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Original Article

Uropathogens in Catheterized ICU Patients: Frequency, Pattern and Antimicrobial Susceptibility

Aneela Arshad[1], Muna Malik[1], Khadija Aftab[1], Hassan Raza Heral[2], Fatima Syed[1], Muazam Abbas[1]
[1]Department of Microbiology, King Edward Medical University, [2]Mayo Hospital, Lahore.

Abstract

Background: Catheter-associated urinary tract infections (CAUTIs) are among the leading healthcare-associated infections in intensive care units (ICUs), contributing to prolonged hospitalization, antimicrobial resistance, and increased mortality. Locally relevant data from Pakistani ICUs on uropathogen profiles and resistance patterns are limited.
Objective: To determine the frequency, microbiological profile, and antimicrobial susceptibility of uropathogens causing CAUTI in catheterized ICU patients at a tertiary care hospital in Lahore, Pakistan.
Methods: A cross-sectional study was conducted from December 2024 to April 2025 in the Medical ICU of Mayo Hospital, Lahore. Urine samples from 70 eligible patients were cultured on CLED, Blood, and MacConkey agars, followed by Gram staining and biochemical identification. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method according to CLSI 2024 guidelines. Phenotypic extended-spectrum beta-lactamase (ESBL) and carbapenemase detection were performed. Data were analysed using SPSS version 26.0.
Results: Eighteen of 70 patients (25.7%) had culture-confirmed CAUTI. Predominant isolates were *Candida albicans* (33.3%), *Klebsiella pneumoniae* (27.8%), *Escherichia coli* (16.7%), *Acinetobacter* spp. (16.7%), and *Staphylococcus aureus* (5.5%). ESBL was confirmed in 60% *K. pneumoniae* and 66.7% *E. coli* isolates. All three *Acinetobacter* isolates were carbapenem-resistant. Prolonged catheterization was significantly associated with CAUTI (p =0.003), while female sex and diabetes mellitus also showed notable associations.
Conclusion: The CAUTI affected approximately one in four catheterized ICU patients and was predominantly caused by multidrug-resistant organisms, including ESBL-producing Klebsiella pneumoniae and Escherichia coli and carbapenem-resistant Acinetobacter species, together with a notable proportion of Candida albicans.
Key words: Catheter-related infections, urinary tract infections, drug resistance, multiple, bacterial, intensive care units.

Introduction

Catheter-associated urinary tract infections remain a persistent and largely preventable problem in hospital care. They account for 70-80% of all nosocomial urinary tract infections and roughly a third of total healthcare-associated infections globally.[1,2] Each catheter-day carries an estimated 3-7% incremental bacteriuria risk,[3] and in an ICU where catheterization is near-universal and patients are immunocompromised, this daily risk accumulates and translates into a high overall infection burden.

This burden is unevenly distributed across healthcare systems, falling most heavily on resource-limited settings, where catheter-care resources and infection-control staffing are more constrained than in high-income settings. ICU CAUTI rates in low- and middle-income countries are two to three times higher than in high-income settings,[4] where prevention bundles, closed drainage systems, and nurse-led catheter care are more consistently applied. Within Pakistan,

Corresponding Author:
Khadija Aftab
Department of Microbiology
King Edward Medical University, Karachi.
Email: kaftab18@gmail.com
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MM conceptualized the project. AA did the data collection. HRH & MA performed the statistical analysis. AA & KF did the literature search. Drafting, revision & writing of manuscript were done by AA, MM, KF, HRH & FS.

catheter-related infection data are gradually emerging. Studies from Karachi and Punjab have documented positive culture rates of 23.5-28.5% in catheterized patients.[5,6] Yet ICU-specific CAUTI data from Lahore, home to some of Punjab's largest tertiary hospitals, are still limited, and dedicated ICU antibiograms from the city remain few.

The therapeutic dimension of CAUTI is increasingly complicated by rising antimicrobial resistance. ESBL-producing *Klebsiella pneumoniae* and *Escherichia coli* have been found at rates of 57–70% in Pakistani clinical isolates,[6,7] while carbapenem-resistant *Acinetobacter baumannii* is emerging as a near-untreatable ICU pathogen.[8] Concurrently, *Candida* species driven by broad-spectrum antibiotic use are responsible for a growing proportion of catheter-related infections that require species-level identification before appropriate antifungal therapy can be selected.[9]

Without a current, locally derived antibiogram, clinicians at tertiary care ICUs are left prescribing on the basis of outdated or non-representative data a practice that risks treatment failure and accelerates resistance selection. This study was therefore undertaken to characterize the prevalence, microbiological spectrum, and antimicrobial resistance profile of CAUTI among catheterized ICU patients at Mayo Hospital, Lahore, and to identify clinically actionable patient-level risk factors. The data are intended to directly inform empirical prescribing decisions and institutional infection control policy.

Methods

This cross-sectional study was conducted from December 2024 to April 2025 in the Department of Pathology, King Edward Medical University (KEMU), Lahore, in collaboration with the Medical ICU of Mayo Hospital, Lahore. The study conducted in adherence with the Declaration of Helsinki (revised 2013). Written informed consent was obtained from patients or their authorized representatives.

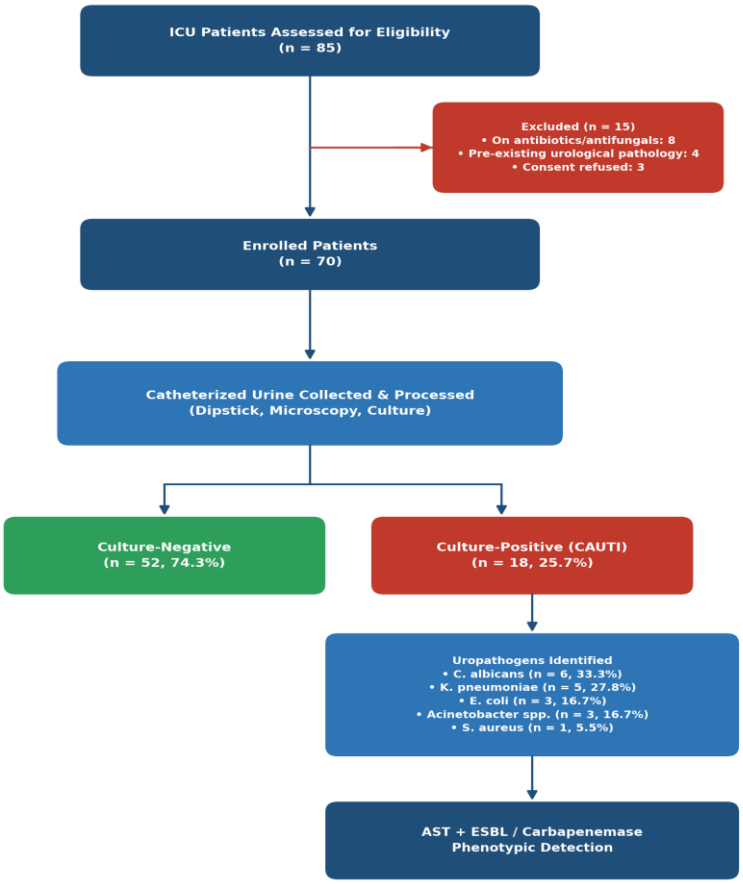

Figure 1: Screening, exclusion, enrolment, and microbiological outcomes.

Sample size and sampling. Using OpenEpi (95% CI; 8% absolute precision; expected CAUTI prevalence 23.5%[21]), An 8% absolute precision was selected to keep the required sample within the achievable ICU recruitment window over the five-month study period while retaining acceptable estimate stability; 67 patients were required. In total, 85 catheterized patients were screened, of whom 15 were excluded on the criteria below, leaving 70 patients enrolled by consecutive non-probability sampling. Inclusion: adults ≥18 years, indwelling urethral catheter in situ for ≥48 hours. Exclusion: patients receiving antibiotic/antifungal therapy at sampling, pre-existing urological malignancy or structural anomaly, or inability to consent. As all infections were detected more than 48 hours after catheter insertion in admitted ICU patients, culture-confirmed cases were regarded as catheter-associated healthcare-associated infections (HAIs). A patient flow diagram is presented in Figure-1.

Specimen collection and processing. Ten millilitres of urine was aseptically aspirated from the catheter sampling port into boric acid-preserved containers and delivered to the laboratory within one hour. Dipstick urinalysis (Combi-10, Roche) and wet-mount microscopy (×400; pyuria ≥10 WBC/HPF) were performed. Urine was cultured on CLED, 5% Blood, and MacConkey agars using the calibrated loop technique. Plates were incubated at 35-37°C for 24-48 hours. Growth of ≥10^5 CFU/mL from a pure or predominant organism was considered significant.

Organism identification and susceptibility. Bacteria were identified by Gram staining and biochemical tests (TSI, urease, citrate, SIM, oxidase, coagulase). *Candida albicans* was confirmed by germ-tube test. Antibiotic susceptibility was determined by Kirby-Bauer disk diffusion on Mueller-Hinton agar (Oxoid), classified as susceptible, intermediate, or resistant (S/I/R) per CLSI M100-ED34 (2024). To meet CLSI zone-spacing requirements, antibiotic discs were distributed across more than one Mueller-Hinton plate per isolate rather than crowded onto a single plate. ESBL production was detected by combined disk synergy test (≥5 mm zone enhancement with clavulanate); carbapenemase production was screened by Modified Hodge Test and confirmed by Carba NP test. Data were analysed using SPSS version 26.0. Categorical associations were tested using the chi-square test, with Fisher's exact test applied wherever an expected cell count was below 5, as occurred in several small subgroups; a *p*-value below 0.05 was taken as significant.

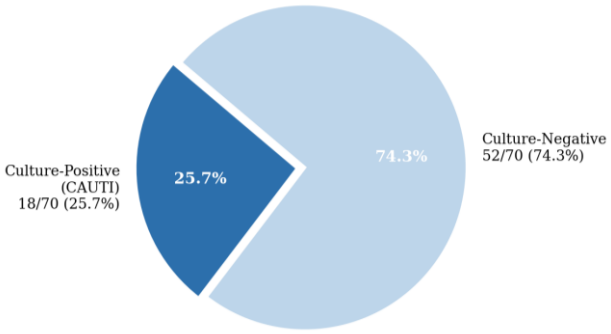

Figure 2: Culture findings among catheterized ICU patients.

Results

Of the 70 enrolled patients, 18 (25.7%) had culture-confirmed CAUTI and 52 (74.3%) were culture-negative (Figure-2). Mean catheterization duration was 11.4 days in CAUTI-positive patients versus 6.3 days in negatives (p =0.003). Female patients comprised 11 of 18 (61.1%) CAUTI-positive cases. Diabetes mellitus was present in 8 of 18 (44.4%) and prior antibiotic exposure in 12 of 18 (66.7%) confirmed CAUTI cases.

The microbiological distribution is shown in Table-1. *Candida albicans* was the most common isolate (6 of 18; 33.3%), followed by *K. pneumoniae* (5 of 18; 27.8%), *E. coli* and *Acinetobacter* spp. (each 3 of 18; 16.7%), and *S. aureus* (1 of 18; 5.5%).

Near-universal cephalosporin and fluoroquinolone resistance was observed in all Gram-negative isolates. Meropenem retained activity against *K. pneumoniae* (susceptible) and

Table: Microbiological profile of CAUTI-positive isolates from catheterized ICU patients.

Microorganism	*n*	*% Positive*	*Gram Stain*	*Identifying Features*
Candida albicans	6	33.3%	—	Yeast; germ-tube positive; cream budding colonies on CLED
Klebsiella pneumoniae	5	27.8%	Gram –ve	Encapsulated rod; mucoid colonies; TSI A/A + gas; urease positive
Escherichia coli	3	16.7%	Gram –ve	Non-capsulated rod; lactose fermenter; indole positive; IMViC ++−−
Acinetobacter spp.	3	16.7%	Gram –ve	Coccobacillus; non-fermenter; oxidase negative; non-motile
Staphylococcus aureus	1	5.5%	Gram +ve	Cocci in clusters; coagulase positive; beta-haemolytic on Blood agar
Total	18	25.7%	—	—

isolates were fully carbapenem-resistant. ESBL was phenotypically confirmed in 60% of *K. pneumoniae* and 66.7% of *E. coli*. *S. aureus* was susceptible to nitrofurantoin, gentamicin, and meropenem, showed intermediate susceptibility to the fluoroquinolones and amoxicillin-clavulanate, and was resistant to all cephalosporins tested and to trimethoprim-sulfamethoxazole. Prolonged catheterization was significantly associated with CAUTI (p =0.003), while female sex and diabetes mellitus also showed notable associations.

Discussion

A CAUTI frequency of 25.7% in this study is consistent with rates documented in comparable South Asian and African ICU settings. Ali et al. reported 28.5% in Karachi[5] and Bizuayehu et al. found 34.1% in an Ethiopian ICU[2] while a pooled South-East Asian review confirmed 25% across 50,000 patients.[10] The lower rates seen in the United States (12.9%) and Europe (19.6%)[4] are generally attributed to more consistent catheter-care protocols, higher nurse-to-patient ratios, and better-resourced infection-control programmes, which are less uniformly available in Pakistan's public tertiary hospitals.

Catheterization duration was the strongest independent risk factor in this study (11.4 vs 6.3 days; p = 0.003). Asmare et al. quantified a 10.6-fold higher CAUTI risk when catheterization lasted ≥8 days,[1] consistent with the known biology of catheter biofilm: beyond five days, mature biofilm communities resist neutrophilic clearance and standard antibiotic concentrations.[11] Female sex, diabetes mellitus, and prior antibiotic exposure were additional consistent risk factors,[2,12,13] pointing to both anatomical vulnerability and impaired host defence as compounding determinants.

Candida albicans (33.3%) dominated our isolate profile a finding less commonly seen in ward-based surveys but well-established in ICU settings with heavy antibiotic burden.[9,14] Antibiotic-mediated suppression of bacterial commensals, combined with parenteral nutrition and corticosteroid use in critically ill patients, creates conditions that allow *Candida* to ascend and colonize the catheterized urinary tract.[9] Species-level identification remains essential for management decisions, as non-albicans *Candida* species may demonstrate reduced azole susceptibility.[14]

Klebsiella pneumoniae (27.8%) showed 60% ESBL positivity, in keeping with Pakistani multicentre data reporting 57-70% ESBL rates in *K. pneumoniae* clinical isolates.[6,7] Similarly, 66.7% of *E. coli* (16.7% of all isolates) were ESBL-positive, consistent with South Punjab uropathogen data.[7] In this study, meropenem was the only reliably active agent against Enterobacteriaceae, although this observation is based on a small number of isolates and should be interpreted with caution; it nonetheless supports culture-guided rather than empirical carbapenem use to preserve this last-resort drug class.[8,15]

Complete carbapenem resistance in all three *Acinetobacter* isolates (16.7%) is the most clinically alarming result of this study. This aligns with Iranian ICU data reporting >90% carbapenem non-susceptibility in *A. baumannii*[8] and with the WHO's classification of carbapenem-resistant *A. baumannii* as a critical-priority pathogen.[16] With no susceptibility to fluoroquinolones, cephalosporins, or carbapenems in our isolates, colistin or high-dose ampicillin-sulbactam remain the only options both associated with significant nephrotoxicity. This highlights the urgent need for culture-confirmed prescribing in any ICU where this organism is circulating.

A further limitation is that antifungal susceptibility testing for *Candida albicans* was not performed, even though it was the single most frequent isolate; this restricts the clinical applicability of the findings to antibacterial therapy and should be addressed as a priority in future work. Prospective multicentre studies incorporating antifungal testing and molecular diagnostics would better define the national CAUTI epidemiology.

Conclusion

In this study, approximately one in four catheterized ICU patients at Mayo Hospital, Lahore, developed CAUTI. The microbiological profile was dominated by *Candida albicans*, ESBL-producing *Klebsiella pneumoniae* and *Escherichia coli*, and fully carbapenem-resistant *Acinetobacter* species, with near-universal resistance to cephalosporins and fluoroquinolones among Gram-negative isolates and meropenem retaining useful activity against Enterobacteriaceae. Prolonged catheterization was the principal risk factor, while female sex, diabetes mellitus, and prior antibiotic exposure were commonly present. These findings support daily review of catheter necessity, culture-guided prescribing informed by a locally updated antibiogram, structured antimicrobial stewardship, and the addition of antifungal susceptibility testing to routine CAUTI management in Pakistani tertiary ICUs.

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Availability of Data: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval: The Institutional Review Board of King Edward Medical University, Lahore approved the study via letter no. 784/RC/KEMU, dated 20/11/2024.

Conflict of Interest: None declared.

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