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ORIGINAL ARTICLE

Pathogens Distribution and Risk Factors of Catheter-Associated Urinary Tract Infections in ICU Patients (A Cross-Sectional Study)

Ola A. Mohamed[1]. Ahmed Sadek[2], Mohamed A. Hassany[3], Amal H. Ali[1]

[1]Department of Medical Microbiology and Immunology, Faculty of Medicine, Aswan University
[2]Department of Medical Microbiology and Immunology, Faculty of Medicine, Assuit University
[3]Department of Internal Medicine, Faculty of Medicine, Aswan University

ABSTRACT

Keyword: Catheter-associated urinary tract infections, ICU, Klebsiella, Nosocomial infections, Uropathogens

*** Corresponding author:** Ola A. Mohamed
Mobile: 01144480087
E-mail: Drolaa.mohamed@gmail.com

Background and Objectives: Catheter-associated urinary tract infections (CAUTIs) represent the most frequent nosocomial infections, accounting for 80% of all UTIs in healthcare settings. Common causative pathogens include *Klebsiella spp., Escherichia coli, Staphylococcus aureus, Enterococcus spp., and Pseudomonas aeruginosa*. This study aims to identify uropathogens associated with CAUTIs in ICU patients at Aswan University Hospital to guide empirical therapy and enhance infection prevention strategies. **Methodology:** A total of 200 patients with indwelling Foley catheters in the ICU at Aswan University Hospital were enrolled between June 2023 and June 2024. Urine samples were collected 48 hours post-catheterization, processed under sterile conditions, and cultured using standard microbiological techniques. **Results:** *Klebsiella pneumoniae* was the most frequently isolated pathogen (39%), followed by *E. coli* (33%), *Staphylococcus aureus* (13%), *Coagulase-negative staphylococci* (3%), *Enterococcus spp.* (4%), *Serratia spp.* (2%), and *Pseudomonas aeruginosa* (1%). CAUTIs were more prevalent among females and patients aged 30-39 and 60-69 years. **Conclusion:** CAUTIs remain a significant source of morbidity and healthcare costs. *Klebsiella pneumoniae and E. coli* are the leading pathogens. Effective CAUTI prevention requires catheter management strategies, reducing catheter duration, and enhancing infection control practices.

INTRODUCTION

The Centers for Disease Control and Prevention (CDC) defines CAUTI as a urinary tract infection that occurs in a patient with an indwelling urinary catheter in place for more than two calendar days on the date of the event, with day of catheter placement being Day 1, and was either present on the day of or the day before removal of the catheter. CAUTI is typically confirmed through urine culture results showing significant microbial growth, often defined as ≥10^5 CFU/ml of urine with no more than two species of microorganisms. Symptoms such as fever, suprapubic tenderness, or costovertebral angle pain may be present but are not always required for diagnosis in asymptomatic bacteriuria cases. (1)

CAUTIs are among the most common healthcare-associated infections, particularly in intensive

care unit (ICU) settings where the use of indwelling urinary catheters is often necessary for critically ill patients. [2] CAUTIs contribute significantly to patient morbidity and mortality, increased hospital stays, and heightened healthcare costs. [3] The presence of a catheter disrupts the natural defense mechanisms of the urinary tract, creating a direct route for pathogens to enter the bladder and establish infection. [4]

Pathogens responsible for CAUTIs in ICU patients often differ in prevalence, resistance profiles, and virulence from those found in other hospital wards, largely due to the unique pressures and conditions within ICUs. [5] Critically ill patients frequently undergo multiple invasive procedures and are exposed to broad-spectrum antibiotics, factors that contribute to the selection of multidrug-resistant organisms (MDROs). [6] These pathogens include, but are not limited to, Gram-negative bacteria such as *Escherichia coli*, *klebsiella spp*. and *Pseudomonas aeruginosa*, as well as Gram-positive organisms like *Enterococcus spp.* and *Staphylococcus aureus*. [7]

The understanding of microbial profiles and resistance patterns of pathogens responsible for CAUTIs in ICU settings is essential for effective prevention, timely diagnosis, and targeted antimicrobial therapy. This paper reviews the prevalent pathogens associated with CAUTIs in ICU patients and the risk factors contributing to infection in this vulnerable population. [8]

Despite the global burden of CAUTI, limited data exist on pathogen profiles in critically ill ICU patients in Egypt. This study seeks to address this gap by identifying predominant uropathogens and risk factors of CAUTI at Aswan University Hospital.

PATIENTS AND METHODS

Study design

A descriptive cross-sectional study conducted in ICUs at Aswan University Hospital, including both medical and surgical ICUs. The study spanned one year From June 2023 to June 2024 and involved 200 patients selected based on calculations from the EpiInfo software.

ICU-admitted patients included from both medical and surgical units who are catheterized, irrespective of gender. Eligible patients must be between the ages of 18 and 70 and meet the criteria for CAUTI.

The excluded patients in this study who are not catheterized, those younger than 18 or older than 70, pregnant women, and patients undergoing chemotherapy.

Additionally, patients with a history of sexually transmitted diseases. If more than two types of organisms are grown from a clinical sample, the sample will be considered contaminated, and such cases will also be excluded from the study.

Methods:

Demographic information such as name, age, sex, underlying clinical condition, date of admission to the ICU, and any history of previous antibiotic intake were recorded.

Sterile urethral indwelling catheters were aseptically placed to patients by qualified physicians in accordance with hospital rules or standard operating procedures, thereby reducing the danger of introducing bacteria to the bladder.

Samples for urine were taken depending on the clinical suspicion of the patients admitted to ICU for more than 48 hours. A freshly voided clean catch midstream urine sample (10–20 mL) was collected with a wide-mouth sterile container with a screw cap before catheter insertion. In patients with short-term (<7 days) catheterization, urine specimens were obtained by sampling through the catheter port using aseptic technique (disinfecting with 70% alcohol) or, if a port was not present, by puncturing the catheter tubing with a needle and syringe after clamping (catheter urine was taken in this case because the risk of contamination is low). In patients with long-term (> 7 days) indwelling catheters, urine samples were collected after the catheter was replaced with a freshly placed catheter.

The urine sample was promptly brought to the microbiology section for culture and wet-mount testing. Urine was cultivated on Cysteine Lactose Electrolyte Deficient (CLED) agar, blood agar and MacConkey agar using a 0.001 ml calibrated wire loop and incubated at 37 °C for 24 hours. An uncentrifuged urine sample was examined using wet mount and Gram staining techniques.

In this study, the identification of uropathogens was carried out using a combination of biochemical tests to differentiate bacterial species based on their metabolic characteristics. Following initial culture, suspected colonies were subjected to a series of standard biochemical reactions for confirmation.

Gram-Negative Bacteria: *E. coli, Klebsiella spp., Proteus spp., and Pseudomonas aeruginosa* were identified using Indole, Methyl red, Voges Proskauer, Citrate, Triple Sugar Iron, Urease, Oxidase, and Motility tests based on their metabolic characteristics. Gram-Positive Bacteria: *Staphylococcus spp., Streptococcus spp., and Enterococcus spp.* were differentiated using Catalase, Coagulase, Bile Esculin, and Mannitol fermentation tests.

The identification of all isolated pathogenic organisms was performed using routine microbiological methods, including Gram staining, culture, and biochemical reactions. When further confirmation was required, an automated identification system, such as VITEK-2(BioMérieux), was employed. Additionally, API-20E (BioMérieux), a manual biochemical identification system, was used for the identification of specific bacterial isolates.

Data Management and Analysis:

Data were analyzed using SPSS v28. Descriptive statistics (percentage) and inferential tests (p-values) determined significance ($p<0.05$).

RESULTS

Our study on 200 catheterized patients identified female gender, hypertension, and diabetes mellitus as key risk factors for catheter-associated urinary tract infections (CAUTI). The culture positivity rate was slightly higher in females (55%) and more frequent in patients over 60 years old. Among bacterial isolates, Gram-negative bacteria dominated, with *Klebsiella spp. and E. coli* most prevalent, while *Staphylococcus aureus* led among Gram-positive bacteria. These findings emphasize the importance of risk factor awareness in CAUTI management.

Table 1: Characteristics of patients.

Difference between groups were analyzed using the Chi-square test although no p-values are reported in this table

Characteristics	**Categories**	**Number**	**%**
Length of stay in the ICU	<7 days	105	52.5
	>7 days	95	47.5
Prior antibiotic treatment	Yes	133	66.5
	No	67	33.5
Age groups (years)	20-29	21	10.05
	30-39	50	25.13
	40-49	31	15.58
	50-59	34	17.09
	60-69	64	32.16
Sex	Male	90	44.72
	Female	110	55.28
Site of admission	Surgical ICU	130	65
	Medical ICU	70	35
Comorbidities	Hypertension (HTN)	53	26.5
	Diabetes Mellitus (DM)	34	17
	Chronic Kidney disease (CKD)	20	10
	Benign Prostatic Hyperplasia (BPH)	10	5

Table 2: The prevalence of CAUTI bacteriuria and the causative organisms.

Note: * refer to p value with significant importance (p value < 0.05).

P-values were calculated using the Chi-square test (Fisher's exact test was applied when counts were below 5).

Organism	**Number**	**%**	**P-value**
Klebsiella pneumonia	78	39	0.65
Escherichia coli	66	33	0.02*
Staphylococcus aureus	26	13	0.47
Enterococcus spp.	8	4	0.72
Coagulase-negative Staphylococcus (CoNS)	6	3	0.51
Burkholderia	5	2.5	0.88
Serratia spp.	4	1.5	0.79
Citrobacter freundii	2	1	0.91
Pseudomonas aeruginosa	2	1	0.68
Acinetobacter baumanni	2	1	0.56
Streptococcus agalactiae	1	0.5	0.73

Table 3: Organisms distribution by patients' characteristics.

Note: * refer to p value with significant importance (p value < 0.05).

P-values were calculated using the Chi square test (Fisher's exact test was applied when counts were below 5).

HTN: Hypertension, DM: Diabetes mellitus, CKD: Chronic kidney disease

Organism	**Age Group (n/%) (p-value)**	**Sex (n/%) (p-value)**	**Top Comorbidities (n/%) (p-value)**	**Total Cases (n)**
Klebsiella pneumonia	**20-39:**12 (15%) (p=0.04) *	**Male:**32 (41%) (p=0.17)	**HTN:**30 (38%) (p= 0.03) *	**78**
	40-59:40 (51%) (p=0.03) *	**Female:**46 (59%) (p=0.21)	**DM:**28 (36%) (p= 0.04) *	
	60-69:26 (34%) (p=0.06)		**CKD:** 10 (13%) (p= 0.08)	
E. Coli	**20-39:**9 (14%) (p=0.02) *	**Male:**25 (38%) (p=0.12)	**HTN:**35 (53%) (p= 0.02) *	**66**
	40-59:33 (50%) (p=0.02) *	**Female:** 41 (62%) (p=0.02) *	**DM:**20 (30%) (p= 0.05) *	
	60-69:24 (36%) (p=0.05) *		**CKD:**11 (17%) (p= 0.06)	
Staphylococcus aureus	**20-39:**7 (27%) (p=0.15)	**Male:**10 (38%) (p=0.10)	**HTN:**12 (46%) (p= 0.07)	**26**
	40-59:12 (46%) (p=0.10)	**Female:**16 (62%) (p=0.30)	**DM:**6 (23%) (p= 0.09)	
	60-69:7 (27%) (p=0.12)		**CKD:**3 (12%) (p= 0.12)	
Enterococcus spp.	**20-39:**1 (50%) (p=0.45)	**Male:**1 (50%) (p=1.00)	**HTN:**1 (50%) (p= 0.15)	**2**
	40-59:1 (50%) (p=0.50)	**Female:**1 (50%) (p=1.00)	**DM:**1 (50%) (p= 0.18)	
	60-69:0 (0%) (p=0.20)		**CKD:**0 (0%) (p= 0.20)	
Pseudomonas aeruginosa	**20-39:**1 (50%) (p=0.50)	**Male:** 2 (100%) (p=0.05) *	**HTN:**1 (50%) (p= 0.22)	**2**
	40-59:1 (50%) (p=0.55)	**Female:**0 (0%) (p=0.20)		
	60-69:0 (0%) (p=0.30)			

DISCUSSION

Urinary tract infections (UTIs) are the most common nosocomial infections, accounting for approximately 35% of all hospital-acquired infections (HAIs). These infections are predominantly linked to the use of equipment for urinary drainage, with urethral catheterization responsible for about 80% of nosocomial UTIs in hospital settings. In cases where catheterization is essential, the

risk of UTI increases with the duration of catheter placement, rising between 3% and 7% daily. A study of 200 patients, confirming that prolonged catheter use significantly elevates infection rates, underscoring the need for limiting catheter use and removing catheters as soon as possible. [(9)]

The statistical analysis of patient characteristics revealed key associations related to ICU admissions. Among the 200 patients, 52.5% (105 patients) had an ICU stay of less than 7 days, while 47.5% (95 patients) stayed 7 days or more. The nearly even distribution suggests that prolonged ICU admission is common, potentially due to severe infections, complications, or

underlying health conditions. Patients with extended ICU stays may have increased exposure to nosocomial pathogens, prolonged antibiotic use, and higher risks of multidrug-resistant infections.

According to **Lee et al.** [10] age group distribution showed the largest proportion of patients belonged to the 60–69 age group (32.16%), followed by 30–39 years (25.13%) and 40–49 years (15.58%). The presence of a substantial number of middle-aged and older adults suggests that age-related immune decline, comorbidities, and hospitalization risks may contribute to ICU admissions. Conversely, younger patients (20–29 years: 10.05%) were the least represented, potentially reflecting their better baseline health status and lower susceptibility to severe infections.

Also **Mohamed et al.** [11] discovered the role of prior antibiotic treatment. A significant majority, 66.5% (133 patients), had received prior antibiotic treatment, whereas 33.5% (67 patients) had not. This highlights the widespread use of antibiotics, possibly for empirical therapy or prior infections. The high proportion of antibiotic-exposed patients raises concerns about antimicrobial resistance, which can complicate treatment outcomes and increase ICU length of stay.

Our findings were also consistent with **Modra et al.*'s*** study [12], Sex-based analysis indicated there was a female predominance (55.28%) compared to males (44.72%), suggesting that women were slightly more likely to be admitted to the ICU in this cohort. This could be attributed to higher rates of urinary tract infections (UTIs), sepsis, and chronic conditions such as diabetes and hypertension in females, which may predispose them to critical illness requiring intensive care.

In terms of ICU type, the majority of patients (65% or 130 patients) were admitted to the Surgical ICU, while 35% (70 patients) were in the Medical ICU. The high proportion of surgical ICU admissions may be due to postoperative infections, complications, and the need for intensive monitoring following major surgical procedures. Medical ICU admissions likely include patients with severe infections, respiratory failure, and chronic disease exacerbations requiring intensive medical management. In contrast, **khanna et al.** [13] A retrospective analysis of unplanned ICU admissions highlighted that medical patients were the majority.

Among comorbidities, the most common comorbidity among ICU patients was hypertension (HTN) (26.5%), followed by diabetes mellitus (DM) (17%), chronic kidney disease (CKD) (10%), and benign prostatic hyperplasia (BPH) (5%). The predominance of hypertension and diabetes underscores their role as major risk factors for severe infections, organ dysfunction, and ICU admission. Chronic kidney disease further contributes to immune suppression and increased susceptibility to sepsis, while BPH, though less prevalent, may be linked to urinary retention and recurrent infections in elderly male patients. [14]

The distribution of bacterial isolates revealed that *Klebsiella pneumoniae* (39.0%) and *E. coli* (33.0%) were the most prevalent pathogens, indicating a high burden of urinary tract and nosocomial infections, whereas the **Venkataraman et al.*'s*** study [15] reported a higher prevalence of *E. coli* (35.7%) and a lower incidence of *Klebsiella species* (28.6%). *Staphylococcus aureus* (13.0%) and *Enterococcus spp.* (4.0%) represent common Gram-positive isolates, while less frequent pathogens, including *Pseudomonas aeruginosa* and *Acinetobacter baumannii* (1.0% each), highlight the presence of opportunistic and multidrug-resistant infections.

E. coli showed a statistically significant difference between groups (p = 0.02), suggesting a meaningful variation in its distribution. In contrast, other organisms had non-significant p-values, indicating no notable differences. Further investigation is needed to understand the factors influencing E. coli prevalence. The findings emphasize the need for effective infection control and antimicrobial stewardship to prevent the spread of resistant bacteria in healthcare settings.

According to the most prevalent organisms in table 2, The statistical analysis of bacterial infections across different patient demographics revealed several significant associations ($p < 0.05$) with age, sex, and comorbidities. *Klebsiella pneumoniae* was significantly more prevalent among the 20–39 (p = 0.04) and 40–59 (p = 0.03) age groups, suggesting that younger and middle-aged individuals were more susceptible to this pathogen. Additionally, a strong correlation was observed between *Klebsiella pneumoniae* and hypertension (p = 0.03) as well as diabetes mellitus (p = 0.04), indicating that underlying metabolic and cardiovascular conditions may increase the risk of infection.

Similarly, *E. coli* exhibited a broad age distribution, with significant associations in 20–39 (p = 0.02), 40–59 (p = 0.02), and 60–69 (p = 0.05) age groups. Notably, *E. coli* showed a female predominance (p = 0.02), aligning with its established role as the leading cause of urinary tract infections (UTIs). Furthermore, *E. coli* was significantly linked to hypertension (p = 0.02) and diabetes (p = 0.05), reinforcing the hypothesis that vascular and metabolic disorders contribute to its pathogenesis.

While *Staphylococcus aureus* and *Enterococcus spp*. did not exhibit statistically significant sex- or age-based differences, *Pseudomonas aeruginosa* was found exclusively in males (p = 0.05), suggesting a potential sex-related predisposition. These findings emphasize that age, sex, and preexisting conditions play a critical role in bacterial infection susceptibility, with metabolic and cardiovascular diseases emerging as key risk factors.

The significant associations identified in this study highlight the importance of targeted prevention strategies, early detection, and personalized treatment approaches for high-risk patient populations, particularly those with hypertension, diabetes, and recurrent infections.

CONCLUSION

This study highlights the high prevalence of nosocomial infections, with *Klebsiella pneumoniae* (39.0%) and *E. coli* (33.0%) as the dominant pathogens, particularly affecting older adults and patients with hypertension and diabetes. *E. coli* showed a female predominance (p = 0.02), while *Pseudomonas aeruginosa* was found exclusively in males (p = 0.05). Prolonged ICU stays (47.5% ≥7 days) and prior antibiotic use (66.5%) further increased infection risks, emphasizing the need for strong infection control and antimicrobial stewardship. These findings underscore the importance of early detection, targeted prevention strategies, and personalized treatment to reduce ICU-related infections and improve patient outcomes.

LIMITATIONS

One potential limitation is selection bias, as patients were only selected from one hospital's ICU, which may not represent other ICUs with different protocols. Additionally, ICU patients often have complex comorbidities, which could influence infection rates and microbial susceptibility. Future

studies should consider multicenter data to enhance representativeness and control for varying healthcare practices.

CONFLICT OF INTEREST

The authors report no conflicts of interest. The study was conducted independently, following ethical guidelines to ensure transparency and impartiality. No external funding or personal relationships influenced the research or its outcomes.

Abbreviation list

1. CAUTI – Catheter-associated urinary tract infection
2. CDC – Centers for Disease Control and Prevention
3. CHD – Chronic heart disease
4. CKD – Chronic kidney disease
5. CONS – Coagulase-negative staphylococci
6. HAIs – Hospital-acquired infections
7. ICU – Intensive care unit
8. MDRO – Multi-drug resistant organisms
9. UTI – Urinary tract infection

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