ORIGINAL RESEARCH

Renal Anatomy and Its Impact on Glomerular Filtration Rate in Diabetic Patients: An observational study

[1]Indla Devasena, [2]Challa Nagasireesha, [3]P.Lakshmana Rao

[1,2]Associate Professor, Department of Physiology, Sri Venkateswara Medical College, Tirupati , Andhra Pradesh, India
[3]Assistant Professor, Department of Anatomy, Government Medical College, Vizianagaram, Andhra Pradesh, India

Corresponding author
Indla Devasena
Associate Professor, Department of Physiology, Sri Venkateswara Medical College, Tirupati , Andhra Pradesh, India
Email: dridevasena@gmail.com

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ABSTRACT

Background: Diabetic nephropathy is a leading cause of chronic kidney disease (CKD). This study investigates the impact of renal anatomy on glomerular filtration rate (GFR) in diabetic patients, comparing those with controlled and uncontrolled diabetes. **Objective:** To evaluate the relationship between renal anatomy (kidney size and cortical thickness) and GFR in diabetic patients and to assess the effect of glycemic control on these parameters. **Methods:** An observational study was conducted with 100 diabetic patients divided into two groups: controlled diabetes (HbA1c ≤ 7%, n=50) and uncontrolled diabetes (HbA1c > 7%, n=50). Renal ultrasound and MRI were used to measure kidney size and cortical thickness. GFR was estimated using the CKD-EPI equation. Correlations between HbA1c, renal anatomy, and GFR were analyzed. **Results:**Mean age: 55 ± 10 years.Kidney length: 11.5 ± 0.8 cm (controlled) vs. 12.1 ± 0.9 cm (uncontrolled) ($p < 0.05$).Cortical thickness: 7.2 ± 0.6 mm (controlled) vs. 6.5 ± 0.5 mm (uncontrolled) ($p < 0.01$).Mean eGFR: 85 ± 12 mL/min/1.73 m² (controlled) vs. 72 ± 15 mL/min/1.73 m² (uncontrolled) ($p < 0.01$).Significant negative correlation between HbA1c and eGFR ($r = -0.65$, $p < 0.001$).Positive correlations between kidney size and eGFR ($r = 0.42$, $p < 0.01$) and between cortical thickness and eGFR ($r = 0.50$, $p < 0.01$).Microalbuminuria: 30% (controlled) vs. 60% (uncontrolled) ($p < 0.05$).Macroalbuminuria: 0% (controlled) vs. 10% (uncontrolled) ($p < 0.05$). **Conclusion:** Renal anatomy significantly affects GFR in diabetic patients, with uncontrolled diabetes leading to greater reductions in GFR. Regular monitoring and management of renal health are crucial for diabetic patients.

Keywords: Diabetic nephropathy, Glomerular filtration rate, Renal anatomy, Kidney size, Cortical thickness, Glycemic control, Microalbuminuria, Macroalbuminuria

INTRODUCTION

Diabetic nephropathy is a major complication of diabetes mellitus and a leading cause of chronic kidney disease (CKD) and end-stage renal disease (ESRD) globally[1,2]. As the prevalence of diabetes continues to rise, understanding the factors that contribute to kidney damage in diabetic patients becomes increasingly important. Among these factors, glycemic control plays a critical role in the progression of renal disease[3]. Poor glycemic control is associated with an accelerated decline in kidney function, highlighting the need for effective diabetes management strategies[4].

Renal anatomy, including kidney size and cortical thickness, has been shown to correlate with kidney function in various populations. However, the relationship between these anatomical parameters and glomerular filtration rate (GFR) in diabetic patients, particularly in relation to glycemic control, remains less well understood[5]. Assessing these anatomical features may provide valuable insights into the structural changes that accompany diabetic nephropathy and their impact on renal function[6].

This observational study aims to evaluate the impact of renal anatomy on GFR in diabetic patients, comparing those with controlled and uncontrolled diabetes. By investigating the correlations between kidney size, cortical thickness, and GFR, this study seeks to elucidate the anatomical changes that occur in diabetic nephropathy and their implications for

renal health. Additionally, the study examines the role of glycemic control in moderating these changes, providing a comprehensive understanding of how diabetes management influences kidney function.

METHODOLOGY

Study Design and Setting

This observational study was conducted at Sri Venkateswara Medical College, Tirupati, from September 2022 to February 2023. The study aimed to evaluate the impact of renal anatomy on glomerular filtration rate (GFR) in diabetic patients, with a focus on the effects of glycemic control.

Study Population

The study included 100 diabetic patients who were recruited from the outpatient department of Sri Venkateswara Medical College. Inclusion criteria were patients aged 18 years or older, diagnosed with diabetes mellitus, and willing to provide informed consent. Patients with known non-diabetic kidney diseases, recent acute kidney injury, or pregnancy were excluded.

Grouping

Patients were divided into two groups based on their HbA1c levels:
Controlled Diabetes Group: HbA1c $\leq$ 7% (n=50)
Uncontrolled Diabetes Group: HbA1c > 7% (n=50)

Data Collection

1. Demographic and Clinical Data: Baseline demographic data (age, gender) and clinical parameters (body mass index [BMI], duration of diabetes, blood pressure) were recorded. HbA1c levels were measured using standardized laboratory techniques.
2. Renal Anatomy Assessment: Renal ultrasound and magnetic resonance imaging (MRI) were performed to assess kidney size and cortical thickness. Kidney length was measured from the upper to lower pole, and cortical thickness was measured at the midpoint of the kidney.
3. Glomerular Filtration Rate (GFR): The estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation, which takes into account serum creatinine levels, age, gender, and race.
4. Proteinuria and Albuminuria: Urine samples were collected to measure microalbuminuria and macroalbuminuria. Microalbuminuria was defined as urinary albumin excretion of 30-300 mg/day, and macroalbuminuria as >300 mg/day.

Statistical Analysis

Statistical analyses were performed using SPSS software version 25.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the Student's t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test. Correlations between variables were assessed using Pearson's correlation coefficient. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with ethical guidelines and standards. Informed consent was obtained from all participants. The study protocol was reviewed and necessary prior permissions taken from concerned authorities.

RESULTS

Demographic Data

The study included 100 diabetic patients, comprising 60 males and 40 females, with a mean age of 55 ± 10 years. The patients were divided into two groups based on their HbA1c levels: controlled diabetes (HbA1c $\leq$ 7%, n=50) and uncontrolled diabetes (HbA1c > 7%, n=50). Baseline characteristics such as body mass index (BMI), duration of diabetes, and blood pressure were recorded (Table 1).

Renal Anatomy Measurements

Renal ultrasound and MRI scans revealed significant variations in kidney size and cortical thickness between the two groups. In the controlled diabetes group, the average kidney length was 11.5 ± 0.8 cm, while in the uncontrolled diabetes group, it was 12.1 ± 0.9 cm ($p < 0.05$). Cortical thickness was also significantly reduced in the uncontrolled diabetes group (6.5 ± 0.5 mm vs. 7.2 ± 0.6 mm, $p < 0.01$).

Glomerular Filtration Rate (GFR)

The estimated glomerular filtration rate (eGFR) was measured using the CKD-EPI equation. The average eGFR in the controlled diabetes group was 85 ± 12 mL/min/1.73 m², compared to 72 ± 15 mL/min/1.73 m² in the uncontrolled diabetes group ($p < 0.01$). A decline in eGFR was more pronounced in patients with a longer duration of diabetes and higher HbA1c levels.

Correlation Analysis

A significant negative correlation was observed between HbA1c levels and eGFR ($r = -0.65$, $p < 0.001$). Additionally, a positive correlation was found between kidney size and eGFR ($r = 0.42$, $p < 0.01$). Cortical thickness also showed a positive correlation with eGFR ($r = 0.50$, $p < 0.01$).

Proteinuria and Albuminuria

Microalbuminuria was present in 30% of patients in the controlled diabetes group and 60% in the uncontrolled diabetes group. Macroalbuminuria was observed in 10% of the uncontrolled diabetes group but was absent in the controlled group ($p < 0.05$). The presence of proteinuria was significantly associated with lower eGFR ($p < 0.01$).

Table 1: Baseline Characteristics of the Study Population

Characteristic	Controlled Diabetes (n=50)	Uncontrolled Diabetes (n=50)	p-value
Age (years)	54 ± 9	56 ± 11	0.35
Gender (Male/Female)	30/20	30/20	1.00
BMI (kg/m²)	28.5 ± 3.4	29.1 ± 3.8	0.40
Duration of Diabetes (years)	10 ± 4	12 ± 5	0.05
Systolic BP (mmHg)	130 ± 15	135 ± 17	0.10
Diastolic BP (mmHg)	80 ± 10	82 ± 12	0.30

Table 2: Renal Anatomy Measurements

Measurement	Controlled Diabetes (n=50)	Uncontrolled Diabetes (n=50)	p-value
Kidney Length (cm)	11.5 ± 0.8	12.1 ± 0.9	<0.05
Cortical Thickness (mm)	7.2 ± 0.6	6.5 ± 0.5	<0.01

Table 3: Glomerular Filtration Rate (eGFR)

eGFR (mL/min/1.73 m²)	Controlled Diabetes (n=50)	Uncontrolled Diabetes (n=50)	p-value
Mean eGFR	85 ± 12	72 ± 15	<0.01

Table 4: Correlation Analysis

Variable 1	Variable 2	Correlation Coefficient (r)	p-value
HbA1c	eGFR	-0.65	<0.001
Kidney Size	eGFR	0.42	<0.01
Cortical Thickness	eGFR	0.50	<0.01

Table 5: Proteinuria and Albuminuria

Condition	Controlled Diabetes (n=50)	Uncontrolled Diabetes (n=50)	p-value
Microalbuminuria (%)	30	60	<0.05
Macroalbuminuria (%)	0	10	<0.05

DISCUSSION

The results of this observational study indicate a significant impact of renal anatomy on glomerular filtration rate (GFR) in diabetic patients, highlighting the importance of kidney size and cortical thickness as indicators of renal function. The study also underscores the critical role of glycemic control in preserving kidney health and preventing the progression of diabetic nephropathy.

Renal Anatomy and GFR

The findings reveal that uncontrolled diabetes is associated with larger kidney size and reduced cortical thickness, both of which are negatively correlated with GFR. These results are consistent with previous studies that have reported renal hypertrophy and cortical thinning as common features in diabetic nephropathy. The increase in kidney size may initially reflect compensatory hyperfiltration; however, over time, it leads to structural damage and a decline in renal function[7,8]. The observed reduction in cortical thickness in the uncontrolled diabetes group further supports this notion, indicating chronic kidney damage and loss of functional renal tissue[9].

Impact of Glycemic Control

Glycemic control, as measured by HbA1c levels, was found to have a profound influence on renal anatomy and function. Patients with controlled diabetes (HbA1c ≤ 7%) had significantly better eGFR, smaller kidney size, and greater cortical thickness compared to those with uncontrolled diabetes (HbA1c > 7%). These findings align with the well-documented benefits of tight glycemic control in slowing the progression of diabetic nephropathy[10]. The significant negative correlation between HbA1c levels and eGFR highlights the detrimental effects of poor glycemic control on kidney function. This underscores the need for stringent glucose management to prevent or delay the onset of renal complications in diabetic patients[11].

Proteinuria and Albuminuria

The higher prevalence of microalbuminuria and macroalbuminuria in the uncontrolled diabetes group indicates a greater degree of kidney damage in these patients. Proteinuria is a key marker of kidney disease progression, and its presence correlates with lower eGFR. This study's findings emphasize the importance of regular monitoring for proteinuria as an early indicator of renal damage, particularly in patients with poorly controlled diabetes[12].

Clinical Implications

The study highlights the significance of renal anatomy assessments in diabetic patients as a means to gauge kidney health and predict renal function decline. Regular monitoring of kidney size and cortical thickness through imaging modalities like ultrasound and MRI can provide valuable insights into the structural changes associated with diabetic

nephropathy. Furthermore, the findings reinforce the critical role of maintaining good glycemic control in preserving renal function and preventing the progression of kidney disease.

Limitations

The study has several limitations. Firstly, it is an observational study, which limits the ability to establish causal relationships. Secondly, the sample size is relatively small and limited to a single center, which may affect the generalizability of the findings. Additionally, the study did not account for other factors that might influence renal anatomy and function, such as hypertension, use of nephrotoxic medications, and co-existing renal conditions.

CONCLUSION

This study demonstrates that renal anatomy, particularly kidney size and cortical thickness, significantly impacts GFR in diabetic patients. Uncontrolled diabetes is associated with greater renal structural changes and a more pronounced decline in GFR. These findings underscore the importance of glycemic control in preserving kidney function and highlight the need for regular renal anatomy assessments in diabetic patients to monitor and manage diabetic nephropathy effectively.

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