Section: General Medicine

Original Research Article

CLINICAL AND MICROBIOLOGICAL PROFILE OF URINARY TRACT INFECTIONS AMONG DIABETIC PATIENTS IN A TERTIARY CARE CENTRE IN SOUTH KERALA

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ABSTRACT

Background: Urinary tract infections (UTIs) are among the most common bacterial infections in patients with diabetes mellitus and are frequently associated with recurrent infections, severe disease, and increasing antimicrobial resistance. Poor glycaemic control and diabetes-related complications increase susceptibility to infection and may influence the microbiological profile and treatment outcomes. **Materials and Methods:** This hospital-based cross-sectional study was conducted among 100 diabetic patients presenting with symptoms suggestive of UTI at a tertiary care centre in South Kerala between December 2018 and November 2019. Clinical details, laboratory parameters, and urine culture and sensitivity results were analysed. Statistical analysis was performed using descriptive and inferential methods. **Result:** The mean age of the participants was 58.74 years. The most common symptoms were increased urinary frequency (82%), dysuria (78%), urgency (67%), cloudy or foul-smelling urine (60%), and suprapubic pain (55%). Systemic manifestations included fever (48%), upper UTI/pyelonephritis (40%), flank pain (35%), and hematuria (22%). Hypertension (46%) was the most common comorbidity, while diabetic neuropathy (50%), nephropathy (46%), and retinopathy (45%) were frequent complications. Culture positivity was observed in 51% of patients. Escherichia coli (37%) was the predominant pathogen, followed by Klebsiella (24%), Proteus (12%), Enterococcus (11%), and Pseudomonas (7%). Higher fasting blood sugar, postprandial blood sugar, and HbA1c levels were associated with increased UTI incidence. Multidrug-resistant organisms were detected in 36% of infections. Significant associations were observed between UTI and hypertension ($p=0.049$), HbA1c levels ($p=0.045$), and hospital stay among MDRO cases ($p=0.004$), while age showed a positive correlation with UTI risk ($\rho=0.192$, $p=0.021$). **Conclusion:** UTIs in diabetic patients are associated with poor glycaemic control, significant comorbidities, and increasing multidrug resistance. Early diagnosis, culture-guided therapy, and effective glycaemic control are essential to reduce complications and improve outcomes.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections in clinical practice, affecting individuals of all age groups and contributing to morbidity and healthcare utilisation worldwide. UTIs involve infection of any part of the urinary system, including the urethra, bladder, ureters, or kidneys. Nearly half of all women experience at least one episode of UTI during their lifetime. While uncomplicated UTIs are usually easily treated, certain patient populations, such as those with underlying comorbidities, are at higher risk for complicated infections and recurrent disease.[1]

Diabetes mellitus is one of the most important risk factors predisposing individuals to UTIs. Patients with diabetes are more susceptible to UTIs due to several mechanisms, including hyperglycaemia-induced immune dysfunction, impaired neutrophil function, autonomic neuropathy leading to bladder dysfunction, and glycosuria. Studies have

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demonstrated that UTIs in diabetic individuals often have a more complicated clinical course, with higher rates of recurrence, hospitalisation, and progression to severe infections such as pyelonephritis or bacteremia compared with non-diabetic patients.[1,2] A study involving 722 diabetic individuals reported positive uropathogen cultures in approximately 35% of patients, with higher occurrence among those with poor glycaemic control.[3]

The microbiological spectrum of UTIs in diabetic patients has been widely studied, with Gram-negative organisms accounting for the majority of infections. Escherichia coli remains the predominant pathogen responsible for UTIs, followed by organisms such as Klebsiella species, Pseudomonas aeruginosa, Proteus species, Enterococcus species, and Staphylococcus species. In many studies, Gram-negative bacteria constitute nearly 80% of uropathogens isolated from urine samples. A study evaluating diabetic patients with UTIs reported that Escherichia coli accounted for approximately 57.9% of infections, followed by Staphylococcus aureus (21.05%) and Klebsiella species (15.79%).[4,5] Similarly, other investigations have identified E. coli as the leading pathogen responsible for UTIs among diabetic patients across different regions.[6]

An important concern in the management of UTIs is the increasing emergence of antimicrobial resistance among uropathogens. Frequent antibiotic exposure, recurrent infections, and prolonged healthcare contact contribute to the development of resistant organisms, particularly in patients with chronic conditions such as diabetes. The emergence of multidrug-resistant organisms (MDROs), including extended-spectrum β-lactamase (ESBL) producing Enterobacteriaceae, has complicated the empirical treatment of UTIs. Studies have reported the presence of ESBL- and carbapenemase-producing uropathogens among diabetic patients, indicating a growing challenge in antibiotic therapy. Increasing antimicrobial resistance has been associated with higher rates of treatment failure, longer hospital stays, and increased healthcare costs.[7,8]

The distribution of uropathogens and their antimicrobial susceptibility patterns varies across geographic regions due to differences in antibiotic usage practices, healthcare infrastructure, and local epidemiology. Therefore, region-specific data are essential for guiding empirical antibiotic therapy and implementing effective antimicrobial stewardship programs. Despite the high prevalence of diabetes in India and particularly in the southern states, there is limited regional data describing the clinical presentation, microbiological spectrum, and antimicrobial resistance patterns of UTIs among diabetic patients in tertiary care settings.

Understanding the clinical characteristics, causative microorganisms, and antimicrobial susceptibility profiles of UTIs in diabetic individuals is important for early diagnosis and appropriate treatment. Hence, the present study aims to evaluate the clinical and microbiological profile, antimicrobial susceptibility, and multidrug resistance patterns of urinary tract infections among diabetic patients in a tertiary care centre in South Kerala.

Objective: To analyse the clinical presentation, identify the causative microorganisms, and determine the antimicrobial susceptibility and multidrug resistance patterns of urinary tract infections among diabetic patients in a tertiary care centre.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted in the Department of General Medicine at Dr SMCSI Medical College, Karakonam, Kerala, from December 2018 to November 2019. Ethical clearance was obtained from the Institutional Ethics Committee before the commencement of the study, and informed consent was obtained from all participants prior to enrollment.

Inclusion criteria

Patients above 18 years of age, diagnosed with diabetes mellitus, who presented with symptoms suggestive of urinary tract infection and were willing to participate.

Exclusion criteria

Patients who had used antimicrobials within two weeks prior to or during data collection, those with a recent history of catheterisation, pregnant women, patients who had undergone urosurgery within the previous 30 days, and individuals with known anatomical or functional abnormalities of the urinary tract.

Methods: A total of 100 diabetic patients presenting with symptoms of UTI who met the inclusion criteria were consecutively enrolled in the study using a non-probability sampling technique. A detailed clinical history was recorded for each patient, including demographic characteristics such as age and sex, associated comorbidities, duration of diabetes, ongoing treatment, complications of diabetes, urinary symptoms, and relevant laboratory findings.

Approximately 10 mL of venous blood was collected under aseptic precautions from each participant for laboratory investigations, including fasting blood sugar (FBS), postprandial blood sugar (PPBS), glycated haemoglobin (HbA1c), blood urea, serum creatinine, C-reactive protein (CRP), haemoglobin (Hb), and total leukocyte count (TLC). Midstream urine samples were collected from all participants in sterile containers for urine routine examination, urine culture, and antibiotic sensitivity testing. Urine cultures showing $\geq 10^5$ colony-forming units (CFU)/mL were further processed for identification of uropathogens using biochemical methods. Antimicrobial susceptibility testing was performed using the modified Kirby–Bauer disc diffusion method. All microbiological investigations were carried out in the Department of Microbiology, Dr SMCSI Medical College, Karakonam.

Data were collected using a semi-structured questionnaire that included the sociodemographic

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profile, diabetic history and treatment details, baseline investigations (FBS, PPBS, HbA1c, CRP, renal function tests, haemoglobin, and total leukocyte count), symptoms of urinary tract infection, and urine examination and culture report findings. Urine samples were collected as freshly voided clean-catch midstream specimens in sterile, leak-proof containers. The samples were stored at 4°C within 30 minutes of collection and transported to the microbiology laboratory within two hours for immediate analysis to ensure accurate identification of uropathogens. The microbiological evaluation included urine routine examination, urine culture and sensitivity testing, and assessment of antimicrobial susceptibility and resistance patterns.

The diagnosis of diabetes mellitus was based on standard criteria, including fasting plasma glucose ≥126 mg/dL after at least 8 hours of fasting, 2-hour plasma glucose ≥200 mg/dL during an oral glucose tolerance test with 75 g of anhydrous glucose as per WHO guidelines, HbA1c ≥6.5% using standardized laboratory methods, or random plasma glucose ≥200 mg/dL in patients with classic symptoms of hyperglycemia or hyperglycemic crisis.

Statistical analysis: Descriptive and inferential statistical analyses were performed for the study. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The Chi-square test was used to assess the association between categorical variables. Independent sample t-tests were applied to compare the mean values. Spearman correlation analysis was used to evaluate the relationship between continuous variables. A p-value of less than 0.05 was considered statistically significant. Data analysis was performed using IBM-SPSS version 25.0 (IBM-SPSS Science Inc., Chicago, IL).

RESULTS

The mean age of the study participants was 58.74 years, with an age range of 40–82 years. The most common symptoms of UTI were increased urinary frequency (82%), dysuria (78%), and urgency (67%), followed by cloudy or foul-smelling urine (60%) and suprapubic pain (55%). Systemic or severe manifestations included fever (48%), upper UTI/pyelonephritis (40%), flank pain (35%), and hematuria (22%), while urinary retention (10%) and emphysematous pyelonephritis (8%) were less frequent. All patients had diabetes mellitus (100%), with hypertension (46%), cardiovascular disease (30%), and cerebrovascular accident (22%) as common comorbidities. Diabetic complications included neuropathy (50%), nephropathy (46%), and retinopathy (45%). Regarding treatment, 44% were on oral hypoglycemic agents (OHA), 43% were on insulin, 11% were on combined therapy, and 2% were not receiving any medication. Recurrent UTI occurred in 32% of patients, and 10% required ICU admission [Table 1].

Table 1: Clinical Characteristics, Comorbidities, Complications, and Treatment Profile

Parameters		Percentage
Clinical Features	Increased Frequency	82%
	Dysuria	78%
	Urgency	67%
	Cloudy/Foul-Smelling Urine	60%
	Suprapubic Pain	55%
	Fever	48%
	Upper UTI (Pyelonephritis)	40%
	Flank Pain	35%
	Hematuria	22%
	Urinary Retention	10%
	Emphysematous Pyelonephritis	8%
Comorbidities	Diabetes Mellitus	100%
	Hypertension	46%
	Cardiovascular Disease	30%
	Cerebrovascular Accident	22%
Diabetic Complications	Diabetic Neuropathy	50%
	Diabetic Nephropathy	46%
	Diabetic Retinopathy	45%
Diabetes Treatment	OHA Only	44%
	Insulin Only	43%
	OHA + Insulin	11%
	No Drugs	2%
Recurrent UTI		32%
ICU admission		10%

For fasting blood sugar (FBS), UTI incidence increased from 10% in patients with FBS <100 mg/dL to 18% in those with 100–125 mg/dL and 40% in those with ≥126 mg/dL. For postprandial blood sugar (PBS), UTI incidence rose from 12% at <140 mg/dL to 22% at 140–199 mg/dL and 48% at ≥200 mg/dL. Similarly, with HbA1c, UTI incidence increased from 8% in patients with HbA1c <5.7% to 15% with 5.7–6.4% and 45% with ≥6.5% [Table 2].

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Table 2: Distribution of Glycemic Control Parameters and UTI Incidence

Parameters	Range (mg/dL)	Mean ± SD	UTI Incidence
FBS	<100	95.4 ± 2.1	10%
	100–125	112.8 ± 6.3	18%
	≥126	175.2 ± 35.1	40%
PBS	<140	138.2 ± 1.5	12%
	140–199	172.5 ± 15.4	22%
	≥200	290.1 ± 62.3	48%
HbA1C	<5.7	5.4 ± 0.2	8%
	5.7–6.4	6.0 ± 0.3	15%
	≥6.5	9.1 ± 1.1	45%

Culture positivity was observed in 51% of cases, while 49% were culture negative. Among the identified pathogens, E. coli (37%) was the most common organism, followed by Klebsiella (24%), Proteus (12%), Enterococcus (11%), Pseudomonas (7%), and Candida (5%), while 4% showed no growth. Among cases of upper UTI, E. coli (40%) remained the predominant pathogen, followed by Klebsiella (25%), Proteus (15%), Pseudomonas (12%), and Enterococcus (8%) [Table 3]. Culture-positive patients had higher mean age (59.2 vs 58.2 years), mean HbA1c (8.7% vs 8.1%), and mean hospital stay (11.6 vs 10.3 days). However, the mean diabetes duration was higher in culture-negative patients (15.7 vs 14.1 years). UTI incidence was higher among patients using SGLT2 inhibitors (55%) compared to those not using SGLT2 inhibitors (30%).

Table 3: Urine Culture Results and Distribution of Uropathogens

Parameters		Percentage
Culture test	Positive	51%
	Negative	49%
Pathogens	E. coli	37%
	Klebsiella	24%
	Proteus	12%
	Enterococcus	11%
	Pseudomonas	7%
	Candida	5%
	No Growth	4%
Upper UTI Pathogens	E. coli	40%
	Klebsiella	25%
	Proteus	15%
	Pseudomonas	12%
	Enterococcus	8%

E. coli demonstrated high resistance to meropenem (85%), nitrofurantoin (75%), and piperacillin–tazobactam (65%), with lower resistance to ciprofloxacin and norfloxacin (10%). Klebsiella showed high resistance to meropenem (90%), followed by amikacin (65%) and nitrofurantoin (60%). Proteus showed resistance to meropenem (90%), amikacin (85%), piperacillin–tazobactam (75%), and ceftazidime (70%). Enterococcus showed 35% resistance to piperacillin–tazobactam but remained fully sensitive to vancomycin and linezolid (100%). Pseudomonas demonstrated moderate resistance to amikacin (75%), meropenem (70%), piperacillin–tazobactam (60%), and ceftazidime (55%) [Table 4]. Multidrug-Resistant Organisms (MDRO) infections were present in 36 patients (36%), while 64 patients (64%) had infections caused by non-MDRO organisms.

Table 4: Antibiotic Resistance Pattern Among Uropathogens

Antibiotic	E.coli	Klebsiella	Proteus	Enterococcus	Pseudomonas
Amikacin	60%	65%	85%	–	75%
Cotrimoxazole	30%	25%	50%	–	–
Nitrofurantoin	75%	60%	N/A	55%	–
Meropenem	85%	90%	90%	–	70%
Piperacillin-Tazobactam	65%	55%	75%	35%	60%
Ceftazidime	30%	30%	70%	–	55%
Amoxicillin-Clavulanate	10%	–	45%	–	–
Gentamicin	45%	45%	65%	–	50%
Ciprofloxacin	10%	20%	40%	–	40%
Norfloxacin	10%	30%	45%	–	35%
Ceftriaxone	20%	–	60%	–	20%
Vancomycin	–	–	–	100%	–
Linezolid	–	–	–	100%	–

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Chi-square analysis showed a significant association between UTI and hypertension (p=0.049) and MDRO with gender (p=0.027), while UTI with cardiovascular disease (p=0.337) and UTI with gender (p=0.118) were not significant. Independent t-test demonstrated a significant difference in HbA1c between UTI-positive and UTI-negative patients (p=0.045) and hospital stay between MDRO and non-MDRO patients (p=0.004), whereas diabetes duration was not significant (p=0.201). Spearman correlation showed no significant correlation between HbA1c and hospital stay (ρ=-0.012, p=0.904) or diabetes duration and UTI risk (ρ=0.134, p=0.058), while age had a significant positive correlation with UTI risk (ρ=0.192, p=0.021) [Table 5].

Table 5: Statistical Analysis of Factors Associated with UTI and MDRO

Tests	Comparisons	Values
Chi-Square Tests	UTI vs Hypertension	0.049
	UTI vs Cardiovascular Disease	0.337
	UTI vs Gender	0.118
	MDRO vs Gender	0.027
Independent t-test	HbA1c (UTI+ vs UTI−)	0.045
	Diabetes Duration (UTI+ vs UTI-)	0.201
	Hospital Stay (MDRO vs Non-MDRO)	0.004
Spearman Correlation	HbA1c vs Hospital Stay	ρ= -0.012, p= 0.904
	Diabetes Duration vs UTI Risk	ρ= 0.134, p= 0.058
	Age vs UTI Risk	ρ= 0.192, p= 0.021

E. coli had the highest association with neuropathy (18.5%), nephropathy (17%), and retinopathy (16.7%), followed by Klebsiella (12%, 11%, 10.8%). Lower proportions were observed with Proteus (6%, 5.5%, 5.4%), Enterococcus (5.5%, 5.1%, 4.9%), Pseudomonas (3.5%, 3.2%, 3.2%), and Candida (2.5%, 2.3%, 2.2%) [Table 6].

Table 6: Distribution of Diabetic Complications According to Uropathogens

Pathogen	Neuropathy	Nephropathy	Retinopathy
E. coli	18.5%	17%	16.7%
Klebsiella	12%	11%	10.8%
Proteus	6%	5.5%	5.4%
Enterococcus	5.5%	5.1%	4.9%
Pseudomonas	3.5%	3.2%	3.2%
Candida	2.5%	2.3%	2.2%

DISCUSSION

Urinary tract infections are a common complication among patients with diabetes mellitus and are often associated with more severe clinical presentations, recurrent infections, and increasing antimicrobial resistance. This study evaluated the clinical presentation, microbiological profile, antimicrobial susceptibility patterns, and multidrug resistance among diabetic patients with UTIs in a tertiary care centre. The study assessed associated comorbidities, diabetic complications, glycaemic control parameters, and the distribution of uropathogens, along with their resistance patterns and factors influencing UTI occurrence and clinical outcomes.

In the present study, UTI among diabetic patients most commonly presented with lower urinary tract symptoms such as increased urinary frequency, dysuria, urgency, cloudy or foul-smelling urine, and suprapubic pain. Systemic manifestations, including fever, flank pain, hematuria, and features of upper urinary tract involvement such as pyelonephritis. Few had severe complications such as urinary retention and emphysematous pyelonephritis, while recurrent urinary tract infections were noted in several diabetic patients. Similar findings have been reported in previous literature, where diabetic patients with urinary tract infection commonly presented with lower urinary tract symptoms such as urinary frequency, urgency, dysuria, and suprapubic pain, while upper urinary tract involvement manifested with systemic symptoms including fever and flank pain.[9]

In the present study, the mean age of the participants was 58.74 years, with patients ranging from 40 to 82 years. There was a significant positive correlation between age and the risk of urinary tract infection. A cross-sectional study investigating the prevalence of urinary tract infections among diabetic patients also reported that older individuals had a significantly higher prevalence of UTI compared to younger patients, highlighting age as an important risk factor.[10] These findings suggest that UTIs are more commonly observed in older individuals with diabetes.

In the present study, several comorbid conditions were observed among diabetic patients with UTI, with hypertension being the most common, followed by cardiovascular disease and cerebrovascular disease. Diabetic complications such as neuropathy, nephropathy, and retinopathy were also frequently noted, with a significant association between hypertension and the occurrence of UTI. Similar findings were reported in a study conducted among patients with type 2 diabetes, where hypertension, insulin therapy, obesity, and nephropathy were

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identified as significant factors associated with an increased risk of urinary tract infection.[11] Ahmed et al. also reported that chronic illnesses including hypertension were common among diabetic patients with UTIs.10 Thus, suggesting that the presence of comorbidities and diabetes-related complications may contribute to an increased susceptibility to urinary tract infections in diabetic individuals.

In the present study, higher levels of fasting blood sugar, postprandial blood sugar, and HbA1c were associated with a greater incidence of UTI among diabetic patients. Patients with poor long-term glycemic control also showed a significantly higher HbA1c level in the UTI-positive group compared to the UTI-negative group. Lenherr et al. also reported similar results, where HbA1c values greater than 8.5% were linked with a 60% higher risk of UTI among diabetics. The risk is increased due to impaired neutrophil chemotaxis, glucosuria, and defective cytokine production, all of which provide a conducive environment for bacterial colonisation.[12,13] These findings indicate that inadequate glycemic control plays an important role in increasing susceptibility to urinary tract infections in individuals with diabetes mellitus.

In the present study, E. coli was the most common pathogen, followed by Klebsiella, Proteus, Enterococcus, Pseudomonas, and Candida. Antibiotic susceptibility analysis revealed high resistance among major uropathogens, particularly E. coli, Klebsiella, and Proteus, to several commonly used antibiotics, while Enterococcus remained sensitive to vancomycin and linezolid. 36% of infections were caused by multidrug-resistant organisms, which were associated with a significantly longer hospital stay and showed a significant association with gender. These results are consistent with research carried out by Flores-Mireles et al., where E. coli was the most common uropathogen in more than 60% of diabetic UTIs, followed by Klebsiella and Proteus species.[14] Research by Tesfaye et al. identified that more than 40% of diabetic UTI patients carried fluoroquinolone-resistant E. coli strains, consistent with our results.[15] These findings highlight the growing challenge of antimicrobial resistance and the importance of culture-guided therapy in diabetic patients with UTI.

Limitations

Being a single-centre study conducted in a tertiary care hospital in South Kerala with a limited sample size, the findings may not be fully generalizable to other populations, and larger multicentric studies could provide greater statistical power. The cross-sectional design provides only a snapshot of UTI incidence and antibiotic resistance without long-term follow-up regarding recurrence or treatment outcomes. Although the association between glycaemic control and UTI risk was assessed, longitudinal glycaemic variations were not evaluated. Similarly, while current antimicrobial resistance patterns were analysed, temporal trends in resistance were not examined. Certain risk factors, such as prior UTI history, catheterisation, and renal impairment, were not extensively analysed. The higher incidence of UTI among SGLT2 inhibitor users was observed, but potential confounders, including hydration status, hygiene practices, and concomitant medications, were not assessed. In addition, treatment outcomes such as clinical cure, recurrence, or readmission were not evaluated, and although Candida infections were identified, detailed antifungal susceptibility testing was not performed.

CONCLUSION

This study highlights the substantial burden of UTIs among diabetic patients, emphasising the role of poor glycaemic control, antimicrobial resistance, and recurrent infections. Diabetes mellitus increases susceptibility to UTIs due to impaired immune function, bladder dysfunction, and persistent hyperglycaemia. Inadequate glycaemic control was associated with a higher risk of infection and recurrence, underscoring the importance of optimal blood glucose management in preventing UTIs. The observed antimicrobial resistance patterns indicate the growing challenge of multidrug-resistant organisms, highlighting the need for rational antibiotic use and culture-guided therapy. Additionally, the presence of comorbidities further complicates infection management, emphasising the importance of a multidisciplinary approach. Regular screening, early diagnosis, and individualised treatment strategies, along with improved glycaemic control and antimicrobial stewardship, are essential to reduce the burden and recurrence of UTIs in diabetic patients.

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