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Bacteriological Spectrum and Antimicrobial Resistance Profile of Catheter-Associated Urinary Tract Infections among Intensive Care Unit patients admitted in a tertiary care facility

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ABSTRACT

Background & Objectives: Catheter-associated urinary tract infection (CAUTI) is one of the most frequent healthcare-associated infections (HAI), particularly among intensive care unit (ICU)patients. CAUTIis associated with significant morbidity, prolonged hospitalization, and rising antimicrobial resistance (AMR). This study aimed to determine the bacteriological spectrum, AMR profile, and CAUTI rate among ICU patients in a tertiary care facility.

Methods: A cross-sectional study was conducted in the Department of Microbiology, M.G.M. Medical College & M.Y. Hospital, Indore, over one year following Institutional Ethics Committee approval. Urine samples from catheterized ICU patients with clinical suspicion of CAUTI were processed by standard microbiological techniques. Identification of isolates was done using microscopy, culture characteristics, and biochemical tests. Antimicrobial susceptibility testing (AST) was performed using the Kirby Bauer disc diffusion method following Clinical Laboratory Standard Institute (CLSI) guidelines. The CAUTI rate was calculated per 1,000 catheter days.

Results: Out of 243 urine samples, 96 (39.5%) were culture positive, yielding 98 isolates. The CAUTI rate was 26.66 per 1,000 catheter-days. Gram-negative bacteria accounted for 70.4% of isolates, with *Escherichia coli* (26.5%) being most frequent, followed by *Pseudomonas aeruginosa* (17.3%) and *Klebsiella pneumoniae* (8.2%). Among Gram-positive isolates (29.6%), *Enterococcus faecalis* (15.3%) predominated. High resistance was observed among Gram-negative isolates to β-lactams, cephalosporins, and fluoroquinolones, with reduced susceptibility even to carbapenems. *E. faecalis* showed resistance to penicillin (80%) and ciprofloxacin (80%), while linezolid and high-level gentamicin remained effective.

Interpretation & Conclusions: The study highlights a high CAUTI burden in ICU patients with predominance of multidrug-resistant Gram-negative bacilli, particularly *Escherichia coli* and *Pseudomonas aeruginosa*. The findings underscore the urgent need for unit-specific antibiograms, strict infection prevention practices, and robust antimicrobial stewardship programmes to guide empiric therapy and contain resistance in critical care settings.

Keywords*:* Catheter-associated urinary tract infection (CAUTI), ICU, antimicrobial resistance (AMR), Escherichia coli, antibiogram.

INTRODUCTION

Healthcare-associated infections (HAIs) include infections that patients acquire while receiving treatment in hospitals or other healthcare institutions and represent a serious problem in contemporary healthcare settings.[1,3] Among these, catheter-associated urinary tract infections (CAUTI) are the most common and clinically significant HAIs.[1,7]

Urinary catheters are essential medical devices used for managing urinary retention, monitoring urine output, and facilitating postoperative recovery.[5] However, when infection prevention and control practices are inadequate, these catheters provide a direct pathway for microorganisms to enter the urinary tract, resulting in CAUTI.[1,5,7]

Patients with indwelling urinary catheters, particularly those admitted to Intensive Care Units (ICUs), are at increased risk of CAUTI due to factors such as impaired immunity, invasive medical devices, prolonged hospitalization, and severity of illness.[6,7,9] CAUTI can lead to serious complications including prostatitis, epididymitis, orchitis, cystitis, pyelonephritis, Gram-negative bacteraemia, endocarditis, vertebral osteomyelitis, septic arthritis, endophthalmitis, and meningitis.[5,7] These complications contribute to increased patient discomfort, prolonged hospital stays, higher healthcare costs, and elevated morbidity and mortality.[2,3,6]

Beyond individual patient outcomes, CAUTI impose a substantial burden on healthcare systems worldwide by increasing resource utilization and financial costs.[2,6] Moreover, the widespread and often inappropriate use of antimicrobial agents has resulted in the emergence of multidrug-resistant (MDR) organisms, complicating the management of these infections.[9,25] Understanding the bacteriological spectrum and antimicrobial resistance (AMR) profile of CAUTI pathogens is therefore crucial for optimizing empirical therapy and strengthening infection prevention and control strategies.[9,25]

Hence, the present study was undertaken to isolate and identify the bacteriological spectrum of CAUTI among ICU patients admitted to a tertiary care facility and to determine their AMR profile to aid clinicians in selecting appropriate antimicrobial therapy. Additionally, the study aimed to determine the current CAUTI rate in the ICUs included in the study.[1,7]

MATERIALS AND METHODS

This is a Cross-sectional study conducted in the bacteriology section of the Department of Microbiology, M.G.M. Medical College & M.Y. Hospital, Indore (M.P.) following one year of the Ethics Committee's acceptance of the study.

Inclusion criteria

1. On the date of sample collection, the patient had an indwelling urinary catheter that had been in place for more than 48 hours in the study's participating ICU OR that had either been removed on the day before the date of sample collection or present for any part of the calendar day on the date of sample collection.
2. At least one of the following signs or symptoms was present in the patient:
    - Fever (higher than 38°C)
    - Suprapubic discomfort or tenderness
    - Pain or tenderness at the costovertebral angle
    - Urinary Urgency
    - Increased Urinary Frequency
    - Dysuria
3. The patient's urine culture shows no more than two kinds of organisms out of which at least one is a bacterium with a concentration of $\geq 10^5$ Colony Forming Unit/ml.

Exclusion criteria

Patients under the age of eighteen.

Sample Processing

Urine samples were inoculated onto blood agar and MacConkey agar and incubated aerobically at 35–37°C for 18–24 hours.[10,11,12] Culture-positive isolates were identified using Gram staining, hanging drop preparation, colony morphology, and standard biochemical tests.[11,12] Antimicrobial susceptibility testing was performed on Mueller-Hinton agar using the Kirby–Bauer disk diffusion method as per Clinical and Laboratory Standards Institute (CLSI) guidelines.[13]

Statistical analysis

After being entered into an Excel sheet, the data was analysed.

RESULTS

In the current study 243 urine samples were received from catheterized ICU patients with clinical suspicion of CAUTI, hospitalized in the tertiary care hospital. Out of 243, 96 (39.50%) tested culture positive.3600 was the total number of urinary catheter days. As a result, CAUTI rate came out to be 26.66 per 1000 catheter days.

TABLE 1- BACTERIOLOGICAL SPECTRUM OF CULTURE POSITIVE CAUTI PATIENTS

Name of the bacterial isolates	Number of bacterial isolates	Percentage (out of 98)

Total bacterial isolates	98	
Gram-negative bacteria	69	70.40%
• ***Escherichia coli***	26	26.53%
• ***Pseudomonas aeruginosa***	17	17.34%
• ***Klebsiella pneumoniae***	8	8.16%
• ***Citrobacter* species**	5	5.10%
• ***Acinetobacter* species**	5	5.10%
• ***Klebsiella oxytoca***	5	5.10%
• ***Proteus vulgaris***	2	2.04%
• ***Enterobacter* species**	1	1.02%
Gram-positive bacteria	29	29.59%
• ***Enterococcus faecalis***	15	15.30%
• ***Enterococcus faecium***	6	6.12%
• **Coagulase-negative *Staphylococcus***	6	6.12%
• ***Staphylococcus aureus***	2	2.04%

TABLE 2- AMR PROFILE OF GRAM-NEGATIVE BACTERIAL ISOLATES

Name of antibiotics	*Escherichia coli* (26)	*Pseudomonas aeruginosa* (17)	*Klebsiella pneumoniae* (8)	*Citrobacter* species (5)	*Acinetobacter* species (5)	*Klebsiella oxytoca* (5)	*Proteus vulgaris* (2)	*Enterobacter* species (1)
Amikacin	9/26 (34.61%)	7/17 (41.17%)	5/8 (62.5%)	2/5 (40%)	4/5 (80%)	2/5 (40%)	2/2 (100%)	1/1 (100%)
Amoxicillin-clavulanate	25/26 (96.15%)	NA	8/8 (100%)	NA	NA	5/5 (100%)	2/2 (100%)	NA
Aztreonam	NA	6/17 (35.29%)	NA	NA	NA	NA	NA	NA
Cefazolin	24/26 (92.30%)	NA	7/8 (87.5%)	NA	NA	5/5 (100%)	NA	NA
Cefoxitin	20/26 (76.92%)	NA	7/8 (87.5%)	NA	NA	4/5 (80%)	NA	NA
Ceftazidime	23/26 (88.46%)	13/17 (76.47%)	7/8 (87.5%)	2/5 (40%)	5/5 (100%)	5/5 (100%)	2/2 (100%)	1/1 (100%)
Ceftriaxone	23/26 (88.46%)	NA	7/8 (87.5%)	5/5 (100%)	5/5 (100%)	4/5 (80%)	2/2 (100%)	1/1 (100%)
Cefuroxime	24/26 (92.30%)	NA	7/8 (87.5%)	NA	NA	4/5 (80%)	NA	NA
Ciprofloxacin	23/26 (88.46%)	7/17 (41.17%)	7/8 (87.5%)	2/5 (40%)	5/5 (100%)	4/5 (80%)	2/2 (100%)	1/1 (100%)
Doxycycline	NA	NA	NA	NA	1/5 (20%)	NA	NA	NA
Fosfomycin	10/26 (38.46%)	NA	NA	NA	NA	NA	NA	NA
Gentamicin	10/26 (38.46%)	NA	6/8 (75%)	2/5 (40%)	5/5 (100%)	2/5 (40%)	2/2 (100%)	1/1 (100%)
Imipenem	16/26 (61.53%)	9/17 (52.94%)	6/8 (75%)	1/5 (20%)	5/5 (100%)	5/5 (100%)	1/2 (50%)	1/1 (100%)
Levofloxacin	15/26 (57.69%)	7/17 (41.17%)	7/8 (87.5%)	2/5 (40%)	3/5 (60%)	2/5 (40%)	0/2 (0%)	1/1 (100%)
Meropenem	15/26 (57.69%)	7/17 (41.17%)	6/8 (75%)	1/5 (20%)	5/5 (100%)	5/5 (100%)	0/2 (0%)	1/1 (100%)
Nitrofurantoin	19/26 (73.07%)	NA	7/8 (87.5%)	4/5 (80%)	NA	5/5 (100%)	NA	1/1 (100%)

Piperacillin-tazobactam	25/26 (96.15%)	12/17 (70.58%)	8/8 (100%)	5/5 (100%)	5/5 (100%)	5/5 (100%)	1/2 (50%)	1/1 (100%)
Tetracycline	12/26 (46.15%)	NA	2/8 (25%)	1/5 (20%)	3/5 (60%)	1/5 (20%)	NA	1/1 (100%)
Tobramycin	10/26 (38.46%)	9/17 (52.94%)	5/8 (62.5%)	1/5 (20%)	4/5 (80%)	1/5 (20%)	2/2 (100%)	0/1 (0%)
Trimethoprim-sulfamethoxazole	20/26 (76.92%)	NA	7/8 (87.5%)	4/5 (80%)	4/5 (80%)	3/5 (60%)	2/2 (100%)	0/1 (0%)

NA-Not Applicable

TABLE 3- AMR PROFILE OF THE GRAM-POSITIVE BACTERIAL ISOLATES

Name of antibiotics	***Enterococcus faecalis* (15)**	***Enterococcus faecium* (6)**	**Coagulase-negative *Staphylococcus* (6)**	***Staphylococcus aureus* (2)**
Ampicillin	9/15(60%)	3/6 (50%)	NA	NA
Azithromycin	NA	NA	2/6 (33.33%)	1/2 (50%)
Cefoxitin	NA	NA	1/6 (16.66%)	0/2 (0%)
Ciprofloxacin	12/15(80%)	5/6 (83.33%)	0/6 (0%)	0/2 (0%)
Clindamycin	NA	NA	6/6 (100%)	2/2 (100%)
Doxycycline	NA	NA	1/6 (16.66%)	0/2 (0%)
Erythromycin	NA	NA	2/6 (33.33%)	1/2 (50%)
Fosfomycin	10/15(66.66%)	6/6 (100%)	NA	NA
Gentamicin	NA	NA	1/6 (16.66%)	0/2 (0%)
Gentamicin high-level	6/15(40%)	2/6 (33.33%)	NA	NA
Levofloxacin	8/15(53.33%)	2/6 (33.33%)	0/6 (0%)	0/2 (0%)
Linezolid	0/15(0%)	0/6 (0%)	0/6 (0%)	0/2 (0%)
Nitrofurantoin	13/15(86.66%)	6/6 (100%)	2/6 (33.33%)	1/2 (50%)
Penicillin	12/15(80%)	5/6 (83.33%)	1/6 (16.66%)	0/2 (0%)
Tetracycline	10/15(66.66%)	3/6 (50%)	2/6 (33.33%)	0/2 (0%)
Trimethoprim-sulfamethoxazole	NA	NA	3/6 (50%)	0/2 (0%)
Vancomycin	7/15(46.66%)	2/6 (33.33%)	NA	NA

NA- Not Applicable

DISCUSSION

CAUTIis among the most common HAI, especially in ICU patients. Their importance stems from both their prevalence and the clinical and financial costs that accompany it. The significant risk that catheterized ICU patients face is highlighted by the current study's CAUTI rate, which was determined to be 26.66 per 1000 catheter days. This result is consistent with rates found in comparable tertiary care facilities throughout India. Devendra Chaudhary et al. reported a rate of 26.92 per 1000 catheter days[14], whereasHarsha V. Patil et al. reported a somewhat lower rate of 21.31 per 1000 catheter days[15].

Gender and age distribution of culture positive CAUTI patients (Fig. 1 & 2)

The current study, had a greater incidence of CAUTI in the male patients than female patients. Devendra Chaudhary et al., Dr. Dinesh Verma et al., and A.S. Omm Viknesh et al.,noted a similar higher burden of CAUTI among male patients in their studies, which is consistent with this male preponderance.[14,16,17] However, Harsha V. Patil, Neha Sharma et al. and Smriti Parihar et al.,[15,18,19], found that female patients had a greater incidence of CAUTI in their respective studies, highlighting the fact that risk variables associated to gender are not consistent across different healthcare facilities.

The study's most noteworthy finding was that younger patients, those in the 31–40 years and 18-30 years age group, had a disproportionately high incidence of CAUTI. In fact, studies by Neha Sharma et al., Dr. Dinesh Verma et al., Smriti Parihar et al and Shweta et al.[16,19,20] has repeatedly shown that patients over 50 years of age have a higher burden of CAUTI.

This age-related disparity may be explained by a number of contextual factors. The kind of ICU admissions at the research site is one important factor. These age ranges frequently have significant proportion of trauma, neurosurgery, and postoperative patients at many tertiary care facilities, especially young men who have been in vehicle crashes or sustained injuries at work. These patients often need intensive monitoring, mechanical breathing, and prolonged catheterization all of which are known risk factors for CAUTI and other HAI.

This surprising pattern highlights the necessity of interpreting CAUTI risk variables using ICU-specific demographic data and advocates for focused therapies based on the predominant patient profile in each ICU.

Bacteriological spectrum of culture positive CAUTI patients (Table-1)

With 70.4% of all isolates being Gram-negative bacilli, the bacteriological spectrum showed a definite prevalence of these bacteria in ICU patients. The most commonly isolated pathogen were*Escherichia coli* (26.53%), followed by *Pseudomonas aeruginosa* (17.34%), *Enterococcus faecalis* (15.30%) and *Klebsiella pneumoniae* (8.16%). *Escherichia coli* is the primary cause of CAUTI in both ICU and non-ICU patients, according to many national studies. Harsha V. Patil et al. and Indranil Bagchi et al.[15,21] discovered that *Escherichia coli* was the predominant uropathogens in 36.99% and34.85% of their CAUTI cases respectively. Even greater frequencies were reported by Tomar et al. and Naveen et al.,[22,23] who reported that *Escherichia coli* accounted for 62.01% and 65.3% of isolates, respectively. The prominent significance of *Escherichia coli* in CAUTI pathogenesis, particularly in India, is firmly reaffirmed by these consistent findings across several tertiary care settings.

Nonetheless, a noteworthy finding of the present investigation is the presence of non-fermenting Gram-negative bacteria, specifically *Pseudomonas aeruginosa* (17.34%) and *Acinetobacter* species which underscores the nosocomial nature of CAUTI in ICU patients.

The identification of the Gram-positive *Enterococcus faecalis* (15.30%) highlights the part that both endogenous flora and external sources play in catheter colonization and subsequent infection. Because of their inherent resilience and capacity to persist on surfaces for extended periods of time, enterococci are known to be persistent in hospital settings.

These microbiological findings are in alignment with data from the Indian Council of Medical Research Antimicrobial Resistance Surveillance Network – 2023 (ICMR AMR Surveillance Network – 2023), which reported *Escherichia coli* and *Klebsiella pneumoniae* as the two most common uropathogens isolated from urine samples across multiple tertiary care hospitals in India. The ICMR AMR Surveillance Network – 2023 data also highlighted an increasing trend in infections caused by non-fermenters, particularly in ICU patients.[25]

AMR profile of the bacterial isolates (Table 2 & 3)

Multidrug-resistant organisms are becoming a greater danger in critical care settings, as evidenced by the current study's AMR profile, which showed a significant level of resistance among uropathogens isolated from ICU patients with CAUTI.

The most commonly isolated organism among Gram-negative pathogens, *Escherichia coli*, demonstrated significant resistance to beta-lactam antibiotics, especially amoxicillin-clavulanate (96.15%), as well as first- to third-generation cephalosporins, fluoroquinolones, and even nitrofurantoin, a medication commonly used to treat lower urinary tract infections. *Escherichia coli* shows persistent resistance to β-lactams, cephalosporins, and fluoroquinolones in tertiary care facilities, according to theICMR AMR Surveillance Network – 2023 dataand findings from several Indian studies, including Nirmala Poddar et al.[25,24] Nonetheless, tetracyclines (like doxycycline), aminoglycosides (like amikacin), and Fosfomycin all maintained comparatively higher efficacy, indicating that these antibiotics might still be used for empirical or targeted therapy in some situations.

Similar to this, *Pseudomonas aeruginosa*, a non-fermenting Gram-negative bacillus commonly linked to nosocomial infections, demonstrated resistance to important antipseudomonal drugs as piperacillin-tazobactam and ceftazidime, which limited the available treatment options, even though aztreonam maintained some action. These results are consistent with the ICMR AMR Surveillance Network – 2023data that show a steady increase in fluoroquinolone and carbapenem resistance in non-fermenters in ICU patients.[25]

Klebsiella pneumoniae, showed concerning levels of resistance, especially to carbapenems. The current study's findings on resistance trends are supported by theICMR AMR Surveillance Network – 2023 data,[25] which reports that *Klebsiella pneumoniae's* sensitivity to piperacillin-tazobactam has decreased to 26.5% and meropenem to 37.6%.Given that carbapenem-resistant *Klebsiella pneumoniae* is frequently linked to high mortality, few available treatments, and a tendency to spread in ICU patients, this observation highlights a serious public health concern.

Enterococcus faecalis was the most common species among the Gram-positive isolates, exhibiting strong resistance to ciprofloxacin (80%), penicillin (80%), and nitrofurantoin (86.66%). These results are consistent with other investigations, such as those by Nirmala Poddar et al.,[24] who found comparable resistance patterns, as well as theICMR AMR Surveillance Network – 2023 data.25 Significant activity against *Enterococcus faecalis* was maintained by linezolid and high-level gentamicin in the current investigation, demonstrating their continued use as treatment alternatives for multidrug-resistant enterococcal infections. Clinically noteworthy is the comparatively preserved susceptibility to linezolid, especially in ICU patients who have few options for parenteral or oral therapy.

All of these results point to the development and persistence of multidrug-resistant organisms, particularly in Gram-negative isolates, which presents a significant obstacle to the treatment of CAUTI in ICU patients. Treatment choices are made more difficult by the identification of high resistance in non-fermenters such as *Pseudomonas aeruginosa* and *Acinetobacter* species, which emphasizes the necessity of effective infection control measures.

CONCLUSION

CAUTI continue to pose a significant clinical challenge in ICU patients, particularly in resource-constrained healthcare settings. The present study demonstrated a CAUTI rate of 26.66 per 1000 catheter days, emphasizing the considerable risk associated with Indwelling Urinary Catheter use among ICU patients. Notably, the burden was higher among male patients and those under 50 years of age.

Escherichia coli was the most common isolate, followed by *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Klebsiella pneumoniae*. Gram-negative bacilli accounted for 70.4% of the bacteriological profile. The results of regional and national research, which all emphasize the prevalence of Gram-negative uropathogens in ICU-acquired infections, are in line with this.

The AMR profile in the present study reveal alarming resistance trends, with *Escherichia coli* and *Klebsiella pneumoniae* exhibiting high levels of resistance to commonly used antibiotics including beta-lactams, cephalosporins, fluoroquinolones, and nitrofurantoin. These findings are consistent with national AMR data, which reports a nationwide decline in the effectiveness of carbapenems and piperacillin-tazobactam, particularly in *Escherichia coli* and *Klebsiella pneumoniae*. Furthermore, the detection of reduced susceptibility to last-resort antibiotics such as imipenem and meropenem suggests the potential presence of carbapenemase-producing strains. The high level of AMR observed, underscores the critical need for local antibiogram-guided empirical therapy.

Enterococcus faecalis was the most common Gram-positive bacteria and showed notable resistance to penicillin, ciprofloxacin, and nitrofurantoin. Nonetheless, in line with national AMR trends, comparatively low rates of resistance to high-level gentamicin and linezolid indicates their effectiveness in enterococcal infections.

This study provides important insights into the demographic pattern,bacteriologicalspectrum, and AMR profileof CAUTI in ICU patients. It underscores the urgent need for establishment of unit-specific antibiograms to guide empirical therapyand strengthening of antimicrobial stewardship programs to curb the misuse and overuse of antibiotics.

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