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Research Paper

Bacterial etiology and prevalence of catheter-associated urinary tract infections in hospitalized patients: A five-year study in Rasht, Iran

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ABSTRACT

Catheter-associated urinary tract infections (CAUTIs) are among the most prevalent healthcare-associated infections, posing substantial clinical and economic burdens. The increasing incidence of antimicrobial resistance among uropathogens further complicates their management, necessitating region-specific surveillance to inform therapeutic strategies. This study aimed to assess the bacterial etiology and antibiotic resistance patterns of CAUTIs over a five-year period in a tertiary referral hospital in northern Iran. A retrospective cross-sectional analysis was conducted on 158 hospitalized patients diagnosed with CAUTIs from 2018 to 2024 at Razi Educational and Medical Center. Urine samples were processed using standard microbiological techniques, and antimicrobial susceptibility testing was performed via the Clinical and Laboratory Standards Institute (CLSI) recommended disk diffusion method. Demographic, clinical, and microbiological data were analyzed using descriptive statistics. The majority of cases were male (53.3%), with a mean age of 63 ± 14.95 years. *Escherichia coli* was the most frequently isolated pathogen (55.7%), followed by *Klebsiella* spp. (17.7%) and *Citrobacter* spp. (12%). High resistance rates were observed among *Enterobacteriaceae*, particularly against cefixime (80.5%), trimethoprim-sulfamethoxazole (79.5%), and ciprofloxacin (73.9%) for *E. coli*. Nitrofurantoin (18.2%) and amikacin (30.2%) with lowest resistance remained the most effective agents. *E. coli* remains the dominant CAUTI pathogen and exhibits high resistance to commonly prescribed antibiotics, underscoring the urgency of local resistance surveillance. Nitrofurantoin and amikacin shows promise as an effective treatment option. These findings highlight the need for targeted antimicrobial stewardship, infection control practices, and continuous regional monitoring to control resistance trends and optimize patient outcomes.

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1. Introduction

Urinary tract infections (UTIs) remain one of the most prevalent bacterial infections worldwide, posing significant clinical and economic burdens across healthcare settings. Affecting individuals across all age groups and genders, UTIs range from uncomplicated cystitis to severe systemic complications such as urosepsis. Within the spectrum of UTIs, catheter-associated urinary tract infections (CAUTIs) are particularly concerning due to their frequency, complexity, and resistance to treatment. CAUTIs account for the majority of nosocomial UTIs and represent nearly half of all hospital-acquired infections, making them the most common healthcare-associated infections globally [1-3].

Indwelling urinary catheters, widely used for managing urinary retention, monitoring fluid output, and providing care in critically ill patients, are major contributors to the development of CAUTIs. The risk of infection increases proportionally with the duration of catheterization, and infection often results from the migration of uropathogens along the catheter surface, frequently facilitated by biofilm formation. These biofilms not only protect bacteria from host immune responses but also significantly impede the efficacy of antimicrobial therapy, promoting chronic infections and persistent colonization [4-6].

The etiology of CAUTIs is complex and varies by region, healthcare environment, and patient-specific risk factors. Common causative agents include Gram-negative bacteria such as *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*, as well as Gram-positive organisms like *Enterococcus* spp. These pathogens are often associated with multidrug-resistant (MDR) phenotypes, further complicating treatment protocols. Notably, many CAUTIs are now caused by members of the ESKAPE group (*Enterococcus faecium*, *Staphylococcus aureus*, *K. pneumoniae*, *Acinetobacter baumannii*, *P. aeruginosa*, and *Enterobacter* spp.), which are notorious for their resistance to multiple antibiotic classes [6,7].

In recent years, the rise in antimicrobial resistance among uropathogens has become a critical public health issue. Resistance to commonly used antibiotics including fluoroquinolones, cephalosporins, and even carbapenems has been increasingly reported. This alarming trend threatens the effectiveness of empirical therapies and necessitates periodic surveillance of local antimicrobial susceptibility patterns to inform treatment guidelines and antimicrobial stewardship efforts [8,9].

The lack of consistent adherence to catheter care protocols, inadequate staff training, and variation in local pathogen profiles contribute to poor outcomes. Consequently, there is a pressing need for evidence-based regional data on the prevalence, causative organisms, and resistance patterns of CAUTIs. Therefore, this five-year retrospective study was conducted at a referral hospital to assess the bacterial etiology and antimicrobial resistance patterns of CAUTIs. The findings aim to provide up-to-date microbial and resistance profiles, supporting more targeted therapeutic approaches and reinforcing the importance of continuous surveillance and infection control practices in hospital settings.

2. Materials and Methods

2.1 Study design and subject

This retrospective cross-sectional study was conducted on patients diagnosed with CAUTs over five years from 2018 to 2024 at Razi Educational and Medical Center, a general tertiary referral hospital affiliated with Guilan University of Medical Science, located in Rasht, the capital city of Guilan province, northern Iran. According to the Centers for Disease Control and Prevention (CDC) recommendation, CAUTI is defined as a UTI occurring in a patient who had an indwelling urinary catheter in place for more than two calendar days on the date of the event, with the catheter in place on the date of the event or the day before [10]. The demographic and clinical information was collected from medical records for all eligible patients. This study was approved by the Ethics Committee of Guilan University of Medical Sciences and conducted in accordance with the Declaration of Helsinki. Informed consent was waived due to the retrospective design. Patient confidentiality was strictly maintained.

2.2 Microbiological procedures

Urine specimens were collected aseptically from patients with suspected CAUTI, either via catheter port aspiration or midstream clean-catch in cases where the catheter had been removed. Samples were promptly transported to the microbiology laboratory and processed within two hours of collection. Each specimen was inoculated onto blood agar and MacConkey agar plates and incubated aerobically at 35–37°C for 24–48 hours. Significant UTI was defined as the growth of $\geq 10^5$ colony-forming units (CFU)/mL of a single uropathogen. Bacterial identification was performed using standard biochemical tests. Antimicrobial susceptibility testing was conducted using the disk diffusion method on Mueller–Hinton agar, following the guidelines of the Clinical and Laboratory Standards Institute (CLSI) [11]. The tested antibiotics included amikacin (AMK), imipenem (IPM), gentamicin (GEN), ceftriaxone (CEF), ciprofloxacin (CIP), trimethoprim-sulfamethoxazole (SXT), nitrofurantoin (NIT), piperacillin (PIP), tetracycline (TET), cefotaxime (CTX), meropenem (MEN), ampicillin (AMP), doxycycline (DOX), vancomycin (VAN), cefepime (CFP), ceftazidime (CAZ), cefoxitin (FOX), piperacillin-tazobactam (TZP), and penicillin (PEN).

2.3 Statically analysis

The collected data were entered into SPSS™ software, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means ± standard deviations.

3. Results

A total of 158 cases of CAUTI were identified among hospitalized patients over a five-year period. Patient ages ranged from 17 to 92 years, with a mean age of 63 ± 14.95 years and a median age of 66 years. Among the 158 patients, 84 (53.3%) were male. Underlying medical conditions were documented in 66 patients (41.8%), while 92 patients (58.2%) had no reported comorbidities. The average length of hospitalization was 38.64 ± 20.96 days, with a median duration of 11 days. The overall recovery rate was 81.6% (129 cases), whereas the mortality rate was 18.4% (29 cases).

The most frequently isolated pathogen was *E. coli*, accounting for 88 cases (55.7%), followed by *Klebsiella* spp. (28 cases, 17.7%), *Citrobacter spp.* (19 cases, 12.0%), *P. aeruginosa* (8 cases, 5.1%), *Enterococcus* spp. (7 cases, 4.4%), *Acinetobacter* spp. (3 cases, 1.9%), *Enterobacter* spp. (2 cases, 1.3%), *S. aureus* (2 cases, 1.3%), and *Staphylococcus epidermidis* (1 case, 0.6%). The prevalence of each pathogens according to demographic and clinical characteristics presented in Table 1 and 2.

This study analyzed the antibiotic resistance patterns of bacterial agents isolated from CAUTI cases, as detailed in Table 3 and 4. *E. coli* as the most prevalent pathogen exhibited high resistance to several commonly used antibiotics, including cefixime (80.5%), trimethoprim-sulfamethoxazole (79.5%), and ciprofloxacin (73.9%). Over half of the isolates were resistant to gentamicin (51.2%) and imipenem (66.7%). Notably, *E. coli* showed the lowest resistance to nitrofurantoin (18.2%) and amikacin (30.2%). *Klebsiella* species demonstrated 100% resistance to SXT. Very high resistance was also noted for cefotaxime (92.8%) and ciprofloxacin (89.3%). Resistance to imipenem (78.8%) and nitrofurantoin (78.6%) was also significant. Amikacin (63.2%) and gentamicin (64.3%) also showed considerable resistance. Among staphylococci isolates, 66.7% were methicillin-resistant. But mostly were susceptible to gentamicin (66.7%), and SXT (66.7%). *Enterococcus* spp. only showed susceptibility against nitrofurantoin (72%).

Table 1. Prevalence of CAUTI pathogens according to age groups and gender.

Bacterial agents	<66years No. (%)	≥66 years No. (%)	Male No. (%)	Female No. (%)	Total No. (%)
E. coli	46 (59.0)	42 (52.5)	35 (47.3)	53 (63.1)	88 (55.7)
Klebsiella spp.	14 (17.9)	14 (17.5)	13 (17.6)	15 (17.9)	28 (17.7)
Citrobacter spp.	7 (9.0)	12 (15.0)	10 (13.5)	9 (10.7)	19 (12.0)
P. aeruginosa	3 (3.8)	5 (6.3)	6 (8.1)	2 (2.4)	8 (5.1)
Enterococcus spp.	3 (3.8)	4 (5.0)	5 (6.8)	2 (2.4)	7 (4.4)
Acinetobacter spp.	2 (2.6)	1 (1.3)	2 (2.7)	1 (1.2)	3 (1.9)
Enterobacter spp.	0 (0.0)	2 (2.5)	0 (0.0)	2 (2.4)	2 (1.3)
S. aureus	2 (2.6)	0 (0.0)	2 (2.7)	0 (0.0)	2 (1.3)
S. epidermidis	1 (1.3)	0 (0.0)	1 (1.4)	0 (0.0)	1 (0.6)

Table 2. Outcome distribution and clinical associations of pathogens in CAUTI cases

Bacterial agents	Clinical outcome		Hospitalization duration		Underlying disease	
	Recovery No. (%)	Deceased No. (%)	≤11 days No. (%)	>11 days No. (%)	Present No. (%)	Absent No. (%)
E. coli	72 (55.8)	16 (55.2)	52 (61.9)	36 (48.6)	45 (48.9)	43 (65.2)
Klebsiella spp.	22 (17.1)	6 (20.7)	8 (9.5)	20 (27.0)	18 (19.6)	10 (15.2)
Citrobacter spp.	18 (14.0)	1 (3.4)	11 (13.1)	8 (10.8)	15 (16.3)	4 (6.1)
P. aeruginosa	7 (5.4)	1 (3.4)	4 (4.8)	4 (5.4)	4 (4.3)	4 (6.1)
Enterococcus spp.	6 (4.7)	1 (3.4)	5 (6.0)	2 (2.7)	4 (4.3)	3 (4.5)
Acinetobacter spp.	1 (0.8)	2 (6.9)	0 (0.0)	3 (4.1)	2 (2.2)	1 (1.5)
Enterobacter spp.	1 (0.8)	1 (3.4)	1 (1.2)	1 (1.4)	2 (2.2)	0 (0.0)
S. aureus	1 (0.8)	1 (3.4)	2 (2.4)	0 (0.0)	1 (1.1)	1 (1.5)
S. epidermidis	1 (0.8)	0 (0.0)	1 (1.2)	0 (0.0)	1 (1.1)	0 (0.0)

Table 3. Antibiotic resistance patterns of Gram-negative isolated pathogens in CAUTI cases

Bacterial agent	Antibiotic	Susceptibility (%)	Resistance (%)
E. coli	AMK	69.8	30.2
	IPM	33.3	66.7
	GEN	48.8	51.2
	CEF	19.5	80.5
	CIP	26.1	73.9
	SXT	20.5	79.5
	NIT	81.8	18.2

Enterobacter spp.	AMK	50	50
	PIP	0.0	100
	TZP	100	0.0
	GEN	50	50
	CTX	100	0.0
	CIP	0.0	100
	SXT	0.0	100
	MEN	0.0	100
	NIT	50	50
Acinetobacter spp.	AMK	33.3	66.7
	IPM	0.0	100
	PIP	0.0	100
	TET	0.0	100
	CFP	33.3	66.7
	CTX	33.3	66.7
	CIP	0.0	100
	SXT	0.0	100
P. aeruginosa	AMK	12.5	87.5
	IPM	12.5	87.5
	PIP	0.0	100
	CFP	25	75
	CAZ	12.5	87.5
	CIP	25	75
Citrobacter spp.	AMK	21	79
	IPM	15.8	84.2
	GEN	10.5	89.5
	CTX	10.5	89.5
	CIP	21	79
	SXT	5.3	94.7
	NIT	21	79
Klebsiella spp.	AMK	36.8	63.2
	IPM	22.2	78.8
	GEN	35.7	64.3
	CTX	7.2	92.8
	CIP	10.7	89.3
	SXT	0.0	100
	NIT	21.4	78.6

Table 4. Antibiotic resistance patterns of Gram-positive isolated pathogens in CAUTI cases

Bacterial agent	Antibiotic	Susceptibility (%)	Resistance (%)
Staphylococci	PEN	0.0	100
	TET	33.3	66.7
	GEN	66.7	33.3
	DOX	33.3	66.7
	FOX	33.3	66.7
	CIP	0.0	100
	SXT	66.7	33.3
Enterococcus spp.	AMP	0.0	100
	TET	0.0	100
	GEN	0.0	100
	DOX	0.0	100
	CIP	0.0	100
	NIT	72	28

4. Discussion

Despite advances in prevention and clinical management, CAUTIs remain a significant healthcare concern, particularly among hospitalized patients undergoing prolonged catheterization. Effective treatment of CAUTIs depends heavily on early identification of causative organisms and their antibiotic susceptibility profiles. Therefore, understanding local microbial prevalence and resistance patterns is essential for optimizing clinical outcomes and guiding empirical therapy [12].

In our study, members of the Enterobacteriaceae family were the most frequently isolated pathogens in CAUTI cases. Among them, *E. coli* was the predominant species (55.7%), followed by *Klebsiella* spp. (17.7%) and *Citrobacter* spp. (12%). These findings are consistent with those of previous studies that have also reported *E. coli* as the leading causative agent of CAUTIs [13-15]. The predominance of *E. coli* can be attributed to its natural colonization of the gastrointestinal tract and its well-known capacity to ascend through urinary catheters, leading to infection [16]. Although less prevalent in our sample, Gram-negative bacilli such as *P. aeruginosa*, *Acinetobacter* spp., and *Enterobacter* spp. remain clinically significant due to their intrinsic resistance mechanisms and their frequent involvement in nosocomial infections, especially among critically ill or immunocompromised patients [17,18].

Our data reveal an alarming pattern of high antimicrobial resistance, especially among *Enterobacteriaceae* isolates. *E. coli*, the most common pathogen in our study, exhibited high resistance rates to cefixime (80.5%), trimethoprim-sulfamethoxazole (79.5%), and ciprofloxacin (73.9%). In contrast, nitrofurantoin demonstrated the lowest resistance rate (18.2%), suggesting its potential as an effective therapeutic agent for treating CAUTIs caused by *E. coli*. It is important to note that antibiotic resistance patterns can vary significantly depending on local antibiotic prescribing practices, regional strain differences, and variations in study design (e.g., hospital-based versus community-based settings). Nevertheless, our findings are consistent with reports from various regions of Iran and around the world, which also demonstrate high levels of resistance in *E. coli* isolates to cephalosporins, while frequently identifying nitrofurantoin as one of the most effective antibiotics for CAUTIs [14,15,19-22]. The similarity in *E. coli* resistance patterns observed in Iran and other countries likely reflects common antibiotic prescribing practices, the global dissemination of resistance determinants such as extended-spectrum beta-lactamases (ESBLs), and cross-border transmission of resistance strains. The sustained efficiency of nitrofurantoin may be attributed to its limited use and restricted indication in uncomplicated UTIs [23] .

This retrospective study has some notable limitations. It was conducted in a single tertiary care center, which may limit the generalizability of the findings to other institutions with different patient demographics, microbial distributions, or antibiotic stewardship policies. Furthermore, antimicrobial susceptibility testing was limited to a restricted panel of commonly used antibiotics, which may have overlooked resistance patterns to newer or less frequently used agents. These factors underscore the need for future prospective, multi-center studies based on more comprehensive and diverse data.

Given the persistent burden of CAUTI in hospitalized patients, our findings showed *E. coli* as the dominant pathogen, reflecting an endogenous origin from the gastrointestinal tract. Its high distribution and antibiotic resistance, particularly to cephalosporins highlight treatment challenges. Given the limited efficacy of cephalosporins, nitrofurantoin appears to be a more suitable therapeutic option, especially for uncomplicated cases. These findings emphasize the need for local resistance monitoring, updated treatment protocols, and strict infection control measures, including improved perineal hygiene, proper catheter care, and limited catheter use. A paradigm shift toward targeted prevention and rational antibiotic use is urgently needed.

Authors’ contributions

Supervision, conceptualization and methodology: TY, MHC, HS; Data collection, analysis and interpretation: EGH, TY, MHC; Writing draft and editing: FAM, MGJ, SPL, HS. All authors have read and approved the final manuscript.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

The study design was confirmed by the ethical committee of the Guilan University of Medical Sciences, Rasht, Iran [IR.GUMS.REC.1402.303]. Informed consent was waived due to the retrospective nature of the study, as approved by the local ethics committee.

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