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ID CASE

Successful Treatment of Acute Prostatitis Caused by Multidrug-Resistant *Escherichia coli* With Tigecycline Monotherapy

Elia Lo Priore,[1] David M Livermore,[2], Niccolo Buetti,[1] Philipp Jent,[1,©] Niklas Pelzer,[3] Carlo Casanova,[4] Hansjakob Furrer,[1] and Baharak Babouee Flury[1,4]

[1]Department of Infectious Diseases, Bern University Hospital, University of Bern, Bern, Switzerland, [2]Norwich Medical School, University of East Anglia, Norwich, United Kingdom, [3]UroSwiss AG, Department of Urology, Oberaargau Regional Hospital, Langenthal, Switzerland, and [4]Institute for Infectious Diseases, University of Bern, Bern, Switzerland

We present a successful treatment, with tigecycline monotherapy, of acute prostatitis caused by multidrug-resistant *Escherichia coli* harboring an NDM-1 carbapemenase along with a CMY-2 cephalosporinase and a TEM ESBL.

Keywords. CMY-2; NDM-1; prostatitis; TEM ESBL; tigecyclin.

CASE

A 79-year-old patient with known bladder neck sclerosis and subsequent chronic polyuria and nocturia presented to the Department of Urology at Bern University Hospital in March 2018 with progressive worsening of symptoms over the preceding 2 weeks and new-onset premicturition pain without fever. The history was notable for a prostate adenoma treated with transurethral resection of the prostate in 2017 and for chronic renal insufficiency (CKD IIIb) since 2015.

Clinical examination revealed marked prostatic tenderness. Urine, obtained after prostate massage at admission, was nitrite positive, and >40 leucocytes/hpf C-reactive protein and white blood cell count were normal. Culture of urine yielded *Escherichia coli* at 10^4 CFU/mL, resistant to β-lactam/β-lactamase inhibitor combinations, cephalosporins, aminoglycosides, classical tetracyclines, antifolates, fosfomycin, and quinolones (Table 1). Microarray analysis (Check-MDR CT103XL, CheckPoints, Wageningen, the Netherlands) detected genes for an NDM-1 carbapenemase, CMY-2-acquired AmpC, and a TEM 164H extended-spectrum β-lactamase (ESBL).

Table 1. Antibiotic Susceptibilities for *E. coli* From Urine Culture

Antibiotic	Interpretation,[a] MIC in mg/L
Amoxicillin-clavulanate	R
Piperacillin-tazobactam	R
Ceftriaxone	R
Cefepime	SDD (4 mg/L)
Ertapenem	I (0.75 mg/L)
Imipenem	S (0.5 mg/L)
Meropenem	S (0.75 mg/L)
Ceftolozane-tazobactam	R (>256 mg/L)
Ceftazidime-avibactam	R (>256 mg/L)
Aztreonam	S (1.5 mg/L)
Ciprofloxacin	R
Gentamicin	R
Tobramycin	R
Trimethoprim-sulfamethoxazole	R
Minocycline	R (16 mg/L)
Doxycycline	R (>256 mg/L)
Tigecycline	S (0.380 mg/L)[b]
Fosfomycin	R
Colistin	S (0.250 mg/L)[b]

Abbreviations: I, intermediate; MIC, minimum inhibitory concentration; R, resistant; S, susceptible; SDD, susceptible dose-dependent.

[a]According to Clinical and Laboratory Standards Institute criteria (M100-S28, 2018).

[b]According to European Committee on Antimicrobial Susceptibility Testing criteria (v8.1, 2018)

[c]Antimicrobial susceptibility of the clinical isolate was determined using disc diffusion, and the results were interpreted according to the breakpoints recommended by the Clinical and Laboratory Standards Institute. Minimum inhibitory concentrations were obtained using Etest (bioMérieux, France) and MTS (Liofilchem, Italy).

A diagnosis of acute prostatitis was established. Due to its multidrug resistance (MDR) and the lack of reasonable alternatives (discussed below), tigecycline therapy was started with a loading dose of 100 mg, followed by 50 mg twice daily, and continued for 4 weeks. Full relief from the premicturition pain and improvement of nocturia and polyuria were apparent at day 8 of treatment. Follow-up cultures up to 7 months post- treatment did not detect regrowth of the MDR *E. coli*. Urinalysis after prostate massage, 4 months post-treatment, revealed no persistent pyuria; this had disappeared at treatment day 6.

DISCUSSION

This case complements 3 previous reports of prostatitis treated with tigecycline [1]; all support the drug's effectiveness as monotherapy for prostatitis with MDR *E. coli*.

For the present case, the choice of this regimen reflected several factors, but primarily the lack of good alternatives. Fluoroquinolones, co-trimoxazole, and fosfomycin—as conventional agents for prostatitis—were precluded by resistance. Imipenem and meropenem

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Correspondence: Elia Lo Priore, MD, Department of Infectious Diseases, Bern University Hospital, Freiburgstrasse 16p, 3010 Bern, Switzerland (elia.lopriore@gmail.com).

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were avoided, despite low minimum inhibitory concentrations (MICs), owing to presence of the bla_{NDM} gene. Similar considerations applied for aztreonam (MIC 1.5 mg/L), which is a substrate for CMY-2 and a likely substrate for TEM 164H enzyme that is expected to have ESBL activity [2]. Furthermore, penetration of β-lactams into prostatic tissue is poor, suggesting against their use (and that of aztreonam/avibactam, which would evade all the β-lactamases present). We avoided colistin because of the patient's renal impairment, enhancing the risk of nephrotoxicity, [3] and because of this drug's uncertain prostatic tissue penetration [4]. Eravacycline, a novel tetracycline, has lower MICs than tigecycline for Enterobacteriaceae [5] and might have been an alternative; however, data on prostatic penetration are lacking, and this antibiotic is not yet available in Switzerland.

Prostatitis presents a different challenge to urinary tract infections (UTIs), where any renally excreted antibiotic is potentially therapeutic. Penetration of antibiotics to the prostate occurs by passive diffusion from plasma and depends upon lipid solubility, dissociation constant, and protein binding [6]. Tetracyclines generally have good prostatic tissue and fluid penetration, but they are not appropriate for UTIs [6]. Although there are few data for tigecycline, minocycline, to which it is structurally related, achieves a prostatic tissue/serum ratio of 0.94 ± 0.39 [7]. Such considerations, coupled with a steady-state serum level of *c.* 0.6 mg/L, suggest that adequate area under the curve/MIC ratios (the critical pharmacodynamic parameter for tigecycline [8]) should be achievable, as related to the susceptibility breakpoint (0.5 mg/L) of the European Committee on Antimicrobial Susceptibility Testing [9]. Tigecycline binds to ribosomal 30S subunits with greater affinity than earlier tetracyclines and evades the resistance conferred by acquired efflux and ribosomal protection [8].

To our knowledge, only 3 previous cases of prostatitis treated with tigecycline monotherapy have been reported [1, 10, 11]. All involved ESBL-producing *E. coli*, and, despite significant differences in treatment duration (2, 6, and 22 weeks, respectively), all showed favorable outcomes. Here we achieved microbiological eradication with tigecycline (MIC 0.38 mg/L). Residual nocturia and polyuria after treatment were interpreted in the context of known bladder neck sclerosis.

Tigecycline has a black box warning from the US Food and Drug Administration and is unsuitable for UTIs owing to largely biliary excretion. It has a mixed history as monotherapy in clinical trials, achieving noninferiority to comparators in skin and soft tissue infection (SSTI) [12], complicated Intra-abdominal Infection (cIAI) [13], and community-acquired bacterial pneumonia (CABP) [14], but failing to do so in diabetic foot infection [15] and in the VAP arm of a ventilator-associated penumonia/Hospital-aquired bacterial penumonia (VAP/HABP) trial [16]. It is most often used as a combination agent against MDR pathogens. Although larger trials or case series studies are needed, the present results support the view that prostatitis might be added to the list of infections where use as monotherapy can reasonably be considered, particularly against MDR *E. coli*.

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References

1. Bates D, Parkins M, Hellweg R, et al. Tigecycline treatment of urinary tract infection and prostatitis: case report and literature review. Can J Hosp Pharm **2012**; 65:209–15.
2. Perilli M, Mancini A, Celenza G, et al. Kinetic study of the effect of histidines 240 and 164 on TEM-149 enzyme probed by β-lactam inhibitors. Antimicrob Agents Chemother **2014**; 58:6294–6.
3. Pogue JM, Lee J, Marchaim D, et al. Incidence of and risk factors for colistin-associated nephrotoxicity in a large academic health system. Clin Infect Dis **2011**; 53:879–84.
4. Magri V, Boltri M, Cai T, et al. Multidisciplinary approach to prostatitis. Arch Ital Urol E Androl **2018**; 90:227–248.
5. Doi Y. Treatment options for carbapenem-resistant Gram-negative bacterial infections. Clin Infect Dis **2019**; 69:565–75.
6. Charalabopoulos K, Karachalios G, Baltogiannis D, et al. Penetration of antimicrobial agents into the prostate. Chemotherapy **2003**; 49:269–79.
7. Goto T, Makinose S, Ohi Y, et al. Diffusion of piperacillin, cefotiam, minocycline, amikacin and ofloxacin into the prostate. Int J Urol **1998**; 5:243–6.
8. Meagher AK, Ambrose PG, Grasela TH, Ellis-Grosse EJ. The pharmacokinetic and pharmacodynamic profile of tigecycline. Clin Infect Dis **2005**; 41(Suppl 5):S333–40.
9. EUCAST: clinical breakpoints. Available at: http://www.eucast.org/clinical_breakpoints/. Accessed 16 November 2018.
10. Geerlings SE, van Donselaar-van der Pant KA, Keur I. Successful treatment with tigecycline of two patients with complicated urinary tract infections caused by extended-spectrum beta-lactamase-producing *Escherichia coli*. J Antimicrob Chemother **2010**; 65:2048–9.
11. Drekonja DM, Johnson JR. Tigecycline treatment for urinary tract infections: case report and literature review. J Chemother **2011**; 23:168–70.
12. Ellis-Grosse EJ, Babinchak T, Dartois N, et al; Tigecycline 300 cSSSI Study Group; Tigecycline 305 cSSSI Study Group. The efficacy and safety of tigecycline in the treatment of skin and skin-structure infections: results of 2 double-blind phase 3 comparison studies with vancomycin-aztreonam. Clin Infect Dis **2005**; 41(Suppl 5):S341–53.
13. Babinchak T, Ellis-Grosse E, Dartois N, et al; Tigecycline 301 Study Group; Tigecycline 306 Study Group. The efficacy and safety of tigecycline for the treatment of complicated intra-abdominal infections: analysis of pooled clinical trial data. Clin Infect Dis **2005**; 41(Suppl 5):S354–67.
14. Bergallo C, Jasovich A, Teglia O, et al; 308 Study Group. Safety and efficacy of intravenous tigecycline in treatment of community-acquired pneumonia: results from a double-blind randomized phase 3 comparison study with levofloxacin. Diagn Microbiol Infect Dis **2009**; 63:52–61.
15. Lauf L, Ozsvár Z, Mitha I, et al. Phase 3 study comparing tigecycline and ertapenem in patients with diabetic foot infections with and without osteomyelitis. Diagn Microbiol Infect Dis **2014**; 78:469–80.
16. Freire AT, Melnyk V, Kim MJ, et al; 311 Study Group. Comparison of tigecycline with imipenem/cilastatin for the treatment of hospital-acquired pneumonia. Diagn Microbiol Infect Dis **2010**; 68:140–51.