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Original Research Article

An Observational Study on Catheter-Associated Urinary Tract Infections in a Medical ICU at a Tertiary Care Center

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Abstract:

Introduction: Catheter-associated urinary tract infection (CAUTI) is a major healthcare-associated infection (HAI), significantly contributing to prolonged hospital stays, increased morbidity, and antimicrobial resistance. The widespread use of indwelling urinary catheters in intensive care units (ICUs) makes CAUTI a critical concern, particularly in critically ill patients. As the risk of bacteriuria increases with each day of catheter use, early removal and adherence to infection control measures are crucial in preventing CAUTI-related complications.

Aim and objectives: To evaluate the incidence, risk factors, microbial profile, and antibiotic resistance patterns of catheter-associated urinary tract infections (CAUTI) in ICU patients to enhance infection control strategies and antimicrobial stewardship.

Materials and Methods: This hospital-based prospective observational study was conducted in the Medical Intensive Care Unit (MICU) of a tertiary care center in Western Gujarat, enrolling 100 catheterized patients. Urine samples were collected and processed for microbial identification and antibiotic susceptibility testing. Patients were monitored for clinical symptoms of CAUTI, and relevant demographic and clinical data were recorded. Bacterial isolates were identified using standard microbiological techniques, and antibiotic susceptibility was assessed following CLSI guidelines. Statistical analysis was performed using descriptive methods and chi-square tests, with a p-value <0.05 considered statistically significant.

Results: A total of 100 catheterized MICU patients were monitored for CAUTI incidence, microbial profile, and antibiotic susceptibility patterns. The majority of patients were in the 51–70 years age group (34%), followed by 11–30 years (26%), with the lowest representation in those above 70 years (18%). CAUTI cases were most frequently observed in the third week of catheterization (55%), followed by the second week (35%), with the lowest occurrence in the first week (10%). Microbial analysis identified Escherichia coli (6%) as the most common pathogen, followed by Enterococcus species (4%) and Pseudomonas species (3%), while 83% of urine cultures were sterile. Antibiotic susceptibility testing revealed high sensitivity of Imipenem (90%) and Colistin (95%) against Gram-negative bacilli, while Nitrofurantoin showed 100% efficacy. Resistance was noted with Ceftazidime (55%) and Piperacillin/Tazobactam (60%), highlighting the need for judicious antibiotic use and infection control measures.

Conclusion: Our study emphasizes the significant role of prolonged catheterization in CAUTI development and highlights the importance of early catheter removal, infection control measures, and antimicrobial stewardship to reduce incidence and combat antibiotic resistance in ICU settings.

Keywords: CAUTI, Catheter-associated urinary tract infection, ICU infections, Antimicrobial resistance, Infection control.

Introduction

Healthcare-associated infections (HAIs) are a significant cause of prolonged hospital stays worldwide, contributing to increased morbidity, healthcare costs, and antimicrobial resistance. [1] Among these, urinary tract infections (UTIs) are one of the most common HAIs, with an estimated prevalence ranging from 1% to 10%, accounting for 30–40% of all reported hospital-acquired infections. [2] The widespread use of indwelling urinary catheters in hospital settings has been directly linked to the majority of these infections, making catheter-associated urinary tract infection

(CAUTI) a major clinical concern. [3] The Centers for Disease Control and Prevention (CDC) defines CAUTI as a urinary tract infection occurring in patients who have had a catheter in place for at least 48 hours. [4] As a preventable but frequently encountered infection, CAUTI remains a critical factor contributing to increased morbidity and mortality among hospitalized patients, particularly those admitted to intensive care units (ICUs). [5] The source of CAUTI can be either endogenous, originating from rectal, vaginal, or meatal colonization, or exogenous, introduced through contaminated medical equipment or the hands of healthcare personnel. [6] The infection can occur through intraluminal pathways, where bacteria ascend via the catheter drainage tube, or extraluminally, through contamination of the collection bag. [7] Several risk factors predispose patients to CAUTI, including female gender, extremes of age, diabetes mellitus, and, most importantly, prolonged catheterization. [8] Studies indicate that with each day of catheter use, the risk of bacteriuria increases by 3–7%, highlighting the critical need for timely catheter removal and strict adherence to infection prevention protocols. [9] Additionally, an indwelling catheter disrupts the normal mechanical wash-out function of urine flow, allowing pathogens to ascend from the bladder to the upper urinary tract, leading to serious complications such as pyelonephritis, septicemia, and multi-drug resistant infections. [10]

Materials and Methods

This hospital-based prospective observational study was conducted in the Medical Intensive Care Unit (MICU) of a tertiary care center in Western Gujarat. The study aimed to assess the incidence, risk factors, microbial profile, and antimicrobial resistance patterns associated with catheter-associated urinary tract infections (CAUTIs) in critically ill patients. The MICU is a high-dependency unit catering to patients requiring intensive monitoring and life-support interventions, making it a crucial setting for evaluating CAUTI-related infections. The study was carried out over a specified period, with patients being followed from the time of urinary catheter insertion until either discharge or death. A total of 100 patients admitted to the MICU, meeting the study's inclusion and exclusion criteria, were enrolled. Patients requiring indwelling urinary catheterization (Foley's catheter) for at least 48 hours were included in the study. The enrolled patients were closely monitored for signs and symptoms of CAUTI, including fever (>38.0°C), suprapubic tenderness, costovertebral angle pain, or new-onset pyuria. Urine samples were collected from patients suspected of CAUTI and processed for microbiological analysis. The study population consisted of a diverse group of critically ill patients with varying comorbidities, requiring prolonged hospitalization and invasive interventions.

All enrolled patients or their legal guardians provided informed consent before participation in the study. Data collection was conducted using a standardized surveillance form, which included demographic details, clinical presentations, urinary catheter-related parameters (duration of catheterization, disconnection history, catheter insertion site care), antimicrobial usage, and laboratory findings. Patients were monitored daily for new-onset CAUTI symptoms, and relevant medical records were reviewed for infection control practices and antibiotic administration history.

Midstream urine samples were collected aseptically from suspected CAUTI cases and processed according to standard microbiological protocols. Samples were inoculated on 5% sheep blood agar and MacConkey agar using a semiquantitative culture method with a calibrated nichrome loop (1 µL). The culture plates were incubated aerobically at 37°C for 18–24 hours, and significant bacterial growth was identified based on standard biochemical tests. A positive CAUTI case was defined by the presence of $\geq 10^5$ CFU/mL of a single bacterial species. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method following Clinical and Laboratory Standards Institute (CLSI) guidelines to determine the resistance patterns of isolated pathogens.

Descriptive statistics were used to analyze the demographic and clinical characteristics of the study population. Quantitative variables were expressed as mean ± standard deviation (SD), while categorical data were presented as proportions and percentages. The final dataset was analyzed using statistical software SPSS version 26.1 to interpret the findings and assess trends in antimicrobial resistance and infection prevention outcomes.

Results

This study comprised 100 patients admitted to the MICU, who were closely monitored from the date of Foley's catheter insertion to the onset of symptoms. Urine samples were collected aseptically and processed in the microbiology laboratory to identify potential pathogens and determine antimicrobial susceptibility patterns.

The Figure 1 presents the demographic distribution of 100 catheterized patients based on age and gender. The majority of patients belonged to the 51–70 years age group (34%), followed by the 11–30 years (26%). The least representation was from patients above 70 years (18%).

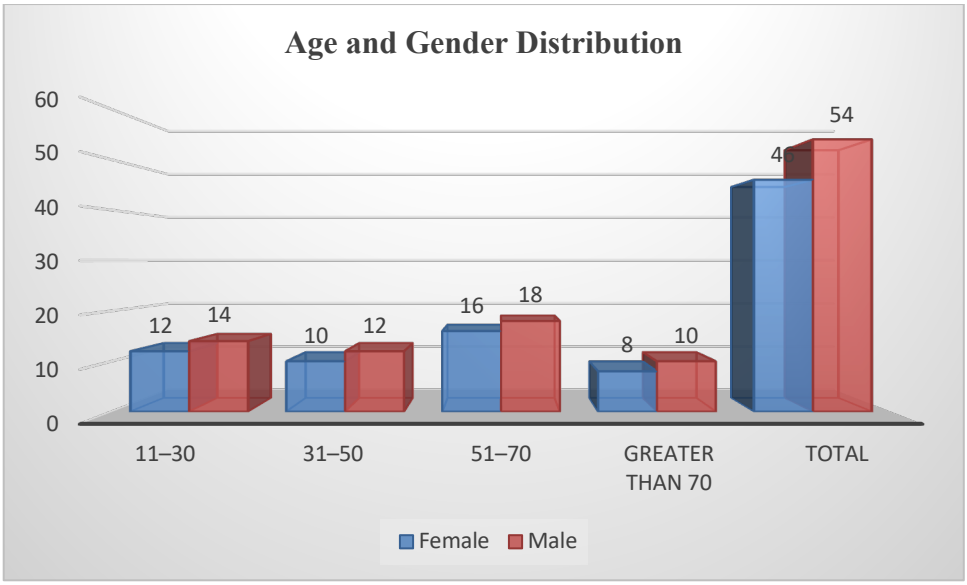

Figure 1: Age and Gender Distribution

The week-wise analysis revealed that CAUTI cases were most commonly detected in the third week of catheterization (55%), followed by the second week (35%), with significantly fewer cases occurring in the first week (10%). The table 1 summarizes the microbial profile of CAUTI cases.

Escherichia coli (6%) was the most frequently isolated pathogen, followed by Enterococcus species (4%) and Pseudomonas species (3%).

The majority of samples (83%) were sterile, indicating that CAUTI cases were limited to a specific subset of patients.

Table 1: Distribution of Organisms Associated with CAUTI (n = 100)

Organisms Isolated	Number	Percentage (%)	95% CI Lower Limit	95% CI Upper Limit
Escherichia coli	6	6%	3.0	10.0
Enterococcus species	4	4%	1.0	7.0
Pseudomonas species	3	3%	1.0	6.0
Enterobacter aerogenes	2	2%	0.5	4.5
Klebsiella species	1	1%	0.2	3.0
Acinetobacter species	1	1%	0.2	3.0
Sterile	83	83%	75	90

The antibiotic susceptibility pattern in our study revealed that Imipenem and Colistin showed the highest efficacy against Gram-negative bacilli (GNB) and Pseudomonas species (90–100%), while Nitrofurantoin exhibited 100% susceptibility for GNB isolates. (Table 2)

Table 2: Antibiotic Susceptibility Pattern

Antibiotics	GNB (n=10)	Enterococcus (n=4)	Pseudomonas (n=3)
Piperacillin/Tazobactam	60%	NA	50%
Ceftazidime	55%	NA	70%
Cefoperazone/Sulbactam	70%	NA	90%
Imipenem	90%	NA	100%
Colistin	95%	85%	100%
Amikacin	85%	NA	80%
Gentamycin	75%	100%	60%
Nitrofurantoin	100%	NA	NA

Discussion

Our study findings align with global research on CAUTI risk factors, microbial profiles, and antibiotic resistance patterns.

Previous studies, such as that by Chenoweth et al. [11], have identified prolonged catheterization as the dominant risk factor for CAUTI, with risk significantly increasing after six days of use. In our study, CAUTI cases were highest in the third week (55%), reinforcing the association between longer catheterization and infection risk. Furthermore, Escherichia coli and Pseudomonas species were among the most commonly isolated pathogens,

similar to findings from Aly et al. [12], who reported Klebsiella pneumoniae and Enterococcus species as predominant CAUTI pathogens in ICU settings. This consistent microbial pattern across studies highlights the endogenous origin of CAUTI pathogens, often derived from the patient's intestinal flora.

Antimicrobial resistance remains a major concern in CAUTI management. Our study demonstrated high sensitivity of Gram-negative bacilli to Imipenem (90%) and Colistin (95%), consistent with global surveillance reports. However, increasing resistance to Ceftazidime (55%) and Piperacillin/Tazobactam (60%) underscores the necessity of antimicrobial stewardship programs. Galiczewski and Shurpin [13] emphasized that direct observation of catheter insertion procedures and adherence to infection control bundles significantly reduce CAUTI rates. Similarly, our study's 83% sterile urine culture rate suggests that strict infection control measures help limit contamination and unnecessary antibiotic use. These findings reaffirm the importance of protocol-based catheter management, early removal strategies, and routine surveillance in reducing CAUTI incidence and preventing antibiotic resistance in ICU settings.

Our study's week-wise CAUTI analysis revealed the highest incidence in the third week (55%), followed by the second week (35%), with the lowest occurrence in the first week (10%), reinforcing the established link between prolonged catheterization and infection risk. Chenoweth et al. [11] similarly reported that bacteriuria rates increase significantly after six days of catheterization, with a higher likelihood of symptomatic CAUTI developing in long-term catheterized patients. Aly et al. [12] emphasized that late-onset CAUTIs are often associated with multidrug-resistant pathogens, necessitating strict infection control measures. Galiczewski and Shurpin [13] demonstrated that CAUTI rates were effectively reduced by implementing direct observation protocols for catheter insertion and maintenance, ensuring adherence to infection prevention guidelines. Our findings align with these studies, underscoring the importance of early catheter removal, strict hygiene practices, and continuous surveillance to prevent late-onset CAUTIs in ICU settings.

Our study identified Escherichia coli (6%) as the most frequently isolated pathogen, followed by Enterococcus species (4%) and Pseudomonas species (3%), with a majority of urine samples (83%) being sterile, suggesting a limited subset of patients developing CAUTI. This microbial distribution is consistent with findings by Chenoweth et al. [11], who reported that Escherichia coli and Pseudomonas aeruginosa are among the leading pathogens in CAUTI cases, often originating from the patient's endogenous flora. Aly et al. [12] similarly observed Klebsiella pneumoniae and Enterococcus species as dominant CAUTI pathogens in ICU patients, reinforcing the importance of strict catheter care protocols to prevent bacterial colonization. Additionally, Galiczewski and Shurpin [13] demonstrated that implementing direct observation protocols during catheter insertion significantly reduced bacterial contamination, emphasizing the role of proper insertion techniques in preventing infections. The high percentage of sterile cultures in our study aligns with the findings of previous research, which suggests that rigorous infection control measures can limit unnecessary antibiotic use and reduce CAUTI incidence.

The antibiotic susceptibility pattern in our study revealed that Imipenem (90%) and Colistin (95%) exhibited the highest efficacy against Gram-negative bacilli (GNB) and Pseudomonas species, while Nitrofurantoin showed 100% susceptibility for GNB isolates. These findings align with those of Aly et al. [12], who reported high sensitivity of Gram-negative pathogens to carbapenems and colistin, highlighting their continued effectiveness against multidrug-resistant strains. However, increasing resistance to Ceftazidime (55%) and Piperacillin/Tazobactam (60%) in our study is concerning and reflects the global trend of rising antimicrobial resistance (AMR) in ICU settings, as noted by Chenoweth et al. [11] Galiczewski and Shurpin [13] emphasized that strict adherence to infection control measures, particularly during catheter insertion and maintenance, significantly reduces CAUTI rates and unnecessary antibiotic usage, further supporting the importance of stewardship programs in controlling AMR. Additionally, our findings corroborate research by Tedja et al. [14], who noted that misuse of broad-spectrum antibiotics contributes to increasing resistance, necessitating regular surveillance and rational antibiotic prescribing. The observed resistance trends in our study highlight the urgent need for antimicrobial stewardship programs, infection prevention strategies, and routine susceptibility testing to optimize CAUTI management and limit the emergence of multidrug-resistant pathogens in critical care settings.

Our study has certain limitations that should be acknowledged. The sample size was relatively small, which may limit the generalizability of the findings to broader ICU populations. Additionally, the study was conducted in a single tertiary care center, and variations in infection control practices across different healthcare settings could influence CAUTI rates and microbial distribution.

Longitudinal follow-up beyond hospitalization was not performed, preventing an assessment of long-

term outcomes related to CAUTI. Furthermore, antibiotic resistance trends were analyzed only at the time of infection, without monitoring potential resistance development over time.

Conclusion

Our study reinforces the critical role of infection control measures, early catheter removal, and antimicrobial stewardship in reducing CAUTI incidence. The findings emphasize the need for strict adherence to aseptic techniques, regular surveillance of catheterized patients, and judicious antibiotic use to prevent complications and combat antimicrobial resistance. Implementing standardized catheter care protocols and continuous monitoring can significantly improve patient outcomes and minimize the burden of CAUTI in intensive care settings.

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