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Bacterial Mapping and Antibiotic Sensitivity Evaluation of Urine Culture and Antibiotics Recommendation for Urologic Patients

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Abstract—— Urinary tract infection (UTI) is one of the most common complications found in managing patients in the field of urology. The biggest challenge in UTI management is antibiotic resistance. In this study, patient data were taken retrospectively from urology patients in 1 year. A total of 643 patients were tested for urine culture, with the most cases of urinary tract stone (35.5%). *Escherichia coli* was the most common bacteria. Cefoperazone sulbactam (91%) was the most sensitive parenteral antibiotics used for the patients, whereas Fosfomycin (85.3%) was the oral antibiotics of choice. Aminoglycoside, Carbapenem groups, Cefoperazone sulbactam, and Piperacillin tazobactam antibiotic groups had a sensitivity level of more than 50% in treating urology patients with UTI. On the other hand, Cephalosporin and Quinolone were discovered to have a lower level of sensitivity. The use of a urinary catheter and DJ stent possibly contributed to the increase of antibiotics resistance. A total of 107 patients (16.6%) were discovered to be infected by Extended-Spectrum Beta-Lactamase (ESBL)-producing bacteria, especially among patients with urethral stricture.

Keywords—— Urinary Tract Infection, Antibiotic Resistance, Antibiotic Sensitivity, *Escherichia coli*

1. Introduction

[1] Urinary tract infection (UTI) is the most common complication in urologic patient management, which reaches 8,1 million cases annually. [2] UTI incidence rate occurs mainly in female patients instead of male patients, with more than 50% of females experiencing at least one urinary tract infection and a 20 to 30% chance of recurrence in their lifetime. [3] It is reported that in the United States, there are more than 6 million UTI cases on outpatient and 479,000 inpatient cases each year. UTI also becomes the leading cause of sepsis, which has a high mortality rate. [4] In Indonesia, according to the Department of Health of the Republic of Indonesia in 2014, they estimated that the number of UTI patients reached 90-100 cases per 100,000 population per year.

[5] The risk factors that can increase UTI occurrence among others are toddlers, pregnant women, patients with spinal injury, diabetes mellitus, multiple sclerosis, or abnormality in urology. Besides, UTI is also often associated with patients who use a urinary catheter. [6] According to Dasgupta et al., *E. coli* is the most common bacteria that causes UTI. As many as 47% of urology patients are outpatients and 31% are inpatients with positive urine cultures.Antibiotic resistance is the biggest challenge in managing UTIs due to the irrational use of antibiotics. This study aims to evaluate the germ patterns and antibiotic resistance and provide recommendations for prophylactic antibiotics and therapy in urologic patients.

2. Material and Method

This research was a retrospective descriptive study, in which the data were taken from the medical records of urological patients who were examined for urine culture at Dr. Soetomo Surabaya. For one year, 643 samples of urology patients were examined for urine culture from April 2019 to March 2020. The inclusion criteria in this research were all outpatient and inpatient medical records in the urology ward. Data were collected using SPSS 26.0 software and displayed in the form of tables and diagrams.

3. Results

From April 2019 to March 2020, 643 urology patients were examined for urine culture in Dr. Soetomo Regional Hospital, Surabaya. Within a year, more male patients (62.5%) than female, but the percentage of positive urine cultures were higher in female patients (74.7%). In terms of age, 2/3 of the patients were adults (19-64 years), with a high positive urine culture (65.9%). The data showed that patients with positive urine cultures were higher in all comorbidity factors. (Table 1).

In this study, urinary tract stones were found in 228 patients (35.5%), with the highest etiology being kidney stones (n = 177, 27.5%). The number of patients based on a more detailed diagnosis is shown in Table 1. Urologic patients with positive urine culture were 358 patients (55.6%), with the highest percentage in patients diagnosed with vesicovaginal fistula (90.9%), BPH (90.5%), and urethral stricture (89.8 %).

Figure 1 shows the comparison data of patients with positive urine cultures based on the classification of the six most urological cases in 1 year. Patients with urinary tract stones became the most cases, with a positive and negative urine culture ratio of 56.6%. The highest percentage of positive urine cultures was in patients with urethral stricture (89.6%). Bacterial infection with Extended-Spectrum Beta-Lactam (ESBL) was also relatively high in the sample of this research, as many as 107 patients (16.6%), with the highest incidence in kidney stone patients (26 patients). Meanwhile, patients with the highest positive ESBL percentage were on the urethral stricture case (33.3%). (Figure 1)

The use of a catheter and Double J (DJ) stent also had a very high percentage of positive urine cultures, which was 40 of 45 patients with a urethral catheter (88.9%), cystostomy catheter (93.8%), nephrostomy (100%) and DJ stent. (76.4%) (Figure 2). Additionally, the ESBL-producing bacterial infections relatively also quite high in patients who used cystostomy catheter, which was 44% of the total patients with a positive urine culture. (Figure 2)

The incidence of UTI or positive urine culture results was relatively high in urologic patients. There were 403 patients (62.6%), with *Escherichia coli* being the most common cause of UTI (n=157, 38,9%) (Figure 3). *Escherichia coli* bacterial infection was primarily diagnosed in patients with a kidney stone (40 patients).Other bacteria that appeared mostly besides *Escherichia coli* were *Pseudomonas sp* (35 patients/8.7%), *Klebsiella pneumonia* (7.2%), and *Enterococcus faecalis* (6.7%). *Staphylococcus epidermidis* and *Corynebacterium non-urolyticum* bacteria also appeared a lot. These two bacteria were still rarely considered pathogenic bacteria that cause UTI because they were included as normal bacteria/ flora. This might occur due to errors during sampling.

One case of urine culture with MRSA *(Methicillin-Resistant Staphylococcus aureus)* was found from the entire research sample, which was a diagnosis of bilateral multiple kidney stones and left severe hydronephrosis. This patient also had a left nephrostomy. This patient was still sensitive to

Gentamicin, Cotrimoxazole, Erythromycin, Chloramphenicol, Teicoplanin, Vancomycin, and Linezolid antibiotics.

The data of detailed antibiotic sensitivity are shown in Figure 4. Antibiotics that still had a sensitivity above 80% included Amikacin, Piperacillin tazobactam, Cefoperazone sulbactam, Cefepime, Fosfomycin, Imipenem, and Meropenem. Until now, there have been no bacteria that are resistant to Vancomycin. Meanwhile, antibiotics with very low sensitivity included Ampicillin (11%), Piperacillin (23%), and Cephazolin (6%).

For oral antibiotics, Erythromycin and Clindamycin still had a reasonably good sensitivity. Vancomycin and Fosfomycin had the best sensitivity among other oral antibiotics, but Ampicillin and Tetracycline were the antibiotics with the greatest resistance. (Figure 4)

Table 2 shows the percentage of antibiotic sensitivity at each urological diagnosis. Amikacin, Gentamicin, Piperacillin Tazobactam, Cefoperazone, Sulbactam, Fosfomycin, Imipenem, and Meropenem were still quite sensitive in all urological cases with a sensitivity of more than 80% according to the recommendations of the 2015 UTI guideline from Indonesian Association of Urology. Quinolone group is still quite sensitive in instances in which cases where the management is mostly open surgery such as urethral strictures, hypospadias, and urethrocutaneous fistula.

Table 3 shows the types of bacteria that occur most frequently based on each diagnosis and the recommended antibiotics according to the highest sensitivity. *Escherichia coli* bacteria is always the most common pathogen causing UTI in all diagnoses except in patients with hypospadias. Antibiotic recommendations were made according to the best antibiotic sensitivity data. Carbapenem (Imipenem and Meropenem) and Vancomycin antibiotics were not included in this recommendation because they had good sensitivity at all diagnoses (> 90%) and were the last option of antibiotics used in daily practice.

4. Discussion

[7] *Escherichia coli* is the leading cause of UTI, in which 50% were hospital-acquired and 85% were community-acquired.[8]*Escherichia coliuropathogenic* (UPEC) bacteria easily infect the urinary tracts because they can attach to and colonize the perineum and urethra and cause an inflammatory reaction urothelium. The invasion allows the UPEC to defeat host defense and become resistant to antibiotic therapy. The process of invasion and formation of IBC (intracellular bacterial communities) gives UPEC the ability to survive in the urinary tract.

In this research data, the percentage of positive urine cultures was higher in females (74.7%). The prevalence of UTI begins to increase at the age above 15 years old (initiation of sexual activity). [9] It is highest in the 4th decade, where at this age there is comorbidity of hypertension, diabetes mellitus, impaired kidney function, and other diseases such as lack of mobilization due to stroke.Comorbidity factors appeared to greatly affect UTI incidence, where there were more than 70% of patients with CKD and paresis/stroke and more than 60% of patients with DM and hypertension had UTI. [10] Similar data were also shown in a study by Shah Ali et al., which stated that the prevalence of UTI in DM patients was 40.2% with more severe and complicated manifestations.

In this research, the majority were patients with urinary tract stones, especially kidney stones (177 patients), with an incidence of UTI of 54.8%. Patients with bladder stones also showed a very high prevalence of UTI by 70%. [11] This was similar to a study conducted by Hizbullah et al., which

showed that 79% of kidney stone patients were accompanied by UTI, with *Escherichia coli* (30%) as the most common pathogenic bacteria.Also, in patients with a diagnosis accompanied by a risk of urinary retention or urinary tract obstruction also appeared to have a high incidence of UTI including urethral stricture (89.8%), benign prostate hyperplasia (90.5%), neurogenic bladder (88.9%), and vesicovaginal fistula (90.9%) as well as vesicoureteral reflux (VUR). [12] These results were higher than the research by Abdullahi et al., which showed that complications that occurred in patients with urinary retention were UTI (24.5%), with the most dominant pathogenic bacteria being *Escherichia coli* (63%) and impaired kidney function (14.5%).[9,12]This was caused by disruption of urine flow and catheter use in patients with urinary retention, making it easier for ascending infection and bacterial growth to occur.

The use of instrumentation, especially catheters (urethra, cystostomy, and nephrostomy) and DJ stent, will also facilitate UTI occurrence. This research showed a very high UTI incidence in patients who use instrumentation (> 75%). [13] According to a study by Piljic et al., it was stated that the percentage of CAUTI (catheter-associated UTI) with symptoms was 57.8%.

[7] According to UTI Management Guideline 2015, 4 education centers hospital in Indonesia, i.e., in Surabaya, Jakarta, Bandung, and Malang stated that oral antibiotics with high sensitivity were Nitrofurantoin, Cephalosporin group II (Cefotiam), and III (Cefixime), Fluoroquinolone, Aminopenicillin (Beta-lactam inhibitor). Meanwhile, parenteral antibiotics were Carbapenem, Cephalosporin group II (Cefotiam), and III (Ceftriaxone, Cefoperazone), Aminoglycoside. This was in line with this study's results, where the most sensitive parenteral antibiotics were Cefoperazone Sulbactam (Cephalosporin generation III), Aminoglycoside, and Carbapenem.But for oral antibiotics, Fluroquinolone, Nitrofurantoin, and Beta-lactam inhibitor groups had a sensitivity of < 50%. In this research, only Clindamycin, Erythromycin, and Fosfomycin antibiotics still had a reasonably good sensitivity.

[9,14] It is stated in previous literature that to treat *E.coli*, oral antibiotics, including Trimethoprim-Sulfamethoxazole (TMP-SMX), Ciprofloxacin, and Nitrofurantoin, are recommended. Meanwhile, Gentamicin is usually chosen as the parenteral alternative.This was different from this research results, which showed that E. coli was sensitive to the Amikacin, Piperacillin-tazobactam, Cefoperazone sulbactam, Fosfomycin, Imipenem, and Meropenem antibiotics.

[15] According to the European Association of Urology (EAU) Guideline, antibiotics recommended for uncomplicated UTI cases are Fosfomycin, Nitrofurantoin, Cephalosporin TMP-SMX if the data on local resistance to *E.coli* bacteria is < 20%. [16,17] The similar antibioticsare recommended by the American Urology Association (AUA) and Urological Association of Asia (UAA) by adding the beta-lactam group (Amoxicillin-Clavulanic Acid) and Fluoroquinolone as an alternative therapy in uncomplicated UTI.[15] According to the EAU guidelines, complicated UTI cases are most often caused by *E.coli, Proteus sp, Klebsiella, Pseudomonas,* and *Enterococcus* bacteria with recommended antibiotics, i.e., Aminoglycosides, Extended-spectrum Penicillin, and third-generation Cephalosporins. For patients with suspected ESBL / multidrug resistance, Tazobactam and Carbapenem class of antibiotics are recommended. Fluoroquinolone class of antibiotic is only recommended in mild infection.

Antibiotic resistance is a significant problem in UTI management, especially those caused by *Extended-Spectrum Beta-Lactam* (ESBL) producing bacteria. In this study, the ESBL bacterial infection reached 16.6%, which were the pathogenic bacteria of *E.coli* (89 patients) and *Klebsiella*

pneumonia (15 patients). Antibiotics that were sensitive to ESBL bacteria included Amikacin (95.2%), Cefoperazone sulbactam (86.5%), Piperacillin tazobactam (77.7%), Fosfomycin (96.9%), Imipenem (97%), and Meropenem. (95.1%). In comparison, the fluoroquinolone class of antibiotics had a low sensitivity (20-25%) for ESBL bacteria. [18] Similar data in a study by Polo JM et al. also showed that ESBL bacteria had a high resistance to Fluoroquinolone (81.2%) and Piperacillin tazobactam (52.9%) groups. [15] Meanwhile, antibiotics with low resistance levels to ESBL bacteria included the Carbapenem (11.8%) and Amikacin (12.1%) groups.

Dr. Soetomo Regional General Hospital Surabaya is one of the topreferral hospitals in eastern Indonesia. The patients in this hospital have previously undergone treatment and are exposed to many antibiotics in other hospitals. This is one of the causes of the high antibiotic resistance rate at Dr. Soetomo Regional General Hospital. However, if it is viewed from the hospital data below, it is not much different. [4] According to the data in Soebandi Regional General Hospital Jember, antibiotics that still had fairly good sensitivity to the urine culture results of UTI patients were Amikacin, Fosfomycin, Gentamicin, and Meropenem. While the Cephazolin, Ampicillin, and TMP-SMX antibiotics have high resistance. [19] Similar data were also presented in a study at the Moewardi Regional General Hospital Surakarta, where Amikacin and Meropenem antibiotics had a sensitivity of > 85% while Ciprofloxacin and Cefixime had very low sensitivity < 15%.

5. Study Limitations

In writing this study, the researchers were aware of several limitations, including the lack of data on oral antibiotic sensitivity, short study period, lack of culture data on a fungal infection, and the absence of a history of antibiotic use before urine culture examination.

6. Conclusion

Based on this research's data, it can be concluded that the most bacteria in the urine culture results of urologic patients at Dr. Soetomo Regional General Hospital are the same as the literature, which is*Escherichia coli.* However, for antibiotic sensitivity, aminoglycoside and carbapenem antibiotics still had a reasonably high sensitivity. Meanwhile, Cephalosporin and Fluroquinolone sensitivity decreased compared to the previous literature, except for Cefoperazone sulbactam, which still had a low resistance rate.

7. References

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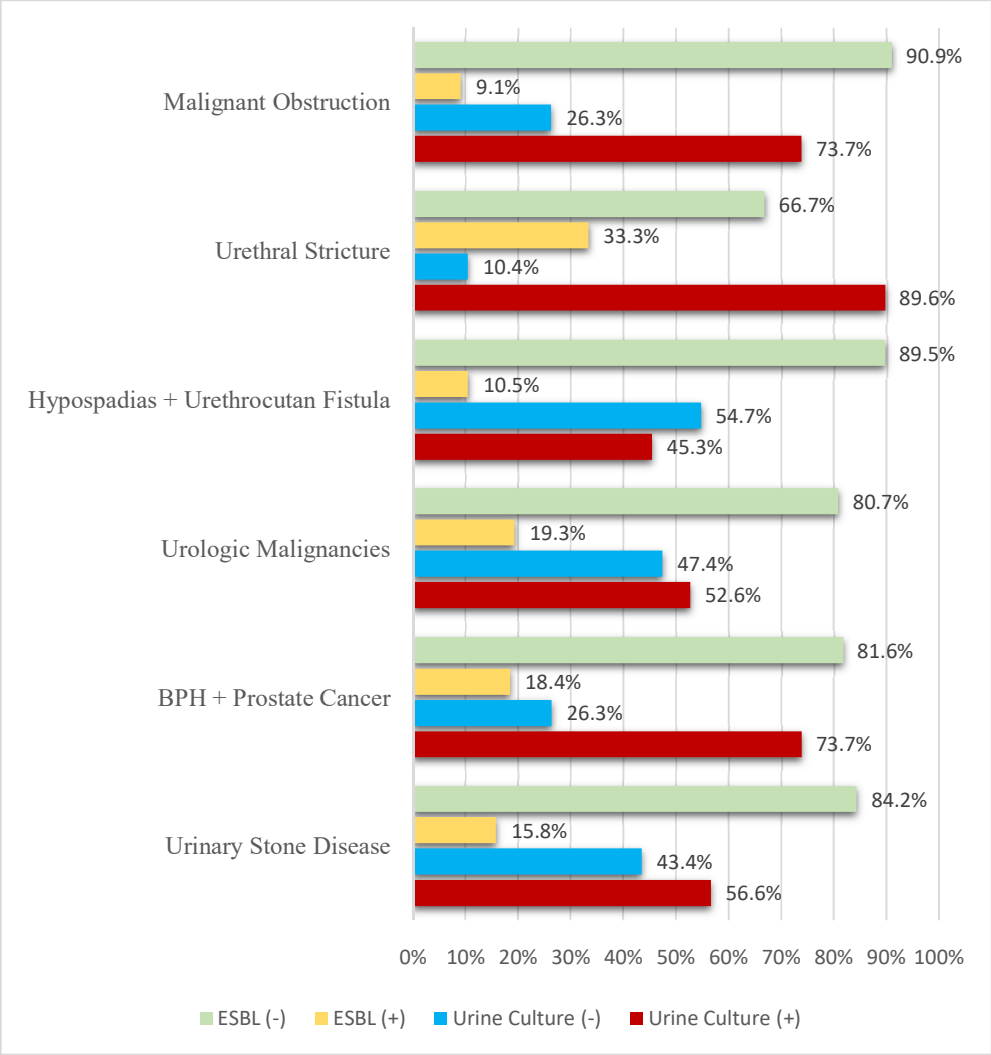
Tables and Figures

Table 1. Characteristics of Research Data

Characteristics	Number of Patients (%)	Positive Urine Culture (%)	Negative Urine Culture (%)
Sex			
- Male	402 (62.5)	222 (55.2)	180 (44.8)
- Female	241 (37.5)	180 (74.7)	61 (25.3)
Age (According to WHO)			
- Pediatric (≤18 years old)	133 (20.7)	67 (50.4)	66 (49.6)
- Adult (19 - 64 years old)	431 (67.0)	284 (65.9)	147 (34.1)
- Geriatric (≥ 65 years old)	79 (12.3)	51 (64.6)	28 (35.4)
Comorbidity			
- Diabetes mellitus	59 (9.2)	39 (66.1)	20 (33.9)
- Hypertension	114 (17.7)	70 (61.4)	44 (38.6)
- Stroke/paraplegia	11 (1.7)	8 (72.7)	3 (27.3)
- Immunocompromised	8 (1.2)	6 (75.0)	2 (25.0)
- TBC	2 (0.3)	1 (50.0)	1 (50.0)
- CKD	97 (15.1)	75 (77.3)	22 (22.7)
Diagnosis			
- Kidney Stone	177 (27.5)	97 (54.8)	80 (45.2)
- Ureter Stone	34 (5.3)	20 (58.8)	14 (41.2)
- Bladder Stone	17 (2.6)	12 (70.6)	5 (29.4)
- BPH	21 (3.3)	19 (90.5)	2 (9.5)
- Urethral Stricture	49 (7.6)	44 (89.8)	5 (10.2)
- Hypospadias	66 (10.3)	26 (39.4)	40 (60.6)
- Urethrocutaneous Fistula	23 (3.6)	13 (56.6)	10 (43.5)
- Vesicovaginal Fistula	11 (1.7)	10 (90.9)	1 (9.1)
- Bladder Cancer	41 (6.4)	24 (58.5)	17 (41.5)
- Prostate Cancer	17 (2.6)	9 (52.9)	8 (47.1)
- Kidney Cancer	11 (1.7)	3 (27.3)	8 (72.7)
- Penile Cancer	4 (0.6)	3 (75.0)	1 (25.0)
- DJ Stent in situ	13 (2.0)	11 (84.6)	2 (15.4)
- Malignant Obstruction	98 (15.2)	73 (74.5)	25 (25.5)
- Neurogenic Bladder	9 (1.4)	8 (88.9)	1 (11.1)
- Urethral stenosis	20 (3.1)	11 (55.0)	9 (45.0)
- Congenital Anomaly	5 (0.8)	3 (60.0)	2 (40.0)
- VUR	8 (1.2)	6 (75.0)	2 (25.0)
- Urogenital trauma	8 (1.2)	5 (62.5)	3 (37.5)
- Others	11 (1.7)	6 (54.5)	5 (45.5)

Figure 1. Comparison of the Results of Urine Culture and Patients with ESBL-Producing Bacterial Infection Based on Diagnosis



Description:

- Urinary tract stone consists of kidney stone, ureteral stone, and bladder stone.
- Urological malignancies include kidney cancer, ureteral cancer, bladder cancer, and penile cancer
- Malignant obstruction is a case of obstruction due to gynecological and digestive malignancies leading to urinary diversion

Figure 2. Comparison of Urine Culture of Patients Who Use Catheter and DJ Stent

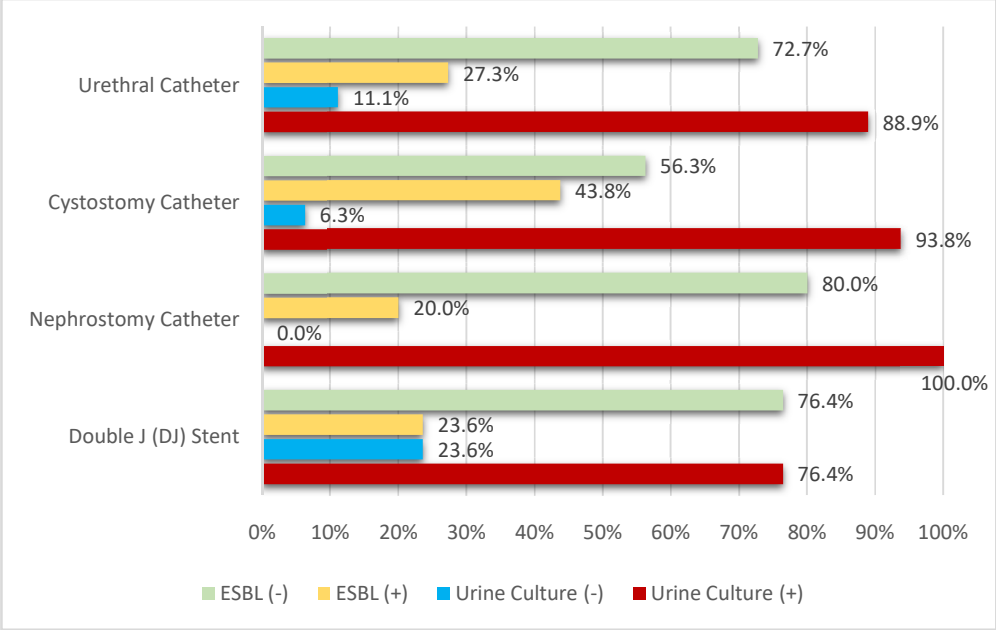


Figure 3. Distribution of Bacteria in Urine Culture of Urologic Patients

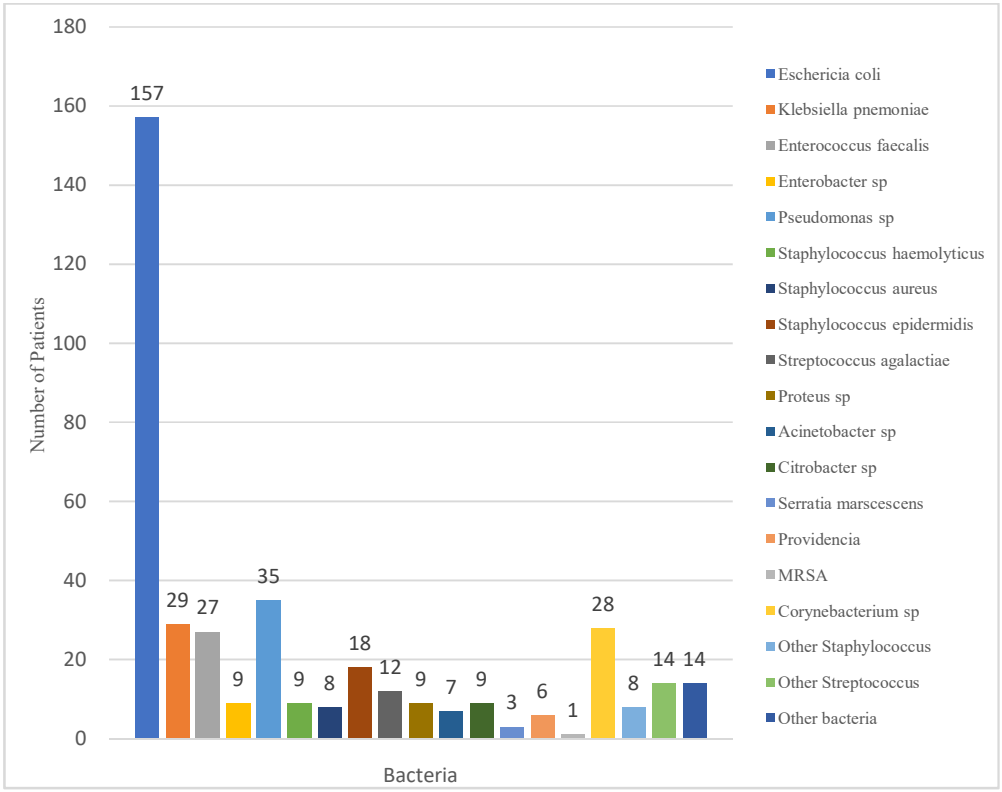


Figure 4. Comparison of Antibiotic Sensitivity and Resistance in Urologic Patients

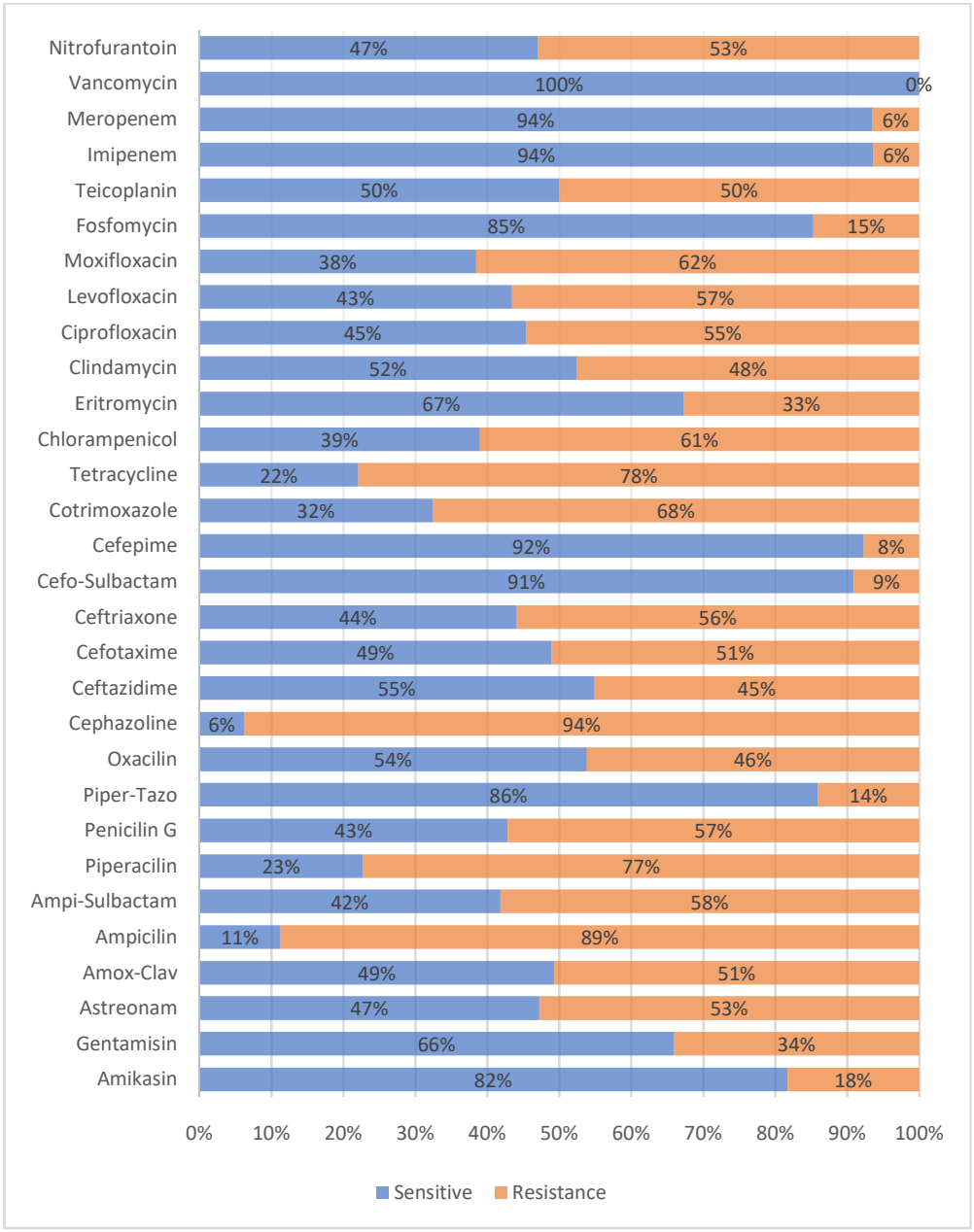

Nitrofurantoin 47% 53%
Vancomycin 100% 0%
Meropenem 94% 6%
Imipenem 94% 6%
Teicoplanin 50% 50%
Fosfomycin 85% 15%
Moxifloxacin 38% 62%
Levofloxacin 43% 57%
Ciprofloxacin 45% 55%
Clindamycin 52% 48%
Eritromycin 67% 33%
Chlorampenicol 39% 61%
Tetracycline 22% 78%
Cotrimoxazole 32% 68%
Cefepime 92% 8%
Cefo-Sulbactam 91% 9%
Ceftriaxone 44% 56%
Cefotaxime 49% 51%
Ceftazidime 55% 45%
Cephazoline 6% 94%
Oxacilin 54% 46%
Piper-Tazo 86% 14%
Penicilin G 43% 57%
Piperacilin 23% 77%
Ampi-Sulbactam 42% 58%
Ampicilin 11% 89%
Amox-Clav 49% 51%
Astreonam 47% 53%
Gentamisin 66% 34%
Amikasin 82% 18%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Sensitive
Resistance

Table 2. Antibiotic Sensitivity Data Based on Urological Diagnosis

	AM	GN	AT	AC	AP	AS	PP	PG	PT	OX	CZ	CD	CT	CF	CS	CM	CX	TT	CH	ER	CL	CI	LF	MX	FS	TC	IM	MR	VN	NT
KS	80%	59%	51%	58%	10%	39%	21%	50%	80%	80%	10%	47%	48%	45%	91%	100%	29%	21%	47%	64%	47%	34%	30%	23%	95%	91%	91%	91%	100%	63%
US	78%	78%	43%	64%	19%	50%	8%	33%	75%	#	11%	50%	35%	31%	100%	100%	12%	12%	50%	33%	25%	19%	25%	0%	100%	100%	93%	93%	100%	72%
BS	82%	64%	44%	78%	27%	78%	22%	100%	100%	#	0%	27%	27%	27%	100%	0%	36%	27%	0%	100%	0%	30%	30%	33%	100%	100%	89%	100%	#	60%
BP	89%	79%	59%	47%	0%	53%	36%	#	88%	#	11%	56%	59%	53%	94%	100%	38%	25%	0%	#	0%	33%	37%	46%	100%	0%	100%	100%	#	58%
UT	77%	53%	34%	35%	16%	27%	25%	0%	80%	50%	3%	41%	41%	39%	95%	100%	45%	18%	27%	17%	20%	52%	57%	64%	67%	100%	91%	92%	#	43%
HI	83%	93%	29%	17%	8%	29%	0%	33%	100%	0%	0%	40%	64%	56%	100%	#	36%	29%	60%	75%	67%	90%	80%	100%	100%	40%	100%	100%	#	73%
UF	64%	55%	38%	50%	0%	38%	0%	67%	100%	#	17%	38%	55%	55%	88%	100%	60%	25%	67%	67%	33%	75%	64%	67%	67%	#	88%	88%	#	64%
VF	100%	90%	40%	50%	20%	50%	44%	#	100%	#	0%	42%	40%	40%	89%	#	20%	30%	0%	#	#	60%	60%	50%	#	#	100%	100%	#	30%
BC	81%	65%	33%	38%	9%	22%	29%	0%	89%	100%	0%	35%	33%	19%	100%	#	50%	33%	40%	100%	100%	44%	41%	27%	100%	100%	94%	95%	#	52%
PC	88%	75%	50%	25%	0%	25%	25%	#	71%	#	0%	57%	50%	50%	75%	#	20%	17%	0%	#	#	50%	50%	40%	100%	#	100%	83%	#	33%
DJ	75%	56%	83%	86%	22%	83%	33%	0%	100%	100%	0%	83%	63%	63%	50%	#	11%	11%	25%	33%	33%	44%	44%	57%	100%	#	100%	100%	#	33%
NP	78%	63%	65%	51%	12%	50%	23%	58%	94%	44%	6%	61%	68%	58%	89%	#	30%	29%	44%	89%	83%	63%	53%	52%	25%	20%	94%	92%	#	22%
NB	88%	88%	57%	29%	13%	57%	43%	100%	100%	#	0%	44%	63%	63%	100%	#	13%	13%	#	100%	0%	25%	25%	33%	100%	100%	100%	100%	#	25%
ST	90%	55%	67%	50%	9%	67%	22%	0%	78%	0%	17%	55%	56%	44%	89%	100%	36%	9%	0%	#	0%	44%	38%	17%	100%	50%	100%	100%	#	27%
VU	100%	100%	17%	17%	0%	17%	17%	#	67%	#	0%	44%	33%	33%	83%	#	17%	0%	0%	#	#	50%	50%	33%	0%	#	83%	83%	#	0%

Description:

- Green Table : Antibiotic sensitivity ≥ 80% (according to the 2015 guideline recommendations for UTI management)
- Yellow Table : Antibiotic Sensitivity 50-79%
- Hash tag (#) : No data

KS: Kidney Stone; US: Ureter Stone; BS: Bladder Stone; BP: Benign Prostatic Hyperplasia (BPH); UT: Urethral Stricture HI: Hypospadias; UF: Urethrocutaneous Fistula; VF: Vesicovaginal fistula; BC: Bladder Cancer; PC: Prostate Cancer; DJ: DJ stent in situ; NP: Obstructive nephropathy/uropathy due to malignancy; NB: Neurogenic bladder; ST: Ureter stenosis; VU: Vesicoureteral reflux (VUR); AM: Amikacin; GN: Gentamicin; AT: Aztreonam; AC: Amoxicillin Clavulanic acid; AP: Ampicillin; AS: Ampicillin Sulbactam; PP: Piperacillin; PG: Penicillin G; PT: Piperacillin-Tazobactam; OX: Oxacillin; CZ: Cephazolin; CD: Ceftazidime; CT: Cefotaxime; CF: Ceftriaxone; CS: Cefoperazone-Sulbactam; CM:

Cefepime; CX: Cotrimoxazole; TT: Tetracycline; CH: Chloramphenicol; ER: Erythromycin; CL: Clindamycin; CI: Ciprofloxacin; LF: Levofloxacin; MX: Moxifloxacin; FS: Fosfomycin; TC: Teicoplanin; IM: Imipenem; MR: Meropenem; VN: Vancomycin; NT: Nitrofurantoin

Table 3. Summary of Most Dominant Bacteria Causing UTI based on Diagnosis and Recommended Antibiotics

Diagnosis	*Bacteria (%)*	Antibiotic Recommendations
Kidney Stone	*E. coli* (22.6%), *Pseudomonas sp* (6.8%), *K. pneumoniae* (5.1%), *E. faecalis* (4.5%), *Conybacterium sp* (4.5%)	Cefoperazone sulbactam, Amikacin, Piperacillin tazobactam, Erythromycin, Gentamicin
Ureter Stone	*E. coli* (20.6%), *E. faecalis* (8.8%), *Pseudomonas sp* (8.8%), *K. pneumoniae* (5.9%), *S. epidermidis* (5.9%)	Cefoperazone Sulbactam, Amikacin, Gentamicin, Piperacillin tazobactam, Nitrofurantoin
Bladder Stone	*E. coli* (41.2%), *E. faecalis* (8.8%), *Enterobacter sp* (5.9%), *Pseudomonas sp* (5.9%), *S. epidermidis* (5.9%)	Cefoperazone sulbactam, Piperacillin tazobactam, Penicillin G, Erythromycin, Amikacin
BPH	*E. coli* (33.3%), *K. pneumoniae* (14.3%), *E. faecalis* (9.5%), *Enterobacter sp* (9.5%), *Proteus sp* (9.5%)	Cefoperazone sulbactam, Piperacillin tazobactam, Amikacin, Gentamicin, Cefotaxime
Urethral Stricture	*E. coli* (36.7%), *E. faecalis* (10.2%), *Pseudomonas sp* (10.2%), *Enterobacter sp* (6.1%), *Povidencia sp* (6.1%)	Cefoperazone sulbactam, Piperacillin tazobactam, Amikacin, Moxifloxacin, Levofloxacin
Hypospadias	*S. epidermidis* (10.6%), *E. coli* (9.1%), *Corynebacterium sp* (6.1%), *S. haemolyticus* (3.1%)	Cefoperazone sulbactam, Piperacillin tazobactam, All quinolone, Gentamicin, Amikacin
Urethrocutaneous Fistula	*E. coli* (26.1%), *S. agalactiae* (8.7%), *Acinetobacter sp* (4.3%), *Citrobacter* (4.3%), *Streptococcus sp* (4.3%)	Piperacillin tazobactam, Cefoperazone sulbactam, Ciprofloxacin, Erythromycin, Penicillin G
Vesicovaginal Fistula	*E. coli* (45.5%), *Proteus sp* (18.2%), *K. pneumoniae* (9.1%), *Citrobacter sp* (9.1%), *Pseudomonas sp* (9.1%)	Amikacin, Piperacillin tazobactam, Cefoperazone sulbactam, Levofloxacin
Bladder Cancer	*E. coli* (19.5%), *Pseudomonas sp* (7.3%), *K. pneumoniae* (4.9%), *K. pneumoniae* (4.9%), *S. haemolyticus* (4.9%)	Cefoperazone sulbactam, Piperacillin tazobactam, Amikacin, Erythromycin
Urethral Stenosis	E. *coli* (25%), *Enterobacter sp* (6.3%), *Pseudomonas sp* (6.3%), *E. faecalis* (5.0%), *Staphylococcus sp* (5.0%)	Cefoperazone sulbactam, Amikacin, Piperacillin tazobactam, Ampicillin sulbactam
Neurogenic Bladder	*E. coli* (44.4%), *Proteus sp* (22.2%), *K. pneumoniae* (11.1%)	Cefoperazone sulbactam, Piperacillin tazobactam,

		Penicillin G, Erythromycin, Amikacin
Malignant Obstruction	*E. coli* (25.5%), *Corynebacterium sp* (13.3%), *S. agalactiae* (5.1%), *Proteus sp* (5.1%), *Streptococcus sp* (4.1%)	Piperacillin tazobactam, Cefoperazone sulbactam, Erythromycin, Amikacin, Gentamicin