ORIGINAL RESEARCH

The Pathological Impact of Diabetes on Renal Function: A Comprehensive Analysis of Kidney Disease and Therapeutic Advances in Medicine

Abhilasha Sharma[1], Vaibhav Mandava[2]

[1]Assistant Professor, Department of Pathology, Viswabharathi Medical College & General Hospital, Ulchala, Kurnool, Andhra Pradesh, India
[2]Assistant Professor, Department of General Medicine, Alluri Sitarama Raju Academy of Medical Sciences, Eluru, Andhra Pradesh, India

Corresponding Author
Abhilasha Sharma
Assistant Professor, Department of Pathology, Viswabharathi Medical College & General Hospital, Ulchala, Kurnool, Andhra Pradesh, India
Email: Abhilasha.rntmc@gmail.com

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ABSTRACT

Introduction: Diabetes mellitus, a chronic metabolic disorder characterized by persistent hyperglycemia, is one of the leading global health challenges. **Objective:** The main objective of the study is to find the pathological impact of diabetes on renal function.**Methodology:** This observational study was conducted and a total of 169 patients diagnosed with diabetic kidney disease (DKD) were enrolled in the study. Patients with type 2 diabetes with confirmed DKD, as evidenced by persistent albuminuria (≥30 mg/g) and/or reduced estimated glomerular filtration rate (eGFR < 60 mL/min/1.73 m²) over a period of at least three months were included in the study. **Results:** Data were collected from 169 patients, with a mean age of 58.4±12.3 years. The gender distribution was 55% male and 45% female. The mean HbA1c was 8.2±1.5%, indicating poor glycemic control, while the mean eGFR was 48.5±8.9 mL/min/1.73 m², suggesting moderate kidney impairment. The albumin-to-creatinine ratio averaged 215.4±45.7 mg/g, reflecting significant proteinuria. These parameters highlight the participants' high risk for diabetic kidney disease. The SGLT2 group showed a significantly lower mean eGFR decline (4.2 mL/min/1.73 m²) compared to the non-SGLT2 group (8.7 mL/min/1.73 m²), with a p-value of <0.01, indicating superior renal protection. Additionally, the SGLT2 group achieved a 25% reduction in the albumin-to-creatinine ratio, whereas the non-SGLT2 group showed minimal reduction, with a p-value of <0.05. **Conclusion:** It is concluded that this study highlights the substantial benefits of integrating advanced therapies such as SGLT2 inhibitors into DKD management.

INTRODUCTION

Diabetes mellitus, a chronic metabolic disorder characterized by persistent hyperglycemia, is one of the leading global health challenges. Its prevalence continues to rise, driven by aging populations, sedentary lifestyles, and dietary shifts. Among the numerous complications associated with diabetes, renal dysfunction remains one of the most severe and life-threatening [1]. Diabetic kidney disease (DKD), a subset of chronic kidney disease (CKD), is a major cause of end-stage renal disease (ESRD) worldwide, imposing a significant burden on healthcare systems and patients alike.The pathological relationship between diabetes and renal dysfunction is multifaceted, involving intricate mechanisms such as hyperglycemia-induced glomerular damage, oxidative stress, and inflammatory pathways. These processes culminate in the progressive loss of renal function, posing considerable challenges for effective management and treatment [2].Diabetes affects more than 500 million people globally, with type 2 diabetes accounting for approximately 90% of all cases. The International Diabetes Federation predicts that this number will rise significantly by 2045, making the need to address its complications more urgent than ever [3]. Among these complications, DKD stands out not only because of its high prevalence but also because of its devastating impact on patients' quality of life and survival rates. DKD is a leading cause of kidney failure, necessitating dialysis or kidney

transplantation for many patients, both of which are resource-intensive and financially burdensome.The development of DKD is driven by a combination of metabolic and hemodynamic factors [4]. Chronic hyperglycemia plays a pivotal role, leading to the non-enzymatic glycation of proteins and the activation of the polyol and hexosamine pathways. These processes result in increased production of advanced glycation end-products (AGEs), oxidative stress, and pro-inflammatory cytokines, all of which contribute to glomerular and tubular injury [5].Managing DKD involves addressing multiple interrelated factors, including glycemic control, blood pressure regulation, and the mitigation of other cardiovascular risks. Despite advancements in diabetes management, many patients with DKD experience disease progression due to the complexity of its underlying mechanisms and the limitations of current therapeutic options [6].Recent years have witnessed the emergence of novel therapies that hold promise for improving outcomes in DKD. SGLT2 inhibitors, initially developed as glucose-lowering agents, have demonstrated significant renoprotective effects independent of their glycemic control properties [7]. These drugs reduce intraglomerular pressure, decrease proteinuria, and mitigate renal inflammation, making them a game-changer in the management of DKD.Another promising class of therapies includes nonsteroidal mineralocorticoid receptor antagonists (MRAs) such as finer enone, which have shown efficacy in reducing inflammation and fibrosis in the kidneys [8]. Anti-inflammatory and antifibrotic agents targeting specific pathways involved in DKD progression are also under investigation, with several clinical trials yielding encouraging results.Moreover, advancements in precision medicine are paving the way for personalized approaches to DKD management [9]. By identifying genetic, molecular, and metabolic markers associated with disease progression, clinicians can tailor treatments to individual patients, enhancing efficacy and minimizing adverse effects [10].Diabetic kidney disease remains a formidable challenge in modern medicine, with significant implications for public health and individual patients. Understanding the complex interplay of metabolic, hemodynamic, and inflammatory factors underlying its development is essential for devising effective interventions. While traditional therapies have provided a foundation for DKD management, the advent of innovative treatments such as SGLT2 inhibitors, MRAs, and precision medicine offers new hope for improving patient outcomes [11].

Objective

The main objective of the study is to find the pathological impact of diabetes on renal function.

Methodology

This observational study was conducted and a total of 169 patients diagnosed with diabetic kidney disease (DKD) were enrolled in the study. Patients with type 2 diabetes with confirmed DKD, as evidenced by persistent albuminuria (≥30 mg/g) and/or reduced estimated glomerular filtration rate (eGFR < 60 mL/min/1.73 m²) over a period of at least three months were included in the study.

Inclusion Criteria

- Patients aged 18 years or older.
- Diagnosis of type 2 diabetes mellitus with a confirmed history of diabetic kidney disease.
- Evidence of persistent albuminuria (≥30 mg/g) and/or reduced eGFR (<60 mL/min/1.73 m²) for at least three months.
- Willingness to provide informed consent and participate in follow-up evaluations.

Exclusion Criteria

- Patients with non-diabetic kidney diseases or other significant renal pathologies.
- History of kidney transplantation or active enrollment in other interventional trials.
- Severe comorbid conditions that could interfere with study outcomes (e.g., advanced malignancies, uncontrolled cardiovascular diseases).
- Pregnant or lactating individuals.
- Inability or unwillingness to adhere to the study protocol.

Data Collection

Baseline assessments included detailed medical histories, physical examinations, laboratory investigations, and renal function tests. Data collected included demographic information, glycemic control measures (HbA1c levels), renal biomarkers (e.g., serum creatinine, eGFR, and albumin-to-creatinine ratio), and cardiovascular risk factors (e.g., blood pressure and lipid profiles). Information on medication adherence, lifestyle modifications, and adverse events was also recorded to evaluate treatment efficacy and safety.

Statistical Analysis

Data were analyzed using SPSS v16. Continuous variables were expressed as means ± standard deviations, while categorical variables were summarized as percentages. Comparative analyses between baseline and follow-up data were conducted using paired t-tests. Multivariate regression models were employed to identify predictors of renal function decline and therapeutic response.

RESULTS

Data were collected from 169 patients, with a mean age of 58.4±12.3 years. The gender distribution was 55% male and 45% female. The mean HbA1c was

8.2±1.5%, indicating poor glycemic control, while the mean eGFR was 48.5±8.9 mL/min/1.73 m², suggesting moderate kidney impairment. The albumin-to-creatinine ratio averaged 215.4±45.7 mg/g, reflecting significant proteinuria. These parameters highlight the participants' high risk for diabetic kidney disease.

Table 1: Baseline Data Collection

Parameter	Baseline Mean
Age (years)	58.4±12.3
HbA1c (%)	8.2±1.5
eGFR (mL/min/1.73 m²)	48.5±8.9
Albumin-to-creatinine ratio (mg/g)	215.4±45.7
Characteristic	Value
Number of Participants	169
Gender Distribution	55% Male, 45% Female
Mean HbA1c (%)	8.2
Mean eGFR (mL/min/1.73 m²)	48.5
Albumin-to-creatinine ratio (mg/g)	215.4

The treatment group demonstrated a significantly lower mean eGFR decline (5.8 mL/min/1.73 m²) compared to the control group (9.2 mL/min/1.73 m²) with a p-value of <0.01, indicating better preservation of kidney function. Additionally, the treatment group showed a greater reduction in albuminuria (18%) compared to the control group (3%), with a p-value of <0.05.

Table 2: Progression of Renal Function

Parameter	Treatment Group	Control Group	p-value
Mean eGFR Decline (mL/min/1.73 m²)	5.8	9.2	<0.01
Reduction in Albuminuria (%)	18	3	<0.05

The SGLT2 group showed a significantly lower mean eGFR decline (4.2 mL/min/1.73 m²) compared to the non-SGLT2 group (8.7 mL/min/1.73 m²), with a p-value of <0.01, indicating superior renal protection. Additionally, the SGLT2 group achieved a 25% reduction in the albumin-to-creatinine ratio, whereas the non-SGLT2 group showed minimal reduction, with a p-value of <0.05.

Table 3: Impact of SGLT2 Inhibitors

Parameter	SGLT2 Group	Non-SGLT2 Group	p-value
Mean eGFR Decline (mL/min/1.73 m²)	4.2	8.7	<0.01
Albumin-to-creatinine Reduction (%)	25	Minimal	<0.05

Participants aged 18-40 had the lowest mean eGFR decline (4.5 mL/min/1.73 m²) and the highest reduction in albuminuria (20%), suggesting better kidney protection in younger individuals. Those aged 41-60 experienced a moderate eGFR decline (5.7 mL/min/1.73 m²) and an 18% reduction in albuminuria. In contrast, participants aged 61 and above had the highest mean eGFR decline (7.8 mL/min/1.73 m²) and the lowest reduction in albuminuria (12%), reflecting less favorable outcomes in older individuals.

Table 4: Comparative Outcomes Based on Age Groups

Age Group (years)	Mean eGFR Decline (mL/min/1.73 m²)	Reduction in Albuminuria (%)
18-40	4.5	20
41-60	5.7	18
61+	7.8	12

Adherence to the intervention significantly influenced kidney function outcomes. Participants with high adherence (90%+) constituted 45% of the group and exhibited the lowest mean eGFR decline (4.0 mL/min/1.73 m²), indicating better renal preservation. Those with moderate adherence (70-89%), accounting for 35% of participants, experienced a greater mean eGFR decline (6.5 mL/min/1.73 m²). In contrast, the low adherence group (<70%), representing 20% of participants, showed the highest mean eGFR decline (9.0 mL/min/1.73 m²), emphasizing the importance of adherence for optimal kidney outcomes.

Table 5: Medication Adherence and Outcomes

Adherence Level	Percentage of Participants (%)	Mean eGFR Decline (mL/min/1.73 m²)
High (90%+)	45	4.0
Moderate (70-89%)	35	6.5
Low (<70%)	20	9.0

DISCUSSION

The findings of this study provide critical insights into the pathological and clinical implications of diabetic kidney disease (DKD) and reinforce the value of innovative therapeutic strategies. The significant reduction in eGFR decline and albuminuria in patients receiving SGLT2 inhibitors highlights their dual role in glycemic control and renoprotection. These outcomes align with previous research that emphasizes the protective effects of SGLT2 inhibitors on renal function, independent of their glucose-lowering mechanisms [12].A notable observation was the variability in outcomes based on age and medication adherence. Younger patients (aged 18-40) exhibited a slower decline in renal function and a more pronounced reduction in albuminuria, likely attributable to better baseline renal reserve and fewer comorbidities [13]. Conversely, older participants experienced a more rapid decline, underscoring the need for age-specific interventions and closer monitoring in elderly populations [14].Medication adherence emerged as a critical determinant of therapeutic efficacy. Patients with high adherence rates demonstrated markedly better renal outcomes, reinforcing the importance of patient education and support in optimizing treatment adherence. Strategies such as simplified medication regimens, regular follow-ups, and enhanced patient-provider communication are vital to addressing adherence barriers [15].The low incidence of adverse events, particularly severe ones, underscores the safety profile of SGLT2 inhibitors and other advanced therapies. However, the study also identified transient hypoglycemia and mild urinary tract infections as the most common side effects, necessitating vigilant monitoring and prompt management to enhance patient comfort and compliance [16].

Despite the promising findings, this study is not without limitations. The relatively short follow-up period of three years may not capture the long-term progression of DKD or the sustained efficacy of therapies. Additionally, the exclusion of patients with non-diabetic renal diseases and severe comorbidities limits the generalizability of the results to broader populations [17]. Future studies with larger, more diverse cohorts and extended follow-up durations are essential to validate these findings and explore novel therapeutic targets. This study highlights the substantial benefits of integrating advanced therapies such as SGLT2 inhibitors into DKD management.

CONCLUSION

It is concluded that this study highlights the substantial benefits of integrating advanced therapies such as SGLT2 inhibitors into DKD management. By addressing the multifactorial nature of DKD and tailoring interventions to individual patient profiles, it is possible to improve renal outcomes and overall quality of life for individuals affected by this debilitating condition.

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