

BMJ Open Characteristics of urinary tract infection pathogens and their in vitro susceptibility to antimicrobial agents in China: data from a multicenter study

Lu-Dong Qiao,¹ Shan Chen,¹ Yong Yang,² Kai Zhang,³ Bo Zheng,⁴ Hong-Feng Guo,⁵ Bo Yang,⁶ Yuan-Jie Niu,⁷ Yi Wang,⁸ Ben-Kang Shi,⁹ Wei-Min Yang,¹⁰ Xiao-Kun Zhao,¹¹ Xiao-Feng Gao,¹² Ming Chen,¹³ Ye Tian¹⁴

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For numbered affiliations see end of article.

Correspondence to
Professor Ye Tian;
tianye166@126.com

ABSTRACT

Objective: This study assessed the characteristics of pathogens identified in clinical isolates from patients with urinary tract infection (UTI) and their in vitro sensitivity to commonly used antibiotics in the clinical setting in China.

Design and setting: Multicenter study was conducted between January and December 2011 in 12 hospitals in China.

Participants: Urine samples were collected from 356 symptomatic patients treated in the study hospitals for acute uncomplicated cystitis, recurrent UTI or complicated UTI.

Primary and secondary outcome measures:

Minimal inhibitory concentrations (MICs) were measured using broth microdilution according to the Clinical and Laboratory Standards Institute 2011 guidelines. Thirteen antimicrobial agents were tested: fosfomycin tromethamine, levofloxacin, moxifloxacin, cefdinir, cefixime, cefaclor, cefprozil, cefuroxime, amoxicillin/clavulanic acid, cefotaxime, azithromycin, nitrofurantoin and oxacillin. *Escherichia coli* isolates were screened and extended spectrum β -lactamases (ESBL) production was confirmed by a double-disk synergy test.

Results: 198 urine samples were culture-positive and 175 isolates were included in the final analysis. *E coli* was detected in 50% of cultures, followed by *Staphylococcus epidermidis* (9%), *Enterococcus faecalis* (9%) and *Klebsiella pneumoniae* (5%). The detection rate of ESBL-producing *E coli* was 53%. Resistance to levofloxacin was the most common among all the isolates. Nitrofurantoin and fosfomycin tromethamine had the greatest activity against *E coli*; overall, 92% and 91% of isolates were susceptible to these antimicrobials. *E faecalis* had the highest susceptibility rates to fosfomycin tromethamine (100%).

Conclusions: The most frequently identified pathogens in our patients were ESBL-producing *E coli* and *E faecalis*. Fosfomycin tromethamine and nitrofurantoin showed a good antimicrobial activity against UTI pathogens. They may represent good options for the empiric treatment of patients with UTI.

Strengths and limitations of this study

- This study was conducted in 12 major clinical research centres from China. Antibiotic susceptibility was tested with 13 antimicrobial agents that are frequently used in the clinical practice in China.
- A strength of the study is correct subspecification of coagulase negative staphylococci, enterococci and streptococci.
- For several pathogens, due to the relatively low number of tested isolates, differences in susceptibility patterns between various urinary tract infection (UTI) types could not be assessed. No distinction was made between community-acquired and healthcare-associated UTIs.

INTRODUCTION

Urinary tract infections (UTIs) are common infectious diseases in clinical practice. An estimated 150 million people worldwide are diagnosed with a UTI each year,¹ and 40–50% of women present a UTI at least once in their lifetime.^{2–5} The results of a survey performed in the USA estimated that a UTI episode was associated with an average of 6.1 days with symptoms, 2.4 days of reduced activity and 0.4 days of bed rest, thus generating an estimated annual cost (direct and indirect) of 1.6 billion dollars.^{6–8} In China, UTIs account for 9.39–50% of nosocomial infections.^{9 10} Most cases of UTI are caused by Gram-negative bacilli, with *Escherichia coli* accounting for over 90% of uncomplicated UTIs.¹¹ Uncomplicated infections can be treated with short courses of antibiotics, while complicated UTIs require longer and more intensive courses of antibiotics. However, resistance to the commonly used antibiotics is increasing and making treatment more difficult.

In China, clinical isolates of *E coli* have been shown to have resistance rates as high as 20.6–27.9% to amoxicillin/clavulanic acid, 64.7–74% to ciprofloxacin and 71.1–80.1% to piperacillin.^{12 13} Many cases in which UTIs are resistant to conventional treatment have been associated with *E coli* isolates producing extended spectrum β -lactamases (ESBLs). The emergence of these ESBL-producing isolates makes clinical treatment even more difficult. This study assesses the distribution of pathogens of acute uncomplicated cystitis, recurrent UTI or complicated UTI and their in-vitro sensitivity to commonly used antibiotics in the clinical treatment of these infections. These findings will be informative for physicians in their decision-making in empirical medicine, thus contributing to the prevention and mitigation of the increase in drug resistance.

PATIENTS AND METHODS

Source of isolates

Enrolled patients were between 18 years old and 70 years old, suffered from acute uncomplicated cystitis, recurrent UTI or complicated UTI, were symptomatic and were treated in the urology department in 1 of 12 clinical research centres between 26 January and 7 December 2011. The study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Beijing Tongren Affiliated Hospital of Capital Medical University. The study patients signed an informed consent form before any study procedure was conducted. Midstream urine specimens for bacterial culture were collected before treatment. Colony counts higher than or equal to 10^4 colony forming units (CFU)/mL were considered significant.

Antibiotics and reagents

The following antimicrobial agents were used for susceptibility testing: oxacillin, amoxicillin, cefaclor, cefuroxime and nitrofurantoin, obtained from the National Institute for Food and Drug control (Beijing, China); levofloxacin from Daiichi Sankyo (Beijing, China); moxifloxacin and fosfomicin tromethamine produced by Shanxi Qianyuan Pharmaceutical Co., Ltd (Shanxi, China); cefdinir from Jinkang, Tianjin Pharmaceutical Group (Tianjin, China); cefixime from Guangzhou Baiyunshan Pharmaceutical Factory (Guangzhou, China); cefprozil from Bristol-Myers Squibb (Shanghai, China); cefotaxime from Sanjiu Group Shenzhen Jiuxin Pharmaceutical Co., Ltd (Shenzhen, China); azithromycin from Pfizer (Dalian, China) and clavulanic acid from GlaxoSmithKline (Tianjin, China).

The amoxicillin/clavulanic acid combination was used at a ratio of 2:1. For the cefotaxime/clavulanic acid combination, clavulanic acid concentration was kept constant at 4 mg/L. Susceptibility medium (Mueller-Hinton (MH)), ceftazidime (CAZ, 30 μ g) (used to detect ESBLs), amoxicillin/clavulanic acid (AMC, 20 μ g/10 μ g) and cefotaxime (CTX, 30 μ g) susceptibility paper disks were purchased from Thermo Fisher Biochemicals (Beijing) Ltd (Beijing, China).

Tested isolates

The sensitivity test was standardised using the following reference isolates: *Staphylococcus aureus* ATCC 29213, *E faecalis* ATCC 29212, *E coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853, originating from the American-type culture collection.

Clinical isolates were identified in the urine samples collected in the clinical research centres participating in the study. Medium and incubation conditions: *S aureus*, *Enterococcus* spp and Gram-negative bacteria were incubated in MH medium at 35°C for 16–20 h. Susceptibility of staphylococci to oxacillin was assessed using MH agar supplemented with 2% NaCl solution, and 24 h additional incubation. Streptococci were incubated in blood culture medium (5% defibrinated sheep blood added to MH medium) at 35°C in 5% CO₂ (CO₂ incubator) for 20–24 h.

Minimum inhibitory concentration measurement

For minimal inhibitory concentration (MIC) measurement, a standard plate count and double dilution method was used. Bacterial suspensions to be tested were prepared by inoculation with 10^4 CFU of each bacterium, using a multipoint inoculator. The MIC of the antimicrobial agents was measured for a variety of pathogens.

Processing of the results

MIC₅₀ and MIC₉₀ values were calculated, as well as the bacterial resistance rate, the intermediate rate and the sensitivity rate according to the critical concentration standards for antimicrobial drugs promulgated by the Clinical and Laboratory Standards Institute in 2011.¹⁴ ESBL-producing *E coli*, *Klebsiella pneumoniae* and *Proteus mirabilis* were identified using a double-disc synergy test.¹⁵

RESULTS

Distribution of isolates

A total of 356 patients were enrolled and provided a urine sample. Of these, 198 (55.6%) tested positive for significant bacteriuria. In 23 urine samples, the clinical pathogens could not be identified without performing additional tests and were excluded from the analysis. A total of 175 isolates with identified pathogens were included in the final analysis: 116 (66.3%) Gram-negative bacteria and 59 (33.7%) Gram-positive bacteria. *E coli* was the most frequently identified Gram-negative bacteria (in 87 isolates (49.7%)). The most frequently identified Gram-positive pathogens were: *Staphylococcus* spp (in 30 isolates (17.1%)), *Enterococcus* spp (in 19 isolates (10.9%)) and *Streptococcus* spp (in 10 isolates (5.7%)); (table 1).

Of the 175 isolates, 124 (70.9%) were from women, with *E coli* and *K pneumoniae* being the most frequently identified. In men, the most frequently identified pathogens were *E coli* and *E faecalis* (table 2).

Ninety-five isolates were from patients with acute uncomplicated cystitis, 42 from patients with recurrent UTIs and 37 from patients with complicated UTIs (table 3).

Table 1 Number and proportion of isolated pathogens from midstream urine species

Gram-negative bacteria n=116			Gram-positive bacteria n=59		
Bacterium	N	Per cent*	Bacterium	N	Per cent*
<i>Escherichia coli</i>	87	49.71	<i>Staphylococcus aureus</i>	4	2.29
<i>Klebsiella pneumoniae</i>	9	5.14	<i>Staphylococcus epidermidis</i>	16	9.14
<i>Proteus mirabilis</i>	6	3.43	<i>Staphylococcus hominis</i>	5	2.86
<i>Proteus vulgaris</i>	2	1.14	<i>Staphylococcus saprophyticus</i>	2	1.14
<i>Proteus penneri</i>	1	0.57	<i>Staphylococcus haemolyticus</i>	1	0.57
<i>Enterobacter cloacae</i>	2	1.14	<i>Staphylococcus schleiferi</i>	1	0.57
<i>Citrobacter freundii</i>	2	1.14	<i>Staphylococcus warneri</i>	1	0.57
<i>Citrobacter koseri</i>	1	0.57	<i>Enterococcus faecalis</i>	15	8.57
<i>Serratia marcescens</i>	1	0.57	<i>Enterococcus faecium</i>	3	1.71
<i>Pseudomonas aeruginosa</i>	4	2.29	<i>Enterococcus gallinarum</i>	1	0.57
<i>Pseudomonas putida</i>	1	0.57	<i>Streptococcus agalactiae</i>	5	2.86
			<i>Streptococcus oralis</i>	2	1.14
			<i>Streptococcus acidominimus</i>	1	0.57
			<i>Streptococcus haemolyticus</i>	1	0.57
			<i>Streptococcus mitis</i>	1	0.57

*Percentages are computed on a total of 175 isolates.
n, number of isolates analysed; N, number of isolates within a category.

E coli antibiotic resistance

Of the 87 *E coli* isolates, 49.4% were resistant to levofloxacin, 50.6% were resistant to second-generation cephalosporin and 57.5% to third-generation cephalosporin. Forty-six *E coli* isolates (52.9%) were ESBL producers (table 4).

Nitrofurantoin and fosfomycin tromethamine had the greatest activity against *E coli*; overall, 92% and 91% of isolates were susceptible to these antimicrobials. The percentages of isolates positive for *E coli* by UTI type, and the proportion of ESBL-producing isolates are presented in table 3.

Susceptibility results for *K pneumoniae* and *Proteus spp*

Overall, nine isolates were identified as *K pneumoniae* (5.1%) and nine as *Proteus* bacilli (5.1%). The corresponding susceptibility results are presented in table 5.

Antibacterial activity of commonly used antibiotics against coagulase-negative staphylococci and *E faecalis*

For coagulase-negative staphylococci, sensitivity rates ranged from 38.5% for oxacillin to 100% for

nitrofurantoin and resistance rates from 0% for nitrofurantoin to 84.6% for azithromycin. For *Staphylococcus epidermidis*, sensitivity rates ranged from 18.8% for azithromycin to 100% for nitrofurantoin and fosfomycin tromethamine; and resistance rates ranged from 0% for nitrofurantoin and fosfomycin tromethamine to 81.2% for azithromycin. The resistance rate of *E faecalis* against levofloxacin was 60%, while the sensitivity rate to fosfomycin tromethamine and nitrofurantoin was 100%. MIC values for these pathogens are presented in table 6.

DISCUSSION

We demonstrated that, in Chinese patients with symptomatic UTI enrolled from research hospitals, *E coli* was the most frequent pathogen identified in men and women, accounting for 49.7% of the total isolates. Other pathogens identified were *S epidermidis* (9.1%), *E faecalis* (8.6%), *K pneumoniae* (5.1%) and *P mirabilis* (3.4%). The results obtained in this study are similar to those of other studies conducted in China.¹⁶ Although *E coli* was the leading cause of UTI in men, its proportion was lower than in women. The prevalence of *E faecalis*

Table 2 The distribution of pathogens in patients according to gender

Bacteria	Women		Men	
	Number of patients	Per cent	Number of patients	Per cent
<i>Escherichia coli</i>	68	54.84	19	37.25
<i>Klebsiella pneumoniae</i>	9	7.26	0	0
<i>Staphylococcus epidermidis</i>	10	8.06	6	11.76
<i>Enterococcus faecalis</i>	5	4.03	10	19.61
Others	32	2.58	16	3.14
Total	124		51	

Table 3 Bacterial character of different types of UTIs

	Total isolates	Number of Gram-negative bacteria (% [*])	Number of <i>E coli</i> (% [†])	Number of ESBL positive <i>E coli</i> (% [‡])
Acute uncomplicated cystitis	96	68 (70.83)	51 (53.13)	25 (49.02%)
Recurrent UTIs	42	29 (69.05)	21 (50.00)	12 (57.14%)
Complicated UTIs	37	19 (51.35)	15 (40.54)	9 (60.00%)

*Percentages are computed on the number of total bacteria.

†Percentages are computed on the number of Gram-negative bacteria.

‡Percentages are computed on the number of *E coli*.

E coli, *Escherichia coli*; UTIs, urinary tract infections.

infections was higher in men than in women. The infection rate with Gram-negative bacteria was higher in patients with uncomplicated cystitis than in patients with recurrent or complicated UTI, while the infection rate with Gram-positive bacteria showed an inverse trend.

E coli is the most common Gram-negative bacteria identified in UTIs.^{17 18} In our study, the resistance rate of this pathogen to fluoroquinolones (levofloxacin) and to second-generation and third-generation cephalosporin was high, ranging from 49.4% to 57.5%. This is similar to the rates of antibiotic resistance previously reported in Chinese populations.^{19 20} The clinical trials conducted worldwide have reported resistance rates of up to 80% against fluoroquinolones²⁰ and up to 75% against cephalosporin among uropathogenic *E coli*.¹⁹ An important mechanism of antibiotic resistance among pathogens is through ESBL production. ESBL hydrolyses oxyimino- β -lactams such as cephalosporin and monobactam.¹⁹ *E coli* is one of the main ESBL-producing pathogens. ESBL production is transmitted from one bacterium to another through plasmids. These plasmids can carry multiple drug-resistant genes against aminoglycosides, quinolones and sulfamethoxazole at the same time.²¹ The phenomenon of

multidrug resistance has brought tremendous difficulties to the clinical treatment of infection due to limited therapeutic options.^{16 22} Haishen *et al*²³ showed that ESBL-producing *E coli* have a high resistance rate, ranging from 28.6% to 85.7% against the majority of antibiotics (excluding sulfamethoxazole), which is 20% to 80% higher than in *E coli* that do not produce ESBLs.

An increasing prevalence of ESBL-positive bacteria isolated from UTI patients has made the empirical treatment of these diseases difficult. Consequently, carbapenems have been increasingly prescribed as an empirical treatment for complicated UTIs, thus promoting the selection of drug-resistant bacteria and an increased prevalence of flora imbalance and fungal infections. In our study, the proportion of *E coli* varied with the UTI type: the prevalence of *E coli* overall and of ESBL-producing *E coli* was lower in isolates from cases diagnosed with acute uncomplicated cystitis, compared with recurrent and complicated UTIs. The prevalence of ESBL-producing *E coli* reached 60% in isolates from cases diagnosed with complicated UTI. Susceptibility results showed that the resistance rate of ESBL-producing *E coli* isolates against commonly used antimicrobial drugs was higher than the rate observed in

Table 4 Antibacterial activity, bacterial sensitivity, intermediate sensitivity and resistance to antibiotics commonly used against ESBL-negative and ESBL-positive *Escherichia coli*

Antimicrobial drug	ESBL-negative <i>E coli</i> (41 isolates)					ESBL-positive <i>E coli</i> (46 isolates)				
	MIC ₅₀	MIC ₉₀	S%	I%	R%	MIC ₅₀	MIC ₉₀	S%	I%	R%
Fosfomycin tromethamine*	0.125	05	95.1	4.9	0.0	0.125	128	87.0	8.7	4.3
Levofloxacin	1	16	61.0	4.9	34.1	8	32	21.7	15.3	63.0
Moxifloxacin	0.5	32	–	–	–	16	64	–	–	–
Cefdinir	0.25	2	87.8	2.4	9.8	256	>256	4.3	2.2	93.5
Cefixime	0.5	2	82.9	9.8	7.3	32	128	4.3	6.6	89.1
Cefaclor	2	4	90.2	2.5	7.3	>256	>256	2.2	2.1	95.7
Cefprozil	2	8	90.2	0.0	9.8	>256	>256	2.2	2.1	95.7
Cefuroxime	4	16	82.9	7.3	9.8	>256	>256	0.0	0.0	100.0
Amoxicillin/clavulanic acid	4	16	87.8	4.9	7.3	8	16	63.0	34.8	2.2
Cefotaxime	0.062	0.5	95.1	0.0	4.9	64	256	2.2	0.0	97.8
Nitrofurantoin	16	32	90.2	4.9	4.9	16	32	93.5	6.5	0.0

*Determination of the breakpoint of fosfomycin tromethamine to Enterobacteriaceae (sensitivity rate ≤ 64 mg/L; resistance rate ≥ 256 mg/L).

E coli, *Escherichia coli*; ESBL, extended spectrum β -lactamases; I, intermediate; MIC, minimal inhibitory concentration; R, resistant; S, susceptible.

Table 5 Antimicrobial activity, bacterial sensitivity, intermediate sensitivity and resistance to antibiotics commonly used against *Klebsiella pneumoniae* and *Proteus* spp

Antimicrobial drug	<i>K pneumoniae</i> (9 isolates)					<i>Proteus</i> spp (9 isolates)				
	MIC ₅₀	MIC ₉₀	S%	I%	R%	MIC ₅₀	MIC ₉₀	S%	I%	R%
Fosfomycin tromethamine*	1	32	100.0	0.0	0.0	1	>256	55.6	22.2	22.2
Levofloxacin	0.125	>256	66.7	0.0	33.3	1	16	55.6	11.1	33.3
Moxifloxacin	0.062	>256	–	–	–	8	64	–	–	–
Cefdinir	128	256	44.4	0.0	55.6	0.25	32	55.6	0.0	44.4
Cefixime	2	>256	44.4	11.2	44.4	≤0.016	16	77.8	0.0	22.2
Cefaclor	256	>256	44.4	0.0	55.6	>256	>256	44.4	0.0	55.6
Cefprozil	>256	>256	44.4	0.0	55.6	256	>256	44.4	0.0	55.6
Cefuroxime	64	>256	44.4	0.0	55.6	128	>256	44.4	0.0	55.6
Amoxicillin/clavulanic acid	8	16	66.7	33.3	0.0	16	64	44.4	44.5	11.1
Cefotaxime	2	128	44.4	11.2	44.4	0.125	64	66.7	0.0	33.3
Nitrofurantoin	32	256	66.7	22.2	11.1	64	128	11.1	77.8	11.1

*Determination of the breakpoint of fosfomycin tromethamine to Enterobacteriaceae (sensitivity rate ≤64 mg/L; resistance rate ≥256 mg/L). I, intermediate; MIC, minimal inhibitory concentration; R, resistant; S, susceptible.

ESBL-negative *E coli* isolates. We thus consider that in the treatment of complicated UTIs, antibiotics should be indicated based on susceptibility results.

Our findings showed a good antibacterial activity of fosfomycin tromethamine against both ESBL-negative and ESBL-producing *E coli*, with bacterial sensitivity rates of 95.1% and 87% and resistance rates of 0% and 4.3%, respectively. The antibacterial effect of this compound on ESBL-producing *E coli* was slightly inferior to nitrofurantoin but superior to the other tested drugs, and consistent with previously published findings.²⁴ In addition, a significant antibacterial activity was demonstrated against *K pneumoniae*. However, empirical treatment with fosfomycin tromethamine and nitrofurantoin is only indicated in uncomplicated UTIs.

In our study, coagulase-negative staphylococci were the major Gram-positive pathogens identified. Initially considered as part of commensal flora and culture contaminants, since 1970 this type of staphylococci has been recognised as an aetiological agent in a variety of infections.²⁵ The main virulence factor is mucilage polysaccharide (biofilm) production²⁶ facilitating their adhesion to smooth surfaces (such as the uroepithelium)²⁷ and providing resistance against antibiotics and phagocytosis.^{28, 29} In our study, Gram-positive bacteria were isolated more frequently in samples from cases with complicated UTIs than in samples from cases with uncomplicated UTIs. Furthermore, *S epidermidis* was more frequently identified in women, and *E faecalis* was more frequently identified in men than in women. These gender differences observed in the aetiology of

Table 6 Antimicrobial activity, bacterial sensitivity, intermediate sensitivity and resistance to antibiotics commonly used against coagulase-negative *Staphylococcus* spp, *Staphylococcus epidermidis* and *Enterococcus faecalis*

Antimicrobial drug	Coagulase-negative <i>Staphylococcus</i> spp (26 isolates)					<i>S epidermidis</i> (16 isolates)					<i>E faecalis</i> (15 isolates)				
	MIC ₅₀	MIC ₉₀	S%	I%	R%	MIC ₅₀	MIC ₉₀	S%	I%	R%	MIC ₅₀	MIC ₉₀	S%	I%	R%
Fosfomycin tromethamine*	0.25	32	96.2	0.0	3.8	0.25	0.5	100.0	0.0	0.0	32	32	100.0	0.0	0.0
Levofloxacin	0.5	128	50.0	0.0	50.0	4	128	43.8	0.0	56.2	8	32	40.0	0.0	60.0
Moxifloxacin	0.125	16	50.0	23.1	26.9	1	16	43.8	31.2	25.0	1	8	–	–	–
Cefdinir	0.5	>256	61.5	11.6	26.9	0.5	>256	56.3	12.5	31.2	1	>256	–	–	–
Cefixime	16	>256	–	–	–	16	>256	–	–	–	8	>256	–	–	–
Cefaclor	4	64	69.2	19.3	11.5	4	64	68.8	18.7	12.5	64	>256	–	–	–
Cefprozil	1	32	88.5	0.0	11.5	1	32	87.5	0.0	12.5	8	64	–	–	–
Cefuroxime	1	128	88.5	0.0	11.5	1	128	87.5	0.0	12.5	8	>256	–	–	–
Amoxicillin/clavulanic acid	0.5	16	88.5	–	11.5	0.25	16	87.5	–	12.5	0.5	2	–	–	–
Cefotaxime	2	16	88.5	7.7	3.8	2	16	87.5	12.5	0.0	2	>256	–	–	–
Azithromycin	64	>256	15.4	0.0	84.6	>256	>256	18.8	0.0	81.2	>256	>256	–	–	–
Nitrofurantoin	16	32	100.0	0.0	0.0	16	32	100.0	0.0	0.0	32	32	100.0	0.0	0.0
Oxacillin	0.5	128	38.5	–	61.5	0.5	128	37.5	–	62.5	–	–	–	–	–

*Determination of the breakpoint of fosfomycin tromethamine to Enterobacteriaceae (sensitivity rate ≤64 mg/L; resistance rate ≥256 mg/L). I, intermediate; MIC, minimal inhibitory concentration; R, resistant; S, susceptible.

UTIs should be considered in the selection of antibiotics. In our population, susceptibility results showed that *S epidermidis* had a high-resistance rate to levofloxacin (56.2%), but a moderate resistance rate to second-generation and third-generation cephalosporin (12.5%). Fosfomycin tromethamine demonstrated a larger antibacterial activity on coagulase-negative staphylococci than other tested antibiotics. For *S epidermidis*, MIC₅₀ and MIC₉₀ values were 0.25 and 0.5 mg/L, respectively, and sensitivity rates were up to 100%. The rate of resistance of *E faecalis* against levofloxacin was 60%, while the rate of sensitivity for fosfomycin tromethamine and nitrofurantoin was 100%, with MIC values between 8 and 32 mg/L. These results are consistent with those published by Perri *et al.*³⁰ who reported that 51 of the 52 *Enterococcus faecium* and all *E faecalis* isolates tested were susceptible or had intermediate susceptibility to fosfomycin.

CONCLUSION

The results of this multicenter study showed that ESBL-producing *E coli* is the main pathogen causing symptomatic UTIs in this Chinese population. Of concern is that the resistance rate of this pathogen against commonly used antibiotics has increased. Fosfomycin tromethamine and nitrofurantoin showed a good antibacterial activity against identified pathogens, and thus can be considered for use as empirical treatment in uncomplicated UTIs. However, the mechanism on bacterial resistance is complex and diverse, and the phenomenon of multidrug-resistant bacteria has become a global burden. Susceptibility testing is a valuable tool to help in the selection of antibiotic treatment.

Author affiliations

¹Department of Urology, Beijing Tongren Hospital Capital Medical University, Beijing, China

²Department of Urology, Beijing Cancer Hospital, Beijing, China

³Department of Urology, Peking University First Hospital, Beijing, China

⁴Institute of Clinical Pharmacology, Peking University First Hospital, Beijing, China

⁵Department of Urology, Peking University Shougang Hospital (Jieping Wu Urology Center), Beijing, China

⁶Department of Urology, Peking University People's Hospital, Beijing, China

⁷Department of Urology, Second Affiliated Hospital of Tianjin Medical University, Tianjin, China

⁸Department of Urology, First Affiliated Hospital of China Medical University, Shenyang, China

⁹Department of Urology, Qilu Hospital of Shandong University, Jinan, China

¹⁰Department of Urology, Hubei Tongji Hospital, Wuhan, China

¹¹Department of Urology, Hunan Xiangya Second Hospital, Changsha, China

¹²Department of Urology, Shanghai Changhai Hospital, Shanghai, China

¹³Department of Urology, Zhongda Hospital affiliated to Southeast University, Nanjing, China

¹⁴Department of Urology, Beijing Friendship Hospital Capital Medical University, Beijing, China

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