

A Study on Microbial Landscape of Catheter Associated Urinary Tract Infection In Intensive Care Units, Insights From Microbiological Profiling

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Abstract:

Background Healthcare-associated infections (HAIs) are a leading cause of morbidity and mortality in hospitalized patients, with catheter-associated urinary tract infections (CAUTIs) being particularly prevalent in Intensive Care Units (ICUs). CAUTIs are linked to extended hospital stays, increased healthcare costs, and antimicrobial misuse, often caused by Gram-negative bacteria. This study aimed to assess the frequency of CAUTIs, antibiograms, disease patterns, and associated risk factors in the Medical Intensive Care Unit (MICU) to recommend preventive measures. **Methods:** This prospective observational study was conducted at the Department of General Medicine from October 2022 to September 2023. A total of 70 patients admitted to the MICU with indwelling urinary catheters were enrolled using a purposive sampling technique. Urine samples were collected aseptically and processed within 2 hours post-collection. Pathogen identification and antimicrobial susceptibility testing were conducted following the Clinical and Laboratory Standards Institute (CLSI) guidelines of 2019. Data were analyzed to determine CAUTI incidence, pathogen distribution, antibiotic susceptibility, and risk factors. **Results** The CAUTI rate was 9.4 per 1000 catheter days, with an overall incidence of 14.67%. CAUTIs were most common in patients aged 51-70 years (34%) and predominantly affected females (63.63%). *Escherichia coli* was the primary pathogen (45.45%), followed by *Pseudomonas aeruginosa* (27.27%) and *Enterococcus* species (18.18%). Gram-negative bacilli showed high susceptibility to Nitrofurantoin (100%), Imipenem (92.85%), and Colistin (92.85%). Diabetes mellitus was identified as a major risk factor for CAUTI development (17.24%). **Conclusion** The study highlights a significant burden of CAUTIs in the MICU, with *Escherichia coli* being the most prevalent pathogen. The high susceptibility of Gram-negative bacilli to Nitrofurantoin, Imipenem, and Colistin provides useful guidance for empiric therapy. Identifying diabetes mellitus as a major risk factor underscores the need for targeted preventive measures in diabetic patients. Implementing stringent infection control practices, regular monitoring, and judicious antibiotic use is crucial to reducing CAUTI incidence and improving patient outcomes in ICU settings.

Keywords:

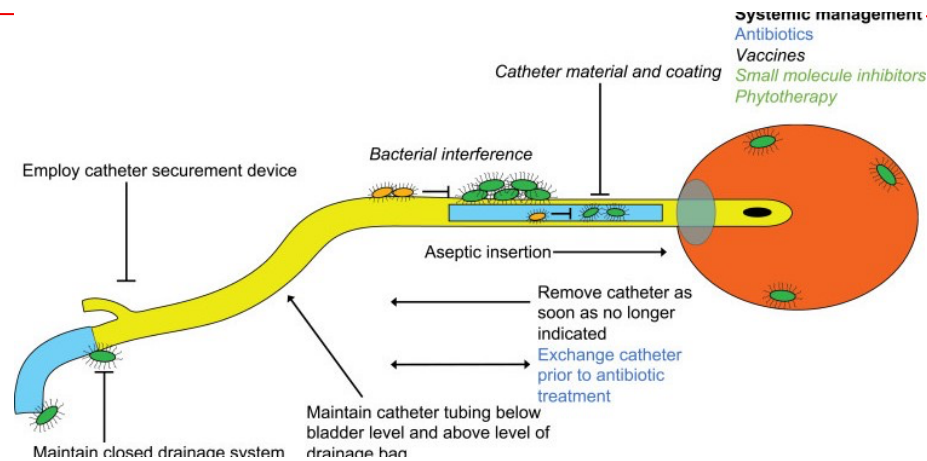
INTRODUCTION

Healthcare-associated infections (HAIs) are a significant concern in modern medicine, representing one of the leading causes of morbidity and mortality among hospitalized patients[1]. These infections, which patients acquire during the course of receiving treatment for other conditions within a healthcare setting, not only complicate patient outcomes but also increase the burden on healthcare systems worldwide. Among the various types of HAIs, catheter-associated urinary tract infections (CAUTIs) stand out as particularly prevalent and problematic, especially within Intensive Care Units (ICUs)[2,3].

ICUs cater to critically ill patients who often require indwelling devices, such as urinary catheters, for extended periods. These devices, while essential for patient management, create a direct pathway for

pathogens to enter the urinary tract, leading to infections. CAUTIs account for a significant proportion of all HAIs in ICU settings, posing a considerable challenge to healthcare providers due to their association with extended hospital stays, increased healthcare costs, and heightened morbidity and mortality rates[4].

The incidence of CAUTIs is closely linked to the duration of catheter use and the conditions under which catheters are managed. Prolonged catheterization increases the risk of biofilm formation on the catheter surface, facilitating the colonization and proliferation of bacteria[5]. Additionally, lapses in catheter care practices, such as inadequate hand hygiene and improper catheter.



Catheter insertion techniques, further exacerbate the risk of infection. Antimicrobial misuse, often seen in the form of unnecessary or inappropriate antibiotic administration, contributes to the emergence of multidrug-resistant organisms, complicating the treatment of CAUTIs[6].

In ICU patients, CAUTIs can manifest as various forms of urinary tract infections, including pyelonephritis, urethritis, cystitis, and prostatitis. These conditions are frequently caused by Gram-negative bacteria, such as *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*, which are known for their resistance to multiple antibiotics[7]. The presence of these infections in critically ill patients, who may already be compromised due to their underlying conditions, can lead to severe complications, including sepsis and renal failure, further jeopardizing patient outcomes.

Given the significant impact of CAUTIs on patient health and healthcare resources, it is imperative to understand the frequency, causative pathogens, antibiograms, and risk factors associated with these infections. This study aims to provide a comprehensive assessment of CAUTI incidence in ICU settings, analyze the bacterial profiles and their resistance patterns, examine the clinical manifestations of the disease, and identify key risk factors contributing to infection. By doing so, the study seeks to inform the development of effective preventive measures and guidelines to mitigate the occurrence of CAUTIs, ultimately enhancing patient care and reducing the burden of HAIs in healthcare facilities.

The study's findings are expected to contribute valuable insights into the epidemiology of CAUTIs in ICUs, guiding healthcare practitioners in implementing evidence-based interventions to prevent these infections. Such interventions may include protocols for catheter insertion and maintenance, antimicrobial stewardship programs to minimize inappropriate antibiotic use, and education and training initiatives for healthcare

personnel on best practices for infection prevention. Through these efforts, it is hoped that the incidence of CAUTIs can be significantly reduced, improving patient outcomes and alleviating the strain on healthcare systems.

MATERIALS AND METHODS

This prospective observational study was conducted at the Department of General Medicine over a one-year period from October 2022 to September 2023. The focus of the study was on patients admitted to the Medical Intensive Care Unit (MICU) who had indwelling urinary catheters.

Study Population and Sampling

A total of 70 patients were enrolled in the study using a purposive sampling technique. Inclusion criteria were patients aged 18 years and above, admitted to the MICU, and requiring an indwelling urinary catheter for more than 48 hours.

Patients with pre-existing urinary tract infections (UTIs) at the time of catheter insertion and those who refused to participate were excluded from the study.

Data Collection

Patient Demographics and Clinical Data

Demographic information, including age, sex, and underlying medical conditions, was collected for all participants. Clinical data, such as the reason for ICU admission, duration of catheterization, use of antibiotics prior to and during the study, and any interventions performed, were recorded.

Urine Sample Collection

Urine samples were collected following strict aseptic protocols to prevent contamination. The urine was aspirated from the sampling port of the catheter using a sterile syringe and transferred into sterile containers. Samples were collected at multiple time points: immediately after catheter insertion, and then every 48 hours until the catheter was removed or until the patient was discharged from the ICU.

Laboratory Procedures

Sample Processing

Urine samples were processed within a 2-hour timeframe post-collection to ensure the integrity of the specimens. Samples were transported to the microbiology laboratory under refrigerated conditions.

Pathogen Identification

Urine specimens were cultured on Cysteine Lactose Electrolyte Deficient (CLED) agar and Bloodagar plates using a calibrated loop method. Plates were incubated aerobically at 37°C for 24–48 hours. Colony counts were performed to determine significant bacteriuria, defined as $\geq 10^5$ colony-forming units (CFU)/mL.

Antimicrobial Susceptibility Testing

Isolated pathogens were identified using standard biochemical tests and confirmed with automated systems if necessary. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, according to the Clinical and Laboratory Standards Institute (CLSI) guidelines of 2019. The antibiotics tested included commonly used agents such as ampicillin, ciprofloxacin, gentamicin, and meropenem, among others. The results were interpreted as susceptible, intermediate, or resistant based on CLSI breakpoints.

Data Analysis

Data were entered into a Microsoft Excel spreadsheet and analyzed using statistical software (e.g., SPSS version 25). Descriptive statistics, such as mean, median, and standard deviation, were used to summarize the demographic and clinical characteristics of the study population. The incidence of CAUTIs, distribution of pathogens, and their antimicrobial resistance patterns were analyzed. Associations between risk factors and CAUTI occurrence were evaluated using chi-square tests and logistic regression analysis, with a p-value < 0.05 considered statistically significant.

Quality Control

All laboratory procedures were conducted with appropriate quality control measures in place. This included the use of control strains for antimicrobial susceptibility testing and adherence to standard operating procedures for culture and identification.

Limitations

The study's limitations include its single-center design and the relatively small sample size, which may affect the generalizability of the findings. Additionally, the observational nature of the study precludes establishing causality between identified risk factors and CAUTI occurrence.

RESULTS AND OBSERVATIONS:

CAUTI Incidence and Demographics

The study observed a CAUTI rate of 9.4 per 1000 catheter days, indicating a substantial burden of these infections in the MICU setting. Out of the 70 patients enrolled, 14.67% (n=11) developed CAUTIs during the study period. The incidence of CAUTIs was highest among patients aged

51–70 years, accounting for 34% of the cases. Gender distribution showed a higher prevalence in females, who represented 63.63% of the CAUTI cases.

Pathogen Distribution

Among the isolated pathogens, *Escherichia coli* was the most prevalent, identified in 45.45% (n=5) of the CAUTI cases. This was followed by *Pseudomonas aeruginosa* in 27.27% (n=3) and *Enterococcus* species in 18.18% (n=2). Other pathogens, including *Klebsiella pneumoniae* and *Proteus mirabilis*, were less frequently isolated.

Antimicrobial Susceptibility Patterns

The antimicrobial susceptibility testing revealed varied resistance patterns among the Gram-negative bacilli. The susceptibility of these pathogens to different antibiotics is summarized below:

- Nitrofurantoin: Gram-negative bacilli showed the highest susceptibility, with a 100% (n=11) susceptibility rate.
- Imipenem: The next most effective antibiotic, with a susceptibility rate of 92.85% (n=10).
- Colistin: Also highly effective, with a 92.85% (n=10) susceptibility rate.
- Other antibiotics tested included ciprofloxacin, gentamicin, and meropenem, which exhibited varying degrees of effectiveness, though with generally lower susceptibility rates compared to Nitrofurantoin, Imipenem, and Colistin.

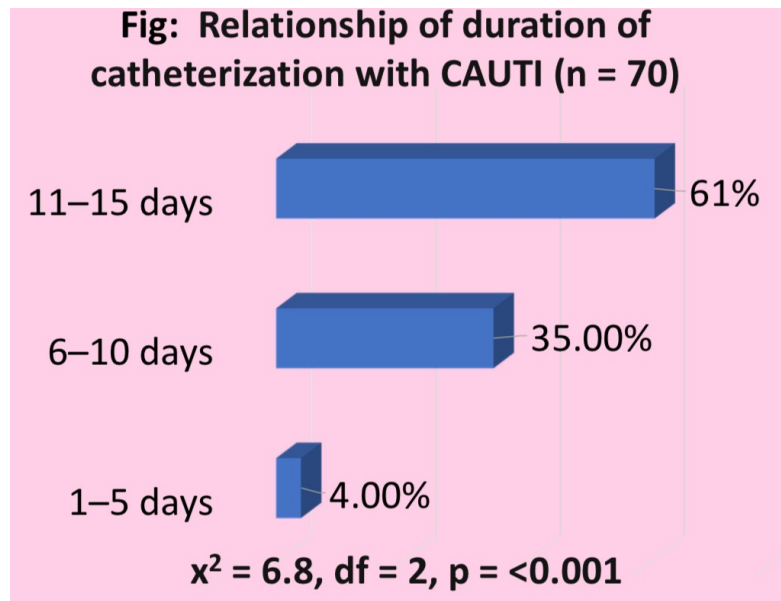
The high susceptibility rates to Nitrofurantoin, Imipenem, and Colistin indicate these antibiotics' potential utility in treating CAUTIs caused by Gram-negative bacteria in this setting.

Risk Factors for CAUTI

The analysis identified several risk factors associated with the development of CAUTIs. Among these, diabetes mellitus emerged as a significant risk factor, with 17.24% (n=2) of the CAUTI cases occurring in diabetic patients. Other contributing factors included prolonged catheterization duration, prior antibiotic use, and the presence of comorbid conditions such as chronic kidney disease and immunosuppression.

Summary of Findings

- CAUTI Rate: 9.4 per 1000 catheter days
- Overall Magnitude: 14.67% of the study population
- Age Group Most Affected: 51–70 years (34% of cases)
- Gender Distribution: Predominantly females (63.63%)
 - Primary Pathogens: *Escherichia coli* (45.45%), *Pseudomonas aeruginosa* (27.27%), *Enterococcus* species (18.18%)
- Antimicrobial Susceptibility:
 - Nitrofurantoin: 100%
 - Imipenem: 92.85%
 - Colistin: 92.85%
- Major Risk Factor: Diabetes mellitus (17.24%)



DISCUSSION

The findings highlight the significant burden of CAUTIs in the MICU, with a notable rate of infection per 1000 catheter days. The predominance of *Escherichia coli* as the primary pathogen aligns with existing literature on CAUTI etiology. The high susceptibility of Gram-negative bacilli to Nitrofurantoin, Imipenem, and Colistin provides valuable insights for empiric therapy choices in the MICU. The identification of diabetes mellitus as a major risk factor underscores the need for targeted preventive strategies in this patient population.

Overall, these results emphasize the critical need for stringent infection control practices, regular monitoring of catheterized patients, and judicious use of antibiotics to reduce the incidence and impact of CAUTIs in ICU settings.

The findings of this study underscore the significant prevalence and impact of CAUTIs in the Medical Intensive Care Unit (MICU). With a CAUTI rate of 9.4 per 1000 catheter days and an overall incidence of 14.67%, the data reflect a substantial burden of infection among critically ill patients. Notably, the study identified a higher prevalence of CAUTIs in diabetic patients (17.24%) compared to nondiabetic patients (14.04%). This discrepancy can be attributed to the increased microbial colonization of the perineal area often seen in diabetic individuals, making them more susceptible to urinary tract infections.

The pathogen distribution in this study aligns with existing literature, with *Escherichia coli* being the most frequently isolated pathogen, followed by *Pseudomonas aeruginosa* and *Enterococcus* species. The predominance of *Escherichia coli* is consistent with its well-documented role as a common causative agent in urinary tract infections, including CAUTIs[8].

The antimicrobial susceptibility patterns observed in this study provide critical insights for empiric therapy. The high susceptibility of Enterobacteriaceae to Nitrofurantoin and Imipenem (92.85%) suggests these antibiotics are effective options for treating CAUTIs caused by these pathogens[9,10]. However, the high resistance rate to Ciprofloxacin (92.85%) among Enterobacteriaceae is concerning, especially given Ciprofloxacin's traditional role in UTI treatment. This finding contrasts with the efficacy typically reported for Ciprofloxacin, as noted by Chatterjee et al. [3], highlighting the need for ongoing surveillance of antibiotic resistance patterns and judicious use of antibiotics to prevent the development of resistance.

A critical observation in this study is the direct relationship between CAUTI rates and the duration of catheterization. This correlation is well-documented in prior research [4, 5], emphasizing the

importance of minimizing catheter use duration to reduce infection risk. Prolonged catheterization facilitates biofilm formation on catheter surfaces, providing a reservoir for microbial growth and increasing the likelihood of infection. Implementing protocols to evaluate the necessity of continued catheterization and promoting timely removal when no longer needed are essential strategies to mitigate CAUTI incidence.

Study Implications

The baseline data provided by this study on CAUTI rates, isolated pathogens, and associated risk factors at our institute offer valuable insights for developing targeted interventions. Understanding the local epidemiology of CAUTIs enables healthcare providers to tailor infection prevention and control measures effectively. For instance, given the high prevalence of

CAUTIs among diabetic patients, targeted strategies such as enhanced glycemic control, meticulous perineal hygiene, and regular monitoring for early signs of infection could be implemented in this high-risk group.

Preventive Strategies

To reduce the incidence of CAUTIs in ICU settings, several preventive measures are recommended:

- **Stringent Infection Control Practices:** Adherence to aseptic techniques during catheter insertion and maintenance is crucial. Regular hand hygiene and the use of personal protective equipment (PPE) can significantly reduce the risk of contamination.
- **Regular Monitoring:** Frequent monitoring of catheterized patients for signs of infection and prompt removal of unnecessary catheters can help mitigate the risk of CAUTIs.
- **Antimicrobial Stewardship:** Judicious use of antibiotics based on local susceptibility patterns is essential to prevent the emergence of resistant strains. Empiric therapy should be guided by current antibiograms, and de-escalation should be practiced based on culture results.
- **Education and Training:** Continuous education and training programs for healthcare personnel on best practices for catheter care and infection prevention can enhance adherence to protocols and improve patient outcomes.

CONCLUSION

This study provides comprehensive baseline data on the incidence, pathogen distribution, and risk factors associated with CAUTIs in the MICU at our institute. The findings highlight a significant burden of CAUTIs, particularly among diabetic patients, and underscore the importance of tailored preventive measures. The high susceptibility of Gram-negative bacilli to Nitrofurantoin and Imipenem offers valuable guidance for empiric therapy, while the notable resistance to Ciprofloxacin emphasizes the need for ongoing antimicrobial stewardship.

The direct correlation between CAUTI rates and catheterization duration reinforces the necessity of minimizing catheter use duration and implementing robust infection control practices. By addressing these factors and adopting targeted interventions, healthcare providers can significantly reduce the incidence of CAUTIs, improve patient outcomes, and alleviate the associated healthcare burden. Future studies should focus on evaluating the effectiveness of implemented preventive strategies and further exploring the underlying mechanisms contributing to the high susceptibility of diabetic patients to CAUTIs.

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