e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(12); 2414-2418

Original Research Article

A Comprehensive Study of Microbiological Profile, Associated Risk Factors and Antibiotic Sensitivity Pattern of Catheter Associated Urinary Tract Infection at a Teaching Hospital

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Received: 25-09-2024 / Revised: 23-10-2024 / Accepted: 26-11-2024
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Conflict of interest: Nil

Abstract:

This study was conducted to assess the microbiological profile, risk factors, and antibiotic resistance patterns of catheter-associated urinary tract infections (CAUTI) in a teaching hospital. The study included all catheterized patients who met the criteria for CAUTI or catheter-associated asymptomatic bacteriuria (CA-ASB). Urine samples from CAUTI patients were further examined. Samples were cultured on MacConkey's agar and Blood agar, and bacterial identification along with antibiotic susceptibility testing were performed using standard biochemical methods. The duration of catheterization and other risk factors were also meticulously recorded. Among 258 urine samples obtained from patients with hospital-acquired infections, 53 met the criteria for CAUTI. The most frequently isolated pathogen was Escherichia coli (51%), followed by Klebsiella spp. (17%) and Pseudomonas spp. (15%). The majority of isolates were from the medicine ward (55%). Gram-negative bacteria were more prevalent than Gram-positive bacteria. The rising incidence of CAUTI presents significant challenges to hospital management and poses a serious risk to patients with underlying health conditions. By adhering strictly to catheter care protocols and implementing infection control measures, the incidence of CAUTI can be significantly reduced.

Keywords: CAUTI- Catheter Associated urinary tract infection, CA-ASB- catheter-associated asymptomatic bacteriuria, HAI- Hospital acquired Infection.

Introduction

Hospital-acquired urinary tract infections (UTIs) are among the most prevalent types of infections acquired in healthcare settings. Catheter-associated urinary tract infections (CAUTI) require immediate diagnosis and treatment to prevent potential chronic kidney complications. These infections are challenging to treat due to the presence of antibiotic-resistant strains of nosocomial bacteria. The Infectious Disease Society of America defines CAUTI as an infection in a patient with an indwelling urinary catheter for more than 48 hours, along with at least one clinical symptom such as a fever above 38°C, suprapubic tenderness, or pain in the costovertebral angle. In contrast, when a patient with a catheter for over 48 hours does not exhibit such symptoms, the condition is categorized as catheter-associated asymptomatic bacteriuria (CA-ASB). Although CA-ASB often occurs after catheterization, not all cases progress to CAUTI. [1] The incidence of hospital-acquired UTIs can vary widely, ranging from 1% to 5% to as high as 100% in patients with an indwelling urinary catheter for more than 48 hours. This variation is influenced by factors such as the type of urinary catheter used, the duration of catheterization, the quality of catheter care, the patient's immune status, and the hospital's infection control practices. [2-4]

Materials and Methods

This observational clinical study was conducted at a teaching hospital from January 2023 to September 2024. The study was carried out across various wards and the Intensive Care Units (ICUs) of the Index Medical College Hospital and

Research Centre in Indore, Madhya Pradesh, India. The study focused on catheterized patients admitted to the hospital who developed a urinary tract infection (UTI) that was not present or incubating at the time of admission. UTIs that developed more than 48 hours after hospital admission were categorized as nosocomial infections. Patients presenting with symptoms such as fever, suprapubic tenderness, or costovertebral angle pain were diagnosed with catheter-associated urinary tract infections (CAUTI) and included in the study.

Sample collection

Urine samples were obtained from patients with indwelling urinary catheters by temporarily clamping the catheter tube to allow for freshly voided urine. Prior to sample collection, the tubing was disinfected using a swab soaked in 70% alcohol. The urine was then collected using a needle and syringe, and transferred into a sterile container for analysis.

Identification of isolates

Urine samples were collected and processed for bacterial isolation and identification. The samples were inoculated onto MacConkey agar and Blood agar plates. Initial identification was performed using Gram staining and examining colony characteristics. The bacterial isolates were further identified through additional biochemical tests, with standard protocols. [5,6].

Antibiotic sensitivity test

The isolated colonies were subjected to antibiotic sensitivity testing, along with the detection of extended-spectrum β-lactamase (ESBL) and metallo-β-lactamase (MBL) enzymes. Vancomycin-resistant strains of Enterococcus species were also identified. These tests were performed using the Kirby-Bauer Disk Diffusion Method, the double disk diffusion test, and the E-test, following the Clinical and Laboratory Standards Institute (CLSI) guidelines from 2018. [7].

Result and Discussion

Samples were collected from various wards and ICUs for analysis between January 2023 and September 2024. A total of 813 patients were identified with hospital-acquired infections (HAI) during this period, of which 258 were diagnosed with hospital-acquired urinary tract infections (UTIs). Among these 258 patients, 130 had indwelling urinary catheters. Of the catheterized patients, 77 (59%) were asymptomatic, with uropathogens identified in their cultures, and were classified as having catheter-associated asymptomatic bacteriuria (CA-ASB). The remaining 53 (41%) patients were symptomatic and diagnosed with catheter-associated urinary tract infections (CAUTI). The study followed up on CA-ASB cases only until the identification of the colonizing organisms, without further clinical follow-up. The distribution of CAUTI isolates by ward revealed that the highest proportion was found in the orthopedic ward (36%), followed by the surgery ward (26%), and the medicine ward (23%). The obstetrics and gynecology ward reported the lowest number of isolates (4%). Additionally, the medicine ICU contributed to 8% of the isolates, with the majority of patients presenting multiple predisposing factors.

Analysis of nosocomial pathogens in CAUTI patients revealed a higher prevalence of Gram-negative isolates compared to Gram-positive ones. Escherichia coli was the most frequently isolated pathogen, accounting for 51% of cases, followed by Klebsiella species (17%) and Pseudomonas species (15%). Among the Gram-positive pathogens, Enterococcus species were identified in 9% of cases.

In this study, the pathogen profile of CA-ASB isolates mirrored that of CAUTI isolates, with a predominance of Gram-negative bacteria (84%) over Gram-positive bacteria (16%). Escherichia coli was the most frequently identified pathogen in CA-ASB cases, accounting for 42%, followed by Klebsiella species (22%), Pseudomonas species (18%), and Enterococcus species (12%).

A thorough analysis was conducted to assess the risk and predisposing factors linked to CAUTI in patients. The results demonstrated a positive correlation between age and CAUTI incidence, with the highest number of isolates found in patients aged over 55 years (62%), followed by those in the 46–55 years age group (15%). The duration of catheterization also played a significant role in the development of CAUTI. Most cases (75%) occurred in patients who had been catheterized for more than 48 hours but less than 7 days, while 21% of cases involved patients with catheters in place for more than 10 days, often due to discharge following surgery or recovery from illness. Additionally, predisposing conditions such as type 2 diabetes mellitus, hypertension, and cerebrovascular accidents were also evaluated during the study period.

The antibiotic sensitivity pattern of Gram-negative uropathogens revealed that all pathogens were 100% sensitive to Colistin. Escherichia coli exhibited 89% sensitivity to Amikacin, while Klebsiella species showed 67% sensitivity to Tigecycline. Pseudomonas species demonstrated the highest sensitivity to Minocycline at 88%. The least effective antibiotics were ciprofloxacin and levofloxacin, with only 25% sensitivity. Furthermore, 45% of the pathogens produced extended-spectrum beta-lactamases (ESBL), and 24% produced metallo-beta-lactamases (MBL),

which could present significant challenges in the treatment of CAUTI patients. The antibiotic sensitivity of the only Gram-positive isolate, Enterococcus species, was also evaluated. The sensitivity pattern indicated that Vancomycin and Teicoplanin were the most effective antibiotics, with 80% sensitivity. However, Enterococcus species showed no sensitivity to Ciprofloxacin, Levofloxacin, and Erythromycin (0%). Additionally, during the study period, 20% of Enterococcus strains were found to be resistant to Vancomycin.

Urinary tract infections (UTIs) are the most prevalent type of nosocomial infection, responsible for 39%–40% of all hospital-acquired infections. This rate is even higher among patients with an indwelling urinary catheter. Contributing factors to the increased incidence of catheter-associated urinary tract infections (CAUTI) include prolonged catheter use, inadequate catheter care, underlying health conditions, and insufficient infection control practices. Approximately 15%–20% of hospitalized patients require urinary catheterization during their stay. As a result, it is recommended to use a closed catheter drainage system for short-term catheterization, and only when absolutely necessary. [8,9].

Pathogens can enter the urinary tract directly through a catheter or during cystoscopy, leading to infections. Bacteria can proliferate either in the urine or on the surface of the catheter. Once bacteria adhere to the catheter, they begin to form a biofilm. Catheter-associated urinary tract infections (CAUTI) can result in secondary bacteremia, potentially causing damage to the bladder. In this study, we compared cases of CAUTI and catheter-associated asymptomatic bacteriuria (CA-ASB) reported by various authors. Bagchi et al. [10], Bhatia et al. [11], and Kizilbash et al. [12] noted a higher incidence of CA-ASB and fewer CAUTI cases among catheterized patients. Our findings were consistent with these results, while other studies reported a higher incidence of CAUTI compared to CA-ASB. [4,13,14,15,16].

The variations in the incidence of CAUTI and CA-ASB can be attributed to differences in infection control policies and catheter management practices in healthcare settings. Effective surveillance of healthcare-associated infections (HAI), including CAUTI, is crucial for the development of robust infection control strategies across all healthcare environments. In this study, the most commonly identified uropathogen in CAUTI patients was E. coli, followed by Klebsiella species and Pseudomonas species. These results are consistent with other CAUTI studies, which also reported E. coli as the predominant pathogen [4,10,16]. In CA-ASB cases, E. coli was the most frequently encountered pathogen, followed by Klebsiella species and Enterococcus species, aligning with findings from Bhatia et al. [11].

In this study, the highest incidence of CAUTI was observed in the orthopedic ward (36%), followed by the surgical ward (26%) and the medicine ward (23%). The isolation rate of CAUTI in ICUs was lower than that in the wards. These differences are expected, as they are influenced by various local factors.

CAUTI isolates showed resistance to commonly used antibiotics, including cephalosporins, fluoroquinolones, and sulfonamides. Similar findings were reported by Kaur et al. [4], Bagchi et al. [10], and Taiwo and Aderounmu [14]. However, more potent antibiotics such as Colistin, Tigecycline, and, to a lesser extent, Imipenem, remained effective against these pathogens. This study also found that 45% of CAUTI pathogens produced extended-spectrum beta-lactamases (ESBL), while 24% produced metallo-beta-lactamases (MBL), a trend consistent with the findings of Kaur et al.[4]. The presence of these resistance mechanisms and the resistance to common antibiotics complicates the treatment of CAUTI, making it more challenging to manage.

The urinary catheter is the most significant risk factor for nosocomial UTIs. Numerous studies have demonstrated that the incidence of UTIs increases with the duration of catheterization, with the risk of infection rising by 1%–5% for each additional day the catheter is in place. Following a single catheter insertion and removal, 1%–20% of patients develop CAUTI. When patients use sterile closed collecting systems, the risk of CAUTI ranges from 10% to 25%. However, if the catheter drains into an open collecting vessel, the likelihood of developing a UTI increases to 100% within four days of hospitalization. Other risk factors, including gender, impaired renal function, and comorbidities, also contribute to the incidence of nosocomial UTIs. The use of systemic antibiotics may help reduce the risk of UTIs in patients. [8,9].

Different studies have employed various time frames for catheterization duration. In this study, patients were followed for catheterization periods ranging from over 48 hours up to a maximum of 23 days. Age was also identified as a significant risk factor for CAUTI. The results of this study demonstrate a positive correlation between age and the incidence of CAUTI, with a higher occurrence observed in older age groups. Most uropathogens were isolated from individuals over the age of 55, which aligns with findings from Bagchi et al.[10] and Kaur et al.[4]. Additionally, we analyzed the gender distribution of CAUTI isolates. Unlike community-acquired UTIs, where females are more commonly affected, this study found a higher incidence of CAUTI in male patients (55%)

compared to female patients (45%).

This study identified several predisposing factors contributing to CAUTI, with type 2 diabetes mellitus being one of the most prominent. Diabetic patients are particularly vulnerable to developing CAUTI during catheterization, a finding consistent with the study by Bagchi et al. [10]. As such, patients with these predisposing factors require careful and specialized catheter management throughout their hospital stay.

Monitoring the incidence of CAUTI, along with associated risk and predisposing factors, is essential for treating physicians, as the causative microorganisms may include multi-drug resistant nosocomial pathogens [17]. Accurate microbiological diagnosis is crucial for ensuring effective treatment [18]. Hospitalized patients often present with comorbidities, immunosuppression, neutropenia, multi-organ involvement, or other hospital-acquired infections, all of which can complicate the management of CAUTI [19,20].

Preventing and effectively treating CAUTI requires strong microbiological support and timely reporting of such incidents across various hospital departments. The Centers for Disease Control and Prevention (CDC) has implemented the "Targeted Assessment for Prevention" strategy to reduce healthcare-associated infections, including CAUTI [21].

Correct antibiotic selection is vital for successful treatment and should be guided by accurate urine culture results. This process involves not only adhering to microbiology laboratory standards but also ensuring proper pre-laboratory practices, such as correct sample collection, storage, and processing, to prevent contamination from other microorganisms. According to the CDC, this approach is integral to the treatment process and includes the urine culture stewardship program for hospitalized patients [22].

Antibiotic stewardship is especially important for UTIs in hospitalized patients, as they are frequently encountered by healthcare providers [23. Given that CAUTI is the most common type of UTI in hospitalized patients, appropriate treatment, thorough patient assessment, laboratory investigations, urine culture sensitivity patterns, and the judicious use of specific antibiotics for the appropriate duration are all essential components of an antibiotic stewardship program at both local and global levels [22,23]. Furthermore, effective prevention of CAUTI relies on proper microbiological laboratory support, rational catheter use, careful catheter care, strict infection control practices, and appropriate antibiotic use [19–24].

Conclusion

The present study found a positive correlation between the incidence of CAUTI and several risk factors, including age, catheter duration, and conditions such as type 2 diabetes mellitus. The rise in antibiotic resistance, along with resistance mechanisms like MBL and ESBL, has made CAUTI increasingly difficult to treat. Our findings also indicate that CAUTI is more common among elderly patients, underscoring the importance of specialized catheter care and precautions when managing this group.

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