

A Study of Risk Factors, Occurrence and Etiology of catheter associated urinary tract infections (CAUTI) in critical care unit

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Abstract

Background: Catheter-associated urinary tract infection (CAUTI) is one of the most common healthcare-associated infections and accounts for nearly half of all hospital-acquired infections. The duration of catheterization, length of ICU stay, and catheterization procedures play a crucial role in the development of catheter-associated bacteriuria (CAB).

Objectives: The aim of this study was to determine the incidence and evaluate the risk factors associated with catheter-associated bacteriuria in patients admitted to the medical intensive care unit (ICU). **Methods:** Patients aged >20 and <85 years who required an indwelling urinary catheter for more than 48 hours and were admitted to the medical ICU were enrolled in the study. Quantitative urine culture was performed once weekly, prior to catheter removal, or when clinical manifestations of urinary tract infection occurred (fever >38°C, dysuria, suprapubic tenderness, or pyuria). The variables analyzed included age, sex, duration of catheterization, length of ICU stay, and severity score at

admission using the APACHE II score.

Results: A total of 90 patients requiring indwelling urinary catheterization were analyzed. The incidence of catheter-associated bacteriuria was 10% (9/90). Most patients were in the age group of 56–65 years, with a predominance of males. The duration of catheterization and length of ICU stay were significantly associated with the development of bacteriuria. The most common organism isolated in CAB cases was *Escherichia coli*, followed by *Enterococcus* species and *Pseudomonas* species. **Conclusion:** Proper aseptic catheter insertion, appropriate maintenance by trained personnel, judicious use of urinary catheterization, and early removal of the catheter are key factors in preventing catheter-associated bacteriuria.

Keywords:

Catheter-associated bacteriuria; Catheter-associated urinary tract infection; Intensive care unit; Risk factors; Microorganisms

Introduction

The indwelling urinary catheter plays an important role in many medical

practices. The National Healthcare Safety Network (NHSN) defines an indwelling urinary catheter as a tube inserted into the urinary bladder through the urethra and left in place for continuous drainage; this definition excludes suprapubic catheters and nephrostomy tubes. [1]

Catheter-associated urinary tract infection (CAUTI) is one of the most common nosocomial infections worldwide, accounting for nearly 30–40% of all healthcare-associated infections. [2–3] Approximately 80% of these infections are associated with the use of an indwelling urinary catheter. The Centers for Disease Control and Prevention (CDC) defines CAUTI as a urinary tract infection that occurs in a patient who had an indwelling urinary catheter in place at the time of infection or within 48 hours prior to the onset of infection. [1] No minimum duration of catheterization has been specified for an infection to be classified as CAUTI. These infections may range from asymptomatic bacteriuria to symptomatic urinary tract infection.

Catheter-associated urinary tract infections are particularly prevalent in intensive care units (ICUs), where patients often require prolonged catheterization for accurate monitoring of urine output. [4] These infections occur due to microbial colonization along the catheter surface, leading to bacterial biofilm formation and increased susceptibility to urinary tract infections. [5] CAUTIs not only prolong hospital stay but also contribute to increased morbidity, rising antimicrobial resistance, and higher healthcare costs. [6]

The presence of an indwelling catheter disrupts the natural defense mechanisms of the urinary tract, thereby facilitating the ascent of pathogens into the bladder and upper urinary tract. [7] The development of CAUTI is influenced by several factors,

including the duration of catheterization, host immunity, and adherence to infection control practices. [8] Aseptic catheter insertion and proper catheter maintenance are therefore crucial in reducing the risk of infection. [9] However, microbial adaptation and biofilm formation on catheter surfaces make treatment difficult, as bacteria embedded in biofilms demonstrate increased resistance to antibiotics and host immune responses.

The most common pathogens implicated in CAUTIs include *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Enterococcus* species, with an increasing prevalence of multidrug-resistant organisms. [10] These infections often require targeted antimicrobial therapy based on culture and antibiotic susceptibility testing.

Effective prevention strategies for CAUTI focus on minimizing unnecessary catheterization, maintaining strict aseptic technique during catheter insertion, and implementing catheter care bundles. Surveillance programs and antimicrobial stewardship also play a vital role in reducing the burden of CAUTIs in healthcare settings. The risk of developing urinary tract infection depends largely on the method and duration of catheterization as well as the quality of catheter care. [11] Urinary tract infections can affect any part of the urinary system, including the kidneys, ureters, bladder, and urethra. [12] More than 70% of UTIs are associated with the use of indwelling urinary catheters and unnecessary urinary instrumentation. [13]

Previous studies have reported that CAUTIs are commonly caused by organisms such as *Escherichia coli* (21.4%), *Enterococcus* species (14.9%), *Pseudomonas aeruginosa* (10%), *Klebsiella pneumoniae* (7.75%), and *Enterobacter* species (4.15%). [8,9]

Several risk factors have been associated with the development of CAUTI, including female gender, prolonged duration of catheterization, immunocompromised status, advanced age, and prolonged ICU stay. [14] CAUTIs may lead to several complications such as prostatitis, epididymitis, bladder spasm, and orchitis in males, and cystitis, pyelonephritis, urosepsis, endocarditis, endophthalmitis, meningitis, and bloodstream infections. [15] Therefore, the present study aims to assess the incidence and independent risk factors associated with catheter-associated bacteria in ICU patients, including severity of illness at admission using the APACHE II score, duration of catheterization, length of ICU stay, and antibiotic exposure during hospitalization.

Materials and Methods

Study Design and Setting

This hospital-based prospective observational study was conducted in the Medical Intensive Care Unit (ICU) of a tertiary care hospital at Sri Balaji Institute of Medical Sciences, Raipur, Chhattisgarh. The study aimed to evaluate the prevalence, microbiological profile, and risk factors associated with catheter-associated urinary tract infections (CAUTIs). The study was carried out over a period of one year.

The study was conducted in a 50-bedded ICU where critically ill patients requiring urinary catheterization were monitored for the development of CAUTIs. A total of 90 patients who met the inclusion and exclusion criteria were enrolled in the study. All patients admitted to 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 determine the incidence of CAUTIs by prospectively

monitoring patients and identifying factors associated with 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 ($>38.0^{\circ}\text{C}$)
 - Suprapubic tenderness
 - Costovertebral angle pain or tenderness
 - Positive urine culture showing no more than two bacterial species, with at least one organism demonstrating growth $\geq 10^5$ colony-forming units (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 infection prior to catheter insertion.

Data Collection

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

Patient Demographics

- Age
- Gender
- Comorbidities
- ICU admission diagnosis

Urinary Catheter-Related Data

- Duration of catheterization
- Site of insertion
- Catheter care practices
- History of antimicrobial use

Microbiological Findings

- Pathogen identification
- Antimicrobial resistance patterns

Clinical Outcomes

- Resolution of infection
- Length of ICU stay
- Patient outcome (discharge or mortality)

Definition of CAUTI Event

The event time frame for CAUTI was defined as a 14-day period starting from the date of infection diagnosis. Any

pathogens detected during this period were considered part of the same CAUTI episode. No new CAUTI event was assigned within this window to avoid duplicate reporting.

Urine Sample Collection and Laboratory Processing

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 calibrated 1 μ L nichrome loop (1.3 mm diameter). The culture plates were incubated aerobically at 37°C for 18–24 hours.

Pathogen Identification

Isolated organisms were identified by Gram staining, biochemical characterization, and species-level identification using standard microbiological methods.

Age and Gender Distribution

Antibiotic Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.

Statistical Analysis

Data were analyzed using descriptive and inferential statistical methods. Quantitative variables were expressed as mean \pm standard deviation (SD), while categorical variables were presented as frequencies and percentages. The Chi-square test was used to determine the association between risk factors and the incidence of CAUTI. A p-value of <0.05 was considered statistically significant. Statistical analysis was performed using SPSS software version 28.

Results

A total of **90 patients** who required an indwelling urinary catheter were enrolled and analyzed in the study.

Table 1: Age and gender distribution among study participants

Variables	Frequency (N=90)	Percentage (%)
Age groups		
45–55 years	21	23.3
56–65 years	55	61.1
66–75 years	14	15.6
Gender		
Male	65	72.2
Female	25	27.8

The majority of patients belonged to the 56–65 years age group (61.1%), with a predominance of male patients (72.2%). The mean age of the study population was 55.2 years.

APACHE II Score Distribution

Table 2: Distribution of APACHE II score among study patients

APACHE II Score Frequency (N=90) Percentage (%)

15–19	36	40
20–24	28	31.1
25–29	19	21.1
30–34	7	7.8

The APACHE II score ranged from 15 to 35. Most patients (40%) had an APACHE II score between 15–19, with a mean APACHE II score of 25.6.

Risk Factors Associated with Catheter-Associated Bacteriuria

Table 3: Risk factors among study subjects

Variables	Category	Frequency (N=90)	Percentage (%)
Received antibiotics	Yes	86	95.6
	No	4	4.4
Duration of catheterization	3–7 days	25	27.8
	8–15 days	52	57.8
	16–21 days	13	14.4
ICU stay	<1 week	30	33.3
	1–2 weeks	55	61.1

2–3 weeks 5 5.6

Most patients (95.6%) received antibiotics during their hospital stay. The duration of catheterization was 8–15 days in 57.8% of patients, while 61.1% of patients had an ICU stay of 1–2 weeks.

Patients who developed bacteriuria had a longer duration of catheterization compared to those who did not develop bacteriuria. Statistical analysis showed that duration of catheterization was the only variable that demonstrated a statistically significant association with bacteriuria ($p < 0.05$). Other variables such as age, gender, length of ICU stay, antibiotic exposure, and severity score

did not show statistically significant association.

Incidence of Catheter-Associated Bacteriuria

The **incidence of catheter-associated bacteriuria (CAB)** in the present study was **10% (9/90)**.

Among these patients:

- Two patients were initially asymptomatic but developed **dysuria and fever during the second week**, and urine examination confirmed bacteriuria.
- Six patients were detected with **CAB at the end of the second week during routine urine examination**.
- Two patients showed **bacteriuria at the time of catheter removal**, although they remained **asymptomatic**.

Mortality among CAB Patients

Table 4: Mortality rate among CAB patients

Mortality	Frequency (N=90)	Percentage (%)
Death in 1st week	1	0.9
Death in 2nd week	5	4.5

Microorganisms Isolated from CAB Patients

Table 5: Organisms isolated from patients with catheter-associated bacteriuria

Microorganism	Frequency	Percentage (%)
<i>Escherichia coli</i>	35	38.9
<i>Enterococcus</i> species	25	27.8
<i>Pseudomonas aeruginosa</i>	15	16.7
<i>Proteus</i> species	15	16.7

The most commonly isolated pathogen was *Escherichia coli* (38.9%), followed by *Enterococcus* species (27.8%), *Pseudomonas aeruginosa* (16.7%), and *Proteus* species (16.7%).

Discussion

Catheter-associated urinary tract infection (CAUTI) is one of the most significant device-associated healthcare-acquired infections. The use of an indwelling urinary catheter is associated with an increased risk of bacteriuria, symptomatic urinary tract infections, bacteremia, and other complications, which may ultimately increase patient morbidity and healthcare costs. Periodic in-service training should therefore be provided to healthcare workers involved in catheter care, emphasizing proper catheterization techniques and awareness of potential complications. Understanding the etiology and risk factors of CAUTI is essential for designing and implementing effective preventive strategies. [16]

A total of 90 patients were included in the present study. The age of the patients ranged from 27 to 81 years, with a mean age of 55.2 years. Among them, 65 were males and 25 were

females. The majority of patients were catheterized for urinary retention, while others required catheterization for urinary incontinence and monitoring of urine output. Three different catheter sizes were used in the study (16 Fr, 18 Fr, and 22 Fr), with 18 Fr catheters being the most commonly used. Abnormal serum creatinine levels were observed in 20 (22.2%) patients. In the present study, female gender was not identified as a significant risk factor for CAUTI. This finding differs from several previous studies that reported a higher susceptibility among females. [17] The smaller number of female participants in the present study may explain this difference. The incidence of catheter-associated bacteriuria (CAB) in this study was 10%, which is comparable with the findings of Decker SG et al. [18] and Letica-Kriegel AS et al. [19], who reported incidences of 9% and 10%, respectively. The present study also found that CAB occurred more frequently in patients aged 56–65

years, which is consistent with the findings of Girard R et al. [20]. This may be attributed to the higher prevalence of chronic illnesses and reduced immunity among older patients. In the present study, CAB was more common among male patients. This finding is consistent with the study conducted by Yakusheva O et al. [21]. However, several other studies, such as those conducted by Teshager et al. [22] and Saint S et al. [23], have reported a higher prevalence among female patients. The duration of catheterization and length of ICU stay were positively correlated with the development of bacteriuria, which is consistent with the findings reported by Karlsson et al. [24] and Rubi H [4]. Prolonged catheterization provides greater opportunity for microbial colonization and biofilm formation along the catheter surface, thereby increasing the risk of infection.

Several additional factors have also been identified as potential risk factors for CAUTI, including prolonged catheterization, catheter insertion outside the operating theatre, diabetes mellitus, malnutrition, elevated serum creatinine (>2 mg/dL), ureteric stents, improper positioning of the drainage tube, and antimicrobial drug therapy. [25] In the present study, *Escherichia coli* was the most frequently isolated organism, followed by *Enterococcus* species, *Pseudomonas aeruginosa*, and *Proteus* species. These findings are comparable with studies conducted by Bizuayehu et al. [26] and S. Teferi et al. [27], which also reported *E. coli* as the predominant pathogen in CAUTI.

The present study also observed that antibiotic exposure was not a protective factor against CAB. This finding contrasts with the study conducted by Tissot et al. [28], which reported that antibiotic therapy may reduce the risk of bacteriuria. However, excessive antibiotic use may contribute to the

development of antimicrobial resistance and should therefore be used judiciously. The most effective strategies for preventing CAB include judicious use of urinary catheterization, minimizing the duration of catheter use, and ensuring early removal of the catheter whenever clinically feasible. Additionally, strict aseptic technique during catheter insertion and proper catheter maintenance by trained healthcare personnel are essential to reduce infection risk.

Conclusion

The clinical significance of bacteriuria in ICU patients should be emphasized, as the presence of bacteria in the urinary tract can lead to urosepsis, prolonged hospital stay, and the emergence of multidrug-resistant organisms. The present study identified prolonged duration of catheterization and extended ICU stay as important risk factors for catheter-associated bacteriuria. These findings highlight the importance of limiting the duration of catheterization and ensuring appropriate indications for catheter use. Implementation of strict infection control measures, proper catheter care practices, and timely removal of indwelling catheters can significantly reduce the incidence of catheter-associated bacteriuria in ICU settings.

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