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Original Research Article

Clinical and Microbiological Profile of Catheter Associated Bacteriuria at a Tertiary Care Hospital

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Abstract:

Introduction: Catheter-associated bacteriuria (CA-bacteriuria) is the presence of significant bacterial growth in the urine of patients who are currently or recently catheterized, with or without urinary symptoms. When symptoms are present, termed a catheter-associated urinary tract infection (CAUTI). CAUTI is the most prevalent healthcare-associated infection worldwide, primarily linked to the widespread and often inappropriate use of urinary catheters in hospitals and long-term healthcare facilities.

Aim and Objectives: 1) To identify urinary pathogens and assess their antimicrobial resistance patterns in catheterized patients. 2) To determine the rate of CA-bacteriuria. 3) To explore the relationship between CA-bacteriuria and high-risk clinical conditions.

Methodology: The study analyzed 682 urine samples from patients catheterized for over 48 hours (June 2022–May 2023), processing them per standard protocols, with pathogen identification and antibiotic susceptibility testing performed using the VITEK 2 Compact system.

Results: Catheter-associated bacteriuria was detected in 132 patients (19.35%), with gram-negative bacilli accounting for 61.36% of isolates, predominantly *Escherichia coli* (21.21%). The highest prevalence was observed among male patients and individuals aged 50 years or older, with diabetes emerging as the most frequent associated risk factor. In most cases, catheterization duration was under 10 days. *E. coli* isolates showed complete susceptibility to colistin, while *Candida* species demonstrated 100% sensitivity to micafungin.

Conclusion: Catheter-associated bacteriuria is a significant healthcare issue. Key factors include age, diabetes, catheter duration, and antimicrobial resistance. Colistin effectively treats gram-negative bacteria, while Vancomycin, Daptomycin, Teicoplanin, and Linezolid are effective against gram-positive bacteria.

Keywords: Catheter-associated bacteriuria (CA-bacteriuria), Catheter-associated urinary tract infection (CAUTI), Antimicrobial resistance, Diabetes mellitus.

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Introduction

Catheter-associated bacteriuria is among the most frequent healthcare-related infections globally, occurring in approximately 1–10% of patients and accounting for 30–40% of all hospital-acquired infections [1]. Around 80% of urinary tract infections acquired in healthcare facilities are associated with catheterization, known as CAUTI [2]. Being admitted to the ICU is linked to a markedly higher likelihood of CAUTI occurrence [3].

CA-bacteriuria, or catheter-associated bacteriuria, is characterized by the presence of substantial bacteriuria in a patient who has undergone recent catheterization or is currently catheterized, regardless of whether urinary tract symptoms or signs are evident. CA-bacteriuria is classified as: (1) CAUTI is defined as the presence of catheter-associated bacteriuria in a patient who also exhibits symptoms or clinical signs attributable to the urinary tract. (2) Catheter-associated asymptomatic bacteriuria describes the detection of bacteriuria in catheterized patients who show no symptoms or signs of urinary tract involvement [2]. When a patient has an indwelling catheter for 48 hours or more and subsequently develops UTI-related signs and symptoms, the condition is classified as symptomatic CAUTI. Cases in which a catheter was removed after two days of use and UTI diagnostic criteria were satisfied on the day of removal or the day thereafter were also categorized as CAUTI [2].

The presentation may involve urinary tract–specific symptoms or nonspecific systemic signs like fever, urinary urgency or frequency, malaise, incontinence, pelvic discomfort, and tenderness in the costovertebral angle region. The diagnostic criterion for bacteriuria generally falls between 10^3 and 10^5 CFU per milliliter [2].

Indwelling catheters promote symptomatic infections by providing a surface that facilitates microbial adhesion and growth [1]. CAUTI may be caused by either endogenous or exogenous pathogens. Infections from endogenous origins occur due to the colonization of microorganisms in the meatal, rectal, or vaginal areas. Exogenous sources are linked to catheter insertion or manipulation by healthcare workers. Notably, infections can still develop despite the use of aseptic techniques and closed, sterile drainage systems [4].

Possible complications of CAUTI range from fever, urethritis, and cystitis to acute pyelonephritis, kidney stones, and, in advanced cases, bloodstream infections [2].

Frequent exposure to diverse microorganisms leads to the common isolation of antibiotic-resistant organisms in CAUTI. Acting as a major source of antimicrobial resistance, these infections are further complicated when antibiotics are used indiscriminately, increasing cross-infection risks in catheterized individuals [5]. This leads to extended hospital admissions and higher healthcare expenses for both the patient and the institution. Ultimately, it contributes to greater morbidity and mortality. With the rising prevalence of multidrug-resistant organisms, timely diagnosis becomes essential [2].

Objectives: To identify the micro-organism and its antimicrobial susceptibility pattern from the urine sample of a catheterized patient and evaluate the rate of catheter-associated bacteriuria. We also want to determine the association of CA-bacteriuria with high-risk conditions.

Methodology

Study Design and Duration: From June 2022 to May 2023, we undertook a prospective observational study at a tertiary care hospital to investigate relevant clinical parameters.

Inclusion Criteria: Samples from the catheterized patient (>48 hours) received at the Department of Microbiology of a tertiary care hospital were applied in the study.

Exclusion Criteria: Urine specimens collected from a uro-bag or catheterization for <48 hours were excluded from our study.

Urine was examined macroscopically for odour, red colour, or cloudiness. A wet mount was performed after centrifugation to assess crystals, casts, pus cells, blood cells, epithelial cells, and bacteria. The specimens were inoculated onto Nutrient agar, Blood agar, and MacConkey agar plates, followed by incubation at 35 ± 2 °C for 18–24 hours. Identification and antibiotic susceptibility testing of microorganisms were conducted using the VITEK-2 compact system with GN, AST N405 (Enterobacteriaceae), and AST N406 (non-fermenters) cards. Gram-positive organism identified by the VITEK-2 GP card, with susceptibility testing via AST P628, following CLSI M100 guidelines. [6-8]

The VITEK-2 YST card confirmed identification and antifungal susceptibility was tested using YS08 for Candida spp., following CLSI M44-A2 guidelines. [9]

We collected demographic and clinical details of patients from the Hospital Information System (HIS) for analysis.

Results:

Out of 1521 urine samples, 682 (44.84%) patients are catheterized. Among these, 19.35% specimens show growth on culture. Table 1 shows that in patients with catheterization for less than 10 days, significant bacteriuria was observed in 21.97% of cases with pyuria and 27.76% without pyuria. For those with catheterization longer than 10 days, significant bacteriuria occurred in 5.30% of patients with pyuria and 6.06% without. Bacteriuric patients typically have pyuria, regardless of symptoms.

Table 1: Distribution of Catheter-associated bacteriuria concerning catheter days, pyuria, colony counts and symptoms

Catheter days	n (%)	Pyuria (WBC /HPF)	n (%)	CFU /ml	Symptomatic n (%)	Asymptomatic n (%)	Total N (%)
<10	107 (81.06%)	<5	58 (43.94%)	$<10^5$	7 (5.30%)	16 (12.12%)	23 (17.42%)
				$>10^5$	18 (13.64%)	16 (12.12%)	34 (25.76%)
		>5	49 (37.12%)	$<10^5$	8 (6.06%)	12 (9.09%)	20 (15.15%)
				$>10^5$	8 (6.06%)	21 (15.91%)	29 (21.97%)
>10	25 (18.94%)	<5	15 (11.36%)	$<10^5$	4 (3.03%)	3 (2.27%)	7 (5.30%)
				$>10^5$	4 (3.03%)	4 (3.03%)	8 (6.06%)
		>5	10 (7.58%)	$<10^5$	1 (0.75%)	2 (1.51%)	3 (2.27%)
				$>10^5$	4 (3.03%)	3 (2.27%)	7 (5.30%)

Table 2 shows that in patients with catheterization for less than 10 days, Gram-negative Enterobacterales were the most common 49(37.12%), primarily E. coli (19.70%) and Klebsiella spp. (11.36%). Non-fermenting isolates accounted for 14(10.61%), mainly Pseudomonas spp. (9.09%). Candida spp. was isolated in 39(26.52%), and Gram-positive cocci (GPC) in 9(6.82%). For catheterization durations longer than 10 days, Enterobacterales (8.33%) and non-fermenters (5.30%) were comparable, with increased prevalence of Pseudomonas (4.54%) and GPC (2.27%), but lower Candida (3.03%).

Table 2: Micro-organism distribution in Catheter-associated bacteriuria with catheter days

Organisms		**Catheter days**		
		<10 days n (%)	**>10 days n (%)**	**Total**
Gram-positive cocci	S. aureus	3 (2.27%)	0 (0%)	3 (2.27%)
	Enterococcus spp.	6 (4.54%)	3 (2.27%)	9 (6.82%)
	Total	9 (6.82%)	3 (2.27%)	12 (9.09%)
Gram-negative bacilli Enterobacterales	E. coli	26 (19.70%)	2 (1.51%)	28 (21.21%)
	Klebsiella spp.	15 (11.36%)	5 (3.79%)	20 (15.15%)
	Providencia app.	8 (6.06%)	3 (2.27%)	11 (8.33%)
	Proteus spp.	0 (0%)	1 (0.75%)	1 (0.75%)
	Total	49 (37.12%)	11 (8.33%)	60 (45.45%)
Gram-negative bacilli Non-fermenters	Pseudomonas spp.	12 (9.09%)	6 (4.54%)	18 (13.64%)
	Acinetobacter spp.	2 (1.51%)	1 (0.75%)	3 (2.27%)
	Total	14 (10.61%)	7 (5.30%)	21 (15.91%)
Candida spp.	**Total**	35 (26.52%)	4 (3.03%)	39 (29.55%)

Table 3 shows that among patients with short-term indwelling catheters, 107 (81.06%) had catheterization for less than 10 days. The majority of patients were aged 50 years or older (61.36%), with 50.76% experiencing catheterization for less than 10 days. Male patients (61.36%) predominated in cases of catheter-associated bacteriuria. Comorbidities such as diabetes (43.18%), hypertension (28.79%), elevated creatinine levels (30.3%), and nephrological causes (23.48%) were more frequently observed in the group with catheterization duration of less than 10 days.

Table: 3 Risk factors for Catheter-associated Bacteriuria

Risk factors	**Total**	**Catheter days**	
		<10 days n (%)	**>10 days n (%)**
Catheter-related factors			
Type and duration of catheter			
Indwelling short-term (<30 days) catheter	132 (100%)	107(81.06%)	25 (18.94%)
Patient-related factors			
Age in years			
1-12	3 (2.27%)	2 (1.51%)	1 (0.75%)
12-50	48 (36.36%)	38 (28.79%)	10 (7.57%)
>=50	81 (61.36%)	67 (50.76%)	14 (10.61%)
Gender			
Male	81 (61.36%)	65 (49.24%)	16 (12.12%)
Female	51 (38.64%)	42 (31.82%)	9 (6.82%)
Comorbidities			
Diabetes mellitus	57 (43.18%)	46 (34.85%)	11 (8.33%)
Hypertension	38 (28.79%)	30 (22.73%)	8 (6.06%)
Nephrological cause	31 (23.48%)	23 (17.42%)	8 (6.06%)
Neurological cause	12 (9.09%)	10 (7.57%)	2 (1.51%)
Raised Creatinine (>1.3 mg/dl)	40 (30.3%)	35 (26.52%)	5 (3.79%)

Table 4 shows that vancomycin, teicoplanin, tigecycline, linezolid, rifampicin, and daptomycin demonstrated 100% susceptibility against Staphylococcus aureus and Enterococcus spp. Colistin exhibited the highest susceptibility among agents tested against Enterobacterales and non-fermenters. Tigecycline showed the greatest activity against Enterobacterales. For antifungals, caspofungin and micafungin were efficacious against Candida albicans and Candida glabrata, with some variability in susceptibility to other Candida species. Conversely, fluconazole had the lowest susceptibility rates against C. glabrata and C. guilliermondii.

Table: 4 Antimicrobial % susceptibility profile of micro-organisms isolated in Catheter-associated bacteriuria

Antibacterial	**Gram-positive cocci**			**Gram-negative bacilli - Enterobacterales**			**Non-fermenters**	
Group wise class	**S. aureus n (%)**	**E. faecalis n (%)**	**E. faecium**	**E. coli n (%)**	**K.pneumonie n (%)**	**P. rettgeri n (%)**	**P.aeruginosa n (%)**	**ABC n (%)**
Penicillins								
Oxacillin	1 (33.33%)	-	-	-	-	-	-	-
Cephalosporins								
Ceftriaxone				1 (4.35%)	0 (0%)			
Ceftazidime				1 (20%)	0 (0%)	0 (0%)	1 (5.56%)	0 (0%)
Cefepime				3 (10.71%)	0 (0%)	0 (0%)	1 (5.56%)	0 (0%)
BLBLI								
amoxicillin-clavulanic acid				7 (30.43%)	6 (31.58 %)			
Cefoperazone-sulbactam				7 (25.00%)	1 (5.00%)	0 (0%)	1 (5.56%)	0 (0%)
Piperacillin-tazobactam				7 (25%)	0 (0%)	1 (9.09%)	1 (5.56%)	0 (0%)
Carbapenems								
Imipenem				9 (32.14%)	1 (5%)	0 (0%)	1 (5.56%)	0 (0%)

Meropenem				9 (32.14%)	1 (5%)	0 (0%)	1 (5.56%)	0 (0%)
Ertapenem				6 (26.09%)	1 (5.26%)			
Monobactams								
Aztreonam				1 (20%)	0 (0%)	2 (18.18%)		
Glycopeptide								
Vancomycin	3 (100%)	3 (100%)	6 (100%)					
Teicoplanin	3 (100%)	3 (100%)	6 (100%)					
Fosfomycin								
Fosfomycin				19 (100%)				
Aminoglycosides								
Amikacin				19(67.86%)	2 (10.53%)	0 (0%)	14(82.35%)	0 (0%)
Gentamicin				11(39.29%)	1 (5.26%)	0 (0%)		0 (0%)
Tetracycline								
Tetracycline	2 (66.67%)	0 (0%)	1 (16.67%)					
Minocycline				3 (60%)	0 (0%)			0 (0%)
Glycylcyclines								
Tigecycline	3 (100%)	3 (100%)	6 (100%)	26(92.86%)	8 (40%)			2(66.67%)
Lincosamides								
Clindamycin	2 (66.67%)							
Oxazolidinones								
Linezolid	3 (100%)	3 (100%)	6 (100%)					
Fluoroquinolones								
Ciprofloxacin	0 (0%)	1 (33.33%)	0 (0%)	1 (3.57%)	0 (0%)	0 (0%)	2 (11.11%)	0 (0%)
Levofloxacin	0 (0%)	1 (33.33%)	0 (0%)	1 (20%)		0 (0%)	1 (5.56%)	0 (0%)
Nitrofuran								
Nitrofurantoin	2 (66.67%)	2 (100%)	3 (33.33%)					
Rifamycins								
Rifampicin	3 (100%)							
Lipopeptides								
Daptomycin	3 (100%)	2 (66.67%)						
Polymyxins								

Colistin				28 (100%)	18 (90%)		16(88.89%)	3(100%)
Antifolates								
Cotrimoxazole	2 (66.67%)			6(21.43%)	2 (10%)	1 (9.09%)		0 (0%)

Antifungal	**Candida albicans**	**Candida glabrata**	**Candida guilliermondii**	**Candida tropicalis**
Caspofungin	19 (100%)	2 (100%)	3 (75%)	14 (100%)
Micafungin	19 (100%)	2 (100%)	4 (100%)	14 (100%)
Flucytosine	19 (100%)	2 (100%)	3 (75%)	12 (85.71%)
Voriconazole	19 (100%)	1 (50%)	2 (50%)	11 (78.57%)
Amphotericin B	17 (89.47%)	1 (50%)	3 (75%)	11 (78.57%)
Fluconazole	15 (78.95%)	1 (50%)	1 (25%)	9 (64.29%)

Discussion:

Catheter-associated urinary tract infections (CA-UTIs) represent the most frequent healthcare-associated infection, contributing to as much as 40% of all such cases. The incidence further increases in patients with an indwelling urinary catheter [2]. In this study, among 682 urine samples analyzed, 132 patients (19.35%) had indwelling catheters. Of these, 54 patients (40.91%) were symptomatic and classified as having catheter-associated urinary tract infections (CAUTIs). The remaining 78 patients (59.09%) were asymptomatic but showed uropathogen growth on culture, thus identified as having catheter-associated asymptomatic bacteriuria (CA-ASB). Similarly, Panjwani et al. reported that among 123 catheterized patients, 59% were asymptomatic with positive cultures (CA-ASB), while 41% had symptoms consistent with CAUTIs, showing comparable rates of catheter-associated bacteriuria [10]. Bacteriuria without pyuria is also noted in our study. Catheterization and various non-infectious conditions can both lead to the development of pyuria. Therefore, pyuria is not the sole criterion for diagnosing CAUTI or for initiating antimicrobial treatment. Significant bacteriuria is seen irrespective of symptoms, and lower CFU are seen in symptomatic patients. That is why significant bacteriuria is not a reliable marker or in combination with pyuria [11,12,13].

Organism-wise distribution: In this study, out of 132 catheterized patients, E. coli was identified in 21.21%, K. pneumoniae in 15.15%, P. aeruginosa in 13.64%, Enterococcus spp. in 6.82%, S. aureus in 2.27%, and Candida spp. in 29.55%. In Shiva Verma et al. study, Candida spp. accounted for 30.8%, E. coli for 19.2%, K. pneumoniae for 11.5%, and P. aeruginosa accounted for 7.7%, which is consistent with the findings of the current study [1]. This suggests that the most common organism causing catheter-associated bacteriuria is Candida spp., highlighting its role as an emerging pathogen. Poddar et al. reported isolation rates of 25% for E. coli, 19% for Klebsiella, 11% for Proteus, and 22% for Enterococcus spp., all of which were higher than those found in the present study [14]. Bashir et al. and Ramakrishnan et al. observed E. coli to be the predominant Gram-negative bacillus, [15,16] whereas Saleem et al. documented K. pneumoniae as the leading isolate among Gram-negative organisms [17]. Prolonged antibiotic therapy can disturb the normal bacterial flora, promoting overgrowth and colonization of the urinary tract by Candida spp. These yeasts can form biofilms on catheter surfaces, while urinary stasis and pH alterations caused by indwelling catheters further favour their proliferation. Among Enterobacterales, E. coli remains the primary cause of CAUTI, as it is a common intestinal commensal with a strong ability to colonize and form biofilms on urinary catheters, facilitating ascending infections.

Gender-wise distribution: In the present study, males accounted for 61.36% of cases, while females represented 38.64%, indicating a higher prevalence among men. Comparable results were reported by Shiva Verma et al., Panjwani et al., Ramakrishnan et al., and Saleem et al., who also noted increased bacteriuria rates in males [1,10,16,17]. In contrast, Bashir et al. and Subudhi et al. documented lower rates of catheter-associated bacteriuria in male patients [15,18]. Factors such as prolonged catheterization, prostate disorders, and associated comorbidities contribute to the elevated risk of CAUTIs in men. Adherence to proper catheter maintenance, good hygiene practices, and prompt catheter removal can reduce this risk.

Age-wise distribution: we observed that the maximum age group affected is >=50 years (61.36%). Many studies specifically identify that old age as a significant risk factor for CAUTI. In Shiva Verma et al. mean age in years was 54±8 which showed similar results to the present study and Aumeran et al. mean age was 71±12 which was found to be CA bacteriuria was most commonly seen in the older age group [1,19]. Bashir et al. showed the most common age group was <50 years (72.34%), opposite to the present study [15]. The elderly age group undergoes more surgeries (e.g., abdominal, orthopedic, gynaecological, and urological procedures) which often require indwelling urinary catheters postoperatively. Work-related stress, poor hydration, and inadequate hygiene may increase the risk.

Risk factor: Diabetes Mellitus (43.18%) consistently appears as a major risk factor across multiple studies, including the present study, Gade et al. (2023) and Rubi et al. (2022) [3,20]. This highlights the vulnerability of diabetic patients to CAUTI, likely due to factors such as impaired immune response and neuropathy. Poorly controlled high blood glucose levels can create a nutrient-rich environment that supports bacterial growth. Hypertension (28.79%) and nephrological (23.48%) causes, seen in the present study, fall under the broader category of "co-morbid conditions" frequently mentioned in the reference articles, particularly Gade et al. (2023) and Aumeran et al. (2021) [3,19]. This suggests that systemic health issues significantly increase CAUTI risk. The emphasis on diabetes, hypertension, and nephrological causes aligns with the recognition of underlying health conditions as significant predisposing factors for these infections. Some antihypertensive medications, such as diuretics, can alter urine output and composition, potentially influencing the urinary tract environment.

Anti-microbial susceptibility testing: The present study found that E. coli was most susceptible to Colistin, Fosfomycin, and Tigecycline, and this aligns with findings in Gade et al. (2023) and Poddar et al. (2020), which also reported Colistin's effectiveness, especially against multidrug-resistant isolates [3,14]. The present study also noted high resistance among Enterobacteriaceae to commonly used antimicrobial agents, which is consistent with observations in Verma et al. (2019) and Poddar et al. (2020), indicating a trend of increasing resistance, particularly to fluoroquinolones [21,14]. Regarding Gram-positive organisms, this study reported Enterococcus spp. showing susceptibility to Linezolid, Teicoplanin, Tigecycline, and Vancomycin, a finding supported by Poddar et al. (2020) [7]. Furthermore, the publication article identified Methicillin-resistant S. aureus (MRSA), which is a clinically significant observation given the challenges associated with treating these resistant strains; these isolates showed susceptibility towards Linezolid, Daptomycin, Rifampicin, Teicoplanin, Tigecycline, and Vancomycin. Finally, concerning antifungal susceptibility, the present study found that Candida spp. was 100% susceptible to Micafungin, with Caspofungin also effective against several Candida species, while Fluconazole exhibited lower susceptibility.

Conclusion

Catheter-associated bacteriuria is a major healthcare concern, requiring careful management. This study highlights key factors, including age distribution, risk factors, catheter duration, and antimicrobial resistance. A higher prevalence is noted in the >=50 years of age group, with diabetes mellitus being a significant risk factor. Antimicrobial resistance is increasing, though Colistin remains effective against certain organisms. The findings underscore the need to consider patient age, underlying conditions, catheter duration, and resistance patterns for effective prevention and management.

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