP), and carotid intima-media thickness (CIMT) in patients with non-insulin dependent diabetes mellitus. This study included 55 non-insulin dependent diabetes mellitus patients and 40 non-diabetic control patients. For all participants, EFT and AVP were determined by echocardiographic method and CIMT was calculated using an ultrasonographic exam. The EFT and CIMT values were found to be significantly increased in the non-insulin dependent diabetes mellitus group. On the other hand, aortic velocity propagation was decreased in the non-insulin dependent diabetes mellitus group compared to non-diabetic patients (EFT; 8.43 ± 1.68 versus 6.36 ± 2.21 mm, $p < 0.001$; CIMT; 0.92 ± 0.24 versus 0.58 ± 0.18 mm, $p < 0.001$; and AVP; 28.20 ± 16.02 versus 58.10 ± 17.50 , $p < 0.01$, respectively). Significantly higher EFT and CIMT values were found in addition to lower AVP values in non-insulin dependent diabetes mellitus patients. Moreover, we demonstrated that there was a strong correlation between EFT, CIMT, and AVP.

Key words: Epicardial fat thickness, Aortic velocity propagation, Carotid intima-media thickness, Echocardiography, Non-insulin dependent diabetes mellitus.

INTRODUCTION

Epicardial adipose tissue (EAT) is present between the pericardium and the myocardial outer wall. Epicardial fat thickness (EFT) can be quantified by using computed tomography or echocardiography, and epicardial fat volume can be measured with magnetic resonance imaging (Iacobellis & Bianco 2011, Gorter et al. 2008). The EAT and myocardium share the same microcirculation. It has been well demonstrated that several adipokines and inflammatory cytokines interacting with the myocardium originate from EAT (Iacobellis et al. 2005). EAT has multiple protective roles in inflammation

and atherosclerosis, which is mediated by adiponectin (Fitzgibbons & Czech 2014).

Diabetic patients have an increased risk of cardiovascular disease due to the progression of atherosclerosis (Boyle 2007). Obesity, non-insulin dependent diabetes mellitus (NIDDM) and insulin resistance are all pro-inflammatory states related to increased adiposity (Vela et al. 2007), and EFT has a strong association with obesity, impaired fasting glucose, insulin resistance and diabetes mellitus (Şengül & Özveren 2013). EFT is considered an indicator of cardiovascular risk, and EFT thickness, measured by echocardiography, was found to be associated with metabolic syndrome (Iacobellis et al. 2003).

Atherosclerosis damages the arterial walls by increasing arterial resistance, and it is well known that aortic stiffness is an independent marker of cardiovascular disease, predicting mortality and morbidity (Arnett et al. 1994). Aortic velocity propagation (AVP), a recently defined measurement, reflects the presence of aortic stiffness and is measured with an echocardiographic method. Measurement of AVP is based on the propagation velocity of the descending thoracic aorta. Previous research has shown that EFT is correlated with carotid intima-media thickness (CIMT) and arterial stiffness in patients with NIDDM (Korkmaz et al. 2014, Cetin et al. 2013). EFT, CIMT and AVP measurements could provide additional information on assessing subclinical atherosclerosis in NIDDM patients. We hypothesized that EFT might be related to AVP and CIMT in patients with NIDDM. The aim of the study was to evaluate EFT, AVP and CIMT in NIDDM patients and then investigate association among those parameters.

MATERIALS AND METHODS

This study included a total of 95 cross-sectionally chosen patients (55 patients with NIDDM and 40 non-diabetic patients) older than 18 years belonging to our clinic between September 2016 to July 2017. Patients with the following conditions were excluded from the study: uncontrolled hypertension, anemia, left ventricular dysfunction, valvular pathology, echogenic anomalies, any effusion, atrial fibrillation, aortic aneurysms, acute coronary syndromes, coronary arterial disorder, abnormal thyroid function, chronic lung disease, renal or hepatic dysfunction, known malignancy, systemic infection or inflammatory disorders. Patients were divided into two groups; group 1 consisted of 55 patients with NIDDM (the patient group),

and group 2 had 40 non-diabetic patients, which formed the control group. Informed consent was obtained from all patients prior to the study. This study was performed according to the principles stated in the Declaration of Helsinki and was approved by the local ethics committee of the Van Training and Research Hospital.

Physical examinations including anthropometric measurements, history, and basic laboratory tests were performed. All participants underwent echocardiography examination. After an overnight fast of at least 8 hours, blood samples were taken from the antecubital vein with an atraumatic puncture and sent to the laboratory for analysis.

Blood pressure measurements were taken on the physical examination. Hypertension was defined as systolic blood pressure measurements of ≥ 140 mmHg, diastolic values of ≥ 90 mmHg, or a requirement for antihypertensive medication. Hyperlipidemia was defined as the presence of total cholesterol levels ≥ 220 mg/dl or triglyceride levels ≥ 150 mg/dl. Diagnosis of NIDDM was based on the criteria of American Diabetes Association (ACE/ADA Task Force on Inpatient Diabetes 2006). Patients who used tobacco either actively or previously (>10 pack-years) were defined as smokers. Routine electrocardiography (ECG) was recorded in each patient, and each patient underwent complete transthoracic echocardiography following the American Society of Echocardiography guidelines (Schiller et al. 1989).

The transthoracic echocardiography was performed at rest, with the patient in the left lateral decubitus position, using an echocardiographic device (Vivid S6, General Electric, Horton, Norway) with a 3.0-MHz transducer. Two experienced cardiologists blinded to clinical data performed the echocardiographs. Echocardiographic images

were also recorded, and offline measurements were performed.

Color M-mode Doppler recordings were obtained from the suprasternal window in the supine position. The cursor was placed parallel to the main direction of flow in the descending aorta. The Nyquist limit was adapted to 30–50 cm/s, switching to the M-mode with a recorder sweep rate of 200 mm/s. If the slope of the flame was unclear, baseline shifting was used to change the aliasing velocity until a clear delineation of the velocity slope was obtained (Figure 1). AVP was then calculated by dividing the distance between the points corresponding to the beginning and end of the propagation slope by the duration between the corresponding time points. Thus, AVP corresponds to the velocity at which the flow is propagating down the artery. The mean of at least three measurements was recorded as the AVP. The intra- and inter-observer variability for AVP measurement was excellent, with a correlation coefficient of 0.92 and 0.90, respectively.

The EFT was measured on the free wall of the right ventricle from the parasternal long-axis view, using the aortic annulus as an

anatomic reference. The thickness of the free right ventricular wall was measured at the end-systolic period. When a space was found without echogenic view between visceral pericardium and myocardium, it was measured as epicardial fat. To measure EFT, the thickest area was chosen to measure, preferably the right supraventricular area (Figure 2). The average value of the three cardiac cycles was noted. The intra-observer and inter-observer variabilities for EFT had correlation coefficients of 0.94 and 0.90, respectively.

Carotid arteries were evaluated using a Logiq 7 (General Electronic, Waukesha, WI, USA) with a 7.5-MHz transducer. All examinations were performed by two experienced radiologist who were blinded to the patients' clinical information. Measurements were performed for the right and left carotid arteries and involved primary transverse and longitudinal scanning of the common carotid artery, bifurcation and internal carotid. The patient was lying in a supine position with their head directed away from the side of interest and neck slightly extended. The CIMT was measured on the far wall, 1 cm from the bifurcation of the common carotid artery, as

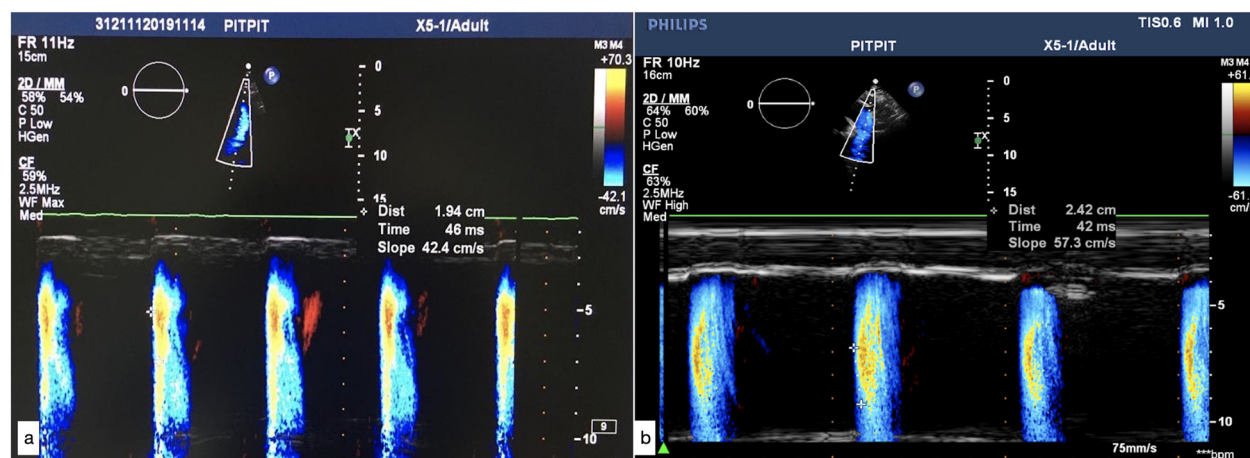


Figure 1. Aortic velocity propagation (AVP) in a patient with diabetes mellitus disease (AVP=42.4 cm/s) (Figure 1a), and in a control subject (AVP=57.3 cm/s) (Figure 1b). The AVP was calculated by dividing the distance between points corresponding to the beginning and end of the propagation slope by the duration between corresponding time points.

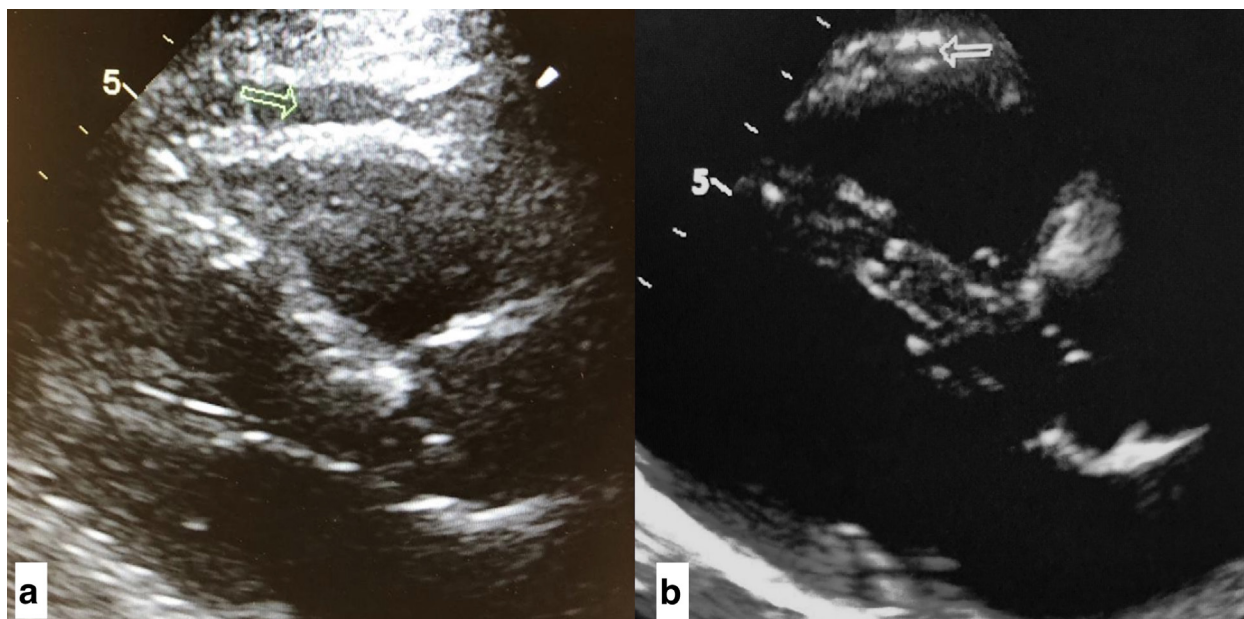


Figure 2. Measurement of Epicardial fat thickness in a patient who has diabetes mellitus disease (Figure 2a), and in a control subject (Figure 2b). Epicardial fat thickness (EFT) perpendicular to right ventricular free wall (arrow). EFT-identified as an echo-free space between the myocardium and visceral pericardium from the parasternal long-axis view on two-dimensional echocardiography, was measured perpendicularly in front of the right ventricular free wall at end-systole.

the distance between the lumen intima interface and the media-adventitia interface (Sidhu & Desai 1997). The CIMT was measured from the frozen frame of a suitable longitudinal image. At least three measurements were performed on both sides, and the average measurement was taken as the CIMT. All measurements were made at a plaque-free site. The intra- and inter-observer correlation coefficients were 0.93 and 0.88.

Statistical analysis

SPSS software version 20.0 for Windows (SPSS Inc, Chicago, IL, USA) was used for analysis. The Kolmogorov-Smirnov test was used to verify that continuous variables were normally distributed. Variables having normal distribution were expressed as mean \pm standard deviation (SD), while variables with abnormal distributions were expressed as median with interquartile range (IQR). Categorical data were noted as

percentages. Student's unpaired t-test was used for comparison of two groups. Fisher's exact test or chi-square test was applied for comparing frequencies of nominal variables. The correlation analysis was performed with a Pearson test. Independent factors related to EFT and AVP were analyzed with a multivariate stepwise linear regression model. The cut-off values for EFT and CIMT were calculated by receiver-operating characteristic (ROC) curve analysis. The p-value of <0.05 was accepted as statistically significant.

RESULTS

There were 95 patients, 55 patients with NIDDM in the patient group and 40 non-diabetic patients in the control group. Table I shows the clinical data of the patients. There were no demographic and clinical differences found between the groups regarding gender, diastolic

Table I. Baseline demographic features and laboratory parameters of the study population.

	Diabetes mellitus (n=50)	Control (n=45)	p
Age (years)	58.8±8.8	47.3±8.8	<0.01
Male %(n)	36(20)	40(55)	0.07
Height (meter)	162.6±6.8	168.9±8.6	<0.01
Weight (kg)	81.5±10.5	78.3±13.8	0.20
BMI (kg/m ²)	30.7±3.7	27.5±5.0	<0.01
Waist circumference (cm)	106.8±10.2	96.8±14.6	<0.01
Hypertension %(n)	60(33)	27(11)	<0.01
Hyperlipidemia %(n)	45(25)	10(4)	<0.01
Smoking %(n)	12(7)	30(12)	0.03
Systolic BP (mm Hg)	129.6±18.4	120.6±15.3	0.01
Diastolic BP (mm Hg)	85.6±12.8	82.2±9.4	0.16
Heart rate (bpm)	79.9±14.5	78.9±14.3	0.74
Hemoglobin (g/dL)	13.6±1.1	14.6±1.4	<0.01
Hematocrit (%)	41.2±3.6	43.9±4.1	<0.01
Platelet count (103/mm ³)	230.2±46.2	229.9±43.2	0.97
Serum glucose (mg/dl)	183.2±42.1	94.1±13.3	<0.01
Aspartate transaminase (U/l)	22.8±9.8	19.9±7.0	0.12
Alanine transaminase (U/l)	25.4±12.6	24.0±11.4	0.58
Creatinine (mg/dl)	1.0±0.1	0.8±0.2	<0.01
Total cholesterol (mg/dl)	201.2±36.1	200.8±36.4	0.96
Triglyceride (mg/dl)	198.7±85.9	219.6±91.5	0.25
High density lipoprotein (mg/dl)	38.2±8.5	37.0±10.9	0.55
Low density lipoprotein (mg/dl)	126.9±29.5	121.2±30.1	0.36
Diabetes mellitus duration (years)	5(1-27)		
HbA1c (%)	8.2±1.6		
OAD %(n)	63(35)		
Insulin %(n)	11(6)		
OAD+Insulin %(n)	25(14)		

BMI, Body mass index; BP, Blood pressure; HbA1c, Glycolized hemoglobin; OAD, Oral Antidiabetic Drug. p value was calculated by the student's t test or Chi-square test. Values are mean ±SD or median [25th, 75th] and number (percentage). p<0.05 was considered statistically significant.

pressure values, and heart rate. Age, body mass index (BMI), hypertension, hyperlipidemia, and systolic blood pressure measurements were higher in the NIDDM group. Only serum creatinine and blood glucose levels were higher in the NIDDM group, whereas hemoglobin and

hematocrit levels were found to be higher in the control group. In the echocardiographic analysis, the end-diastolic and end-systolic diameter of the left ventricle and the ejection fraction were higher in the control group, while the mitral A velocity, mitral deceleration time, CIMT and EFT

were markedly higher and AVP were markedly lower in the NIDDM group (Table II). There was statistically significant difference in AVP and EFT values between groups, as shown in Figures 3 and 4. Moreover, CIMT measurements were significantly higher in the NIDDM group (Figure 5). Tables III and IV present the correlation analyses between the EFT, AVP and clinical parameters. There was a statistically significant negative correlation between the EFT and AVP ($r = -0.337$, $p = 0.001$) (Figure 6). Multivariate linear regression analyses revealed a correlation between the EFT, AVP, and various parameters presented in Tables V and VI. In the multivariate linear analyses,

CIMT ($\beta = 2.623$, 95% CI [0.724, 4.522], $p = 0.007$) was found to be an independent predictor of EFT. Furthermore, CIMT ($\beta = -29.667$, 95% CI [-44.507, -14.827], $p < 0.001$) was an independent marker of AVP. In the ROC curve analyses, an EFT and CIMT of 7.3 mm and 0.65 mm, respectively, were determined to be effective cut-off points for subclinical atherosclerosis in diabetes mellitus patients, with sensitivity values of 76% and 92% and specificity values of 70% and 78%, respectively (EFT, AUC = 0.78, $p = 0.001$, 95% CI [0.694, 0.882]; CIMT, AUC = 0.892, $p = 0.001$, 95% CI [0.819, 0.965]; Figure 7).

Table II. Echocardiography parameters in the study groups.

	Diabetes mellitus (n=50)	Control (n=45)	p
Ejection Fraction (%)	59.8±1.5	61.0±1.9	<0.01
Aorta systolic diameter (mm)	2.9±0.3	2.9±0.3	0.79
Aorta diastolic diameter (mm)	3.3±0.3	3.2±0.3	0.55
Left atrial diameter (mm)	3.4±0.3	3.5±0.4	0.89
IVS (cm)	1.2±0.1	1.0±0.1	<0.01
PWD (cm)	1.1±0.1	1.0±0.1	<0.01
LVEDD (cm)	4.0±0.4	4.2±0.4	0.03
LVESD (cm)	2.9±0.4	3.1±0.3	<0.01
Mitral E (m/sec)	0.7±0.1	0.7±0.1	0.47
Mitral A (m/sec)	0.8±0.1	0.7±0.2	<0.01
DT (msec)	206.9±30.1	185.0±17.8	<0.01
IVRT (msec)	81.2±14.5	81.0±4.4	0.90
CIMT (mm)	0.9±0.2	0.5±0.1	<0.01
EFT (mm)	8.4±1.6	6.3±2.2	<0.01
AVP (cm/s)	28.2±16.0	58.1±17.5	<0.01

IVS, interventricular septum; PWD, posterior wall diameter; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; Mitral E, early diastolic mitral flow velocity; Mitral A, late diastolic mitral flow velocity; DT, deceleration time; IVRT, isovolumic relaxation time; CIMT, carotid intima-media thickness; EFT, Epicardial fat thickness; AVP, Aortic velocity propagation. p value was calculated by the student's t test. Results were presented as Mean ±SD. $p < 0.05$ was considered statistically significant.

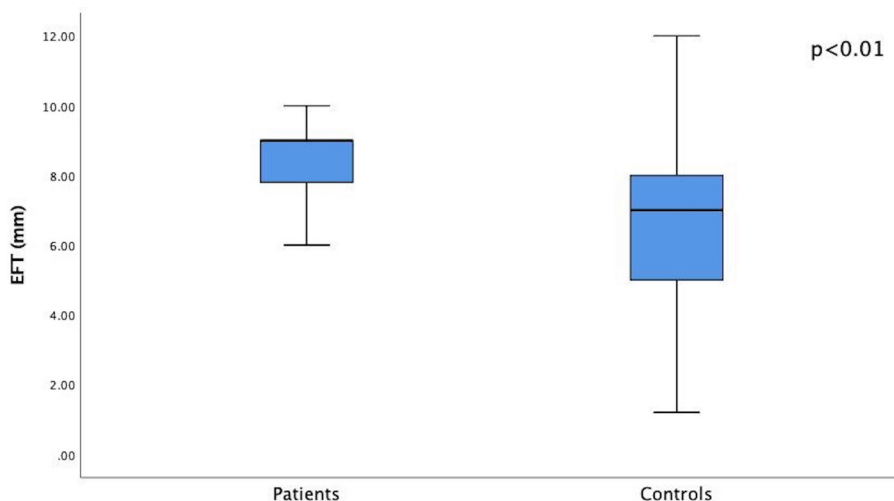


Figure 3. Epicardial fat thickness (EFT) values between study groups. (EFT:8.4±1.6 mm vs 6.3±2.2 mm p<0.01). p value was calculated by the student's t test. p<0.05 was considered statistically significant.

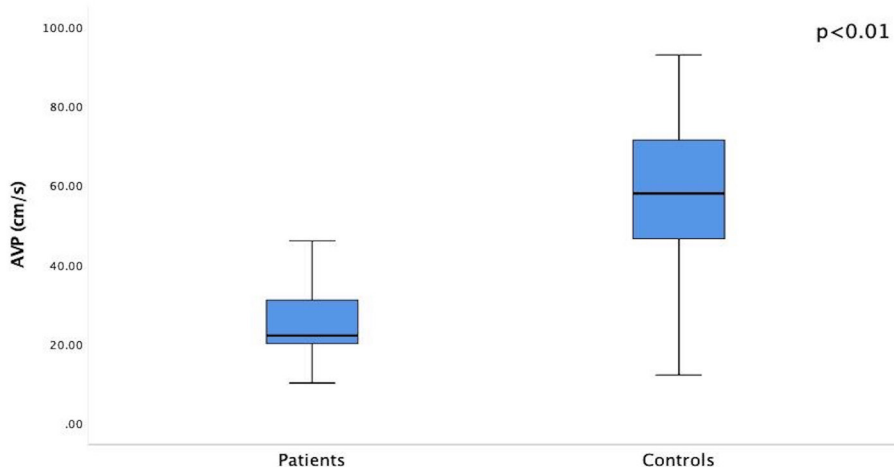


Figure 4. Aortic velocity propagation (AVP) values between study groups. (AVP:28.2±16.0 cm/s vs 58.1±17.5 cm/s p<0.01). p value was calculated by the student's t test. p<0.05 was considered statistically significant.

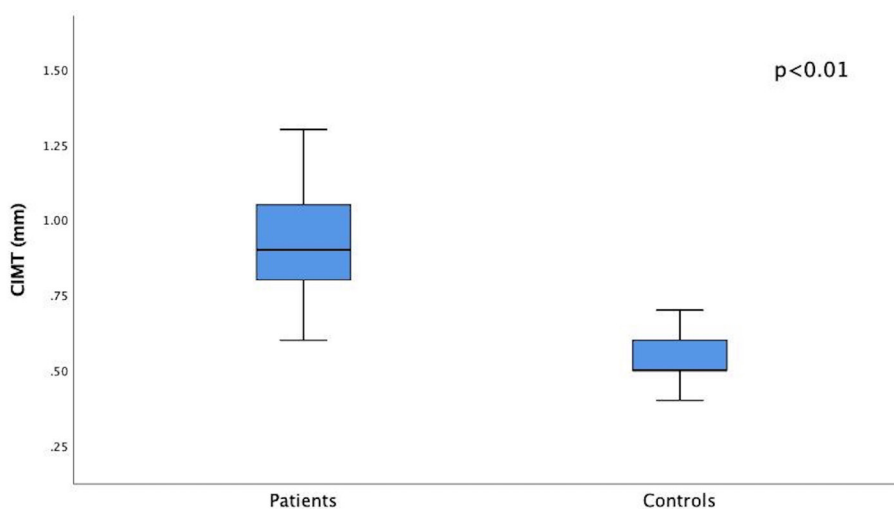


Figure 5. Carotid intima-media thickness (CIMT) levels between study groups. (0.9±0.2 mm vs 0.5±0.1 mm p<0.01). p value was calculated by the student's t test. p<0.05 was considered statistically significant.

Table III. Correlation between Epicardial fat thickness (EFT) and clinical parameters.

	r	p	R²
Age	0.394	<0.001	0.155
BMI	0.225	0.028	0.051
Waist Circumference	0.256	0.012	0.066
Hemoglobin	-0.078	0.455	0.006
Serum glucose	0.382	<0.001	0.146
Diabetes mellitus duration	0.137	0.318	0.019
HbA1c	0.361	<0.001	0.130
Ejection Fraction	-0.12	0.245	0.014
Aorta systolic diameter	0.008	0.941	0.000
Aorta diastolic diameter	0.038	0.716	0.001
CIMT	0.413	<0.001	0.171
AVP	-0.337	0.001	0.114

BMI, Body mass index; HbA1c, Glycolized hemoglobin; CIMT, carotid intima-media thickness; AVP, Aortic velocity propagation. Pearson test was used to analyze the relationship between EFT and study variables where appropriate. correlation coefficient (r). p<0.05 was considered statistically significant.

Table IV. Correlation between Aortic velocity propagation (AVP) and clinical parameters.

	r	p	R²
Age	-0.550	<0.001	0.303
BMI	-0.296	0.004	0.088
Waist Circumference	-0.288	0.005	0.083
Hemoglobin	0.341	0.001	0.116
Serum glucose	-0.521	<0.001	0.271
Diabetes mellitus duration	-0.110	0.423	0.012
HbA1c	-0.569	<0.001	0.324
Ejection Fraction	0.182	0.078	0.033
Aorta systolic diameter	-0.064	0.538	0.004
Aorta diastolic diameter	-0.120	0.248	0.014
CIMT	-0.628	<0.001	0.394
EFT	-0.337	0.001	0.114

BMI, Body mass index; HbA1c, Glycolized hemoglobin; CIMT, carotid intima-media thickness; EFT, Epicardial fat thickness. Pearson test was used to analyze the relationship between AVP and study variables where appropriate. Correlation coefficient (r). p<0.05 was considered statistically significant.

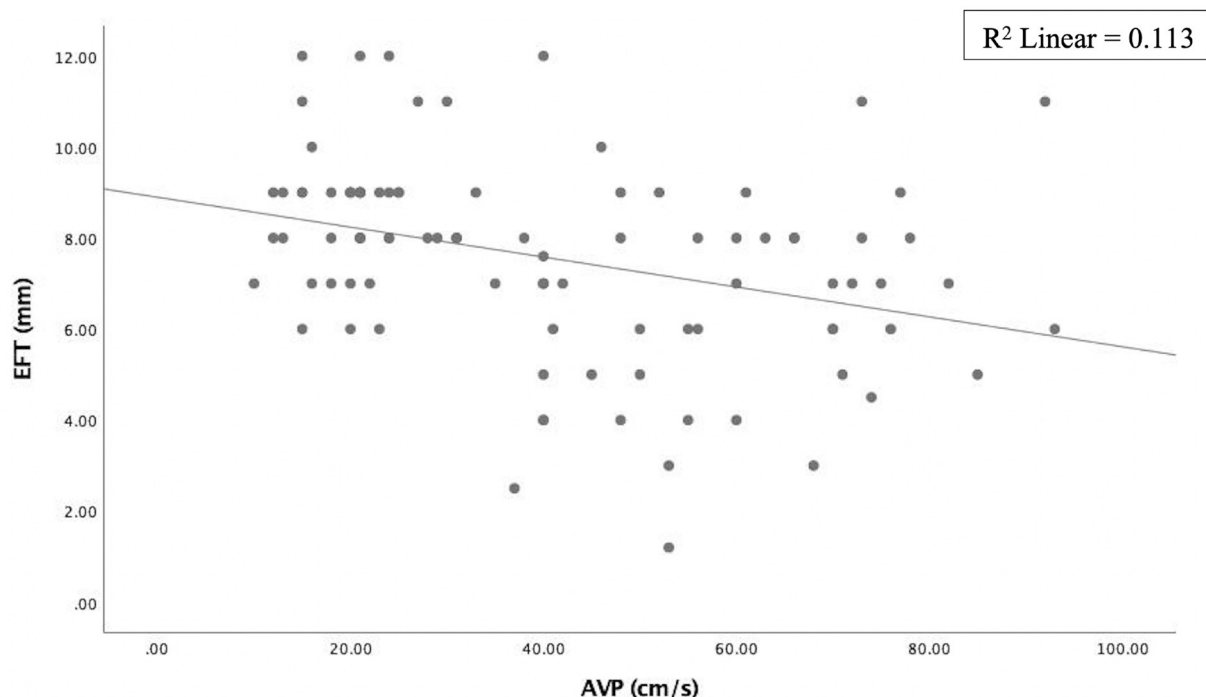


Figure 6. Correlation between Epicardial fat thickness (EFT) and Aortic velocity propagation (AVP) ($r=-0.337$, $p=0.001$, $R^2=0.114$). Pearson test was used to analyze the relationship between EFT and AVP variables. Correlation coefficient (r). $p<0.05$ was considered statistically significant.

Table V. Independent predictors for Epicardial fat thickness (EFT) by multivariate linear regression analysis.

	B	t	p	%95CI
CIMT	3.256	4.374	0.001	1.778-4.735

CIMT, carotid intima-media thickness. B, Regression coefficient; t, Degree of freedom; CI, confidence interval; $p<0.05$ was considered statistically significant. ($R^2=0.171$ F=19.130). ($p>0.05$ was excluded).

Table VI. Independent predictors for Aortic velocity propagation (AVP) by multivariate linear regression analysis.

	B	t	p	%95CI
CIMT	-30.869	-4.105	<0.001	-45.806 (-) -15.931
Glucose	-0.112	-3.411	0.001	-0.178 (-) -0.047
Age	-0.484	-2.500	0.014	-0.868 (-) -0.099

CIMT, carotid intima-media thickness. B, Regression coefficient; t, Degree of freedom; CI, confidence interval; $p<0.05$ was considered statistically significant. ($R^2=0.714$ F=31.632). ($p>0.05$ was excluded).

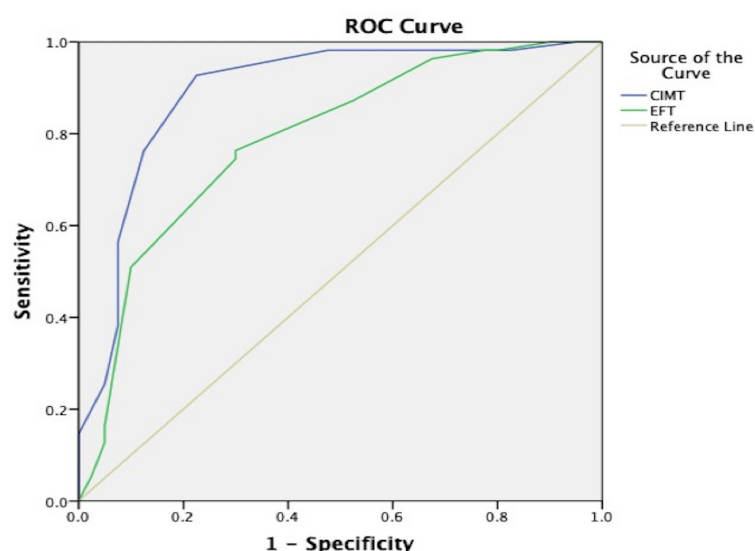


Figure 7. Receiver-operating characteristic (ROC) curve analyses of epicardial fat thickness (EFT) and carotid intima-media thickness (CIMT). Values of 7.3 mm and 0.65 mm for EFT and CIMT, respectively, were determined to be effective cut-off points for subclinical atherosclerosis in patients with NIDDM, with sensitivity values of 76% and 92% and specificity values of 70% and 78%, respectively (EFT, AUC = 0.78, $p = 0.001$, 95% CI [0.694, 0.882]; CIMT, AUC = 0.892, $p = 0.001$, 95% CI [0.819, 0.965]). (AUC, Area under curve; CI, confidence interval).

DISCUSSION

We found that EFT was associated with AVP in NIDDM patients. As far as we know, this is the first study to focus on the correlation between EFT and AVP in patients with NIDDM. This study demonstrated three significant findings within the patients with NIDDM. First, EFT and CIMT were significantly higher and AVP was significantly lower in the NIDDM group. Second, an inverse correlation between the EFT and AVP values was observed. Lastly, CIMT was an independent marker of EFT and AVP. These results showed that higher EFT, CIMT and lower AVP values might be related to the progression of atherosclerosis in NIDDM patients.

EFT has modulatory role on cardiac function and morphology; therefore, it contributes to the progression of atherosclerosis (Vela et al. 2007). A recent study demonstrated that EFT is associated with cardiovascular risk factors (Folsom et al. 2000). Alexopoulos et al. 2010 found a significant association between epicardial fat and CAD by cardiac computed tomography. Furthermore, another study revealed a relationship between EAT and clinical features of metabolic syndrome such as high blood pressure, high levels of LDL

cholesterol, and insulin resistance (Pierdomenico et al. 2013).

Patients with NIDDM have increased cardiovascular disease risk and accelerated atherosclerosis (Boyle 2007). Characteristically, increased EFT is seen in diabetic patients, and a positive association between BMI, visceral adiposity and waist circumference have been reported (Lau & Muniandy 2011). Increased EFT in NIDDM patients might be related to altered insulin sensitivity. Significantly higher EAT volume measured by tomography was shown in patients with NIDDM compared to non-diabetic subjects in a report by Wang et al. 2009. In a recent study, it was demonstrated that the EFT values of NIDDM patients were significantly higher than the control group. In the same study, a correlation between EFT and NIDDM was observed, and the longer the duration of NIDDM, the greater the increase in EFT was observed (Wang et al. 2017). Kim et al. 2012 measured EFT by cardiac magnetic resonance imaging and found that EFT is an independent risk factor for marked coronary arterial stenosis in NIDDM patients who are asymptomatic. In addition, Hirata et al. 2017 reported greater EFT in a diabetic coronary arterial disease group compared to a non-diabetic coronary arterial disease group.

In the light of this data, they suggested that this finding could be a useful tool for predicting coronary arterial diseases in patients with NIDDM. In our study, we found significantly higher EFT in the NIDDM group. Additionally, we demonstrated that EFT is positively correlated with age, waist circumference, BMI, serum glucose levels, HbA1c, CIMT, and inversely correlated with AVP.

We know that EAT is antiatherogenic and anti-inflammatory, which makes it cardioprotective. However, increased EAT can turn cardiotoxic via the increasing local inflammation (Iacobellis & Bianco 2011). Adiponectin has an antiatherogenic effect with the improvement of endothelial function, and it was shown to be underexpressed in the EAT of patients with CAD (Eiras et al. 2008). Sacks & Fain 2007 showed paracrine effects of EAT for the development of atherogenesis. Ansaldo et al. 2019 stated that the shift of the EAT from its physiological towards a dysfunctional role stimulates the initiation of CAD. Furthermore, paracrine secretion of pro- and anti-inflammatory cytokines from EAT plays a role in the adipocyte-related inflammation and atherosclerosis (Iacobellis & Barbaro 2008). The mechanism underlying these associations may be linked to a disordered secretory profile of EAT (Shimabukuro et al. 2013). Thus, increased EAT might produce more inflammatory cytokines that affect vascular function. The EAT was shown to produce inflammatory biomarkers such as interleukin (IL)-1b, IL-6, TNF alpha, and monocyte chemoattractant protein (MCP-1) in patients with CAD (Mazurek et al. 2003). Therefore, EAT plays a vital role as a local inflammatory burden in patients with CAD. Moreover, Çelik et al. 2014 demonstrated that there was a negative correlation between EAT and endothelial function and increased EAT might predict endothelial function in NIDDM patients.

AVP is a simple and easily measurable echocardiographic parameter that can be used

in a routine echocardiographic examination. An increase in arterial resistance decreases the AVP flow. Arterial stiffness is a well-known risk factor for atherosclerosis (Franklin et al. 2001). The mechanisms of the associations between EFT and arterial stiffness have not yet been fully established. There is a strong association between EAT and impaired glucose intolerance causing arterial dysfunction (Nakanishi et al. 2003). Arterial stiffness in patients with NIDDM is the result of accumulation of glycosides on the arterial wall (Brownlee et al. 1988). In addition, EAT is a source of proinflammatory factors that boost inflammation, resulting in atherosclerotic changes and arterial stiffness (Chatterjee et al. 2009).

An independent relationship between EFT and arterial stiffness was reported by Kim et al. 2013. Badran et al. previously showed the effects of NIDDM on arterial elasticity in normotensive diabetes, finding significantly higher pulse pressure in groups of patients with NIDDM. Additionally, the systolic velocity of the aortic wall was significantly lower in NIDDM patients compared to the control group. In the same study, there was a strong negative correlation between the aortic elasticity and duration of diabetes (Badran & Elnoamany 2006). The authors suggested that poor glycemic control and a longer duration of diabetes mellitus a detrimental effect on aortic elastic properties. These findings in previous studies are consistent with our results: similarly, we found that AVP was increased in NIDDM patients. We also found that AVP is correlated with BMI, waist circumference, age, serum glucose levels, HbA1c, CIMT and EFT, and that CIMT, serum glucose levels, and age are independent risk markers of AVP in NIDDM patients.

In subclinical atherosclerosis, the carotid intima-media thickness has been identified as a risk factor (Bauer et al. 2012). Mandal et al. 2016

evaluated EFT and CIMT in NIDDM patients and showed that NIDDM patients had significantly increased CIMT and EFT values in comparison to non-diabetic subjects. Furthermore, CIMT was evaluated as an independent risk factor for EFT in the same study. Additionally, in a study performed by Cetin et al. 2013, EFT was positively correlated with the time of NIDDM, levels of HbA1c, anthropometric measurements, and CIMT. Moreover, they found that waist circumference and CIMT were independent predictors of EFT in NIDDM patients. Similarly, in the current study, we found that CIMT was higher in NIDDM patients, and it was significantly related to EFT and AVP.

Our study findings suggest that EFT, CIMT and AVP measurements could provide additional information on assessing subclinical atherosclerosis, and individuals with increasing EFT, CIMT and decreasing AVP should receive more attention to reduce unfavorable cardiovascular risk factors and the development of future cardiovascular diseases. Also, EFT and AVP calculation by echocardiography requires very little time and can be easily applied during an examination for evaluation of morphological and functional cardiac parameters in patients with NIDDM. It helps us to predict cardiovascular risks, prevent further development of cardiovascular complications by applying more intensive therapy and improve the prognosis. As far as we know, this is the first study to focus on the correlation between EFT, CIMT and AVP in patients with NIDDM. We believe that our study adds valuable information to the current literature on the importance of evaluating the predictors of subclinical atherosclerosis in NIDDM patients.

Limitations

There were few limitations in this work. First, this was a single-center study based on a relatively small group of patients. We could not confirm EFT measured by magnetic resonance and computed

tomography imaging methods. Additionally, as EAT has a three-dimensional distribution, two-dimensional echocardiography may not be able to completely assess the total amount of epicardial adiposity. Another limitation was that the suprasternal images of some patients were not suitable to obtain a precise measurement of AVP. Additionally, cardiac anatomy and cardiac output conditions may affect the AVP measurements. Finally, all data were based on a single measurement and may not reflect the association of EFT and AVP in terms of changes over time.

CONCLUSION

This paper reported that EFT and CIMT were higher and AVP was lower in patients with NIDDM. EFT measured using echocardiography was significantly correlated with AVP and CIMT. Based on these results, we suggest the accuracy and usability of EFT, CIMT and AVP measured by echocardiography in the suspect of subclinical atherosclerosis in patients with NIDDM. Further studies are needed to increase the study population and to attain more accurate findings.

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