Journal of Cardiovascular Disease Research
ISSN: 0975-3583,0976-2833 VOL 14, ISSUE 7, 2023

Antimicrobial Susceptibility Profiles of Urinary Pathogens in Patients with Diabetes Mellitus

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Abstract

Background:
The null hypothesis of this study states that there is no significant difference in the clinical and microbiological profiles of urinary tract infections (UTIs) between diabetic patients and non-diabetic controls. **Aim and Objective:** To evaluate the antimicrobial susceptibility patterns of microorganisms isolated from the urinary tract in diabetic and non-diabetic individuals. **Materials and Methods:** This study included adults aged 18 years and above, of both sexes. Participants were categorized into two groups: diabetic patients with a confirmed diagnosis of diabetes mellitus, and healthy non-diabetic controls without any known chronic illness. Diabetic participants were recruited during routine visits to hospital diabetic clinics. Blood samples and midstream urine specimens were collected from a total of 220 individuals (130 diabetics and 120 non-diabetics). **Results:** Among the 130 diabetic patients, asymptomatic bacteriuria (ASB) was detected in 59 individuals (42%). A significantly higher risk of ASB was observed in those with a history of frequent UTIs (Odds Ratio [OR] = 8.889, 95% Confidence Interval [CI]: 2.876–30.924) and recurrent UTIs (OR = 5.478, 95% CI: 1.946–8.675). Staphylococci were the most frequently isolated organisms in urine cultures. Diabetic patients also demonstrated a significantly higher prevalence of Candida species compared to the control group ($P < 0.001$). Antimicrobial susceptibility testing revealed similar resistance patterns in both groups, particularly against erythromycin, cotrimoxazole, and flucytosine. **Conclusion:** Diabetic individuals appear to be more susceptible to bacteriuria, influenced by factors such as female gender, menopause, recurrent UTIs, and lower educational attainment. Notably, a lack of formal education was associated with a higher incidence of bacteriuria, suggesting the importance of health literacy in managing and preventing UTIs, especially among diabetic populations.

Introduction

Chronic hyperglycemia in diabetes mellitus can adversely affect various organ systems, including those not directly involved in immune defense, thereby increasing susceptibility to infections. Impaired local circulation due to both macrovascular and microvascular complications can delay immune responses and prolong wound healing [1]. Additionally, sensory neuropathy in the lower limbs may reduce pain perception, leading to unnoticed injuries that are poorly managed, increasing the risk of infection [2]. Autonomic neuropathy may also contribute to incomplete bladder emptying, thereby promoting urinary stasis and creating a favorable environment for bacterial colonization [3]. Furthermore, glucosuria—elevated glucose levels in the urine—has been shown to facilitate the growth of certain bacteria and fungi, such as Candida species [4].

Diabetic individuals are at increased risk for various infections, including those affecting the bladder, kidneys, vagina, gums, skin, and feet [5]. Among these, urinary tract infections (UTIs) are particularly prevalent, ranking as the sixth most common complication associated with diabetes [6]. Numerous studies have established a strong association between diabetes and UTIs, with infections frequently caused by organisms such as Escherichia coli, Klebsiella pneumoniae, Streptococcus agalactiae, Enterococcus faecalis, coagulase-negative Staphylococcus, Streptococcus pyogenes, and Candida albicans [7,8].

While lower urinary tract infections, such as cystitis and asymptomatic bacteriuria, are generally mild and treatable with antibiotics, they may progress to more severe infections involving the kidneys and ureters if not managed properly. Diabetic patients are particularly vulnerable to upper urinary tract infections, including pyelonephritis and renal or perinephric abscesses [9]. In severe cases, emphysematous infections may occur, characterized by gas production from bacterial fermentation, posing significant health risks. Though the exact mechanisms linking diabetes to UTIs remain under investigation, there is growing evidence that lower urinary tract infections can ascend and lead to more serious complications in diabetic individuals [10]. The **null hypothesis** of this study posits that there is no significant difference in the clinical and microbiological profiles of UTIs between diabetic and non-diabetic individuals. **Therefore, the objective** of the present study is to assess and compare the antimicrobial susceptibility patterns of uropathogens isolated from diabetic and non-diabetic patients.

Materials & Methods:

Adults (18 years and older) of both sexes were included in the study. The study population was divided into two groups: diabetic patients, who had diabetes mellitus, and non-diabetic controls, who appeared healthy and had no history of diabetes or any underlying illness. Diabetic patients were enrolled in the study during routine check-ups at hospital diabetic units. During free diabetes/hypertension screening exercise, non-diabetic controls were recruited from the general community. Clustered sampling was used because participants were sampled at specific locations, specifically diabetic

outpatient departments. Purposive sampling was used because the study targeted adults (aged 18 and over), and clustered sampling was used because participants were sampled at specific locations. Participant inclusion criteria include all males and non-pregnant females > 18 years of age., subjects who consented or assented to participate in the study, people not suffering from any known underlying.

Table 1: Antimicrobial susceptibility patterns of Gram-positive bacteria

Statistical analysis: sickness as stated in the questionnaire, people who had not taken antibiotics or steroids for one week preceding the sample analyses. Participant exclusion criteria include people <18 years of age, all pregnant women, people suffering from any chronic disease such as hypertension, hepatitis, rheumatoid arthritis, cancer, HIV/AIDS, heart disease, and kidney disease, and people who had received antibiotics or steroids for one week before sample collection.To analyze all of the data, the Chi-square test was performed, and after that, the statistical program for the social sciences was used to compute the odds ratio for each variable to identify factors that increase the likelihood of ASB (SPSS). To conduct a more in-depth examination of the variables that were substantially connected, it was necessary to take into consideration immutable aspects such as age and gender. A multivariate logistic regression study was carried out to ascertain which demographic, medical, and laboratory parameters best predict ASB in diabetic people.

Results:

The hierarchical cluster for the antimicrobial resistance pattern of Gram-positive bacteria revealed 4 distinct clusters namely: Vanco-E-Cfx; E-Cfx-Aug; Genta-Doxy; Cotrim-Ox. The Genta-Doxy cluster was the most active against Gram-positive bacteria while Cotrim-Ox was the least active. A total of 71 isolates of GPC were tested for their susceptibility to 8 different antibiotics (Table 1). Gram-positive bacteria exhibited high resistance to oxacillin (63; 88 %), cotrimoxazole (48; 67 %), and augmentin (35; 52 %). All isolates of S. aureus were resistant to 3 of the antibiotics (Augmentin, vancomycin, and oxacillin). Similarly, all NGS strains were resistant to vancomycin but no resistance was demonstrated against gentamicin. All Gram-positive bacteria except Coagulase negative Staphylococci (CNS) did not show any resistance to gentamicin. A comparison of the antibiotic resistance with the site of isolation revealed that Gram-positive isolates from the urinary tract were generally more resistant than those from the oral cavity. However, this difference was not statistically significant (P = 0.127).

Anti biotics	GBS (n = 3)	CNS (n = 58)	S. aureus (n = 5)	NGS (n = 5)	Total (n =71)	
Augmentin	1 (50.0)	26 (45.8)	4 (100)	4 (66)	35(52)	
Cefuroxime	0 (0.0)	20 (33.9)	0 (0.0)	0 (0.0)	20 (28)	
Doxycycline	0 (0.0)	10 (18)	0 (0.0)	0 (0.0)	10 (14)	
Cotrimoxazole	2 (100)	38 (67.8)	2 (50.0)	6 (83)	48 (67)	
Vancomycin	1 (50.0)	13 (22.2)	4 (100)	6 (100)	24 (33)	

Table 2: Distribution of asymptomatic bacteriuria with respect to age and gender in diabetic patients and non-diabetic control

Age	Diabetics with ASB (n = 55)	Non-diabetics with ASB (n = 31)	Total Number with ASB (n = 86)
18-30yrs	5 (8 %)	5 (15 %)	10 (12%)
31-40yrs	5 (8 %)	4 (12 %)	9 (11 %)
41-50yrs	18 (32 %)	7 (24 %)	25 (29 %)
51 and above	27 (52 %)	15 (49 %)	42 (49 %)
χ2-test: χ2 = 6.783; P = 0.856		**χ2-test: χ2 = 4.931; P = 0.571**	
Gender			
Male	6 (10 %)	4 (12.9 %)	10 (11 %)
Female	49 (90 %)	27 (87.01 %)	76 (88 %)
χ2-test: χ2 = 18.325; P < 0.001		**χ2-test: χ2 = 21.482;P < 0.001**	

Table 3: Prevalence of asymptomatic bacteriuria among diabetic patients and non-diabetic controls

Participant type	Prevalence of Bacteriuria n (%)	95%CI LB – UP	Total
Diabetic patients	55 (42 %)	34- 66.8	130

Non-diabetic controls	31 (28.3%)	,18.6 – 35	120
Total	**86 (35 %)**	**29 – 42**	**250**

$\chi 2$-test: $\chi 2 = 9.523$; df = 1; P = 0.019

Generally, regardless of diabetic status, participants aged 50 years and above presented more than 42 (48.8 %) with ASB while those less than 40 years presented least (44; 51.2 %) with ASB (Table 2). However, there was no significant difference in the distribution of ASB concerning age in both diabetic patients (P = 0.856) and non-diabetic controls (P = 0.571). On the other hand, a highly significant difference was noticed in the distribution of ASB concerning sex in both diabetic patients and non-diabetic controls (P < 0.001).86 (35%) of the 250 subjects had substantial bacteriuria (Table 3). It was also discovered that more diabetic patients (59; 42%) than non-diabetic controls (31; 28.3%) had significant ASB, and the difference in prevalence between diabetic patients and non-diabetic controls was significant (P = 0.019).Two hundred and fifty midstream urine samples yielded 102 isolates (Figure 1). Candida, Klebsiella, Serratia, Staphylococcus, Streptococcus, Escherichia, Pantoea, Proteus, Citrobacter, and Enterobacter were among the many microbes identified. Staphylococcus (31; 30%), Klebsiella (17; 17%), Candida (16; 16%), Escherichia coli and Serratia (11; 11%), and other gram-negative bacteria were the most frequently isolated taxa.

Discussion

Diabetes Mellitus is highly prevalent in India and is associated with numerous complications, including an increased susceptibility to infections [11]. Urinary tract infections (UTIs) are a significant clinical concern in diabetic patients due to their potential for severe outcomes [12]. Despite the well-documented relationship between diabetes and infectious diseases, limited data exist regarding the microbiological profile and antimicrobial resistance patterns of UTIs in diabetic populations, particularly in regions like Indore. This case-control study aimed to investigate these factors in diabetic and non-diabetic individuals aged 18 and above.

Among the 250 participants (130 diabetics and 120 non-diabetic controls), asymptomatic bacteriuria (ASB) was detected in 52% of diabetic patients and 48% of non-diabetics. These findings are higher than those reported in previous studies, which noted ASB prevalence ranging from 5.3% to 26% in diabetics [13] and 3.5% to 15% in non-diabetics [14]. Regional studies, including those from Nigeria (36.1%) [16], Cameroon (47.2%), and Italy (18.5%), reveal considerable variability in ASB prevalence, likely due to differences in geographic location, diagnostic methods, and study design [19].

In this study, **coagulase-negative Staphylococcus** was the most frequently isolated organism (30%), followed by **Klebsiella** (16%), **Candida** (16%), and **E. coli** (10%). While E. coli has traditionally been considered the predominant uropathogen in UTIs [20], our findings suggest a shift toward Gram-positive organisms, particularly in diabetic individuals. The higher isolation rate of **Candida spp.** among diabetic patients may be attributed to glucosuria, which creates a favorable environment for fungal

proliferation. Notably, **Serratia spp.** was exclusively isolated from diabetic participants, while **Klebsiella spp.** was more frequently observed in non-diabetic controls, indicating potential differences in microbial colonization linked to metabolic status.

Candida isolates showed high resistance to **flucytosine** (92.7%), moderate resistance to **fluconazole** (50.6%), and lower resistance to **miconazole** (33.3%). The high resistance to flucytosine underscores the importance of combination therapy with azoles [22]. These findings align with previous reports indicating rising azole resistance, especially among non-albicans Candida species [23]. Resistance to **nystatin** was not observed, which is consistent with the relatively low resistance reported for polyene antifungals.

Most bacterial isolates demonstrated significant resistance to **oxacillin**, **cotrimoxazole**, **erythromycin**, and **clindamycin**, with **coagulase-negative Staphylococci (CNS)** showing the highest resistance among Gram-positive organisms. Alarmingly, 15% of CNS isolates were resistant to **gentamicin** and 22.5% to **vancomycin**, raising concerns about the circulation of multidrug-resistant strains. The observed **vancomycin resistance in S. aureus** may be attributed to the expression of **VanA-type resistance genes** [24].

Among Gram-negative bacteria, the highest resistance was recorded against **gentamicin**, whereas resistance to **ciprofloxacin** was comparatively lower. Moderate to high resistance was also observed to second- and third-generation cephalosporins. The widespread resistance to **ceftriaxone**, likely due to **extended-spectrum beta-lactamase (ESBL)** production, mirrors trends seen in other developing countries [25]. In particular, resistance to **amoxicillin** (87%), **piperacillin** (74%), and **cotrimoxazole** (73%) has been frequently documented, largely due to overuse. **Nitrofurantoin**, typically associated with low resistance rates, showed moderate resistance in our study, potentially indicating emerging cross-resistance. **E. coli** isolates demonstrated multidrug resistance, especially to **gentamicin**, **nalidixic acid**, **doxycycline**, **cefuroxime**, and **erythromycin**, consistent with previous studies [26].

Notably, **gentamicin resistance** differed significantly between Gram-negative (73.3%) and Gram-positive (8.5%) isolates, likely due to the presence of **efflux pumps** in Gram-negative bacterial membranes [27]. No significant differences in antimicrobial resistance were observed between oral and urine isolates or between diabetic and non-diabetic groups ($P > 0.05$), suggesting similar environmental exposure to antimicrobial agents in both populations.

In summary, this study highlights a moderately high rate of antimicrobial resistance among urinary isolates in both diabetic and non-diabetic patients. The predominance of coagulase-negative Staphylococci and Candida in diabetics emphasizes the need for accurate microbial identification and tailored treatment strategies. The widespread and often unregulated use of antibiotics may contribute to rising resistance trends, underscoring the need for antimicrobial stewardship and periodic surveillance of resistance patterns.

Conclusion

This study highlights two key findings among diabetic patients: a high prevalence of

asymptomatic bacteriuria (ASB) and a potential shift in the microbial profile associated with urinary tract infections. Notably, **coagulase-negative Staphylococci** and **Candida species** emerged as significant uropathogens, underscoring their clinical importance in diabetic individuals. Furthermore, factors such as **gender**, **menopausal status**, **history of recurrent UTIs**, and **lack of formal education** were associated with increased susceptibility to bacteriuria. The link between lower educational attainment and higher risk of infection suggests the need for targeted health education and preventive strategies, especially among vulnerable diabetic populations.

Conflict of interest:
The present study authors do not have any conflict of interest among themselves

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