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Case Report

Extended-Spectrum β-Lactamase-Producing *Escherichia coli* Refractory to Nitrofurantoin and Fosfomycin Treatment: A Case Report Associated with Nephrolithiasis

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Abstract: Urinary tract infections (UTIs) are highly prevalent, with *Escherichia coli* being the main etiological agent. Therefore, this study aims to report a case of UTI complicated by nephrolithiasis, caused by ESBL-producing *E. coli* and refractory to treatment, highlighting clinical aspects, the resistance profile, and management. This study is descriptive (case report) with clinical and laboratory follow-up. Diagnosis and susceptibility profiling were based on urinalysis, urine cultures, and an automated system following BrCAST guidelines, combined with ultrasound examinations and assessment of therapeutic response. The female patient had a history of recurrent UTIs, persistent bacteriuria caused by ESBL-producing E. coli, and bilateral nephrolithiasis. Despite in vitro susceptibility to nitrofurantoin and fosfomycin and hospitalization for intravenous antibiotic therapy (piperacillin/tazobactam), the condition evolved with early recurrences and successive therapeutic failures. Refractoriness resulted from a dual mechanism: pharmacokinetic limitations and physical protection of the stones by a probable bacterial biofilm, demonstrating the ineffectiveness of purely conservative therapies in the presence of obstructive barriers. Definitive management of UTIs complicated by nephrolithiasis necessarily requires source control through surgical intervention for complete clearance, eliminating the bacterial reservoir and interrupting the infectious cycle.

Keywords: Enterobacteriaceae; Nephrolithiasis; Bacterial Resistance; Urinary Tract Infections; Urine Culture.

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1. Introduction

Urinary tract infections (UTIs) are among the most prevalent infections worldwide, with most cases attributed to bacterial pathogens, affecting approximately 150 million people annually [1]. *Escherichia coli* is the main pathogen isolated, accounting for approximately 80% of reported cases [2]. The clinical management of these infections has become a complex challenge due to the spread of ESBL-producing *E. coli* strains, enzymes capable of inactivating penicillins, monobactams, and third-generation cephalosporins through hydrolytic activity [3, 4].

Clinically, UTIs range from asymptomatic to symptomatic presentations and are classified as uncomplicated or complicated [5, 6]. Uncomplicated UTIs occur in individuals without anatomical abnormalities or comorbidities and are subdivided into lower

UTIs (such as cystitis, characterized by dysuria, urinary frequency, hematuria, and suprapubic pain) and upper UTIs (such as pyelonephritis) [7, 8]. In contrast, complicated UTIs are associated with risk factors that increase susceptibility or the likelihood of treatment failure, such as renal calculi, catheterization, urinary tract obstruction, immunosuppression, and diabetes mellitus [9, 10], and may present with fever, flank pain, chills, nausea, and vomiting [11]. Furthermore, it is important to emphasize that female anatomy, characterized by a shorter urethra located close to the perianal region, facilitates the ascending migration of enterobacteria from the intestinal microbiota, making women disproportionately more susceptible [12, 13].

Infections caused by ESBL-producing enterobacteria may progress from uncomplicated conditions to severe complications, such as sepsis [14]. Additionally, the discrepancy between *in vitro* susceptibility and the clinical response *in vivo* represents a challenge in daily medical practice. In this context, the present study aims to report a case of UTI associated with nephrolithiasis, caused by ESBL-producing *E. coli*, that exhibited clinical refractoriness to treatment with nitrofurantoin and fosfomycin despite *in vitro* susceptibility, highlighting the clinical findings, resistance profile, and therapeutic management adopted.

2. Case Report

A 49-year-old female patient from Itapajé, Ceará, Brazil, with no other known comorbidities and denying a history of diabetes mellitus, systemic arterial hypertension, dyslipidemia, or autoimmune diseases, began follow-up at the Unichristus Health and Imaging School Clinic (CESIU), presenting with dysuria, cloudy urine for 1 month, nocturia associated with urinary urgency, stress urinary incontinence (sneezing, coughing, and lifting weights), and an unmeasured fever 20 days earlier that resolved after the use of dipyrone. In addition, she reported a sensation of incomplete bladder emptying and low back pain for approximately 1 year, with a previous diagnosis of nephrolithiasis and progressive worsening over the preceding months. The patient underwent antibiotic therapy with cephalexin for a suspected urinary tract infection (UTI).

Five months later, the patient returned to the outpatient clinic with partial improvement of the urinary tract infection following treatment with cephalexin, but with occasional episodes of dysuria and suprapubic pain, without the need for further antibiotic therapy. She continued to experience stress urinary incontinence, as well as urinary urgency and nocturia, and was subsequently referred to the urogynecology outpatient clinic for specialized evaluation.

After an interval of 14 months, the patient was seen again at the clinic, reporting persistent dysuria and dark-yellow urine for approximately 1 year. She also reported persistent stress urinary incontinence and a sensation of incomplete bladder emptying. She experienced episodes of nocturia, waking up to four times during the night, with an approximately 5-year history. Based on the clinical presentation, the diagnostic hypotheses of UTI and mixed urinary incontinence were considered. Laboratory tests, including urinalysis and urine culture, were requested, as well as a urodynamic study for further investigation.

The patient underwent urinary tract ultrasonography to investigate recurrent UTIs and nephrolithiasis. The examination revealed kidneys in normal anatomical position, with preserved dimensions and regular contours, and renal parenchyma with normal thickness and echogenicity. Bilateral nephrolithiasis was observed, characterized by echogenic renal calculi with posterior acoustic shadowing in the calyceal groups of both kidneys, measuring between 0.7 and 1.6 cm. Bilateral hydronephrosis was also identified, moderate on the right and mild on the left. The bladder showed adequate filling (approximately 356.9 mL), regular walls, and anechoic content.

One month later, the patient attended the outpatient clinic reporting improvement in dysuria and the previously dark urine discoloration. However, episodes of urinary incontinence during strenuous physical activity persisted, in addition to urinary leakage with

mild exertion, a sensation of incomplete bladder emptying, and nocturia. Urinalysis was performed at the Unichristus Clinical Analysis Laboratory School (LEAC), revealing cloudy urine, marked leukocyturia (+++), and hematuria (>10 cells per field) (Table 1).

Table 1. Progression of the clinical condition throughout outpatient follow-up.

Visit	Symptoms	Other Examinations	Urinalysis	Culture*	Treatment
1st	Dysuria, nocturia, urinary incontinence, unmeasured fever, and low back pain	Complete blood count (leukocytosis, neutrophilia); Biochemical tests (hyperuricemia)	–	–	Cephalexin (7 days)
2nd	Dysuria, dark urine, urinary incontinence, nocturia, and pelvic pain	–	–	–	–
Follow-up interval (1 year)					
3rd	Dysuria, nocturia, urinary retention, and urinary incontinence	Urodynamic study (renal lithiasis)	Leukocyte esterase +++; Hematuria +; Bacteriuria +++	*E. coli* (ESBL)	–
4th	Nocturia, urinary retention, and urinary incontinence	–	Leukocyte esterase +++; Hematuria +++; Bacteriuria +++; Oxalate +	*E. coli* (ESBL)	Fosfomycin (3 g – single dose)
5th	Dysuria, nocturia, urinary retention, and urinary incontinence	–	Leukocyte esterase +++; Hematuria ++; Bacteriuria +++	*E. coli* (ESBL)	Nitrofurantoin (14 days)
6th	Dysuria, polyuria, urinary retention, urinary incontinence, and urinary urgency	–	Leukocyte esterase +++; Hematuria ++; Bacteriuria +++	*E. coli* (ESBL)	Fosfomycin (1 sachet – once weekly for 2 weeks)
7th	Dysuria, polyuria, urinary retention, urinary incontinence, and urinary urgency	–	–	–	Piperacillin/tazobactam (intravenous)

8th	Dysuria, polyuria, urinary retention, urinary incontinence, and urinary urgency	–	Leukocyte esterase +++; Hematuria ++; Bacteriuria +++	*E. coli* (ESBL)	Fosfomycin single dose + nitrofurantoin – 6 months; oral immunoprophylaxis / vaginal estriol

* Culture results are presented in Table 2.

Urine culture was also performed ~~(Figure 1) (~~Figure 2), demonstrating growth of ESBL-producing *E. coli* at >100,000 CFU/mL, with resistance to cephalexin and cefuroxime and susceptibility to fosfomycin and nitrofurantoin (Table 2). Urine cultures were processed according to the Standard Operating Procedure (SOP) of the LEAC, using quantitative and qualitative analyses. Using a 1-µL bacteriological loop, the samples were inoculated onto CLED agar (Figures 2A and 2B) and MacConkey agar, using quantitative and semi-quantitative inoculation techniques, respectively. Following inoculation, the plates were incubated at 34 ± 2 °C for 24 to 48 hours. Samples were considered positive when they demonstrated microorganism growth with a count equal to or greater than 100,000 CFU/mL.

Table 2. Evolution of the antimicrobial susceptibility profile over different periods.

Antimicrobial	**3rd Visit**		**4th Visit**		**5th Visit**		**6th Visit**		**8th Visit**	
	MIC (µg/mL)	**INT**	**MIC (µg/mL)**	**INT**	**MIC (µg/mL)**	**INT**	**MIC (µg/mL)**	**INT**	**MIC (µg/mL)**	**INT**
Amikacin	≤8	S	≤8	S	≤8	S	≤8	S	≤8	S
Ampicillin	>8	R*	>8	R*	>8	R*	>4	R*	>8	R*
Aztreonam	>4	R*	>4	R*	>4	R*	>4	R*	>4	R*
Cephalexin	>16	R*	>16	R*	>16	R*	>16	R*	>16	R*
Cefepime	>4	R*	>4	R*	>4	R*	>4	R*	>4	R*
Cefotaxime	16	R*	16	R*	8	R*	8	R*	16	R*
Ceftazidime	>4	R*	>4	R*	>4	R*	>4	R*	>4	R*
Ciprofloxacin	>1	R*	>1	R*	>1	R*	>1	R*	>1	R*
Ertapenem	≤0.12	S	≤0.12	S	≤0.12	S	≤0.12	S	≤0.12	S
Fosfomycin	≤8	S	≤8	S	≤8	S	≤8	S	≤8	S
Gentamicin	≤2	S	≤2	S	≤2	S	≤2	S	≤2	S
Imipenem	≤2	S	≤2	S	≤2	S	≤2	S	≤2	S
Levofloxacin	>1	R	>1	R	>1	R	>1	R	>1	R
Meropenem	≤0.12	S	≤0.12	S	≤0.12	S	≤0.12	S	≤0.12	S
Nitrofurantoin	≤64	S	≤64	S	≤64	S	≤64	S	≤64	S
Piperacillin/tazobactam	≤8	S	≤8	S	≤8	S	≤8	S	≤8	S
Tobramycin	≤2	S	≤2	S	≤2	S	≤2	S	≤2	S

* ESBL-producing strain. MIC = Minimum Inhibitory Concentration. INT = Categorical interpretation of antimicrobial susceptibility according to BrCAST criteria. S = Susceptible: high probability of therapeutic success using the standard antimicrobial dosing regimen. R = Resistant: high probability of therapeutic failure even when exposure is increased. ESBL = Extended-spectrum β-lactamase.

Figura 1. Urinary sediment microscopy.

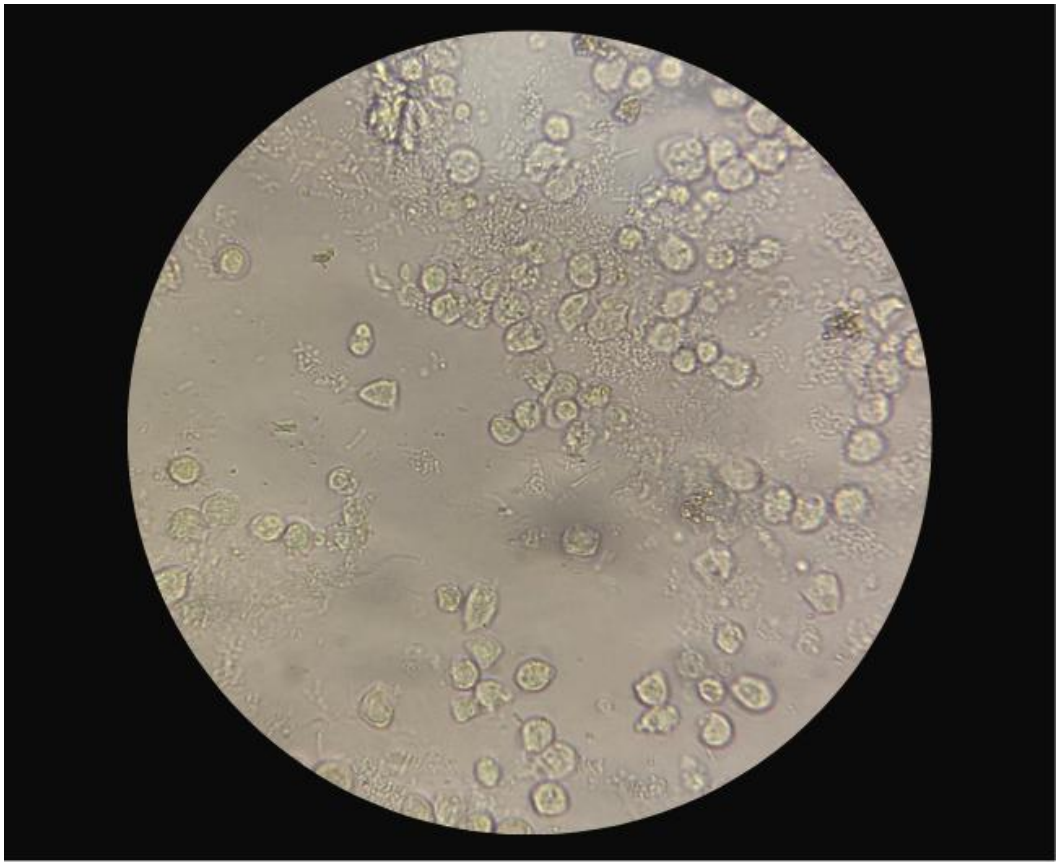
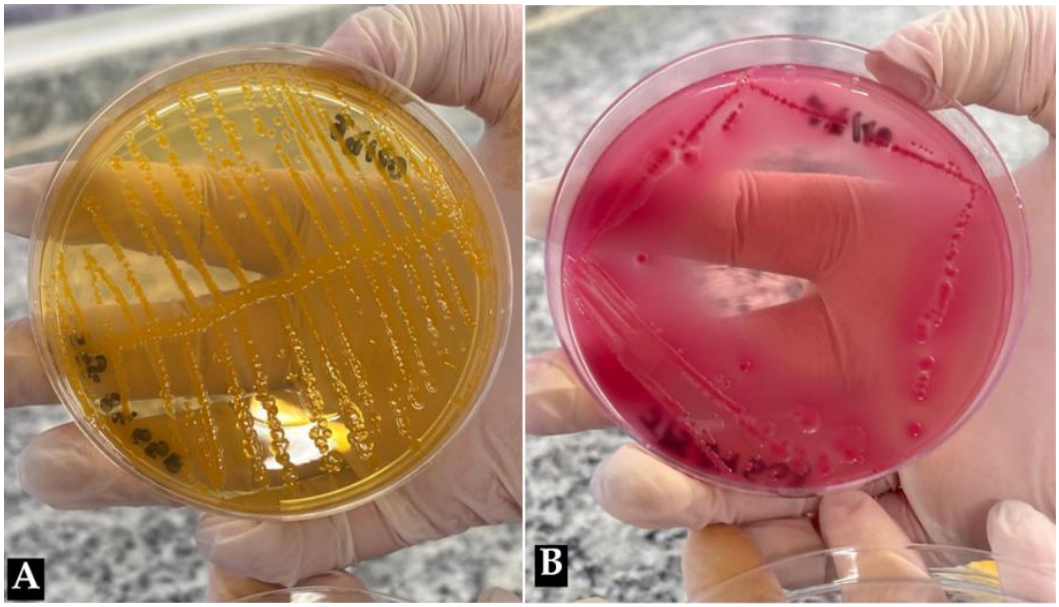


Figura 2. Crescimento bacteriano. A. Crescimento bacteriano em ágar CLED. B. Crescimento bacteriano em ágar MacConkey.



Microscopic analysis was performed in two stages. First, immediately after the urine samples arrived at the laboratory, they were centrifuged at 1,500 rpm for 5 minutes, followed by discarding the supernatant and preparing a slide with the sediment. The slide was then air-dried at room temperature and stained using the Gram method, allowing

preliminary visualization of bacterial morphology [15]. Bacterial identification and antimicrobial susceptibility testing were performed using the MicroScan® NC53 combined panel for Gram-negative bacteria (Beckman Coulter®), with readings performed using the autoSCAN-4 semiautomated system. This system uses broth microdilution and colorimetric methods for testing.

After inoculation with a standardized bacterial suspension equivalent to a 0.5 McFarland turbidity standard, mineral oil (2 drops) was added to the wells corresponding to glucose, urea, lysine, hydrogen sulfide (H_2S), arginine, ornithine, and decarboxylase base to create appropriate anaerobic conditions. The panel was then incubated at 35 °C for 24 hours. After incubation, specific colorimetric reagents were added to selected wells for biochemical reactions. In the nitrite well, sulfanilic acid (1 drop) and N,N-dimethyl reagent (1 drop, after 5 seconds) were added; Kovacs reagent (3 drops) was added to the indole well; ferric chloride (1 drop) was added to the phenylalanine deaminase well; and KOH (1 drop) and alpha-naphthol (1 drop, after 20 seconds) were added to the Voges-Proskauer well.

The biochemical reactions were read and interpreted automatically by the MicroScan® system using its analysis software, which identified the bacterial species as *E. coli* with a probability greater than 98%, with a morphological profile consistent with that observed on the culture plates. Antimicrobial susceptibility testing was interpreted according to the breakpoints established by the *Brazilian Committee on Antimicrobial Susceptibility Testing (BrCAST)*, using the version in effect as of April 13, 2024 (Table 2). When specific criteria were not available for the genus or species analyzed, the parameters recommended by the Clinical and Laboratory Standards Institute (CLSI) were used, according to the *Performance Standards for Antimicrobial Susceptibility Testing* (CLSI M100-S24).

Based on these findings, treatment with fosfomycin 3 g as a single dose was initiated, and a new urine culture was requested, with follow-up scheduled for 1 month later. After 2 months, the patient returned for reassessment following previous treatment with a single 3-g dose of fosfomycin, reporting persistent dysuria and persistence of the previously described urinary symptoms, with only partial improvement in the sensation of incomplete bladder emptying and no changes in urine odor or color. The new urine culture again demonstrated growth of ESBL-producing *E. coli* at >100,000 CFU/mL, susceptible to nitrofurantoin (Table 2). Given the persistence of the urinary infection, treatment with nitrofurantoin for 14 days was initiated (Table 1), and a new urinalysis and urine culture were requested for follow-up.

During a new assessment 2 months later, the patient reported persistent urinary symptoms compatible with UTI, despite treatment with nitrofurantoin for 7 days. The urine culture performed 11 weeks after the previous culture identified growth of ESBL-producing *E. coli* at >100,000 CFU/mL, showing resistance to penicillins, cephalosporins, monobactams, fluoroquinolones, and sulfonamides, while maintaining susceptibility to carbapenems, aminoglycosides, β-lactam/β-lactamase inhibitor combinations, as well as fosfomycin and nitrofurantoin (Table 2). Given the isolation of ESBL-producing *E. coli* in the urine culture and the clinical course, a new therapeutic regimen with fosfomycin was initiated (Table 1), along with follow-up urinalysis and urine culture. Considering the history of bilateral nephrolithiasis associated with hydronephrosis, the patient was referred for specialized urological evaluation.

Approximately 2 months after the previous assessment, the patient returned for follow-up. Despite previous treatment with fosfomycin at a dosage of one sachet weekly for 2 weeks, the patient reported persistent UTI symptoms. She also reported ongoing follow-up with a urologist because of bilateral nephrolithiasis associated with hydronephrosis, with surgical intervention recommended. Given the persistence of the clinical condition, the history of previous outpatient treatments, and the previously identified microbiological profile (ESBL-producing *E. coli*), hospital admission was recommended for clinical

and laboratory monitoring, initiation of intravenous antibiotic therapy guided by susceptibility testing, assessment of potential infectious complications, including pyelonephritis, and determination of the need for hospital-based supportive care. In addition, the importance of appropriate treatment for resolution of the condition and prevention of complications was reinforced.

Approximately 1 month after the previous assessment, the patient attended the outpatient clinic for follow-up. She reported that, in early October 2025, she had been hospitalized for 8 days at a hospital in the municipality of Itapajé, as previously recommended, where she received intravenous piperacillin/tazobactam for 7 days. She reported being discharged from the hospital asymptomatic; however, approximately 4 days before the consultation, she developed recurrent urinary symptoms compatible with recurrent UTI. Given the recurrence of symptoms after hospital treatment, a new urinalysis, urine culture, and laboratory tests were requested for clinical and microbiological reassessment.

The patient returned to the clinic 3 weeks later for evaluation of the requested tests, reporting persistent dysuria and urinary urgency. She denied the need for additional antibiotic therapy or hospitalization since the previous assessment, as well as fever or other systemic symptoms. The new urinalysis showed hemoglobin (++), marked leukocyturia (+++), positive nitrite, and a homogeneous microbiota consisting of Gram-negative bacilli. The urine culture again demonstrated growth of ESBL-producing *E. coli* at >100,000 CFU/mL, susceptible to aminoglycosides, carbapenems, β-lactam/β-lactamase inhibitor combinations, fosfomycin, nitrofurantoin, and sulfamethoxazole-trimethoprim, with resistance to penicillins, cephalosporins, monobactams, and fluoroquinolones (Table 2). Based on the clinical and microbiological findings, treatment with a single dose of fosfomycin was initiated, together with nitrofurantoin prophylaxis for 6 months while the patient awaited surgical management of nephrolithiasis. Adjunctive measures were also introduced, including oral immunoprophylaxis and vaginal estriol, with the aim of assisting in the control of recurrent urinary tract infections and associated symptoms.

3. Discussion and Conclusion

The association between nephrolithiasis and recurrent urinary tract infections (UTIs) is well documented and reflects the clinical profile of the patient described herein [16, 17, 18]. Stone formation involves factors such as dehydration, dietary factors, anatomical abnormalities, alterations in urinary pH and volume, hypocitraturia, and supersaturation with calcium, oxalate, or uric acid [19, 20, 21]. The clinical presentation may range from asymptomatic disease to dysuria, hematuria, and gastrointestinal symptoms, some of which were observed in the present patient [21]. When concomitant nephrolithiasis is associated with resistant pathogens, such as ESBL-producing *Escherichia coli*, clinical complexity increases, posing substantial challenges to antimicrobial selection [10].

In the management of uncomplicated UTIs, nitrofurantoin and fosfomycin are considered first-line options, whereas beta-lactams are generally reserved for settings involving resistance [22]. Recent studies have shown that urinary isolates of ESBL-producing *E. coli* retain substantial in vitro susceptibility to fosfomycin (>90%) [23] and nitrofurantoin (>80%) [24, 25]. However, despite the susceptibility observed in laboratory testing, the patient experienced successive treatment failures, highlighting the need to reassess the pharmacological regimen according to current international guidelines. Such recurrences serve as a clinical warning that the condition may have progressed beyond a simple UTI, requiring investigation of underlying factors, such as anatomical or functional abnormalities, incomplete bladder emptying, or nephrolithiasis, which may harbor bacterial biofilms that protect pathogens from antimicrobial activity [26].

Fosfomycin was administered weekly with the intention of providing secondary prophylaxis for recurrent UTIs rather than treating an acute episode [27, 28]. However, this weekly interval differs from the dosing regimens recommended by international guidelines, which establish a single 3-g dose for acute uncomplicated cystitis or shorter

intervals, every 48 to 72 hours, when used for complicated infections [26]. From a pharmacodynamic perspective, although the drug achieves high urinary concentrations, such prolonged intervals may leave urinary concentrations substantially below the Minimum Inhibitory Concentration (MIC) for uropathogens, thereby reducing the bactericidal effect and potentially contributing to therapeutic failure and selection of resistant strains [29, 30]. Additionally, nitrofurantoin was used in the setting of upper urinary tract involvement, evidenced by low back pain and hydronephrosis, as an outpatient management alternative while the underlying uropathy was being investigated. However, because nitrofurantoin is rapidly excreted in the urine and achieves negligible or undetectable serum and renal parenchymal tissue concentrations, it is formally contraindicated in suspected pyelonephritis or complicated UTI with obstructive uropathy, in which microbiological control critically depends on antibiotics with adequate serum and renal parenchymal bioavailability [31, 32, 30, 26].

In addition to pharmacokinetic and pharmacodynamic limitations, the persistence of clinical symptoms despite in vitro susceptibility may be explained by the possible biofilm microenvironment [33]. In nephrolithiasis, *E. coli* may organize into microcolonies surrounded by an extracellular matrix and adhere to the surface and interior of renal calculi [34]. These structured bacterial communities exhibit considerably increased antimicrobial tolerance, often requiring concentrations 10 to 1,000 times higher than conventional planktonic MICs for eradication [35, 36]. This protective niche may explain the apparent therapeutic failure and persistence of the condition even after prolonged treatment regimens.

Following failure of oral therapy, the transition to parenteral therapy with piperacillin/tazobactam is supported by the literature. In a retrospective study of complicated UTIs caused by ESBL-producing *E. coli*, Zhang et al. (2023) observed a clinical success rate of 73% with piperacillin/tazobactam, comparable to that of meropenem (75%) [37]. Similarly, Branton et al. (2023) found no statistically significant difference in clinical cure between piperacillin/tazobactam (96.9%) and carbapenems (95.7%) among hospitalized patients [38]. However, the symptomatic relapse observed after parenteral treatment reinforces that antibiotic therapy alone is insufficient for definitive resolution in the presence of nephrolithiasis.

The early recurrence after 7 days of intravenous piperacillin/tazobactam illustrates the failure of a purely suppressive strategy in the setting of complicated upper urinary tract infection. Possible biofilms formed on significant renal calculi (>1 cm) may substantially reduce the diffusion of beta-lactams, including agents with activity against ESBL-producing strains, such as piperacillin/tazobactam [39, 40, 41]. The therapeutic failure described herein suggests that, in the absence of source control, namely stone removal, the duration of antimicrobial therapy is a secondary factor compared with the mechanical barrier. Nevertheless, it should be acknowledged that, given the persistence of obstructive symptoms and the history of multidrug resistance, pharmacological optimization with carbapenems would have represented a more robust approach to reducing the bacterial burden, although without urological intervention, microbiological failure would ultimately have remained likely.

The clinical outcome of this patient underscores a common management approach centered on repeated attempts to eradicate bacteriuria rather than resolving the underlying obstructive cause. For more than 2 years, prioritizing oral antibacterials (fosfomycin and nitrofurantoin) in the setting of hydronephrosis and calyceal stones measuring up to 1.6 cm represented an ineffective therapeutic strategy, as these agents have pharmacokinetic characteristics primarily suited to the lower urinary tract and are unable to eradicate lithiasic reservoirs in the upper urinary tract. Continued outpatient management with successive conservative treatments in the presence of bilateral obstructive uropathy and progressive symptoms may have delayed resolution of the condition, prolonging the patient's vulnerability to severe complications, such as chronic renal inflammation and urosepsis. This case demonstrates that, in patients with nephrolithiasis and recurrent UTI, surgical intervention should not be regarded simply as a postponable elective procedure,

but rather as functionally necessary to interrupt the persistence of infection and antimicrobial resistance. The transition from repeated antibiotic therapy to surgical relief of obstruction represents the key step toward definitive resolution.

In this context, guidelines from major international urological societies, including the European Association of Urology (EAU Guidelines on Urolithiasis) and the American Urological Association (AUA Guidelines on Surgical Management of Kidney and Ureteral Stones), emphasize that complete removal of stone fragments is the intervention capable of interrupting the infectious cycle associated with persistent stone disease [42, 43, 26]. To achieve definitive stone clearance, percutaneous nephrolithotomy (PCNL) is established in the EAU and AUA guidelines as the preferred surgical modality and standard approach for large-volume complex or staghorn calculi (>2 cm or multifocal stones), given its high stone-free rate in a single procedure and its ability to decompress the collecting system [43, 27].

In cases of moderate stone burden or as an adjunctive intervention, flexible ureterorenoscopy with laser lithotripsy (FURS) is an effective minimally invasive option for accessing difficult-to-reach stones and removing residual fragments [44, 27]. The clinical relevance of complete stone clearance lies in the fact that even microscopic residual fragments may retain viable bacterial biofilms within their mineral matrix; therefore, complete surgical debridement and relief of urinary tract obstruction are required to eliminate the bacterial reservoir, restore urinary flow dynamics, and prevent progression to chronic pyelonephritis, renal atrophy, and urosepsis [42, 27].

This study has important methodological limitations that should be acknowledged. First, the absence of serial serum creatinine measurements and estimated glomerular filtration rate (eGFR) data limits a more comprehensive assessment of the actual impact of bilateral hydronephrosis and antimicrobial therapy on the patient's renal function. Second, although the pattern of clinical refractoriness and persistent infection strongly suggests the possibility of biofilm formation associated with nephrolithiasis, a phenomenon widely described in the literature as contributing to high antimicrobial tolerance, direct morphological or microbiological confirmation of biofilm formation could not be performed because the patient is still awaiting surgical stone removal. Therefore, the contribution of biofilm remains a clinical and literature-based inference without direct laboratory confirmation by microscopy.

In summary, this clinical case demonstrates that infectious refractoriness may result from a dual mechanism: the pharmacokinetic and pharmacodynamic limitations of the oral and parenteral regimens employed and the physical protection conferred by renal calculi through possible biofilm formation. Although pharmacological optimization with carbapenems may represent a robust rescue option for the management of ESBL-producing strains in complicated UTI, definitive therapeutic success fundamentally depends on source control through surgical intervention (PCNL/FURS) to achieve complete stone clearance, which is the approach aligned with international urological guidance to eliminate the potential bacterial reservoir and interrupt the cycle of recurrence.Parte superior do formulário

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Conflicts of Interest: All other authors declare no conflicts of interest.

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