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ROLE OF ULTRASOUND IN DIAGNOSIS OF DIABETIC NEPHROPATHY IN ADULT

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Abstract: Diabetes mellitus (DM) is a condition marked by insufficient regulation of blood glucose levels. It includes various subtypes such as type 1, type 2, maturity-onset diabetes of the young, gestational diabetes, neonatal diabetes, and steroid-induced diabetes. The purpose of the study was to assess the role of ultrasound imaging in diagnosing Diabetic Nephropathy and to relate ultrasonographic kidney characteristics to laboratory results. A case series study was carried out at the Department of Radiology and Diabetic Center of Ajdabia Hospital in Libya, from March 2023 to December 2023, involving Libyan diabetic patients aged between 18 and 85 years. The results indicated that 149 diabetic patients participated, with ages spanning from 18 to 85. The predominant finding from the kidney ultrasound scans was normal. A statistical correlation was identified between Glomerular Filtration Rate (GFR) and the duration of Diabetes Mellitus (p value < 0.05). However, no significant statistical differences were observed between the duration of DM and the results of the Renal Function Test (RFT), Albuminuria, kidney size, parenchymal thickness, and parenchymal echogenicity (P value > 0.05). In conclusion, it is suggested that renal length and parenchymal thickness are not particularly reliable indicators of the severity or progression of diabetic nephropathy. Conversely, cortical hyperechogenicity has been recognized as a sign of renal functional impairment. Thus, transabdominal ultrasonography seems to be an effective technique for identifying early renal changes in diabetic patients.

Keywords: Diabetes mellitus, Nephropathy, Ultrasound scan, ESRD

1. Introduction

Diabetes mellitus (DM) is a long-term metabolic disorder marked by sustained high blood glucose levels, caused either by insufficient insulin production or impaired cellular response to insulin. The most prevalent forms, type 1 and type 2 diabetes, account for the majority of cases (Al-Rubeaan, 2015; American Diabetes Association, 2013). People with diabetes are at a substantially higher risk of developing chronic kidney disease (CKD), affecting roughly one in three adults. In 2019, diabetes-related kidney disease was responsible for about 2 million deaths, including 1.5 million directly, with an additional 460,000 deaths occurring in 2020 (Zahra & Simanjorang, 2024). Proper management of diabetes including lifestyle modifications such as diet and exercise, pharmacologic treatment, and routine monitoring can prevent or delay the onset of complications (GBDCN, 2020). Diabetic nephropathy defined as the progressive decline of kidney function, may eventually result in end-stage renal disease (ESRD), with diabetes being the leading cause worldwide (Burrows, 2022). Diagnosis typically involves clinical evaluation, including history-taking, physical examination, and imaging studies such as X-ray, ultrasonography (USG), CT, MRI, or renal biopsy.

Ultrasonography is a cost-effective and widely available modality for assessing kidney morphology in diabetic patients and for excluding other causes of nephropathy (Batuman, 2012). Sonographic manifestations of diabetic nephropathy vary, ranging from normal findings to features consistent with CKD. Common ultrasound characteristics include decreased renal length, reduced cortical thickness, increased renal parenchymal echogenicity, marginal contour irregularities, and papillary calcifications (Ham et al., 2023). While ultrasound measurements such as renal length and parenchymal thickness provide useful structural information, they can be influenced by observer variability. Some studies have shown that renal length may not reliably reflect disease progression in diabetic nephropathy (Shaw, 2016), whereas renal cortical thickness and kidney volume may serve as better indicators of functional impairment (Beland et al., 2010). Furthermore, renal cortical echogenicity has been found to strongly correlate with histopathological changes and serum creatinine levels, highlighting its value as a functional biomarker (Smith et al., 2022). Overall, ultrasound assessment of diabetic kidneys is essential for early detection of nephropathy, monitoring disease progression, and informing clinical management, complementing laboratory evaluations such as serum creatinine, urea, and Glomerular Filtration Rate (GFR).

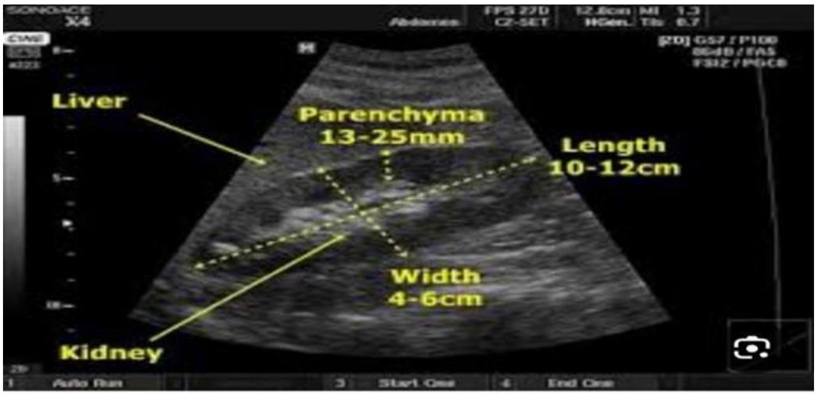

Figure 1. Normal kidney dimensions: the width measured (4-6 cm), length measured (10-13) and parenchymal thickness measured (13-25 mm)

Source: The authors (2025)

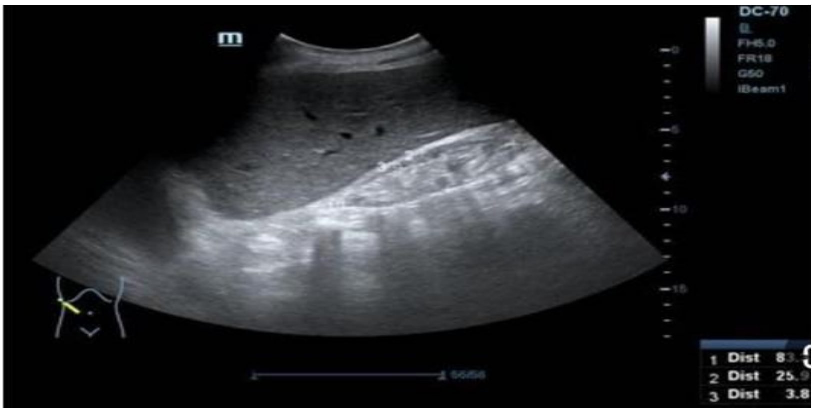

Figure 2. Reveals small kidney size and raised parenchymal echogenicity with reduced parenchymal thickness in diabetic patient compared to the image in (Figure 1).

Source: The authors (2025)

2. Research Method

A descriptive case-series study was conducted on 149 adult diabetic patients at the Department of Radiology and Diabetic Center, Ajdabia Hospital, Libya. Renal ultrasound examinations were performed using a GE ultrasound system with a 3.5–5 MHz curvilinear transducer in grayscale B-mode (See Figure 3). Renal parameters assessed included renal length (interpolar), cortical thickness, and parenchymal echogenicity (compared with liver and spleen). Patients were examined in supine and lateral positions. Laboratory parameters included serum urea, creatinine, HbA1c, albuminuria, and estimated GFR. Statistical analysis was performed using SPSS version 25. Continuous variables were expressed as mean ± SD, and categorical variables as frequencies and percentages. Chi-square and Student's t-tests were used. A p-value < 0.05 was considered statistically significant.

Figure 3. The curvilinear probe that used in abdomen scan with frequency range from 3-5 MHZ

Source: The authors (2025)

For assessment of renal parameters like renal length (measured by interpolar length), renal parenchymal echogenicity, compared with echogenicity of adjacent normal organs (liver and spleen), renal cortical thickness (cortico- medullary thickness), and biochemical parameter were recorded for comparison, patient in supine and lateral position (Figure 4).

Figure 4. Patient position at USS scan in supine position and the probe placed at the midaxillary line (imaginary anatomical line) in oblique orientation

Source: The authors (2025)

The Statistical Package for the Social Sciences (SPSS) version 25 for Windows was used to analyze the collected data. Continuous variables were presented as mean and standard deviation (SD). Categorical variables were expressed as frequencies and percentages. The Chi-square test was used to compare categorical data, and summary tables and figures were included as needed. The Student t-test was used for variable comparisons. A significance level below 0.05 was the threshold for statistical significance.

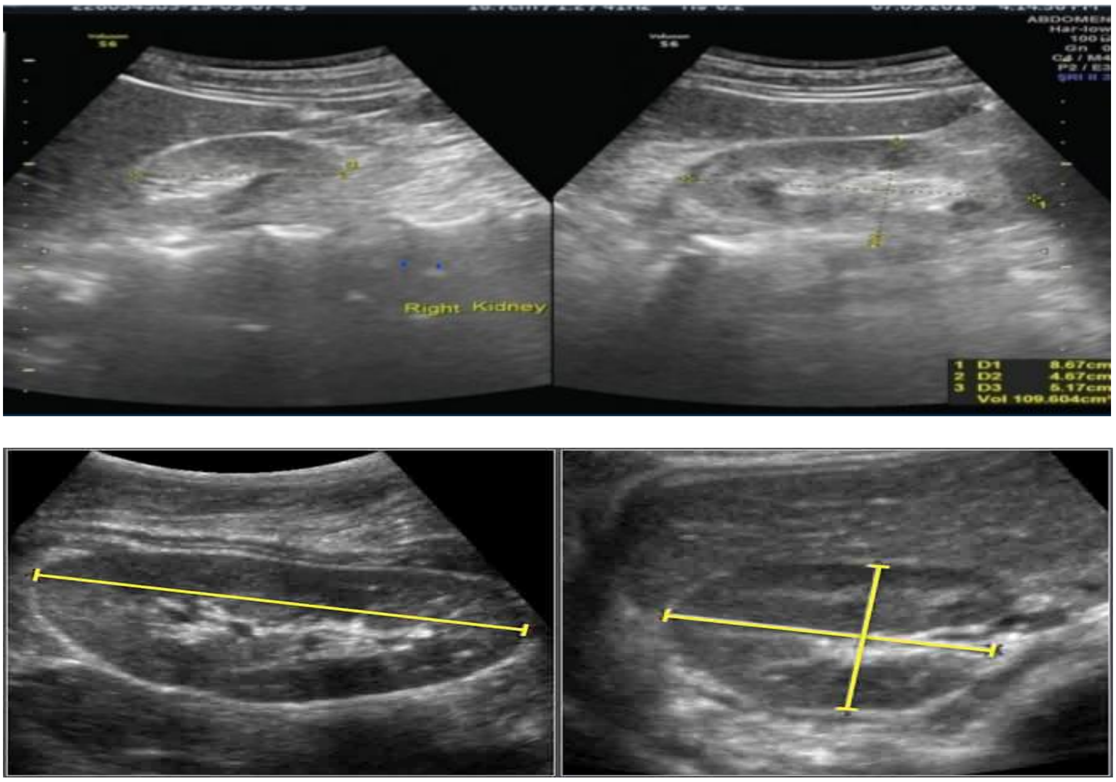

Figure 5. Ultrasonographic measurement of the length, depth and width of the kidney. Kidney volume is calculated using the ellipsoid formula as Length x Width x Depth x 0.523.

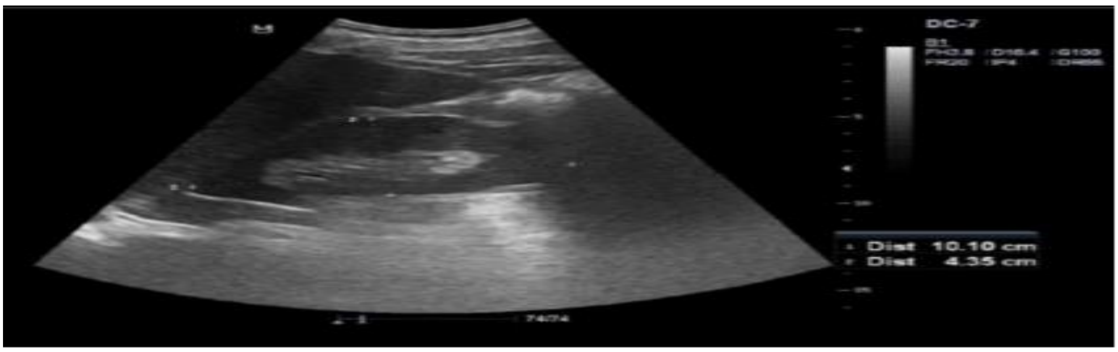

Figure 6. Echogenicity grading by comparing between liver and adjacent kidney echo the kidney should not be hyper echoic than the liver

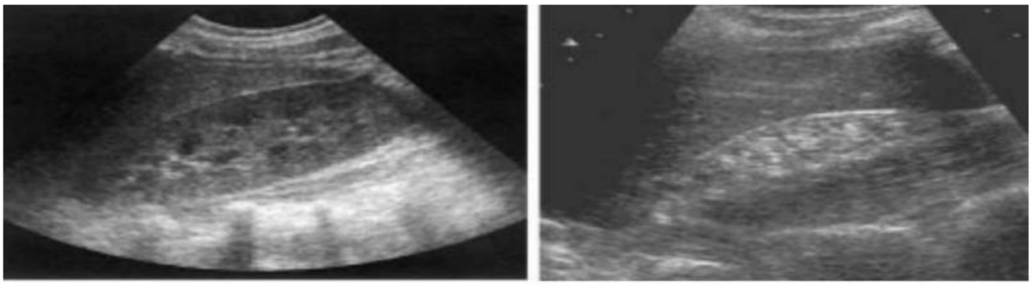

Figure 7. Normal renal echogenicity raised echogenicity with reduced size

Figure 8. On the left image: small kidney size with noticeable parenchymal thickness reduction (small atrophic kidney) comparing with normal kidney size that displays on right image

3. Results Analysis

One hundred and forty-nine patients were included in this study, with ages ranging from 18 to 85 years and a mean age of 57.93 ± 12.183 years. Seventy-three of the patients were males (49%) and seventy-six were females (51%). The vast majority of the patients weighed between 60 to 100 kg (82.6%), with 10.7% weighing less than 60 kg and 6.7% weighing more than 100 kg. The duration of diabetes mellitus (DM) was found to be more than 15 years in 38.4% of patients, 10-15 years in 35.6%, 5-10 years in 11.4%, 1-5 years in 11.4%, less than 1 year in 0.7%, and less than 6 months in 2.7%. Additionally, 79.9% of the patients had a positive family history of DM, while 20.1% had a negative family history. The study revealed that out of 149 patients, 80 (53.7%) were on oral hypoglycemic treatment, 45 (30.2%) were on both oral hypoglycemic and insulin, and 24 (16.1%) were on insulin injections. The vast majority of the patients, 106 (71.1%), were regular with their treatment, while 43 (28.9%) were irregular. Furthermore, 85 (57%) patients had high HbA1c levels, 37 (24.8%) had controlled levels, and 27 (18.1%) had uncontrolled levels of HbA1c. According to the laboratory data of renal function tests (RFT), 124 (83.2%) patients had normal blood urea levels, while 25 (16.8%) had high (abnormal) levels. Similarly, 127 (85.2%) patients had normal serum creatinine levels, while 22 (14.8%) had raised levels. Albuminuria was found in 109 (73.2%) patients, with 35 (23.5%) having microalbuminuria and five (3.4%) having macroalbuminuria. In terms of glomerular filtration rate (GFR), 89 (59.7%) had normal kidney function, 44 (29.5%) had mild loss, 9 (6%) had moderate to severe loss, 6 (4%) had mild to moderate loss, and 1 had severe loss of kidney function.

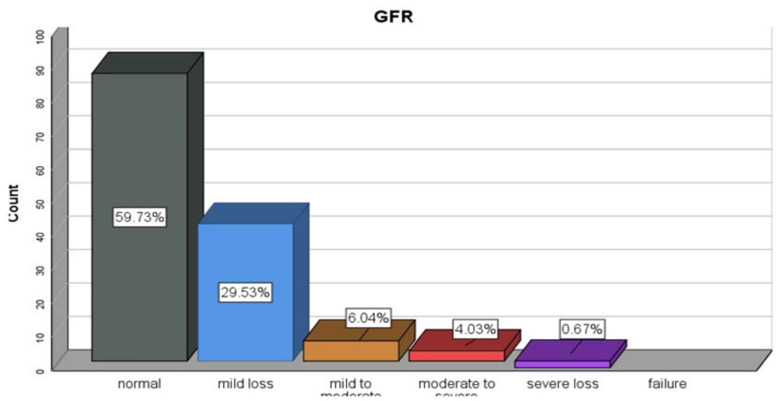

Figure 9. GFR result of the diabetic patients

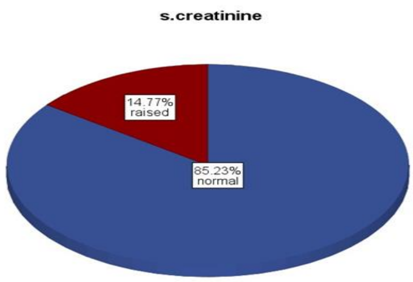

Figure 10. S. Creatinine level

Table 1. Distribution of the patients according to their Urea level

Urea	Frequency	Percentage
Normal	124	83.2%
Abnormal	25	16.8%
Total	149	100%

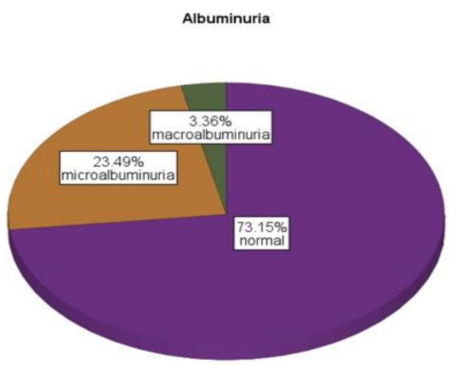

Figure 11. albuminuria level

Table (2) shows that 141 (94.6%) of the patients had normal kidney size, while only 8 (5.4%) had abnormal kidney size (small or large). In Table (3), 119 (79.9%) patients had normal parenchymal thickness of the kidney, 29 (19.5%) had decreased parenchymal thickness, and 1 patient (0.7%) had increased thickness. Figure (4) displays the ultrasound examination of the patients' parenchymal echogenicity of both kidneys, with the vast majority being normal in 123 (82.6%) patients, and 26 (17.4%) patients having raised parenchymal echogenicity.

Table 2. Kidneys size measurement

	Frequency	Percentage
Normal	141	94.6%
Abnormal	8	5.4%
Total	149	100%

Table 3. Measurement of corticomedullary thickness

	Frequency	Percentage
Decrease	29	19.5%
Normal	119	79.9%
Increase	1	0.7%
Total	149	100%

Table 4. Parenchymal echogenicity

	Frequency	Percentage
Normal	123	82.6%
Raised	26	17.4%
Total	149	100%

Table 5. Distribution of the patients according to parenchymal Echogenicity of kidneys and S.creatinine results

		Echogenicity		Total
		Normal	Raised	
s.creatinine	Normal	117	10	127
		95.1%	38.5%	85.2%
	Raised	6	16	22
		4.6%	61.5%	14.8%
Total		123	26	149
		100%	100%	100%

The results shows that the patients with normal s. creatinine 117 (95.1%) patients had normal parenchymal echo, 10 (38.5%) patients had raised parenchymal echogenicity with normal Creatinine level. Furthermore, there were 6 (4.9%) of patients had raised s. creatinine patients with normal parenchymal echogenicity and 16 (61.5%) patients had raised parenchymal echogenicity. Most of patients had normal kidneys size in Uss with different history of DM, and only 8 (5.4%) patients had abnormal kidneys size. Table (6) shows that normal kidney size in 122 (86.5%) patients with normal s. creatinine and 19 (13.5%) patients with raised s. creatinine. Abnormal kid. Size in 5 (62.5%) patients with normal s. creatinine and in 3 (37.5%) patients with raised s. creatinine level.

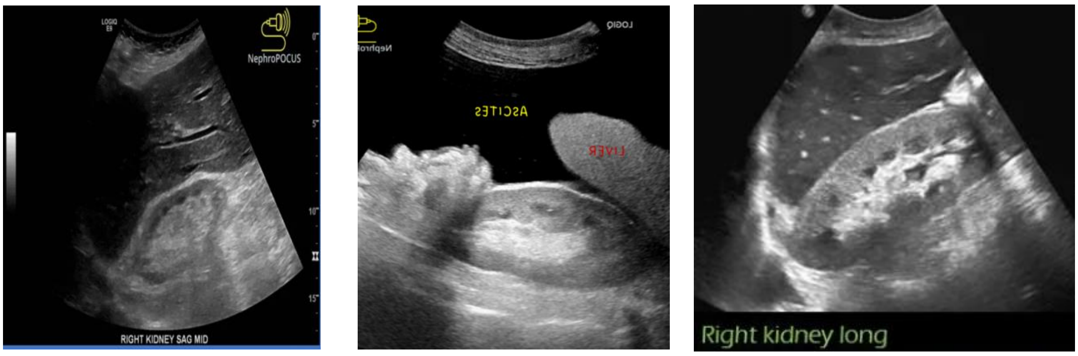

Figure 10. Hyperechoic kidney obtained from a patient with CKD stage IV. Note the loss of cortico- medullary differentiation, typically seen in CKD, also in the middle image the ascites that indicate ESRD

Table 6. Distribution of the patients according to their HbA1c and S. creatinine results

		Hb A1c		**Total**
		Normal	**Abnormal**	
Serum creatinine	Normal	122	5	127
		86.5%	62.5%	85.2%
	Raised	19	3	22
		13.5%	37.5%	14.8%
Total		141	8	149
		100%	100%	100%

Table 7. Distribution of the patients according to their GRF and chronicity of DM

		GFR					Total
		normal	mild loss	mild to moderate	moderate to severe	severe loss	
How Long DM	Less than six months	2	1	0	1	0	4
		50.0%	25.0%	0.0%	25.0%	0.0%	100.0%
	From 6 months to less than one year	1	0	0	0	0	1
		100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	From one year to less than 5 years	10	6	0	1	0	17
		58.8%	35.3%	0.0%	5.9%	0.0%	100.0%
	From 5 years to less than 10 years	10	5	2	0	0	17
		58.8%	29.4%	11.8%	0.0%	0.0%	100.0%
	From 10 years to less than 15 years	41	10	1	1	0	53
		77.4%	18.9%	1.9%	1.9%	0.0%	100.0%
	More than 15 years	25	22	6	3	1	57
		43.9%	38.6%	10.5%	5.3%	1.8%	100.0%
Total		89	44	9	6	1	149
		59.7%	29.5%	6.0%	4.0%	0.7%	100.0%

4. Discussion

A total of 149 patients participated in our study, of whom 73 (49%) were male and 76 (51%) were female. The mean age of the participants was 57.93 years (refer to Table 1). No specific pattern of sonographic grading was observed across different age groups, and the findings were consistent between males and females. Diabetic nephropathy is one of the most common complications of diabetes mellitus, making accurate diagnosis crucial for effective treatment and improved patient outcomes. Evaluation typically involves a combination of clinical history, patient complaints, and radiological investigations such as ultrasonography, with laboratory tests providing further confirmation. Ultrasonography is widely available, cost-effective, and provides real-time information regarding renal size and echogenicity. In this study, renal length was measured as the longest diameter on a posterior oblique image. A length below 8 cm was considered reduced and indicative of chronic kidney disease, while lengths above 14 cm were considered enlarged. Kidney size was affected in 8 patients (5.4%), whereas 141 patients (94.6%) had kidneys of normal size. By comparison, Moccia et al. (1980) reported altered kidney size in 57% of patients with chronic kidney disease. Normal parenchymal thickness ranges from 1.5 to 2 cm. In our study, 119 patients (79.9%) had normal parenchymal thickness, while 29 (19.1%) showed reduced thickness. These findings align with those of Moghazi et al. (2005), who reported a mean parenchymal thickness of 1.71 cm. Ultrasonography was also able to identify underlying causes of chronic renal impairment, such as renal calculi or polycystic kidney disease.

Serum creatinine and urea levels were used as markers of renal function, with glomerular filtration rate serving as an additional index. Our study demonstrated a good correlation between renal cortical echogenicity and serum creatinine and urea levels. Although bilateral renal length and parenchymal thickness tended to decrease with progression of diabetes, this decrease was not statistically significant ($p > 0.05$). Therefore, renal length and parenchymal thickness may not serve as reliable indicators of diabetic nephropathy severity or progression. This is consistent with findings by Shaw et al. (2016), who reported that renal length did not show a linear relationship with disease progression. In patients with diabetes, secondary renal parenchymal changes, such as cortical hyper-echogenicity, have been reported as indicators of functional impairment. Beland et al. (2010) noted that renal cortical thickness measured by ultrasonography is a better indicator of renal function than renal length, showing a significant correlation with GFR using the Cockcroft-Gault equation ($p < 0.0001$), whereas the relationship between GFR and renal length was weaker ($p = 0.003$). Jayanth et al. (2018) observed that both renal length and parenchymal thickness decreased as diabetic nephropathy progressed. Other recent study by Smith et al. (2022) emphasized the importance of renal cortical echogenicity as a biomarker of kidney health, reporting strong correlations with histopathologic severity and serum creatinine levels, while renal length and parenchymal or cortical thickness did not show significant correlations with renal function

5. Conclusion

Ultrasound scanning has been the best choice for assessing diabetic induced nephropathy. It reveals that the diabetes has a direct impact on kidney morphology with renal volume enlargement and cortical thickening in the early stages, followed by atrophy and abnormal echogenicity in the late stages.

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