Bakht Alruda University Refereed Scientific Journal (UBJSR), Issue (42) Volume (1)
September, 2025. ISSN: 1858-6139, Online, Arab Impact Factor (AIF: 1.25)

Detection of Diabetic Kidney Disease among Sudanese Type 2 Diabetes Mellitus using biomarkers, Kosti Diabetic Center White Nile State, 2025.

Osman Y Younis[1] Salah E. I.[2]
[1] Department of clinical chemistry, faculty of Medical laboratory Science, University Of Health science -Kosti, Sudan.
[2] Department of Biochemistry, faculty of medicine and health sciences Managil University, Sudan.

Received: 05/07/2025 **Published: 30/09/2025**

Abstract

This study aimed to assess the spread out of diabetic kidney disease (DKD) among Sudanese Type2 diabetic patients by investigating level of blood glucose, Cystatin-C, and serum Creatinine concentration, as biomarkers. Midray BA-88A semi-automated chemical analyzer, spectrophotometer were used. Enzymatic spectrophotometric glucose oxidase method for determine glucose level, (Jaffe method) for determine creatinine concentration and the Genrui PA50 Specific Protein Analyzer Semi-automated instrument was Opened, The test item *CYS-C* and sample type (serum) at the item column were Selected for CYS-level. 400 samples were selected and organized as follows 250 as cases and 150 healthy individual persons for control purposes. The study concluded the mean age of diabetic patients with DKD (95) was 63.7± 12.95), and for those without DKD, 155 was 59.7 ± 13.11. There was a statistically significant difference in age between the two groups (P-value = 0.02). The mean fasting blood glucose levels for patients without DKD and with DKD were 174.16 ± 4.4 and 223.6 ± 6.6, respectively. There was a statistically significant difference in fasting blood glucose levels between the two groups (P-value = 0.001). The mean duration of diabetes for patients without DKD was 2.4 ± 0.05, and for patients with DKD was 2.7 ± 0.07. There was a statistically significant difference in the duration of diabetes between the two groups (P-value = 0.001). The mean levels of Cystatin C for patients without DKD was1.5±0.13 and patients with DKD was 1.08±0.08, there was a statistically significant difference in Cystatin C levels between the two groups (P-value = 0.001). The mean concentration of Creatinine for patients without DKD was 1.84±0.53 and patients with DKD was 1.27±0.47 there was a statistically significant difference in Creatinine concentration between the two groups (P-value = 0.001).

Keywords: CKD, serum creatinine, blood glucose, Cystatin C

Introduction

Diabetic kidney disease (DKD) is a major public health problem characterized by elevated urine albumin excretion or reduced glomerular filtration rate or both [1, 2, 3]. Persistent abnormalities of either urinary albumin excretion or eGFR, significant urinalysis abnormalities lasting three months lead to the diagnosis of DKD in people with diabetes [4.5]. It is a type of progressive kidney disease affecting approximately 40% of patients with diabetes and it is one of the most common causes of end-stage renal disease (ESRD) worldwide [6, 7]**.** The complication of diabetes is considered to be the main cause of death among patients on dialysis in developed countries. While the overall prevalence of chronic kidney disease (CKD) in Sudan is estimated to range between 8–11%, the mortality risks of kidney disease increased by 31.1% in patients with diabetes [8-9].

Hypertension and hyperglycemia accelerate the development and progression of DKD, they are key risk factors of DKD and may include long duration of diabetes; non-glycemic control, blood pressure, obesity, cigarette smoking and an extent to genetic predisposition [10,11]. Hyperglycemia contributes to development and progression of DKD via multiple molecular mechanisms such as gene polymorphism of angiotensin converting enzyme (ACE).Limited data are available regarding the risk factors associated with the development of diabetic kidney disease (DKD) among Sudanese adults with type 2 diabetes mellitus (T2DM)[12,13].

Cystatin C is a low molecular weight protein that is an endogenous cysteine proteinase inhibitor and has a high correlation with GFR. Because of its small size Cystatin C is freely filtered by renal glomeruli and does not return to the blood stream and not secreted by renal tubules it has been suggested to be closer to the "ideal" endogenous marker [14], and it is measured from blood stream by the glomerular filtration in the kidneys. If kidney function and glomerular filtration rate decline, the blood levels of Cystatin C raise. Plasma levels of Cystatin C are a more precise test of kidney function than plasma creatinine [15, 16],Serum biomarkers, such as serum creatinine (SCr) and serum cystatin C (SCysC), have been widely used to evaluate renal function in patients who have chronic kidney disease (CKD)[16].

objective

To assess the spread out of diabetic kidney disease (DKD) among Sudanese Type2 diabetic patients by investigating level of blood glucose, Cystatin-C, and serum Creatinine as biomarkers

Material and Methods

Study design

An analytical case-control hospital-based study is designed.

Study area

The study was carried out at Kosti Teaching Hospital, Diabetic Center, Kosti city which is considered as the most important and biggest town at about 360 kilometer south to Khartoum, the capital of Sudan, in Latitudes (13.1522° or 13° 9' 7.9" north) and Longitudes (32.6725° or 32° 40' 21" east) According to (https://en.m.wikipedia.org/wiki/white_Nile_(state))

Study duration

This study was carried out during December 2022 to 2025.

Study variables

Dependent variables

Fasting Blood Glucose, serum Creatinine, serum Cystatin C.

Independent variables:

Included: Age, gender, Residence, Level of education and Family history of DM

Study population

The study included adult Sudanese known as having type2 diabetes mellitus attended to Diabetic Center at Kosti teaching hospital for follow up.

Sample size:

400 samples was selected and organized as follows 250 as cases and 150 healthy individual persons for control purposes

Inclusion criteria

Type 2 Diabetic patients aged from 25-80 years of both gender and Healthy individuals were included as the control group.

Exclusion criteria

Patients with hypertension, thyroid disease, heart disease, and type 1diabetes, patients on dialysis or transplanted were excluded and those who refused to participate.

Ethical approval

Ethical approval for the study was obtained from the research board of Faculty of Medical Laboratory Sciences, University of EL Imam EL Mahdi.

Ethical permission

The permission was taken from the Local Kosti Diabetic Center authorities.

Informed consent

All patients were informed about the objectives of the study before sample collection; written informed consent for participation in the study was obtained from each participant.

Data analysis:

The data were analyzed by using SPSS (version 26; SPSS Inc., Chicago, IL) software and linear regression analysis.

Sample collection

From each participant, blood and urine samples were collected, 5 ml of venous blood was collected, 2.5ml was taken into EDTA blood containers then stored in -80c for DNA Extraction and 2.5mL into plain containers, immediately separated after centrifugation at (3000rp/min for 5minutes) and tested for fasting blood glucose, serum Creatinine and serum Cystatin C levels.

Measurement of serum Fasting Blood Glucose:

Test principle:

Glucose level was determined by an enzymatic spectrophotometric glucose oxidase method. The basic principle is that, Glucose is oxidized by glucose oxidase (GOD) enzyme to produce gluconate and hydrogen peroxide (H_2O_2). The H_2O_2 is then oxidatively coupled with 4 amino-antipyrene (4-AAP) and phenol in the presence of peroxidase (POD) enzyme to yield a red Quinoneiminequinoeimine dye that is measured at 500 nm with a spectrophotometer. Glucose in the sample originates, by means of the coupled reactions described below, a colored complex that can be measured by spectrophotometry.

Glucose + O_2 + H_2O $\xrightarrow{\text{glucose oxidase}}$ Gluconate +H_2O_2

$2H_2O_2$ + 4-Aminoantipyrine +Phenol $\xrightarrow{\text{peroxidase}}$ Quinoneimine+4H_2O

The absorbance at 500 nm is proportional to concentration of glucose in the sample. The method has linearity from 0.0126 mmol/l (0.23 mg/dl) to 27.5 mmol/l (500 mg/dl).

Procedure:

	Blank	Standard	Sample
Glucose standard(S)	**-**	**10µL**	**-**
Sample	**-**	**-**	**10µL**
Reagent (A)	**1000µL**	**1000µL**	**1000µL**

After mixed and incubated for 10 minutes. The absorbance (A) of the standard and the sample were measured at 500 nm against the blank using Mindray BA-88A semi-automated chemical analyzer. The glucose concentration expressed as mg/dl. Quality control samples were run in the same way as patient samples; finally test results were documented on screen.

Measurement of serum Cystatin C:

Test Principle:

CYS-C of the sample has an agglutination reaction with the rabbit anti human CYS-C antibody latex particles suspension of the reagent. The reaction formed antigen-antibody complex, which has turbidity. With a certain amount of antibody, its turbidity is in direct proportion to the CYS-C of the sample. By detecting the reaction change at specific wavelengths and referring to the multi-point calibration curve, the CYS-C content in the sample can be calculated. The reagents are pre-calibrated, each specific calibration curve has been recorded into the magcard and each detection kits are allocated with one magcard.

Procedure

The Genrui PA50 Specific Protein Analyzer Semi-automated instrument was Opened, The test item *CYS-C* and sample type (serum) at the item column were Selected. Lot at the batch No. column to enter the card-swiping interface was tick; the corresponding magcard was sated into the magnetic induction area. One cuvette and sterile tips, accurately 300µL from buffer solution, and then add 10µL from sample were taken. The cuvette was placed into the test channel. The instrument prompts (please add Antiserum) then accurately 100µL Antiserum added. The corresponding channel (Start bottom) immediately press and the instrument mix automatically. When the test finished the instrument automatically display and print the test result.

Measurement of serum creatinine:

Principle

Creatinine in the sample reacted with picric acid in alkaline medium forming a coloured complex (Jaffe method). The complex formation rate was measured in a short period to avoid interferences.

Creatinine + Picric acid Alkaline Solution Creatinine Picrate (ceoloure Complex)

Procedure

The working reagent was prepared by mixing equal volumes of reagent A and reagent B.

Sample type (serum), unit (mg/dL) and patient number were selected. 100µL from sample and 1000µL from working reagent, mixed gentially, then immediately was taken by Mindray BA-88A semi-automated chemical analyzer. Quality control samples were run in the same way as patient samples; finally test results were documented on screen.

Results and Discussion

Results:

The mean age of diabetic patients with DKD (95) was 63.7± 12.95), and for those without DKD, 155 was 59.7 ± 13.11. There was a statistically significant difference in age between the two groups (P-value = 0.02).Table (1) .

According to gender the percentage of males was 77 (30.8%) and females78 (31.2%) for without DKD and males51 (20.4%) and females 44 (17.6%) for those with DKD groups. There was no statistically significant difference in gender distribution between the two groups (P-value = 0.53). Table (1)

The mean duration of diabetes for patients without DKD was 2.4 ± 0.05, and for patients with DKD was 2.7 ± 0.07. There was a statistically significant difference in the duration of diabetes between the two groups (P-value = 0.001).

the table provided information on the residency for patients without DKD (urban96 (89.9%), rural59 (65.1%)) respectively and the residency for patients with DKD (urban49 (55.1%), rural 46 (39.9%)) respectively. There were no statistically significant difference in residency between the two groups (P-value = 0.10)

Table (1) showed the mean fasting blood glucose levels for patients without DKD and with DKD were 174.16 ± 4.4 and 223.6 ± 6.6, respectively. There was a statistically significant difference in fasting blood glucose levels between the two groups (P-value = 0.001).

The mean levels of Cystatin C for patients without DKD was1.5±0.13 and patients with DKD was 1.08±0.08, there was a statistically significant difference in Cystatin C levels between the two groups (P-value = 0.001) table (1).

Table (1) provided the mean concentration of Creatinine for patients without DKD was 1.84±0.53 and patients with DKD was 1.27±0.47 there was a statistically significant difference in Creatinine concentration between the two groups (P-value = 0.001).

Table (1): Basic Demographics and clinical characteristics of type 2 diabetic patients with and without Diabetic Kidney Disease

Variables		T2DM without DKD n=155(62%)	T2DMwithDKD n=95 (38%)	p-value
Age (M ±SD)		59.7±13.11	63.7±12.95	0.02
Gender	Male	77 (30.8%)	51 (20.4%)	0.53
	Female	78 (31.2%)	44 (17.6%)	
Fasting Blood Glucose	(M ±SD)	174.16±4.4	223.6±6.6	0.001
Diabetic duration	(M ±SD)	2.4±0.05	2.7±0.07	0.001
Residency	Urban	96 (89.9%)	49 (55.1%)	
	Rural	59 (65.1%)	46 (39.9%)	0.10
Cystatin C	(M ±SD)	1.08±0.08	1.5±0.13	0.001
Creatinine	(M ±SD)	1.27±0.47	1.84±0.53	0.001

Discussion:

This analytical study was conducted in the Diabetic Center, Kosti Teaching Hospital in White Nile State, Sudan among 250 Type2 diabetic cases (115 male and 135 female) and 150 apparently healthy volunteers (84 male and 66 female) as the control group. Our results showed a significant increase in mean age of patients with DKD+ (59.7±13.11) and the patients without DKD-(63.7±12.95) (P-value 0.02), this result agreed with Roy S, Schweiker-Kahn O, et al.2021 [17] and Farah, Randa I., et al. 2021[18]. who reported that the mean age of the patients with DKD+ was significantly greater than the patients without DKD-.while our results was disagree with Wang, Tingli, et al.2022[19] and Erdogmus, Siyar, et al. 2018[20]. According to the gender, our results revealed insignificant difference between patients with DKD+ and patients without DKD- (p.value 0.53) Table (1), this result agreed with that reported by Wei, Jing, et al.2022 [21] and Roy S, Schweiker-Kahn O, et al.2021 [17] and disagree with Yu, Margaret K., et al.2012[22] and Al-Ataa, H.M., 2020[23] whom reveled that there was significant difference of gender between DKD+ and DKD- .

We found a significant increase of the mean duration of diabetes among patients with positive DKD+ compared to patients with negative DKD- (P-value 0.001) Table (1). This result agreed with, Taha, T. A. A., et al.2022 [24] and Farah, R.I., Al-Sabbagh, et al 2021[25],), Akhtar, Mohammed, et al.2020 [26]. they revealed that Duration of diabetes has a direct effect on the progression of DKD among Sudanese with Type 2 Diabetes Mellitus, and Duan, Jiayu, et al.2023[27]. Reported that diabetic duration had a statistically significant effect on DKD. But this result disagrees with Abo-elnasr, Mohamed Sabry, et al.2020 [28] who reported that when comparing both groups(DKD+ and DKD-) there was no statistically significant difference regarding DM duration.

In this study we reported that the fasting blood glucose level is a significant risk factor for DKD, (P-value 0.001) Table (1), this result agreed with Altemtam, N., Russell, J., & El Nahas, M.2012[29], Tong, Xue, et al. 2020[30]. Gong, Lei, et al.2021 [31] Ali, H., Abu-Farha, et al.2022 [32].

This study revealed significant increase in the mean Cystatin C levels among patients with positive DKD+ than the negative DKD- (p-value 0.001), table (1); The elevated Cystatin C levels in the patients with DKD group suggest that the diabetic patients with Diabetic Kidney Disease may be experiencing compromised kidney function and the difference in Cystatin C levels serve up an important marker for identifying and quantifying the severity of kidney dysfunction in diabetic individuals. Our results showed the Cystatin C is thought to be strong biomarker for DKD, this result is same as Liao, X., Zhu, Y. and Xue, C., 2022[33], Mansour, Ahmed E., et al.2023[34], Farah, Nizar M., et al.2023[35]as a result of Gupta, UshaKumari, et al.2022[36]. Ma, Cheng-Cheng, et al.2020[37], and matching with Mohammed, N. B., et al.2014[38] they reported that among Sudanese patients with Type 2 Diabetes Mellitus, plasma levels of Cystatin C are significantly raised andlikewise Omer, Maha Ali, et al.2019[39], Al-Rubeaan, Khalid, et al.2017[40] Abushama, Samah H., Ibrahim A. Ali, and Eltayeb Osman Elfaki.2020[41] demonstrated Cystatin C could be considered as a good candidate for the early detection of renal dysfunction in type 2 diabetic patients with normoalbuminuria.

The study found that the mean Creatinine concentration is significantly increased in DKD+than DKD- patients (P-value 0.001) table (1). These results agreed with many studies done in white Nile, like Karar1i, Tarig, et al.2013[42] were found the higher levels of plasma Creatinine may be indicative of progressive renal disease and nephropathy among diabetic patients, in addition to Shigidi, Mazin MT, Wieam N. Karrar.2021[43], SALIH, Ola Ahmed Faduly Mohamed, et al.2014[44]. Whereas Abeadalla, Abdarahiem A, et al. 2018[45]

Conclusion:

The present study is concluded that:

1. DKD is a problem among Sudanese patients with Type 2 Diabetes Mellitus.
2. Serum Cystatin C and Creatinine levels were strong biomarkers for DKD.
3. Cystatin C was found to be the superior biomarker for early detection of DKD in Type 2 diabetic patients.

Recommendations:

Serum Cystatin C and Creatinine should be measured as parts of the routine assessment of renal function test for Type 2 diabetic patients.

References:

Sawyer A, Zeitler E, Trachtman H, Bjornstad P. Kidney Considerations in Pediatric Obesity. *Current Obesity Reports*. 2023 ;12(3):332-344.

Hussain S, Jamali MC, Habib A, Hussain MS, Akhtar M, Najmi AK. Diabetic kidney disease: An overview of prevalence, risk factors, and biomarkers. *Clinical Epidemiology and Global Health*. 2021 Jan ; 9(1):2-6.

Hoogeveen EK. The epidemiology of diabetic kidney disease. *Kidney and Dialysis*. 2022 Aug 1;2(3):433-42.

Agrawal P, Singh S, Khurana M, Agarwal K, Pursnani N, Gautam A. Interpretation of urine routine report of a diabetic patient: A review. *Journal of Diabetology*. 2022 Oct 1;13(4):317-21.

Febrianto D, Soelistijo SA, Tjempakasari A. Correlation between Serum High-Sensitivity C-Reactive Protein Level and Severity of Albuminuria Measured by Urine Albumin-to-Creatinine Ratio in Type 2 Diabetic Patients 2020.

González-Pérez A, Saez M, Vizcaya D, Lind M, Rodriguez LG. Incidence and risk factors for mortality and end-stage renal disease in people with type 2 diabetes and diabetic kidney disease: a population-based cohort study in the UK. *BMJ Open Diabetes Research and Care.* 2021 Oct 1;9(1):e002146.

Thurlow JS, Joshi M, Yan G, Norris KC, Agodoa LY, Yuan CM, Nee R. Global epidemiology of end-stage kidney disease and disparities in kidney replacement therapy. *American journal of nephrology*. 2021 Apr 15;52(2):98-107.

Dal Canto E, Ceriello A, Rydén L, Ferrini M, Hansen TB, Schnell O, Standl E, Beulens JW. Diabetes as a cardiovascular risk factor: An overview of global trends of macro and micro vascular complications. *European journal of preventive cardiology*. 2019 Dec;26(2_suppl):25-32.

Tomic D, Shaw JE, Magliano DJ. The burden and risks of emerging complications of diabetes mellitus. *Nature Reviews Endocrinology*. 2022 Sep;18(9):525-39.

Warren AM, Knudsen ST, Cooper ME. Diabetic nephropathy: an insight into molecular mechanisms and emerging therapies. *Expert opinion on therapeutic targets*. 2019 Jul 3;23(7):579-91.

Rico-Fontalvo J, Aroca G, Cabrales J, Daza-Arnedo R, Yánez-Rodríguez T, Martínez-Ávila MC, Uparella-Gulfo I, Raad-Sarabia M. Molecular mechanisms of diabetic kidney disease. *International Journal of Molecular Sciences*. 2022 Aug 4;23(15):8668. page

Mohandes S, Doke T, Hu H, Mukhi D, Dhillon P, Susztak K. Molecular pathways that drive diabetic kidney disease. *The Journal of clinical investigation*. 2023 Feb 15;133(4).page

Shigidi MM, Karrar WN. Risk factors associated with the development of diabetic kidney disease in Sudanese patients with type 2 diabetes mellitus: a case-control study. Diabetes & Metabolic Syndrome: *Clinical Research & Reviews*. 2021 Nov 1;15(6):102-320.

Pottel H, Björk J, Rule AD, Ebert N, Eriksen BO, Dubourg L, Vidal-Petiot E, Grubb A, Hansson M, Lamb EJ, Littmann K. Cystatin C–based equation to estimate GFR without the inclusion of race and sex. *New England Journal of Medicine*. 2023 Jan 26;388(4):333-43.

Wang Y, Levey AS, Inker LA, Jessani S, Bux R, Samad Z, Khan AR, Karger AB, Allen JC, Jafar TH. Performance and determinants of serum creatinine and cystatin C–based GFR estimating equations in South Asians. *Kidney International Reports*. 2021 Apr 1;6(4):962-75.

Khusainova MA. CYSTATIN C IS AN EARLY MARKER OF DECREASED KIDNEY FUNCTION. Oriental renaissance: *Innovative, educational, natural and social sciences.* 2023;3(1):485-90.

Roy S, Schweiker-Kahn O, Jafry B, Masel-Miller R, Raju RS, O'Neill LM, Correia CR, Trivedi A, Johnson C, Pilot C, Saddemi J. Risk factors and comorbidities associated with diabetic kidney disease. *Journal of Primary Care & Community Health*. 2021 Oct;12:21501327211048556.

Farah, Randa I., et al. "Diabetic kidney disease in patients with type 2 diabetes mellitus: a cross-sectional study." *BMC nephrology* 22.1 (2021): 223.

Wang, Tingli, et al. "Whether Renal Pathology Is an Independent Predictor for End-Stage Renal Disease in Diabetic Kidney Disease Patients with Nephrotic Range Proteinuria: A Biopsy-Based Study." *Journal of Clinical Medicine* 12.1 (2022): 88.

Erdogmus, Siyar, et al. "Non-diabetic kidney disease in type 2 diabetic patients: prevalence, clinical predictors and outcomes." *Kidney and Blood Pressure Research* 42.5 (2018): 886-893.

Wei J, Wang B, Shen FJ, Zhang TT, Duan Z, Zhou DM. Diagnostic value of triglyceride and cystatin C ratio in diabetic kidney disease: a retrospective and prospective cohort study based on renal biopsy. *BMC nephrology*. 2022 Dec;23(1):1-8.

Yu MK, Lyles CR, Bent-Shaw LA, Young BA, Pathways Authors. Risk factor, age and sex differences in chronic kidney disease prevalence in a diabetic cohort: the pathways study. *American journal of nephrology*. 2012 Sep 4;36(3):245-51.

Al-Ataa HM. Assessment of Renal Change in Diabetic Patients by Using Computed Tomography. 2020 (Doctoral dissertation, Sudan University of Science and Technology).

Taha TA, Elmamoun A, Ismaeil AA, Abderahman NA, Ahmed MA. Estimation of chronic kidney disease among diabetic patients using the CKD-EPI equation. *J Comm Med and Pub Health Rep.*2022;3(05).

Farah RI, Al-Sabbagh MQ, Momani MS, Albtoosh A, Arabiat M, Abdulraheem AM, Aljabiri H, Abufaraj M. Diabetic kidney disease in patients with type 2 diabetes mellitus: a cross-sectional study. *BMC nephrology.* 2021 Dec;22(1):1-8.

Akhtar M, Taha NM, Nauman A, Mujeeb IB, Al-Nabet AD. Diabetic kidney disease: Past and present. *Advances in anatomic pathology*. 2020 Mar 24;27(2):87-97.

Duan J, Liu D, Zhao Z, Liang L, Pan S, Tian F, Yu P, Li G, Liu Z. Short-term duration of diabetic retinopathy as a predictor for development of diabetic kidney disease. *Journal of Translational Internal Medicine*. 2023 Dec 20;11(4):449-58.

Aboelnasr MS, Shaltout AK, AlSheikh MR, Abdelhameed AH, Elrefaey W. Diabetic kidney disease in patients newly diagnosed with type-2 diabetes mellitus: incidence and associations. *Saudi Journal of Kidney Diseases and Transplantation*. 2020 Jan 1;31(1):191-9.

Altemtam N, Russell J, El Nahas M. A study of the natural history of diabetic kidney disease (DKD). *Nephrology Dialysis Transplantation*. 2012 May 1;27(5):1847-54.

Tong X, Yu Q, Ankawi G, Pang B, Yang B, Yang H. Insights into the role of renal biopsy in patients with T2DM: a literature review of global renal biopsy results. *Diabetes Therapy*. 2020 Sep;11:1983-99.

Gong L, Wang C, Ning G, Wang W, Chen G, Wan Q, Qin G, Yan L, Wang G, Qin Y, Luo Z. High concentrations of triglycerides are associated with diabetic kidney disease in new-onset type 2 diabetes in C hina: Findings from the C hina C ardiometabolic D isease and C ancer C ohort (4C) S tudy. *Diabetes, Obesity and Metabolism.* 2021 Nov;23(11):2551-60.

Ali H, Abu-Farha M, Hammad MM, Devarajan S, Bahbahani Y, Al-Khairi I, Cherian P, Alsairafi Z, Vijayan V, Al-Mulla F, Attar AA. Potential Role of N-Cadherin in Diagnosis and Prognosis of Diabetic Nephropathy. *Frontiers in Endocrinology*. 2022 May 31;13:882700.

Liao X, Zhu Y, Xue C. Diagnostic value of serum cystatin C for diabetic nephropathy: a meta-analysis. *BMC Endocrine Disorders*. 2022 Dec;22(1):1-2.

Mansour AE, Abdelmoniem RO, Elbadawy AM, Ibrahim WM. The utility of estimation of glomerular filtration rate by serum cystatin C as a predictor of diabetic kidney disease in both type I and type II diabetic patients: a single center study. *The Egyptian Journal of Internal Medicine.*2023 Sep 11;35(1):64.

Farah NM, Abbas AM, Alameen AA, Shalabi MG, Elderdery AY, Eltayeb LB, Babker AM, Mohamed H, Aedh AI. Impact of Cigarette Smoking on Serum Cystatin C and Creatinine Levels and MAU: A Case-Control Study. *Biomedicine.*2023;13(1):58-61.

Gupta UK, Mahajan M, Gupta S, Kumar N, Gupta S. CYSTATIN C AS AN EARLIER MARKER OF NEPHROPATHY IN TYPE 2 DIABETICS OF JAMMU REGION. Group. 2022 Feb;1(70):17-5.

Ma CC, Duan CC, Huang RC, Tang HQ. Association of circulating cystatin C levels with type 2 diabetes mellitus: a systematic review and meta-analysis. *Archives of Medical Science.* 2020 Apr 24;16(3):648-56.

Mohammed NB, Elabid BH, Ahmed SM, Sadik IA, Aabid AM. Assessment of Plasma Cystatin C among Sudanese Patients with Type II Diabetes Mellitus. Sudan *Journal of Medical Sciences*. 2014 Jun 19;9(1):39-42.

Omer MA, Abdelkarim ZY, Wdidi S, Ali AE. Relationship between Inflammatory Biomarkers (CRP, TNF-alpha, Interleukin 6, and cystatin C) and Renal Function Tests among Type 2 Diabetes Mellitus-Khartoum.

Al-Rubeaan K, Siddiqui K, Al-Ghonaim MA, Youssef AM, Al-Sharqawi AH, AlNaqeb D. Assessment of the diagnostic value of different biomarkers in relation to various stages of diabetic nephropathy in type 2 diabetic patients. *Scientific reports*. 2017 Jun 2;7(1):2684.

Abushama SH, Ali IA, Elfaki EO. Effects of Type II Diabetes Mellitus on Serum Creatinine Level & Estimated Glomerular Filtration Rate among Type II Diabetic Sudanese Patients Living in Khartoum State September–December 2020.

Karar1i T, Fadoli O, Almajed F, Qureshi S. ESTIMATION OF MICROALBUMINURIA AND CREATININE LEVEL AMONG SUDANESE PATIENTS WITH TYPE-2 DIABETES MELLITUS IN WHITE NILE STATE-SUDAN.

Shigidi, Mazin Mt, and Wieam N Karrar. "Risk factors associated with the development of diabetic kidney disease in Sudanese patients with type 2 diabetes mellitus: A case-control study." *Diabetes & metabolic syndrome.*2021;15,6:102320. doi:10.1016/j.dsx.2021.102320

Salih, Ola Ahmed Faduly Mohamed. Evaluation of Microalbuminuria and Plasma Creatinine in Type-2 Diabetes Mellitus Patients-White Nile State-Sudan. Diss. Sudan University of Science and Technology, 2014.

Abeadalla AA, Bashir AA, Abdalla IM, Ali IA, Awad KM, Mohmed AA, Musa OA. Normal reference value of adult Sudanese serum creatinine and urea in Khartoum state. *Int J Health Sci Res*. 2018;8(6):19-24.