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Evaluation of the Role of Estimated Glucose Disposal Rate in Assessment of Renal Functions in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Background: Insulin resistance (IR) is a recognized contributing factor to diabetic nephropathy in diabetic patients. However, data regarding its significance in the development of nephropathy in this population remain limited. The estimated glucose disposal rate (eGDR), a novel biomarker for insulin sensitivity derived from three clinically accessible variables, was originally established in type 1 diabetes (T1D) and has recently been validated in type 2 diabetes (T2D) using the gold-standard euglycemic-hyperinsulinemic clamp technique.

Objective: We hypothesized that a diminished eGDR is associated with an elevated risk of diabetic nephropathy (DN) in individuals with T2D.

Patients and Methods: Forty patients with T2D were recruited from the Internal Medicine Department, Tanta University Hospitals, as well as 20 healthy individuals as control, between November 2022 and August 2023. eGDR (mg/kg/min) was calculated using the formula: 24.31 - (12.22 × waist to hip ratio)- (3.29 × hypertension, 1=yes 0=no) - (0.57 × HbA1c%). A lower eGDR indicates higher IR.

Results: The study included patients aged between 27 and 70 years. eGDR showed a significant increase across all study groups (p-value < 0.001). Individuals with diabetes and chronic kidney disease demonstrated a lower eGDR compared to other groups.

Conclusions: A higher eGDR is strongly associated with a lower risk of diabetic nephropathy in individuals with T2D, suggesting that IR plays a significant role in the pathogenesis of DN.

Keywords: Type 2 diabetes; Renal Dysfunction; eGDR.

INTRODUCTION

Diabetes mellitus (DM) is a major worldwide public health issue. Recent worldwide estimates suggest that this illness impacts 415 million individuals and is projected to increase to 642 million by 2040 [1]. DM refers to a group of diverse metabolic illnesses defined primarily by chronic hyperglycaemia that results from impaired insulin production, impaired insulin action, or a combination of both, which progress to severe microvascular and macrovascular problems as (diabetic retinopathy, peripheral neuropathy and diabetic kidney disease) [2].

Type 2 diabetes mellitus is a diverse condition marked by persistent hyperglycaemia. The postulated aetiological variability arises from genetic inheritance and its interaction with environmental circumstances. Impaired secretion of insulin, and reduced sensitivity to insulin are the primary pathophysiological characteristics responsible for the onset of hyperglycemia in T2D [3].

The correlation among insulin resistance (IR) and T2D has been acknowledged for more than fifty years. IR is significant. It isn't only the most potent predictor of future T2D development, but it also serves as a target for therapy once hyperglycemia occurs [4].

Estimated glucose disposal rate (eGDR) showed to be practical measure predictor of IR in individuals with diabetes mellites type 2. It is equation that includes clinical indicators assessed in practice to evaluate the extent of sensitivity to insulin and good discriminator of diabetic complications [5]. The assessment relies on clinical criteria such as the waist-to-hip ratio (WHR), the existence of hypertension, and HbA1c levels, with lower values signifying increased IR. The score had been utilised in several studies to evaluate clinical chronic consequences of diabetes in the T2D populations [6].

The incidence of chronic kidney disease (CKD) has risen in recent decades, along with the rise in diabetes, the primary contributors to CKD [7]. Diabetic kidney disease (DKD), a consequence of DM, is prevalent, impacting over 40% of individuals with T2DM. It may eventually result in end-stage renal disease [8].

It was showed that T2DM individuals with chronic consequences, as peripheral neuropathy, diabetic retinopathy and DKD, exhibit substantially decreased estimated glucose disposal rate compared with patients without chronic complication [9].

We hypothesized in this study that a diminished eGDR is associated with an elevated risk of diabetic nephropathy (DN) in cases with T2D.

PATIENTS AND METHODS

This cross-sectional had been conducted on 40 participants aged >18 years old, both genders, diagnosed as DM Type 2. and 20 healthy individuals as control. The work had been conducted from November 2022 to August 2023.

Criteria for exclusion had been individuals with glomerulonephritis, patients on renal dialysis, autoimmune diseases, inflammatory bowel diseases, chronic infection, active immunosuppressive therapy, pregnancy, and malignancy

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Participants were also categorised into three groups: Group (I): healthy individuals as a control group, Group (II): T2D patients without chronic kidney disease and Group (III): T2D patients with CKD.

Each participant had been exposed to full taking of history including personal and family history, comprehensive clinical examinations including measurement of blood pressure, calculation of and measuring hip and waist circumference, and laboratory tests [blood urea and serum creatinine levels, eGFR, lipid profile (total cholesterol, LDL, HDL, and triglycerides), fasting and 2h post-prandial plasma glucose, complete urine analysis, full blood picture test, albumin / creatinine ratio, and HbA1C.

The investigations were done: HbA1C by Siemens Dimension, serum urea creatinine -lipid profile -FBG and 2h pp – Albumin/ creatinine ratio by Thermo Konelab Prime and CBC b

y Full Autonomic blood cell counter PCE 210N.

Measurement of Estimated Glucose Disposal Rate (eGDR):

eGDR had been measured depending on this equation:

$24.31 - (12.22 \times \text{waist to hip ratio}) - (3.29 \times \text{hypertension}) - (0.57 \times HbA_{1c})$, where the values are milligrammes/kilogramme/minute. Hypertension had been characterised by a blood pressure of ≥130/85 mmHg and/or the usage of antihypertensive drugs [10].

* Hypertension (yes = 1/no = 0)

IR had been evaluated using the eGDR. Individuals with an eGDR of < 7.5 mg/kg/min had been categorized as having IR. It serves as a proxy for IR to forecast long-term outcomes in individuals with T2D [11].

Ethical considerations:

The study was done after being accepted by the Research Ethics Committee, Tanta University (approval code: 36264MS78/2/23). All patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

Data were analyzed using IBM SPSS 23.0 (SPSS Inc., Chicago, IL, USA). Qualitative data were presented as numbers and percentages, while quantitative data were expressed as mean and standard deviation for normally distributed variables, and median with interquartile range (IQR) for abnormally distributed variables. The Kolmogorov-Smirnov test was applied to assess normality of distribution, with statistical significance considered at a p-value ≤ 0.05. Various statistical tests were employed: the Chi-square test for categorical variables to compare different groups; the Student's t-test for normally distributed quantitative variables to compare two groups; the Mann-Whitney test for abnormally distributed quantitative variables to compare two groups; the F-test (ANOVA) for normally distributed quantitative variables to compare more than two groups; and the Kruskal-Wallis test for abnormally distributed quantitative variables to compare more than two groups, with Post hoc testing for pairwise comparisons. Relationships between variables were analyzed using Pearson correlation method. Receiver operating characteristic (ROC) curve analysis was used to compare the ability of variables to distinguish between patient groups. P < 0.05 was considered significant.

RESULTS

No substantial variation existed between all groups under the study as regards age and sex.

Table 1: Comparing between the groups under the study in terms of demographic data.

Groups / Parameters	Group I		Group II		Group III		P- Value
	N	(%)	N	(%)	N	(%)	
	20	33.33%	20	33.33%	20	33.33%	
Age (Years)							**P1**=0.076[a] **P2**=0.164[b] **P3**=0.078[b]
Min - Max	29 – 71		27 - 69		28 – 70		
Mean ± SD	56.4 ± 10.5		48.35 ± 11.25		53.45 ± 11.49		
			50.9 ± 11.51				
Gender **Male** **Female**	12 (60%) 8 (40%)		11 (55%) 9 (45%)		7 (35%) 13 (65%)		**P1**=0.247[c] **P2**=0.204[c] **P3**=0.273[c]

Group I: Control**, Group II:** diabetic individuals without chronic kidney disease, **Group III:** diabetic individuals with chronic kidney disease**, N:** number**, (a):** one-way ANOVA test, **(b):** Independent-sample T-Test, **(c):** Chi-square test, **P1:** P-value among groups, **P2:** P-value among (group II and group III), **P3:** P-Value (group II + group III and group I).

A significant variation existed between groups, group III shows significant increase regarding the duration of diabetes**,** hypertension, and use of ACEI and ARBS in comparison to other groups. But no significant difference regarding smoking.

Table 2: Comparing between the groups under the study as regards duration of diabetes and smoking status, hypertension, and use of ACEI and ARBS:

Groups / Parameters	Group I		Group II		Group III		P- Value
	N	(%)	N	(%)	N	(%)	
	20	33.33%	20	33.33%	20	33.33%	
Duration of diabetes (Years)							**P2<0.001****[(b)]
Min – Max	----------		1 – 10		2 - 25		
Mean ± SD	----------		6.10 ± 2.85		14.95 ± 6.63		
Smoking status **No** **Yes**	 15 (75%) 5 (25%)		 13 (65%) 7 (35%)		 16 (80%) 4 (20%)		**P1**=0.551[(c)] **P2**=0.288[(c)] **P3**=0.836[(c)]
Hypertension **No** **Yes**	 20 (100%) 0 (0%)		 14 (70%) 6 (30%)		 3 (15%) 17 985%)		**P1<0.001****[(c)] **P2<0.001****[(c)] **P3<0.001****[(c)]
Use ACEI and ARBS **No** **Yes**	 20 (100%) 0 (100%)		 20 (100%) 0 (100%)		 14 (70%) 6 (30%)		**P1<0.001****[(c)] **P2=0.008***[(c)] **P3**=0.068[(c)]

Group I: Control**, Group II:** diabetic individuals without chronic kidney disease, **Group III:** diabetic individuals with CKD**, N:** number**, (b):** Independent-Sample T-Test, *: Statistically significant at $p \leq 0.05$, **: Highly statistically significant at $p < 0.001$, **P1:** P-value among groups, **P2:** P-value among (group II and group III), **P3:** P-Value (group II + group III and group I).

Diabetic patients with chronic kidney disease (group III) showed higher BMI and W/H ratio than other groups.

Table (3): Comparing between all the groups under the study regarding BMI, W/H ratio:

Groups / Parameters	Group I		Group II		Group III		P- Value
	N	(%)	N	(%)	N	(%)	
	20	33.33%	20	33.33%	20	33.33%	
BMI (Kg/m^2)							**P1=0.012***[(a)] **P2**=0.109[(b)] **P3=0.004***[(b)] **P1A**= 0.244 **P2B=0.003*** **P3C**=0.062
Min – Max	22.8 – 28.5		24.5 – 31.2		25 – 35.7		
Mean ± SD	26.72 ± 1.33		27.59 ± 1.50		29.0 ± 3.53		
			28.3 ± 2.77				
W/H ratio							**P1<0.001****[(a)] **P2<0.001****[(b)] **P3=0.003***[(b)] **P1A**= 0.339 **P2B<0.001**** **P3C<0.001**
Min – Max	0.72 – 1.02		0.76 - 1.08		0.95 – 1.1		
Mean ± SD	0.93 ± 0.076		0.95 ± 0.085		1.04 ± 0.034		
			0.99 ± 0.079				

Group I: Control**, Group II:** diabetic individuals without chronic kidney disease, **Group III:** diabetic individuals with CKD**, N:** number**, W/H ratio:** waist to hip ratio**, BMI:** body mass index, **(a):** one-way ANOVA test, **(b):** Independent-Sample T-Test, *: Statistically significant at $p \leq 0.05$, **: Highly statistically significant at $p < 0.001$, **P1:** P value among groups, **P2:** P value between (group II and group III), **P3:** P value (group II + group III and group I), **P1A:** p value for comparing between group I and group II, **P2B:** p value for comparing between group I and group III, **P3C:** p value for comparing between group I and group III.

Hb, HDL and EGFR were substantially decreased in group III contrasted to other groups. Platelets, WBCs, serum creatinine, blood urea, ACR, s. triglycerides and LDL had been substantially greater in group III contrasted to other groups.

Table 4: comparing between the groups under the study in terms of laboratory investigations

	Group I (n=20)	Group II (n=20)	Group III (n=20)	P
Hb(g/dL)	12.31 ± 0.79	11.68 ± 0.79	10.57 ± 0.88	**P<0.001**[(a)]**
Platelets(10^3/µL)	271.2 ± 7.53	262.65± 7.28	273.65± 8.25	**P =0.890[(a)]**
WBCs(10^3/µL)	7.68 ± 1.58	8.59 ± 1.50	7.81 ± 1.79	**P1=0.168[(a)]**
Scr (mg/dL)	0.69 ± 0.12	0.91 ± 0.13	1.91 ± 0.81	**P1<0.001**[(a)]**
S. Triglycerides (mg/dL)	98.93 ± 16.08	184.95 ± 5.77	196.70 ± 5.19	**P1<0.001**[(a)]**
HDL (mg/dl)	67.60 ± 6.34	58.25 ± 7.32	52.10 ± 6.79	**P1<0.001**[(a)]**
Cholesterol (mg/dL)	179.11 ± 11.91	210.9 ± 22.86	234.4 ± 49.41	**P1<0.001**[(a)]**
LDL (mg/dL)	98.25 ± 12.11	130.30 ± 12.07	138.6 ± 13.57	**P1<0.001**[(a)]**
Blood urea (mg/dL)	24.85 ± 6.34	63.95 ± 2.37	77.55 ± 13.65	**P1<0.001**[(a)]**
FBG (mg/dL)	83.05 ± 6.44	160.7 ± 16.54	212.2 ± 51.43	**P1<0.001**[(a)]**
2h-PPBG (mg/dL)	128.4 ± 6.19	234.35 ± 31.73	300.8 ± 79.61	**P1<0.001**[(a)]**
HbA1C (%)	5.19 ± 0.27	7.5 ± 0.74	9.68 ± 1.62	**P1<0.001**[(a)]**
ACR (mg albumin/g Cr)	14.5 (9.2)	22 (4.8)	186.5 (719.3)	**P1<0.001**[(b)]**
eGFR (ml/min/1.73m^2)	101.13 ± 8.74	76.88 ± 10.19	57.91 ± 3.09	**P1<0.001**[(a)]**

Data are displayed as mean ± SD or median (IQR), **Group I:** Control**, Group II:** diabetic individuals without chronic kidney disease, **Group III:** diabetic individuals with CKD**, N:** number**,** **: Highly statistically significant at p < 0.001, Hb: hemoglobin, WBCs: white blood cells, ACR: albumin creatinine ratio, eGFR: estimation glomerular filtration rate, Scr: serum creatinine, FBG: fasting blood glucose, 2h-PPBG :2 hours post prandial glucose, (a): Independent-Sample T test, (b): Mann Whitney U test.

Table 5: Association between eGDR and other parameters

Variables	eGDR	
	r	P
Age	-0.062	0.640
Sex	-0.065	0.619
Diabetes duration	-0.957	0.001**
Systolic blood pressure	-0.605	0.001**
Diastolic blood pressure	-0.480	0.001**
ACEI and ARBS	-0.81	0.03*
BMI	-0.330	0.01*
W/H ratio	-0.545	0.001**
FBG	-0.636	0.001**
2h-PP	-0.636	0.001**
HbA1C	-0.699	0.001**
Hemoglobin	0.448	0.001**
Platelets	-0.095	0.472
TLC	-0.042	0.751
Urea	-0.628	0.001**
Creatinine	-0.567	0.001**
ACR	-0.437	0.001**
eGFR	0.627	0.001**
Urine analysis	-0.725	0.001**
Triglycerides	-0.398	0.002*
HDL	0.540	0.001**
LDL	-0.510	0.001**
Cholesterol	-0.466	0.001**
CRP	-0.582	0.001**
Albuminuria	-0.739	0.001**

*: Statistically significant at p ≤ 0.05 **: Highly statistically significant at p ≤ 0.001, **eGDR:** Estimated glucose disposal rate, **r:** Pearson correlation, **BMI:** body mass index, **ACEI and ARBS:** angiotensin-converting enzyme inhibitors and angiotensin receptor blockers, **W/H ratio:** waist to hip ratio, **FBG:** Fasting blood glucose**, 2h-PP:** postprandial blood glucose, **HbA1C:** hemoglobin A1C, **TLC:** Total leucocytic count, **eGFR:** estimated glomerular filtration rate, **ACR:** albumin/creatinine ratio, **LDL:** low density lipoprotein, **HDL:** high density lipoprotein, **CRP:** C reactive protein.

At a cutoff value of 3.210; the area under the curve was 0.942 (**Table 6 and Figure 1)**.

Table (6): Receiver operating characteristic (ROC) curves analysis of eGDR to discriminate individuals with type 2 diabetes without chronic kidney disease (n = 20) from individuals with type 2 diabetes with chronic kidney disease (n = 20).

Parameters	AUC	p	95% CI	Cutoff	Sensitivity	Specificity	PPV	NPV
eGDR	0.942	0.001*	(0.863 – 1.022)	3.210	95%	75%	79.16%	93.75%

eGDR: estimated glucose disposal rate, **p-value: Probability value, AUC:** Area under a curve, **CI:** Confidence Intervals, **NPV:** Negative predictive value, **PPV:** Positive predictive value, *: Statistically significant**.**

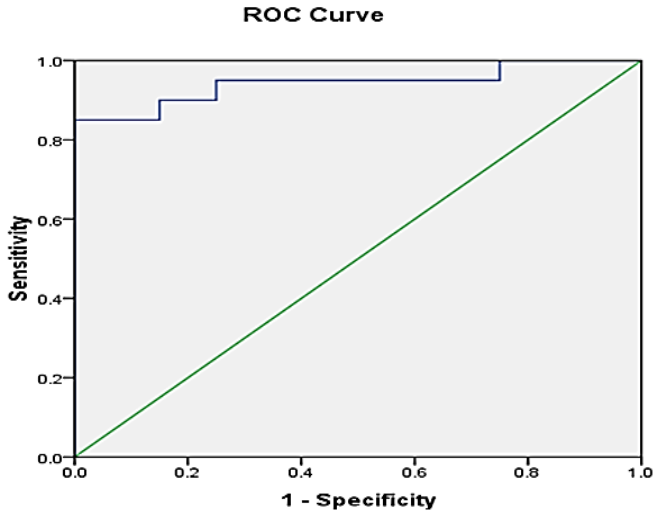

Figure 1: ROC curves analysis of eGDR to discriminate individuals with type 2 diabetes without chronic kidney disease (n = 20) from individuals with type 2 diabetes with chronic kidney disease (n = 20).

DISCUSSION

The eGDR has been suggested as a novel practical metric for IR, since it correlates with IR assessed by clamp techniques. A benefit of eGDR is the simplicity where it could be computed utilising basic clinical parameters such waist circumference (or BMI), glycated hemoglobin (HbA1c) value and hypertension status, allowing this a pragmatic marker to study IR in clinic settings [5].

Existence of hypertension and HbA1c and decreased levels imply increased IR. The score has been utilised in multiple studies to evaluate clinical diabetic chronic consequences in the T2D population, revealing that individuals with diabetic kidney disease (DKD), diabetic peripheral neuropathy (DPN), or diabetic retinopathy (DR) demonstrate elevated IR contrasted to those without chronic conditions [6].

Our study revealed that diabetic individuals with albuminuria showed higher duration of diabetes than diabetic patients without albuminuria (p-value < 0.001), that agreed with a work by **Inassi and Vujayalakshmy** performed on 120 participants with T2D. Three groups were established, each including 40 recipients, categorised by diabetes duration: below 5 years, 5 to 10 years, and over 10 years. Forty normal, healthy persons had been involved into the control group. Parameters like blood pressure, serum creatinine, blood urea, and urinary albumin have been compared with controls, revealing that prolonged duration correlates with renal function impairment, shown by elevated blood urea, serum creatinine, and urinary albumin levels [12].

Our study showed that there was an insignificant variance among all studied groups as regards smoking status (p-value > 0.05). **In contrast to this study**, A meta-analysis by **Su *et al*.** indicated that smoking is a statistically substantial risk factor for DN. A total of 21 relevant works had been chosen and subjected to pooled analysis. The overall odds ratio (OR) for smoking among those suffering from diabetic nephropathy compared to those with no DN was 1.70 (95% confidence interval 1.48–1.95). No indications of publishing bias were identified [13].

In contrast of this study, a meta-analysis of prospective cohort studies by **Liao *et al*.,** included over 203,337 individuals, revealed that smoking individuals had a heightened chance to develop diabetic nephropathy in contrast to non-smokers [14].

Regarding hypertension, there was a significant variation among all studied groups (p-value < 0.05) and a significant increase existed among all studied groups as regards systolic BP, and diastolic BP (p-value < 0.001). Diabetic individuals with CKD group showed higher systolic blood pressure and DBP than other groups. **This is in line** with a study conducted by **Cheung** [15] and demonstrated that T2D and hypertension often co-occur in the same person, indicating shared predisposing factors, that may be genetic or environmental. While the genetic factors contributing to hypertension and diabetes need to be

clarified, the environmental determinants of these conditions are well established. Obesity and physical inactivity are the two primary characteristics that predispose individuals to both illnesses.

Regarding the use of ACEI or ARB, there was a significant variation between all groups under the study as regards use of ACEI or ARBs (p-value < 0.05). Also, there was a substantial variation between groups 2, 3 as regards use of ACEI or ARBs (p-value < 0.05). While no substantial variation existed between group 1 and groups 2 and 3 (p-value > 0.05) as regards use of ACEI or ARBs. Recently, a meta-analysis of 44 trials on ACEI utilise indicated a 93.3% likelihood of beneficial impacts on renal results and a 77.2% likelihood on cardiovascular outcomes. The Kidney Disease: Improving Global Outcomes (KDIGO) study group now suggests RAAS inhibitors for diabetic individuals exhibiting both hypertension and albuminuria. A recent meta-analysis of 31 trials indicates that aldosterone antagonists decrease UACR by 24.5% [16].

Regarding the BMI, it showed that a significant increase existed between all studied groups. Diabetic patients with albuminuria group showed higher BMI than other groups. Also, no significant variation existed among group II and group III as regards BMI (p-value > 0.05). This is in agreement with a comparative work of BMI in diabetic and non-diabetic persons in the Nepalese populations conducted by **Shah *et al.*** [17] which compares BMI between 200 diabetic individuals and 100 non-diabetic individuals and BMI of the diabetic individuals was demonstrated to be over that of non-diabetic individuals.

Regarding Hip/waist ratio, there was a significant increase between all studied groups as regards the W/H ratio (p-value < 0.001). Diabetic individuals with CKD group revealed a higher W/H ratio than other groups. **This is in accordance with** a work performed by **Blaslov *et al*.,** [18]. It included 125 overweight individuals with T2DM attending their yearly inpatient visit. Metabolic profiles, anthropometric indices (WHtR and WC), and urine albumin excretion were assessed and computed. Subjects had been categorised into two groups based on the prevalence of DN. Findings: Thirty-six individuals (28.8%) fulfilled the criteria of diagnosis for DN. The WHtR and WC had been elevated in the cohort with DN. WHtR had a positive correlation with UAE (r = 0.828, p < 0.001). Also, this **agreed** with the meta-analysis **Zhao *et al.*** [19]**,** who intended to examine the correlation between visceral fat area (VFA), WC, WHR, and WHtR and DKD in individuals with T2D. 14 cross-sectional investigations were included. The aggregated findings revealed a substantial disparity in continuous WC, VFA, and WHR/WHtR among those who had DKD versus those with no DKD (standard mean difference, SMD, 0.24, 95% confidence interval, CI, 0.13–0.36, p = 0.000).

Our study revealed that individuals with T2D with the albuminuria group showed higher FBG (212.2 ± 59.43). Also, a significant reduction existed when comparing the normal control group and type 2 diabetic patient groups as regard FBG (p-value < 0.001). **Our work revealed that** a substantial increase exists between all groups under study as regards 2hpp (p-value < 0.001). individuals with T2D with the albuminuria group showed higher 2hPP (300.8 ± 79.61). Also, a significant variation existed when comparing the normal control group and individuals with T2D with the albuminuria group as regard 2hPP (p-value < 0.001). While a significant variation existed among the normal control group and individuals with T2D without albuminuria and individuals with T2D with albuminuria as regard 2hPP (p-value > 0.001).

Our work revealed that individuals with T2D with the albuminuria group showed higher HbA1C (9.68 ± 1.62). **These results is in accordance with a systematic review performed in** Oman Obtained by **Alrawahi *et al*.** [20] found a 42.5% incidence of DN, with significant risk variables including prolonged diabetes duration, familial history of DN, and inadequate glycaemic management (elevated HbA1c). 3-year retrospective cohort research including 604 Korean individuals with T2D conducted by **Song *et al*.** [21] corroborated that HbA1c fluctuation and dyslipidaemia are risk factors for the advancement of DN, irrespective of eGFR and urine ACR.

Our study showed that T2D patients with the albuminuria group showed lower HB (10.57 ± 0.88) in comparison to other groups. Also, individuals with T2D with the macroalbuminuria group show decreased HB (p-value < 0.001).

This finding is in line with study by **Bonakdaran *et al*.** [22]**,** outpatients, with T2D were chosen. those with substantial renal impairment exhibited considerably greater levels of anaemia contrasted to those with mild renal failure (30% Vs. 9%, p<0.001). Individuals with diabetes and macro albuminuria exhibit a greater prevalence of anaemia contrasted to those with micro albuminuria (32.4% vs. 8.4%, p<0.001). Individuals with micro albuminuria exhibit a greater prevalence of anaemia contrasted to those without increased albuminuria (8.4% vs. 5.7%, p<0.001).

Our study showed that there was an insignificant variation among all studied groups as regard platelets and TLC (p-value > 0.05). **However**, a descriptive study by **Kocak *et al*.** [23] examined a total of 162 participants (79 females and 83 male) who were included in the research. In the study, 76 participants (47%) had DN, whereas 86 participants (53%) were in the non-nephropathy group; it was shown that individuals with DN had a greater platelet count (p-value < 0.05) than patients without DN; as platelets play an essential role in the inflammatory processes in the progression of DN.

Our work revealed that a significant variation existed among all studied groups, as regard urea, and creatinine (p-value < 0.001). individuals with T2D with the albuminuria group showed higher urea and creatinine; (77.55 ± 13.65) and (1.91 ± 0.81) respectively. **Our study revealed that** a significant variation existed among all studied groups regarding urinary albumin/creatine ratio and estimated glomerular infiltration. Individuals with T2D with the albuminuria group showed higher A/C with a median (719.3); there a significant increase in group III in compression to group I and groups II as regards ACR

This agreed with a prospective and controlled study performed in the Biochemistry Laboratory of Izmir Ataturk Training and Research Hospital by **Aslan *et al.*** [24], which reported that patients in the albuminuric group had lower eGFR compared with other groups.

Our study showed that diabetic individuals with CKD group had higher triglycerides (p-value < 0.001) and an insignificant variance existed between group II and group III as regards triglycerides, (p-value > 0.05). **Similarly, regarding cholesterol** individuals with T2D with the albuminuria group (group III) showed higher cholesterol with a median of (234.4 ± 49.41) mg/dL. **Also, LDL** individuals with T2D with the albuminuria group showed higher LDL with a median of (138.6 ± 13.57) mg/dL. **As regards HDL**, diabetic individuals with CKD group showed lower HDL than other groups (p-value < 0.001).

This agreed with A cross-sectional study **Shahwan *et al.*** [25], that was carried out the 291 enrolled diabetic patients, 22.3% exhibited hypercholesterolaemia (TC ≥ 200), whereas 61.9% presented with hypertriglyceridemia. Elevated LDL-C levels (≥130) were seen in 8.9% of individuals, whereas HDL-C levels were below 40 mg/dl in 54.3% of cases. Individuals with HbA1c values ≥ 7.0% exhibited substantially elevated total cholesterol (TC) and aberrant LDL-C levels contrasted to individuals with HbA1c < 7.0%.

The results of the lipids profile in our study are similar to retrospective research conducted by **Palazhy and Viswanathan** [26] that included individuals with T2DM with overt nephropathy in study group I (n=89) and those with no nephropathy in study group II (n=92). The two cohorts had been equivalent in age and duration of DM. Data on TG, TC, HDL-C, LDL-C, urea, and creatinine had been extracted from the sheets of cases. The TG/HDL-C ratio, an indirect indicator of small dense LDL particles (sdLDL), and the eGFR had been computed utilising specific formulae. Dyslipidaemia was more common in diabetics with manifest nephropathy. Increased total cholesterol and hypertriglyceridemia were much more common in persons with diabetic nephropathy compared to those without. Additionally, LDL-C levels were substantially greater in those with DN contrasted to those with no DN. Group II had a greater frequency of reduced serum HDL-C levels compared to the DN group. **Conversely**, they contested the findings of **Huang *et al.*** [27], which involved a study in China with 253 patients diagnosed with T2DM, of whom 115 presented with early-stage DN, in contrast with 210 healthy age- and sex-matched individuals. The study revealed no substantial variations in total cholesterol, LDL, and HDL levels between the patient and control groups (P > 0.05 for all).

Our study showed that there was a substantial difference between all studied groups a (p-value < 0.001). Diabetic patients with albuminuria showed lower eGDR than other groups. Also, there was a substantial difference among group II and group III as regards eGDR (p-value < 0.001). **This agreed** with A retrospective cohort study by **Peng *et al.*** [28]. This research retrospectively analysed 1,083 participants with T2DM who had a baseline eGFR of ≥60 mL/min/1.73 m², aged over 18 years, with each patient having been hospitalised two or more times at an interval of 5 ± 0.5 years. Restricted cubic spline linear regression studies indicated a strong association between baseline eGDR and follow-up eGFR (F = 13.4, P < 0.001). After controlling for age, diabetes duration, sUsA, TG, LDL, BMI, and BUN, this correlation was statistically significant (F = 10.3, P <0.001)**.**

Additionally, the prospective cohort research by **Penno *et al.*** [29] included 15,773 individuals with T2D from 19 Italian diabetes clinics between 2006 and 2008. Sensitivity of insulin had been evaluated using the eGDR, that was corroborated using the euglycemic-hyperinsulinemic clamp method. As of October 31, 2015, vital status was obtained for 15,656 patients (99.3%). Subjects were categorised into eGDR tertiles from T1 (≥ 5.35 mg/kg/min) to T3 (≤ 4.14 mg/kg/min, indicating the strongest IR). Albuminuria levels raised steadily from T1 to T3. The association between eGDR and the group of albuminuria was significant (p=0.018).

The limitations of this study include its cross-sectional design, which precludes the establishment of causal relationships between eGDR and diabetic nephropathy. The relatively small sample size, particularly within subgroup analyses, may limit the generalizability of the findings. Additionally, the reliance on clinical variables such as waist-to-hip ratio, HbA1c, and hypertension status for eGDR calculation may not capture the full complexity of IR. The exclusion of patients with other significant comorbidities or on renal dialysis, while necessary for study design, could have further narrowed the applicability of the results to broader patient populations. Finally, the study's single-center nature may limit its external validity across different healthcare settings.

CONCLUSION

eGDR has been considered as new and practical measure of insulin resistance (IR), which is very common in T2DM. Also (e GDR) could be utilised as an early method for early prediction of DN.

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