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Urinary Tract Infections in Diabetic Patients: Clinical and Microbiological Perspectives

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Abstract

Objective: This study aimed to evaluate the clinical features, associated risk factors, microbiological spectrum, and antimicrobial susceptibility patterns of urinary tract infections (UTIs) among patients with diabetes mellitus (DM). It further explored the relationship between diabetic complications and the presence of bacteriuria.

Method: A cross-sectional, descriptive study was conducted in the Department of General Medicine from January 2024 to October 2024. A total of 100 diabetic patients were enrolled based on defined inclusion and exclusion criteria. Clinical examination, urine culture, and laboratory investigations including fasting plasma glucose, HbA1c, and ultrasonography were performed. Midstream urine samples were cultured on MacConkey, blood, and chocolate agars. Isolated organisms were identified, and antibiotic sensitivity testing was done using the Kirby-Bauer disc diffusion method. Data were analyzed using SPSS v26, and statistical significance was considered at $p < 0.05$.

Results: Out of 100 participants, 45% exhibited bacteriuria. Type II diabetes was more prevalent among those with bacteriuria. No statistically significant association was observed between bacteriuria and sex, age, or treatment type. However, poor glycemic control (HbA1c >10%) was more common in the bacteriuric group. The most frequently isolated pathogen was *Escherichia coli* (36%), followed by *Pseudomonas* (18%), *Klebsiella* (15%), *Enterococcus* (13%), *Acinetobacter* (9%), and *Candida* (9%). Carbapenems such as meropenem and imipenem showed the highest sensitivity. Bacteriuria was notably more frequent in patients with nephropathy, diabetic foot, and retinopathy.

Conclusion: Diabetic patients, especially those with complications and poor glycemic control, are at a significantly higher risk for UTIs. *E. coli* remains the predominant uropathogen, and rising antimicrobial resistance underscores the need for regular microbiological surveillance and tailored antibiotic therapy.

Keywords: Urinary Tract Infection, Diabetes Mellitus, Bacteriuria, Antimicrobial Resistance, Microbiological Profile

Introduction:

Diabetes mellitus (DM) is a chronic and progressive metabolic disorder marked by persistent hyperglycemia due to either inadequate insulin production or resistance to insulin's action¹. The global burden of DM has been rising at an alarming rate, with its prevalence increasing from 4.7% in 1980 to 8.5% in 2014 among adults aged 18 years and older, according to the World Health Organization². This metabolic condition not only affects carbohydrate metabolism but also impairs lipid and protein metabolism, contributing to widespread systemic complications. Among the many health issues associated with DM, the increased susceptibility to infections remains a critical concern³. This predisposition is largely due to a range of immune system impairments that render diabetic patients more vulnerable to infectious diseases, and when infections occur, they often follow a more severe and prolonged course⁴.

One of the most common and clinically significant infections in individuals with diabetes is urinary tract infection (UTI). The relationship between DM and UTIs is particularly important because the altered immune response in diabetic patients leads to frequent, recurrent, and sometimes complicated infections¹. Multiple studies have highlighted that individuals with DM are approximately 1.2 to 2.2 times more likely to develop UTIs than non-diabetic individuals^{3,5}. There are several pathophysiological reasons for this increased risk. Diabetic patients often have impaired immune system activity due to impairment at several levels. Diabetic patients also have impaired innate immune responses, experiencing with different components of the immune system⁶. For example, C4 is a complement protein and without sufficient amounts of C4, opsonization and clearance of bacteria is reduced. A major propellant of the immune response is the production of cytokines and, in the case of patients with diabetes, there is a reduction in the production of IL-1 and IL-6, in mononuclear cells, to aid the inflammatory response used to battle infection. Additionally, with chronic hyperglycemia, advanced glycation end products (AGEs), are formed and accumulated, creating physiological abnormalities that limit normal immune signalling and result in downregulation of the major histocompatibility complex (MHC) class I molecules, impairing normal antigen presentation and reducing the activity of cell-mediated immunity⁴.

A significant part of the increased occurrence of UTIs in diabetic patients is also a result of Polymorphonuclear cells (PMNs) mechanistic dysfunction. PMNs in patients with diabetes have impaired chemotaxis, adherence, phagocytosis, and microbial killing, all very important actions of the innate immune response³. A complication of long-standing diabetes is Autonomic neuropathy, leading to impaired bladder function. One variation of neuropathic bladder is diabetic cystopathy, which further, allows for a favorable environment, for bacterial growth and infection⁷. Due to this lack of infection prevention in a familiar environment, UTIs in diabetic patients are more prevalent and typically more complicated, having a greater incidence of ascending infections, renal involvement, and systemic spread⁸.

Asymptomatic bacteriuria is also particularly common among those with diabetes. It is often unrecognized until urine cultures become positive for bacteria in patients with diabetes. Even just asymptomatic bacterial colonization can have significant clinical implications in these patients. Therefore, there is strong rationale for early routine assessment for bacteriuria and urinary tract infections (UTIs) in populations with diabetes. With appropriate treatment, a simple UTI can be recognized and treated quickly - thus potentially preventing their subsequent complications of pyelonephritis & renal scarring, as well as sepsis, all of which will be more likely among these patients and change the course of care⁷.

The current study will take an initial step toward a better understanding of the clinical and microbiological features of UTIs in people with diabetes mellitus. The study will characterize typical presenting symptomatology, evaluate the associated risk factors found among patients presenting with urinary tract infections, demographic variables correlated with urinary infection, and then further characterize the organisms isolated, and isolate & describe the predominant organisms associated with UTIs in people with diabetes, & antimicrobial resistance data associated with these organisms. Because of the clinical implications, information regarding management will specifically refer to bacteriuria among those with as symptoms of UTIs & the findings can lead to more informed & specific strategies for management of diabetic patients with urinary presentations. The research question for this study focuses on: What are the clinical features and associated risk factors of urinary tract infections in patients with diabetes mellitus? The second goal of the study is to characterize the microbiological spectrum of the pathogens associated with UTIs and their resistance and susceptibility to commonly used antimicrobial agents. By using the same set of questions, both studies will contribute toward the clinical evidence that can allow for better decisions regarding the prevention and treatment of urinary tract infections in patients with diabetes, ultimately leading to better health outcomes, and reducing the burden of health care.

MATERIAL AND METHODS:

The current is a quantitative, descriptive cross-sectional study that was conducted in the Department of General Medicine in the period between January 2024 and October 2024. The subjects in this study were selected based on diagnosis of diabetes mellitus proven by fasting plasma glucose more than 126mg/dL after an overnight fast and postprandial plasma glucose level, more than 180mg/dL: and clinical and microbial features of UTI. The target measure showed that 69% of the participants received antibiotics within the last 14 days preceding the survey. Sample size was estimated from an earlier study using the following parameters; the confidence interval of 95%, The study power of 80 % and an $\alpha= 5\%$. In estimating the sample size of the study, the figure that was arrived at was 100 participants. Before the conduct of the study, there was approval from the Institutional Ethics Committee. However, special permission was obtained from all the participants before the study through written informed consent. Initially after creating and defining the inclusion and exclusion criteria.

METHOD:

Total 100 patients were recruited into this study. A clinical examination was done to check for symptomatology of UTI- axillary temperature, pulse rate, blood pressure, Suprapubic tenderness CVA tenderness and Abdominal examination was done. Sterile) midstream urine samples were also obtained from all the patients under aseptic procedures and were taken for routine and culture. Among these plates, MacConkey agar, blood agar and chocolate agar were used in culturing the urine. Consequently, reactions were carried out at 37 degrees Celsius for a period of between 24 to 48 hours. Strain identification was done with reference to colony morphology antimicrobial susceptibility, lactose fermentation test and biochemical test. Identification of antibiotic sensitivity correctly done through the use of the Kirby-Bauer disc diffusion method. These investigations were CBC, fasting and postprandial blood sugar test and Ultrasonography (USG) done for reviewing any amount of urine left in the bladder and other genitourinary abnormalities if any.

STATICAL ANALYSIS:

All the data were entered in an Excel spreadsheet sheet and analyzed using the Statistical Package for the Social Sciences version 26. Cross-tabulation of demographic profile and chi-square test were adopted for analyzing nominal-and ordinal-level data, while descriptive and inferential statistics

including paired t test were used in analyzing interval and ratio data in the study. The statistical measurement where by the end of the study, the level of signification widely agreed upon was set at $p < 0.05$.

Results:

Over a period of ten months, 100 patients meeting the inclusion and exclusion criteria were enrolled in the study. Among these, 45 patients had bacteriuria, while 55 patients did not. The relationship between urinary tract infection (UTI) with and without bacteriuria was analyzed in relation to various demographic and clinical factors, including sex, age, type of diabetes, treatment modality, HbA1c levels, and fasting plasma glucose (FPG), as shown in table 1.

Patient variables		Patient with bacteriuria	Patient without bacteriuria	P value
Number of patients		45	55	
Sex	Male 50	16	29	0.404
	Female 50	30	29	
Age	>40 yrs	5	5	0.768
	40-50 yrs	10	11	
	51-60 yrs	15	15	
	61-70 yrs	14	17	
	>70 yrs	1	7	
Types of diabetes mellitus	Type I	10	6	0.056
	Type II	24	60	
Type of treatment	Insulin	8	6	0.179
	Oral drug	24	52	
	Both	4	6	
Hb Alc(%)	<6.5	1	3	0.064
	6.6 to 10	17	39	
	>10	15	25	
Fasting plasma glucose (mg/dl)	<100	3	2	0.109
	111 to 200	12	25	
	>200	20	38	

Table-1: Demography and clinical characteristic of patients

The microbiological profile of the 45 patients with bacteriuria revealed the following organisms: Escherichia coli (16 isolates, 36%), Klebsiella spp. (7 isolates, 15%), Enterococcus (6 isolates 13%), Pseudomonas (8 isolates, 18%), Acinetobacter (4 isolates 9%), and Candida (4 isolates 9%). Antimicrobial sensitivity patterns showed that among the 16 E. coli isolates, 8 were sensitive to fluoroquinolones, 2 to piperacillin, and 6 to piperacillin-tazobactam. Fourteen isolates were sensitive to meropenem. Klebsiella spp. isolates were sensitive to meropenem, imipenem, ceftriaxone, ceftazidime, aminoglycosides, piperacillin, and fluoroquinolones. Enterococcus isolates were

sensitive to imipenem and linezolid. Pseudomonas isolates were sensitive to fluoroquinolones, imipenem, and meropenem. Acinetobacter isolates were sensitive to aminoglycosides.(fig 1)

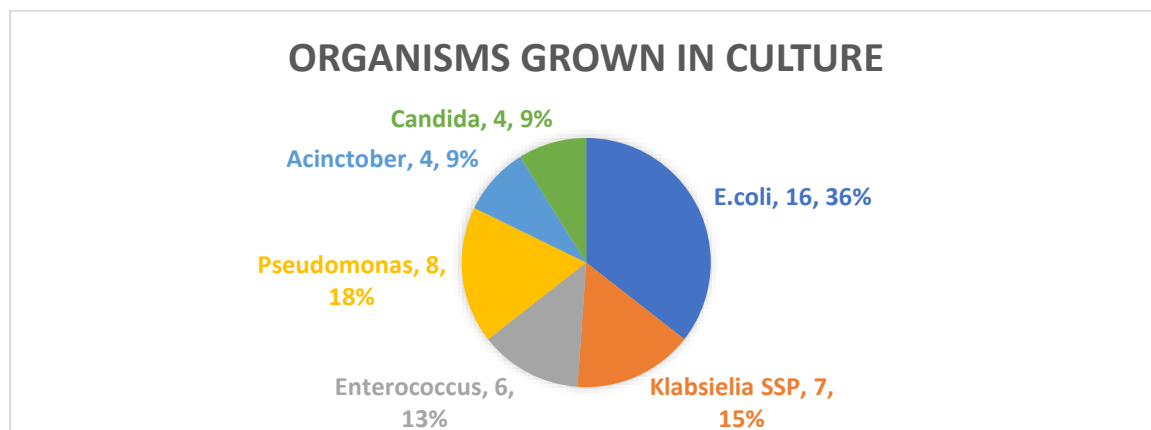


Fig 1: organism % observe during urine culture

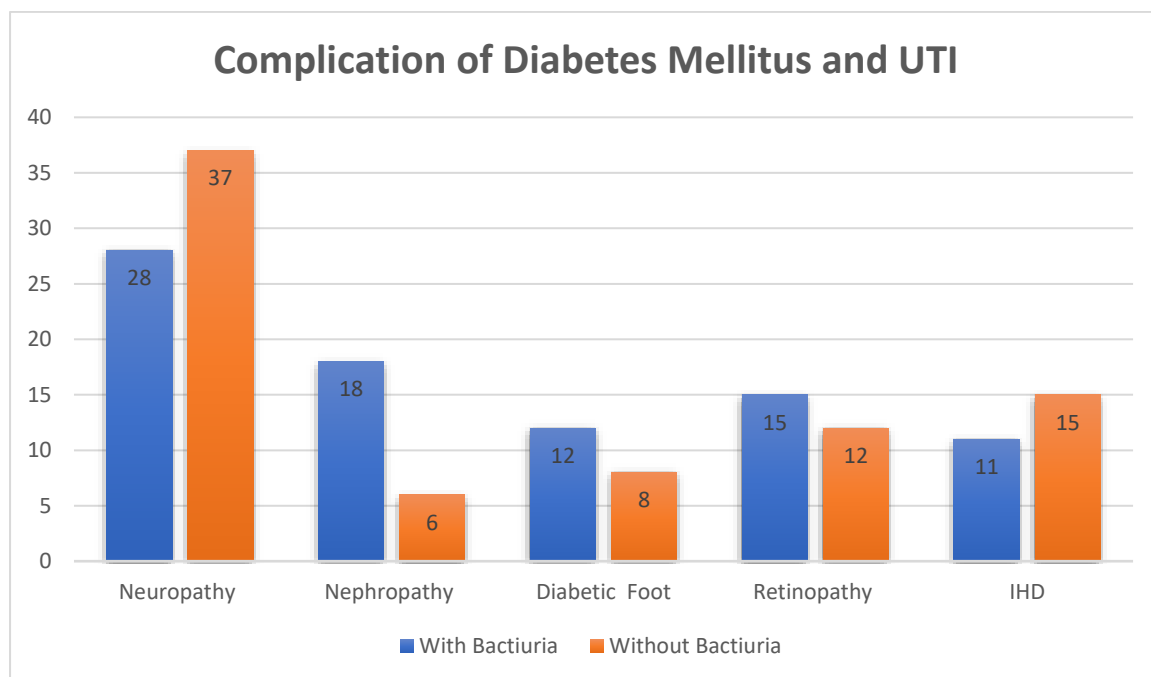


Table-2: Relation between complication of diabetes mellitus and UTI

The relationship between diabetic complications and UTI was also analyzed as shown in table 2. Neuropathy was present in 65 patients, 28 (43.07%) had bacteriuria, and 37 (56.92%) did not. Nephropathy was present in 24 patients, 18 having bacteriuria and 6 without. Diabetic foot ulcer was present in 20 patients, of whom 12 had bacteriuria, and 6 did not. Retinopathy was present in 27 patients, with 15 having bacteriuria and 12 without. Ischemic heart disease was present in 26 patients, of whom 11 had bacteriuria, and 15 did not.

Discussion:

The results comprise the clinical and microbiological characteristics of urinary tract infections (UTIs) in patients with diabetes mellitus (DM), thereby contributing to both national and international literature emphasizing the increased vulnerability of diabetic individuals towards developing UTIs^{1-3,9}. Over the

course of almost ten months, out of 100 patients, 45% were found to have bacteriuria which confirms these individuals face a high risk of UTIs. Our study data regarding diabetes and UTI-tract infection concur with other studies conducted in comparable regions. A good example is Hamdan et al.'s study in 2015 which showed women with diabetes had asymptomatic bacteriuria at a higher rate than non-diabetics, further supporting the hypothesis that diabetes and its associated weakened immune system make one more prone to urinary infections¹⁰.

Sex distribution in our series demonstrated an almost equal pattern of UTIs in male and female diabetic patients, unlike what is traditionally reported where UTIs are reported to be more common in females in general population. In our results, there was no correlation between age and bacteriuria and the latter was evenly distributed in different age groups^{11,12}. This conclusion are in agreement with others that age is a factor for UTI susceptibility, but it is the length of time and control of diabetes that matter more¹³.

With respect to the diabetes type and the form of treatment, type 2 diabetes was more commonly observed in our series of patients with bacteriuria. It is also noted increased infection burden in patients with type II diabetes especially those with poor glycemic control¹⁴. Our results on HbA1c and fasting plasma glucose support once more the association between worse glycemic control and higher UTI risk¹⁵. Although in the present study, there were no statistically significant p-values, the trend toward an higher bacteriuria frequency in the poorly controlled diabetics was apparent. Some studies showed that hyperglycemia is a major contributor of neutrophils' dysfunction and cytokine release, which compromises the host response to infections⁶.

The most frequent etiological agent was *Escherichia coli* (36%) and *Pseudomonas*, *Klebsiella*, *Enterococcus*, *Acinetobacter*, and *Candida* were the other microorganisms found. This is consistent with global reports that *E. coli* is dominant uropathogen both in diabetic and non-diabetic patients^{4,5,16}. *E.coli* was also found to be the predominant isolate followed by *Klebsiella* and *Pseudomonas*¹⁷.

Interestingly, the pattern of antibiotic sensitivity in our work had a much higher resistance rate. The commonly used antibiotics but carbapenems like imipenem, meropenem were the most effective and this is in agreement with what was obtained in a Lagos study that emphasising emergence of drug resistance in diabetic UTI isolates¹⁸. Furthermore, we found a significant correlation between diabetic complications and the frequency of UTI. *Battleria* was more frequent in patients with nephropathy ($P = 0.02$), diabetic foot ($P = 0.001$) and retinopathy ($P = 0.005$)³. This confirms results from another study that showed that vascular impairment and compromised host defense mechanisms made microvascular consequences of diabetes a strong predictor of UTI¹⁹.

CONCLUSION:

One of the most significant risk factors linked to UTIs was determined to be diabetic neuropathy. *Klebsiella* species were reported to have the second-highest number of bacterial isolates, followed by *Escherichia coli*. It is necessary to closely monitor the situation in elderly diabetes patients, particularly those with poor glycemic control, as they are at risk of having complex UTIs.

Conflict of Interest: Authors did not have any conflict of interest.

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