Original Article

# Clinical characteristics and risk factors of catheter-associated urinary tract infections caused by *Klebsiella Pneumoniae*

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**Background:** The clinical characteristics and risk factors of catheter-associated urinary tract infections (CAUTIs) caused by *Klebsiella pneumoniae* (*KP*) have not been well investigated.

**Methods:** This retrospective study performed at a university teaching hospital in China from January 2012 to November 2017 analyzed data for 227 patients with urinary tract infection (UTI) caused by *KP*. Patients' demographic characteristics and clinical outcomes were recorded. Risk factors were analyzed using a binary logistic regression model.

**Results:** Of 227 patients with *Klebsiella pneumoniae*-related urinary tract Infection (*KP*-UTI), the infection was catheter-associated in 90 patients. More than half of them were male (60%), over 60 years old, hospitalized in general ward, always acquired in hospital, and got a longer hospitalization more than one month. The *Klebsiella pneumoniae*-related catheter-associated urinary tract infections (*KP*-CAUTIs) patients always combined with lots of chronic comorbidities. A high proportion of invasive device, extended-spectrum β-lactamase (ESBL) expression and multidrug resistance (MDR) were found in *KP*-CAUTIs patients. When taken antimicrobial activity into consideration, *KP*-CAUTIs patients performed resistance to most antibiotics in varying degrees. Logistic regression analysis revealed that after grouping by ESBL expression and in-hospital mortality among patients with *KP*-CAUTI, complicated urinary tract infection (cUTI) was an independent risk factor for ESBL positive *KP*-CAUTIs [odds ratio (OR) 59.256; 95% CI, 3.417–1,027.628; P=0.005], whereas congestive heart failure was identified as an independent risk factor for in-hospital mortality (OR 25.592; 95% CI, 2.376–275.629; P=0.008) in *KP*-CAUTI patients.

**Conclusions:** Patients with *KP*-CAUTI displayed distinctive characteristics. cUTI and congestive heart failure were independently associated with ESBL expression and in-hospital mortality in patients with *KP*-CAUTI.

**Keywords:** Catheter-associated urinary tract infections (CAUTIs); *Klebsiella pneumoniae* (*KP*); extended-spectrum β-lactamase (ESBL); mortality; risk factors

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## Introduction

Urinary tract infections (UTIs) represent 12.9% of healthcare-associated infections and 23% of infections in the intensive care unit (ICU), with approximately 70% of them being catheter-associated (CAUTIs) (1-3). CAUTIs occur at a rate of 3–10% per day of catheterization and approach a frequency of 100% within 30 days of hospitalization (4). The onset of CAUTIs can significantly affect patients' clinical outcomes, including a longer stay in the hospital, higher healthcare expenditures, and the overuse of antibiotics, as well as the possibility of higher mortality rates (5-7).

The presence of a catheter creates a special environment for bacteria colonization and biofilm formation, which increase the risk of infection and weaken the efficacy of treatment (8). *Klebsiella pneumoniae* (*KP*), as a normal flora of the gastrointestinal tract, often causes UTIs through cross-transmission (9). In many studies, *KP* was identified as the second most prevalent pathogen following by Escherichia coli among Enterobacteriaceae in UTIs (8-10). As a result of the indiscriminate and widespread use of antibiotics, *KP* produces high levels of extended-spectrum β-lactamase (ESBL), which causes resistance to most antibiotics excluding carbapenems. However, multidrug-resistant isolates of *KP*, including resistant to carbapenems isolates, have been detected recently, leading to the failure of empirical therapy and inevitably increased mortality (11).

Although Ikeda and colleagues reported a nosocomial infection outbreak of ESBL producing *KP* in patients with CAUTI in 2018, little is known regarding *Klebsiella pneumoniae*-related catheter-associated urinary tract infections (*KP*-CAUTIs) (12). Our study aimed to summarize the clinical characteristics and identify the risk factors of *KP*-CAUTIs to improve our understanding of this infection.

We present the following article in accordance with the STROBE Checklist (available at http://dx.doi.org/10.21037/apm-20-1052).

## Methods

### *Study design*

A retrospective study of Chinese patients with *Klebsiella pneumoniae*-related urinary tract Infection (*KP*-UTI) was conducted in Renji Hospital affiliated with the Shanghai Jiaotong University of Medicine, an 1800-bed tertiary care university teaching hospital in Shanghai, China. The study period was January 1, 2012 to November 31, 2017. Clinical manifestations were determined from medical charts. The study was observational in that the administration of antimicrobial agents and therapeutic managements were controlled by patients' physicians, and not by the investigators.

We collected records for all patients with a urine culture yielding *KP* levels >$10^5$ colony-forming units/ml with only one microorganism present, as well as a diagnosis of UTI by clinicians. The exclusion criteria were as follows: (I) outpatients; (II) patients less than 18 years old at the time of admission; (III) recurrent episodes (only the first instance of a positive *KP* urine culture in patients with UTI was included in our study); (IV) a history of hospitalization for more than 24 h within the 90 days before the index hospitalization; (V) hospital stay exceeding 6 months; and (VI) inpatients with incomplete or unavailable medical records.

### *Definitions*

The onset of UTI was defined as the date on which the first *KP*-positive urine sample was collected. CAUTI was diagnosed using only urine cultures collected more than 2 days after catheterization. Non-CAUTI was defined by positive urine cultures in patients who did not undergo catheterization. Hospital-acquired UTI were defined as infection in which the first positive culture was obtained more than 48 h after hospital admission or within 48 h after discharge from the hospital. Complicated UTI (cUTI) was originally defined by the US Food and Drug Administration (FDA) as the presence of at least one of the following findings: indwelling urinary catheter, urinary retention, neurogenic bladder, obstructive uropathy, renal impairment caused by intrinsic renal disease, renal transplantation, urinary tract modifications, or pyelonephritis with normal urinary tract anatomy (13). To further understand CAUTIs in our research, we defined cUTI as UTI or CAUTI combined with at least one of the following findings: urinary retention, neurogenic bladder, obstructive uropathy, renal impairment caused by intrinsic renal disease, renal transplantation, urinary tract modification, or pyelonephritis with normal urinary tract anatomy. The duration of catheterization was defined as length between the date of catheterization and that on which the first positive urine culture was collected. Length of stay (LOS) was defined as time from admission until discharge or death in the hospital. In-hospital mortality was defined as death of

 

any cause during hospitalization.

Clinical variables examined in patients with *KP*-UTI included age, gender, hospitalized ward, comorbidities, insertion of invasive devices, and laboratory findings., multidrug resistance (MDR) was defined as acquired resistance to three or more of the following antimicrobial classes: aminoglycosides (gentamicin, tobramycin or amikacin); carbapenems (imipenem); first-/second-generation (cefazolin) and third-/fourth-generation (cefotaxime or ceftazidime) cephalosporins; fluoroquinolones (ciprofloxacin or levofloxacin or norfloxacin); tetracycline; ampicillin-sulbactam; chloramphenicol; and trimethoprim-sulphamethoxazole. Carbapenem-resistant Enterobacteriaceae (CRE) was defined as an Enterobacteriaceae isolate that was resistant to carbapenems. Bloodstream infections (BSIs) by *KP* (*KP*-BSIs) were defined as the presence of *KP* in blood cultures in patients with simultaneous *KP*-UTI.

### *Microbiology*

*KP* isolates were identified using the Vitek 2 Advanced Expert System (bioMèrieux, Marcy l'Etoile, France), and antibiotic susceptibility was tested using the Kirby-Bauer agar disk diffusion method. Antibiotic susceptibility was interpreted according to the European Committee on Antimicrobial Susceptibility Testing guidelines (14).

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Renji Hospital Ethics Committee (Shanghai Jiaotong University School of Medicine) (NO. [2018]231) and individual consent for this retrospective analysis was waived.

### *Statistical analysis*

Student's *t*-test was used to compare continuous variables, and the chi-squared test or Fisher's exact test was used to compare categorical variables. A stepwise logistic regression model was applied to identify independent risk factors for *KP*-CAUTIs in subgroup analysis. Risk factors with P values less than 0.10 in the univariate analysis were included in the initial model, and forward stepwise selection was performed to develop the final model. A P value less than 0.05 was considered statistically significant. All data were analyzed using IBM SPSS Statistics for Windows (version 22.0). Odds ratios (ORs) and 95% CIs were calculated to evaluate the strength of any association.

## Results

### *Clinical characteristics of KP-CAUTIs*

A total of 227 patients with *KP*-UTI were identified during the study period, including 90 patients with catheter. The *KP*-CAUTIs patients represented their unique clinical characteristics. More than half of them were male (60%), over 60 years old, hospitalized in general ward, always acquired in hospital, and got a longer hospitalization more than one month. The *KP*-CAUTIs patients frequently combined with lots of chronic comorbidities, such as hypoproteinemia, solid tumor, and congestive heart failure. More than half of *KP*-CAUTIs patients were equipped with invasive devices such as central venous catheter and thoracic and abdominal drainage tube. ESBL expression and MDR were also found in them. When taken antimicrobial activity into account, *KP*-CAUTIs patients performed resistance to most antibiotics in varying degrees (*Table 1*).

### *Comparison of patients with KP-CAUTI subgrouped by ESBL expression*

We divided all 90 patients with *KP*-CAUTI into two subgroups according to the presence or absence of ESBL. Compared with the ESBL positive subgroup (n=58), significant differences were observed regarding the rates of ICU occupancy, hospital acquisition, combined with cUTI, duration of catheterization, and LOS in the hospital in the ESBL negative group (P<0.001, P<0.001, P=0.021, P<0.001, and P=0.001, respectively). Regarding comorbidities, the ESBL positive subgroup was more likely to present with congestive heart failure, cerebrovascular accident, and septic shock, as well as lower rates of leukemia/lymphoma (P=0.003, P=0.026, P=0.013, and P=0.042, respectively). The ESBL positive subgroup also exhibited obvious differences in the rates of invasive device use and occurrence of MDR and CRE (all P<0.005, *Table 2*).

Multiple potential risk factors were included in multivariate logistic regression analysis. ESBL positive *KP*-CAUTIs were found to be significantly associated with cUTI (OR 59.256; 95% CI, 3.417–1027.628; P=0.005), and a trend toward a correlation between central venous catheterization and *KP*-CAUTIs was discovered (OR 63.648; 95% CI, 0.973–4,163.155; P=0.052) (*Table 3*).

### Comparison of patients with *KP*-CAUTI subgrouped by in-hospital mortality or not

We divided all patients with *KP*-CAUTI into two

**Table 1** Clinical characteristics of KP-CAUTIs patients

| Characteristic | N=90 |
|---|---|
| Age (year), n (%) | |
| 18–45 | 6 (6.7) |
| 46–60 | 19 (21.1) |
| 61–75 | 32 (35.6) |
| >75 | 33 (36.7) |
| Gender (male), n (%) | 54 (60.0) |
| Hospitalization ward, n (%) | |
| General ward | 63 (70.0) |
| ICU | 27 (30.0) |
| Hospital acquired UTIs, n (%) | 65 (72.2) |
| Complicated UTIs, n (%) | 31 (34.4) |
| Length of stay (mean ± SD) (day) | 38.34±42.83 |
| In-hospital mortality, n (%) | 14 (15.6) |
| Comorbidities, n (%) | |
| Diabetes mellitus | 17 (18.9) |
| Chronic respiratory disease | 18 (20.0) |
| Chronic liver disease | 8 (8.9) |
| Chronic kidney disease | 24 (26.7) |
| Congestive heart failure | 32 (35.6) |
| Solid tumor | 36 (40.0) |
| Leukemia/lymphoma | 3 (3.3) |
| Cerebrovascular accident | 17 (18.9) |
| Septic shock | 22 (24.4) |
| Immunosuppression | 14 (15.6) |
| Hypoproteinemia | 52 (57.8) |
| Invasive device, n (%) | |
| Central venous catheter | 49 (54.4) |
| Ventilation | 38 (42.2) |
| Nasogastric feeding tube | 43 (47.8) |
| Thoracic and abdominal drainage tube | 48 (53.3) |
| Lab finding | |
| WBC (mean ± SD), ($\times10^9$/L) | 9.78±4.67 |
| BPC (mean ± SD), ($\times10^9$/L) | 210.17±103.13 |
| Hemoglobin (mean ± SD), (g/L) | 107.84±27.75 |
| Albumin (mean ± SD), (g/L) | 33.21±7.85 |
| CRP (mean ± SD), (mg/L) | 45.31±44.29 |
| PCT (mean ± SD), (ng/mL) | 2.39±7.85 |
| ESR (mean ± SD), (mm/h) | 37.39±31.1 |
| Creatine (mean ± SD), (mmol/L) | 118.06±155.82 |
| Blood glucose (mean ± SD), (mmol/L) | 7.22±6.23 |
| ESBL (+), n (%) | 58 (64.4) |
| MDR (+), n (%) | 61 (67.8) |
| CRE (+), n (%) | 27 (30.0) |
| Bloodstream infection with KP, n (%) | 3 (3.3) |
| Antimicrobial activity of KP (resistance), n (%) | |
| Second generation cephalosporins | 64 (71.1) |
| Third generation cephalosporins | 51 (56.7) |
| Forth generation cephalosporins | 51 (56.7) |
| Cefoperazone-sulbactam | 53 (58.9) |
| Aminoglycosides | 41 (45.6) |
| Fluoroquinolones | 56 (62.2) |
| Carbapenems | 27 (30.0) |
| Piperacillin-Tazobactam | 74 (82.2) |

*KP*-CAUTIs, *Klebsiella pneumoniae*-related catheter-associated urinary tract infection; WBC, white blood cell, BPC, blood platelet cell, CRP, C-reactive protein, PCT, procalcitonin, ESR, erythrocyte sedimentation rate; ESBL, extended-spectrum β-lactamase; MDR, multidrug resistance; CRE, Carbapenem-resistant Enterobacteriaceae.

**Table 2** Risk factors analysis of ESBL positive KP-CAUTIs

| | ESBL (+), (n=58) | ESBL (–), (n=32) | P value |
|---|---|---|---|
| Age (year), n (%) | | | 0.985 |
| 18–45 | 4 (6.9) | 2 (6.3) | |
| 46–60 | 12 (20.7) | 7 (21.9) | |
| 61–75 | 20 (34.5) | 12 (37.5) | |
| >75 | 22 (37.9) | 11 (34.4) | |
| Gender (male), n (%) | 34 (58.6) | 20 (62.5) | 0.823 |
| Hospitalization ward, n (%) | | | <0.001 |
| General ward | 33 (56.9) | 30 (93.7) | |
| ICU | 25 (43.1) | 2 (6.3) | |
| Hospital acquired UTIs, n (%) | 49 (84.5) | 16 (50) | <0.001 |
| Complicated UTIs, n (%) | 43 (74.1) | 16 (50) | 0.021 |
| Time of catheter (mean ± SD) (day) | 26.38±30.19 | 5.56±7.19 | <0.001 |
| Length of stay (mean ± SD) (day) | 50.5±47.74 | 16.31±17.23 | 0.001 |
| In-hospital mortality, n (%) | 10 (17.2) | 4 (12.5) | 0.763 |
| Comorbidities, n (%) | | | |
| Diabetes mellitus | 12 (20.7) | 5 (15.6) | 0.779 |
| Chronic respiratory disease | 14 (24.1) | 4 (12.5) | 0.272 |
| Chronic liver disease | 6 (10.3) | 2 (6.3) | 0.707 |
| Chronic kidney disease | 15 (25.9) | 9 (28.1) | 0.809 |
| Congestive heart failure | 27 (46.6) | 5 (15.6) | 0.003 |
| Solid tumor | 23 (39.7) | 13 (40.6) | 1.000 |
| Leukemia/lymphoma | 0 (0) | 3 (9.4) | 0.042 |
| Cerebrovascular accident | 15 (25.9) | 2 (6.3) | 0.026 |
| Septic shock | 19 (32.8) | 3 (9.4) | 0.013 |
| Immunosuppression | 7 (12.1) | 7 (21.9) | 0.238 |
| Hypoproteinemia | 38 (65.5) | 14 (43.8) | 0.074 |
| Invasive device, n (%) | | | |
| Central venous catheter | 39 (67.2) | 10 (31.3) | 0.001 |
| Ventilation | 33 (56.9) | 5 (15.6) | <0.001 |
| Nasogastric feeding tube | 36 (62.1) | 7 (21.9) | <0.001 |
| Thoracic and abdominal drainage tube | 37 (63.8) | 11 (34.4) | <0.001 |
| MDR (+), n (%) | 57 (98.3) | 4 (12.5) | <0.001 |
| CRE (+), n (%) | 27 (46.6) | 0 (0) | <0.001 |
| Bloodstream infection with KP, n (%) | 3 (5.2) | 0 (0) | 0.550 |

ESBL, extended-spectrum β-lactamase; *KP*-CAUTIs, *Klebsiella pneumoniae*-related catheter-associated urinary tract infection; MDR, multidrug resistance; CRE, Carbapenem-resistant Enterobacteriaceae.

**Table 3** Multivariate logistic regression analysis of ESBL positive KP-CAUTIs

| | OR (95% CI) | P |
|---|---|---|
| Complicated UTIs, n (%) | 59.256 (3.417–1,027.628) | 0.005 |
| Central venous catheter | 63.648 (0.973–4,163.155) | 0.052 |

ESBL, extended-spectrum β-lactamase; *KP*-CAUTIs, *Klebsiella pneumoniae*-related catheter-associated urinary tract infections.

subgroups according to death in hospital or not, and relevant conditions were compared via univariate analysis. Fourteen patients died during hospitalization. Between the two subgroups, significant differences were found regarding the ICU occupancy rate, frequency of combined cUTI, duration of catheterization, and LOS (P=0.004, P=0.019, P=0.008, and P=0.001, respectively). Regarding comorbidities, the in-hospital mortality subgroup had higher rates of congestive heart failure and septic shock (P<0.001 and P=0.001, respectively). Patients in the in-hospital mortality subgroup were more likely to use invasive devices and exhibit infection with CRE (both P=0.002). Concerning antimicrobial activity, the subgroups only displayed a difference in the frequency of resistance to carbapenems (P=0.002, *Table 4*).

According to multivariate logistic regression analysis, only congestive heart failure was significantly associated with in-hospital mortality in patients with *KP*-CAUTI (OR 25.592; 95% CI, 2.376–275.629; P=0.008) (*Table 5*).

## Discussion

Although *KP* has had an increasingly important role in infection at various sites (i.e., urinary tract, pulmonary, bloodstream, biliary tract) in recent years, there has been little research on CAUTIs caused by *KP* (9,11,15,16). To our knowledge, this is the first population-based study of *KP*-CAUTIs in China.

Urinary catheterization has long been recognized as a major risk factor for healthcare-associated UTIs. CAUTIs are amongst the most common nosocomial infections, and they are also considered among the most common complications associated with indwelling urinary catheters (17). Female was identified as an independent risk factor for CAUTIs in a study by Gillen *et al.* because of their shorter and wider urethra (18). However, Hagerty *et al.* did not find the same relevance in their study (19). In our study, more than half of patients with *KP*-CAUTI were male, which differs from previous findings. This may be explained by their underlying or functional urethra obstruction with age makes catheterization necessary, which may change the microbial environment of urine, resulting in biofilm formation, and emergence of drug-resistant bacteria. Catheterization always results in a higher rate of ICU admission and longer LOS, which are linked to substantial morbidity and mortality. In the US, approximately 60% of ICU and 20% of general ward patients undergo catheterization, which increases the risk of hospital-acquired CAUTIs (20,21). In addition, CAUTIs were linked to 2.4 additional inpatient days among pediatric patients in Goudie's study. Similar findings were reported in adult patients by Clarence, who found that CAUTIs increased LOS in the ICU and hospital by a median of 13 and 2.4 days, respectively (5,22). Clarence also identified an association between CAUTIs and increased crude hospital mortality even after restricting the analysis (5). A nearly 3-fold increase in mortality among hospitalized patients with CAUTI was reported by Platt (23). The most commonly cited indications for catheter use were the need for accurate input or output monitoring in critically ill patients, perioperative use, and prolonged immobilization (24). Catheterization is extremely necessary among patients with fatal or bedridden comorbidities such as congestive heart failure, septic shock, or cerebrovascular accident, which always present with consumptive malnutrition as reported in our study. Both Li and Loveday identified diabetes mellitus and chronic kidney diseases as high risk factors for CAUTIs for possible kidney injury and infection (25,26); however, our data did not reveal such tendency. This may be related to differences in study designs and populations, but their potential mechanisms are worthy of further study. What we can confirm is that patients who exhibit prolonged LOS in the hospital after catheterization usually have serious underlying comorbidities which make them more susceptible to infections as well as increased antibiotic resistance and mortality.

ESBL is an enzyme usually produced by Enterobacteriaceae species that makes them resistant to several antibiotics commonly used to treat UTIs (27). In a program of 199 hospitals from 42 countries worldwide conducted by Castanheira *et al.* over 20 years, the second most common isolate with an ESBL phenotype was *KP* (43.7%). They also found that the most common multidrug-resistant species was *KP* (35.2%), and carbapenem-resistant *KP* was found to be the main driver of CRE positivity, comprising 71.1% of such isolates. These isolates were linked to delayed diagnosis and management, increased ICU admission, high

 

**Table 4** Risk factors analysis of in-hospital mortality in patients with KP-CAUTI

| | In-hospital mortality, (n=14) | non-in-hospital mortality, (n=76) | P value |
|---|---|---|---|
| Age (year), n (%) | | | 1.000 |
| 18–45 | 1 (7.1) | 5 (6.6) | |
| 46–60 | 3 (21.4) | 16 (21.1) | |
| 61–75 | 5 (35.7) | 27 (35.5) | |
| >75 | 5 (35.7) | 28 (36.8) | |
| Gender (male), n (%) | 7 (50.0) | 47 (61.8) | 0.554 |
| Hospitalization ward, n (%) | | | 0.004 |
| General ward | 5 (35.7) | 58 (76.3) | |
| ICU | 9 (64.3) | 18 (23.7) | |
| Hospital acquired UTIs, n (%) | 12 (85.7) | 53 (69.7) | 0.334 |
| Complicated UTIs, n (%) | 13 (92.9) | 30 (39.5) | 0.019 |
| Time of catheter (mean ± SD) (day) | 36.14±32.75 | 15.82±24.13 | 0.008 |
| Length of stay (mean ± SD) (day) | 74.29±53.62 | 31.72±37.32 | 0.001 |
| Comorbidities, n (%) | | | |
| Diabetes mellitus | 1 (7.1) | 16 (21.1) | 0.292 |
| Chronic respiratory disease | 5 (35.7) | 13 (17.1) | 0.144 |
| Chronic liver disease | 1 (7.1) | 7 (9.2) | 1.000 |
| Chronic kidney disease | 3 (21.4) | 21 (27.6) | 0.752 |
| Congestive heart failure | 13 (92.9) | 19 (25.0) | <0.001 |
| Solid tumor | 5 (35.7) | 31 (40.8) | 0.776 |
| Leukemia/lymphoma | 1 (7.1) | 2 (2.6) | 0.402 |
| Cerebrovascular accident | 5 (35.7) | 12 (15.8) | 0.130 |
| Septic shock | 9 (64.3) | 13 (17.1) | 0.001 |
| Immunosuppression | 3 (21.4) | 11 (14.5) | 0.451 |
| Hypoproteinemia | 11 (78.6) | 41 (53.9) | 0.140 |
| Invasive device, n (%) | | | |
| Central venous catheter | 13 (92.9) | 36 (47.4) | 0.002 |
| Ventilation | 12 (85.7) | 26 (34.2) | 0.001 |
| Nasogastric feeding tube | 12 (85.7) | 31 (40.8) | 0.003 |
| Thoracic and abdominal Drainage tube | 11 (78.6) | 37 (48.7) | 0.046 |
| ESBL (+), n (%) | 10 (71.4) | 48 (63.2) | 0.763 |
| MDR (+), n (%) | 10 (71.4) | 51 (67.1) | 1 |
| CRE (+), n (%) | 9 (64.3) | 18 (23.7) | 0.002 |
| Bloodstream infection with KP, n (%) | 1 (7.1) | 2 (2.6) | 0.402 |

**Table 4** (*continued*)

**Table 4** (*continued*)

| | In-hospital mortality, (n=14) | non-in-hospital mortality, (n=76) | P value |
|---|---|---|---|
| Antimicrobial activity of KP (resistance), n (%) | | | |
| Second generation Cephalosporins | 10 (71.4) | 54 (71.7) | 1 |
| Third generation Cephalosporins | 10 (71.4) | 41 (53.9) | 0.257 |
| Forth generation Cephalosporins | 11 (78.6) | 40 (52.6) | 0.085 |
| Cefoperazone-sulbactam | 10 (71.4) | 43 (56.6) | 0.383 |
| Aminoglycosides | 9 (64.3) | 32 (42.1) | 0.152 |
| Fluoroquinolones | 9 (64.3) | 47 (61.8) | 1 |
| Carbapenems | 9 (64.3) | 18 (23.7) | 0.002 |
| Piperacillin-Tazobactam | 13 (92.9) | 61 (80.3) | 0.450 |

*KP*-CAUTI, *Klebsiella pneumoniae*-related catheter-associated urinary tract infection; ESBL, extended-spectrum β-lactamase; MDR, multidrug resistance; CRE, Carbapenem-resistant Enterobacteriaceae.

**Table 5** Multivariate logistic regression analysis of in-hospital mortality in patients with KP-CAUTI

| | OR (95% CI) | P |
|---|---|---|
| Congestive heart failure | 25.592 (2.376–275.629) | 0.008 |

*KP*-CAUTI, *Klebsiella pneumoniae*-related catheter-associated urinary tract infection.

mortality, increased hospital cost, and longer LOS in the hospital (27,28). Both Ranjan Dash and Søraas reported that diabetes mellitus is significantly associated with ESBL expression in patients with UTI. However, we did not obtain similar results in our study, which may be the result of our focus on *KP*-CAUTIs opposed to a broader analysis of patients with UTI (29,30). An in-depth and specific study should be conducted to clarify the mechanisms. cUTI, as defined by the FDA, applies to pyelonephritis or UTI in a host with predisposing conditions that have been associated with high rates of treatment failure and serious complications, especially relapse and the development of antibiotic resistance (14,31,32). As a type of cUTIs by FDA, CAUTIs always arise in patients with critical illness, perioperative state, or prolonged immobilization. To deeply study CAUTIs, we focused on patients with CAUTI and other structural urinary tract disorders separately for further comparison. In our study, cUTI was distinctively related to ESBL positive *KP*-CAUTIs. This may be attributable to abnormal urination, prolonged urinary retention, and microbial culturing, which increase the risk of antibiotic resistance. Additional studies are needed to gain insights into their underlying relationships. Interestingly, we found an underlying correlation between central venous catheterization and ESBL positive *KP*-CAUTIs in our subgroup analysis. Central venous catheterization, which had not previously been studied, was cited as a risk factor for nosocomial bacteremia secondary to UTIs in a study by Sante providing a foundation for further investigation (33).

In-hospital mortality is the utmost worst prognosis for patients, every link of diagnosis and treatment process can influence disease trend even lead to medical treatment failure eventually. Several variables, including age, disease state, indwelling with catheter, LOS, microbial infection, or antibiotic resistance, can increase the risk of death. However, only congestive heart failure was identified as an independent risk factor for death in hospital among patients with *KP*-CAUTI in our study. As a fatal disease itself, congestive heart failure requires catheterization for accurately monitoring input and output. The catheter itself and duration of catheterization both increase the risk of nosocomial death. However, in a study by Allison, congestive heart failure was surprisingly associated with a lower risk of CAUTIs in their population (34). The reason for this conclusion may be possibly explained by differences in the populations (age, sample size, country, and setting). Further studies with larger multicenter samples are needed to confirm this correlation.

There were several limitations in our study. Firstly, our data were obtained from a single hospital, which resulted in a less diverse and representative population of patients. Secondly, our study was retrospective, carrying a certain risk of bias. Thirdly, the data were obtained from a

 

hospital in southeastern China, and the findings may not be generalizable to other regions.

## Conclusions

Our study provided new insights into CAUTIs, as clinical characteristics and risk factors for this infection were identified. Patients with *KP*-CAUTI exhibited unique features. cUTI was identified as an independent risk factor for ESBL positive *KP*-CAUTIs, and congestive heart failure was identified as an independent risk factor for in-hospital mortality among patients with *KP*-CAUTI. We believe this article will provide meaningful information for clinicians in daily practice, and additional large-scale, multicenter studies are needed to investigate this special group.

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## Footnote

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