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Original Article

Visceral adiposity index in female with type 2 diabetic mellitus and its association with the glycemic control

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ABSTRACT

Aims: Visceral Adiposity Index (VAI) is suggested as a surrogate marker for visceral adipose tissue dysfunction. It is an empirical-mathematical model, sex-specific, based on metabolic and anthropometric parameters. Diabetes mellitus is growing in an expanding fashion globally. The aim of this study to study the association between VAI and glycemic control in women with type 2 diabetes mellitus (T2DM).
Materials and methods: A total of 300 T2DM female aged (25–60 years) were enrolled in this cross-sectional study. Subjects were recruited from Baghdad medical city during the period from January 2017 to July 2018.
Body mass index (BMI), waist circumference (WC), blood pressure was measured and fasting blood sample was analyzed for blood glucose, glycated hemoglobin(HbA1c), and lipid profile. VAI was calculated in addition to triglyceride-glucose (TyG) derived indices. Statistical analysis was done by SPSS version 23. The study was ethically approved.
Results: Patients with high VAI showed poor glycemic control, dyslipidemia, elevated TYG index, TYGWC and TYGBMI. The number of diabetics with poor glycemic control increased across the VAI quartiles. The area under the curve in ROC analysis demonstrated that VAI had a good predictive ability to identify the state of glycemic control as compared to other anthropometric measures (WC, BMI) or combined metabolic and anthropometric measures (TyGWC, TyGBMI).
Conclusion: increased VAI adversely affects the glycemic control in women with T2DM.

1. Introduction

Visceral adiposity is one of the public health challenges worldwide. It is associated with many disorders such as cardiovascular disease, metabolic syndrome, impaired lipid and glucose metabolism, and some malignancies as breast, prostate, and colon cancers. It is linked with the key elements characterizing the cardiometabolic risk [1,2]. Dysfunctional visceral adipose tissue has been described as a morbidity and mortality risk factor in both normal weight and obese subjects [1,3].

Magnetic resonance imaging (MRI) and Computerized tomography scan (CT) can quantify visceral fat tissue and distinguish between various types of body fat distribution, especially subcutaneous and visceral fat tissue, but these techniques are expensive and not available in every clinical setting [4] So, there is a need for simple alternatives marker that can quantify visceral fat. Many anthropometric measures were suggested such as WC, BMI, waist-to-height ratio, but these measures cannot distinguish between subcutaneous and visceral fat mass [5].

Instead, the Visceral Adiposity Index (VAI) was suggested as a surrogate marker of visceral adiposity [6]. VAI is an empirical-mathematical model, sex-specific, based on metabolic parameters (triglycerides (TG), high density lipoprotein cholesterol (HDL-C) and anthropometric parameters (Body mass index and Waist circumference) [7].

A previous study revealed that there is a strong correlation between the calculated VAI and the MRI-measured body visceral adiposity, and suggested that it could be a useful marker of visceral adipose functionality [8]. Accordingly, several studies have investigated the association between visceral adiposity, estimated by VAI, and different diseases and concluded that VAI was significantly related to the metabolic syndrome [9], cardiovascular events, including cerebrovascular and coronary artery disease [10]

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dysglycemia [11,12] and hypertension [13].

Diabetes mellitus is growing in an expanding fashion globally. Glycemic control has a pivotal role in controlling Its micro and macro vascular complications The occurrence of these complications depends largely on the degree of glycemic control [14]. According to the American Diabetes Association guidelines the primary target for glycaemic control in diabetics is suggested to be HbA1c level <7.0% [15]. The impact of obesity on clinical workload and care provided for diabetic patients has not attracted much awareness. The aim of this study to study the association between VAI and HbA1c in type 2 diabetic patients.

2. Subjects and methods

2.1. Study population

During January 2017 to July 2018, three hundred twenty three consecutive diabetic female were initially included in this cross-sectional study. Subjects were recruited from Baghdad medical city and private clinics.

Inclusion criteria: T2DM female aged 25–60 years on oral hypoglycemic drugs.

Exclusion criteria: Pregnant and lactating women or those with polycystic ovary syndrome, subjects with type 1 diabetes, existing or history of major medical illness such as, cancer, thyroid dysfunction, endocrine, mental or physical disability, pendulous abdomen, the presence of morbid obesity, the use of fibrates, severe hypertriglyceridemia.(serum triglycerides is more than 3.15 mmol/L (279 mg/dL)). After exclusion of participants who were aged <25 or >60 years, patients with any of the above conditions or patients with missing data, the remaining participants were 300.

2.2. Anthropometric measurements

Body weight and height were taken with participants barefoot and in light clothing, and measured to the nearest 0.1 kg and 0.1 cm, respectively. WC was measured with tape measure to the nearest 0.1 cm at a midpoint between the bottom of the rib cage and the top of the iliac crest, following exhalation. BMI was calculated as weight (kg) divided by the square of height (meters).

Systolic and diastolic blood pressures (SBP/DBP) were measured twice using mercury sphygmomanometers and the readings were averaged.

The effect of glycemic control on different parameters was evaluated by categorizing all the patients into two categories on the basis of HbA1c levels; < 7% good glycemic control, ≥ 7% poor glycemic control. The selection of these cutoff values of HbA1c was based on earlier studies [15].

2.3. Biochemical measurements

Venous blood samples were collected from all participants after 12h fasting. Serum was allowed to clot and was centrifuged at 5000 rpm for 10 min. The supernatant clean serum was then pipetted. Hemolysed samples were excluded. Fasting plasma glucose (FPG) was assessed by the glucose oxidase method (Randox Laboratories Ltd, UK]. HbA1c was measured with high-performance liquid chromatography. Total cholesterol(TC), High density lipoprotein(HDL-C) and TG were determined using enzymatic methods with an automated chemistry analyzer. low density lipoprotein(LDL-C)level were estimated by the Friedewald equation [16]. All blood analyses were performed with strict quality control.

2.4. Index calculation

VAI was calculated as follows: [6,7].

VAI: Women: [WC/(36.58 + 1.89 × BMI)] × (TG/0.81) × (1.52/HDL)

VAI Men: [WC/(39.68 + 1.88 × BMI)] × (TG/1.03) × (1.31/HDL)

(Where the TG and HDL-C concentrations are in mmol/L).

TyG:Lin (TG × Glucose/2) where the TG and glucose level were measured in mg/dL [17].

TyGBMI: TyG × BMI [18]

TyGWC: TyG × WC [19]

Patients were categorized by their VAI levels into quartiles as < 1.48, 1.49–2.04, 2.05–2.8 and ≥2.8.

Statistical analysis: All statistical analyses were performed using SPSS software 23.0 software (SPSS Inc., Chicago, IL). The data are represented as mean ± standard deviation (SD) or standard error of mean (SEM). A *P* value of less than 0.05 was considered statistically significant. Chi square tests were used to compare categorical variables with percentages. Comparisons between groups were performed by analysis of variance (ANOVA) test as appropriate. The associations between VAI and clinical features were assessed using linear regression and correlation analysis. Receiver-operating characteristic (ROC) analyses were performed to assess and compare the discriminative power of VAI and other adiposity-based measures for poor glycemic control. The area under the receiver operating characteristics curve (AUC) and 95% confidence intervals (CIs) were computed.

The study was approved by the Ethics Committee of Al-Kindy college of Medicine-University of Baghdad. Written consent was obtained from each subject at the start of the study.

3. Result

The characteristics of the study population are presented in Table 1 the mean age of the participants was 55.55 ± 9.3.

Table 2 represents the baseline characteristics of the study populations by VAI quartile. In comparisons of the variables at baseline, all variables, except age and systolic blood pressure, were greater in higher VAI quintiles. However, HDL-C was inversely associated with VAI quartiles. The percentage of diabetics with poor

Table 1
Baseline, clinical, anthropometric and biochemical characteristics of participants.

Characters	mean ± SD
Age (years)	55.55 ± 9.3
Visceral adiposity Index	2.45 ± 1.51
Fasting Blood Sugar (mg/dl)	187.18 ± 3.44
Hemoglobin A1c Level (%)	8.7 ± 2.1
Serum Triglyceride (mg/dl)	147.95 ± 3.47
Low Density Lipoprotein LDL (mg/dl)	102.28 ± 2.59
High Density Lipoprotein HDL (mg/dl)	44.75 ± 3.02
Serum Cholesterol (mg/dl)	173.66 ± 44
Very Low Density Lipoprotein (mg/dl)	28.47 ± 1.08
Systolic Blood Pressure (mm Hg)	137.24 ± 21.1
Diastolic Blood Pressure(mm Hg)	85.85 ± 10.5
Body Mass Index ($kg/m^{2)}$	29.66 ± 5.07
Waist Circumference (cm)	100.59 ± 10.83
TyG	9.37 ± 0.59
TyG BMI	279.88 ± 54
TyG WC	944.69 ± 122.91

Results are expressed as mean ± SD (or SEM as appropriate).

Table 2
The baseline characteristics of the study populations by VAI quartile.

	First quartile Less than 1.48	Second Quartile 1.48–2.04	Third Quartile 2.04-2.8	Fourth Quartile More than 2.8	P value
Number	76	80	71	73	
Age (years)	55.63 ± 8.5	55.26 ± 10.57	55.63 ± 10.44	55.76 ± 8.35	0.862
Dm duration (year)	8.78 ± 0 .86	7.98 ± 0 .815	7.57 ± .929	7.69 ± 0.79	0.980
Visceral adiposity Index	1.29 ± 0.18	1.78 ± 0.18	2.41 ± 0.21	4.43 ± 1.7	0.000
Fasting Blood glucose (mg/dl)	167.34 ± 8.	173.12 ± 6.8	186.9 ± 8.7	200.26 ± 8.1	0.014
Hemoglobin A1c (%)	8.31 ± 2.3	8.35 ± 1.9	8.72 ± 1.6	9.22 ± 1.7	0.017
Serum Triglyceride (mg/dl)	100.85 ± 19	107.68 ± 17	148.20 ± 30	213.8 ± 60	0.000
Low Density Lipoprotein (mg/dl)	89 ± 4.6	101 ± 4.1	108. ±5.1	107 ± 5.4	0.021
High Density Lipoprotein (mg/dl)	46.47 ± 2.2	45.87 ± 2.3	44.55 ± 2.04	42.53 ± 3.1	0.000
Serum Cholesterol (mg/dl)	155.58 ± 41.	170 ± 37.	179 ± 41	191 ± 49	0.000
Very Low Density Lipoprotein (mg/dl)	21.41 ± 1.87	22.24 ± .709	26.71 ± 2.257	44.62 ± 1.962	0.144
Systolic Blood Pressure (mm Hg)	133.4 ± 17	138.2 ± 20	141.8 ± 23	134.9 ± 20	0.090
Diastolic Blood Pressure(mm Hg)	83.9 ± 9	85.9 ± 9	86.72 ± 10.	86.74 ± 10	0.278
Body Mass Index (kg/m^2)	27.99 ± 4.4	28.58. ±4.2	29.57 ± 4.1	30.79 ± 5.1	0.002
Waist Circumference (cm)	97.51 ± 11	99.43 ± 8	100.20 ± 9	103.54 ± 9	0.002
TyG	8.93 ± .0.4	9.1 ±. 0.39	9. 46 ±. 0.4	9.86 ± 0.5	0.000
TyG BMI	250.33 ± .41	264.22 ± .38	279.88 ± .41	308.97±. 55	0.000
TyGWC	871.16 ± 108	905.29 ± .83	948.2 ± 101	1021.88 ± 108	0.000
Glycemic control (more than 7%)	54(71%)	59(73.75%)	61(85.9%	68(93.1%)	0.001
Glycemic control (less than 7%)	22(29%)	21(26.25%)	10(14.1%)	5(6.9%)	

Results are expressed as mean ± SD (or SEM as appropriate).
P value less than 0.05 is statistically significant.

Table 3
The correlations between VAI and different biochemical and anthropometric parameters.

Visceral adiposity Index	r	p
Age (years)	0.035	0.552
Dm duration (year)	−0.053	0.345
Fasting Blood Sugar (mg/dl)	0.154**	0.009
Hemoglobin A1c Level (%)	0.157**	0.007
Serum Triglyceride (mg/dl)	0.765**	0.000
Low Density Lipoprotein LDL (mg/dl)	0.095	0.112
High Density Lipoprotein HDL (mg/dl)	−0.525**	0.000
Very Low Density Lipoprotein LDL (mg/dl)	0.749	0.000
Serum Cholesterol (mg/dl)	0.248**	0.000
Systolic Blood Pressure (mm Hg)	0.014	0.809
Diastolic Blood Pressure(mm Hg)	0.141**	0.016
Body Mass Index (kg/m$^{2)}$	0.263	0.000
Waist Circumference (cm)	0.199**	0.001
TyG	0.557**	0.000
TyG BMI	0.450**	0.000
TyG WC	0.443**	0.000

P less than 0.05 is statistically significant.

glycemic control also increased across the VAI quartiles.

Table 3 showed the correlations between VAI and different biochemical and anthropometric parameters.

We assessed the potential power of VAI to discriminate the state of poor glycemic control (HbA1C more than 7) as compared with that of TyGWC, TyGBMI, WC and BMI using ROC analysis, VAI had largest AUC (Table 4).

4. Discussion

In the present study we evaluated the association of VAI with HbA1c in women with T2DM.We found that patients with increased VAI showed poor glycemic control, dyslipidemia, elevated TYG index, TYGWC and TYGBMI. The number of diabetics with poor glycemic control increased across the VAI quartiles. In addition, VAI showed marked correlations with HbA1C, FBG,TG, HDL-C, DBP,WC,BMI, TYG and its derived indices.

Visceral fat accumulation is regarded as the key cornerstone of metabolic derangement since it affect metabolism by different pathway as releasing Non-esterified fatty acids, glycerol, adipocytokines (resistin, leptin, adiponectin), and proinflamatory cytokines as interleukin-6 [20].

The link between visceral adiposity and poor glycemic control can be explained at least to a certain extent by the excessive release of free fatty acids from the visceral adipose tissue, In addition, visceral fat have higher rates of lipolysis than subcutaneous fat and visceral adipose tissue lipolysis show less suppression by insulin, in turn this may lead to increased delivery of free fatty acid to the liver by the portal circulation. And finally stimulate hepatic glucose production by fatty acids. Beside that, the hepatic insulin removal is well known to be interfered by fatty acids, which may further augment the insulin resistance [21].

Gastaldelli et al. studied the metabolic impact of visceral fat accumulation in T2DM by means of two specialized techniques; the euglycemic insulin clamp and MRI and found that visceral fat had a significant negative outcome over glycemic control through a

Table 4
Area under the curve of different parameters in predicating poor glycemic control.

Test Result	Area under the curve	Asymptotic Sig	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
VAI	0.670	0.000	0.596	0.744
TyGBMI	0.574	0.131	0.477	0.655
TyGWC	0.655	0.000	0.572	0.737
WC	0.540	0.354	0.455	0.624
BMI	0.491	0.838	0.404	0.579

VAI:visceral adiposity index TyGBMI: triglyceride −glucose-body mass index TyGWC triglyceride −glucose-waist circumference WC: waist circumference BMI: body mass index.

decrease in peripheral insulin sensitivity and an increase in gluconeogenesis [22].

The findings of this study is in consistent with the finding of previous studies that demonstrated that in T2DM the glycemic control is associated with the VAI [23]. And that elevated VAI level are positively associated with the presence of pre-diabetes and diabetes in Chinese adults [12].

A study concluded that HbA1c is suggested to be 0.8% higher for each 50-cm [2] increase in the visceral fat, and suggest the measurement of the visceral fat as a part of clinical phenotyping [22].

In the current study the area under the curve demonstrated that VAI had good predictive power to identify the state of poor glycemic control as compared to other anthropometric measures (WC,BMI) and combined metabolic and anthropometric measures (TyGWC,TyGBMI).

Our study has several limitations. First, this study was cross-sectional and limited in its capacity to conclude causality. Second, ectopic fat is not measured.

In conclusion; increased VAI adversely affect the glycemic control in women with T2DM. Given that both Diabetes Mellitus and visceral obesity are major health burden worldwide. We believe that the findings presented in our research will be beneficial for the diabetic care providers by taking into consideration the VAI as part management strategy.

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