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Original Research Article

A Study on Catheter-Associated Urinary Tract Infections in the Medical ICU of a Western Gujarat Tertiary Care Hospital

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Abstract:

Introduction: CAUTIs are common ICU infections caused by bacterial colonization and biofilm formation on catheters, leading to increased morbidity and antimicrobial resistance. Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa are predominant pathogens. Prolonged catheterization and poor aseptic practices heighten infection risks. Early catheter removal and strict infection control are key to reducing CAUTI rates in ICU patients.

Materials and Methods: This hospital-based prospective observational study was conducted in a 15-bedded Medical ICU over one year, enrolling 100 patients requiring Foley's catheterization. Patients were followed from catheter insertion to discharge or death. Inclusion criteria included >48 hours of catheterization and clinical signs of infection, while those with pre-existing UTIs or fungal infections were excluded. Urine samples were collected aseptically and processed using standard microbiological techniques, with antibiotic susceptibility testing (AST) conducted per CLSI guidelines. Data analysis was performed using SPSS version 21.1, with statistical significance set at $p<0.05$.

Results: In our study, 12% of catheterized patients developed CAUTI, with a rate of 8.4 per 1000 urinary catheter days. The majority of patients were 51–70 years old (36%), with a male predominance (55%). Escherichia coli was the most common pathogen (6%), followed by Enterococcus (4%) and Pseudomonas (3%). CAUTI incidence increased with catheter duration, rising from 2.86% in 1–5 days to 50% beyond 11 days. Antibiotic susceptibility testing showed high efficacy of Nitrofurantoin (100%), Imipenem (91.67%), and Colistin (91.67%) against Gram-negative bacteria, while Enterococcus exhibited 100% susceptibility to High Gentamycin and Linezolid.

Conclusion: CAUTI remains a significant concern in ICU patients, with prolonged catheterization increasing infection risk. Strict infection control measures, timely catheter removal, and targeted antibiotic therapy are essential to reducing CAUTI rates and improving patient outcomes.

Keywords: CAUTI, ICU infections, Catheter duration, Antibiotic susceptibility.

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Introduction

Catheter-associated urinary tract infections (CAUTIs) are among the most prevalent healthcare-associated infections, particularly in intensive care units (ICUs), where patients require prolonged catheterization for urine output monitoring. [1] These infections arise due to microbial colonization along the catheter surface, leading to bacterial biofilm formation and increased susceptibility to urinary tract infections (UTIs). [2]

CAUTIs not only prolong hospital stays but also contribute to increased morbidity, antibiotic resistance, and healthcare costs. [3] The presence of an indwelling urinary catheter disrupts the body's natural defense mechanisms, facilitating the ascent of pathogens into the urinary tract and increasing the likelihood of infection. [4] The etiology of CAUTIs is largely influenced by the duration of catheterization, host immunity, and adherence to infection control practices. [5] Aseptic insertion and proper catheter maintenance are crucial in minimizing the risk of infection. [6]

However, microbial adaptation and biofilm development make treatment challenging, as bacteria embedded in biofilms exhibit increased resistance to antibiotics and host immune responses. Common pathogens implicated in CAUTIs include Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, and

Enterococcus species, with an increasing prevalence of multidrug-resistant strains. These infections pose significant therapeutic challenges, often requiring targeted antimicrobial therapy guided by susceptibility testing. [7]

Effective CAUTI prevention strategies emphasize reducing unnecessary catheter use, adhering to strict aseptic techniques during insertion, and implementing catheter care bundles. Surveillance programs and antimicrobial stewardship play a crucial role in minimizing the burden of CAUTIs in hospital settings.

Material and Methods

This hospital-based prospective observational study was conducted in the Medical Intensive Care Unit (ICU) of a tertiary care hospital in Western Gujarat. The study aimed to evaluate the prevalence, microbiological profile, and risk factors associated with catheter-associated urinary tract infections (CAUTIs). The research was carried out over a one-year period. The study was conducted in an 15-bedded ICU, where critically ill patients requiring urinary catheterization were monitored for the development of CAUTIs.

A total of 100 patients who met the inclusion and exclusion criteria were enrolled in the study. All admitted patients in the ICU requiring urinary catheterization with an indwelling Foley's catheter were prospectively followed from the day of catheter insertion until discharge or death. The study aimed to analyze the incidence of CAUTIs by tracking patients over time and identifying key factors contributing to infection development.

Inclusion Criteria:

- Patients with an indwelling urinary catheter for more than 48 hours.
- Patients exhibiting at least one of the following clinical signs or symptoms:
  - Fever (>38.0°C).
  - Suprapubic tenderness.
  - Costovertebral angle pain or tenderness.
- Positive urine culture with no more than two bacterial species identified, with at least one organism showing growth $\geq 10^5$ CFU/mL.

Exclusion Criteria:

- Patients with mixed flora (>2 species of microorganisms) in urine cultures.
- Presence of Candida species, yeast, or fungal infections as the primary pathogen.
- Patients with pre-existing urinary tract infections prior to catheter insertion.

Patients meeting the inclusion criteria were monitored daily using a standardized case report form. The collected data included:

- Patient Demographics: Age, gender, comorbidities, and ICU admission diagnosis.
- Urinary Catheter-Related Data: Duration of catheterization, site of insertion, catheter care practices, and history of antimicrobial use.
- Microbiological Findings: Pathogen identification and antimicrobial resistance patterns.
- Clinical Outcomes: Resolution of infection, length of ICU stay, and patient outcome (discharge or mortality).

The event time frame for CAUTIs was defined as a 14-day period starting from the date of infection diagnosis, during which any detected pathogens were recorded under the initial CAUTI event. No new CAUTI events were assigned within this window to prevent duplicate reporting.

Urine Sample Collection and Laboratory Processing

Midstream urine samples were collected aseptically from catheterized patients and processed using standard microbiological techniques.

- Culture Method: Uncentrifuged urine samples were inoculated onto 5% sheep blood agar and MacConkey agar using a 1 µL nichrome loop (1.3 mm diameter). The plates were incubated aerobically at 37°C for 18-24 hours.
- Pathogen Identification: Isolates were subjected to Gram staining, biochemical characterization, and species-level identification.
- Antibiotic Susceptibility Testing (AST): Performed using the Kirby–Bauer disk diffusion method, following Clinical and Laboratory Standards Institute (CLSI) guidelines.

Data were analyzed using descriptive and inferential statistical methods. Quantitative variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as proportions. The Chi-square test was used to determine the association between risk factors and CAUTI incidence. A p-value of <0.05 was considered statistically significant. Statistical analysis was performed using SPSS software version 21.1.

Results

This study comprised 100 patients admitted to the MICU, monitored from Foley's catheter insertion to the onset of symptoms, with urine samples processed in the microbiology laboratory. The CAUTI rate was calculated as 8.4 per 1000 urinary catheter days (UCD). In our study, among 100 catheterized patients, 12 (12%) were diagnosed with catheter-associated urinary tract infections (CAUTI). The majority, 78 (78%), had sterile urine cultures, while 10 (10%) showed the presence of Candida species. The majority of patients were aged 51–70 years (36%), with a male predominance (55%). (Table 1)

Table 1: Age and Gender Distribution (n = 100)

Age (Years)	Female (n, %)	Male (n, %)	Total (n, %)
11–30	14 (31.1%)	15 (27.3%)	29 (29.0%)
31–50	7 (15.6%)	15 (27.3%)	22 (22.0%)
51–70	16 (35.6%)	20 (36.4%)	36 (36.0%)
Greater than 70	8 (17.8%)	5 (9.1%)	13 (13.0%)
Total	45 (100.0%)	55 (100.0%)	100 (100.0%)

The figure 1 illustrates the relationship between the duration of catheterization and the occurrence of CAUTI. Most patients (70%) were catheterized for 1–5 days, with only 2 CAUTI cases (2.86%). However, the prevalence of CAUTI increased significantly with longer durations, with 6 cases (30%) in 6–10 days and 5 cases (50%) in 11–15 days.

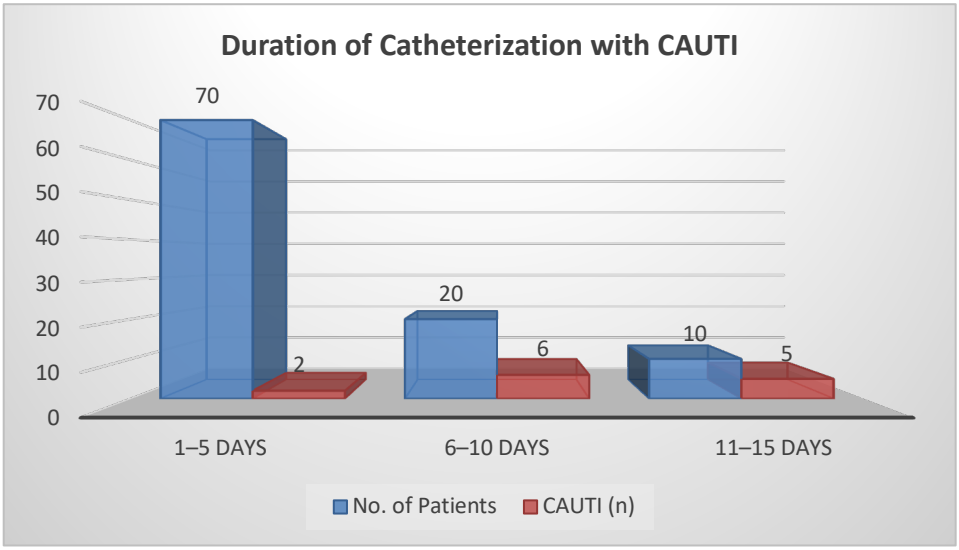

Figure 1: Duration of Catheterization with CAUTI

The table 2 shows the distribution of organisms associated with CAUTI. Escherichia coli was the most common pathogen (6%), followed by Enterococcus species (4%) and Pseudomonas species (3%). Other organisms included Enterobacter aerogenes (2%), Klebsiella species (1%), and Acinetobacter species (1%). The majority of samples (78%) were sterile.

Table 2: Distribution of Organisms Associated with CAUTI

Organisms Isolated	Number	Percentage (%)
Escherichia coli	6	6.00
Enterococcus species	4	4.00
Pseudomonas species	3	3.00
Enterobacter aerogenes	2	2.00
Klebsiella species	1	1.00
Acinetobacter species	1	1.00
Sterile	78	78.00

In our study, among Gram-negative bacteria (GNB), the highest susceptibility was observed for Nitrofurantoin (100%), Imipenem (91.67%), and Colistin (91.67%). For Enterococcus species, 100% susceptibility was noted for High Gentamycin, Linezolid, and Nitrofurantoin. Pseudomonas species showed complete susceptibility (100%) to Ceftazidime/Clavulanic acid, Cefoperazone/Sulbactam, Imipenem, Colistin, and Tobramycin.

Discussion

In our study, the CAUTI rate was 8.4 per 1000 urinary catheter days, with an infection prevalence of 12% among catheterized patients. The majority (78%) had sterile urine cultures, while 10% showed Candida species. Age-wise, most patients were 51–70 years (36%), with a male predominance (55%). Several studies provide comparable findings. Sandhu et al. [8] reported a CAUTI incidence of 4.41 per 1000 catheter days in their tertiary care setting, with Escherichia coli as the dominant

isolate. Similarly, Yadav et al. [9] observed a higher CAUTI incidence of 8.73 per 1000 catheter days, emphasizing the impact of prolonged catheter use and inadequate aseptic techniques in intensive care settings. Sushitha et al. [10] found a 7.03 per 1000 catheter day rate, supporting the notion that CAUTI risk escalates with duration of catheterization and underlying comorbidities.

Regarding demographic distribution, Soundaram et al. [11] reported that males were more frequently catheterized than females, similar to our study, where males comprised 55% of the cohort. The increased prevalence in males can be attributed to higher ICU admissions, comorbid conditions, and catheter use in critically ill patients. Menon et al. [12] also documented a higher CAUTI risk in older age groups, correlating with our finding that the 51–70 years age group had the highest CAUTI prevalence (36%). Overall, our findings align with existing literature, reinforcing the need for strict infection control measures, optimized catheter use, and periodic surveillance to reduce CAUTI rates in ICU settings.

Table 3: Antibiotic Susceptibility Pattern of Isolates (n = 20)

Antibiotics	GNB (n = 12)	Enterococcus (n = 5)	Pseudomonas (n = 3)
Ampicillin	2 (16.67%)	0	NA
Piperacillin/Tazobactam	7 (58.33%)	NA	2 (66.67%)
Cefotaxime	1 (8.33%)	NA	NA
Ceftazidime	3 (25.00%)	NA	2 (66.67%)
Ceftazidime/Clavulanic acid	9 (75.00%)	NA	3 (100.00%)
Cefoperazone/Sulbactam	8 (66.67%)	NA	3 (100.00%)
Cefepime	3 (25.00%)	NA	2 (66.67%)
Imipenem	11 (91.67%)	NA	3 (100.00%)
Vancomycin	NA	4 (80.00%)	NA
Aztreonam	1 (8.33%)	NA	2 (66.67%)
Colistin	11 (91.67%)	NA	3 (100.00%)
Amikacin	10 (83.33%)	NA	2 (66.67%)
Gentamycin	9 (75.00%)	NA	2 (66.67%)
High Gentamycin	NA	5 (100.00%)	NA
Doxycycline	9 (75.00%)	NA	NA
Tetracycline	1 (8.33%)	2 (40.00%)	NA
Linezolid	NA	5 (100.00%)	NA
Tobramycin	NA	NA	3 (100.00%)
Ciprofloxacin	1 (8.33%)	1 (20.00%)	NA
Cotrimoxazole	9 (75.00%)	NA	1 (33.33%)
Nitrofurantoin	12 (100.00%)	5 (100.00%)	NA
Fosfomycin	5 (41.67%)	4 (80.00%)	NA

In our study, the duration of catheterization had a direct impact on CAUTI occurrence, with a low infection rate (2.86%) in pat0ients catheterized for 1–5 days, which increased significantly to 30% in 6–10 days and 50% in 11–15 days. This trend highlights that prolonged catheter use is a major risk factor for CAUTI development. Similar patterns have been observed in other studies. Sushitha et al. [10] reported that each additional day of catheterization increases CAUTI risk by 3–10%, emphasizing biofilm formation as a major contributor. Tyson et al. [13] found that CAUTI rates dropped from 5.1 to 2.0 per 1000 catheter days after implementing a nurse-driven catheter removal protocol, reinforcing that early catheter removal is crucial in preventing infections. Similarly, Menon et al. [12] observed a CAUTI incidence of 17.83 per 1000 catheter days, particularly in patients with extended catheter use beyond 7 days.

The study by Yadav et al. [9] also aligns with these findings, reporting that longer catheter duration led to increased bacterial colonization and infection rates, with a CAUTI incidence of 8.73 per 1000 catheter days. Additionally, Sarita et al. [9] emphasized the need for frequent catheter reassessment and strict aseptic precautions to minimize infection risks.

Our findings strongly support the importance of limiting unnecessary catheterization and implementing timely removal protocols, as prolonged use significantly escalates the risk of biofilm-mediated infections and antibiotic resistance in ICU patients.

In our study, Escherichia coli was the most common pathogen isolated (6%), followed by Enterococcus species (4%) and Pseudomonas species (3%), while 78% of cultures remained sterile, suggesting that not all catheterized patients develop infections, reinforcing the importance of

aseptic techniques in catheter care. Several studies report similar microbial patterns. Sushitha et al. [10] observed E. coli as the leading CAUTI pathogen, responsible for 53% of infections, followed by Klebsiella pneumoniae and Pseudomonas aeruginosa. This suggests that E. coli remains the predominant CAUTI-causing uropathogen across different ICU settings, likely due to its ability to colonize the urinary tract via adhesion factors and biofilm formation. Menon et al. [12] reported Klebsiella pneumoniae and Pseudomonas species as major contributors, reinforcing the increasing multidrug-resistant (MDR) nature of these pathogens in ICU settings.

The presence of Enterococcus (4%) and Acinetobacter (1%) in our study aligns with findings from Yadav et al. [9], where Gram-positive pathogens were noted in 10% of CAUTI cases, highlighting the emerging role of non-fermenting bacteria and resistant Gram-positive species in catheter-related infections. Tyson et al. [13] emphasized that early catheter removal significantly reduces the incidence of MDR infections, as prolonged catheter use fosters biofilm formation, making antibiotic penetration difficult. These findings highlight the need for regular microbiological surveillance and antimicrobial stewardship programs, as CAUTI pathogens are evolving with rising antibiotic resistance. Effective infection control measures, aseptic catheter insertion, and timely catheter removal remain essential strategies to mitigate the burden of CAUTI in critically ill patients.

In our study, Gram-negative bacteria (GNB) showed the highest susceptibility to Nitrofurantoin (100%), Imipenem (91.67%), and Colistin (91.67%), while Enterococcus species exhibited 100% sensitivity to High Gentamycin, Linezolid, and Nitrofurantoin. Pseudomonas species were fully susceptible (100%) to Ceftazidime/Clavulanic acid, Cefoperazone/Sulbactam, Imipenem, Colistin, and Tobramycin, indicating effective treatment options. Similar trends were observed in Sushitha et al. [10], where Nitrofurantoin (84%), Imipenem (84%), and Piperacillin-Tazobactam (75%) were the most effective agents against Gram-negative isolates. Yadav et al. [9] also found high susceptibility to Imipenem and Colistin, while resistance to third-generation cephalosporins was increasing, emphasizing the importance of carbapenem stewardship. Tyson et al. [13] highlighted that early catheter removal reduces antibiotic resistance, as prolonged catheterization fosters biofilm formation, making bacteria more resilient. Our findings reinforce the critical need for antimicrobial stewardship, routine susceptibility testing, and strict infection control measures to prevent the rise of multidrug-resistant CAUTI pathogens in ICU settings.

Our study is limited by its single-center design, which may affect the generalizability of findings to other settings. The sample size was moderate, and factors such as comorbidities and prior antibiotic use were not extensively analyzed. Additionally, long-term follow-up on antibiotic resistance patterns was not conducted.

Conclusion

Our study underscores the significance of catheter-associated urinary tract infections (CAUTI) as a major concern in ICU patients, emphasizing the impact of prolonged catheterization on infection risk. The predominance of multidrug-resistant pathogens highlights the need for stringent infection control measures, judicious antibiotic use, and routine surveillance. Effective strategies such as timely catheter removal, adherence to aseptic techniques, and antimicrobial stewardship are crucial in reducing CAUTI rates and improving patient outcomes in critical care settings.

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