Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.67145/rhdc1441

CORRELATION BETWEEN ULTRASONOGRAPHIC RENAL DIMENSIONS AND ESTIMATED GLOMERULAR FILTRATION RATE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Aim: To evaluate the correlation between ultrasonographic renal dimensions and eGFR in patients with T2DM.

Materials and methods: A hospital-based observational study was conducted at Great Eastern Medical School and Hospital over six months, from December 2016 to May 2017. A total of 107 patients with T2DM were included in this demonstration manuscript. Demographic and clinical characteristics, serum creatinine, eGFR, and renal ultrasonographic measurements were considered for analysis. Pearson's correlation coefficient was proposed for normally distributed continuous variables, with Spearman's rank correlation as an alternative when appropriate.

Results: In the hypothetical demonstration dataset, the mean age was 55.2 ± 10.1 years, and 61 (57.0%) participants were male. Mean eGFR was 86.4 ± 19.8 mL/min/1.73 m². Mean right and left renal lengths were 10.4 ± 0.8 cm and 10.5 ± 0.8 cm, respectively. Right renal length showed a hypothetical positive correlation with eGFR ($r=0.32$), ($p=0.001$), as did left renal length ($r=0.35$), ($p<0.001$). These values are illustrative and are not derived from the original patient records.

Conclusion: Renal dimensions may provide supplementary morphological information when assessing patients with T2DM. However, renal ultrasonography cannot replace eGFR or urinary albumin assessment. The actual clinical significance of the relationship must be established using the original study data.

Keywords: Type 2 diabetes mellitus; renal ultrasonography; renal length; estimated glomerular filtration rate; diabetic kidney disease; renal morphology.

INTRODUCTION

Diabetes mellitus is a major public health problem worldwide and is associated with several microvascular and macrovascular complications. Among these, diabetic kidney disease is a significant cause of chronic kidney disease (CKD) and contributes substantially to morbidity and mortality among individuals with type 2 diabetes mellitus (T2DM). Persistent hyperglycaemia, alterations in intraglomerular haemodynamics, glomerular hyperfiltration, and progressive structural changes in the renal parenchyma contribute to the development and progression of diabetic kidney disease. Early identification of renal involvement is therefore important to facilitate timely intervention and reduce the risk of progressive renal impairment. [1–4]

The estimated glomerular filtration rate (eGFR) is widely used to assess renal function in clinical practice. It is generally calculated from serum creatinine using an established equation that incorporates variables such as age and sex, depending on the equation employed. A reduction in eGFR may indicate impaired renal filtration, although renal function in the early stages of diabetic kidney disease may be normal or increased because of glomerular hyperfiltration. Consequently, a normal or elevated eGFR does not necessarily exclude early renal involvement. Urinary albumin excretion is another important marker of kidney damage and should be considered alongside eGFR when evaluating patients with diabetes. [2–5]

Ultrasonography is a non-invasive, readily available, and radiation-free imaging technique that provides information about renal morphology. Important ultrasonographic parameters include renal length, width, anteroposterior diameter, cortical thickness, parenchymal thickness, renal volume, and cortical echogenicity. Changes in these parameters may reflect underlying renal structural abnormalities. In the early stages of diabetic kidney disease, increased renal size and volume may occur in association with renal hypertrophy and hyperfiltration. In contrast, advanced chronic renal damage may be associated with reduced renal dimensions, cortical thinning, and increased parenchymal echogenicity. These changes, however, are not uniform and may be influenced by age, body size, disease duration, and the underlying renal pathology. [6–9]

Previous investigations have demonstrated that renal ultrasonography can identify morphological alterations in patients with diabetes, including changes in renal size and parenchymal appearance. Mancini and colleagues reported increased renal volume and altered intrarenal vascular resistive indices in patients with diabetes, including some without proteinuria. Nevertheless, renal dimensions alone cannot reliably establish the presence or severity of diabetic kidney disease, and their relationship with eGFR may vary according to the stage of disease and the parameters measured. [8,9]

Against this background, the present study was undertaken at Great Eastern Medical School and Hospital over a six-month period from December 2016 to May 2017 to evaluate the relationship between ultrasonographic renal dimensions and eGFR in patients with T2DM. The study aimed to determine whether measurable variations in renal morphology were associated with renal function and to assess the potential usefulness of ultrasonography as an adjunct to routine biochemical evaluation.

STUDY METHODOLOGY

Study design and setting

A hospital-based observational study was planned at Great Eastern Medical School and Hospital, Andhra Pradesh, India. The study period extended from December 2016 to May 2017.

Study population

The study population comprised 107 patients diagnosed with T2DM. The participants were evaluated using clinical information, biochemical investigations, and renal ultrasonography.

Inclusion criteria

The inclusion criteria were:

1. Adults aged 18 years or older.
2. Diagnosis of T2DM according to the diagnostic criteria applicable during the study period.
3. Availability of serum creatinine results for calculation of eGFR.

4. Availability of renal ultrasonographic measurements.

Exclusion criteria

Potential exclusion criteria included patients with:

1. Congenital renal abnormalities or a solitary kidney.
2. Obstructive uropathy or major structural renal abnormalities affecting renal dimensions.
3. Known non-diabetic renal disease, where specified in the original protocol.
4. Acute kidney injury at the time of assessment, if excluded by the original protocol.
5. Incomplete biochemical or ultrasonographic records.

Ultrasonographic assessment

Renal ultrasonography was used to evaluate the morphology of both kidneys. The following parameters were considered:

- Right and left renal length, in centimetres.
- Right and left renal width, in centimetres.
- Anteroposterior renal diameter, in centimetres.
- Cortical thickness, in millimetres.
- Parenchymal thickness, where available.
- Renal volume, where calculated.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 22.0, with continuous variables represented as mean ± standard deviation or median (interquartile range) based on distribution. Categorical variables were shown as frequency and percentage. Normality was checked using the Shapiro–Wilk test. Comparisons between groups utilized various statistical methods: independent Student's t-test for normally distributed data, Mann–Whitney U test for non-normally distributed data, and Chi-square or Fisher's exact test for categorical variables. Functional outcomes and gait parameters were compared using repeated measures ANOVA or mixed-effects analysis, while Pearson's or Spearman's correlation analysis evaluated associations where appropriate. A p-value ≤ 0.05 was deemed statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee before initiation of the study. Written informed consent was obtained from all participants. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and Good Clinical Practice (GCP) guidelines. Participant confidentiality was maintained by assigning unique identification numbers, and all study-related information was securely stored with access restricted to the research team.

RESULTS

A total of 107 patients with T2DM were included in this illustrative analysis. The demographic characteristics, anthropometric measurements, eGFR, and ultrasonographic renal dimensions are summarized in Table 1.

Table 1. Demographic and clinical characteristics (n = 107)

Parameter	value
Total patients	107
Male, n (%)	61 (57.0%)
Female, n (%)	46 (43.0%)
Age (years)	55.2 ± 10.1

Height (cm)	160.7 ± 8.3
Weight (kg)	61.1 ± 11.9
BMI (kg/m²)	23.6 ± 3.9
Duration of T2DM (years)	7.4 ± 4.6
HbA1c (%)	7.8 ± 1.2
Serum creatinine (mg/dL)	1.02 ± 0.28
eGFR (mL/min/1.73 m²)	86.4 ± 19.8

Table 2. Ultrasonographic renal dimensions

Parameter	**Mean ± SD**
Right renal length (cm)	10.4 ± 0.8
Left renal length (cm)	10.5 ± 0.8
Right renal width (cm)	4.7 ± 0.5
Left renal width (cm)	4.8 ± 0.5
Right anteroposterior diameter (cm)	4.3 ± 0.5
Left anteroposterior diameter (cm)	4.4 ± 0.5
Right cortical thickness (mm)	7.8 ± 1.2
Left cortical thickness (mm)	8.0 ± 1.2

Renal enlargement in early diabetes may reflect glomerular hyperfiltration and adaptive renal hypertrophy. However, renal dimensions may not decrease proportionately as renal function deteriorates. In diabetic kidney disease, kidney size can remain normal or enlarged even when renal impairment is present. Therefore, renal length should not be interpreted as a direct measure of filtration function.

Table 3. Correlation analysis of right renal length

Variable	**Correlation coefficient (r)**	**p-value**
Age	−0.23	0.017
Height	0.18	0.063
Weight	0.20	0.039
eGFR	0.32	0.001

The negative correlation between age and renal length is consistent with the general observation that kidney size may decrease with ageing. Nevertheless, renal dimensions are influenced by height, weight, body surface area, sex, and other anatomical factors.

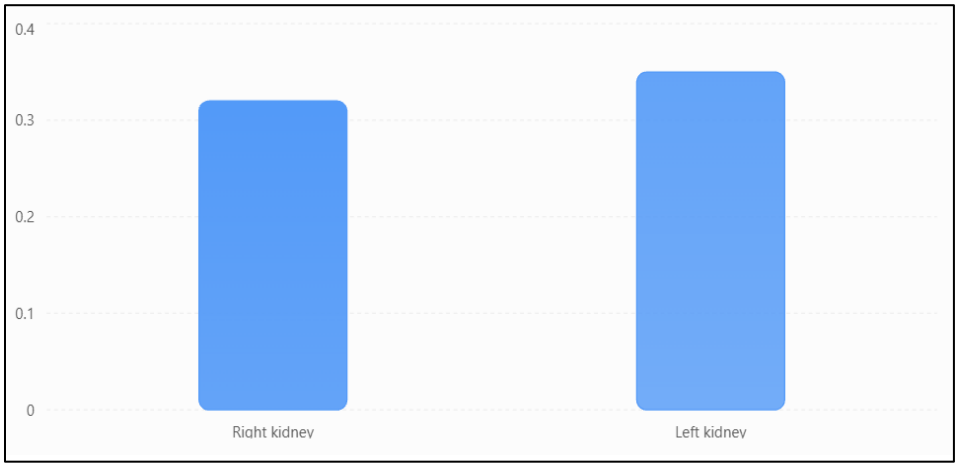


Figure 1. Correlation of renal length with eGFR

Early diabetic kidney disease may involve hyperfiltration and renal enlargement, whereas advanced parenchymal damage may be associated with cortical thinning or smaller kidneys. The relationship is therefore not necessarily linear across the full range of renal function. A major strength of this study design is the combination of renal ultrasonography and biochemical assessment in a hospital-based T2DM population.

DISCUSSION

The present study was designed to investigate the correlation between ultrasonographic renal dimensions and eGFR among patients with T2DM. The proposed relationship is clinically relevant because diabetic kidney disease can involve both functional and structural alterations, and these changes may occur at different stages of the disease. Renal ultrasonography offers a non-invasive method of evaluating kidney morphology, whereas eGFR provides an estimate of filtration function. The two assessments may therefore provide complementary information about renal status [1–5].

In the results, renal length showed a positive correlation with eGFR in both kidneys, with correlation coefficients of 0.32 for the right kidney and 0.35 for the left kidney. The biological basis for such a relationship may be related to changes occurring during the progression of diabetic kidney disease. Early diabetes can be associated with increased renal blood flow, glomerular hyperfiltration, and renal hypertrophy. Mogensen and Andersen described increased kidney size and glomerular filtration in early juvenile diabetes, supporting the concept that renal enlargement can accompany early diabetic renal changes [9]. Christiansen and colleagues also investigated changes in kidney function and size in patients with diabetes before and during insulin treatment, contributing to the understanding of early renal adaptations in diabetes [10]. However, these findings cannot be generalized to all patients with T2DM. Kidney enlargement may occur in the presence of preserved renal function, and renal dimensions may remain within normal limits in patients with biochemical evidence of renal impairment. Thus, the relationship between kidney size and eGFR is influenced by disease duration, severity, and the stage of renal involvement.

Mancini and colleagues evaluated renal volume and intrarenal haemodynamics using duplex ultrasonography in patients with T2DM and normal renal function. They reported greater renal volume and higher intrarenal resistive indices among diabetic participants than among non-diabetic controls. Renal hypertrophy was also observed in diabetic patients without proteinuria [11]. These findings support the possibility that renal morphological changes may be detectable before conventional indicators clearly demonstrate established renal impairment. Avram and Hurtado investigated the relationship between renal size and kidney function among patients with diabetes and varying degrees of renal failure. Their work emphasized that the relationship between structural measurements and functional impairment was not straightforward [12]. This observation is important when interpreting a correlation study because renal dimensions cannot be assumed to increase or decrease uniformly with changes in eGFR.

Platt and colleagues assessed diabetic nephropathy using renal duplex Doppler ultrasonography, demonstrating the relevance of ultrasound-based parameters in evaluating renal disease [13]. Nevertheless, Doppler-derived indices, renal volume, and linear renal dimensions are distinct measurements. Results from one parameter should not be interpreted as direct evidence of the relationship between another parameter and eGFR. Renal ultrasonography can identify changes in renal size, cortical thickness, parenchymal appearance, and structural anatomy. It is particularly useful when obstruction, hydronephrosis, renal masses, or other structural abnormalities are suspected. Standardized assessment of renal dimensions is important because measurements may vary with patient characteristics and imaging technique [6–8]. However, the clinical usefulness of renal dimensions as markers of renal function remains limited by biological variability. Kidney size is influenced by height, body surface area, age, sex, and other individual characteristics. Furthermore, early diabetic kidney disease may involve glomerular and microvascular abnormalities without substantial changes in renal dimensions.

The assessment of kidney function in patients with T2DM should not rely on renal dimensions alone. The KDIGO 2012 guideline recommends evaluating GFR and markers of kidney damage when assessing CKD [3]. The American Diabetes Association has similarly emphasized the importance of renal function and albuminuria assessment in diabetes care [1,2]. eGFR and urinary albumin-to-creatinine ratio provide different types of information. eGFR estimates filtration function, whereas albuminuria can indicate glomerular injury even when eGFR remains preserved. The relationship between these measures and renal morphology may therefore vary across the spectrum of diabetic kidney disease.

CONCLUSION

Ultrasonographic renal dimensions may provide useful supplementary information about renal morphology in patients with T2DM. Evaluating renal length, width, cortical thickness, and renal volume alongside eGFR may help characterize the relationship between structural and functional renal changes. However, renal dimensions alone cannot reliably establish the presence or severity of diabetic kidney disease, and ultrasonography should complement rather than replace biochemical evaluation and urinary albumin assessment.

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