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ORIGINAL ARTICLE

Hospital-acquired Urinary Tract Infections in Patients with Diabetes and Urinary Catheterization

Lin-Fang Chen [1], Tsong-Yih Ou [2,3], Sing-On Teng [2,3], Fu-Lun Chen [2,3], Tai-Chin Hsieh [2,3], Wen-Sen Lee [2,3]*

[1] Department of Nursing, Wan Fang Medical Center, Taipei Medical University, Taipei, Taiwan
[2] Division of Infectious Disease, Department of Internal Medicine, Wan Fang Medical Center, Taipei Medical University, Taipei, Taiwan
[3] Department of Internal Medicine, School of Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

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Objective: Urinary tract infection (UTI) is the most common hospital-acquired infection. Foley catheter-related UTI is associated with increased mortality, morbidity, length of hospital stay, and costs. Few studies have compared the pathogens by bacterial strains, resistance to antibiotics, comorbidities, and related risk factors in hospital-acquired UTI patients with or without diabetes and with or without a Foley catheter. The objective of this study was to compare the variables of hospital-acquired UTI between these two groups.

Methods: In this retrospective chart review study, we included hospital-acquired UTI patients (hospitalization time > 48 hours) with either diabetes or a Foley catheter from a medical center in Taipei (Taiwan) between January 1, 2011 and December 31, 2012. We excluded patients with positive urine culture for bacteria within 48 hours of admission. Clinically related information was collected using case data sheets.

Results: We analyzed 595 patients with hospital-acquired UTI; the infection rate of hospital-acquired UTI in our study was significantly higher in patients with a urinary catheter ($n = 497$) than in those without ($p < 0.05$). Regardless of the status of diabetes, all hospital-acquired UTI patients with a urinary catheter had higher mortality (27% vs. 19%) and bloodstream infection rates (14% vs. 9%) than those without a urinary catheter. Predictably, both groups (i.e., groups with and without a urinary catheter) had more Gram-negative strains, with *Escherichia coli, Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* being the most commonly isolated pathogens. The fungal infection rate was significantly higher in the urinary catheter group than in the nonurinary catheter group (37% vs. 25%; $p < 0.05$). Among the 78 pathogenic strains isolated from patients who died, the microorganisms found were fungi (39%), Gram-negative bacteria (31%), and Gram-positive bacteria (8%). Of the patients with a urinary catheter, age, length of hospital stay, number of comorbidities, and duration of infection after admission were all significantly higher in the diabetic group than in the nondiabetic group ($p < 0.05$).

Conclusion: Unlike having diabetes, having a urinary catheter was a significant risk factor for hospital-acquired UTI ($p < 0.001$). However, diabetic patients with a urinary catheter had a longer length of hospital stay than those without a urinary catheter. The resistance rate of *E. coli* to first-generation cephalosporins was higher in diabetic patients with a urinary catheter. Fungal infections, renal insufficiency, and cerebral vascular accident were significantly ($p < 0.01$) related risk factors for mortality. *Candida* deaths outnumbered other bacterial infections, and fungal UTI was the most prominent infection in nosocomial urinary catheterized patients.

1. Introduction

Hospital-acquired urinary tract infections (UTIs) often cause severe complications, especially in patients who are older, bed ridden, have diabetes, or have urinary indwelling Foley catheters.[1,2] Most patients with diabetics have complicated UTIs.[1,3,4] Therefore, experts recommend treating these patients with antibiotics for a

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* Corresponding author. Wen-Sen Lee, Division of Infectious Disease, Department of Internal Medicine, Wan Fang Medical Center, Taipei Medical University, Number 111, Section 3, Hsing Long Road, Taipei 116, Taiwan.
E-mail: W.-S. Lee <89425@wanfang.gov.tw>

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longer period than those without diabetes.[1,3–5] Malfunction in macrophage phagocytosis can explain the major cause of infection in UTI patients with diabetes.[3,4] Other factors that may increase the rate of UTIs in this population are urinary dysfunction, urinary overflow, emptying problems, fecal and urinary incontinence, and dysfunction of the urinary bladder.[4,6–8] In addition to patient characteristics, some hospital practices can also inadvertently increase the occurrence of UTIs. Catheter-related UTI is associated with increased mortality, morbidity, length of hospital stay, and costs compared with noncatheter-related UTI.[9–11] Erben et al reported that 87.9% of hospital-acquired UTIs are associated with the use of a urinary catheter.[7,9] Catheters also increase the formation of biofilms, which help grow pathogens that tolerate or resist various antibiotics.

Previous studies have reported that *Escherichia coli* was the most common pathogen responsible for UTI in both diabetic and nondiabetic patients.[1] However, few studies have looked at the differences in the type of pathogens and their drug resistance in diabetic and nondiabetic patients with or without a urinary catheter. UTIs caused by resistant pathogens are associated with longer hospital stays, increased medical expenses, and greater disease complexity.[2,5] In this study, we intended to compare the differences in pathogen type and resistance, comorbidities, the effect on prognosis, and related risk factors for hospital-acquired UTI in patients with or without diabetes, and with or without a urinary catheter.

2. Methods

2.1. Study patients and procedures

In this retrospective review of medical records, we studied hospitalized patients with or without diabetes and with or without a urinary catheter. The study duration was from January 1, 2011, to December 31, 2012 (595 hospital-acquired patients; 497 patients with urinary catheterization). The main inclusion criteria were hospitalized patients with UTI and with urinary catheters for more than 72 hours. Patients were excluded if they had positive urine culture for bacteria within 48 hours of admission or had positive urine culture for more than two bacterial species. We also collected other related information from patient's medical records. The Taipei Medical University joint Institutional Review Board (TMU-JIRB 100019) approved this study.

2.2. Statistical analysis

Statistical analysis was performed to compare the risk factors, differences in pathogens, drug resistance, and mortality rate between groups. The numbers of comorbidities (hypertension, acute and chronic renal insufficiency, cerebral vascular accident, and tumor history) were tallied to produce a comorbidity index. All collected data were analyzed separately with descriptive statistics, t tests, Chi-square tests, and Cox regression survival analysis. We analyzed the data with Statistical Package for Social Science version 16.0 for Windows (SPSS, Inc., Chicago, Illinois, USA). The differences between groups were considered significant if $p < 0.05$.

3. Results

A total of 599 urinary pathogens were isolated from 451 patients diagnosed with hospital-acquired UTI during the study period. Four patients who were clinically diagnosed as having hospital-acquired UTI but had negative urine culture were excluded. Overall, 595 strains were used for data analysis.

Table 1 Demographic and comorbidity data (based on with or without a urinary catheter) of hospital-acquired UTI patients during the study period

	Foley group ($n = 497$ [83.5%])	No Foley group* ($n = 98$ [16.5%])
Demographics		
Age (y)	73 ± 16	73 ± 16
Length of hospital stay (d)	50 ± 38	43 ± 38
Female (%)	263 (53)	56 (57)
Day of infection after admission	27.5 ± 24	24 ± 31
Death (%)	132 (27)	19 (19)
Bloodstream infection (%)	69 (14)	9 (9)
Comorbidities		
Comorbidity score*	2.26 ± 1.2	2.07 ± 1
Hypertension (%)	314 (63)	63 (64)
Cerebral vascular accident (%)*	245 (51)	38 (39)
Diabetes (%)	220 (44)	35 (36)
Acute and chronic renal insufficiency (%)	185 (37)	29 (30)
Tumor history (%)	148 (30)	38 (39)

*$p < 0.05$ ($N = 595$).
Data are shown as mean ± standard deviation or number (%). Comorbidity score is a tally of total comorbidities (those listed).
UTI = urinary tract infection.

Table 1 lists demographic and comorbidity data of hospital-acquired UTI patients during the study period based on urinary catheter use. Table 2 shows the classification of pathogens isolated from hospital-acquired UTI patients based on urinary catheter use. Table 3 shows demographic data of hospital-acquired UTI patients with urinary catheters, and with or without the status of diabetes. Table 4 provides demographic and comorbidity data of diabetic patients with hospital-acquired UTI using urinary catheters. Table 5 lists the various pathogens of hospital-acquired UTI in diabetic patients with or without urinary catheters. Table 6 presents the logistic regression analysis of risk factors for mortality from hospital-acquired UTI during the study period.

4. Discussion

Traditionally, the most common cause of hospital-acquired UTI in patients with urinary catheters with or without diabetes is *E. coli*.[3,8]

Table 2 Classification of pathogens of hospital-acquired UTI by patients with or without urinary catheters

	Foley group ($n = 497$) Number (%)	No Foley group ($n = 98$) Number (%)
Gram-negative bacteria	224 (51)	47 (60)
Escherichia coli	82 (36.6)	28 (59.6)
Pseudomonas aeruginosa	43 (19.2)	9 (19.1)
Klebsiella pneumoniae	38 (17)	5 (10.6)
Acinetobacter baumannii	22 (9.8)	0 (0)
Enterobacter cloacae	21 (9.4)	0 (0)
Proteus mirabilis	12 (5.4)	3 (6.4)
Serratia marcescens	6 (2.7)	2 (4.3)
*Fungi**	184 (37)	24 (25)
Candida albicans	104 (56.6)	14 (58.3)
Torulopsis glabrata	36 (19.2)	6 (25)
Candida tropicalis	28 (15.2)	2 (8.3)
Candida parapsilosis	15 (8.2)	2 (8.3)
Yeast-like fungus	1 (0.5)	0 (0)
Gram-positive bacteria	53 (10.6)	13 (13.2)
Enterococcus faecium	30 (48.3)	5 (33.3)
Enterococcus faecalis	20 (32.3)	4 (26.7)
Staphylococcus aureus	3 (4.8)	4 (26.7)
Facultative anaerobic bacteria	73 (15)	15 (15)

*$p < 0.05$ ($N = 595$).
Some small numbers are not listed, the percentage numbers are rounded.
Data are shown as mean number (%).
UTI = urinary tract infection.

Table 3 Demographic and clinical data of hospital-acquired UTI patients with urinary catheters, and with or without the status of diabetes mellitus during the study period

Patient demographics	With diabetes ($n = 255$)	Without diabetes ($n = 242$)
Age (y)	75 ± 13	71 ± 18*
Length of hospital stay (d)	56 ± 43	46 ± 32*
Female (%)	122 (56)	141 (51)
Number of comorbidities	3.15 ± 0.8	1.55 ± 0.9*
Onset of infection after admission(d)	30 ± 25	25 ± 23*
Deaths (%)	62 (28)	70 (25)
Blood infections (%)	31 (14)	38 (14)
Comorbidities		
Hypertension (%)	181 (82)	133 (48)*
Cerebral vascular accident (%)	120 (55)	134 (48)
Acute renal failure (%)	104 (47)	81 (29)*
Tumor history (%)	67 (31)	81 (30)

*$p < 0.05$ ($N = 497$).
Data are shown as mean ± standard deviation or number (%).
UTI = urinary tract infection.

However, in this study (Table 2), the most significantly common cause of hospital-acquired UTI in patients with a urinary catheter with or without diabetes mellitus was *Candida* spp. (37% vs. 25%, $p < 0.05$). In recent years, changing trends have been reported in epidemiology and pathogenesis of UTIs, especially in old-age and bed-ridden patients with a urinary catheter.[8–11] Candiduria in urinary catheterized patients is an emerging microbiological trend.[12]

The rate of infections (Table 1) of hospital-acquired UTI in our study was significantly higher in patients with a urinary catheter than in those without (83.5% vs. 16.5%, $p < 0.001$), whereas the infection rates of those two groups with or without diabetes had no difference. The present results agree with those in the published reports.[13–16] Unlike having diabetes, having a urinary catheter is a risk factor for hospital-acquired UTI. However, for diabetic patients with hospital-acquired UTI (Table 4), hospital stays were significantly longer with a urinary catheter than in those without one (55 ± 43.4 days vs. 35.5 ± 17.1 days, $p < 0.05$). Milan and Ivan found that resistance is higher in patients with a urinary catheter, because hospital-acquired UTIs are complicated clinically. In this study, among Gram-negative infections of hospital-acquired UTI (Table 2), *E. coli* was the most common pathogen in both groups, and the resistance rate of *E. coli* to first-generation cephalosporins was significantly higher in patients with a urinary catheter (7% vs. 3%, $p < 0.05$), regardless of the status of diabetes (Table 5).[13–16] These findings are compatible with those in the study by Milan and Ivan.[16]

Table 4 Demographics and comorbidities of diabetic patients with hospital-acquired UTI, and with or without a urinary catheter

Urinary catheterization	Foley ($n = 220$)	No Foley* ($n = 35$)
Demographics		
Age (y)	74.9 ± 13.4	77 ± 12.4
Length of hospital stay (d)	55.5 ± 43.4	35.5 ± 17.1*
Day of infection after admission	30.4 ± 24.6	20 ± 24.4
Female (%)	122 (55)	24 (68)
Deaths (%)	62 (28)	5 (14)
Blood infections (%)	31 (14)	4 (11)
Comorbidities		
Hypertension (%)	181 (82)	32 (91)
Acute renal failure (%)	104 (47)	12 (34)
Cerebral vascular accident (%)	120 (55)	16 (46)
Tumor history (%)	67 (31)	11 (31)

*$p < 0.05$ ($N = 255$).
Data are shown as mean ± standard deviation or number (%).
UTI = urinary tract infection.

Table 5 Pathogens of hospital-acquired UTI in diabetic patients with or without a urinary catheter

	Foley group ($n = 220$)	No Foley group* ($n = 35$)
Gram-negative bacteria (%)	103 (47)	19 (54)
Escherichia coli (%)	31 (30)	8 (22)
E. coli resistant to first-generation cephalosporins (%)	15 (7)	1 (3)
Fungi (%)	83 (38)	10 (29)
Gram-positive bacteria	34 (16)	6 (17)
Facultative anaerobic bacteria	23 (11)	5 (14)

*$p < 0.05$ ($N = 255$).
UTI = urinary tract infection.

Table 6 A logistic regression analysis of risk factors for mortality from hospital-acquired UTI during the study period

	OR	95% CI
Acute renal failure	2.192*	1.610–3.003
Fungal infection versus G (−) infection	2.056*	1.104–3.828
Cerebral vascular accident	1.767*	1.250–2.497
Hypertension	1.241	0.848–1.816
Urinary catheter	1.121	0.682–1.842
G (−) versus G (+) infection	1.109	0.586–2.098
Diabetes	1.080	0.761–1.531
Bloodstream infections	0.741	0.507–1.085
Tumor history	0.739	0.530–1.031

CI = confidence interval; OR = odds ratio; UTI = urinary tract infection; G (+) = Gram-positive bacteria; G (−) = Gram-negative bacteria.
*$p < 0.05$.

In the group of hospital-acquired UTI patients with a urinary catheter (Table 3), we found that age, length of hospital stay, numbers of comorbidities, and duration of infection after admission were all significantly higher in those with diabetes than those without ($p < 0.05$). Bonadio et al reported that strains of *E. coli* did not show any difference in resistance to ampicillin, cotrimoxazole, and ciprofloxacin, if the patients do not have a urinary catheter.[3] We found that the mortality rate for patients with hospital-acquired fungal UTI (Table 6) was significantly higher than for those with Gram-negative or Gram-positive infections [odds ratio (OR) = 2.056, 95% confidence interval (CI) = 1.104–3.828, $p < 0.05$].

Candida infections were the most common among hospital-acquired UTI in this study, especially in the urinary catheter group (Table 2). Previous studies showed that hospital-acquired fungal UTI is more common in those with diabetes.[3,8,13] However, we found that fungal UTI was significantly higher than bacterial infections in both diabetic and nondiabetic patients with a urinary catheter (OR = 2.056; 95% confidence interval = 1.104–3.828, $p < 0.05$). Therefore, we predict that the prevalence of common pathogens of hospital-acquired UTI is changing, possibly due to improper use of antibiotics.

The readers are cautioned in overinterpreting the study results because this study has two major limitations, namely, (1) the use of retrospective chart review and (2) lack of complete data on indicators for blood glucose control. Therefore, we are unable to determine the relationship of poor glycemic control with the likelihood of hospital-acquired UTI.

This study indicated the need for active surveillance of pathogens responsible for hospital-acquired UTI and their resistance at regular intervals. A urinary catheter is responsible for the occurrence of nosocomial UTI, and it is a more important source of resistant bacteria and *Candida* infections. *Candida* species have emerged as the most common pathogen in patients with hospital-acquired UTI and contributed to the morbidity and mortality of inpatients. Therefore, nosocomial infection control needs to be enforced.

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