Nitrofurantoin susceptibility among antimicrobial resistant uropathogens

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Abstract

Background

Antimicrobial resistance is the biggest threat in real time to health the world over. The World Health Organization (WHO) has recognised antimicrobial resistance (AMR) as one of the top ten public health threats to humanity. AMR, apart from increasing the morbidity and mortality also adds to the health costs by prolonging hospital stay and by increasing the need for high-cost antimicrobials. Of the many infections caused by the AMR bacterial pathogens urinary tract infections (UTI) are significant. All UTI need to be treated as UTI can results in complication such as pyelonephritis and urosepsis.

With the increase in infections caused by multidrug resistant and extensively drug resistant bacteria, treatment of these infections has become a huge challenge. In urinary tract infections caused by antibiotic resistant bacteria, drugs like nitrofurantoin can be used with good outcome. This study attempts to analyse the susceptibility of nitrofurantoin in drug resistant uropathogens

Methods

Consecutive, non-duplicate isolates of bacteria obtained from urine samples of inpatients and outpatients were included in the study. There wasa total of 947 bacterial isolates between August 2022 and November 2022. Nitrofurantoin minimum inhibitory concentration (MIC)was obtained from the Vitek2 bacterial identification system.

Results

The total number of isolates during the study period from urine culture was 947. Escherichia coli(E.coli) was the most common isolate(n=438;46%), the second most common isolate was Klebsiella pneumoniae(K.pneumoniae)(n=172;18%). The most frequent gram positive isolate was enterococcus(n=32;3.37%). There was a total of 232 extended spectrum beta lactamase (ESBL) producers,out of which78% were susceptible to nitrofurantoin. Total number of ESBL E.coli were 147(33.5%) out of which 87%(128)were susceptible to nitrofurantoin. Total number of ESBL K.pneumoniae were 40, out of which 55%(n=22)were susceptible to nitrofurantoin. AmpC beta lactamase was found to be produced by 174 isolates out of which 108(62%) isolates were susceptible to nitrofurantoin. A total of 288 isolates were carbapenemase producers and 63% of these were susceptible to nitrofurantoin.

Conclusion

Drugs that were used in the past like nitrofurantoin can be used with good results in urinary tract infections caused by drug resistant pathogens

Key words

Uropathogens, extended spectrum beta lactamase, AmpC beta lactamase, Carbapenemase, nitrofurantoin

Introduction

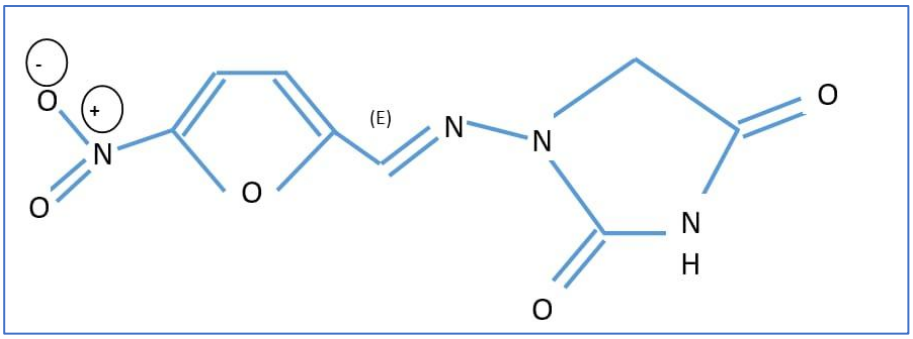
Urinary tract infections (UTI) are one of the most common causes, for which medical attention is sought (1). A massive 401.61 million cases of UTI have occurred at the global level in the year 2019 with 236,790 deaths (5). It is estimated that half of all adult women develop at least one episode of uncomplicated UTI in their lifetime. In addition to being a frequent cause of outpatient visits, it also is a frequent cause of hospital admissions when it presents with complications like pyelonephritis or urosepsis. UTI is also an important health care associated infection with approximately 10% of patients developing UTI in the health care settings.

The commonest organisms causing UTI are those that belong to Enterobacterales with *Escherichia coli* (*E. coli*) being the most common particularly in the community acquired UTI. *Klebsiella pneumoniae(K.pneumoniae)*, *Enterobacter*, *Citrobacter*, *Proteus* are the other enterobacerales that commonly cause UTI. Non fermenter gram negative bacteria like *Pseudomonas aeruginosa*, *Acinetobacter* and gram positive cocci like *Staphylococcus aureus, Enterococci, and Staphylococcus saprophyticus* are other important causes of UTI (1).

The causative bacterial agents of UTI have remained the same over decades, however the antimicrobial resistance of these organisms have significantly changed with most of them developing resistant to many antimicrobials (7). With the widespread antimicrobial resistance among bacteria, treatment of infections caused by these UTI causing bacterial agents has been a great challenge. A significant number of these produce extended spectrum beta lactamases (ESBL), AmpC beta lactamases, and carbapenemases and a vast majority of these show resistance to fluroquinolones.

Infectious Diseases Society of America (IDSA) recommends Trimethoprim-sulphamethoxazole, and nitrofurantoin as the first line drugs in cystitis. Nitrofurantoin is a urinary antibiotic that has been in use since the early 1950s. It acts at multiple levels that include bacterial cell wall, bacterial proteins and nucleic acids (6). It is effective in UTI caused by the antimicrobial resistant bacterial pathogens effecting cure in up to 79-92% of cases. Nitrofurantoin is safe, can be used in pregnant women (6) for even up to 38 weeks of gestation (7). Because it is predominantly excreted in the urine, only very little reaches the intestine and hence it does not cause rarely causes change in the composition of the bacterial flora of the intestine. Resistance to nitrofurantoin, in spite of being in use for more than 60 years, is very little (7). This is because of the multiple mutations that have to happen for the development of resistance.

Structure of Nitrofurantoin



Nitrofurantoin can be used in uncomplicated lower urinary tract infections caused by the most common uropathogens E.coli, K.pneumoniae, Enterococcus, and Staphylococcus aureus (6,7). And nitrofurantoin is cidal to the uropathogens (18). Knowledge of nitrofurantoin susceptibility among uropathogens will aid in empiric therapy and definitive therapy of lower UTI. Thus aim of the current study is to determine the susceptibility of nitrofurantoin among uropathogens that are multidrug resistant.

Materials and methods

This was a prospective study done in the department of clinical microbiology in a tertiary care teaching hospital in South India. The study was done from August 2022 to November 2022. The study was approved by the Institution Ethical Committee (IEC). (IEC number SMC/IEC/2022/05/020)

Midstream clean catch urine samples and catheterized urine samples from inpatients and outpatients received in the clinical microbiology laboratory were streaked on cysteine lactose electrolyte deficient agar plates (CLED agar medium), using the semiquantitative plating method and incubated for 18-24 hours at 37°C. Isolates obtained in significant colony counts from urine samples of inpatients and outpatients with correlating gram smear findings were included. Isolates from repeat samples of urine and isolates obtained in insignificant colony counts were excluded.

Cultures in significant colony counts ($\geq 10^5$ colony forming units) at the end of incubation period were processed by the Vitek2 automated bacterial identification system for identification and antimicrobial susceptibility and the minimum inhibitory concentration (MIC) was obtained from the same. The antibiogram and the susceptibility profile were statistically analysed using Chi-square test. P value of < 0.05 was used as significant.

Results

This prospective study was undertaken to determine nitrofurantoin susceptibility in antimicrobial resistant uropathogens.

The total number of isolates was 947 of which 46% were Escherichia coli(n=438) and 18% (n=172) were Klebsiella pneumoniae. Enterococcus was the most common gram positive isolate (n=32; 3.37% of all isolates). The other organisms isolated were Enterobacter, Citrobacter, Proteus, Morganella, Pseudomonas aeruginosa, Acinetobacter baumannii, Staphylococcus aureus and Staphylococcus saprophyticus.

Of the total 438 Escherichia coli isolates 87% were susceptible to nitrofurantoin. However, 65% of all Klebsiella pneumoniae (n=172) isolates were resistant to nitrofurantoin.

In our study, among the E.coli isolates(n=438), 32% were resistant to aminoglycosides, 41% were resistant to quinolones, and 47% showed resistance to carbapenems. Only 0.004% of the isolates were resistant to Fosfomycin. Of the carbapenem resistant E.coli(n=206), 77% were susceptible to nitrofurantoin.

Among the Klebsiella pneumoniae isolates 26% of the isolates exhibited resistance to aminoglycosides, 39% were resistant to quinolones. Carbapenem resistance was 30% among these isolates. Out of the carbapenem isolates 27% were susceptible to nitrofurantoin.

Total number of ESBL E.coli were 147(33.5%) out of which 87%(128)were susceptible to nitrofurantoin. Total number of ESBL K.pneumoniae were 40, out of which 55%(n=22)were susceptible to nitrofurantoin

The total number of ESBL producers was 232 (24% of total isolates), and 30% of the total isolates(n=288) were carbapenemase producers. Out of the 232 ESBL producers, 78% were susceptible to nitrofurantoin. Of the 288 carbapenemase producers 63% were susceptible to nitrofurantoin.

AmpC beta lactamase was found to be produced by 174 isolates out of which 108(62%) isolates were susceptible to nitrofurantoin.

Total No. of isolates: 947									
IPD	648	% of prevalence	No. of Nitrofurantoin resistant strains	% of Nitrofurantoin resistant strains	**OPD**	299	% of prevalence	No. of Nitrofurantoin resistant strains	% of Nitrofurantoin resistant strains
Escherichia coli	296	46	41	14	Escherichia coli	142	47	16	11
Klebsiella pneumoniae	124	19	81	65	Klebsiella pneumoniae	48	16	31	65
Enterococcus species	27	4	14	52	Enterococcus species	5	2	1	20
Enterobacter species	29	4	19	66	Enterobacter species	8	3	3	38
Citrobacter species	19	3	7	37	Citrobacter species	13	4	3	23
Serratia species	23	4	5	22	Serratia species	6	2	1	17
Proteus species	7	1	4	57	Proteus species	6	2	5	83
Providencia species	4	1	0	0	Morganella species	6	2	4	67
Morganella species	6	1	3	50	Acinetobacter species	13	4	0	0
Acinetobacter species	18	3	0	0	Staphylococcus species	8	3	0	0
Staphylococcus species	13	2	0	0	Pseudomonas aeruginosa	19	6	NA	NA
Pseudomonas aeruginosa	36	6	NA	NA	Other Genus and Species	25	8	2	8
Other Genus and Species	46	7	4	9					

Table 1: Prevalence of uropathogens and its susceptibility percentage to Nitrofurantoin

Escherichia coli

IPD/OPD	Drug	Susceptibility	Aminoglycoside		Cephalosporin		Carbapenem		Trimethoprim sulfamethoxazole		Fosfomycin		Quinolone		Polypeptides		Tetracycline	
			Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant
OPD	Nitrofurantoin	Susceptible (126)	86	40	64	62	102	24	4	121	126	0	66	60	126	0	93	33
		Resistant (16)	11	5	9	7	4	12	1	15	16	0	1	15	16	0	16	0
	Chi square		0.0016 p=0.968		0.169 p=0.68		23.48 p<0.05		0.385 p=0.5345		NA		12.12 p < 0.05		NA		NA	
Amp C Producers = 24																		
IPD	Nitrofurantoin	Susceptible (255)	165	90	189	66	125	130	5	250	253	2	184	71	255	0	157	98
		Resistant (41)	35	6	29	12	1	40	1	40	41	0	9	32	41	0	41	0
	Chi square		6.879 p=0.0087		0.208 p=0.64		31.347 p=2.167		0.040 p=0.84		NA		0.32 p=0.5694		NA		NA	
Amp C = 91, OXA = 4, SHV = 12																		

Table 2: Comparison of Antibiotic susceptibility profile with Nitrofurantoin Susceptible and resistant Escherichia coli isolates

Klebsiella pneumoniae

IPD/OPD	Drug	Susceptibility	Aminoglycoside		Cephalosporin		Carbapenem		Trimethoprim sulfamethoxazole		Fosfomycin		Quinolone		Polypeptides		Tetracycline	
			Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant
OPD	Nitrofurantoin	Susceptible (17)	14	3	12	5	4	3	2	15	13	4	9	8	12	5	4	13
		Resistant (31)	29	2	26	5	25	6	2	29	17	14	23	8	31	0	31	0
	Chi square		1.47 p=0.22		1.174 p=0.27		1.745 p=0.18		0.405 p=0.52		2.192 p=0.13		2.23 p=0.135		10.17 p=0.001		32.51 p=1.189	
Amp C Producers = 9																		
IPD	Nitrofurantoin	Susceptible (43)	31	12	26	17	32	11	4	39	26	17	29	14	25	18	12	31
		Resistant (81)	53	28	68	13	49	32	4	77	40	41	44	37	81	0	81	0
	Chi square		0.570 p=0.45		8.44 p=0.003		2.40 p=0.12		0.88 p=0.34		1.38 p=0.23		1.99 p=0.15		NA		NA	
Amp C = 42, OXA = 1																		

Table 3: Comparison of Antibiotic susceptibility profile with Nitrofurantoin Susceptible and resistant Klebsiella pneumoniae isolates

Other Enterobacteriaceae (Enterobacter, Citrobacter, Serratia, Proteae family)

IPD/OPD	Drug	Susceptibility	Aminoglycoside		Cephalosporin		Carbapenem		Trimethoprim sulfamethoxazole		Fosfomycin		Quinolone		Polypeptides		Tetracycline	
			Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant
OPD	Nitrofurantoin	Susceptible (23)	22	1	16	7	20	3	7	16	20	3	20	3	23	0	15	8
		Resistant (16)	15	1	10	6	11	5	2	14	10	6	12	4	16	0	16	0
	Chi square		0.0702 P=0.7910		0.212 P=0.645		1.918 P=0.166		1.7909 P=0.19		3.179 P=0.07		0.916 P=0.339		NA		NA	
Amp C Producers = 4																		
IPD	Nitrofurantoin	Susceptible (50)	41	9	37	13	39	11	23	27	40	10	38	12	42	8	44	6
		Resistant (38)	35	3	32	6	27	11	8	30	28	10	26	12	38	0	38	0
	Chi square		1.87 P=0.171		1.329 P=0.249		0.556 P=0.455		5.88 P=0.15		0.490 P=0.483		0.625 P=0.42		NA		NA	
Amp Cproducers = 4																		

Table 4: Comparison of Antibiotic susceptibility profile with Nitrofurantoin Susceptible and resistant other Enterobacteriaceae isolates

Total no. of Nitrofurantoin resistant isolates were 244 and susceptible isolates were 703

	No. of isolates	**% of isolates**
Nitrofurantoin resistant Total ESBL Producers	52	21
Nitrofurantoin sensitive total ESBL producers	180	26
Nitrofurantoin resistant Total Carbapenamase producers	106	43
Nitrofurantoin sensitive Total Carbapenamase producers	182	26

Table 5: Prevalence of Nitrofurantoin Resistant - ESBL and Carbapenamase producers

OPD	Acinetobacter species (13)		Staphylococcus species (8)		Enterococcus species (5)	
	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant
Aminoglycoside resistant	7(54%)	6(46%)	4(50%)	4(50%)	NA	
Carbapenem resistant	9(69%)	4(31%)	NA		NA	
ESBL producing	9(69%)	4(31%)	NA		NA	
Quinolone resistant	10(77%)	3(23%)	5(63%)	3(38%)	5(100%)	0
Trimethoprim sulfamethoxazole resistant	10(77%)	3(23%)	5(63%)	3(38%)	5(100%)	0
HLG resistant	NA		NA		1(20%)	4(80%)
MLSB	NA		7(88%)	1(13%)	3(60%)	2(40%)
Tetracycline resistant	13(100%)	0	5(63%)	3(38%)	2(40%)	3(60%)
Methicillin resistant	NA		4(50%)	4(50%)	NA	
Vancomycin resistant	NA		8(100%)	0	5(100%)	0(0%)

IPD

	Acinetobacter species (18)		Staphylococcus species (13)		Enterococcus species (27)	
	Susceptible	Resistant	Susceptible	Resistant	Susceptible	Resistant
Aminoglycoside resistant	10(56%)	8(44%)	1(8%)	12(92%)	27(100%)	0(0%)
Carbapenem resistant	17(94%)	1(6%)	NA		NA	
ESBL producing	13(72%)	5(28%)	NA		NA	
Quinolone resistant	16(89%)	2(11%)	2(15%)	11(85%)	16(59%)	11(41%)
Trimethoprim sulfamethoxazole resistant	16(89%)	2(11%)	0(0%)	13(100%)	27(100%)	0(0%)
HLG resistant	NA		NA		14(52%)	13(48%)
MLSB	NA		7(54%)	6(46%)	17(63%)	10(37%)
Tetracycline resistant	13(72%)	5(28%)	10(77%)	3(23%)	14(52%)	13(48%)
Methicillin resistant	NA		4(31%)	9(69%)	NA	
Vancomycin resistant	NA		9(69%)	4(31%)	25(93%)	2 (7%)
Penicillin resistant	NA		9(69%)	4(31%)	NA	

Table 6: Prevalence of other (Gram positive cocci and Non fermentative Gram negative coccobacilli) uropathogens that were susceptible to Nitrofurantoin

Discussion

In uncomplicated UTI, nitrofurantoin and cotrimoxazole are recommended as first line antimicrobials (9). Nitrofurantoin is concentrated in the urine (18) and it is available in oral formulation. The adverse drug reactions are minimal (10) and it is safe in pregnancy. Because it acts at multiple levels, antimicrobial resistance among uropathogens to nitrofurantoin is very low. It is active against both gram positive and gram negative pathogens in UTI. All the features make nitrofurantoin as an ideal agent for both empiric therapy and treatment.

For decades the causative agents of UTI has remained the same, however the antimicrobial resistance pattern of these uropathogens have changed, with them acquiring more resistance to the commonly used antimicrobials in UTI.In a study done in North India, (8), E.coli is the most the most common uropathogen isolated and the second most common gram negative pathogen is K.pneumoniae. Also another study done on the bacterial profile and their antimicrobial susceptibility pattern of uropathogens in India in 2022 by Kanika Bhargava(11) states that the most frequent bacterial agent of UTI to be E.coli, followed by Proteus and Klebsiella.Michela Tutone, in her study done in 2022 in Europe(13) to analyse the susceptibility of uropathogens to different antimicrobials states that the principal pathogens causing UTI was E.coli(72.5%) and K.pneumoniae(9.7%). In this study enterococcus is being recorded as the commonest gram positive cocci causing(13) UTI. These findings are in agreement with our study where we record that E. coli is the most common gram negative bacteria causing UTI, followed by K.pneumoniae among the gram negative bacilli.

In our study, among the E.coli isolates(n=438), 32% were resistant to aminoglycosides, 41% were resistant to quinolones, and 47% showed resistance to carbapenems. Only 0.004% of the isolates were resistant to Fosfomycin. Of the carbapenem resistant E.coli(n=206), 77% were susceptible to nitrofurantoin. In their study by Bhargava et al, it is documented that 77% and 50% of E.coli are susceptible to amikacin and gentamicin respectively(11), findings which are similar to our study. The same study reports susceptibility rates of 57% and 37.2% to imipenem and meropenem respectively in E.coli isolates which is also similar to our study findings. Susceptibility of E.coli isolates to cotrimoxazole on our study was only 2.6% , however in the study by Bhargava et al it is 39.8%, significantly higher than in our study. While our study finds 41% resistance to fluoroquinolones, Bhargava et al reports a susceptibility rate of only 3.8% to ciprofloxacin in E.coli. A study done in Lebanon reports that 78% and 83% of E.coli as being susceptible to amikacin and gentamicin respectively(23). This same study reports that in E.coli, 69% susceptibility to ciprofloxacin , 100% susceptibility to imipenem and meropenem, and 55% susceptibility to cotrimoxazole. This study also reports 96% susceptibility to Fosfomycin. In our study, we found that 97% of E.coli isolates to be resistant to cotrimoxazole and only 0.004% resistance to Fosfomycin.In their study by Sokhn et al(23), 78% of E.coli are reported to be susceptible to amikacin and 83% to gentamicin.. Sokhn et al reports 55%, 69.4%, 100% susceptibility of E.coli to cotrimoxazole, ciprofloxacin and carbapenems respectively and 96% susceptibility to Fosfomycin.Michela Tutone (13)study finds that less than 70% of E.coli isolates were inhibited by trimethoprim sulfamethoxazole and 80% of E.coli being susceptible to

Ciprofloxacin. In our study 59% of E.coli isolates were found to be susceptible to ciprofloxacinand there was a 97% resistance to cotrimoxazole in E.coli.

In our study, among the Klebsiella pneumoniae isolates 26% of the isolates exhibited resistance to aminoglycosides, 39% were resistant to quinolones. Carbapenem resistance was 30% among these isolates. Out of the carbapenem isolates 27% were susceptible to nitrofurantoin. In their study by Bhargava et al 82% and 86% of K. pneumoniae were susceptible to susceptible to amikacin and gentamicin respectively(11). Bhargava et al study also reports 73% and 41% susceptibility in K. pneumoniae to imipenem and meropenem respectively, in our study carbapenem resistance was 30% in K.pneumoniaeisolates.In their study by Sokhn et al(23)78% of K.pneumoniae are reported to be susceptible to amikacin, in our study aminoglycoside susceptility of K.pneumoniae was 74% which is similar to our observation. Sokhn et al reports 61.4%, 66%, 100% susceptibility of K.pneumoniae to cotrimoxazole, ciprofloxacin and carbapenems respectively and 96.9% susceptibility to Fosfomycin.In our study 93% of K.pneumoniae isolates were found to be resistant to cotrimoxazole.

Extended spectrum beta lactamases are enzymes that inactivate upto third generation cephalosporins, for which beta lactam-beta lactamase combination drugs or carbapenems are used in treatment (9). In our study 33.5% of E.coli and 23% of K.pneumoniae were found to be ESBL producers.Also in our study we found that 87% of ESBL E.coli and 55% of ESBL Klebsiella pneumoniae to be susceptible to nitrofurantoin. A study done in 2018 by Neeraj Kumar Turala to determine nitrofurantoin susceptibility in ESBL producing E.coli and K.pneumoniae, finds that 93.7% of ESBL E.coli and 57.7% ESBL K.pneumoniae as being susceptible to nitrofurantoin(12).In our study we found that 87% of ESBL E.coli and 55% of ESBL Klebsiella pneumoniae to be susceptible to nitrofurantoin. In the study on ESBL uropathogens Sajjad Raja in 2019 records that 93% of ESBL E.coli and 43% of ESBL Klebsiella species as being susceptible to nitrofurantoin.(17). In a study done in 2010 on ESBL uropatogens byS.auer et al records that 94%of ESBL E.coli as being susceptible to nitrofurantoin.(18).In a study by Sonali Bhattar et al (8) on nitrofurantoin for uropathogens records that 80% of ESBL producing E. coli and 47.61% of ESBL producing K.pneumoniae were susceptible to nitrofurantoin, which is similar to our study findings.Similar observations are also made by MJ Gharavi et al in his study on ESBL uropathogens.(16) and in a study by Sajjad araja(17). A study by DusiRatna Harika et al on nitrofuraoin efficacy in ESBL producers find that 88.4%of ESBL E.coli and 58.9% K.pneumoniae were susceptible to nitrofurantoin(19).Michela Tutone(13) records that 96.5% of E.coli that were not susceptible to cefpodoxime were being susceptible to nitrofurantoin. These findings are similar to the findings of our study.

AU Amladi, in her study on carbapenem resistant Enterobacteriaceae causing UTI(14) finds that 51% of carbapenem resistant E.coli to be susceptible to nitrofurantoin. In our study we found that 77% of carbapenem resistant isolates of E.coli and 27% of Klebsiella pneumoniae were found to be susceptible to nitrofurantoin.In her study done in 2014, Shanmugam et al (15) records that 64% of E.coli to be ESBL producers and 40% of K.pneumoniae produced ESBL. She also finds that 58% of these were susceptible to

nitrofurantoin. In this study, 76% of E.coli are found to be resistant to co-trimoxazole, our study also records a high percentage of resistance I E.coli to the drug at 97%. In our study 93% of K.pneumoniae isolates are found to be resistant to cotrimoxazole, in her study by Shanmugam et al, it is 69%. Our study finds quinolone resistance in E.coli and K.pneumoniae to be 41% and 39% respectively. In Shanmugam's study quinolone resistance is recorded to be high with E.coli showing 89% resistance and K.pneumoniae showing 56% resistance. Our study records that 77% of carbapenem resistant E.coli are being susceptible to nitrofurantoin, Shanmugam et al's study records that 51% of carbapenem E.coli are susceptible to nitrofurantoin.This study finds that 65% of ESBL producers and 51% carbapenamase producers as being susceptible to nitrofurantoin.

Conclusion:

With the worldwide spread of antimicrobial resistance among uropathogens, treatment of these infections has become difficult. Because of the significant level of production of different types beta lactamases and carbapenemases, drugs that are non beta lactam or non carbapenem will be optimal for treatment as well as empiric therapy in UTIs. Nitrofurantoin , because of its efficacy , favourable safety profile and availability of oral formulation of this drug, an ideal choice to treat uncomplicated lower urinary tract infections. Using drugs like nitrofurantoin also can save the higher drugs like carbapenems can be reserved for more serious infections.

Limitations and Future Scope:

The current study did not include genetic characterization of nitrofurantoin resistance. This study helps to understand the current scenario of Uropathogens prevalence and its susceptibility to nitrofurantoin which will be useful in the management of patients with Lower Urinary Tract Infection.

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