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Original Article

Antimicrobial Resistance Pattern of *Escherichia Coli* Isolated From Patients With Urinary Tract Infection in Tehran, Iran, in 2021

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Abstract

Background and aims: Urinary tract infections (UTIs) are intense public health problems and are precipitated by a variety of pathogens. This study was performed to determine the frequency of bacterial agents of UTIs and the antibiotic resistance pattern of *Escherichia coli* in urinary culture samples of patients at Shahid Ashrafi Esfahani hospital in Tehran, Iran.

Methods: A cross-sectional study was conducted on all urinary tract cultures from January 2021 to January 2022 at Shahid Ashrafi Esfahani hospital in Tehran, Iran. Urine culture and antimicrobial susceptibility tests were performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Statistical analyses were performed by appropriate descriptive and inferential tests such as the chi-square test using Stata version 17, and the level of significance was set at 0.05.

Results: The mean age of patients with *E. coli* was 50.2 ± 1.8 (confidence interval = 46.6-53.8) years, and their age range was between 6-87 years. The highest prevalence of infection occurred in men over 60 years of age and in women aged 40-60 years. Further, the highest resistance and the highest sensitivity were related to ceftazidime (CAZ) and cefotaxime (CTX), respectively.

Conclusion: In this study, the highest resistance and sensitivity belonged to CAZ and CTX, respectively. In addition, CTX is the primary antibiotic prescribed to deal with UTIs in medical practice.

Keywords: Antimicrobial resistance pattern, *Escherichia coli*, Urinary tract infection

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Introduction

Only 19 years after the discovery of antibiotics by Alexander Fleming in 1928, the first global report of penicillin resistance was reported. In later years, *Escherichia coli* resistance to fluoroquinolone was reported.[1-3] The World Health Organization (WHO) called on people around the world to unite on antibiotic resistance. Accordingly, 2011 was named by the WHO as "Combating drug resistance and its global spread"[4]. According to the Centers for Disease Control and Prevention and WHO, antimicrobial resistance (AMR) is described as non-susceptibility to a minimum of one agent in three or greater antimicrobial categories.[5] Urinary tract infections (UTIs) are intense public health problems precipitated by a variety of pathogens.[6] In 80% of cases, *E. coli* is a common pathogen in UTIs, and the production of a wide range of beta-lactamase produced by *E. coli* is spreading around the world.[7] AMR remains a major public health concern in all regions.[8] Unfortunately, AMR related to *E. coli* is growing worldwide. Due to the unpredictable pattern of antimicrobial susceptibility of the Enterobacteriaceae family, if antimicrobial treatment is considered, antibiotic susceptibility testing should be performed. This disease affects 150 million people every year worldwide.[9] In a study, this microorganism was introduced as the most common cause of UTIs and bacteriuria in Iran.[10] Since the pattern of drug resistance is affected by the epidemiology of every region, understanding this pattern is very important. Therefore, this study was conducted to determine the frequency of bacterial agents of UTIs in *E. coli* and to determine the pattern of antibiotic resistance in urinary culture samples of patients at Shahid Ashrafi Esfahani hospital in Tehran.

Materials and Methods

A cross-sectional study was conducted on all urinary tract cultures from January 2021 to January 2022 at Shahid Ashrafi Esfahani hospital in Tehran. Finally, 122 samples were included in this study. Patients were divided into male and female groups based on gender and were also divided into four age groups: less than 20 (n = 15, 12.30%), 20-40 (n = 19, 15.57%), 40-60 (n = 49, 40.16%), and above 60 (n = 39, 31.97%) years, respectively. Urine culture and antimicrobial susceptibility tests were performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Middle patients' urine was collected

in sterile containers. Urine samples containing a colony count greater than 10^5 CFU/mL were considered UTIs. In the laboratory, urine samples were cultured in blood agar and MacConkey agar media under sterile conditions and incubated for 24 hours at 37°C. Microbial growth identification was performed by gram stain and disc diffusion technique. The utilized discs (Padtan Teb, Iran) included norfloxacin (NOR, 10 μg.disk^{-1}), azithromycin (AZM, 15 μg.disk^{-1}), imipenem (IPM,10 μg.disk^{-1}), gentamycin (GM, 10 μg.disk^{-1}), piperacillin (PIP, 10 μg.disk^{-1}), amikacin (AN, 30 μg.disk^{-1}), ciprofloxacin (CP, 5 μg.disk^{-1}), ceftizoxime (CT, 30 μg.disk^{-1}), ceftazidime (CAZ, 30μg.disk^{-1}), cefotaxime (CTX, 10 μg.disk^{-1}), nalidixic-acid (NA, 30 μg.disk^{-1}), nitrofurantoin (FM, 300 μg.disk^{-1}), cefixime (CFM, 5 μg.disk^{-1}), ampicillin (AMP, 10 μg.disk^{-1}), cephalexin (CIP, 30 μg.disk^{-1}), ceftriaxone (CRO, 30 μg.disk^{-1}), and sulfamethoxazole-trimethoprim (1.25/23.75 μg.disk^{-1}). *E. coli* ATCC 25922 was used as an antibiogram control.

Statistical Analysis

Data collection was carried out from sheet information and entered into Stata version 17. For descriptive analysis, the frequency and percentage were used, and for inferential statistics, the chi-square test was applied to test the research hypotheses. The level of significance was considered at 0.05.

Results

During the study period, out of all samples from outpatients suspected of UTI in the urine culture of 122 patients, the number of colonies was equal to or greater than 10^5 CFU/ml. Further, 80 (65.57%) patients infected with *E. coli* were females. The distribution of microbial-resistance to antibiotics by the patient age groups is presented in Table 1. The mean age of patients with *E. coli* was 50.2 ± 1.8 (CI = 46.6-53.8) years, and their age range was 6-87 years. The highest prevalence of infection occurred in men over 60 years of age and in women aged 40-60 years. The sex ratio in the study group was approximately 0.50 (40 males and 82 females).

According to the results of an antibiogram in Table 2, the highest drug resistance in both men and women was CAZ, AMP, and NA, respectively. Further, in the two gender groups, the highest drug resistance belonged to three antibiotics: CTX, FM, and IPM. Likewise, the highest sensitivities in men were related to CT (80.0%), CTX (75.0%), and IPM (70.0%), respectively, and in women were related to IPM (81.8%), CTX (81.7%), and CT (75.7%), respectively. Moreover, the relationship between gender and AN and AZM antibiotics was significant ($P < 0.05$). In other words, the gender distribution in the above antibiotics was not the same; however, the other antibiotics were not statistically significantly related to gender ($P > 0.05$).

According to Table 3, regardless of gender grouping, the highest resistance was related to CAZ (74.59%), AMP (71.31%), and NA (64.75%) antibiotics, and the highest sensitivity was related to CTX (79.51%), IPM (77.87%), and CT (77.05%) antibiotics, respectively.

The frequency of multidrug-resistant (MDR) to 3, 4, 5, 6, 7, and more than 7 of total 17 antimicrobial agents were 6 (4.9%), 16 (13.1%), 37 (30.3%), 24 (19.6%), 32 (26.2%), and 7 (5.7%), respectively. Of the 92.2% MDR isolates, the most prevalent patterns were resistant to more than 5 (37; 30.3%), followed by 7 (32; 26.2%), and 6 (24; 19.6%) of antimicrobial agents (Figure 1).

Table 1. The Distribution of Microbial-Resistance to Antibiotics by the Patient Age Groups (n = 122)

Age (y)	Gender	
	Male No. (%)	Female No. (%)
<20	6 (40.00)	9 (60.00)
20-40	7 (36.84)	12 (63.16)
40-60	12 (24.00)	38 (76.00)
>60	15 (38.46)	24 (61.54)
Total	40 (32.79)	82 (67.21)

Discussion

Similar to other studies, in this study, *E. coli* was one of the main causes of UTIs in patients referred to the hospital.[11-13] In this study, the most infected people with *E. coli* were women, which is consistent with other studies.[14,15] Furthermore, the antibiotic pattern of *E. coli* strains was studied in this study, and it was found that *E. coli* has the highest antibiotic resistance and the highest antibiotic susceptibility for the dual antibiotics of CAZ 91 (74.5%) and CTX 97 (79.5%), respectively. CTX is recommended by the Food and Drug Administration as a first-line treatment for UTIs.[16] An obvious and worrying increase in CTX- and CAZ-resistant strains has been reported in a study by Oteo et al.[17,18] Numerous factors, including the inhumane use of antibiotics in agriculture and veterinary medicine, etc contribute to the spread of antibiotic resistance.[19] In the study by Butta et al, 84.7% of patients were resistant to AMP, which was slightly higher than the results of the present study (71.3%). They found that the isolates were resistant to fluoroquinolones such as CP 97%, which was much higher than that of this study (22.1%), and the isolates showed 1.7% resistance to FM, which was lower than the results of the present study (10.6%).[20] Fluoroquinolones such as CP are currently recommended as a second-line uncomplicated drug in the treatment of urinary tract infections (UTIs).

Limitations

This study faced some limitations. First, this is a single-center retrospective study using existing data collected over years with a small samples size. It is possible that we could have missed cases such as those who were treated without any culture testing or received antibiotics before urine collection for culture. Second, there was no access to some clinical information of the patients such

Table 2. Distribution of Anti-biotic Susceptibility of Bacteria Isolated From Urine Culture in Females and Males

Antibiotic	Anti-biotic Susceptibility						*P* Value
	Female (n = 82)			Male (n = 40)			
	Sensitive No. (%)	Intermediate No. (%)	Resistance No. (%)	Sensitive No. (%)	Intermediate No. (%)	Resistance No. (%)	
Amikacin (AN)	30 (36.5)	38 (46.3)	14 (17.0)	22 (55.0)	8 (20.0)	10 (25.0)	0.01
Ampicillin (AMP)	11 (13.4)	11 (13.4)	60 (73.2)	3 (7.5)	10 (25.0)	27 (67.5)	0.21
Azithromycin (AZM)	15 (18.4)	40 (48.7)	27 (32.9)	9 (22.5)	10 (25.0)	21 (52.5)	0.03
Cefixime (CFM)	10 (12.2)	20 (24.3)	52 (63.5)	1 (2.5)	14 (35.0)	25 (62.5)	0.14
Cefotaxime (CTX)	67 (81.7)	9 (10.9)	6 (7.3)	30 (75.0)	5 (12.5)	5 (12.5)	0.60
Ceftazidime (CAZ)	6 (7.3)	14 (17.0)	62 (75.6)	5 (12.5)	6 (15.0)	29 (72.5)	0.63
Ceftizoxime (CT)	62 (75.7)	9 (10.9)	11 (13.4)	32 (80.0)	3 (7.5)	5 (12.5)	0.81
Ceftriaxone (CRO)	55 (67.0)	10 (12.3)	17 (20.7)	27 (67.5)	5 (12.5)	8 (20.0)	0.99
Cephalexin (CN)	5 (6.1)	67 (81.7)	10 (12.2)	5 (12.5)	29 (72.5)	6 (15.0)	0.40
Ciprofloxacin (CP)	51 (62.2)	12 (14.6)	19 (23.2)	24 (60.0)	8 (20.0)	8 (20.0)	0.73
Gentamycin (GM)	35 (42.6)	16 (19.5)	31 (37.9)	18 (45.0)	11 (27.5)	11 (27.5)	0.44
Imipenem (IPM)	67 (81.8)	6 (7.3)	9 (10.9)	28 (70.0)	6 (15.0)	6 (15.0)	0.29
Nalidixic-Acid (NA)	10 (12.2)	19 (23.2)	53 (64.6)	6 (15.0)	8 (20.0)	26 (65.0)	0.86
Nitrofurantoin (FM)	56 (68.2)	19 (23.3)	7 (8.5)	26 (65.0)	8 (20.0)	6 (15.0)	0.54
Norfloxacin (NOR)	17 (20.7)	43 (52.5)	22 (26.8)	10 (25.0)	23 (57.5)	7 (17.5)	0.51
Piperacillin (PIP)	43 (52.4)	21 (25.6)	18 (22.0)	16 (40.0)	10 (25.0)	14 (35.0)	0.27
Trimethoprim (SXT)	26 (31.8)	17 (20.7)	39 (47.5)	13 (32.5)	7 (17.5)	20 (50.0)	0.91

Table 3. Distribution of Antibiotic Susceptibility of Bacteria Isolated From Urine Culture

Antibiotic	Sensitive No. (%)	Intermediate No. (%)	Resistance No. (%)
Amikacin (AN)	52 (42.62)	46 (37.70)	24 (19.67)
Ampicillin (AMP)	14 (11.48)	21 (17.21)	87 (71.31)
Azithromycin (AZM)	24 (19.67)	50 (40.98)	48 (39.34)
Cefixime (CFM)	11 (9.02)	34 (27.87)	77 (63.11)
Cefotaxime (CTX)	97 (79.51)	14 (11.48)	11 (9.02)
Ceftazidime (CAZ)	11 (9.02)	20 (16.39)	91 (74.59)
Ceftizoxime (CT)	94 (77.05)	12 (9.84)	16 (13.11)
Ceftriaxone (CRO)	82 (67.21)	15 (12.30)	25 (20.49)
Cephalexin (CN)	10 (8.20)	96 (78.69)	16 (13.11)
Ciprofloxacin (CP)	75 (61.48)	20 (16.39)	27 (22.13)
Gentamycin (GM)	53 (43.44)	27 (22.13)	42 (34.43)
Imipenem (IPM)	95 (77.87)	12 (9.84)	15 (12.30)
Nalidixic-Acid (NA)	16 (13.11)	27 (22.13	79 (64.75)
Nitrofurantoin (FM)	82 (67.21)	27 (22.13)	13 (10.66)
Norfloxacin (NOR)	27 (22.13)	66 (54.10)	29 (23.77)
Piperacillin (PIP)	59 (48.36)	31 (25.41)	32 (26.23)
Trimethoprim (SXT)	39 (31.97)	24 (19.67)	59 (48.36)

as the results of treatment, so determining the rate of the outcome was impossible.

Conclusion

Due to the spread of antibiotic-resistant *E. coli* urinary strains and subsequent treatment costs, it is necessary to pay attention to the rational use of antibiotics. In the present study, the highest resistance and sensitivity belonged to CAZ and CTX, respectively. Further, in medical practice, CTX is the primary antibiotic prescribed to deal with UTIs.

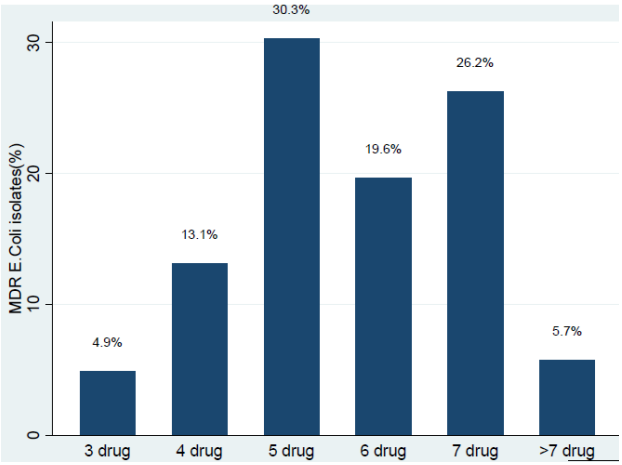

Figure 1. Frequency of MDR *E. coli* (n = 122) According to Its Resistance to Three or More Antimicrobial Agents. *Note.* MDR: Multidrug-resistant*; E. coli: Escherichia coli*

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Conflict of Interest Disclosures

The authors would like to confirm no conflict of interests.

Ethical Approval

All patient information was kept via coding confidential.

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