ORIGINAL ARTICLE

An Observational Study from Northern India to Evaluate Catheter-associated Urinary Tract Infection in Medical Intensive Care Unit at a Tertiary Care Center

Smriti Parihar[1], Rajni Sharma[2], Sulika V Kinimi[3], Sidhya Choudhary[4]

Received on: 05 May 2023; *Accepted on:* 26 July 2023; *Published on:* 31 August 2023

Abstract

Background: Healthcare-associated infections are the leading cause of morbidity and mortality in hospitalized patients. Catheter-associated urinary tract infection (CAUTI) is a leading infection in ICU settings. This study aims to evaluate the patient and catheter-related factors contributing to the urinary tract infection as well as implementing the preventive measures ultimately curbing down the burden of healthcare-associated infections.

Material and methods: This is a hospital-based observational study conducted in Department of Microbiology, from October 2020 to September 2021. A total of 150 patients admitted to Medical Intensive Care Unit (MICU) with the indwelling urinary catheter were included. Urine samples were collected with proper aseptic precautions and processed within 2 hours of collection. Identification and antimicrobial susceptibility testing of the isolated pathogens was done as per CLSI guidelines 2019.

Results: In this study, the CAUTI rate was 9.4 per 1000 urinary catheter days, while the overall magnitude was 14.67%. It was predominantly reported in 51–70-years age group (34%), and females (63.63%) outnumbered males (36.36%), with *Escherichia coli* being the commonest pathogen. The highest incidence was reported in the 3rd week of catheterization with diabetes being a predominant risk factor (17.24%).

Conclusion: This study provides baseline data on CAUTI rate, pathogens isolated, and risk factors at our institute. The overall goal is to identify, educate, and implement best-practice measures for prevention and curbing down the incidence rates of catheter-associated urinary tract infections.

Keywords: Catheter-associated urinary tract infection, Healthcare-associated infection, Medical intensive care unit, Urinary tract infection.

Indian Journal of Critical Care Medicine (2023): 10.5005/jp-journals-10071-24519

Highlights

- CAUTI rate was 9.4 per 1000 urinary catheter days.
- *Escherichia coli* was the predominant isolated pathogen.
- Duration of catheterization was the major risk factor causing CAUTI.
- Proper training of healthcare personnel and cautious use of antibiotics may reduce the incidence of infections in critical care settings.

Introduction

Healthcare-associated infections are an important cause of prolonged hospital stay, around the globe.[1,2] Urinary tract infections (UTIs) are considered as one of the most common healthcare-associated infections (HCAIs) with an estimated prevalence of 1–10%, accounting for 30–40% of all HCAIs reported by hospital settings.[3] Majority of infections of urinary tract are directly linked to the widespread use of indwelling catheters in these settings.[4,5]

The Center for Disease Control and Prevention (CDC) provides a definition for CAUTI, which pertains to patients who have a catheter inserted and left in place for 48 hours or longer.[6] Catheter-associated urinary tract infection has been a significant factor contributing to illness and death among hospitalized patients.[7,8]

The source of infection is either endogenous, i.e., via meatal, rectal, and vaginal colonization, or exogenous, i.e., via the contaminated equipment or hands of the healthcare personnel. The route of infection can be intraluminal (from the catheter drainage tube junction) or extraluminal (contaminated collection bag).[9]

The risk factors include female gender, extremes of age, diabetes mellitus, and prolonged catheterization duration.[10] The duration of catheterization is the most important factor in the development of bacteriuria, as its daily usage increases the risk of infection by 3–7%.[4]

An indwelling catheter interrupts the normal mechanical washout effect of the urinary stream, making patients more susceptible

[1,4]Department of Microbiology, Government Medical College, Kota, Rajasthan, India

[2]Department of Microbiology, SMS Medical College, Jaipur, Rajasthan, India

[3]Department of Microbiology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

Corresponding Author: Sidhya Choudhary, Department of Microbiology, Government Medical College, Kota, Rajasthan, India, Phone: +91 9475582944, e-mail: sidhyach@gmail.com

How to cite this article: Parihar S, Sharma R, Kinimi SV, Choudhary S. An Observational Study from Northern India to Evaluate Catheter-associated Urinary Tract Infection in Medical Intensive Care Unit at a Tertiary Care Center. Indian J Crit Care Med 2023;27(9):642–646.

Source of support: Nil

Conflict of interest: None

to symptomatic infections. This, in turn, can result in the infection ascending from the bladder to the ureter and kidney, ultimately requiring the use of antimicrobial medications.[11]

It can be prevented by maintaining closed urinary drainage system and early removal of catheter. Surveillance, proper training of healthcare personnel, and implementation of bundle care approach aids in reduction of cases in ICU settings.[12]

Urinary tract is a vast reservoir of resistant microorganisms with threat of cross infection.[13] *Escherichia coli, Klebsiella* species, *Proteus* species, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, Coagulase-negative *Staphylococcus*, and *Enterococcus* species are the important culprits. It can cause genitourinary complications, septicemia, skeletal involvement, and over the years, bladder cancer[14] that causes distress to the patient, prolonged hospital stay, economic loss, and mortality.

The study is planned to determine the proportion, risk factors, as well as the etiological agents associated with catheter-associated UTI and their antibiotic susceptibility profile. This will aid in improvising hospital infection control, institutional antibiotic policies, and minimizing the burden of hospital-acquired infections.

Materials and Methods

Study Population and Design

The current research is a hospital-based prospective observational study carried out at the Department of Microbiology. The study was based on an 18-bedded Medical Intensive Care Unit (ICU) and took place from October 2020 to September 2021.

Sample Size

A total of 150 patients satisfying the inclusion and exclusion criteria, admitted to the medical ICU requiring urinary catheter (Foley's catheter), were surveyed during this period and were followed up from admission until the outcome (discharge/death).

Ethical Clearance

The study protocol was proceeded after the approval of the Institutional Ethical Clearance Committee and Research Review Board (82/MC/EC/2020).

Inclusion Criteria

- Patient having at least one of the following signs or symptoms:
  - Fever (>38.0°C).
  - Suprapubic tenderness.
  - Costovertebral angle pain or tenderness.
- Patient having an indwelling urinary catheter that was in place for >2 days on the date of event.
- Patient having a urine culture with no more than two species of organisms identified, at least one of which is a bacteria of ≥10^5 CFU/mL.

Exclusion Criteria

- Mixed flora (>2 species of microorganisms).
- *Candida* species or yeast not otherwise specified.
- Mold and dimorphic fungi.

Collection of Data

The cases fulfilling the inclusion criteria were identified for surveillance. The required data were collected as per the standardized HAI case report form for each case daily at the same time, which included:

Table 1: Distribution of isolates among catheterized patients ($n = 150$)

Isolates	*No. of catheterized patients*
CAUTI	22 (14.67%)
Sterile	114 (76%)
Candida	14 (9.3%)
Total	150

- Numerator data (patient demographic, clinical, urinary catheter, and diagnosis of a CAUTI event).
- Denominator data (the daily number of patients with urinary catheter).
- Urinary catheter-related information (site, duration of insertion, disconnection of catheter, and use of any antimicrobials) was collected from the patient's record file and analyzed.
- Event time frame – It is a 14-day period (considering date of event = day 1) when UTI is considered to be ongoing. Organisms identified during the event time frame are added to the case report form of the initial UTI. No new UTIs can be reported for the patient during these 14 days.

Specimen Processing

The uncentrifuged urine samples were semiquantitatively cultured with standard nichrome loop of diameter 1.3 mm (delivering 1 µL) on 5% sheep blood and MacConkey agar that was incubated aerobically at 37°C for 18–24 hours. Isolates were subjected to Gram staining and further identification by the biochemical reactions along with their antimicrobial susceptibility testing by Kirby–Bauer disk diffusion method.

Statistical Analysis

The descriptive statistics for quantitative and qualitative data were calculated as mean, standard deviation, and proportions, respectively. The association between qualitative variables is tested through Chi-square test.

Results

This study comprised of 150 patients admitted to the MICU. They were followed and monitored from the date of Foley's catheter insertion to the appearance of symptoms. Urine samples were received and processed at the microbiology laboratory.

Rate of CAUTI per 1000 urinary catheter days (UCD).

$$CAUTI\ Rate = \frac{Number\ of\ reported\ CAUTI}{Number\ of\ urinary\ catheter\ days} \times 1000 = \frac{22}{2316}$$

$$= 9.4\ per\ 1000\ UCD$$

Among 150 catheterized patients, CAUTI was reported in 22 (14.67%), whereas 14 (9.3%) had *Candida* isolates and 114 (76%) were sterile (Table 1). CAUTI rate was 9.4 per 1000 urinary catheter days, while the overall magnitude was 14.67%. The majority of cases were reported in the 51–70-years age group (34%) followed by 11–30 years (28.66%), while the least was in >70-years group (16%) (Table 2). CAUTI cases were the highest in the third week (50%) followed by the second (34.48%) and first (3.81%) week (Table 3). Higher magnitude (17.24%) of CAUTI was observed in diabetic patients. The most common pathogen isolated was *E. coli* 9 (6%) followed by *Enterococcus* species 6 (4%), *Pseudomonas* species 5 (3.33%), *Enterobacter aerogenes* 3 (2%), *Klebsiella* species,

Table 2: Age and gender distribution ($n = 150$)

	No. of patients catheterized		
Age (Years)	*Female*	*Male*	*Total*
11–30	21	22	43 (28.66%)
31–50	10	22	32 (21.33%)
51–70	24	27	51 (34%)
Greater than 70	13	11	24 (16%)
Total	68	82	150

Table 3: Relationship of duration of catheterization with CAUTI ($n = 150$)

Duration of catheterization	*No. of patients*	*CAUTI (%)*
1–5 days	105	4 (3.81%)
6–10 days	29	10 (34.48%)
11–15 days	16	8 (50%)
Total	150	22 (14.67)
$\chi^2 = 2.11$	Degree of freedom = 2	*p*-value = 0.348

Table 4: Distribution of organisms associated with CAUTI (out of 150)

*Organisms isolated^*	*Number*	*Percentage**	*95% CI*	
			Lower limit	*Upper limit*
Escherichia coli	9	6%	2.8	11.1
Enterococcus species	6	4%	1.5	8.5
Pseudomonas species	5	3.33%	1.1	7.6
Enterobacter aerogenes	3	2%	4	5.7
Klebsiella species	1	0.67%	0.01	3.7
Acinetobacter species	1	0.67%	0.01	3.7
Sterile	114	76%	68.4	82.6

^25 organisms found in 22 CAUTI cases, 3 patients isolated 2 each.
*Percentage of samples isolated with pathogens out of 150 samples

and *Acinetobacter* species 1 (0.67%) each (Table 4). Antibiotic susceptibility pattern of Gram-negative bacilli revealed high susceptibility (100%) to Nitrofurantoin, followed by Imipenem and Colistin (92.85%) (Table 5).

Discussion

Over 5 million patients in critical care hospital settings undergo urinary catheter insertion, putting them at an increased risk for CAUTI and its associated consequences.[15] Globally, the urinary catheter is recognized as the primary factor that increases the chances of developing UTIs. In the event that the catheter is not implanted aseptically, it may act as a portal of entry for the pathogen.[16,17] In this study, the CAUTI rate was calculated as 9.4 per 1000 urinary catheter days in 150 catheterized patients with 2316 catheter days, which is in accordance with other studies.[18,19] The overall magnitude of CAUTI in our study is 14.67%, which is similar to Verma S et al.[13] and Alam J et al.[20] Here, the reduced incidence of CAUTI is a result of strict adherence to infection control practices, proper hand hygiene, and the effective implementation of a catheter care bundle.

Table 5: Antibiotic susceptibility pattern of isolates ($n = 25$)

Antibiotics	*GNB (n = 14)*	*Enterococcus (n = 6)*	*Pseudomonas (n = 5)*
Ampicillin	3 (21.42%)	0	NA
Piperacillin/ Tazobactam	8 (57.14%)	NA	3 (60%)
Cefotaxime	2 (14.28%)	NA	NA
Ceftazidime	8 (57.14%)	NA	4 (80%)
Ceftazidime/ Clavulanic acid	11 (78.57%)	NA	NA
Cefoperazone/ Sulbactam	9 (64.28%)	NA	5 (100%)
Cefepime	4 (28.57%)	NA	3 (60%)
Imipenem	13 (92.85%)	NA	5 (100%)
Vancomycin	NA	5 (83.33%)	NA
Aztreonam	NA	NA	3 (60%)
Colistin	13 (92.85%)	NA	5 (100%)
Amikacin	12 (85.71%)	NA	4 (80%)
Gentamycin	11 (78.57%)	NA	3 (60%)
High Gentamycin	NA	6 (100%)	NA
Doxycycline	12 (85.71%)	NA	NA
Tetracycline	NA	2 (33.33%)	NA
Linezolid	NA	6 (100%)	NA
Tobramycin	NA	NA	5 (100%)
Ciprofloxacin	1 (7.14%)	2 (33.33%)	NA
Cotrimoxazole	11 (78.57%)	NA	1 (20%)
Nitrofurantoin	14 (100%)	6 (100%)	NA
Fosfomycin	NA	5 (83.33%)	NA

The magnitude of CAUTI was higher in female (63.63%) than male patients (36.36%), which is in agreement with other studies such as Patil and Patil[21] and Nadeem R et al.[22] This female predominance is due to short urethra, its proximity to the anus, and dilatation of the urethra, which makes it easier for bacteria to spread, leading to infection. Hence, in females, catheterization should be done when absolutely indicated.

This study reported that the magnitude of CAUTI is directly proportional to the duration of catheterization, which is in agreement with other studies.[23–26] This implies that the best approach to decrease the occurrence of CAUTI is to only use indwelling catheters when absolutely necessary or, at the very least, to minimize the duration of catheterization.

The magnitude of CAUTI among diabetics was higher (17.24%) as compared with nondiabetic patients (14.04%). One potential reason for this could be that individuals with diabetes have an increased risk of microbial colonization in their perineum, rendering it more susceptible to infections.

E. coli plays an important role as it possesses pili capable of binding to the urinary epithelium and preventing their elimination by urine flow. *E. coli* was the most common pathogen isolated, followed by *Pseudomonas* species, and *Enterococcus* species 6 (4%) was predominant among the Gram-positive cocci. A similar

finding was observed in previous studies, where *E. coli* was the most common pathogen isolated.[27]

Antimicrobial susceptibility pattern of the isolates obtained in this study showed that most of the Gram-negative bacilli were multidrug-resistant. Antibiotic susceptibility of Enterobacteriaceae revealed that the isolates were highly susceptible to Nitrofurantoin followed by Imipenem (92.85%). However, it showed resistance against Ciprofloxacin (92.85%) which is considered highly effective in the treatment of UTIs (Table 5). This is in agreement to Chatterjee N et al.[28] Most Enterobacteriaceae have high susceptibility to aminoglycosides, carbapenem, and nitrofurantoin. Among Gram-positive cocci, *Enterococcus* species were highly susceptible (100%) to high-level Gentamycin, Linezolid, and Nitrofurantoin, followed by Vancomycin (83.33%). The high resistance rate observed in our study might be attributed to the study's design, which focused on ICU patients. Hence, antibiotic stewardship program plays an important role in hospitalized patients with UTI as it is very frequently encountered by treating physicians.

Herein, acknowledging the limitation of the study, which is small sample size, as it was conducted during COVID era. A large data could have given better insight into the study.

Conclusion

The CAUTI rate at our institution was 9.4 per 1000 urinary catheter days. Our study identified three risk factors: female gender, duration of catheterization, and diabetes mellitus. Gram-negative pathogens were predominantly isolated with high susceptibility to aminoglycosides, carbapenem, and nitrofurantoin. The primary objective for all patients with catheters should be the prevention of CAUTI, rather than focusing on treatment after it occurs.

Surveillance allows the health system to estimate the burden of cases, associated risk factors, detecting outbreaks, as well as evaluating the role of preventive strategies and monitoring the quality of infection control practices.

Orcid

Smriti Parihar https://orcid.org/0009-0001-6691-2980
Rajni Sharma https://orcid.org/0009-0003-2197-3477
Sulika V Kinimi https://orcid.org/0009-0001-1758-6058
Sidhya Choudhary https://orcid.org/0000-0002-6567-1038

References

1. Saint S, Lipsky BA. Preventing catheter-related bacteriuria: Should we? Can we? How? Arch Intern Med 1999;159(8):800–808. DOI: 10.1001/archinte.159.8.800.
2. Foxman B. Epidemiology of urinary tract infections: Incidence, morbidity, and economic costs. Am J Med 2002;113(Suppl 1A):5S–13S. DOI: 10.1016/s0002-9343(02)01054-9.
3. Lee JH, Kim SW, Yoon BI, Ha US, Sohn DW, Cho YH. Factors that affect nosocomial catheter-associated urinary tract infection in intensive care units: 2-Year experience at a single centre. Korean J Urol 2013;54(1):59–65. DOI: 10.4111/kju.2013.54.1.59.
4. Nicolle LE. Catheter associated urinary tract infections. Antimicrob Resist Infect Control 2014;3:23. DOI: 10.1186/2047-2994-3-23.
5. Parida S, Mishra SK. Urinary tract infections in the critical care unit: A brief review. Indian J Crit Care Med 2013;17(6):370–374. DOI: 10.4103/0972-5229.123451.
6. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36(5):309–332. DOI: 10.1016/j.ajic.2008.03.002.
7. Stamm WE. Catheter-associated urinary tract infections: Epidemiology, pathogenesis, and prevention. Am J Med 1991;91(3B):65S–71S. DOI: 10.1016/0002-9343(91)90345-x.
8. Warren JW. Catheter-associated urinary tract infections. Infect Dis Clin North Am 1997;11(3):609–622. DOI: 10.1016/s0891-5520(05)70376-7.
9. Jain M, Kaushal R, Bharadwaj M. Infection surveillance analysis of catheter associated urinary tract infections in obstetrics and gynecology department of a tertiary care hospital of North India. Int J Reprod Contracept Obstet Gynecol 2018;7(1):215–219. DOI: 10.18203/2320-1770.ijrcog20175848.
10. Chenoweth CE, Gould CV, Saint S. Diagnosis, management, and prevention of catheter-associated urinary tract infections. Infect Dis Clin 2014;28(1):105–119. DOI: 10.1016/j.idc.2013.09.002.
11. Bereket W, Hemalatha K, Getenet B, Wondwossen T, Solomon A, Zeynudin A, et al. Update on bacterial nosocomial infections. Eur Rev Med Pharmacol Sci 2012;16(8):1039–1044. PMID: 22913154.
12. Rosenthal VD, Todi SK, Alvarez-Moreno C, Pawar M, Karlekar A, Zeggwagh AA, et al. Impact of a multidimensional infection control strategy on catheter-associated urinary tract infection rates in the adult intensive care units of 15 developing countries: Findings of the International Nosocomial Infection Control Consortium (INICC). Infection 2012;40(5):517–526. DOI: 10.1007/s15010-012-0278.
13. Verma S, Naik SA, Deepak TS. Etiology and risk factors of catheter associated urinary tract infections in ICU patients. IP Int J Med Microbiol Trop Dis 2017;3(2):65–70. DOI: 10.18231/2455-6807.2017.0015.
14. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. Clin Infect Dis 2010;50(5):625–663. DOI: 10.1086/650482.
15. Vyawahare CR, Gandham NR, Misra RN, Jadhav SV, Gupta NS, Angadi KM. Occurrence of catheter-associated urinary tract infection in critical care units. Med J Dr DY Patil University 2015;8(5):585–589. DOI: 10.4103/0975-2870.164974.
16. Doddaiah V, Harikumar S, Krishna K, Swathi J, Thygaraja R. Catheter associated urinary tract infection at Vasavi Hospital, Bangalore, India. Int J Curr Res 2020;12(02):10380–10383. DOI: 10.24941/ijcr.38062.02.2020.
17. Lundstrom T, Sobel J. Nosocomial candiduria: A review. Clin Infect Dis 2001;32(11):1602–1607. DOI: 10.1086/320531.
18. Masih SM, Goel S, Singh A, Khichi SK, Vasundhara, Tank R. Epidemiology and risk factors of healthcare associated infections from intensive care unit of a tertiary care hospital. Int J Res Med Sci 2016;4(5):1706–1710. DOI: 10.18203/2320-6012.ijrms20161254.
19. Tomar APS, Kushwah A, Shah H. identification and susceptibility pattern of gram-negative bacterial isolates of Catheter Associated urinary Tract Infections (CAUTI) in a tertiary care institute. Indian J Microbiol Res 2017;4(4):373–376. DOI: 10.18231/2394-5478.2017.0082.
20. Alam J, Verma PK, Kala S, Rawat V. Incidence and microbiology of catheter associated urinary tract infection in hospitalized patients in a tertiary care hospital in Kumaon region. International Journal of Research and Review 2020;7(5):114–117. DOI: 10.5281/zenodo.3938495.
21. Patil HV, Patil VC. Clinical, bacteriology profile, and antibiotic sensitivity pattern of Catheter associated Urinary tract infection at tertiary care hospital. Int J Health Sci Res 2018;8(1):25–35. Available from: https://www.ijhsr.org/IJHSR_Vol.8_Issue.1_Jan2018/5.pdf.
22. Ruqaiyah Nadeem, Furquan Alam, Dimple Raina, Gaurav Saxena. Bacteriological Profile in the Catheter Associated Urinary Tract Infection (CAUTI) Patients in a Tertiary Care Hospital of Uttarakhand, India. International Journal of Health and Clinical Research 2021;4(18):77–80. Available from: https://ijhcr.com/index.php/ijhcr/article/view/2905.
23. Mohammadzadeh M, Behnaz F. Incidence and risk factors of catheter-associated urinary tract infection in Yazd – Iran. Int J Urol Nurs 2012;6(2): 60–65. DOI: 10.1111/j.1749-771X.2011.01133.x.

24. Lee NG, Marchalik D, Lipsky A, Rushton HG, Pohl HG, Song X. Risk factors for catheter associated urinary tract infections in a Pediatric Institution. J Urol 2016;195(4 Pt 2):1306–1311. DOI: 10.1016/j.juro.2015.03.121.
25. Md. Yousuf Khan, Venkateshwarlu C, Sreenivas G, Rahul P. Study of incidence and risk factors of urinary tract infection in catheterized patients admitted at tertiary care hospital, Nizamabad, Telangana State, India. IAIM 2016;3(8):83–92.
26. Podkovik S, Toor H, Gattupalli M, Kashyap S, Brazdzionis J, Patchana T, et al. Prevalence of catheter-associated urinary tract infections in neurosurgical intensive care patients – The overdiagnosis of urinary tract infections. Cureus 2019;11(8):e5494. DOI: 10.7759/cureus.5494.
27. Vikram B. Gohil, Adhish V. Vyas, Milan S. Vaghasia. The prospective study of urinary tract infection among indoor patients who underwent catheterization. International Journal of Contemporary Medical Research 2020;7(5):E5–E8. DOI: 10.21276/ijcmr.2020.7.5.2.
28. Chatterjee N, Chatterjee C, Ghosh S, Mukhopadhyay M, Brahmachari R, Patar K. Pattern of urinary antibiograms in a tertiary care hospital of Eastern India. J Assoc Physicians India 2016;64(4):26–30. PMID: 27734638.
29. Allegranzi B, Bagheri Nejad S, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet 2011;377(9761):228–241. DOI: 10.1016/S0140-6736(10)61458-4.
30. Lakhani JD, Lakhani SJ, Meera S, Sanket P, Sandeep J. Appropriate use of antimicrobial agents in urinary tract infections: Perception of physicians and resident doctors. J Integr Health Sci 2019;7(1):19–24. DOI: 10.4103/JIHS.JIHS_18_19.