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Research Article

Prevalence of Catheter-Associated Urinary Tract Infection and Antimicrobial Resistance among Hospitalized Patients in Shendi Town, Sudan

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Abstract

Background: Catheter-associated urinary tract infection (CAUTI) is among the most common healthcare-associated infections worldwide. Prolonged catheterization facilitates bacterial colonization and biofilm formation, increasing the risk of infection and antimicrobial resistance. This study aimed to determine the prevalence of catheter-associated urinary tract infections (CAUTIs) and evaluate the antimicrobial susceptibility patterns of bacterial isolates.

Methods: A descriptive cross-sectional hospital-based study was conducted in Shendi Town, River Nile State, Sudan, from January to April 2025. Fifty urine samples were collected aseptically from hospitalized patients with indwelling urinary catheters. Samples were cultured on CLED agar, and bacterial isolates were identified using colony morphology, Gram staining, and biochemical tests. Antimicrobial susceptibility testing was performed using the agar diffusion method.

Results: Out of 50 collected samples, 44 (88%) showed bacterial growth. *Staphylococcus aureus* was the most frequently isolated organism (46%), followed by *Streptococcus agalactiae* (18%), *Pseudomonas aeruginosa* (14%), *Klebsiella pneumoniae* (11%), *Escherichia coli* (9%), and *Staphylococcus epidermidis* (2%). Gram-positive bacteria accounted for 65.9% of isolates, while Gram-negative bacteria represented 34.1%. High resistance rates were observed against ciprofloxacin (68.1%), levofloxacin (66%), and norfloxacin (75%).

Conclusion: The study demonstrated a high prevalence of catheter-associated bacterial infections among hospitalized patients in Shendi Town, with *Staphylococcus aureus* being the predominant isolate. The high resistance rates to commonly used fluoroquinolones highlight the urgent need for continuous surveillance, rational antibiotic use, and strict infection prevention measures to reduce catheter-associated infections and antimicrobial resistance. The findings emphasize the importance of antimicrobial stewardship and strict catheter management protocols.

Keywords: Catheter-associated urinary tract infection, CAUTI, Antimicrobial resistance, *Staphylococcus aureus*, Urinary catheter, Bacterial infection, Sudan

Introduction

Indwelling urinary catheters are among the most commonly used medical devices in hospitalized patients for urinary drainage, monitoring urine output, perioperative management, and the treatment of urinary retention. Foley catheters, the most widely used type, are equipped with an inflat-

able balloon that secures the catheter within the bladder and facilitates continuous urine drainage [1]. Although urinary catheterization is an essential medical intervention, its use is frequently associated with infectious complications, particularly catheter-associated urinary tract infections (CAUTIs),

which represent one of the leading healthcare-associated infections worldwide [2]. The introduction of closed urinary drainage systems has significantly reduced the incidence of catheter-associated infections by minimizing bacterial contamination compared with previously used open drainage systems. Nevertheless, the risk of infection increases progressively with the duration of catheterization, with approximately 3–7% of catheterized patients developing bacteriuria for each additional day of catheter use [3]. Microorganisms may gain access to the urinary tract through either the internal lumen or the external surface of the catheter, where they adhere to the catheter material and develop biofilms. Biofilm formation protects bacteria from host immune defenses and antimicrobial agents, resulting in persistent infections that are difficult to eradicate [3]. Catheter-associated urinary tract infections account for a substantial proportion of hospital-acquired infections and are associated with increased morbidity, mortality, prolonged hospitalization, and higher healthcare costs [4]. In addition, CAUTIs contribute to approximately 20% of healthcare-associated bloodstream infections in acute care hospitals and an even greater proportion in long-term care facilities [5]. The most frequently isolated pathogens include *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Staphylococcus epidermidis*, many of which possess the ability to form biofilms and exhibit multidrug resistance, making treatment increasingly challenging [6,7]. Antimicrobial resistance among CAUTI-associated pathogens has emerged as a major global public health concern. The widespread and often inappropriate use of broad-spectrum antibiotics in hospitalized patients has accelerated the emergence of resistant bacterial strains, thereby reducing treatment options and increasing the risk of treatment failure [7]. Fluoroquinolones, including ciprofloxacin, levofloxacin, and norfloxacin, are commonly prescribed for urinary tract infections; however, resistance to these agents has increased considerably in many parts of the world [8–10]. Despite the growing burden of healthcare-associated infections in Sudan, published data regarding the prevalence of catheter-associated urinary tract infections and antimicrobial resistance patterns among hospitalized patients remain limited. Reliable local epidemiological data are essential to support evidence-based infection prevention strategies, optimize empirical antimicrobial therapy, and guide antimicrobial stewardship programs. Therefore, the present study was conducted to determine the prevalence of catheter-associated urinary tract infections among hospitalized patients in Shendi Town, Sudan, identify the bacterial pathogens involved, and evaluate their antimicrobial susceptibility patterns.

Materials and Methods

Study Design

A descriptive cross-sectional hospital-based study was con-

ducted to determine the prevalence of catheter-associated bacterial infections and to evaluate the antimicrobial susceptibility patterns of bacterial isolates among hospitalized patients with indwelling urinary catheters.

Study Area

The study was conducted in Shendi Town, River Nile State, Sudan. Shendi is located approximately 150 km northeast of Khartoum on the eastern bank of the River Nile. Samples were collected from different hospitals in Shendi Town and processed at the Microbiology Laboratory, Faculty of Medical Laboratory Sciences, Shendi University.

Study Duration

The study was carried out over a four-month period from January 2025 to April 2025.

Study Population

The study population included hospitalized patients with indwelling urinary catheters admitted to hospitals in Shendi Town during the study period.

Inclusion Criteria

- Hospitalized patients with indwelling urinary catheters.
- Patients who agreed to participate in the study.

Exclusion Criteria

- Patients without indwelling urinary catheters.
- Patients who refused participation in the study.
- Patients with incomplete clinical information.

Sample Size and Sampling Technique

A total of 50 urine samples were randomly collected from catheterized patients using sterile urine containers under aseptic conditions.

Data Collection

Data were collected using a structured questionnaire containing demographic and clinical information, including gender, duration of catheterization, and antibiotic usage history.

Specimen Collection

Urine specimens were collected aseptically from catheterized patients according to standard microbiological procedures. Samples were obtained either from the catheter tube or urine collection bag using sterile techniques and were transported immediately to the microbiology laboratory for analysis.

Culture and Isolation of Bacteria

Urine samples were cultured on Cystine Lactose Electrolyte Deficient (CLED) agar media for the isolation and identification of urinary bacterial pathogens. The inoculated plates were incubated aerobically at 37°C for 24 hours. After incubation, plates were examined for significant bacterial growth based on colony morphology and lactose fermentation characteristics.

Identification of Bacterial Isolates

Bacterial isolates were identified using Gram staining and standard biochemical tests.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the agar diffusion method on Mueller–Hinton agar according to standard microbiological procedures. Pure bacterial colonies were emulsified in sterile physiological saline to achieve turbidity equivalent to the McFarland standard. The bacterial suspension was inoculated evenly onto Mueller–Hinton agar plates using sterile cotton swabs. Antibiotic discs containing ciprofloxacin, levofloxacin, and norfloxacin were placed onto the inoculated media using sterile forceps. The plates were incubated aerobically at 37°C for 18–24 hours. The diameters of inhibition zones were measured in millimeters and interpreted as sensitive or resistant according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (2024) [11].

Preservation of Bacterial Isolates

Pure bacterial isolates were preserved on suitable culture media and stored at 4°C in a refrigerator for further analysis and confirmation.

Data Analysis

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Frequencies and percentages were calculated. Associations between categorical variables were evaluated using the Chi-square test or Fisher’s exact test where appropriate. A p-value <0.05 was considered statistically significant.

Results

A total of 50 catheterized patients were included in this study. Among them, 33 (66%) were males and 17 (34%) were females (Table 1). A total of 44 bacterial isolates were recovered from catheter-related infections. Gram-positive bacteria represented the majority of isolates 29 (65.9%), while Gram-negative bacteria accounted for 15 (34.1%). The most frequently isolated organism was *Staphylococcus aureus* 20 (46%), followed by *Streptococcus agalactiae* 8 (18%), *Pseudomonas aeruginosa* 6 (14%), *Klebsiella pneumoniae* 5 (11%), *Escherichia coli* 4 (9%), whereas *Staphylococcus epidermidis* showed the lowest prevalence 1 (2%) (Table 2). Equal numbers of specimens were collected from catheter tubes and catheter bags, with 25 samples obtained from each source. However, bacterial growth was more frequently detected in catheter bags 24 (48%) compared to catheter tubes 20 (40%) (Table 3). Regarding the duration of catheterization, patients who used indwelling catheters for more than one month demonstrated the highest bacterial growth rate 19 (43.18%), followed by those catheterized for one week to one month 15 (34.09%), while the lowest growth

rate was observed among patients catheterized for less than one week 10 (22.7%) (Table 4). Concerning antibiotic use, bacterial growth was identified in 28 (63.6%) patients who had previously used antibiotics, whereas 16 (36.3%) isolates were recovered from patients without prior antibiotic use (Table 5). Antimicrobial susceptibility testing revealed high resistance rates among bacterial isolates against fluoroquinolone antibiotics. Norfloxacin showed the highest resistance rate 75%, followed by ciprofloxacin 68.1% and levofloxacin 66%. In contrast, levofloxacin demonstrated the highest sensitivity rate 34.09%, followed by ciprofloxacin 31.8% and norfloxacin 27.2% (Table 6).

Gender	Frequency	Percentage
Male	33	66%
Female	17	34%
Total	50	100%

Table1: Distribution of study participants according to gender

Bacterial isolate	Gram reaction	Frequen- cy	Per- centage
<i>Staphylococcus aureus</i>	Gram positive	20	46%
<i>Streptococcus agalactiae</i>	Gram positive	8	18%
<i>Staphylococcus epidermidis</i>	Gram positive	1	2%
<i>Pseudomonas aeruginosa</i>	Gram negative	6	14%
<i>Klebsiella pneu- moniae</i>	Gram negative	5	11%
<i>Escherichia coli</i>	Gram negative	4	9%
Total	—	44	100%

Table2: Distribution of isolated bacterial species according to Gram reaction

Specimen source	Growth	No growth	Total
Tube	20	5	25
Bag	24	1	25
Total	44	6	50

Table3: Distribution of bacterial growth according to specimen source

Duration of cath- eterization	Frequency	Bacterial growth	Percentage of growth
Less than 1 week	20	10	22.7%

1 week–1 month	25	15	34.09%
More than 1 month	5	19	43.18%
Total	50	44	100%

Table4: Distribution of bacterial growth according to duration of catheterization

Antibiotic use	Frequency	Bacterial growth	Percentage
Yes	40	28	63.6%
No	10	16	36.3%
Total	50	44	100%

Table5: Distribution of bacterial growth according to antibiotic use

Antibiotic	Sensitivity (%)	Resistance (%)
Ciprofloxacin	31.8%	68.1%
Levofloxacin	34.09%	66%
Norfloxacin	27.2%	75%

Table6: Antibiotic susceptibility pattern of bacterial isolates

Discussion

Catheter-associated urinary tract infections (CAUTIs) remain among the most common healthcare-associated infections worldwide and continue to represent a major clinical challenge because of their association with prolonged hospitalization, increased healthcare costs, and the emergence of antimicrobial-resistant pathogens. In the present study, bacterial growth was detected in 88% of catheterized patients, indicating a high prevalence of catheter-associated bacterial infections among hospitalized patients in Shendi Town. This high prevalence may be attributed to prolonged catheterization, inadequate catheter care practices, and frequent exposure to antibiotics, all of which facilitate bacterial colonization and biofilm formation on urinary catheters. Among the isolated organisms, *Staphylococcus aureus* was the predominant pathogen (46%), followed by *Streptococcus agalactiae* (18%), *Pseudomonas aeruginosa* (14%), *Klebsiella pneumoniae* (11%), and *Escherichia coli* (9%). These findings differ from many previous studies in which Gram-negative organisms, particularly *Escherichia coli* and *Klebsiella pneumoniae*, were the predominant uropathogens associated with CAUTIs [12–14]. The predominance of *S. aureus* observed in the present study may reflect differences in hospital environments, infection prevention practices, patient characteristics, patterns of antibiotic use, and geographical variations in bacterial epidemiology. The predominance of Gram-positive bacteria (65.9%) over Gram-negative bacteria also contrasts with findings from Ghana, where Gram-nega-

tive organisms constituted the majority of isolates recovered from catheterized patients, with *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* being the most frequently identified pathogens [17]. Similar observations have been reported in Sierra Leone, where Gram-negative bacteria accounted for most CAUTI isolates and were associated with increasing antimicrobial resistance among hospitalized patients [19]. These discrepancies may be explained by regional differences in bacterial ecology, antimicrobial prescribing practices, healthcare infrastructure, and infection control measures. The present study demonstrated that bacterial contamination was more frequent in urine specimens obtained from catheter collection bags than from catheter tubing. This observation may be related to prolonged urine stagnation within drainage bags, which promotes bacterial multiplication and biofilm development. Inadequate catheter handling and prolonged use of drainage systems may further increase the likelihood of contamination. Comparable findings have been reported previously, emphasizing the importance of maintaining closed urinary drainage systems and adhering to strict catheter care protocols to minimize infection risk [15]. A clear association was also observed between prolonged catheterization and bacterial growth. Patients with longer catheterization periods exhibited higher infection rates than those catheterized for shorter durations. This finding is consistent with previous studies demonstrating that the duration of catheterization is one of the strongest predictors of CAUTI because prolonged catheter use enhances bacterial adherence, biofilm maturation, and persistent colonization of catheter surfaces [13,16,19]. Antimicrobial susceptibility testing revealed high resistance rates to fluoroquinolones, including norfloxacin (75%), ciprofloxacin (68.1%), and levofloxacin (66%). These findings indicate a concerning level of antimicrobial resistance among catheter-associated pathogens and are consistent with reports from Sudan and other countries, where increasing resistance to commonly prescribed antibiotics has significantly limited empirical treatment options [18–20]. The widespread empirical use of fluoroquinolones, self-medication, incomplete treatment courses, and inadequate antimicrobial stewardship programs may contribute substantially to the emergence of resistant bacterial strains. Furthermore, bacterial growth was detected in a considerable proportion of patients with a history of antibiotic use, suggesting that previous antimicrobial exposure may have selected resistant organisms capable of surviving conventional therapy. Similar observations have been reported in hospitalized patients in Sudan, where urinary pathogens demonstrated high levels of resistance to several commonly prescribed antimicrobial agents, highlighting the urgent need for continuous surveillance and evidence-based antimicrobial prescribing practices [18]. Overall, the findings of this study emphasize the substantial burden of catheter-associated urinary tract infections among hospitalized patients in Sudan and highlight the urgent need for improved infection

prevention strategies. Strict adherence to aseptic catheter insertion techniques, early catheter removal whenever clinically appropriate, implementation of antimicrobial stewardship programs, and continuous microbiological surveillance are essential to reduce the incidence of CAUTIs and limit the spread of antimicrobial resistance. Future multicenter studies involving larger sample sizes and molecular characterization of resistance genes and biofilm-associated virulence factors are recommended to provide a more comprehensive understanding of CAUTIs in Sudan.

Limitations

This study had several limitations. The sample size was relatively small and limited to hospitals in Shendi town, which may affect the generalizability of the findings to other regions of Sudan. Bacterial identification was based only on conventional culture and biochemical methods without molecular confirmation techniques. In addition, the study focused only on bacterial pathogens and did not investigate fungal infections. Antibiotic susceptibility testing was limited to three fluoroquinolone antibiotics, while other antimicrobial agents were not evaluated. Furthermore, the cross-sectional study design limited the ability to establish causal relationships between risk factors and catheter-associated infections.

Conclusion

This study highlights the considerable burden of CAUTIs among hospitalized patients in Shendi Town and demonstrates alarming resistance to commonly prescribed fluoroquinolones. Continuous surveillance, antimicrobial stewardship, and adherence to infection prevention protocols are essential to reduce CAUTI incidence and combat antimicrobial resistance.

Recommendations

Proper aseptic techniques should be followed during catheter insertion and maintenance to reduce infection risk. Urinary catheters should only be used when necessary and removed as early as possible. Regular culture and antibiotic susceptibility testing are recommended for early diagnosis and appropriate treatment. Antibiotics should be prescribed according to sensitivity results to minimize antimicrobial resistance. Continuous training of healthcare workers on infection control and catheter care is also recommended. Further studies with larger sample sizes and molecular techniques are needed to better understand catheter-associated infections in Sudan.

Declarations

Consent

The patient's written consent has been collected

Ethical Approval

Ethical approval was obtained from the Faculty of Medical Laboratory Sciences, Shendi University. Informed consent was obtained from all study participants before sample collection. Patient confidentiality and privacy were maintained throughout the study period.

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Competing Interests

Authors have declared that no competing interests exist.

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