In Vitro Antibiotic Susceptibility and Species Distribution of Uropathogenic Agents Isolated from Urine Cultures

İdrar Kültürlerinden İzole Edilen Üropatojen Etkenlerinin Tür Dağılımı ve *İn Vitro* Antibiyotik Duyarlılıkları

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Abstract

Urinary tract infections (UTIs) are among the most common infections in all age groups. The aim of this study was to evaluate etiologic agents, determine antimicrobial resistance rates, and review empirical treatment recommendations in urinary tract infections in a tertiary care hospital. Among the urine samples sent to the microbiology laboratory of our hospital from various units between January 2018 and October 2021, those with pyuria and significant bacteriuria in cultures were included in the study. VITEK 2 (BioMérieux, France) was used to identify the species of bacteria, and antibiotic susceptibilities were determined. The results were evaluated according to EUCAST (European Committee on Antimicrobial Susceptibility Testing) standards. The study included 8516 patients. *Escherichia coli* 66.4% (n=5652), *Klebsiella pneumoniae* 7.8% (n=662), and *Enterococcus* spp. (6.5% (n=553) were isolated from urine samples, respectively. The highest antibiotic resistance was observed against *E. coli* with cefepime (46.7%), ampicillin (44.6%), and piperacillin (39.4%). Other *Gram*-negative and *Gram*-positive uropathogenic strains found in the study exhibited generally high susceptibility to the assessed antibiotics. The results of our research indicated that *E. coli* strains isolated from UTI patients exhibited a lower sensitivity to ampicillin, piperacillin, cefepime, ceftriaxone, ceftazidime, and cefuroxime axetil. Antibiotic resistance rates of UTI agents vary according to regions. Therefore, regional resistance should be taken into account when selecting treatment to improve outcomes and reduce the development of resistance in UTIs.

Keywords: Antimicrobial Susceptibility, Bacteriuria, Urinary Tract Infection, Uropathogen.

Özet

İdrar yolu enfeksiyonları (İYE) her yaş grubunda en sık karşılaşılan enfeksiyonlar arasındadır. Bu çalışma ile üçüncü basamak bir hastanede idrar yolu enfeksiyonlarında etiyolojik ajanların değerlendirilmesi, antimikrobiyal direnç oranlarının belirlenmesi, ampirik tedavi önerilerinin gözden geçirilmesi amaçlanmıştır. Ocak 2018-Ekim 2021 tarihleri arasında hastanemiz mikrobiyoloji laboratuvarına çeşitli birimlerden gönderilen idrarlardan pyüri saptanan ve kültürlerinde anlamlı bakteriüri olanlar çalışmaya dahil edilmiştir. VITEK 2 (BioMérieux, Fransa), kullanılarak bakterilerin tür tanımı yapılmıştır ve antibiyotik duyarlılıkları saptanmıştır. Sonuçlar EUCAST (European Committee on Antimicrobial Susceptibility Testing) standartlarına göre değerlendirilmiştir. Çalışmaya 8516 hasta dahil edilmiştir. İdrar örneklerinden en çok sırasıyla örnekten % 66,4 (n=5652) *Escherichia coli*, % 7,8 (n=662) *Klebsiella pneumoniae*, ve %6,5 (n=553) *Enterococcus spp.*, izole edilmiştir. En yüksek antibiyotik direnci *E. coli*' ye karşı sefepim (%46,7), ampisilin (%%44,6) ve piperasilin (%39,4) antibiyotiklerinde görülmüştür. Çalışmada üropatojen olarak belirlenen diğer *Gram* negatif ve *Gram* pozitif türlerin değerlendirilen antibiyotiklere karşı genel olarak yüksek duyarlılık gösterdiği tespit edilmiştir. Araştırmamızın sonucunda, İYE hastalarından izole edilen *E. coli* suşlarının ampisilin, piperasilin, sefepim, seftriakson, seftazidim ve sefuroksim aksetile karşı daha düşük bir duyarlılık sergilediğini göstermiştir. İYE etkenlerinin antibiyotik direnç oranları bölgelere göre değişmektedir. Bu nedenle, İYE'lerde sonuçları iyileştirmek ve direnç gelişimini azaltmak için tedaviyi seçerken bölgesel direnç dikkate alınmalıdır.

Anahtar Kelimeler: Antimikrobiyal Duyarlılık, Bakteriüri, İdrar Yolu Enfeksiyonu, Üropatojen.

Introduction

The term urinary tract infection (UTI) refers to any form of infection of the urethra, bladder, prostate, or kidneys (1). Urinary tract infections (UTIs) represent the most frequent bacterial infections across all age demographics and are the main bacterial infections in both nosocomial and community-acquired contexts (2). The frequency of UTIs changes with age, sex, and geographic location; however, they are more prevalent in women (3, 4). Every year, the world reports approximately 400 million UTIs, leading to over 200,000 fatalities (5). The annual global cost for treating UTIs is believed to reach 150 billion dollars. Research on the annual global cost of UTIs in Turkey is still insufficient (6).

Facultative anaerobes are frequently implicated in UTIs, with *Escherichia coli* being the most identified pathogen. It accounts for approximately 85% of UTIs diagnosed in primary healthcare settings and around 50% of nosocomial infections. *Klebsiella pneumoniae, Staphylococcus spp., Enterococcus* spp*.,* group B *Streptococcus, Pseudomonas aeruginosa*, and *Proteus mirabilis* are the next most isolated uropathogens (4, 7). When a UTI is suspected, patients are generally administered empirical antibiotics as an initial course of treatment until culture results and the antibiogram are accessible (8). The antibiotics that are most often chosen for treatment include quinolones, aminopenicillins, combinations of beta-lactam and beta-lactamase inhibitors, trimethoprim-sulfamethoxazole (SXT), fosfomycin, nitrofurantoin, aminoglycosides, and second and third generation oral cephalosporins (9). Antibiotic resistance should be taken into account while selecting antibiotics for effective therapy (10). Monitoring of antibiotic resistance status is necessary to identify the best antibiotic to employ in treatment. Antibiotic resistance rates exhibit variability across cities, hospitals, and clinics, making it essential for each institution to conduct regular and systematic surveillance of their resistance profile (11). Increased levels of resistance result in changes to the treatment protocol, extended duration of therapy, and caused expenses (6).

The purpose of this study was to evaluate the etiologic agents of urinary tract infections and to determine the distribution of antimicrobial resistance in a tertiary care university hospital in Turkey.

Material and Method

Study Design

The urine culture and antibiogram results of urine samples of all patients sent to the microbiology laboratory of our hospital from the inpatient and outpatient departments of Niğde Ömer Halisdemir University Training and Research Hospital were evaluated retrospectively. The study spanned a period from January 2018 to October 2021. All age groups were included in the study.

Bacterial Identification and Antimicrobial Susceptibility Testing

Urine samples were obtained from patients with suspected UTI by midstream urine, urine bag, or catheterization method after evaluating the patient's age, clinical status and according to international guidelines (12). Standard methods were used for culture. Urine samples of 10 μL were inoculated onto blood agar (BA) and eosin methylene blue agar (EMBA) plates. After incubation at 37°C for 18-24 h, isolates with $\geq 10^5$ cfu/mL were considered as the causative agents. Microorganisms were determined based on colony appearance, *Gram* staining, and biochemical reactions. Subsequently, the isolated uropathogens were identified by species using an automated system VITEK 2 (BioMérieux, France) according to the manufacturer's recommendations. Antibiotic susceptibility testing of bacteria was also performed with the VITEK-2 automated system. The clinical evaluation of antimicrobial susceptibility was conducted in accordance with the prevailing EUCAST (The European Committee on Antimicrobial Susceptibility Testing) recommendations (13). Standard strains from the American Type Culture Collection (ATCC) were used to ensure quality control. The following antibiotics were tested: trimethoprim-sulfamethoxazole (TMP-SXT), Amoxicillin-clavulanate (AMP), ampicillin (AMR), ampicillin-sulbactam (SAM), piperacillin-Tazobactam (TZP), piperacillin (PIP), gentamicin (GEN), meropenem (MEM), imipenem (IPM), ertapenem (ERT), ciprofloxacin (CIP), fosfomycin (FO), nitrofurantoin (NFT), cefuroxime axetil (CXM), cefepime (CEP), cefoxitin (CFX), ceftazidime (CAZ), ceftriaxone (CRO), cefaclor (CEC), amikacin (AMK).

Only the initial sample from each patient within the same year was included in the study. Samples considered contaminated were excluded from the research. Furthermore, data from patients with

ambiguous outcomes and unclear sample information were excluded from the study.

Statistical Analysis

Data were analyzed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Categorical data were presented as frequencies and percentages, while continuous numerical data were expressed as mean ± standard deviation and minimum-maximum values.

Results

The research was performed from January 2018 to October 2021, including samples from 8,516 patients. Overall, the patients in this research, 5756 (67.6%) were female, and 2760 (32.4%) were male. Cases predominantly occurred in patients under 14 years of age, including 39.6% (n=3372). The distribution of patients by year was as follows: 22.1% (n=1882) in 2020, 18.6% (n=1580) in 2021, 29.2% (n=2487) in 2019, and 30.1% (n=2567) in 2018.

When the distribution of microorganisms grown in urine cultures was analyzed, 66.4% (n=5652) *Escherichia coli*, 7.8% (n=662) *Klebsiella pneumoniae*, 6.5% (n=553) *Enterococcus* spp., 4.3% (n=365) *Klebsiella* spp., 2.4% (n=203) *Proteus mirabilis*, 2.1% (n=180) *Proteus* spp., 2% (n=170) *Staphylococcus* spp., 1.4% (n=117) *Pseudomonas aeruginosa*, 1.1% (n=93) *Streptococcus* ssp., 0.8% (n=68) *Enterobacter cloacae*, 0.7% (n=62) *Acinetobacter baumanni*, and 4.6% (n=391) others (Table 1). Other species, also shown as others in Table 1, were *Candida albicans*, coagulase-negative *Staphylococcus*, *Citrobacter* spp., *Pseudomonas* spp., *Enterobacter* spp., *Providencia* spp., *Morganella* spp., *Burkholderia cepacia*, *Serratia* spp., *Shigella* spp., and *Raoultella ornithinolytica*.

The antibiotic susceptibility of bacteria cultured from urine was evaluated (Table 2). Resistance percentages were determined based on the cumulative quantity of bacteria associated with each antibiotic. The highest antibiotic resistance was noted in *E. coli* (20.6%) and *K. pneumoniae* (3.9%). The study revealed that *E. coli*, the most frequently isolated species, exhibited resistance to the following antibiotics: cefepime (46.7%),

ampicillin (44.6%), piperacillin (39.4%), ceftriaxone (37.5%), cefuroxime axetil (33.0%), ceftazidime (32.7%), amoxicillin-clavulanate (29.7%), cefaclor (26.5%), ciprofloxacin (25.7%), and trimethoprim-sulfamethoxazole (25.5%). *K. pneumoniae* was resistant to piperazine (16.6%), cefuroxime axetil (8.6%), and ceftazidime (7.1%). Overall, 67.2% of all samples included were susceptible, while 32.8% were resistant.

Discussion

Urinary tract infections are severe, potentially fatal infections that occur in patients at high risk of disease progression (e.g., pregnant women, patients with concomitant anatomical or functional deficiencies of the urinary tract) or are caused by multidrug-resistant uropathogens (14). Antimicrobial resistance is a significant risk to health eliciting global apprehension, as evidenced by announcements from the World Health Organization's (WHO) "Global Action Plan on Antimicrobial Resistance" (15). UTIs are a major financial burden on Turkey healthcare systems, affecting 17.8% of outpatient admissions annually (6). Thus, monitoring UTIs is critical, both for public health and financial considerations. The purpose of this study was to evaluate the bacteria isolated from UTIs in a tertiary care hospital and to determine antibiotic resistance levels. Urine culture is the standard method for diagnosing UTIs (16). Therefore, the diagnostic performance of the tests was evaluated by considering urine culture positivity as a reference.

UTIs are more common in women because of their shorter urethra and its closeness to the rectum, which promotes microbial ingress into the urinary system (16). The shorter urethra in women, the easier ascent of bacteria into the urinary tract, hence increasing the likelihood of UTIs (17). A prior study in Romania revealed that 79.3% exhibited multiple positive urine culture findings (18). In another investigation conducted in Turkey, 82.1% (n=1304) of 1588 patients with UTIs were identified as female (19). In our study, the prevalence of urine culture growth was greater in the female population (67.6%), and this data was compatible with the literature.

Table 1. Distribution of bacterial species according to departments.

Name of Departments	Escherichia coli	Klebsiella pneumonia	Klebsiella spp.	Proteus mirabilis	Proteus spp.	Enterobacter cloacae	Acinetobacter baumannii	Pseudomonas aeruginosa	Staphyloccoccus spp.	Streptoccoccus ssp.	Enterococcus spp.	Others	Total
Urology	1639	131	90	28	25	23	7	30	56	49	162	113	2353 (27.6%)
Infectious Diseases and Clinical Microbiology	229	27	8	2	2	1	3	4	6	2	17	20	321 (3.8%)
Child Health and Diseases	1450	222	145	85	86	25	4	24	51	17	132	101	2342 (27.5%)
Gynaecology and Obstetrics	365	29	8	6	1	0	1	0	11	7	4	9	441 (5.2%)
General Intensive Care Unit	149	43	14	3	5	1	17	11	5	2	51	26	327 (3.8%)
Internal-Surgical Intensive Care Unit	93	20	13	2	4	1	9	3	5	0	49	11	210 (2.5%)
Emergency Service	814	63	34	48	40	8	2	7	14	6	23	34	1093 (12.8%)
Internal Diseases	235	27	10	3	2	3	3	7	4	2	19	15	330 (3.9%)
Palliative Care Centre	42	7	3	4	2	0	1	6	1	0	5	12	83 (1%)
Pulmonary Diseases	66	4	4	4	0	0	1	2	3	0	12	1	97 (1.1%)
Others	570	89	36	18	13	6	14	23	14	8	79	49	919 (10.8%)
Total	5652 (66.4%)	662 (7.8%)	365 (4.3%)	203 (2.4%)	180 (2.1%)	68 (0.8%)	62 (0.7%)	117 (1.4%)	170 (2%)	93 (1.1%)	553 (6.5%)	391 (4.6%)	8516

Table 2. Antibiotic susceptibility rates of uropathogens

Bacteria Name	Trimethoprim-Sulfamethoxazole		Amoxicillin-Clavulanate		Ampicillin		Ampicillin-Sulbactam		Piperacillin-Tazobactam		Piperacillin		Gentamicin		Meropenem		Imipenem		Ertapenem	
	S %*	R%**	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%
Escherichia coli	43.5	25.5	42.9	29.7	27.4	44.6	67.6	14.1	50.9	13.5	24.8	39.4	60.3	11.6	64.1	0.9	65.0	0.8	66.9	3.4
Klebsiella pneumonia	5.9	2.8	7.4	5.2	0.0	7.5	1.6	0.9	8.3	5.4	0.0	16.6	7.1	1.8	13.4	2.4	11.6	1.5	12.0	2.4
Klebsiella spp	3.4	1.4	3.2	1.7	0.3	3.2	1.7	0.9	2.7	2.9	0.0	2.1	3.0	1.5	3.4	0.2	4.8	0.7	3.9	1.6
Proteus mirabilis	1.2	1.1	2.5	0.3	1.3	0.8	2.9	0.1	2.3	0.1	3.0	2.3	1.9	0.7	2.8	0.1	0.2	2.1	2.6	0.1
Proteus spp.	1.4	1.0	1.5	0.4	0.7	0.8	3.2	0.3	1.1	0.0	0.0	0.4	1.4	0.5	0.7	0.0	0.8	0.4	0.6	0.2
Enterobacter cloacae	0.9	0.0	0.0	1.5	0.0	1.1	0.0	0.0	1.3	0.5	0.8	1.6	1.0	0.0	1.9	0.1	1.7	0.1	1.7	0.3
Acinetobacter baumannii	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2	0.0	0.0	0.1	0.8	0.2	1.9	0.1	1.6	0.0	0.0
Pseudomonas aeruginosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.5	2.3	3.0	1.0	0.2	2.2	0.7	1.4	1.4	0.0	0.0
Staphyloccoccus spp.	2.0	0.2	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	1.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Streptoccoccus ssp	1.0	0.1	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enterococcus spp.	0.9	3.3	0.0	0.0	5.6	3.2	2.9	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0
Others	2.3	1.4	0.8	2.6	0.4	2.7	0.4	0.8	4.7	1.9	1.5	2.5	3.9	1.1	4.2	0.8	4.4	1.3	3.4	0.8
Total	62.6	37.4	58.4	41.6	36.1	63.9	80.7	19.3	72.9	27.1	32.2	67.8	81.4	18.6	92.8	7.2	90.1	9.9	91.1	8.9

Bacteria Name	Ciprofloxacin		Fosfomycin		Nitrofurantoin		Cefuroxime-Axetil		Cefepime		Cefoxitin		Ceftazidime		Ceftriaxone		Cefaclor		Amikacin	
	S %	R%	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%	S %	R%	S%	R%
Escherichia coli	41.5	25.7	75.9	3.0	70.0	3.3	36.0	33.0	22.0	46.7	52.2	15.3	31.5	32.7	34.6	37.5	52.0	26.5	59.1	6.2
Klebsiella pneumonia	6.6	3.1	5.7	1.9	6.1	2.4	11.1	8.6	1.3	4.1	13.1	3.7	7.5	7.1	5.8	6.2	4.8	2.7	11.0	1.5
Klebsiella spp	2.3	2.2	1.8	1.9	3.6	1.7	2.0	1.2	2.0	6.6	2.9	1.2	2.1	1.5	2.3	3.4	4.0	2.8	4.7	1.4
Proteus mirabilis	1.6	0.6	1.5	0.2	0.0	1.7	3.2	0.7	0.5	0.4	3.0	0.2	2.2	0.7	1.8	0.6	2.1	0.2	2.7	0.2
Proteus spp.	1.0	0.6	1.4	0.2	0.2	1.4	0.0	0.3	2.1	1.1	0.4	0.3	0.5	0.4	0.9	0.6	1.6	1.1	1.6	0.4
Enterobacter cloacae	1.0	0.1	0.8	0.4	0.8	0.1	0.1	1.6	0.2	0.1	0.0	3.1	1.2	0.8	0.9	0.6	0.0	0.0	1.5	0.0
Acinetobacter baumannii	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.2	1.6	0.0	0.0	0.0	0.1	0.2	1.3
Pseudomonas aeruginosa	0.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.4	0.0	0.0	2.0	1.7	0.0	0.0	0.0	0.0	2.1	0.2
Staphyloccoccus spp.	1.0	1.0	1.0	1.0	0.1	0.0	0.0	0.0	0.0	0.0	1.3	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1
Streptoccoccus ssp	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Enterococcus spp.	2.1	2.7	0.1	0.0	3.8	1.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Others	2.7	1.6	2.3	0.9	2.3	0.8	0.9	1.3	3.7	3.3	1.6	5.1	4.0	2.2	2.3	2.0	0.2	1.8	4.5	0.9
Total	60.5	39.5	90.4	9.6	87.5	12.5	53.3	46.7	35.0	65.0	74.4	33.7	51.3	48.7	48.9	51.1	64.7	35.3	87.8	12.2

*S%: percentage of sensitive strains **R%: percentage of resistant strains

Table 2. Antibiotic susceptibility rates of uropathogens (Continued)

Bacteria Name	Others		Total	
	S %	R%	S%	R%
Escherichia coli	30.8	25.1	47.1	20.6
Klebsiella pneumonia	3.9	4.5	6.5	3.9
Klebsiella spp	2.1	1.4	2.7	1.8
Proteus mirabilis	1.6	0.7	1.8	0.7
Proteus spp.	1.3	0.3	1.1	0.5
Enterobacter cloacae	0.2	0.7	0.7	0.5
Acinetobacter baumanni	0.3	0.5	0.1	0.5
Pseudomonas aeruginosa	0.9	0.5	0.7	0.4
Staphyloccoccus spp.	5.0	2.8	1.3	0.8
Streptoccoccus ssp	2.5	0.7	0.6	0.1
Enterococcus spp.	7.4	2.6	2.1	1.2
Others	2.2	2.0	2.5	1.7
Total	58.2	41.8	67.2	32.8

*S%: percentage of sensitive strains **R%: percentage of resistant strains

Urosepsis and UTIs in humans are primarily caused by *E. coli*, which is the most commonly isolated bacterial species in such infections (20). In our study, *E. coli* was the most predominant isolate with 66.4% (n=5652), followed by *K. pneumoniae* with 7.8% (n=662). In a study performed in a different state hospital in our country from 2016 to 2019, the predominant causal agent of urinary tract infections was *E. coli* (55.6%), subsequently followed by *K. pneumoniae* (14.2%) (21). In another study done in a different territory hospital in Turkey, it was found that *E. coli* (69%), and then *K. pneumoniae* (15%) were the most commonly found bacteria in patients with UTIs (22). The presence of a high rate of *Gram*-negative bacterial growth in our study is consistent with other studies. Because of the fact that *Enterobacteriaceae* family includes the most common UTI pathogens, the high rate of *Gram*-negative bacteria isolated in our study was considered to be consistent with the literature.

Effective management of UTIs, which are common around the world, is essential to reducing undesirable consequences and the emergence of resistance. This can be achieved by promptly administering appropriate empirical treatment based on antibiotic susceptibility testing (10).

TMP-SMX, amoxicillin-clavulanate, and cephalosporins are commonly prescribed in our country to treat UTIs, whereas amoxicillin, cefixime, and nitrofurantoin are used as prophylaxis. It is recognized that there is a significant prevalence of resistance to ampicillin and TMP-SMX utilized for empirical treatment of UTIs in Turkey (3). In our study, resistance to ampicillin was found to be 44.6% in *E. coli*, while TMP-SMX resistance was 25.5%. Additionally, resistance to TMP-SMX and ampicillin was observed to be minor in other strains identified. A retrospective study conducted in this country from 2018 to 2019 revealed that ampicillin (75.80%) and TMP-SMX (49%) exhibited the highest resistance rates against *E. coli*, the most commonly isolated species in UTIs (11). According to Şencan et al. 27.4% of *E. coli* bacteria from patients with UTIs were resistant to TMP-SMX, while 49.8% were resistant to ampicillin. (19). A different study in our country revealed ampicillin resistance rates of 67.4% in *E. coli* and 100% in *Klebsiella* spp., whereas TMP-SMX resistance was reported at 33.2% in *E. coli* and 30% in *Klebsiella* spp. (23). Duran et al. showed that *E. coli* strains exhibited resistance rates of 64% to ampicillin, and 42.6% to TMP-SXT (21). Our findings were consistent with the literature. Considering these resistance rates, empirical treatment with ampicillin or TMP-SMX without culture findings would be insufficient for individuals with suspected UTIs.

In this study, we found that *E. coli* causing UTIs showed resistance to third-generation cephalosporins (ceftriaxone 37.5%, ceftazidime 32.7%) and fourth-generation cephalosporins (cefepime 46.7%), as well as to the oral medications cefuroxime axetil (33%) and cefaclor (26.5%). However, *Klebsiella* spp. strains did not show significant resistance to cephalosporins. Kömürlüoğlu et al. reported ceftriaxone resistance at 47.1%, cefuroxime axetil resistance at 34.6%, ceftazidime resistance at 30.2%, and cefepime resistance at 26.8% in *E. coli*. The study revealed resistance rates of 36.9%, 39.4%, and 44.8% for cefepime, ceftazidime, and cefuroxime axetil against Klebsiella spp., respectively (3). Ceftriaxone resistance was 33.6% in *E. coli* and 38.4% in *Klebsiella* spp., whereas ceftazidime resistance was 22.1% in *E. coli* and 36.4% in *Klebsiella* spp., according to a study by Konca et al. (24). Baran and Küçükcan detected cefepime resistance at 33.1% in *E. coli* and 41% in *Klebsiella* spp., cefuroxime axetil resistance at 34.4% in *E. coli* and 38.4% in *Klebsiella* spp., and ceftazidime resistance at 17.1% in *E. coli* and 26.5% in *Klebsiella* spp. (25). The resistance rate of *Klebsiella* spp. strains to cephalosporins was found to be lower than in the literature. This decrease was associated with the number of isolates. In our study, the resistance results obtained for cephalosporins against *E. coli* were found to be compatible with the data of Turkey.

Nevertheless, it was considered that the antibiogram results should serve as the foundation for selecting a cephalosporin in first-line therapy due to the elevated resistance profile.

Carbapenems are the preferred group for parenteral treatment of UTIs caused by resistant pathogens (23). Yüksek et al. established that *E. coli* had a susceptibility of 99.80% to imipenem and 93.95% to ertapenem (26). Ertapenem susceptibility was 95.4% for *E. coli* and 67.4% for *Klebsiella* spp. among inpatients, whereas imipenem susceptibility was 92.5% for *E. coli* and 64% for *Klebsiella* spp. in a separate study conducted in Turkey (2). There was no evidence of resistance meropenem in the Tuna et al. research (27). In the study we conducted, *E. coli* exhibited meropenem resistance of 0.9%, imipenem resistance of 0.8%, and ertapenem resistance of 3.4%, whereas *K. pneumonia* showed meropenem resistance of 2.4%, imipenem resistance of 1.5%, and ertapenem resistance of 2.4%. In the present study, we additionally identified other strains that were very susceptible to carbapenems. Consequently, we highlight the necessity of caution about the emergence of resistance, despite advocating for the utilization of carbapenems in hospitalized cases with multi-resistant infections.

According of its susceptibility to beta-lactamase enzymes, penicillins are frequently administered in conjunction with beta-lactamase inhibitors to enhance their efficacy (26). In the present study, the sensitivity of piperacillin was 24.8% without beta-lactamase inhibitor, and the sensitivity was 50.9% in combination with the beta-lactamase inhibitor tazobactam in *E. coli*. Çilburnuoğlu et al. reported piperacillin tazobactam resistance in *E. coli* as 20% in their study (11). Kömürlüoğlu et al. reported piperacillin tazobactam resistance as 22.3% in *E. coli* (3). Amoxicillin-clavulanate resistance was determined as 5.2% in *K. pneumoniae*, and 29.7% in *E. coli* in our research. Yüksek et al. reported 56.8% susceptibility to amoxicillin clavulanic acid in *E. coli* (26). Karamanlıoğlu et al. found that 57.9% of *E. coli* and 58% of *Klebsiella* spp. in outpatients with UTIs were resistant to amoxicillin-clavulanate (2). The research we conducted revealed that resistance to amoxicillin-clavulanate was lower than reported in the literature. This issue is thought to be associated with the antibiotic utilization policies of our hospital.

Based on ciprofloxacin resistance in the present study, *E. coli, K. pneumonia* and *Enterococcus* sp. were 25.7%, 3.1% and 2.7% resistant, respectively. Ciprofloxacin resistance to *E. coli* was 36.2%, *Klebsiella* spp. were 41.3%, and *Enterococcus* spp. were 54.2%, according to a study performed in Turkey (25). A separate investigation determined that 68.15% of *E. coli* were susceptible to ciprofloxacin (26). The study conducted by Şencan et al., ciprofloxacin resistance was determined as 20.4% in *E.coli*, 21.3% in *Klebsiella* spp., and 40.5% in *Enterococcus* spp. (19). A retrospective investigation in Turkey revealed ciropfloxacin resistance rates of 69.9% in *E. coli* and 49.0% in *Klebsiella* spp. (6). The current investigation revealed lower rates of ciprofloxacin resistance in comparison to existing literature. Nonetheless, it was believed that ciprofloxacin should not be the primary treatment option due to the prevalence of ciprofloxacin resistance in Turkey.

Antibiotic resistance rates and the causes of UTIs tend to vary throughout centers (26). Consequently, the present study determined that uropathogens were not susceptible to ampicillin, piperacillin, cefuroxime axetil, cefepime, ceftazidime, and ceftriaxone. It was thought to be more appropriate to avoid utilizing ampicillin and TMP-SMX in empirical treatment because of their rates of resistance. However, all *Gram*-negative and *Gram*-positive isolates were mostly sensitive to amikacin, meropenem, imipenem, piperacillin tazobactam, nitrofurantoin, and gentamicin. These antibiotics can be used as a therapy option for UTIs, based on the results.

The present study had some limitations. The retrospective methodology, single-center outcomes, and narrow service area of the center, which may have resulted in a constrained geographic sample, were limitations. An appropriate degree of missingness exists in the retrospective data analysis of our investigation. Another limitation was the heterogeneity of the subject group. Patients with insufficient or incomplete information were eliminated from the study. Nonetheless, we believe that the limitations of our study do not significantly alter the results of the data.

Conclusion

In conclusion, although *E. coli* is the main UTI agent, pathogens and their susceptibilities can change in various patient groups. Uropathogens exhibited a lower sensitivity to ampicillin, piperacillin, cefepime, ceftriaxone, ceftazidime, and cefuroxime axetil in the current patient population. On the other hand, there was

significant susceptibility to amikacin, carbapenems, ampicillin-sulbactam, piperacillin-tazobactam, fosfomycin, nitrofurantoin, gentamicin, and cefoxitin. The current findings may be crucial for identifying trends in antimicrobial sensitivity, assisting physicians in selecting suitable antibiotics, and preventing misuse or overuse of these antibiotics. We believe that this approach will enhance the prolonged use of current antibiotics and diminish elevated healthcare expenses.

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