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Perirenal Fat Thickness in Relation to Glomerular Filtration Rate in Adult Males with Type 2 Diabetes

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Abstract

Obesity has been recognized as a major public health problem. It is an important risk factor for the development and progression of CKD in patients with diabetes. It also leads to significant lipid deposition within and around other tissues (ectopic fat storage), the marked increase in ectopic fat around the organs may eventually impair their functions. The aim of this work is to assess the relationship between perirenal fat thickness (PrFT) and eGFR in adult males with type 2 diabetes mellitus. This cross-sectional study was conducted on a total number of sixty male participants, aged from 40-65 years, who were known to have type 2 diabetes according to the American Diabetes. Association (ADA 2021). They were recruited from the outpatient endocrinology clinic at Al-Zahraa University Hospital, Cairo Governorate, Egypt, during the period from June 2021 to December 2021. There was a statistically significant difference between all groups (who were classified according to Body mass index (BMI) regarding the age, weight, W.C and LDL. According to PrFT, it was found that there was statistically significant difference between the two groups regarding patients' weight, BMI, W.C, creatinine, Urinary Albumin creatinine ratio, (ACR). and eGFR. The patients' height, weight, BMI, W.C, and ACR were found to be significantly and positively correlated with PrFT, and it was significantly and negatively correlated with eGFR. Studying the predictors of PrFT, by unvariant regression analysis, revealed that height, weight, BMI, and waist circumference were the most significant predictors and that weight and W.C were superior to height and BMI. In this study, the Cutoff value of PrFT in the detection of GFR less than 60 ml/min/1.73m2, was 30.15mm, its sensitivity was found to be 72.2%, specificity 69% (AUC: 0.729), with diagnostic accuracy 70%. PrFT was independently and negatively correlated with eGFR, suggesting a possible role of PrFT in kidney dysfunction in T2DM patients. Patients that had impaired kidney functions had large PrFT. Patients that had PrFT >30.15ml had higher W.C, BMI, creatinine and ACR. Perirenal fat thickness had positive

correlation with BMI, WC and ACR. The most predictive factors for PrFT were weight and W.C. According to ROC curve, the diagnostic Cutoff value of PrFT in detection of GFR less than 60 ml/min/1.73m2, was 30.15mm, its sensitivity was found to be 72.2%, specificity 69% (AUC: 0.729), PPV =50%, NPV= 85.3%, with diagnostic accuracy 70%.

Keywords: Perirenal Fat Thickness; Glomerular Filtration Rate; Type 2 Diabetes

1. Introduction

Obesity has been recognized as a major public health problem [1]. In humans and most animal models, the development of obesity leads to significant lipid deposition within and around other tissues (ectopic fat storage) [2]. There is growing evidence that a marked increase in ectopic fat around the organs may eventually impair their functions [3].

Diabetic kidney disease is one important complication of diabetes. Except for hyperglycemia, many factors including obesity have been reported to be risk factors for diabetic kidney. Obesity is associated with the development and progression of chronic kidney disease (CKD). Multiple mechanisms including 00chronic inflammation, increased oxidative stress and hyperinsulinemia have been proposed to initiate and maintain kidney injury in obese patients [4].

It has been suggested that the relationship between obesity and diabetic kidney disease may depend on the distribution of adipose tissue rather than the overall content of adipose tissue [5].

BMI, a traditional indicator of general obesity, was reported to be related to impaired kidney function in type 2 diabetes [6]. However, abdominal obesity-related parameters, such as waist circumference (WC) and visceral adipose tissue (VAT), have been shown to be superior to BMI for predicting the development and progression of CKD in patients with diabetes [7]. Perirenal fat is a fat pad surrounding the kidneys, located between the renal fibrous membrane and the renal fascia in the retroperitoneal space [8]. Anatomy studies have confirmed that perirenal fat has a complete system of blood supply, lymph fluid drainage, and innervation compared to classically connective tissue [9].

Recently, new anthropometric and imaging methods have been used to assess visceral fat in clinical practice and research [10]. CT is an accurate and reliable tool to estimate perirenal fat thickness (Simoni et al., 2020). It was found that perirenal fat thickness could predict reduced glomerular filtration rate in patients with type 2 diabetes [5].

The aim of this work is to assess the relationship between Perirenal fat thickness and eGFR in adult males with type 2 diabetes mellitus.

2. Patients and Methods

Written informed consent was taken from all participants after an explanation of the study. This cross-sectional study was conducted on a total number of sixty male participants, aged from 40-65 years, who were known to have type 2 diabetes according to *ADA*, [11]. They were recruited from the outpatient endocrinology clinic at Al-Zahraa University Hospital, Cairo Governorate, Egypt, during the period from June 2021 to December 2021. This study was approved by the institutional review board of Faculty of Medicine for Girls, Al-Azhar University, Cairo (AFMG IRB, reference number: 202001091) and was obliged to the standards of the Declaration of Helsinki

2.1 Inclusion criteria

40-65 years old (males) with Type 2 Diabetes Mellitus diagnosed based on the American Diabetes Association criteria

[11]. Males were chosen as perirenal adipose tissue (PRAT0 being much more developed in men compared to women, without a direct relationship between the body mass index (BMI) and its volume, leading to more accurate and reliable results in males than females [12].

2.2 Exclusion criteria

Subjects with type 1 diabetes mellitus, subjects with renal transplant or on dialysis, subjects with renal morphological abnormalities (solitary, ectopic or polycystic kidney), subjects with Liver cirrhosis or liver cell failure, subjects with Chronic obstructive lung disease (COPD) and subjects with history of malignancy.

2.3 Patients were subjected to the following

The patients were divided into 3 groups according to BMI: Group 1 BMI < 30; Group 2 BMI (30-35); Group 3 BMI > 35. And divided into 2 groups according to eGFR: group A e GFR < 60 and group B eGFR ≥60. And divided according to PrFT into 2 groups: group A: PrFT < 30.15 and group B: PrFT > 30.15.

2.4 Full medical history

Including age, sex, duration of diabetes and symptoms suggesting presence of diabetes complications.

2.5 Complete clinical examination, including

Chest, heart, abdomen, neurological examination and measurement of blood pressure.

2.6 Anthropometric measurements including

Wt, Ht, BMI and WC.

2.7 Laboratory Investigations, included

FBS& 2 hrs PPB, HbA1c, lipid profile including TC, TG, HDL-C and LDL-C, liver functions (ALT) and (AST)levels and kidney Function Tests including blood urea and uric acid.

Estimated glomerular filtration rate (eGFR) [mL/min/1.73m²] was calculated by the Modification of Diet in Renal Disease (MDRD) equation [13].

2.8 Imaging study

Abdominal Computed Tomography (CT) to assess perirenal fat thickness

2.9 Methodology

2.9.1 Morning midstream urine samples were taken from patients without previous exercise before taking the samples for measurement of urine Albumin–to-Creatinine Ratio (ACR). Urinary Albumin in (mg) and Creatinine in (gm) were measured using DIRUI CS-T240 Auto-Chemistry Analyzer and Albumin/creatinine Ratio was measured for each patient in (mg/gm). Normal range (<30 mg/gm), Microalbuminuria (30-300 mg/gm) and Macroalbuminuria (>300 mg/gm) [11].

2.9.2 Calculation of estimated glomerular filtration rate (eGFR) by the Modification of Diet in Renal Disease (MDRD) equation [13]:

$$GFR\ (mL/min/1.73\ m^2) = 175 \times (S_{cr})^{-1.154} \times (Age)^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African American})$$ (conventional units)

2.9.3 Imaging techniques

Assessment of perirenal fat thickness was carried out by a single experienced radiologist with Aquilion Prime CT 160 slice (Toshiba –Jaban) using slice thickness 0.5 cm. All patients undergoing a CT without contrast and axial cuts for both kidneys were done. Perirenal fat thickness was measured from the lower pole of the left kidney to the anterior abdominal wall. Perirenal fat thickness was the maximal distance between the lower pole of the left kidney and the inner limit of the abdominal wall [14].

2.10 Statistical analysis

The following tests were used: Shapiro test, chi square, fisher's exact test, student t-test and ANOVA test. Correlations: Was done to assess the strength of association between two quantitative variables. Bivariate Correlations were assessed using Pearson's or Spearman's correlation coefficient, depending on the nature of the data.

2.10.1 Receiver operating characteristic (ROC) curve

Sensitivity, specificity, PPV, NPV, and accuracy were calculated using the receiver operating characteristic (ROC) curve and the cross tab's function, the confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p value was considered significant as follows: P-value ≥ 0.05 was considered non-significant, P-value < 0.05 was considered significant.

2.10.2 Regression analysis

A linear logistic regression model was conducted for prediction of Perirenal fat thickness.

3. Result

As shown in Table 3, in this table, participants were classified according to their BMI into three groups. it was found that there was a significant difference between all groups regarding patients' age, weight, W.C, and LDL. And there was a significant difference between group 1 (BMI<30) and group 2 (BMI 30-35) regarding age, weight and WC While there was a significant difference between group 1(BMI<30) and group 3 (BMI>35) regarding weight and WC. And There was significant difference between group 2 (BMI 30-35) and group 3 (BMI>35) regarding weight, W.C, and LDL. As shown in table 4, patients were subdivided according to eGFR into 2 groups. Group A with GFR < 60 ml/min/1.73m2 and group B with GFR ≥ 60 ml/min/1.73m2. Expectedly, it was found that group A with GFR<60 had significantly higher levels of creatinine than group B with GFR ≥ 60.

As shown in Table .5, patients were divided into 2 groups according to the cut-off value of perirenal fat thickness (30.15mm). Patients with PrFT >30.15 mm had a significant difference compared to those with PrFT <30.15mm, higher in both BMI and W.C.

As shown in Table 6 significant positive correlation between PrFT and patients' height, weight, BMI, W.C, and ACR, while was negatively correlated with eGFR in all studied subjects.

As shown in Table .7 correlating W.C with all studied parameters, it was found to have significance and positive correlation with patients' weight and BMI**.** Also, W.C was found to be significantly and positively correlated with patients' PrFT. As shown in Table .8, this table revealed that height, weight, BMI, and W.C were the most significant predictors and that weight and W.C were superior to height and BMI.

As shown in table 9 the Cutoff value of perirenal fat thickness in detection of GFR <60 ml/min/1.73m2 was 30.15mm, its sensitivity was found to be 72.2%, specificity 69% (AUC: 0.729), PPV =50%, NPV= 85.3%, with diagnostic accuracy 70%.

Table 1: Clinical characteristics and laboratory profile of all subjects studied.

All patients (n= 60)	Mean ± SD	Median	Range
Age (years)	55.10 ± 6.199	55.50	40- 65
Height (cm)	172.50 ± 6.196	173.00	160- 190
Weight (kg)	90.28 ± 15.854	88.00	60- 120
BMI (kg/m2)	30.32 ± 4.916	31.15	20.20- 39.20
W.C (cm)	105.95 ± 12.029	105.00	83-129
SBP (mmHg)	126.83 ± 16.234	120.00	100- 160
DBP (mmHg)	79.33 ± 9.319	80.00	60- 100
Disease duration (years)	11.52 ± 8.135	8.50	2, 38
FBG (mg/dl)	198.97 ± 67.513	202.50	67-424
2hpp	275.08 ± 80.723	278.50	110-500
HbA1c (%)	9.52 ± 2.051	9.35	5.70-16
ALT (U/L)	28.85 ± 14.323	28.00	9.00-93
AST (U/L)	26.80 ± 11.590	25.00	9- 71
LDL (mg/dl)	97.20 ± 39.996	90.30	17.20-200
HDL (mg/dl)	36.51 ± 5.043	35.00	27- 59
Cholesterol (mg/dl)	178.53 ± 43.582	180.5	108- 280
Triglycerides (mg/dl)	202.30 ± 151.77	174.50	52-1268

Table 2: Kidney functions and Perirenal fat thickness of all studied subjects:

All patients (n= 60)	Mean & SD	Median	Range
Urea (mg/dl)	33.35 ± 8.497	32.00	17-57
Creatinine (mg/dl)	1.20 ± 0.230	1.19	0.80- 1.98
Uric acid (mg/dl)	5.66 ± 1.607	5.50	3.00-9.10
ACR	45.78 ± 40.892	33.10	9.40- 234.90
eGFR (ml/min/1.73m2)	71.06 ± 15.291	71.34	37.60-103.10
PrFT (mm)	30.13 ± 8.442	29.55	12.40- 61.20

Table 3: Comparison of clinical and laboratory data of all subjects studied according to BMI

	Group I BMI < 30 (n= 26)	Group II BMI 30-35 (n= 24)	Group III BMI > 35 (n= 10)	P	P1	P2	P3
Age (years)	53.19 ± 6.548	57.42 ± 5.274	54.50 ± 6.042	0.049	0.047	1	0.601
Height (cm)	172.73 ± 4.984	173.08 ± 7.569	170.50 ± 5.543	0.532	1	1	0.827
Weight (kg)	76.42 ± 8.001	97.23 ± 10.897	109.60 ± 8.262	< 0.001	< 0.001	< 0.001	0.003
W.C (cm)	96.64 ± 6.981	109.13 ± 9.817	121.60 ± 4.061	< 0.001	< 0.001	< 0.001	<0.001
SBP (mmHg)	126.35 ± 14.937	126.88 ± 18.167	128.00 ± 16.193	0.964	1	1	1
DBP (mmHg)	78.08 ± 8.953	81.04 ± 9.086	78.50 ± 11.068	0.515	0.805	1	1
Disease duration (years)	13.27 ± 9.652	10.00 ± 6.916	10.60 ± 6.077	0.344	0.482	1	1
FBG (mg/dl)	193.12 ± 64.040	196.33 ± 61.776	220.50 ± 90.020	0.543	1	0.850	1
2hpp (mg/dl)	259.42 ± 72.961	277.33 ± 77.567	310.40 ± 102.208	0.236	1	0.278	0.832
HbA1c (%)	9.12 ± 1.883	9.71 ± 2.157	10.07 ± 2.222	0.392	0.939	0.660	1
ALT (U/L)	32.27 ± 18.505	27.13 ± 9.028	24.10 ± 10.888	0.234	0.618	0.383	1
AST (U/L)	29.42 ± 13.243	25.46 ± 10.325	23.20 ± 9.053	0.274	0.688	0.457	1
LDL (mg/dl)	97.32 ± 33.887	85.60 ± 36.591	124.70 ± 51.734	0.031	0.853	0.179	0.026
HDL (mg/dl)	35.68 ± 3.468	37.33 ± 6.302	36.70 ± 5.293	0.517	0.767	1	1
Cholesterol (mg/dl)	179.46 ± 41.475	174.33 ± 45.710	186.20 ± 47.107	0.768	1	1	1
Triglycerides (mg/dl)	182.46 ± 52.208	195.63 ± 65.997	269.90 ± 354.935	0.295	1	0.377	0.591
Urea (mg/dl)	33.92 ± 8.064	33.38 ± 7.795	31.80 ± 11.564	0.803	1	1	1
Creatinine (mg/dl)	1.20 ± 0.202	1.24 ± 0.271	1.13 ± 0.190	0.459	1	1	0.642
Uric acid (mg/dl)	5.63 ± 1.801	5.87 ± 1.551	5.24 ± 1.210	0.583	1	1	0.914
ACR	34.58 ± 27.501	31.41 ± 22.598	36.17 ± 48.780	0.894	1	1	1
eGFR (ml/min/1.73m2)	70.46 ± 13.579	65.93 ± 16.460	77.90 ± 15.846	0.117	0.886	0.579	0.121
PrFT (mm)	27.63 ± 5.636	31.21 ± 10.615	34.00 ± 7.295	0.090	0.391	0.127	1

P1: Comparison between three groups, P1: Comparison between group1 & group2, P2: Comparison between group1 & group3, P3: Comparison between group2 & group3.

Table 4: Comparison of clinical and laboratory data according to eGFR of all studied subjects

eGFR	Group A e GFR < 60 (n= 19)	Group B eGFR ≥ 60 (n= 41)	P
Age (years)	55.00 ± 6.351	55.15 ± 6.207	0.933
Height (cm)	173.16 ± 5.679	172.20 ± 6.466	0.580
Weight (kg)	93.53 ± 15.925	88.77 ± 15.788	0.283
BMI (kg/m2)	31.08 ± 4.286	29.97 ± 5.194	0.418
W.C (cm)	106.32 ± 11.518	105.78 ± 12.404	0.873
SBP (mmHg)	126.05 ± 18.751	127.20 ± 15.168	0.802
DBP (mmHg)	80.00 ± 10.000	79.02 ± 9.098	0.709
Disease duration (years)	11.32 ± 7.000	11.61 ± 8.692	0.898
FBG (mg/dl)	203.58 ± 76.450	196.83 ± 63.862	0.722
2hpp (mg/dl)	268.11 ± 78.362	278.32 ± 82.549	0.652
HbA1C (%)	10.01 ± 2.140	9.29 ± 1.994	0.213
ALT (U/L)	28.63 ± 17.098	28.95 ± 13.077	0.937
AST (U/L)	26.42 ± 10.762	26.98 ± 12.080	0.865
LDL (mg/dl)	98.04 ± 43.117	96.80 ± 39.018	0.912
HDL (mg/dl)	36.84 ± 4.451	36.36 ± 5.341	0.734
Cholesterol (mg/dl)	187.37 ± 52.098	174.44 ± 39.063	0.289
Triglycerides (mg/dl)	190.84 ± 47.505	207.61 ± 181.305	0.694
Urea (mg/dl)	37.79 ± 9.566	31.29 ± 7.184	0.005
Creatinine (mg/dl)	1.44 ± 0.215	1.09 ± 0.135	< 0.001
Uric acid (mg/dl)	5.67 ± 1.403	5.65 ± 1.710	0.980
AC/R	42.03 ± 42.594	29.66 ± 20.996	0.136
PrFT (mm)	35.23 ± 9.352	27.76 ± 6.905	0.001

Table 5: Comparison of clinical and laboratory data according to PrFT of all subjects studied

PrFT (mm)	PrFT < 30.15 (n= 34)	PrFT > 30.15 (n= 26)	P
Age (years)	55.29 ± 6.279	54.85 ± 6.208	0.784
Height (cm)	171.15 ± 5.832	174.27 ± 6.322	0.052
Weight (kg)	83.87 ± 12.398	98.65 ± 16.169	< 0.001
BMI (kg/m2)	28.73 ± 4.686	32.40 ± 4.482	0.003
W.C (cm)	102.18 ± 11.257	110.73 ± 11.446	0.006
SBP (mmHg)	127.21 ± 15.035	126.35 ± 17.975	0.841
DBP (mmHg)	78.68 ± 8.101	80.19 ± 10.815	0.537
Disease duration (years)	11.76 ± 8.064	11.19 ± 8.376	0.790
FBG (mg/dl)	199.50 ± 62.835	198.27 ± 74.461	0.945
2hpp (mg/dl)	279.65 ± 87.861	269.12 ± 71.575	0.621
HbA1C (%)	9.36 ± 1.738	9.73 ± 2.420	0.498
ALT (U/L)	29.06 ± 13.509	28.58 ± 15.593	0.899
AST (U/L)	27.76 ± 12.265	25.54 ± 10.749	0.466
LDL (mg/dl)	98.52 ± 40.076	95.46 ± 40.616	0.772
HDL (mg/dl)	37.08 ± 5.544	35.77 ± 4.292	0.322
Cholesterol (mg/dl)	179.94 ± 43.170	176.69 ± 44.904	0.777
Triglycerides (mg/dl)	210.79 ± 194.199	191.19 ± 66.010	0.624
Urea (mg/dl)	32.32 ± 7.223	34.69 ± 9.911	0.174
Creatinine (mg/dl)	1.15 ± 0.241	1.27 ± 0.201	0.019
Uric acid (mg/dl)	5.54 ± 1.690	5.81 ± 1.512	0.516
AC/R	24.96 ± 17.017	44.84 ± 38.418	0.029
eGFR (ml/min/1.73m2)	73.58 ± 14.594	65.06 ± 15.531	0.040

Table 6: Correlation between Perirenal fat thickness and other parameters in all studied subjects

All patients (n= 60)	Perirenal fat thickness Correlation coefficient (r)	P
Age (years)	-0.034	0.798
Height (cm)	0.275	0.034
Weight (kg)	0.407	0.001
BMI (kg/m2)	0.303	0.019
W.C (cm)	0.434	0.001
Disease duration (years)	-0.052	0.695
SBP (mmHg)	-0.070	0.598
DBP (mmHg)	0.020	0.881
FBG (mg/dl)	-0.029	0.826
2hpp (mg/dl)	-0.075	0.567
HbA1C (%)	0.045	0.735
ALT (U/L)	0.005	0.967
AST (U/L)	-0.049	0.708
LDL (mg/dl)	-0.124	0.346
HDL (mg/dl)	-0.136	0.299
Cholesterol (mg/dl)	-0.088	0.505
Triglycerides (mg/dl)	-0.037	0.780
Urea (mg/dl)	0.164	0.210
Creatinine (mg/dl)	0.097	0.460
Uric acid (mg/dl)	0.084	0.525
AC/R	0.293	0.023
eGFR (ml/min/1.73m2)	-0.288	0.026

Table 7: Correlation between Waist circumference and other all parameters in all studied subjects

All patients (n= 60)	Waist circumference Correlation coefficient (r)	P
Age (years)	0.243	0.063
Height (cm)	0.144	0.277
Weight (kg)	0.765	< 0.001
BMI (kg/m2)	0.749	< 0.001
SBP (mmHg)	-0.010	0.937
DBP (mmHg)	0.055	0.681
Disease duration (years)	0.063	0.636
FBG (mg/dl)	0.107	0.421
2hpp (mg/dl)	0.198	0.133
HbA1C (%)	0.181	0.170
ALT (U/L)	-0.209	0.113
AST (U/L)	-0.164	0.216
LDL (mg/dl)	0.042	0.751
HDL (mg/dl)	-0.096	0.467
Cholesterol (mg/dl)	-0.136	0.304
Triglycerides (mg/dl)	0.222	0.090
Urea (mg/dl)	-0.122	0.358
Creatinine (mg/dl)	-0.073	0.585
Uric acid (mg/dl)	-0.094	0.479
AC/R	-0.073	0.581
eGFR (ml/min/1.73m2)	0.050	0.704
PrFT (mm)	0.434	0.001

Table 8: Univariate regression analysis for prediction of Perirenal fat thickness.

All patients (n= 60)	R2	B	Constant	P
Height (cm)	7.5%	0.374	-34.42	0.034
Weight (kg)	16.6%	0.217	10.544	0.001
BMI (kg/m2)	9.2%	0.520	14.36	0.019
W.C (cm)	18.9%	0.303	-1.82	0.001

Table 9: Diagnostic profile and cut-off value of Perirenal fat thickness in detection of GFR less than 60 ml/min/1.73 m^2 in the current study.

	Perirenal fat thickness
AUC	0.729
95% CI of AUC	0.598, 0.861
P	0.005
Cutoff value	30.15
Sensitivity	72.2%
Specificity	69%
PPV	50.0%
NPV	85.3%
Accuracy	70%

AUC: Area under the curve. PPV: Positive predictive value. NPV: Negative predictive value. CI: Confidence interval.

4. Discussion

Obesity has been recognized as a major public health problem [1]. Obesity, particularly when accompanied by an excess of visceral or ectopic fat, is a major risk factor for diseases, including insulin resistance, type 2 diabetes, nonalcoholic fatty liver disease and cardiovascular disease [15]. In humans, the development of obesity leads to significant lipid deposition within and around other tissues (ectopic fat storage) [2]. There is growing evidence that a marked increase in ectopic fat around the organs may eventually impair their functions [3]. It has been suggested that the relationship between obesity and diabetic kidney disease may depend on the distribution of adipose tissue rather than the overall content of adipose tissue [5]. Perirenal fat is a fat pad surrounding the kidneys, located between the renal fibrous membrane and the renal fascia in the retroperitoneal space [8]. It was found that perirenal fat thickness could predict reduced glomerular filtration rate in patients with type 2 diabetes [5]. CT is an accurate and reliable tool to estimate perirenal fat thickness [16]. The present cross-sectional study was conducted on a total of sixty male participants, aged from 40-65 years, who were known to have type 2 diabetes according to ADA [11]. They were recruited from the outpatient endocrinology clinic at Al-Zahraa University Hospital during the period from June 2021 to December 2021. Aim of the study is to assess the relationship between Perirenal fat thickness and eGFR in adult males with Type 2 diabetes mellitus. In the current study, the mean patients' age was (55.10 ± 6.199 y). Being more than 45 years of age is a risk factor for type 2 diabetes, as the likelihood of developing the condition increases drastically after 45 years of age [17].

Similar studies were done at this age range such as: Fang et al [18], Lamacchia et al. [19], Shen et al. [20], Chen et al [5] and Geraci et al. [21]. BMI is a traditional indicator of general obesity [22]. In the current study, the mean BMI was (30.32 ± 4.916) kg/m2, so our study participants were within the obesity range. The

incremental association of BMI on the risk of T2DM is stronger for people with a higher BMI relative to people with a lower BMI [23]. Although the BMI captures the degree of overweight and obesity, it ignores body fat distribution. Measuring W.C is a simple means of assessing the levels of visceral fat. However, current obesity and diabetes guidelines only recommend that W.C should be measured from a BMI of 25 kg/m^2, as this is the level at which the increased risk is thought to start [24]. In the current study results have revealed that the mean W.C was (105.95 ± 12.029) cm. This is in agreement with results of Shen et al. [20], Fang et al. [18], Chen et al. [5], Geraci et +al. [21] and Jia et al [25].

In the current study, patients were normotensive as the mean SBP was (126.83 ± 16.234) mmHg and the mean DBP was (79.33 ± 9.319) mmHg. These results are in accordance with Lamacchia et al. [19], While In contrast to Chen et al.[5] , Geraci et al.[21] , Shen et al.[20] and D'Marco et al.[26] .

In the current study, the mean duration of diabetes was (11.52 ± 8.135) years. Those results are similar to Lamacchia et al. [19], Fang et al. [19] and Jia et al. [25], while in contrast to Chen et al. [5]. Student patients studied in the present study were uncontrolled, as the mean FBS was (198.97 ± 67.513) mg/dl and the mean 2hpp was (275.08 ± 80.723) mg/dl, while in Shen et al. [(21)] study, the mean FBS was 140 mg/dl and in D'Marco et al. [26] the mean FBS was (107.4 ± 33.8) mg/dl.

In the current study, the mean glycated hemoglobin was (9.52 ± 2.051) %. It was high as most patients were uncontrolled. This is with results of Fang et al. [18] and Jia et al. [25], while against to Chen et al. [5], Lamacchia et al. [19] and Shen et al. [20].

Type 2 diabetes patients have been reported to be associated with a higher incidence of abnormal liver function tests (LFT) compared to individuals without diabetes, with elevated ALT being the most common abnormality [27]. In the current study, the mean ALT was (28.85 ± 14.323) U/L, and the mean AST was (26.80 ± 11.590) U/L. which were within the normal values. These results are in accordance with Shen et al. [20] study and Ni et al. [27] study.

A cross-sectional study from Iran demonstrated a rise of ALT and AST in 10.4% and 3.3% of type 2 diabetes patients respectively [28].

According to a study in Sudan, where 50 diabetic patients and 30 normal control subjects were tested for liver function, the means of ALT, AST were reported to be significantly higher among diabetics compared to the control. However, the mean values were within the normal range [29].

Higher total cholesterol and LDL-C level is significantly associated with higher risk of T2DM, while HDL are able to rescue diabetes-related vascular complications through diverse mechanisms. Such protective functions of HDL, however, can be rendered dysfunctional within the pathological milieu of DM, triggering the development of vascular complications [(30)].

In the current study, the mean total cholesterol was (178.53 ± 43.582) mg/dl, the mean LDL level was (97.20 ± 39.996) mg/dl, while the mean HDL level was (36.51 ± 5.043) mg/dl. Similar results were obtained by Lamacchia et al. [19], Geraci et al. [21], Ricci et al. [31] and D'Marco et al. [26].

In the current study, the mean triglycerides were (202.30 ± 151.77) mg/dl, it exceeds the normal level, which is 150-199 mg/dl. These results are in accordance with Lamacchia et al. [19], Ricci et al. [31], D'Marco et al. [26] and Shen et al. [20].

Diabetic nephropathy (DN) develops in approximately 40% of patients who are diabetic and is the leading cause of chronic kidney disease (CKD) worldwide [32]. In the current study, regarding the kidney functions of all studied subjects the mean blood urea level was (33.35 ± 8.497) (mg/dl) and the mean serum creatinine level was (1.20 ± 0.230) mg/dl. The elevated levels of blood urea and serum

creatinine are the measures of glomerular damage [33]. Blood urea and serum creatinine in diabetic patients significantly increased with increasing duration of diabetes [34]. On the contrary Geraci et al. [21] founds creatinine level within the normal range.

Recognition of high serum uric acid as a risk factor for diabetes has been a matter of debate for a few decades, since hyperuricemia has been presumed to be a consequence of insulin resistance rather than its precursor. However, recent findings suggest that uric acid could be related to the development of diabetes [35].

In the current study, the mean uric acid level was (5.66 ± 1.607) (mg/dl). On the contrary, Lamacchia et al. [19], Fang et al. [18], Chen et al. [5] and Jia et al. [25] found normal levels of uric acid, while Geraci et al. [21] and Shen et al. [20] found higher levels of uric acid.

Urine albumin-to-creatinine ratio is a sensitive biomarker of nephropathy in type 2 DM patients who have a considerable risk factor for developing renal impairment [36].

In the current study, the mean AC/R was (45.78 ± 40.892). It was high as the patients were uncontrolled for a long duration, similar results in Lamacchia et al. [19], Fang et al. [18] and Shen et al. [20].

The eGFR is a significant predictor of ESRD and of mortality in T2DM [37]. In the current study, the mean eGFR was (71.06 ± 15.291) (ml/min/1.73m2). Which is low as the patients were uncontrolled DM for long period. On the contrary, Lamacchia et al. [19], Fang et al. [18], Chen et al. [5], Geraci et al. [21], Shen et al. [20] and Jia et al. [25] found higher level of eGFR in their studies.

Perirenal fat is a fat pad surrounding the kidneys, located between the renal fibrous membrane and the renal fascia in the retroperitoneal space [38]. In this study, the Cutoff value of PrFT in the detection of GFR less than 60 ml/min/1.73m2, was 30.15 mm; its sensitivity was found to be 72.2%, specificity 69% (AUC: 0.729), with diagnostic accuracy of 70%. Similarly, Geraci et al. [21], this is lower than Chen et al. [5], and more than Fang et al. [18] and Jia et al. [25]. Obesity is an important risk factor for the development and progression of CKD in patients with diabetes. The most commonly used indices of obesity, such as BMI and WC, have shown an independent association with renal damage and a prognostic impact on the development of CKD [39]. The eGFR is a significant predictor of ESRD and of mortality in T2DM [37]. In the current study, it was found that group A with GFR<60 had significantly higher levels of creatinine than group B with GFR ≥ 60. This is in agreement with Vu et al. study [40].

In the current study, it was found that there was no significant difference between the 2 groups regarding uric acid. This is against D'Marco et al. [26] study. Also, it was found that group A had statistically significant higher levels of perirenal fat thickness than group B. This could be explained by the fact that adipokines and inflammatory factors secreted by PrFT not only influence insulin sensitivity and glucose and lipid metabolism but also directly affect renal hemodynamics and renal function [3], similar to Lamacchia et al. [19] and Chen et al. [5]. In the present study. Patients with PrFT >30.15mm had significant difference compared to those with PrFT <30.15 mm, being higher in both BMI and W.C. This is in agreement with Fang et al. [18] study. Also, it was noted that Patients with PrFT >30.15mm had significantly lower eGFR compared to those with PrFT <30.15mm. These results are in agreement with Geraci et al. [21]. Many investigators have explored the association between PrFT and metabolism. PrFT has been confirmed to be related to metabolic risk factors such as uric acid, HDL-c, TG and uric acid [19], which is in contrast with the results of this study. In the current study, perirenal fat thickness was found to be significantly and positively correlated with patients' height, weight, BMI, W.C and Urinary Albumin creatinine ratio, Similar results were obtained by Fang et al. [18]. Also, in the current study,

perirenal fat thickness was found to be significantly and negatively correlated with eGFR , Fang et al. [18] results were the same. In the current study, there was no correlation between perirenal fat thickness and HDL-c, TG or uric acid. In contrast, Fang et al. [18]. Chen et al. [5] the study demonstrated that perirenal fat could independently predict CKD incidence in patients with T2DM .More importantly, perirenal fat had a higher predictive value for CKD than total, subcutaneous, or visceral fat in T2DM patients.

In the current study, correlating W.C with all studied parameters, it was found to have significance and a positive correlation with patients' weight and BMI. This is in agreement with Gierach et al. [41]. Also, W.C was found to be significantly and positively correlated with patients' PrFT, this is similar to Fang et al. [18] and Favre et al. [14].

Studying the predictors of PrFT, by univarient regression analysis, revealed that height, weight, BMI, and W.C, were the most significant predictors and that weight and W.C were superior to height and BMI.

This study strength is that we measured PrFT by CT instead of ultrasonography which is the most accurate and reliable method. However, there are some limitations in our study as well. First, the cross-sectional design in the present study helps to generate hypotheses but does not allow us to define the cause–effect relationship between Perirenal fat thickness expansion and renal dysfunctional profile in T2DM patients. Further studies are needed to verify these hypotheses. Second, the small size of the sample. Third, to study a group of diabetic female patients as well.

5. Conclusion

PrFT was independently and negatively correlated with eGFR, suggesting a possible role of PrFT in kidney dysfunction in T2DM patients. Patients that had impaired kidney functions had large perirenal fat thickness. Patients that had perirenal fat thickness >30.15ml had higher W.C, BMI, creatinine and ACR. Peri renal fat thickness had positive correlation with BMI, WC and ACR. The most predictive factors for perirenal fat thickness were weight and W.C. According to ROC curve, the diagnostic Cutoff value of perirenal fat thickness in detection of GFR less than 60 ml/min/1.73m2, was 30.15mm, its sensitivity was found to be 72.2%, specificity 69% (AUC: 0.729), PPV =50%, NPV= 85.3%, with diagnostic accuracy 70%.

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