

SONOGRAPHIC EVALUATION OF RENAL PARENCHYMAL & DIMENSIONAL VARIATIONS IN TYPE II DIABETIC PATIENTS IN PAKISTAN

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Abstract

Background: Type II Diabetes Mellitus can cause progressive kidney damage leading to diabetic nephropathy. Ultrasonography is a non-invasive and reliable method for evaluating renal parenchymal changes and kidney dimensions. **Objective:** To assess renal parenchymal echogenicity and renal dimensions in Type II diabetic patients using ultrasonography. **Material and method:** A cross-sectional study was conducted on 68 patients with Type II Diabetes Mellitus at Idrees Hospital, Sialkot. Patients aged 30–70 years of both genders were included using convenient sampling. Renal ultrasonography was performed to assess kidney dimensions, cortical thickness, echogenicity, and corticomedullary differentiation. Clinical and laboratory data, including serum creatinine and eGFR, were also recorded. All findings were documented on a structured proforma. Data were analyzed using SPSS version 22.0. **Results:** A total of 68 diabetic patients (mean age 52.56 ± 11.29 years) were included. Grade I renal parenchymal disease was the most common finding. Increased echogenicity was seen in >90% of patients, with reduced or absent corticomedullary differentiation in most cases. Renal dimensions were below normal. HbA1c showed a negative correlation with renal size, while a positive correlation was observed with diabetes duration. Higher parenchymal grades were associated with lower eGFR and higher serum creatinine, indicating worsening renal function. **Conclusion:** Renal parenchymal abnormalities are common in Type II Diabetes Mellitus, most often Grade I, and are associated with poor glycemic control and longer disease duration. Ultrasonography is an effective, non-invasive tool for early detection and monitoring of diabetic nephropathy.

INTRODUCTION

The kidneys (or renal organs) are a pair of organs

located (temporally) in the retroperitoneal (meaning: behind the peritoneal cavity (i.e.

abdominal cavity) region of the abdominal cavity along each side of the vertebral column. Each kidney is between the level of (the first) twelfth thoracic vertebra (TH12) and (the third) lumbar vertebra (L3). The right kidney is situated slightly lower than the left kidney because of the liver occupying space above the right kidney. Each adult (on average) kidney measures around 10-12 cm (length), 5-7 cm (width), and 3-5 cm (thickness). The kidneys help keep our body in balance (homeostasis), which includes regulating (fluid) volume, (electrolyte) concentration, (blood pH) acid-base balance, (regulating) blood pressure and filtering waste products from the blood through producing urine (Jastaniah et al., 2013) The medulla contains the renal pyramids, forming two kinds of channels called minor calyces and major calyces. The calyces allow urine produced in the kidney to flow into the renal pelvis and subsequently into the ureter. The kidneys contain millions of nephrons that filter and absorb urine to help keep the body healthy. In addition to urine filtration, the kidneys have many other important functions such as producing erythropoietin, a hormone that maintains blood pressure; activating vitamin D, and regulating the renin-angiotensin-aldosterone system. (Yadav et al., 2025) Ultrasound delivers sufficient anatomical imagery to evaluate renal anatomy and pathology without doing any harm to the patient using x-ray radiation or nephrotoxic contrast materials. Ultrasound measurements can be used to evaluate a variety of things about the kidneys including their size, thickness of the renal cortex, amount of echogenicity within the kidney, degree of corticomedullary differentiation, and vascularity of the renal arteries and veins. In healthy adult kidneys, the renal cortex typically appears less echogenic than either the liver or spleen, however, the medullary pyramids can appear much more echogenic when compared to those same structures within the liver or spleen. The increase in echogenicity associated with the renal cortex, the decrease in thickness of the renal cortex, and the inability to differentiate between the renal cortex and the medulla are all

significant sonographic signs of renal parenchymal disease or chronic kidney disease. (Yaprak et al., 2017) Ultrasound Grading System for Kidneys. Ultrasound grading system for kidneys is based on ultrasound examination of the cortex and the corticomedullary distinction, and has the following grades: Grade 0 (Normal): normal echogenicity and good cortico-medullary distinction Grade 1 (Mild): mild increase in echogenicity and good cortico-medullary distinction. Grade 2 (Mild-Moderate): echogenicity similar to liver, mild decrease in corticomedullary distinction. Grade 3 (Moderate): Marked increase in echogenicity, poor cortico-medullary distinction and early thinning of cortical tissue. Grade 4 (Severe): Very high echogenicity, absent cortico-medullary distinctions, significant cortical atrophy, reduction in size of the kidney. This grading system provides a means for evaluating the progress of chronic renal disease and correlating changes in the kidney's appearance to function. Sonographic measurements such as length of kidney, corticomedullary distinction, and echogenicity of renal cortex do not allow for differentiating various types of renal health illnesses in Individuals with renal parenchymal disease [18.19]. Increased cortical echogenicity, on the other hand, is a non-specific sign of renal parenchymal illness. Sonographic parameters for assessing renal parenchymal disease include the size of the kidney, contour, cortico-medullary distinctions, thickness of the cortex, and prominence of the medullary pyramids [20.21]. In a healthy kidney, the renal cortex generates lower-intensity back-scattered echoes than that of the liver, spleen, or renal sinus. In contrast, the renal medulla is somewhat hypoechoic [22]. Renal length and parenchymal thickness diminish as CKD progresses, whereas parenchymal echogenicity rises [23]. Permanent damage is indicated by a renal length of less than 10cm and increased echogenicity [24]. Diabetes and hypertension are two of the most prominent chronic non-communicable diseases, both of which are common triggers for end-stage renal failure [25.26]. Ultrasound is the initial imaging

modality utilized to explore the kidneys it is critical in the diagnosis of renal illness. The radiologist will be able to understand the clear criteria and detrimental findings that are symptomatic of pathology, allowing them to recognize it early and design a treatment strategy to avoid complications

Method

Data were collected over 3 to 4 months at Idrees Hospital in Sialkot, Pakistan. We included a total of 68 patients with Type II Diabetes Mellitus in our study. Each patient gave written consent after we explained the purpose of the study. We recorded laboratory data, including serum creatinine and eGFR levels. A renal ultrasound was done to check kidney size, cortical thickness and echogenicity. We documented our findings using a form. We also collected data such, as patient age, gender and how long they had diabetes. We made sure to keep information confidential throughout the study. The data were collected at one point in time. Trained sonographers have conducted renal ultrasound studies utilizing an established B-mode scanning method using convex transducers operating at frequencies between 3.5 and 5 MHz. Each subject was positioned in supine and oblique positions, to maximize image quality for both kidneys. Systematic scanning of each kidney was completed in both longitudinal and transverse orientations, and the following parameters were examined and compared with

normal reference ranges for renal length (9-12 cm), width (4-6 cm), parenchyma thickness (3-4 cm), normal cortical thickness (7-10mm), parenchyma echogenicity graded from 0-4 based on relative echogenicity of liver, and corticomedullary differentiation. All sonographic observations were documented using an organized Performa and subsequently matched with associated biochemical information.

Result

In the present study, descriptive and inferential statistical analyses were performed to evaluate sonographic renal parenchymal abnormalities and dimensional variations in patients with Type II Diabetes Mellitus. Descriptive statistics were used to summarize demographic, clinical, biochemical, and sonographic variables. Pearson's correlation analysis was applied to determine the relationship between HbA1c and renal sonographic measurements, while Spearman's rank correlation was used to assess the association between HbA1c and duration of diabetes. An independent samples t-test was performed to compare renal parameters between male and female participants. The association between duration of diabetes and renal parenchymal grade was examined using the Chi-square test, whereas one-way ANOVA was used to compare eGFR and serum creatinine across different renal parenchymal grades. Statistical significance was considered at a p-value of <0.05.

Table 1: Descriptive Statistics of Clinical and Biochemical Variables (N = 68)

Variable	N	Min	Max	Mean	SD
Age(Years)	68	18	75	52.56	11.29
HbA1c(%)	68	3.75	11.60	7.99	1.43

Diabetes duration	68	1	24	996	4.89
eGFR(ml/min)	68	10	103	48.65	22.52
Blood Urea (mg/dl)	68	20	150	52.22	24.53
Seru Creatinine (mg/dl)	68	0.70	7.5	2.44	1.33

Based on results from all 68 participants diagnosed with Type 2 Diabetes Mellitus there are 33 male (48.5%) and 35 female (51.5%) indicating that participants were evenly split by sex (Table 1). The average age of all participants was 52.56 years (SD = 11.29) with an age range from 18 to 75 years. The average length of time diagnosed with diabetes was 9.96 years (SD = 4.89), ranging from one year to twenty-four. The average hemoglobin A1c (HbA1c) for all participants was 7.99% (SD = 1.43) and ranged from 3.75% to 11.60%. These numbers reflect the variability of glycemic control in all

participants within this study. The average serum creatinine was 2.44 mg/dL (SD = 1.33), ranging from 0.70 mg/dL to 7.50 mg/dL. The average blood urea nitrogen (BUN) was 52.22 mg/dL (SD = 24.53) and ranged from 20.00 mg/dL to 150.00 mg/dL. The average estimated Glomerular filtration rate (eGFR) was 48.65 mL/min (SD = 22.52) and had a minimum of 10.00 mL/min and a maximum of 103.00 mL/min, demonstrating that there were significant amounts of participants that were within the range of decreased renal function.

Table 2: Distribution of Antidiabetic Medications (N = 68)

Medication	Frequency	Percentage
Glibenclamide	1	1.5
Insulin	48	70.6
Metformin	18	26.5
Self-management	1	1.5

Table 2 shows the current distribution of antidiabetic medications. The most commonly

prescribed was insulin, which was given to 48 (70.6%) patients; metformin was used by 18

(26.5%) patients; and Glibenclamide and self-management without pharmacologic therapy

were each noted to be used by 1 (1.5%) patient.

Table 3: Descriptive Statistics of Sonographic Renal Measurements (N = 68)

Measurement	N	Min	Max	Mean	SD
Right Kidney Length (cm)	68	5.90	13.00	8.95	1.42
Right Kidney Width (cm)	68	2.30	5.50	3.94	0.40
Right Kidney Height (cm)	68	2.03	4.80	3.64	0.39
Right Cortical Thickness (mm)	68	3.00	20.00	10.80	3.50
Left Kidney Length (cm)	68	5.30	13.60	8.97	1.59
Left Kidney Width (cm)	68	2.00	5.70	4.17	0.49
Left Kidney Height (cm)	68	2.50	5.60	4.04	0.45
Left Cortical Thickness (mm)	68	4.00	22.00	12.26	3.54

Table 4: Frequency Distribution of Renal Parenchymal Grades, Left and Right Kidneys (N = 68)

Grade	Frequency	Percentage
Left Renal Parenchymal Grade		
Normal	1	1.5
Grade I	30	44.1
Grade II	20	29.4
Grade III	17	25.0
Right Renal Parenchymal Grade		
Normal	1	1.5
Grade I	32	47.1
Grade II	19	27.9
Grade III	15	22.1

The renal parenchymal grade distribution for both kidneys is provided in Table 4. For the left kidney, most patients had Grade I parenchymal disease (n = 30; 44.1%) followed by Grade II (n = 20; 29.4%) and III (n = 17; 25%). One patient (1.5%) had normal left renal parenchyma. Similarly, the right kidney had patients with Grade I parenchymal disease (n = 32; 47.1%) most

often followed by Grade II (n = 19; 27.9%) and III (n = 15; 22.1%). One patient per kidney each had normal parenchyma and one with Grade IV parenchyma for a total of two patients (1.5%). The cumulative frequency of Grade I, II and III parenchymal disease was 98.5% bilaterally revealing normal renal parenchyma is infrequently seen in this cohort of diabetics.

Table 5: Distribution of Renal Echogenicity and Corticomedullary Differentiation (N = 68)

Category	Frequency	Percentage
Left Kidney Echogenicity		
Normal	5	7.4

Increased	63	92.6
Right Kidney Echogenicity		
Normal	6	8.8
Increased	62	91.2
Left Corticomedullary Differentiation		
Present	6	8.8
Reduced	35	51.5
Lost	27	39.7
Right Corticomedullary Differentiation		
Present	11	16.2
Reduced	29	42.6
Lost	28	41.2

There is a frequency distribution of renal echogenicity and corticomedullary differentiation for both kidneys in Table 5. Increased renal echogenicity occurred in 63 (92.6%) left kidneys and 62 (91.2%) right kidneys; normal renal echogenicity occurred in only 5 (7.4%) left kidneys and 6 (8.8%) right kidneys.

With respect to CMD, loss of CMD occurred in 27 (39.7%) left kidneys and reduced CMD occurred in 35 (51.5%) left kidneys; only 6

(8.8%) left kidneys could be classified as having preserved CMD. For the right kidneys, there was a loss of CMD in 28 (41.2%) right kidneys, reduction of CMD in 29 (42.6%) right kidneys and preserved CMD in 11 (16.2%) right kidneys. This combined total of lost and reduced CMD was greater than 90% for both sides, which illustrates significant parenchymal degradation throughout the population.

Table 6: Pearson Correlations between Sonographic Renal Measurements and HbA1c

Renal dimension	r	p-value	Significance
Right kidney length with HbA1c	-.270*	0.026	Significant (p<0.05)

Left kidney length with HbA1c	-.366**	0.002	Significant (p<0.01)
Right kidney width with HbA1c	-.255*	0.036	Significant (p<0.05)
Left kidney width with HbA1c	-.259*	0.033	Significant (p<0.05)
Right kidney height with HbA1c	-.198	0.106	Non-significant
Left kidney height with HbA1c	-.312**	0.010	Significant (p<0.01)
Right kidney thickness with HbA1c	-.333**	0.005	Significant (p<0.01)
Left kidney thickness with HbA1c	-.321**	0.008	Significant (p<0.01)

The relationship between HbA1c and ultrasound kidney size measurements (height, width, and length) were assessed with a Pearson correlation coefficient. Most kidney size measurements had a statistically significant negative correlation with HbA1c. The length of the right kidney had a statistically significant negative correlation with HbA1c ($r = -.270$, $p = .026$) while there was a greater magnitude of correlation between HbA1c and the length of the left kidney ($r = -.366$, $p = .002$). The width of both the right ($r = -.255$, $p = .036$) and left kidney ($r = -.259$, $p = .033$) as well as the height of the left kidney ($r = -.312$, $p = .010$) had statistically significant negative correlations with HbA1c. The cortical thickness of both kidneys (right; $r = -.333$, $p = .005$ and left; $r = -.321$, $p = .008$) had a statistically significant negative correlation with HbA1c at the 0.01 level. The height of the right kidney ($r = -.198$, $p = .106$) did not produce a statistically significant correlation with HbA1c.

Table 7: Spearman Correlation Between HbA1c and Duration of Diabetes (N = 68)

Variable pair	p	P-value	N
HbA1c(%) × Diabetes Duration (years)	.368**	0.002	68

An assessment of how HbA1c (%) correlates to diabetes duration (years) via the Spearman correlation coefficient has demonstrated a statistically significant ($p=0.002$) positive

correlation, $p=0.368$ (N=68) (see Table 7). As such, individuals who have experienced diabetes for a longer period of time will typically have higher values of HbA1c.

Table 8: Comparison of Sonographic and Biochemical Parameters between Male and Female Patients

Parameter	Gender	N	Mean	SD	t-value	p-value	Significance
Right Kidney Length (cm)	Male	33	9.12	1.35	1.941	0.056	Non-Significant (p > 0.05)
	Female	35	8.79	1.48			
Left Kidney Length (cm)	Male	33	9.18	1.51	1.953	0.055	Non-Significant (p > 0.05)
	Female	35	8.77	1.66			
Right Cortical Thickness (mm)	Male	33	11.20	3.40	1.835	0.071	Non-Significant (p > 0.05)
	Female	35	10.42	3.60			
Left Cortical Thickness (mm)	Male	33	12.65	3.35	1.776	0.080	Non-Significant (p > 0.05)
	Female	35	11.89	3.70			

eGFR (ml/min)	Male	33	46.20	21.50	-1.724	0.089	Non-Significant (p > 0.05)
	Female	35	50.96	23.40			

Independent sample t-tests were performed on renal dimensions, cortical thickness and eGFR for male and female study participants. Neither the mean right kidney length for males (mean 9.12 ± 1.35 cm) nor for females (mean 8.79 ± 1.48 cm) was significantly different from one another ($t = 1.941$, $p = 0.056$) nor was the mean left kidney length larger in males (mean 9.18 ± 1.51 cm) when compared to females (mean 8.77 ± 1.66 cm) ($t = 1.953$, $p = 0.055$). Males were also significantly thicker (mean 11.20 ± 3.40 mm) than females (mean 10.42 ± 3.60 mm) at the right cortical thickness; however, this difference did not achieve statistical significance ($t = 1.835$, $p = 0.071$). The left cortical thickness of males (mean 12.65 ± 3.35 mm) was significantly thicker than that of females (mean 11.89 ± 3.70 mm), but this difference was also not statistically significant ($t = 1.776$, $p = 0.080$). Males had a lower eGFR (mean 46.20 ± 21.50 mL/min) compared to females (mean 50.96 ± 23.40 mL/min); however, this difference was not statistically significant as well ($t = -1.724$, $p = 0.089$). All p-values were greater than 0.05, indicating that no statistically significant differences exist between renal parameters compared by gender and that was true for this study as well. To investigate the relationship between periods of time against levels of parenchymal changes to the kidneys caused due to diabetes Mellitus; a chi-square analysis was conducted to test for the presence of an association and a statistically significant association was found between these two variables ($\chi^2 = 14.852$, $p = 0.002$).

Of the individuals with a duration of diabetes under ten years, the majority had grade I (22 out

of 34); whereas there were far fewer who demonstrated parenchymal changes of grade II (8 out of 34) or grade III (3 out of 34). Conversely, for individuals with a duration of diabetes of ten years or greater, there was a higher proportion of grade II (12 out of 34) or grade III (14 out of 34) renal parenchymal changes.

These results indicate there is a statistically significant relationship between time since diagnosis of diabetes and severity of renal parenchymal change.

Table 9: Chi-Square Test of Independence Showing the Association between Duration of Diabetes and Renal Parenchymal Grade

Duration of Diabetes	Normal	Grade I	Grade II	Grade III	Total	Chi-Square (χ^2)	p-value
< 10 Years	1	22	8	3	34	14.852	0.002
$\geq$ 10 Years	0	8	12	14	34		(Significant)
Total	1	30	20	17	68		

Table 10: Comparison of eGFR and Serum Creatinine across Left Renal Parenchymal Grades

Parameter	Grade I (n=30)Mean $\pm$ SD	Grade II (n=20)Mean $\pm$ SD	Grade III (n=17)Mean $\pm$ SD	F-value	p-value	Significance
eGFR (ml/min)	58.45 $\pm$ 18.20	45.12 $\pm$ 19.30	33.56 $\pm$ 15.40	12.641	<0.001	Highly Significant
Serum Creatinine (mg/dl)	1.65 $\pm$ 0.65	2.55 $\pm$ 1.10	3.68 $\pm$ 1.55	18.320	<0.001	Highly Significant

A one-way analysis of variance (ANOVA) revealed that renal parenchyma grades exhibited statistically significant differences from one another with regard to estimated glomerular filtration rate (eGFR) as well as creatinine levels measured in serum (F = 12.641, $p < 0.001$; F = 18.320, $p < 0.001$ respectively); mean values for eGFR decreased consistently through time from 58.45 ml/min for grade I, to 45.12 ml/min for grade II, and finally to 33.56 ml/min for grade III whereas mean serum creatinine concentrations were observed to increase throughout the three different increments of renal parenchyma grade (i.e., grade I 1.65 mg/dl; grade II 2.55 mg/dl;

grade III 3.68 mg/dl). These results suggest that a change in the extent of disease in the renal parenchyma has an impact on both the severity of decline in renal function and the magnitude (i.e., quantity or concentration) of creatinine in serum.

Discussion

The present investigation explored the relationship between sonographic renal findings and Type II Diabetes Mellitus in a Pakistani population. A total of 68 diabetic patients were evaluated using renal ultrasonography together with biochemical investigations of the total cohort, 33 males (48.5%) and 35 females (51.5%)

were studied. The mean age of study participants was 52.56 years $\pm$ 11.29 years, and the mean duration from diabetes diagnosis was 9.96 years $\pm$ 4.89 years. The results demonstrate a cohort that is middle-aged and has had a long history of diabetes an important risk factor for developing and progressing Type II diabetes nephropathy. The mean HbA1c level of 7.99% $\pm$ 1.43% indicates that the majority had suboptimal glycemic (blood sugar) control. The mean serum creatinine level (2.44 mg/dL $\pm$ 1.33 mg/dL) and estimated Glomerular Filtration Rate (48.65 mL/min 22.52 mL/min) indicate a significant component of participants suffer from moderate renal impairment. Assessment of renal parenchymal echogenicity demonstrated that 44%-47% were diagnosed as having

Grade I involvement, 28%-29% with Grade II, 22%-25% with Grade III, and the remaining 1.5% of kidneys were considered to have normal parenchyma. Abnormal parenchymal tissue was present in 98.5% of all kidneys, thus this population has a high prevalence of renal involvement as a result of diabetes. The preponderance of kidneys diagnosed with Grade I and II involvement suggests that the majority of patients in this population have early to moderate nephropathy; however, the large number of patients diagnosed with Grade III involvement suggests that many of the cohort members have sustained substantial structural damage to their kidneys. Correlation analyses revealed that for every 1% decrease in HbA1c, there will be a decrease in kidney size; the left kidney length exhibited the strongest negative correlation (r 0.366), followed closely by right cortical thickness (r -0.333) and left cortical thickness (r -0.321). Overall, these data support that when glycemic control is poor, there is a progressively reduced size and cortical thickness of the kidneys. These data support the view that chronic hyperglycemia directly contributes to structural renal injury and highlight the need for maintaining normal glycemic control to limit nephropathic progression. There is a highly significant correlation between the length of time a person has had diabetes and the severity of

nephropathy graded by renal parenchymal grade ($\chi^2=14.852$) $p=0.002$). The majority of patients with a duration of disease less than 10 years exhibited grade I nephropathy changes; whereas, the majority of patients with a duration of disease greater than or equal to 10 years exhibited grade II and III nephropathy changes. This finding provides evidence for the progressive nature of diabetic nephropathy and supports the theory that long-standing hyperglycemia accelerates the progression of renal damage. On the whole, sonographically renal abnormalities are frequently found within Type II diabetic Mellitus patients and correlate highly with poor glycemic control, increased duration of time spent being diagnosed, and reduced renal function. Examples of renal parenchymal damage include decreased kidney size (<9 cm) compared to healthy individuals, loss of renal cortical thickness as evidenced by echogenicity changes, poor ill-defined differentiation of corticomedullary regions by means of decreased contrast between 2 adjacent structures, etc. This supports the indication of a negative association between increases or decreases in glycemic control and duration of time that person has had a diagnosed disease (HbA1c) or biochemical markers of renal function.

Conclusion.

Ultrasound can identify increased echogenicity and reduced cortical parenchymal thickness, as well as reduced renal size. Renal parenchymal abnormalities are common in Type II

Diabetes Mellitus, most often Grade I, and are associated with poor glycemic control and longer disease duration.

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