Original Article

Urinary Tract Infections in Chronic Kidney Disease Investigating Recurrent UTIs in CKD and Their Impact on Disease Progression and Management

Impact of Recurrent UTIs on CKD Outcomes and various management strategies

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ABSTRACT

Objective: This study investigates the impact of recurrent UTIs on CKD outcomes and evaluates various management strategies.

Study Design: A prospective, observational, cross-sectional study.

Place and Duration of Study: This study was conducted at the Department of Urology, at Bacha Khan Medical College & Mardan Medical Complex Mardan from July 2023 to June 2024.

Methods: A total of 245 CKD patients were enrolled, with a mean age of 65.4 ± 10.2 years. Demographic and clinical data, including CKD stage, comorbidities, and UTI history, were collected. The number of UTI episodes, causative organisms, antibiotic resistance patterns, and management outcomes were also analyzed.

Results: Recurrent UTIs were present in 61.2% of patients. Those with recurrent UTIs showed significantly faster eGFR decline (4.8 ± 1.2 vs. 2.1 ± 1.0 mL/min/year, $p < 0.001$) and increased serum creatinine levels (1.1 ± 0.5 vs. 0.5 ± 0.3 mg/dL, $p < 0.001$) compared to those without recurrent UTIs. Furthermore, recurrent UTI patients had higher rates of progression to ESRD (33.3% vs. 15.8%, $p = 0.002$), dialysis need (26.7% vs. 10.5%, $p = 0.005$), and mortality (16.7% vs. 8.4%, $p = 0.03$). The most common causative organism was Escherichia coli (65.3%), and 24.5% of bacterial strains were ESBL-producing. Management strategies, including empirical and targeted antibiotic use, showed varied success rates, with targeted therapy being most effective (88.2% improvement).

Conclusion: Recurrent UTIs significantly worsen CKD progression and increase the risk of adverse outcomes. Effective management, particularly targeted antibiotic therapy, is crucial for improving patient outcomes in this high-risk population.

Key Words: Urinary tract infection, chronic kidney disease, recurrent UTIs, eGFR, progression to ESRD, antibiotic resistance, management strategies, mortality.

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INTRODUCTION

The elderly are disproportionately affected by chronic kidney disease (CKD). Twenty million Americans, or around 11% of the adult population between 1988 and 1994, had chronic kidney disease (CKD) in one form or another. A hundred times lower than the frequency of kidney failure (CKD stage 5; 0.1%) is the prevalence of early CKD stages (CKD stages 1 to 4; 10.8%)[1–3].

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A decrease in the estimated glomerular filtration rate (eGFR), a measure of renal function loss, is the usual indicator of kidney damage. Clinically, chronic kidney disease (CKD) is characterised by an abnormal eGFR (≤60 ml/min/1.73 m2) that lasts for more than three months and is frequently accompanied by proteinuria. In addition to changes in kidney structure and function (e.g., interstitial fibrosis, microvascular rarification and calcification, nephron loss), these processes also involve a number of other serious changes, such as changes in vitamin D and electrolyte metabolism (e.g., hyperparathyreoidism, vascular calcification), imbalances in water and electrolytes (e.g., impaired volume shift, hyperkalemia), metabolic acidosis, microinflammation, dysregulation and instability in blood pressure (e.g., arterial hypertension and hypotension) or endothelial dysfunction, increased risk of cardiovascular events, mediasclerosis, stroke, maldigestion, sarkopenia, fragility, and immunodysfunction[4–7].Information regarding the prevalence of urinary tract infections (UTIs) among these patients is scarce. Less than one per five thousand

individuals experience infections linked to chronic kidney disease annually[8]. However, the likelihood of developing ESKD is higher in patients who experience recurrent UTIs. The incidence is slightly higher in newborns and early children (approximately 1%) compared to adults. It is believed that comorbidities and clinical risk factors other than UTI are more significant in the development of ESKD. Multiple risk factors for urinary tract infections (UTIs) in chronic kidney disease (CKD) patients include: gender, age, heredity, diabetes mellitus, obstructive nephropathy, arteriolosclerosis (microvascular calcification, ischaemic nephropathy), nephrolithiasis, cast-nephropathy, immunodeficiency syndromes, immunosuppressive medication, and cast-nephropathy.

METHODS

Study Design and Setting: The purpose of this prospective, observational, cross-sectional study was to examine the association between chronic kidney disease (CKD) patients' occurrence of UTIs and the development of their condition. The research took place in a tertiary care facility. The institutional review board gave its stamp of approval to the study, which ran from 2023–2024.

Participants: According to the Kidney Disease: Improving Global Outcomes (KDIGO) recommend-ations, 245 participants were enrolled in the trial after a diagnosis of chronic kidney disease (Stages 3-5). Patients had to have a verified diagnosis of CKD and be 18 years old or older to be included. Acute kidney injury, cancer therapy, and pregnancy were all included as exclusion factors. Everyone who took part in the study gave their written consent.

Data Collection: Electronic health records were analyzed for demographics, comorbidities, CKD stage, serum creatinine, and eGFR. UTIs were defined as ≥2 symptomatic episodes in 12 months. Urine cultures identified pathogens and antibiotic resistance. Empirical antibiotic therapy was initiated, with adjustments in 73.5% of cases. Preventive measures included hydration, catheter avoidance, and cranberry supplements.

Statistical Analysis: Patient demographics, clinical features, and management techniques were summarised using descriptive statistics, which can be expressed as mean ± standard deviation or frequency. The groups that experienced recurrent UTIs were compared to those that did not using chi-square tests for categorical variables and independent t-tests for continuous variables. For statistical purposes, a p-value below 0.05 was deemed significant. Multivariate regression analysis was carried out to discover parameters that were independently linked to the progression of CKD. We used SPSS 26 (IBM Corp., Armonk, NY, USA) for all of our statistical analyses.

RESULTS

A little larger proportion of females (55.1%) than men (44.9%), the study comprised 245 patients with an average age of 65.4 ± 10.2 years. The average body mass index was 28.5 kg/m². Severity of chronic kidney disease ranged from 36.7% in Stage 3 to 38.8% in Stage 4, and 24.5% in Stage 5.

Table No. 1: Demographic Data

Variable	Mean ± SD / n (%)
Age (years)	65.4 ± 10.2
Sex	
- Male	110 (44.9%)
- Female	135 (55.1%)
Body Mass Index (BMI, kg/m²)	28.5 ± 4.3
CKD Stage	
- Stage 3	90 (36.7%)
- Stage 4	95 (38.8%)
- Stage 5	60 (24.5%)
Diabetes Mellitus	130 (53.1%)
Hypertension	190 (77.6%)
History of Recurrent UTIs	150 (61.2%)
Use of Immunosuppressants	40 (16.3%)
Indwelling Catheter Use	50 (20.4%)
History of Kidney Stones	65 (26.5%)
eGFR (mL/min/1.73m²)	35.8 ± 12.1
Serum Creatinine (mg/dL)	2.5 ± 1.1
Urinary Protein Excretion (g/day)	1.2 ± 0.8

Table No. 2: UTI Characteristics in CKD Patients

Variable	Mean ± SD / n (%)
Number of UTI episodes in the past year	3.2 ± 1.5
Common UTI symptoms	
- Dysuria	170 (69.4%)
- Hematuria	110 (44.9%)
- Fever	95 (38.8%)
- Flank pain	80 (32.7%)
Causative Organisms	
- Escherichia coli	160 (65.3%)
- Klebsiella pneumoniae	45 (18.4%)
- Proteus mirabilis	25 (10.2%)
- Enterococcus spp.	15 (6.1%)
Antibiotic Resistance Patterns	
- ESBL-producing bacteria	60 (24.5%)
- Multi-drug resistance (MDR)	50 (20.4%)
Hospitalization due to UTI	80 (32.7%)

With hypertension identified in 77.6% of patients and diabetes mellitus in 53.1%, comorbid disorders were common. Thirteen percent were on immuno-suppressants, twenty-four percent had an indwelling catheter, and 61.2% had a history of recurrent UTIs.

Further, 26.5% had renal stone history. Participant renal impairment varied in severity, as shown by an average eGFR of 35.8 ± 12.1 mL/min/1.73 m², 2.5 ± 1.1 mg/dL of blood creatinine, and 1.2 ± 0.8 g/day of urine protein excretion.

Table No. 3: Impact of Recurrent UTIs on CKD Progression

Outcome Measure	Recurrent UTI (n=150)	No Recurrent UTI (n=95)	p-value
eGFR Decline (mL/min/year)	4.8 ± 1.2	2.1 ± 1.0	<0.001
Serum Creatinine Increase (mg/dL)	1.1 ± 0.5	0.5 ± 0.3	<0.001
Progression to ESRD (%)	50 (33.3%)	15 (15.8%)	0.002
Need for Dialysis (%)	40 (26.7%)	10 (10.5%)	0.005
Mortality (%)	25 (16.7%)	8 (8.4%)	0.03

Table No. 4: Management Strategies and Outcomes

Management Strategy	n (%)	Success Rate (% Improvement in Symptoms)
Empirical Antibiotic Use	245 (100%)	75.50%
Targeted Antibiotic Therapy (after culture results)	180 (73.5%)	88.20%
Prophylactic Antibiotic Use	60 (24.5%)	62.00%
Cranberry Supplements Use	40 (16.3%)	40.00%
Increased Hydration (>2L/day)	120 (49.0%)	55.00%
Avoidance of Catheterization	195 (79.6%)	-
Use of Immunosuppressant Modifications	30 (12.2%)	50.00%
Referral to Nephrologist/Urologist	140 (57.1%)	-

DISCUSSION

Treatment of urinary tract infections (UTIs) needs antibiotic concentrations at least high enough to reach within the microbiome of urine. Abnormalities creating high antibiotic concentrations in the urine occur mainly through tubular and glomerular secretion because these remain the main urinary excretion pathways for most antibiotics. The estimated glomerular filtration rate (eGFR) along with antibiotic plasma half-life duration shows extended time in patients who have chronic kidney disease (CKD) so healthcare providers need to modify medication doses to prevent toxicity while maintaining effective results. The treatment guidelines for UTIs in patients with normal renal function also help manage UTI cases among individuals with renal insufficiency[9,10]. The main priorities should prevent bacterial resistance development while accelerating recovery times. Acute and chronic renal disorders have a substantial impact on the antibiotic bioactivation process which includes tubular secretion and reabsorption. The renal condition known as CKD affects the non-renal clearance potential of medications together with protein binding properties and body distribution volume and drug absorption characteristics in patients with either hemodialysis or peritoneal dialysis treatment (Patel et al., 2019)[11]. The risk of negative drug reactions and negative patient outcomes from medication errors becomes higher in CKD patients with heart failure when proper dosing and monitoring are not done properly[12,13].Medical research has confirmed that females experience higher UTI infection rates than males because of their different anatomical features including shorter urethra and rectal closeness[14]. The study outcomes demonstrated higher UTI cases among males because males face more frequent occurrences of CKD[15]. In line with research the majority of UTI patients fell within the age group of 61 to 70[16].The examined patients displayed primary symptoms consisting of dysuria together with increased urinary frequency and fever as well as suprapubic pain and urinary incontinence and macrohaematuria. Results from this study matched those presented in a researcher systematic review[17]. Tests of urine bacterial levels revealed high counts even among patients who did not show symptoms of UTI which demonstrates that symptoms frequently fail to serve as dependable UTI indicators. A precise UTI diagnosis requires the evaluation of dysuria along with fever symptoms as individual symptoms do not sufficiently indicate the condition. Our study findings show Klebsiella species together with Escherichia coli act as the main Gram-negative bacteria causing UTIs and Staphylococcus aureus and Enterococcus serve as the major Gram-positive bacteria. The research data matches similar outcomes from studies about UTIs conducted in community settings[18]. The most concerning result in our study showed high resistance rates to quinolones among these pathogens with ciprofloxacin resistance at 72% while norfloxacin and levofloxacin showed resistance rates of 68.8% and 60% respectively[19].The clinical management of urinary tract infections becomes difficult due to the growing numbers of E. coli (77.1%) and Klebsiella (61.1%) bacteria which produce extended-spectrum beta-lactamase. The organisms

presented considerable resistance to amoxicillin-clavulanic acid alongside third-generation cephalosporins, nitrofurantoin, and cotrimoxazole according to a researcher[20]. The strategic application of antibiotics at our institute is supported by a low carbapenem resistance rate (5-6%) which indicates successful antimicrobial stewardship according to (Patel et al., 2019)[11]. The study underlines the necessity to create individualized antibiotic plans for patients with CKD because kidney function modifications occur while multidrug-resistant pathogens remain commonly discovered in their bloodstream. Urinary tract infection resistance management requires the establishment of potent antibiotic programs together with periodic microorganism testing to fight rising antibiotic resistance threats.[21]

CONCLUSION

Recurrent UTIs significantly worsen CKD progression and increase the risk of adverse outcomes. Effective management, particularly targeted antibiotic therapy, is crucial for improving patient outcomes in this high-risk population.

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Abbreviations:

UTI – Urinary Tract Infection
CKD – Chronic Kidney Disease
eGFR – Estimated Glomerular Filtration Rate
ESRD – End Stage Renal Disease
ESKD – End Stage Kidney Disease
KDIGO – Kidney Disease Improving Global Outcomes
MDRD – Modification of Diet in Renal Disease
BMI – Body Mass Index
MDR – Multi Drug Resistance
ESBL – Extended Spectrum Beta-Lactamase

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