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Original article

Study of Risk Factors for Catheter-Associated Urinary Tract Infection

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ABSTRACT

Background and aims. *Catheter-associated urinary tract infections (CAUTIs) are the most common causes of UTIs in ICU cases. Many risk factors are associated with its incidence. This study aimed to determine related risk factors contributing to urinary tract infection and to identify contaminated bacteria species, as well as their susceptibility profiles to the most commonly used antimicrobial agents.* ***Methods.*** *The study was performed at the University of Tripoli from February to May 2022. 180 catheterized patients from different clinical wards in ICUs at University Teaching Hospital, Tripoli city Libya, were included in this research. Two urine samples were taken from all patients before and after catheterization. The samples were cultured according to the standard microbiological procedures. Isolates were identified by conventional identification methods. The questionnaire was submitted to all patients to collect information such as age, gender, and health condition.* ***Results****. The age of the patients varied from a minimum of 15 years to a maximum of 73 years with a mean age of 37.82 years. Among them 96(53.33%) were males and 84(46.67%) were female patients. Out of 180 catheterized patients, only 93(51.67%) patients showed significant growth. On multivariate analysis, age, sex, duration of catheterization, and diabetes, were found to be the significant risk factors associated with CAUTI ($p<0.05$). All the urine cultures were monomicrobial. Gram-negative isolated species 69(74.19%), and Gram-positive isolated species 24(25.81%) Most common organism grown in culture was Escherichia coli 27 (29.03%) followed by Klebsiella pneumoniae 18 (19.36%), Pseudomonas aeruginosa 12 (12.90%), Enterococcus fecalis 12 (12.90 %), Staphylococcus aureus 9(9.67%), Enterobacter spp 6(6.45%), and Citraobacter spp, Acinetobacter spp, Streptococcus spp 3(3.23).* ***Conclusion****. An understanding of the risk factors in the development of CAUTI, significantly helps in reducing the additional burden on the health care system.*

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INTRODUCTION

Urinary Tract Infections is a worldwide with an incidence of approximately 35% [1]. UTI among catheterized patients are on the rise, and poor patient response to antibiotics is due to erratic use of antibiotics. Catheterized-UTI were related to increased morbidity, mortality, and prolonged hospital stay duration [2,3]. The microorganisms associated with CAUTI include bacteria, fungi, and other pathogens, and the insertion of a urinary catheter is one of the risk factors for CAUTI [4]. The infectious agents migrate into the bladder through the catheter tubing that is a result of the improper insertion of the catheter, obstruction of the flow of urine, or accumulation of urine in the bladder that increases the growth of microorganisms [5]. They are particularly frequent in elderly patients because of the presence of additional CAUTI risk factors, such as advanced age, urinary function abnormalities, presence of chronic diseases, and immune dysfunction, as well as reports of inappropriate utilization of indwelling urinary catheters in this population [6].

The Centers for Disease Control and Prevention defined CAUTI as clinical symptoms and laboratory evidence of UTI in a patient who has had an indwelling urethral catheter in place for more than 2 days. CAUTI patients experience a sensation of illness, a temperature, rigidity, mental changes, weakness, flank pain, an unset of blood in urine, pelvic pain, difficulty

or frequent urination, or suprapubic pain or tenderness [7]. Indwelling urinary catheters are commonly employed as a bladder management strategy in healthcare and are known to be overused in hospitals [8,9]. There are widely used, with an estimated 15% to 25% of hospitalized adults having an indwelling catheter for a portion of their hospitalization [10]. The risk of CA-UTI increases in the intensive care unit (ICU), where incidence rates range between 3.6 and 14.71 per 1000 urine catheter days [11].

Bacteriuria or Candiduria is almost inevitable in nearly half of the patients who require an indwelling urinary catheter for more than 5 days. The duration of catheterization is the most important determinant of bacteriuria. There is a 3–7% daily risk of acquiring CAUTI when an indwelling urinary catheter is in place, and the risk is higher for women and older individuals [12]. Furthermore, patients with catheter-associated bacteriuria have a 3% risk of developing bacteremia, and even asymptomatic bacteriuria may be associated with enhanced-hospital mortality rates. [13]. The bacteria that cause AUTI might be exogenous, such as through contaminated healthcare workers' hands or equipment, or endogenous, such as from rectal, meatal, or vaginal colonization moreover many of these bacteria are part of patients' endogenous, bowel flora, but they can be acquired from the hospital as well Datta et al [14, 15]. There they can multiply, causing an infection. Further, contamination of the drainage bag upon insertion or disruption in the tubing junction may also result in bacterial migration via the drainage system. In addition, the drainage bag may not be emptied often enough or urine in the catheter bag may flow backward into the bladder and also irregular cleaning of a catheter can cause contamination. Thereby increasing the risk for CAUTI.

UTIs, including CAUTIs, can be caused by several bacterial species, including uropathogenic, *Staphylococcus aureus, Enterococcus faecalis, Group B Streptococcus, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa,* and *Enterobacter spp.* However, the most common causative agent for UTI and CAUTI is Uropathogenic *Escherichia coli* [16,17]. Therefore, the aim of this study was to determine the patient and catheter-related risk factors contributing to the urinary tract infection, and to identify contaminated bacteria species, as well as their susceptibility profiles to the most commonly, used antimicrobial agents.

METHODS

Study design

This study has conducted at the microbiology laboratory department of medical laboratories science, and collected specimens from ICUs at University Teaching Hospital, Tripoli city, Libya from February to May 2022. The ethical research committee gave ethical approval for the study. The questionnaire was submitted to all patients to collect information such as age, gender, and health condition.

Study population

A total of 180 patients, were included in the study, 96 male and 84 female. Aged were between 15-73 years. The patients who participated in the study were from different wards of ICUs. In this study two samples were taken; urine samples were collected from patients before catheterization, and urine samples were collected from a bag of catheterized patients who stayed on a catheter for more than 48 h.

Sample collection and transport

Urine specimens were collected directly from the catheter or tubing, after disinfection of the drain end-piece with chlorhexidine-alcohol 0.5%. Urine samples were collected aseptically using a sterile needle and syringe from the distal edge of the catheter tube into the sterile urine container, and transported to the microbiology laboratory, for analysis within 30 minutes. Urine analysis, culture, and antibiotic susceptibility testing were tests done. Data was collected using sample characteristics Performa, CAUTI assessment checklist, which consisted of a checklist for signs and symptoms of CAUTI, and Performa for the microbiological count as per centers for disease control and prevention guidelines. Sample characteristics Performa comprised of nine items i.e. CAUTI assessment checklist consists of the assessment of signs and symptoms i.e. Feel fever and chills, feel pain in the lower abdomen or groin, urinary urgency, urinary frequency, dysuria, feel a burning sensation during urination, urine look cloudy and have a strong odor, blood in the urine, deposits in the catheter tube, and the presence of at least one of these signs or symptom for the occurrence of symptomatic CAUTI.Is required as per CDC guidelines and Performa for the microbiological count, which consists of the assessment of the

patient for the presence of the positive urine culture with a microbiological count of 105 or more as recommended in CDC guidelines.

Isolation and identification of microorganisms

Urine samples were inoculated, onto nutrient agar plates using calibrated sterile wire loop, capable of transferring 0.001 mL. The inoculated plates were incubated at 37˚C for 24 hours and observed for growth and in case of no growth, the plate was incubated for up to 48 hours before declaring the absence of bacterial growth. After incubation, the bacterial growth on the cultures isolated onto blood agar, mannitol salt agar, MacConkey agar CLED agar, and CA-ASB is diagnosed when one or more organisms are present at quantitative counts $\geqslant 10^5$ CFU/ml from an appropriately collected urine specimen in a patient with no symptoms attributable to urinary infection. Lower quantitative counts may be isolated from urine specimens prior to $\geqslant 10^5$ CFU /ml being present, but these lower counts likely reflect the presence of organisms in biofilm-forming along the catheter, rather than bladder bacteriuria [18]. All strains isolated from the patient were identified by the routine standard laboratory procedure. This is based on colony morphology, hemolytic pattern, microscopic examination, and biochemical tests.

Bacterial antibiotic susceptibility testing

Antimicrobial susceptibility testing was performed based on the Kirby Bauer disc diffusion method using Clinical and Laboratory Standard Institute guidelines. [19-21]. Pure culture of respective bacteria isolates and inoculated to Mueller Hinton agar plates. The inoculated plates were left at room temperature to dry for 3–5 min and a set of antibiotic discs were placed on the plates. The following antibiotic discs with their respective concentrations were used: erythromycin [E, 15 µg]; amikacin [AK, 30g]; ampicillin [AM, 10g]; cephalexin [CL, 30g]; gentamycin [GM10 µg]; ciprofloxacin [CIP, 5 µg]); ceftriaxone [CRO 30 µg]; amoxicillin, (AML, 25 µg); nitrofurantoin [F,300 µg]; tetracycline [TE,30 µg].

Statistical analysis

The raw data were entered into excel spreadsheets and later imported to SPSS software version 26 (IBM Corp., Armonk, N.Y, USA). Descriptive statistics of demographic and clinical variables were summarized and presented as a percentage, mean with respective standard deviation for continuous variables, and frequencies and percentages for categorical variables. Age was categorized into Two categories i.e., $\leqslant$ 50 years and >50 years. Different species of bacteria were sorted out and proportions of each isolated bacterium were compared to assess the most prevalent species involved in CAUTIs. Chi-square test was used to compare CAUTI cases according to age group, and gender i.e., evaluations were carried out at a 95% confidence level and $P < 0.05$ was considered statistically significant. Results were presented in form of tables.

RESULTS

A total of 180 patients were included in the study. The demographic and clinical characteristics of the study participants were given in Table 1. The age of the patients varied from a minimum of 15 years to a maximum of 73 years with a mean age of 44 years. It showed that among 180 patients, 96(53.33%) were males and 84 (46.67%) were female patients. The urine culture from 180 catheterized patients, showed significant growth after 48 hours of catheterization indicating an overall CAUTI incidence of 93(51.67%) patients.

Table 1. Demographic and clinical characteristics of study participants

Variable	Total tested (180)	Bacterial CAUTIs, 93(52%)	P value
Male **Female**	96(53.33%) 84(46.67%)	%)71.3836(57(61.29%)	0.200
Age category	≤ 50 years	> 50 years	0.00
Positive, n(%) **Negative, n(%)**	30 (32.26%) 66(77.78%)	63(67.74%) 21(22.22%)	
Gender	Male	Female	0.02
Positive, n(%) **Negative, n(%)**	36(38.71%) 60(68.97%)	57(61.29%) 27(31.03%)	

Catheter days stay	≤ Week, n (%)	> Week n (%)	
Positive, n (%) **Negative, n (%)**	(19.35%)18 39(44.83%)	75(80.65%) 48(55.17%)	0.03
Diabetes	Present	Absent	
Positive, n(%) **Negative, n (%)**	42(45.16%) 15(17.24%)	%)54.8451(72(82.76. %)	0.020
Urethral swelling around the catheter	Present	Absent	
Positive n(%) **Negative n (%)**	48(51.61%) 12(13.79%)	45(48.39%) 75(86.21%)	0.00

The results show that there was a statistically significant difference in CAUTI incidence according to gender ($\chi 2$ (1) = 5.511, P = 0.02), female had higher cases of CAUTI n= 57(61.29%), compared to male with lower cases of CAUTI n= 36(38.71%); A statistically significant difference in CAUTI incidence according to the length of stay of catheters ($\chi 2$ (1) = 4.492, P = 0.034). Patients with longer catheter days had higher cases of CAUTI n = 75(80.65%) compared to patients with short catheter days n = 18(19.35%). Aged years old, patients who were ⩽ 50 years had higher cases of CAUTI n = 30(32.26%) compared to patients who were above 50 years n = 63(67.74%) indicating statistically significant differences in the CAUTI incidence according to age category ($\chi 2$ (1) = 11.446, P = 0.00). Following Diabetes, ($\chi 2$ (1) = 5.398, P = 0.020), and Urethral swelling around the catheter ($\chi 2$ (1) = 9.644, P = 0.00), were found to be the significant risk factors associated with CAUTI. Of them, the drainage system and duration of catheterization were the most important factors as shown in Table [1].

Table 2. Frequency and percentage of patients according to the signs and symptoms of CAUTI

Characteristics	Yes, n(%)	No, n(%)
Feel pain in the lower abdomen or groin	42(23.33%)	138(76.67%)
Feel fever and chills	60(33.33%)	120(66.67%)
Urinary urgency	72(40%)	108(60%)
Urinary frequency	84(46.67%)	96(53.33%)
Dysuria	66(36.67%)	114(63.33%)
Feel a burning sensation during urination	69(38.33%)	111(61.67%)
Urine looks cloudy and has a strong odor	87(48.33%)	93(51.67%)
Blood in the urine	54(30%)	126(70%)
Deposits in the catheter tube	72(40%)	108(60%)

Findings of urine culture were given in Table [3]. All the urine cultures were monomicrobial. Gram-negative isolated species 69(74.19%), and Gram-positive isolated species 24(25.81%) Most common organism grown in culture was *Escherichia coli* 27(29.03 %) followed by *Klebsiella pneumoniae* 18(19.36%), *Pseudomonas aeruginosa* 12(12.90%), *Enterococcus fecalis* 12(12.90%), *Staphylococcus aureus* 9(9.68%), *Enterobacter spp* 6(6.45%), *Citraobacter spp*, *Acinetobacter spp*, *Streptococcus spp* 3(3.23%), as shown in Table [3].

Table 3. Species isolated from bacteremia attributed to catheter-acquired urinary infection

Variable	Number, n= (93)	%
Gram-negative isolated species		
Escherichia coli	27	29.03%
Klebsiella pneumoniae	18	19.35%
Pseudomonas aeruginosa	12	12.90%

Enterobacter spp	6	6.45%
Citraobacter spp	3	3.23%
Acinetobacter baumannii	3	3.23%
Gram-positive isolated species		
Enterococcus fecalis	12	12.90%
Staphylococcus aureus	9	9.68%
Streptococcus spp	3	3.23%

Identified bacteria isolates 93(51.67%) were tested for susceptibility to ten antibiotics. High resistance in gram-negative isolates collection. *Acinetobacter baumannii* was 100% resistant to all tested antimicrobials. Gram-positive isolates showed extreme resistance against AK, CIP, AML 100%, 75%, *Staphylococcus aureus*, and *Enterococcus fecalis*, respectively, as shown in Table [4].

Table 4. Prevalence and antimicrobial resistance of bacterial agents isolated from CAUTI

Antibiotic	***E. coli*** **n = 27**	***K. pneumoniae*** **n = 18**	***P. aeruginosa*** **n = 12**	***Enterobacter spp*** **n = 6**	***Citraobacter spp*** **n = 3**	***A. baumannii*** **n = 3**	***S aureus*** **n = 9**	***E. fecalis*** **n = 12**
E (15 µg)	19(70.37 %)	6(33.33%)	3(25%)	0	0	3(100%)	3(33.33 %)	6(50%)
AK (30 µg)	18(66.67 %)	6(33.33%)	3(25%)	0	0	3(100%)	9(100%)	3(25%)
AM (10 µg)	19(70.37 %)	6(33.33%)	6(50%)	3(50%)	3(100%)	3(100%)	3(33.33 %)	3(25%)
CL (30 µg)	9(33.33 %)	3(16.67%)	6(50%)	3(50%)	3(100%)	3(100%)	3(33.33 %)	6(50%)
GM(10 µg)	6(22.22 %)	3(16.67%)	3(25%)	3(50%)	3(100%)	3(100%)	3(33.33 %)	3(25%)
CIP (5µg)	19(70.37 %)	6(33.33%)	0	3(50%)	0	3(100%)	9(100%)	9(75%)
CRO (30 µg)	9(33.33 %)	6(33.33%)	3(25%)	0	3(100%)	3(100%)	3(33.33 %)	6(50%)
AML(25 µg)	9(33.33 %)	6(33.33%)	6(50%)	3(50%)	3(100%)	3(100%)	9(100%)	9(75%)
F (300 µg)	15(55.56 %)	15(83.33%)	6(50%)	3(50%)	3(100%)	3(100%)	6(66.67 %)	3(25%)
TE (30 µg)	12(44.44 %)	6(33.33%)	6(50%)	3(50%)	3(100%)	3(100%)	3(33.33 %)	3(25%)

Erythromycin [E, 15 µg]; Amikacin [AK, 30g]; Ampicillin [AM, 10g]; Cephalexin [CL, 30g]; Gentamycin [GM10 µg]; Ciprofloxacin [CIP, 5 µg]); Ceftriaxone [CRO 30 µg]; Amoxicillin, (AML, 25 µg); Nitrofurantoin [F,300 µg]; Tetracycline [TE,30 µg].

DISCUSSION

Indwelling urinary catheters are a routine in most urological patients. As with any medical innovation, the benefits of the catheters must be weighed against their potential adverse effects. The most common adverse effect is CAUTI. Previous studies have identified certain risk factors that were significantly associated with CAUTI [22]. In our study, five factors were independently predictive of an increased risk of catheter-associated urinary tract infection. Age (p-value 0.00), because catheterized patients who are above 50 years have an increased risk of developing CAUTI due to reduced body immunity [12, 23]. Gender (p-value 0.02) females were associated with a significantly increased risk. because shorter urethra in females and its proximity to the perineum are factors determining an increased risk in females. Duration of catheterization (p-value 0.03), duration of catheterization was found to be a very significant risk factor. Also revealed that a longer duration of catheterization is associated with an increased chance of ascending infections either intra or

extraluminal. In a study conducted in an Indian hospital by Leelakrishna most significant risk factor for CAUTI was the duration of catheterization (P-value <0.0001) [22]. Diabetes (P-value 0.02) diabetics were consistently found to be associated with an increased risk of CAUTI in a study by [24] that is similar to our study. The possible explanation is that diabetics have increased colonization of organisms in their perineum and urine in diabetics also supports the growth of microorganisms. Altered host immunity in diabetics may also play a role though yet to be investigated. Urethral swelling around the catheter (P-value 0.00). The incidence of CAUTI in our study was 51.67%, comparable to studies done by Benson Musinguzi et al, who reported a CAUTI incidence of 51.4%. The Incidence of CAUTI was 51.67% which reflects a high risk of developing hospital-acquired CAUTI in patients with indwelling urinary catheters at the University Teaching Hospital. This study is in agreement with numerous studies [25] [26] [12] [23]. Revealing CAUTI as the most common hospital-acquired infection among admitted patients. The high incidence of CAUTI at University Teaching Hospital may be attributed to poor hygiene practices regarding catheter handling [27]. The current study reported a CAUTI incidence of 0.9% in Australia as opposed to 51.67%. This finding is reflective of the role of hygiene in preventing CAUTI. The results from the present study showed that CAUTI rates are greater in patients with long-stayed urethral catheters. This is congruent with previous findings.[26]. The longer the catheter stays in situ, the higher the probability of developing CAUTI. The risk of acquiring catheter-associated bacteriuria is five percent for each day the catheter is in situ from day 5, this increases to 100 percent when the urethral catheter is in place for four weeks [22]. The prevalence was especially high in elderly patients, which could be attributed to weakened immunity [26].

In our study, five factors were independently predictive of an increased risk of catheter-associated urinary tract infection. Age, duration of catheterization, diabetes, and urethral swelling around the catheter, those parameters were found to be significant risk factors. The predominance of Gram-negative bacilli especially *E. coli* and *K. pneumoniae* is in agreement with the study done in Benin showing gram-negative bacilli as the most common cause of hospital-acquired CAUTI [27]. This may be due to colonization of the perineum by enteric bacteria that gain access to the urinary tract during catheterization [28]. Gram-negative bacteria that cause CAUTI have several virulence factors related to motility, adhesion, immune avoidance, biofilm formation, and nutrient acquisition that facilitate colonization and survival within the urinary tract [29]. Gram-positive bacteria rarely cause UTI, *Staphylococcus aureus*, *E. fecalis* in this study, and S. aureus a fact that can be attributed to possession of lipoteic acid in the cell wall. This facilitates adhesion to the mucosal epithelium such that the bacterium is not flushed during urination [30].

The predominant growth of single bacteria was seen in 51.67% of used urinary catheters resistance to antibiotics is a growing concern worldwide. In this study, *E. coli* had the highest resistance to all antibiotics Table [5]. Relatedly, all bacteria isolates showed resistance to antibiotics that are commonly prescribed to treat UTIs. This makes it hard for clinicians to have wide choices of antibiotics for the prescription to catheterized patients with CAUTI. All Gram-negative isolates were sensitive to Imipenem and Gentamicin more than the isolates that were sensitive to Amikacin the isolates were sensitive to ciprofloxacin and Gatifloxacin, Amoxycillin was found the most resistant drug in all the isolated pathogens, *Enterococcus fecalis*, and *Staphylococcus aureus*. *E. coli*, *P. aeruginosa*, *E. fecalis*, and *S. aureus* are susceptible to Ciprofloxacin, Amikacin, Gatifloxacin Ceftriaxone followed by Gatifloxacin which showed high sensitivity against Antibiotics. E. faecalis resistant to Cefixime Table [3].

CONCLUSION

CAUTI is an important device-associated healthcare-acquired infection. The use of an indwelling urethral catheter is related to an increase in the occurrence of symptomatic urinary tract infection and bacteremia. The Incidence of CAUTI among patients with indwelling urinary catheters at University Teaching Hospital, Tripoli city Libya is high (51.67%), and it is mainly caused by *E. coli* and *K. pneumoniae* These bacteria are resistant to the most commonly used antibiotics. There is a need to emphasize CAUTI prevention strategies and use culture and sensitivity tests before prescription antibiotics.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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