Section: Microbiology

Original Research Article

ROLE OF NITROFURANTOIN IN URINARY ISOLATES AT A TERTIARY CARE HOSPITAL

Pritha Pramanick[1], Arpita Sarkar[2], Anirban Nandi[3]

[1]Assistant Professor, Department of Microbiology, Jagannath Gupta Institute of Medical Sciences and Hospital, Budge Budge, Kolkata, India.
[2]Assistant Professor, Department of Microbiology, Jagannath Gupta Institute of Medical Sciences and Hospital, Budge Budge Kolkata, India.
[3]Associate Consultant, Department of Urology, Fortis Hospital, Anandapur, Kolkata, India.

Received *: 20/03/2025*
Received in revised form *: 11/05/2025*
Accepted *: 31/05/2025*

Corresponding Author:
Dr. Anirban Nandi,
Associate Consultant, Department of Urology, Fortis Hospital, Anandapur, Kolkata, India.
Email: anirban1cnmc@gmail.com

DOI: 10.70034/ijmedph.2025.2.434

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (2); 2403-2407

ABSTRACT

Background: Urinary tract Infections (UTI) are among the most common infectious diseases in humans. Most common organisms that produce UTI come from the flora of Intestinal tract. Increasing bacterial resistance against standard antibiotics has become a major challenge for the treatment of urinary infections. To fight this problem, an old drug Nitrofurantoin is getting good attention in recent times.

Materials and Methods: This study was conducted in Department of Microbiology at Jagannath Gupta Institute of Medical Sciences and Hospital, Budge, Budge, Kolkata, India.

Results: Out of 1,000 urine samples, 23% showed bacterial growth, mainly E. coli (74%) and Enterococcus spp. (26%), with most patients being female and over 50. Vancomycin was most effective against Enterococcus, while Nitrofurantoin, Fosfomycin, and carbapenems were effective against E. coli and other Gram-negative bacteria. High resistance was observed to Penicillin, fluoroquinolones, and older antibiotics, especially in E. coli and Klebsiella spp.

Conclusion: This study emphasizes the urgent need for continued antimicrobial monitoring and responsible antibiotic usage. Nitrofurantoin stands out as a highly effective, safe, and accessible treatment for UTIs, especially against E. coli.

Keywords: Escherichia coli, Nitrofurantoin, Urinary tract Infections, Urinary isolates.

INTRODUCTION

Urinary tract infections (UTIs) are among the most prevalent infectious diseases in humans.[1] The primary source of the causative organisms is the intestinal flora.[2-4] The inappropriate and excessive use of antibiotics has led to the development of resistance among these bacteria,[3] thereby contributing to the wider spread of antimicrobial resistance.[5] The increasing resistance of bacteria to commonly used antibiotics has become a major challenge in the treatment of UTIs .

In response to this growing issue, nitrofurantoin, a relatively older antibiotic, has regained attention due to its sustained effectiveness. Despite more than 70 years of extensive global use against uropathogens, acquired resistance to nitrofurantoin remains remarkably low.[6] Traditionally, nitrofurantoin was not recommended for patients with renal impairment, particularly those with a creatinine clearance rate below 60 mL/min. However, recent studies suggest that it may be safely used in patients with clearance rates as low as 40 mL/min.[1-5]

In the past few decades, fluoroquinolones and cephalosporins have been widely used to treat UTIs, leading to increased bacterial resistance.[7] Although multidrug-resistant Escherichia coli are a significant cause of community-acquired UTIs globally, nitrofurantoin remains a valuable option to treat these infections.[8] It is a suitable choice due to its minimal resistance, low risk of side effects, and efficacy comparable to trimethoprim-sulfamethoxazole.[9]

Initially introduced in 1952 for the treatment of acute uncomplicated UTIs, widespread use of nitrofurantoin was seen for several years. However, its popularity declined in the 1970s with the advent of newer oral antibiotics such as co-trimoxazole and β-lactams. The rapid rise in resistance to these newer agents has, however, renewed the interest in nitrofurantoin.[10-11]

The aim of this study is to evaluate the role of nitrofurantoin in urinary isolates from a tertiary care hospital.

MATERIALS AND METHODS

Study Area: This study was conducted in Department of Microbiology at Jagannath Gupta Institute of Medical Sciences and Hospital, Budge, Budge, Kolkata, India for a period of one year.

Study population: Total population of this study was 1000 cases.

Laboratory procedure: Clean-catch midstream urine samples were collected from patients. Urine sample was processed immediately. Refrigeration was done if there was any delay of transportation of urine samples. Urine specimens were processed using standard microbiological procedures. Direct Examination by wet mount was performed to demonstrate the pus cells in urine, followed by Gram staining of urine. Urine sample was then inoculated onto CLED agar (Cystine-Lactose-Elecrtolyte-Deficient) or MacConkey agar and blood agar. The inoculated plates were aerobically incubated for 24-48 hours at 370C. Growth observed on the plates that were inoculated, a colony count of ≥ 105 colony forming units of urine was considered as significant, indicating significant bacteriuria. Conventional biochemical tests were used to identify the bacterial isolates. Antimicrobial susceptibility testing was conducted using the Kirby-Bauer disk diffusion method, in accordance with the latest Clinical and Laboratory Standards Institute (CLSI) guidelines.

Data Analysis: Data were analyzed by using Microsoft Excel.

RESULTS

The total number of 1000 urine specimens were included in this study, with a higher proportion of females (68%) compared to males (32%). Age distribution shows a predominantly elderly demography with majority aged over 50 yrs. Among them, 320 individuals were in the 51–60 yrs age group and 240 in the 61–70yrs age group.

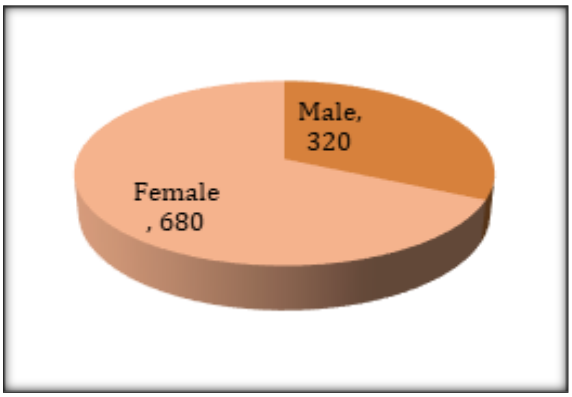

Chart 1: Distribution of cases according to gender

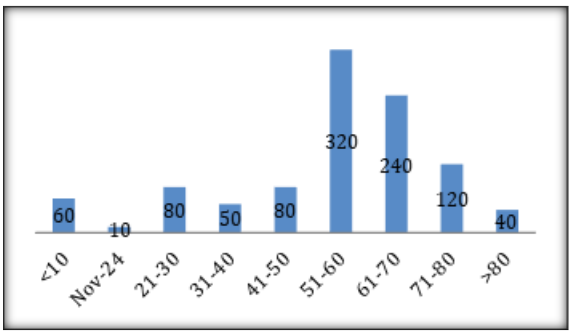

Chart 2: Distribution of cases according to Age group

Among 1,000 samples, 280 showed positive culture and 720 had sterile urine. This means that positive rate of culture was 28%, while the remaining 72% were sterile. The result showed that out of total 280 positive cultures, 170 were identified as Escherichia coli and 60 as Enterococcus species. This indicates that Escherichia coli accounts for the majority of the isolates, comprising approximately 61%, while Enterococcus species make upto 21%.

Table 1: Distribution of cases according to positive culture

Growth	Number of cases
Growth	280
Sterile	720
Total	1000

Table 2: Distribution of cases according to isolates

Isolates	Number of cases
Enterococcus Spp.	60
Escherichia coli	170
Klebsiella spp.	40
Proteus spp.	10
Total	280

Antibiotic susceptibility test were performed for all isolates. For Enterococcus species , The antibiotic susceptibility data indicates that Vancomycin is the most effective antibiotic, showing 100% sensitivity (60 out of 60 isolates) with no resistance. Levofloxacin and Fosfomycin also demonstrate high effectiveness, with 73% and 70% sensitivity, respectively. Teicoplanin shows moderate effectiveness, with 67% of isolates being sensitive. On the other hand, Penicillin exhibits the highest resistance, with 46 out of 60 isolates (77%) resistant and only 15% sensitive. Similarly, Ciprofloxacin shows high resistance levels (38% resistant), while Nitrofurantoin had greater sensitivity (77%) for Enterococcus. Tetracycline, Norfloxacin, and Ampicillin show mixed results, with roughly half or slightly more of the isolates being sensitive, indicating limited therapeutic reliability. Overall, Vancomycin remains the most reliable treatment option, while Penicillin and Ciprofloxacin show significant resistance suggesting less clinical effectiveness.

The antibiotic susceptibility data for E. coli, Klebsiella spp, and Proteus spp. reveals notable differences in resistance patterns across the tested antibiotics.

The table presents antibiotic susceptibility profiles of E. coli, Klebsiella spp., and Proteus spp. across a range of commonly used antibiotics, highlighting varying degrees of sensitivity (S), intermediate resistance (I), and resistance (R).

For E. coli, the most effective antibiotics in terms of sensitivity were Nitrofurantoin (150 sensitive isolates), Norfloxacin (135), Fosfomycin (130), and Imipenem and Amoxicillin-Clavulanate (120 each). However, high resistance was observed against Cotrimoxazole (118) and Ciprofloxacin (122), Ofloxacin (100), and Piperacillin-Tazobactam (130), suggesting limited effectiveness of these agents.

In Klebsiella spp, resistance was notably higher across most antibiotics. The best-performing agents were Piperacillin-Tazobactam (23 S), Ampicillin-sulbactam (22 S), and Gentamycin (21 S). Despite this, there was substantial resistance to Levofloxacin (38 R), Cefepime (36 R), and Meropenem (32 R), indicating these antibiotics are less suitable for treating Klebsiella infections.

Proteus spp. generally showed moderate susceptibility. Nitrofurantoin (8 S) and Fosfomycin (7 S) had relatively better effectiveness. Resistance was lower compared to Klebsiella, though Levofloxacin (8 R), Cefepime (6 R), and Ceftriaxone (6 R) still exhibited some resistance.

Overall, the data suggests Nitrofurantoin, Fosfomycin, and carbapenems (Imipenem, Meropenem) were among the most effective options for treating infections caused by these Gram-negative bacteria, while fluoroquinolones, older cephalosporins, and sulfonamides show reduced effectiveness, especially against E. coli and Klebsiella spp.

Table 3: Antibiotic susceptibility pattern of Enterococcus spp

Antibiotics	**S**	**I**	**R**
Nitrofurantoin	46	0	14
Tetracycline	30	9	21
Vancomycin	60	0	0
Teicoplanin	40	10	10
Penicillin	9	5	46
Norfloxacin	34	4	22
Fosfomycin	42	8	10
Ampicillin	33	12	15
Levofloxacin	44	0	16
Ciprofloxacin	20	17	23

Table 4: Antibiotic susceptible pattern of E. coli, Klebsiella spp, Proteus spp

	E. coli			**Klebsiella spp.**			**Proteus spp.**		
Antibiotics	S	I	R	S	I	R	S	I	R
Amoxcycillin –Clavulanate	120	0	50	8	0	32	8	0	2
Levofloxacin	90	10	70	2	0	38	2	0	8
Meropenem	90	20	60	7	1	32	7	1	2
Imipenem	120	20	30	6	2	32	6	2	2
Cefepime	80	40	50	4	0	36	4	0	6
Nitrofurantoin	150	10	10	35	1	4	8	1	1
Fosfomycine	130	20	20	7	3	30	7	3	0
Norfloxacin	135	10	25	15	0	25	10	0	0
Cotrimoxazole	42	10	118	8	0	32	8	0	2
Ofloxacin	50	20	100	5	0	35	5	0	5
Ciprofloxacin	48	0	122	8	2	30	8	2	0
Gentamycin	60	90	20	21	9	10	6	0	4
Amikacin	30	20	120	14	2	24	8	2	0
Ceftriaxone	70	30	70	16	2	22	4	0	6
Ceftazidime	60	40	70	10	15	15	3	5	2
Cefixime	90	40	40	13	0	27	6	2	2
Piperacillin-Tazobactam	40	0	130	23	0	17	5	1	4
Amoxcycillin	120	20	30	1	5	34	4	4	2

Ampicillin-sulbactam	40	0	130	22	0	18	2	4	4
Ampicillin	70	30	70	18	5	17	5	5	0

DISCUSSION

The antibiotic susceptibility patterns of Enterococcus spp., Escherichia coli, Klebsiella spp., and Proteus spp. isolated from urinary tract infections (UTIs) in this study provide important insight into the evolving trends of Nitrofruantoin in UTI at a tertiary care hospital. The data reveal a concerning rise in resistance to several commonly used antibiotics, complicating empirical therapy for UTIs.

In this study, Enterococcus spp. (60) isolated from urinary tract infections demonstrated highest susceptibility to Vancomycin (100%), followed by Nitrofurantoin (76.7%), Levofloxacin (73.3%), and Fosfomycin (70%), indicating these agents remain effective treatment options for enterococcal UTIs. The complete sensitivity to Vancomycin aligns with previous findings that glycopeptides continue to be reliable against most Enterococcus faecalis strains, though ongoing surveillance is necessary due to the global emergence of Vancomycin-resistant enterococci (VRE).[12] Penicillin resistance was notably high (76.7%), limiting its empirical use, a trend similarly reported in other studies where Enterococcus faecium predominates.[13] Tetracycline and Ciprofloxacin showed moderate to high resistance, further supporting the need to reserve fluoroquinolones due to rising resistance rates and limited efficacy.[14] Given its favorable susceptibility and pharmacokinetics in the urinary tract, Nitrofurantoin remains a first-line oral option for uncomplicated enterococcal UTIs.[15] This study highlights the importance of local antibiogram data to guide effective treatment and preserve antibiotic efficacy.

Among the tested organisms, E. coli, the most frequent uropathogen, showed the highest sensitivity to Nitrofurantoin (150 sensitive isolates), reaffirming its role as a preferred agent for uncomplicated UTIs. Nitrofurantoin also demonstrated moderate activity against Klebsiella spp. (35 sensitive isolates) and Proteus spp. (8 sensitive isolates). Although Nitrofurantoin is typically less effective against Klebsiella and Proteus due to intrinsic resistance, the observed susceptibility in this study suggests potential variability among strains and warrants further investigation.[16-17]

Resistance to fluoroquinolones, including Ciprofloxacin and Ofloxacin, was alarmingly high across all three organisms, especially E. coli (120 resistant isolates each). These findings are consistent with global reports of increasing fluoroquinolone resistance due to widespread and often inappropriate use.[18] Cotrimoxazole and Amikacin also showed reduced activity, highlighting the diminishing efficacy of older antibiotics.

Third-generation cephalosporins, such as Cefixime, Ceftriaxone, and Ceftazidime, displayed moderate to high resistance levels, particularly in Klebsiella spp, likely reflecting extended-spectrum beta-lactamase (ESBL) production.[19] Carbapenems (Imipenem and Meropenem) retained good activity against E. coli but showed reduced effectiveness in Klebsiella spp. and Proteus spp., emphasizing the urgent need to reserve these agents for confirmed multidrug-resistant infections.[20]

Nitrofurantoin's continued efficacy, particularly against E. coli, is a key finding of this study. It acts through multiple mechanisms that inhibit DNA, RNA, protein, and cell wall synthesis, thereby reducing the potential for resistance development.[21] Its pharmacokinetics—achieving high urinary concentrations with minimal systemic exposure—makes it ideal for uncomplicated lower UTIs.

Despite concerns regarding its limited activity against Klebsiella and Proteus, the current study showed moderate susceptibility, suggesting a potential reevaluation of its utility against select strains of these organisms in specific settings.[21]

CONCLUSION

This study highlights the pressing need for ongoing antimicrobial surveillance and responsible antibiotic use. Nitrofurantoin remains a highly effective, safe, and accessible option for the treatment of urinary tract infections, particularly against E. coli. Its judicious use can improve the therapeutic regimen and contribute significantly to delay the spread of antimicrobial resistance.

REFERENCES

1. Azad, U., Khan and Mohd, S., Zaman. 2006. Biomedical Research, Multidrug resistance pattern in Urinary Tract Infection patients in Aligarh, Vol 17, No: 3.
2. Bauer, A.W., Kirby, W.M., Sherris, J.C., Turck, M. 1966. Antibiotic susceptibility testing by a standardized single disk method. Am. J. Clin. Pathol., 45(4): 493-6.
3. Cattell, W.R., Mc Sherry, M.A., North East, A., Powell, E., Brooks, H.J.L. and O' Grady, F. 1974. Periurethral enterobacterial carriage in pathogenesis of recurrent urinary infection.
4. British Med. J., 4: 248 252. Clinical and Laboratory Standards Institute antimicrobial susceptibility testing standards. M100-S25, Vol. 35, No. 3
5. Color Atlas and textbook of Microbiology by Koneman. 5th edition page 597-599.
6. Christiansen N, Nielsen L, Jakobsen L, Stegger M, Hansen LH, Frimodt-Moller N. Fluoroquinolone resistance mechanisms in urinary tract pathogenic Escherichia coli isolated during rapidly increasing fluoroquinolone consumption in a low-use Country. Microb Drug Resist. 2011;17(3):395-406.
7. Lee DS, Lee SJ, Choe HS. Community-acquired urinary tract infection by Escherichia coli in the era of antibiotic resistance. Biomed Res Int. 2018;2018:7656752. https://doi.org/10.1155/2018/7656752
8. Gupta K, Hooton TM, Naber KG, Wullt B, Colgan R, Miller LG, et al. International clinical practice guidelines

for the treatment of acute uncomplicated cystitis and pyelonephritis in women: A 2010 update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. Clin Infect Dis. 2011;52(5):e103-20.
9. Kashanian J, Hakimian P, Blute M Jr, Wong J, Khanna H, Wise G, et al. Nitrofurantoin: The return of an old friend in the wake of growing resistance. BJU Int. 2008;102(11):1634-37.
10. McKinnell JA, Stollenwerk NS, Jung CW, Miller LG. Nitrofurantoin compares favorably to recommended agents as empirical treatment of uncomplicated urinary tract infections in a decision and cost analysis. Mayo Clin Proc. 2011;86(6):480-88.
11. Cetinkaya Y, Falk P, Mayhall CG. Vancomycin-resistant enterococci. Clin Microbiol Rev. 2000;13(4):686–707.
12. Arias CA, Murray BE. The rise of the Enterococcus: beyond vancomycin resistance. Nat Rev Microbiol. 2012;10(4):266–78.
13. Chow JW. Aminoglycoside resistance in enterococci. Clin Infect Dis. 2000;31(2):586–9.
14. Hooton TM, Gupta K. Urinary tract infections and asymptomatic bacteriuria in older adults. Infect Dis Clin North Am. 2007;21(3):673–89.
15. Gupta K, Hooton TM, Naber KG, et al. International clinical practice guidelines for the treatment of acute uncomplicated cystitis and pyelonephritis in women. Clin Infect Dis. 2011;52(5):e103–20.
16. Kahlmeter G. An international survey of the antimicrobial susceptibility of pathogens from uncomplicated urinary tract infections: the ECO·SENS Project. J Antimicrob Chemother. 2003;51(1):69–76.
17. Tandogdu Z, Wagenlehner FM. Global epidemiology of urinary tract infections. Curr Opin Infect Dis. 2016;29(1):73–9.
18. Paterson DL, Bonomo RA. Extended-spectrum beta-lactamases: a clinical update. Clin Microbiol Rev. 2005;18(4):657–86.
19. Nordmann P, Naas T, Poirel L. Global spread of carbapenemase-producing Enterobacteriaceae. Emerg Infect Dis. 2011;17(10):1791–8.
20. McOsker CC, Fitzpatrick PM. Nitrofurantoin: mechanism of action and implications for resistance development. J Antimicrob Chemother. 1994;33 Suppl A:23–30.
21. Huttner A, Kowalczyk A, Turjeman A, et al. Effect of 5-day Nitrofurantoin vs single-dose Fosfomycin on clinical resolution of uncomplicsated lower urinary tract infection in women. JAMA. 2018;319(17):1781–9.