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Research Article

Renal Vascular and Morphological Alteration in Type 2 Diabetes with Preserved Renal Function: Comparative Analysis Study with Non-diabetic Subjects

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Abstract

Background: Diabetes is a chronic systemic disorder; it is a major cause of chronic kidney disease. Early diagnosis and timely intervention are crucial in preventing further progression. ***Objective***: To evaluate renal changes in type 2 diabetes with normal renal function using ultrasonography compared to healthy controls. ***Methods***: History, anthropometric measures, and laboratory investigations were performed for all participants. All participants were normotensive with normal renal function. For both groups, renal ultrasonography was used to evaluate renal length, parenchymal thickness, interlobar artery diameter, and renal resistive index of the kidneys. Correlation analysis was sought between renal parameters and clinical, anthropometric, and laboratory parameters for the diabetic group. ***Results***: 105 diabetic and 110 healthy controls were included. The mean age of the diabetic group was 53.5 years and 53.6 years in the non-diabetic group. The mean body mass index (BMI) for diabetics was 27.5 and 26.7 in non-diabetics (p>0.05). A significantly higher HbA1c, fasting blood sugar (FBS), and S. creatinine level in diabetics. There was a big difference in the kidney parameters of both groups. Diabetic patients had a significantly longer left kidney, more parenchymal thickness, a resistive index, and a decrease in interlobar artery diameter compared to the non-diabetics. The right kidney length was the same between the groups. Patient age, BMI, diabetes duration, HbA1c, and FBS levels may have predicted these differences. ***Conclusions***: Renal ultrasound is valuable in early detection of structural and vascular changes in the diabetic population.

Keywords: Diabetes mellitus, Renal changes, Renal resistive index, Ultrasonographic dimensions.

التغيرات الوعائية الكلوية والمورفولوجية في مرض السكري من النوع الثاني مع وظائف الكلى الطبيعية: دراسة تحليل مقارن في غير مرضى السكري

الخلاصة
الخلفية: مرض السكري هو اضطراب جهازي مزمن؛ وهو سبب رئيسي لأمراض الكلى المزمنة. يعد التشخيص المبكر والتدخل في الوقت المناسب أمرا بالغ الأهمية في منع المزيد من التقدم. **الهدف**: تقيم هذه الدراسة التغيرات الكلوية في مرض السكري من النوع الثاني مع وظائف الكلى الطبيعية باستخدام الموجات فوق الصوتية مقارنة بالضوابط الصحية. **الطرائق**: تم إجراء أخذ التاريخ والقياسات الأنثروبومترية والفحوصات المعملية لجميع المشاركين. وفقا لمستوى الكرياتينين الطبيعي، كان جميع المشاركين لديهم وظائف كلى طبيعية وجميعهم ذو ظغط دم طبيعي. بالنسبة لكلتا المجموعتين، تم استخدام التصوير بالموجات فوق الصوتية الكلوية لمعرفة طول وسمك وقطر الشريان بين الفصوص ومؤشر المقاومة الكلوية للكلى. تم البحث عن تحليل الارتباط بين المعلمات الكلوية والمعلمات السريرية والأنثروبومترية والمختبرية لمجموعة مرضى السكري. **النتائج**: تم تضمين 105 من مرضى السكري و 110 من الأشخاص الأصحاء. كان متوسط عمر مجموعة مرضى السكري 53.5 سنة و 53.6 سنة في المجموعة غير المصابة بالسكري. كان متوسط مؤشر كتلة الجسم (BMI) لمرضى السكري 27.5 و 26.7 في غير مرضى السكر (p>0.05). كان هناك ارتفاع ملحوظ في مستوى HbA1c، وسكر الدم الصائم (FBS)، و مستوى الكرياتينين لدى مرضى السكر. كان هناك فرق كبير في معلمات الكلى لكلتا المجموعتين. كان لدى مرضى السكري كلية يسرى أطول بكثير، وسمك متني أكثر، ومؤشر مقاومة أعلى، وانخفاض في قطر الشريان الفصحي مقارنة بغير مرضى السكر. كان طول الكلية الأيمن هو نفسه بين المجموعات. كان عمر المريض ومؤشر كتلة الجسم ومدة مرض السكري و HbA1c و FBS بعض العوامل التي يمكن أن تتنبأ بهذه الاختلافات. **الاستنتاجات**: الموجات فوق الصوتية الكلوية ذات قيمة في الكشف المبكر عن التغيرات الهيكلية والأوعية الدموية لدى مرضى السكري.

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INTRODUCTION

Diabetes is a chronic systemic disease caused by metabolic disturbance in insulin secretion and/or insulin action that leads to hyperglycemia with long-term macrovascular and microvascular complications that lead to damage in various body organs, with about 1.5-2.2 million annual deaths before the age of 70 years [1]. Diabetic nephropathy is one of the microvascular complications in diabetes, and it is the leading cause of chronic kidney disease (CKD) [2]. CKD is a global health burden that leads to renal failure; it affects approximately 40% of type 2 diabetic populations [3]. It is characterized by albuminuria and/or a decreased estimated glomerular filtration rate (eGFR), which is calculated through the S. creatinine level [4]. Typically, it develops after 10 years in type 1 diabetes and can be present at the time of diagnosis in type 2 diabetes, because patients are typically asymptomatic in early disease stages [5,6], and a significant proportion of diabetics go to renal impairment without albuminuria [2]. Several researchers reported that changes in diabetic kidney size and shape occur earlier than the development of albuminuria and decrease in eGFR [1], as these biomarkers don't show early structural changes in the kidney [7]. Since early detection is critical in decreasing progression with effective management, a widespread invention is needed to improve the outcomes. Ultrasound imaging provides a good non-invasive tool to detect structural changes in the kidneys; it has a low cost and is suitable for follow-up [8]. Although the current recommendation of diabetic kidney disease screening in diabetic patients is by measures of albumin urea and eGFR [9]. Several studies suggest that renal ultrasound provides useful prognostic information in diabetic patients with renal disease [1,3,6,9]. There are limited studies about structural renal changes in diabetics with normal renal function in comparison with healthy adults. This study aims to study the impact of diabetes on structural renal changes before the development of renal impairment in comparison to healthy control.

METHODS

Study design and setting

It was a case-control retrospective study conducted at the Department of Radiology from September 2024 to July 2025. This included a total of 232 adult subjects: 122 diabetic patients and 110 healthy controls, referred from the endocrine and internal medicine clinic for abdominal ultrasound after taking oral consent. 15 diabetic patients were excluded due to 6 with renal stones, 5 with multiple renal cysts, 1 with renal mass, and 3 uncooperative patients with inadequate breath holding and 2 with severe gaseous bowels, so 105 diabetics were included in the final analysis in comparison with 110 healthy subjects; the sample size was chosen according to meaningful and significant results of previous studies [6,10].

Data collection and laboratory parameters

The socio-demographic data, age, weight in kilograms (kg), and height in meters (m) were recorded, and the body mass index (BMI) calculated as BMI=weight (kg)/height^2 (m^2). History about diabetes duration, smoking, hypertension, heart failure, and other chronic illnesses to confirm inclusion criteria, Laboratory investigations are carried out after an overnight fast for at least 8 hours for fasting blood sugar (FBS), HbA1c, blood urea, serum creatinine, and a general urine exam for albumin.

Inclusion criteria

This study included patients 35-75 years old with a known history of T2DM, non-hypertensive with normal renal function (S. creatinine up to 1.1 mg/dl) [7], with no albumin urea, and healthy control. 40-70 years old without a history of DM or HTN; both groups didn't have history of chronic illness, not consuming alcohol, and not complaining of abdominal pain; all of them gave verbal consent to participate in this study.

Exclusion criteria

Patients with elevated blood urea and S. creatinine or with albuminuria, signs of CKD, renal artery stenosis, renal vein thrombosis, obstructive uropathy, unilateral renal agenesis or hypoplasia, congenital renal anomaly, urinary tract infection, patients with heart or respiratory failure, connective tissue disease, pregnancy, or a history of alcohol consumption and cigarette smoking.

Renal ultrasound and Doppler study

Both kidneys were evaluated with the Samsung HS40 using a convex array probe (C2-8). By an expert radiologist with 10 years of experience with abdominal and Doppler ultrasound according to the AIUM Guideline for the Performance of an Ultrasound Examination [11]**.** The patient was placed in a supine position or right-side-up decubitus to examine the right kidney, with the sonologist sitting on the right side of the patient. The probe was positioned on the flank in an oblique projection, and the left kidney was examined in the left lateral position with the patient's left arm extended over the head, asking the patient for maximum Suspended inspiration, firstly assessment of renal morphology using grey scale ultrasound ,then measuring pole to pole renal length, mean renal parenchymal thickness (from renal sinus to renal capsule at upper , middle , lower renal segment), then power doppler were used with same ultrasound probe to visualized renal vascular structures exclude renal vascular abnormality like renal artery stenosis, renal vein thrombosis, then the color box positioned at three site of renal parenchyma (upper, middle and lower pole) to measure diameter of interlobular artery at mid portion along the renal pyramid , then the pulsed doppler positioning at the interlobar arteries with 2-4 mm sample volume , and less than 60 degrees angle of ionization. We used the lowest pulse repetition frequency for the Doppler spectral flow wave to find the interlobar artery resistive index. The peak systolic velocity and end diastolic velocity were used to do automatic calculation. Resistive index (RI) = Peak systolic flow velocity - End diastolic flow velocity / Peak systolic flow velocity, and then the mean value of interlobar artery diameter and RI measurements was calculated from these three segments. Time required for the renal Doppler study was approximately 15 minutes for each patient. Values of renal length in centimeters, parenchymal thickness in millimeters, interlobar artery diameter in millimeters, and resistive index were recorded for both kidneys in the diabetic and healthy groups and included in the final statistical analysis (Figures 1 and 2).

Figure 1: **A**) Renal ultrasonic measures of renal length and paranchymal thickness; **B**) Power doppler study of interlobar artery.

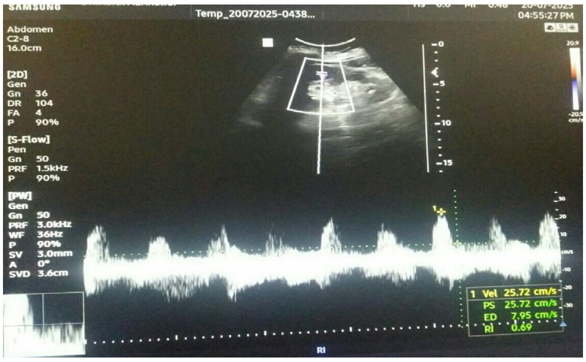

Figure 2: Spectral doppler of interlobar artery with measuring of resistive index.

Ethical considerations

Participation in this study was completely voluntary, with a high desire to do a checkup through abdominal ultrasound, as the examination and laboratory investigations were free without any fees. The study protocol was reviewed and approved by the Institutional Review Board (IRB) with the patient's consent and confidentiality (certificate ID: N 9713, date 17/8/2024).

Statistical analysis

Data were analyzed using Statistical Software for Social Sciences (SPSS) version 26.0. Continuous variables are expressed as mean ± standard deviation (SD), while categorical ones are expressed as frequency and percentage. Differences between two groups using an independent sample t-test for continuous normally distributed variables and a Mann-Whitney U test for continuous abnormally distributed variables. Chi-square test used for comparing categorical variables. In the diabetic group, correlation analysis was performed using Pearson's correlation test; a p-value < 0.05 indicates statistical significance.

RESULTS

The whole participant demographic character is shown in Table 1. The mean age in the diabetic group was 53.5 ± 10.9 years and 53.6 ± 9 years in the nondiabetic group. The mean BMI for the diabetic group was 27.5 ± 3.5, and in the non-diabetic group (26.7 ± 3.4), the difference in patients' characters was not significant.

Table 1: Demographic characteristic of diabetic and healthy subjects

Parameter	Diabetic	Healthy	*p*-value
Age (year)	53.5±10.9	53.6±9.0	0.93
Weight (kg)	80.4±9.6	78.5±9.3	0.15
Height (cm)	166.6±3.6	165.8±4.6	0.14
BMI (kg/m^2)	27.5±3.5	26.7±3.4	0.09

Values are expressed as mean±SD.

The percentage (n) of female participants was 54.2% (n= 57) in the diabetic group and 54.5% (n= 60) in the non-diabetic group. The mean diabetic duration was 5.9 ± 2.2 years. The laboratory parameters shown in Table 2 show a statistically significant difference between groups, with higher HbA1c, FBS, and serum creatinine levels in diabetic patients.

Table 2: laboratory parameter of diabetic and healthy subjects

Parameter	Diabetic	Healthy	*p*-value
HbA1c (%)	7.4±0.9	5.5±0.4	<0.001
FBS (mg/dl)	139.6±15.3	86.3±12.2	<0.001
S. Creatinine (mg/dl)	0.9±0.2	0.8±0.2	0.02

Values are expressed as mean±SD.

There was a significant difference in renal parameters of both kidneys between the groups (Table 3), as the diabetic patients show higher left renal length, bilateral increase in parenchymal thickness, bilateral increase in resistive index (although the whole participant had a normal resistive index not more than 0.7), and bilateral decrease in interlobar artery diameter in comparison with the non-diabetic (p< 0.05). Except for right renal length, no significant difference was noted between the two groups (p= 0.93).

Table 3: comparison of renal parameter between two group

Parameter	Diabetic	Healthy	*p*-value
Right renal length	10.59±0.3	10.58±0.3	0.9331
Right resistive index	0.62±0.04	0.57±0.03	<0.0001
Right parenchymal thickness	16.9±1.0	16.5±1.5	0.023
Right interlobar artery diameter	3.7±0.4	4.0±0.3	<0.0001
Left renal length	10.9±0.5	10.7±0.4	0.001
Left resistive index	0.63±0.04	0.56±0.03	<0.0001
Left parenchymal thickness	17±1.0	16.7±0.9	0.022
Left interlobar artery diameter	3.7±0.18	3.9±0.2	<0.0001

Correlation analysis in diabetic patients was performed using Pearson's correlation test to estimate factors affecting renal morphology and Doppler indices. r is the correlation coefficient, and (p< 0.05) indicates significant correlation (Tables 4 and 5). Right renal length shows a significant positive correlation with BMI (r= 0.24) and HbA1c (r= 0.31), while a negative correlation is seen with patient age (r= -0.22). Similarly, left renal length shows a significant positive correlation with body weight (r= 0.2) and BMI (r= 0.26).

Table 4: Right renal correlation analysis

Renal parameter	Predictor	Correlation coefficient (r)	*p*-value
Right renal length	Age	-0.22	0.022
Right renal length	Weight	0.1	0.3
Right renal length	Height	-0.13	0.06
Right renal length	BMI	0.24	0.013
Right renal length	Diabetes duration	-0.17	0.07
Right renal length	HbA1c	0.31	<0.001
Right renal length	FBS	-0.18	0.07
Right renal length	S. creatinine	0.15	0.08
Right parenchymal thickness	Age	-0.02	0.82
Right parenchymal thickness	Weight	0.004	0.96
Right parenchymal thickness	Height	0.64	<0.001
Right parenchymal thickness	BMI	0.24	0.01
Right parenchymal thickness	Diabetes duration	-0.48	<0.001
Right parenchymal thickness	HbA1c	-0.12	0.36
Right parenchymal thickness	FBS	-0.12	0.2
Right parenchymal thickness	S. creatinine	-0.12	0.24
Right artery diameter	Age	-0.36	<0.001
Right artery diameter	Weight	-0.16	0.08
Right artery diameter	Height	0.47	<0.001
Right artery diameter	BMI	-0.36	<0.001
Right artery diameter	Diabetes duration	-0.57	<0.001
Right artery diameter	HbA1c	-0.008	0.93
Right artery diameter	FBS	-0.44	<0.001
Right artery diameter	S. creatinine	-0.15	0.09
Right resistive index	Age	0.32	<0.001
Right resistive index	Weight	-0.04	0.6
Right resistive index	Height	-0.19	0.65
Right resistive index	BMI	0.16	0.1
Right resistive index	Diabetes duration	0.39	<0.001
Right resistive index	HbA1c	0.45	<0.001
Right resistive index	FBS	0.73	<0.001
Right resistive index	S. creatinine	0.15	0.2

Ultrasound dimensions are measured in mm.

Table 5: Left renal correlation analysis

Renal parameter	Predictor	Correlation coefficient (r)	*p*-value
Left renal length	Age	-0.007	0.94
Left renal length	Weight	0.2	0.04
Left renal length	Height	-0.14	0.13
Left renal length	BMI	0.26	0.007
Left renal length	Diabetes duration	-0.11	0.23
Left renal length	HbA1c	0.039	0.69
Left renal length	FBS	-0.18	0.07
Left renal length	S. creatinine	0.16	0.26
Left parenchymal thickness	Age	-0.26	0.006
Left parenchymal thickness	Weight	0.09	0.33
Left parenchymal thickness	Height	-0.09	0.34
Left parenchymal thickness	BMI	0.15	0.11
Left parenchymal thickness	Diabetes duration	-0.09	0.32
Left parenchymal thickness	HbA1c	-0.05	0.60
Left parenchymal thickness	FBS	0.04	0.62
Left parenchymal thickness	S. creatinine	-0.12	0.24
Left artery diameter	Age	0.11	0.25
Left artery diameter	Weight	0.11	0.25
Left artery diameter	Height	0.16	0.1
Left artery diameter	BMI	0.06	0.54
Left artery diameter	Diabetes duration	-0.29	0.001
Left artery diameter	HbA1c	0.42	<0.001
Left artery diameter	FBS	0.03	0.71
Left artery diameter	S. creatinine	-0.15	0.1
Left resistive index	Age	-0.17	0.07
Left resistive index	Weight	0.24	0.01
Left resistive index	Height	0.19	0.06
Left resistive index	BMI	0.04	0.63
Left resistive index	Diabetes duration	0.32	0.02
Left resistive index	HbA1c	0.15	0.12
Left resistive index	FBS	-0.06	0.48
Left resistive index	S. creatinine	0.18	0.07

Ultrasound dimensions are measured in mm.

There was no significant correlation of either renal length with other parameters. A significant positive correlation is seen between RT renal parenchymal thickness and patient height (r= 0.64) and BMI (r= 0.24), and a significant negative correlation is seen with diabetes duration (r= -0.48). The left renal parenchymal thickness shows a significant negative correlation with patient age (r= -0.26), and no significant correlation is seen with weight, BMI, diabetes duration, HbA1c, FBS, and S. Creatinine. Regarding the interlobar artery diameter on the right side, a significant negative correlation is seen with age, BMI, diabetes duration, and FBS; they demonstrated correlation coefficients of -0.36, -0.36, -0.57, and -0.44, respectively; in addition to a positive correlation with height coefficient (r = 0.47), as a taller person has a wider artery diameter. On the left side, a negative correlation is seen with diabetes duration (r= -0.29), and a positive correlation is seen with HbA1c (r= 0.42). RT renal RI shows a significant positive correlation with age, diabetes duration, HbA1c, and FBS with correlation coefficients of 0.32, 0.39, 0.45, and 0.73, respectively. On the left a positive correlation is seen with weight (r= 0.24) and diabetes duration (r= 0.32), no significant correlation is seen with age, HbA1c, FBS, and S. Creatinine. The RT kidney is affected more than the left one, with multiple predictors affecting renal length, PT, artery diameter and RI.

DISCUSSION

Diabetes is a global health problem with poor outcomes. Its prevalence is increasing; it is one of the most important and life-threatening complications in renal disease that progresses to end-stage renal failure [12]. Ultrasound evaluation of renal morphology is a useful method for all types of renal disease. In most cases of CKD, there is a decrement in renal size due to atrophy and fibrosis; except in DKD, there is normal renal length even with disturbed renal function [13]. This study sought morphological renal changes in diabetics with normal kidney function and found significant changes in renal parameters in comparison to the healthy group, as the length of the left kidney and parenchymal thickness of both kidneys were higher in diabetics than those of non-diabetics, although the difference is small to modest but statistically significant, and these findings indicate structural renal changes, as the increase in renal size might be a compensatory mechanism of hyperfiltration to clear protein from urine [14]. This was similar to observations by Omer *et al.* (2014) and Dsouza *et al*. (2024) [14,15]. A previous study that was carried out on diabetic patients with normal renal function showed an increase in renal volume and parenchymal hypertrophy in comparison with a non-diabetic control [1,6]. In contrast to the study by Ham et al., which showed no significant difference in renal size and parenchymal thickness between diabetic and non-diabetic despite poor renal function, renal length doesn’t correlate with eGFR [16]. Renal length was similar between type 2 DM and non-diabetics, but renal parenchyma thickness was higher in the diabetic group. Koc's observation matched ours; there were no changes in the length of the right kidney between the two groups, even though both groups had thickening of the parenchyma [17]. These findings mean the structural renal changes in diabetics develop before proteinuria and decrease renal function [18]. In this study, although all subjects had a resistive index not more than 0.7, the normal range is 0.47–0.70 [19]. The diabetic group shows a significantly higher resistive index than healthy individuals with decreased interlobar artery diameter of both kidneys; this might be related to the high frequency of macrovascular complications in diabetes with accelerated atherosclerotic changes in renal arteries that lead to thickening of the arterial wall, decreased luminal diameter, and increased flow resistance [20]. Mancini *et al.* and Dsouza *et al*. showed similar observations in diabetics despite normal renal function and no proteinuria [6,15]. Kuttancheri *et al.* found many subjects with RI less than 0.7 were in the early stage of diabetic neuropathy, and the increase in RI was due to interstitial fibrosis based on histopathological analysis [21]. These results mean a decrease in arterial diameter and increased resistance may be due to atherosclerotic changes or renal fibrosis, as proved by Kirteke *et al*. in a study that supports the importance of renal Doppler in the follow-up of diabetic patients [22]. A meta-analysis study by Heather et al suggested that elevated RI can be used for early detection of diabetic neuropathy [3]. The RI of interlobar arteries is a dependable marker of intrarenal changes, and it is an independent predictor of deterioration in renal function [23]. In contrast to the study by Koc, when he noted no difference in renal RI between patients with type 2 diabetes mellitus without diabetic nephropathy and healthy non-diabetics [17]. Regarding the correlation analysis, bilateral renal length shows a significant positive correlation with weight and BMI; that means renal length increases in obesity, which is due to increased whole-body surface area. Similarly, a positive correlation is seen between right renal length and HbA1c, as poor glycemic control leads to renal enlargement, which might be a compensatory mechanism to get rid of extra protein from urine. On the other hand, a significant negative correlation is seen in right renal length and patient age, as with aging the shrinkage in renal length is due to fibrotic changes in the internal organs. Ham *et al*. and Omer *et al*. observe a significant positive correlation between renal volume and diabetic height and BMI and a negative correlation with age; this observation was consistent with our findings [14,16]. In this study there was no significant correlation of renal length with diabetes duration; that means renal changes might be developed at any time from diabetes onset. In contrast to these findings, Omer *et al.* found a decrease in renal size with increasing duration of diabetes [14]. The laboratory parameters don’t predict any changes in renal length apart from HbA1c, despite it reflecting short-term diabetic control. In the context of renal parenchyma, this study showed thicker right renal parenchyma in taller and higher BMI individuals and an ongoing thinning with diabetes duration, while left renal parenchymal thickness decreases only with aging. Each renal parenchyma shows no significant correlation with HbA1c, FBS, and S. creatinine. Regarding the interlobar artery diameter on the right side, a significant negative correlation is seen with age, BMI, and FBS. As with aging and obesity, there is an increased risk of atherosclerotic changes that lead to decreased vessel lumen; similarly, high blood glucose leads to smaller arterial diameter despite it reflecting a short-time glycemic state, while a positive correlation is seen with height, as a taller person has a wider artery diameter, as the size of the internal organ has a linear relation with body height, with a resulting increase in internal vascular diameter. On the left side a positive correlation is seen with HbA1c, as poor glycemic control led to renal hypertrophy as mentioned previously. Both kidneys show a negative correlation between interlobar artery diameter and diabetes duration; that means an artery diameter decrease with time due to parenchymal fibrosis associated with diabetes and atherosclerosis [22]. No past study analyzes predictors affecting renal parenchymal thickness and interlobar artery diameter. RT renal RI shows a significant positive correlation with age, diabetes duration, HbA1c, and FBS; on the left, a positive correlation is seen with weight and diabetes duration; bilaterally, no significant correlation is seen with S. Creatinine. This means the resistive index increased with aging, obesity, longer duration of diabetes, and high levels of HbA1c and FBS; all these changes are due to decreased arterial diameter. Al-Sharkawy observed a significant correlation between RI and HbA1c and S. creatinine; this is consistent with our finding except for S. creatinine, for which there was no significant correlation [24]. So multiple predictors affecting structural and Doppler renal changes in diabetic patients with the RT kidney are affected more than the left. Although the disease is not cured by early diagnosis, early detection of DKD can slow disease progression and prevent development of end-stage renal damage and failure. This study showed the importance of serial patient evaluation and follow-up by ultrasound and Doppler after baseline measures for early detection and prevention of disease progress with effective management.

Study limitations

Limitation of study: the results of this study need to be generalized from multiple centers and with a larger sample size, as it is a single-center study with a small number of diabetic participants. This was because we included participants with type 2 diabetes and without hypertension, and in our area there is a high incidence of associated diabetes and hypertension as they relate to metabolic syndrome.

Conclusion

We suggest that routine renal screening by ultrasound is critical in diabetic patients even with normal renal function, as renal ultrasound and Doppler study provide a good tool in assessing the status of the kidney. A consecutive measurement of renal parameters and resistive index after baseline measures can predict early renal damage even with normal biochemical markers of renal function to reduce and delay progression of diabetic-related kidney disease.

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Conflict of interests

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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