

# An outbreak of multidrug-resistant *Pseudomonas aeruginosa* infections following flexible ureteroscopic stone removal

Sin Woo Lee,\* Seung-Kwon Choi

Department of Urology, Seoul Medical Center, Seoul, 02053, Korea

LEE SW, CHOI S-K. An outbreak of multidrug-resistant *Pseudomonas aeruginosa* infections following flexible ureteroscopic stone removal. *Can J Urol* 2026;33(3):527–535.

**Background:** Postoperative infections are an emerging concern in endourology. This study reports an outbreak of urinary tract infections associated with *Pseudomonas aeruginosa* (PA) in patients who underwent stone removal surgery using flexible ureteroscopy (FURS) at Seoul Medical Center.

**Methods:** Between August and December 2024, five patients who underwent FURS performed by the same surgeon developed postoperative febrile episodes requiring further treatment. Urine cultures from four patients revealed an outbreak of multidrug-resistant PA, prompting environmental cultures and an inspection of the instrument reprocessing procedures led by the hospital's infection control department.

**Results:** Although PA was not isolated from the FURS itself, urine culture results showed identical antibiotic susceptibility profiles, and three patients exhibited temporal continuity, suggesting that the infections were

related to surgery. No PA infections occurred among patients treated by other surgeons using single-use FURS during the same period, indicating that the infections were associated with the reusable FURS used solely by surgeon A. Environmental culturing detected PA on the sink and handle in the cleaning room, and deficiencies in the reprocessing procedures were identified. The FURS reprocessing protocol was revised to include ethylene oxide gas sterilization after each use, twice-daily disinfections of the sink where PA was identified, and replacement of handles and brushes. After implementing improvements to the reprocessing protocol, no further infections were reported over six months.

**Conclusions:** Comprehensive device management may help prevent device related outbreaks. Given the complexity of FURS reprocessing, systematic management by trained personnel and ongoing monitoring are necessary to prevent device-associated infections.

**Key Words:** *Pseudomonas aeruginosa*, multidrug resistance, flexible ureteroscopy, urinary stone surgery, postoperative infection

## Introduction

With the increasing prominence of surgical interventions in the management of urolithiasis, the flexible ureteroscope (FURS) has emerged as a critical tool for urological surgeons.<sup>1</sup> In addition to stone management, FURS can be used to evaluate upper urinary

tract pathology and resect small tumors.<sup>2</sup> However, the increasing use of FURS has raised concerns about device-associated infections. Recently, the Food and Drug Administration (FDA) identified issues with the effectiveness of reusable FURS (r-FURS) reprocessing and the potential risk of associated infections.<sup>3</sup> Conventional flexible endoscopes are generally classified as semi-critical devices because they come into contact with intact tissue or mucosa without entering sterile body cavities, and are therefore disinfected between uses. By contrast, FURS is introduced directly into the sterile urinary tract during surgical procedures. Consequently, they require high-level

Received date 16 September 2025

Accepted for publication 27 November 2025

Published online 26 June 2026

\*Corresponding Author: Sin Woo Lee.

Email: icinoo0923@naver.com

disinfection (HLD) to meet the standards applied to critical devices.<sup>4</sup>

*Pseudomonas aeruginosa* (PA) is a Gram-negative bacillus that can survive in challenging environments. Recent studies have suggested that PA is closely associated with human activity, and is a major cause of morbidity and mortality in humans.<sup>5</sup> Approximately 10% of all catheter-associated urinary tract infections (UTIs) and 16% of UTIs in intensive care unit (ICU) patients are attributable to PA.<sup>6</sup> Infections associated with urological surgeries may result from exogenous sources, including irrigation fluids, endoscopic equipment, disinfectant solutions, and the operating room environment.<sup>7</sup> In particular, when FURS are contaminated with PA, the bacteria can form an exopolysaccharide biofilm that protects them from surfactant-containing detergents and antibiotics, thereby increasing the risk of persistent infection.<sup>8</sup> Notably, FURS possesses a delicate structure that is susceptible to damage during surgical procedures, and such structural impairments can create inaccessible niches that hinder effective cleaning and disinfection, thereby increasing vulnerability to infection.<sup>9</sup> Despite these concerns, only a few cases of infections associated with FURS have been reported to date.

This study aimed to elucidate the underlying causes of repeated Multidrug-resistant PA (MDRPA) outbreaks following stone surgery using FURS at a single institution by conducting environmental cultures and a comprehensive assessment of the FURS reprocessing process.

## Materials and Methods

### *Hospital setting*

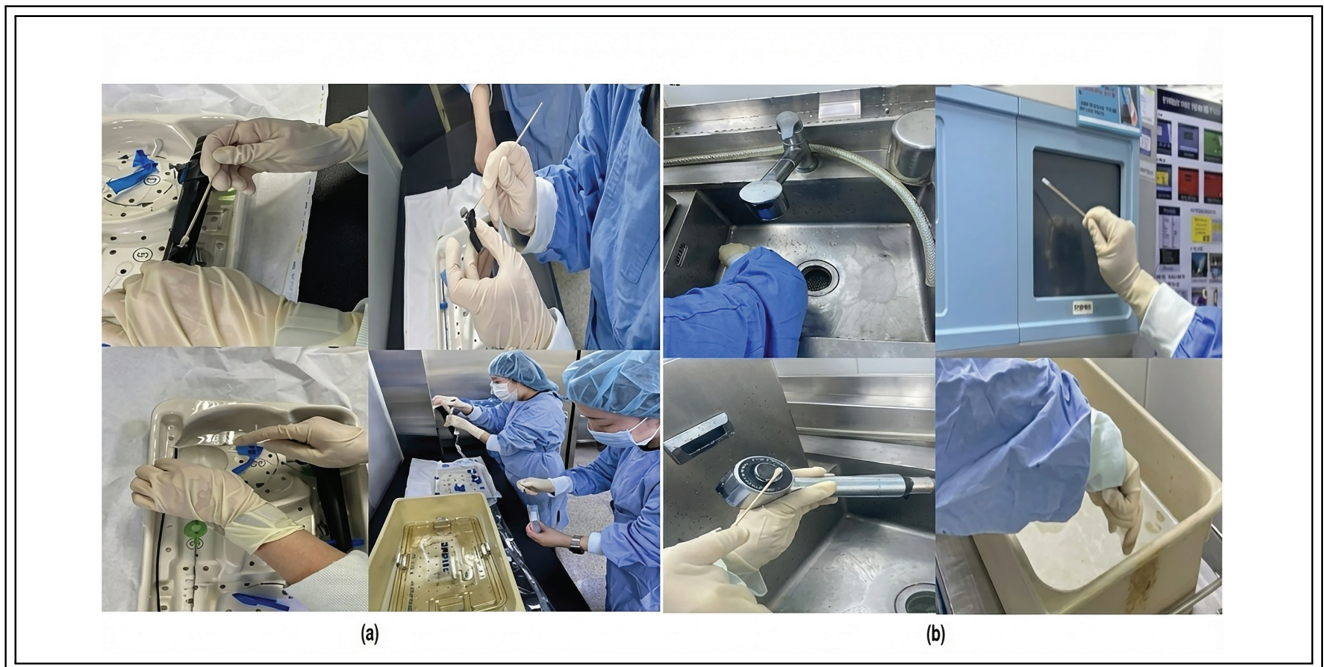
Seoul Medical Center, a regional general hospital in South Korea, manages approximately 100–150 urolithiasis surgeries annually, which are performed by three urologists (A, B, and C). Two types of FURS were used: r-FURS (URF-P5; Olympus, Tokyo, Japan) and single-use FURS (s-FURS; LithoView; Boston Scientific, Marlborough, MA, USA). Urologist A routinely used only r-FURS, whereas urologists B and C used only s-FURS. The reprocessing protocols for r-FURS were as follows. Visible contaminants were rinsed off with tap water, followed by a leakage test. All joints of the FURS and its accessories were cleaned using a dedicated brush. The FURS was immersed in diluted enzyme (SanyZyme, Ultra Clean System Inc., Oldsmar, FL, USA), and its internal channels were irrigated with the same solution. The FURS

was then rinsed with tap water and placed in a drying cabinet. Prior to use, the FURS was immersed in a chemical disinfection solution (PeraSafe, Antec International, Ltd., Suffolk, UK), followed by a final rinse with sterile distilled water to remove residual disinfectant. Ethylene oxide (ETO) sterilization was performed in cases of severe contamination or at the surgeon's request.

### *Epidemiological investigation*

In December 2024, patients 4 and 5, who underwent urolithiasis surgery performed by urologist A at one-week intervals, were consecutively admitted to the emergency department 3–4 days postoperatively. MDRPA was isolated from the urine cultures of two patients without a history of UTIs. Given the clinical context, these infections were suspected to be procedure-related, prompting immediate notification of the hospital's infection control team. The team investigated 23 patients who underwent the same surgical procedure within the previous 3 months, identifying six cases of postoperative febrile infection. Among these cases, MDRPA was isolated from four patients who underwent surgery performed by urologist A, whereas *Escherichia coli* was detected in one patient treated by urologist B. The remaining patient, who underwent surgery performed by urologist A, developed febrile symptoms on postoperative day 3 and subsequently received additional antibiotic treatment at a local hospital. On postoperative day 7, the patient presented at the outpatient clinic with an elevated peripheral white blood cell count. However, urine culture yielded no bacterial growth. The infection control team concluded that the five patients who underwent surgery performed by urologist A and subsequently developed febrile UTIs were highly likely to have acquired device-associated infections. Following deliberations by the Infection Control Committee, an outbreak was officially declared. Environmental surveillance cultures were performed on surgical instruments, reprocessing protocols, and operating room environments.

A total of 35 samples were collected, comprising 30 samples from the environment and 5 from the instruments. All specimens were collected under aseptic conditions to minimize contamination and were subsequently processed for microbial analysis. Environmental objects examined included endoscopes and various devices from different hospital areas. In the cleaning room, specimens were collected from the surfaces of sinks, handles, brushes, detergent solutions, and sedimentation basins. In the sterilization room, samples were obtained from the sterilizer,



**FIGURE 1.** Environmental surveillance cultures. Thirty-five samples were collected (30 from the environment; 5 from instruments). (a) The internal working channel of flexible ureteroscope was flushed with sterile distilled water, concentrated by centrifugation, and cultured. Samples from the distal tip, irrigation plug and instrument channel port were obtained by swabbing with sterile cotton swabs immersed in culture broth, and cultured. (b) Environmental sampling consisted of 30 swab specimens collected from the cleaning room, sterilization room, and operating room. All specimens were collected from the surfaces of the suspected objects using sterile cotton swabs, which were then immersed in culture broth

trays, carts, and disinfection solutions. The environmental objects in the operating room include operating tables, room switches, video systems, handles, keyboards, and computer mice. The internal working channel of the FURS was flushed with sterile distilled water, concentrated via centrifugation, and cultured. An adenosine triphosphate (ATP) surface test was performed using Clean-Trace (3M Inc., Saint Paul, MN, USA) to measure the presence of ATP (<200 relative light units) (Figure 1a). All specimens were collected from the surfaces of the suspected objects using sterile cotton swabs, which were then immersed in culture broth (Figure 1b).

### *Ethics concerns*

This study was approved by the Ethics Committee of Seoul Medical Center, Seoul, Korea (Institutional Review Board (IRB) No. SMC 2025-07-007). This study was conducted in accordance with the principles of the Declaration of Helsinki. The need for informed consent was waived by the aforementioned IRB due to the retrospective nature of this

study. Patient data confidentiality was maintained throughout the study.

### **Results**

Between 29 August (when patient 1 underwent surgery) and 19 December (when patient 5 underwent surgery), 23 patients underwent the same surgical procedure. Of the three surgeons at the hospital, MDRPA was detected solely in patients treated by urologist A, who exclusively used r-FURS. The cohort was comprised of relatively young individuals, none of whom had a history of complicated UTIs before surgery. Patients 1, 3, and 4 presented with large impacted upper ureteral stones, which required prolonged and technically challenging surgical procedures. Patient 5, a healthy 41-year-old woman with a comparatively small (6 mm) stone, was readmitted on postoperative day 3 due to febrile symptoms. The isolation of MDRPA from urine cultures has prompted concerns regarding the etiology of the infection. Notably, no stone surgeries were performed

on patients 3 and 4. Surgeries for patients 4 and 5 were subsequently performed at one-week intervals, indicating that patients 3, 4, and 5 underwent sequential procedures using the same instrument within a closely spaced timeframe (Table 1). Urine cultures from the four patients exhibited identical antibiotic susceptibility testing (AST) results, characterized by resistance to imipenem, intermediate susceptibility to meropenem, and susceptibility to other agents. Stone surgeries in three patients exhibited temporal continuity and four patients had identical AST, suggesting that the UTIs were related to stone surgery. No cases of PA infection were identified during the same period among patients treated by another surgeon, indicating a high likelihood that the infections were associated with the r-FURS used solely by surgeon A. All patients developed fever 2–4 days postoperatively, four of whom were readmitted to the emergency department. Three patients showed clinical improvement after intravenous tazobactam or ciprofloxacin treatment. Additional antibiotic resistance was identified during patient 1's therapy, prompting escalation to intravenous ceftazidime/avibactam treatment, which resulted in clinical improvement. Patient 3 received additional antibiotic treatment at a local hospital before visiting the outpatient clinic. None of the patients developed urosepsis or required ICU management. All patients were confirmed to have negative urine culture results after treatment (Table 2).

The Infection Control Committee performed environmental cultures of the surgical instruments, device-reprocessing facilities, and operating rooms. Culturing the internal and external surfaces of the endoscope, including the working channel, yielded negative results. Additionally, ATP testing performed after HLD revealed no detectable residual proteins. However, multiple issues have been identified during the evaluation of FURS reprocessing procedures. During the instrument cleaning phase, instances were observed in which the instrument channel port was not detached before cleaning; in the absence of a dedicated brush for the working channel, a general-purpose brush was occasionally used. Furthermore, it was confirmed that ETO gas sterilization of r-FURS was performed only twice in the past three years, with no ETO gas sterilization performed during the outbreak period. Several issues were identified through environmental culture assessments. PA was isolated from the surface of sink 1 and the handles of sinks 1 and 3 in a cleaning room used for contaminant removal. Other microbial species were identified on the surfaces and handles of all three

sinks. *Achromobacter* species and *Paenibacillus* were detected in the diluted detergent solution and its container. However, no microbial growth was observed in the cultures of the brushes, ultrasonic cleaner or sedimentation basin. In the sterilization room, *Micrococcus* and *Niallia* species were detected in sterilizer 2, whereas PA was not isolated from the trays, storage carts, or other surfaces. No microbial growth was detected in the initial environmental cultures in the operating room. However, during the second sampling, *Streptomyces* species were isolated from the mouse and keyboard (Table 3).

FURS, an essential instrument for the current surgical treatment of kidney stones, is designed with a small and complex structure to operate within confined anatomical spaces. The procedure is performed in the ureter or renal pelvis; areas with sterile urine require special care. Postoperative inflammation may result in febrile acute pyelonephritis. Reports on infections following stone surgery using FURS suggest that mortality directly attributable to device-related infections is rare. Most reported cases of infection-associated mortality occur in patients with significant underlying comorbidities.<sup>10</sup> Nevertheless, recent studies have begun to document emerging cases of infections potentially associated with the use of FURS. Kumarage et al. reported 13 cases of MDRPA infection associated with FURS. This study identified the absence of bedside cleaning, overnight delays in decontamination, and inadequate drying as the primary causes. These problems have been addressed by improving reprocessing procedures.<sup>9</sup> Chang et al. identified 15 cases of UTIs caused by ertapenem-resistant *Enterobacter cloacae* associated with rigid ureteroscopy. These infections were attributed to failed disinfection of the ureteroscope and resolved after ETO gas sterilization.<sup>11</sup> Outbreaks of MDRPA-induced infections have also been reported in patients undergoing cystoscopy. Derickx et al. identified a drying cabinet as the cause of an outbreak after cystoscopy. This issue was resolved through daily manual inspections and updates to the disinfection protocol.<sup>12</sup> In a study by Kim et al., PA was detected in an enzymatic detergent solution used during cleaning. This issue was resolved by modifying the cleaning solution and methods used.<sup>13</sup> Our study did not find direct device-related infections, as neither bacterial cultures nor ATP assays using FURS yielded positive results. However, PA was detected on the sink and handle used during the cleaning process, and multiple deficiencies were identified during the reprocessing procedures. Since the implementation of the reprocessing protocol, no additional cases of

TABLE 1. Overview of 5 patients in order of subsequent post-operative febrile infection

Number	Patient				
	1	2	3	4	5
Age/sex	Male/40	Male/76	Male/59	Male/52	Male/41
Past history	DM	HTN, DM	None	HTN	None
Operation time (min)	153	110	55	60	30
Position of urinary stone	Impacted upper ureter 15 mm	Impacted upper ureter 12 mm	Upper ureter 9 mm	Impacted upper multiple stone (<11 mm)	Upper ureter 6 mm
Access sheath use (Yes/No)	Yes	Yes	Yes	No	Yes
Date of operation	2024/08/29	2024/09/05	2024/11/21	2024/12/12	2024/12/19
Date of fever/re-admission (ER)	2024/08/31 (fever) 2024/09/19 (ER)	2024/09/09 (ER)	2024/11/25 (ER)	2024/12/16 (ER)	2024/12/22 (ER)
Post-OP urine/blood culture	<i>P. aeruginosa</i> /NG	<i>P. aeruginosa</i> /NG	NG	<i>P. aeruginosa</i> /NG	<i>P. aeruginosa</i> /NG

Note: Abbreviations: HTN, hypertension; DM, diabetes mellitus; ER, emergency room; NG, no growth.

infection related to PA have been reported over a six-month period.

FURS is typically used in sterile environments, necessitating increased vigilance; however, standardized reprocessing protocols and manuals remain insufficient compared to those established for gastroscopy and colonoscopy. The FDA also recommends that healthcare facilities carefully follow the manufacturer’s instructions regarding reprocessing procedures and refrain from using any devices that are damaged or have failed a leak test.<sup>3</sup> However, parameters such as detergent and disinfectant soaking times, working channel cleaning techniques, replacement frequency of dedicated brushes, and the decision to use ETO sterilization or chemical HLD post-procedures are currently determined at the discretion of individual institutions. Legemate et al. reported that despite appropriate reprocessing using chemical HLD, preoperative cultures of FURS yielded uropathogen growth ( $\geq 10$  colony forming units/mL) in approximately 2% (9/398) of cases.<sup>14</sup> This finding suggests the possibility that uropathogens may form biofilms, providing a protective barrier against disinfectant solutions or exhibit resistance to these disinfectants.<sup>11</sup> Although Cindolo et al. reported that infections associated with rigid ureteroscopes

were resolved by substituting chemical HLD with ETO sterilization,<sup>10</sup> Ofstead et al. found that filamentous debris and oily deposits persisted within the working channel and on the external surfaces of instruments despite manual cleaning and gas sterilization, suggesting that these interventions may not constitute a definitive solution.<sup>15</sup> However, a common consensus among studies investigating outbreaks associated with endoscopes is that these instruments should be considered potential reservoirs for infection. Consequently, reprocessing procedures and environmental controls must be improved, and the endoscope should not be used until cultures confirm the absence of microbial contamination.<sup>12</sup>

The present study has several limitations. The implementation of epidemiological typing, such as variable number tandem repeat analysis, could aid in elucidating the epidemiology of outbreak strains and assessing the clonality between endoscope- and patient-associated isolates.<sup>16</sup> However, our institution lacked the facilities to perform such analyses, and because no bacteria were isolated from the FURS, there were limitations in establishing a direct causal relationship. However, environmental cultures detected PA in areas where instruments were cleaned, providing indirect evidence of device-associated

TABLE 2. Laboratory investigation of antibiotic susceptibility for *Pseudomonas aeruginosa*

Type of antibiotics	Patient 1		Patient 2	Patient 3	Patient 4	Patient 5
	1st	2nd	1st	1st	1st	1st
Amikacin (MIC)	S (4)	S ( $\leq 1$ )	S (4)	/	S (4)	S (4)
Cefepime (MIC)	S (8)	I (8)	S (8)	/	S (8)	S (8)
Ceftazidime (MIC)	S (2)	I (16)	S (2)	/	S (2)	S (2)
Ceftazidime/Abibactam (MIC)	/	S	/	/	/	/
Ceftolozane/Tazobactam (MIC)	/	S (0.5)	/	/	/	/
Ciprofloxacin (MIC)	S (0.5)	R ( $\geq 4$ )	S (0.5)	/	S (0.5)	S (0.5)
Imipenem (MIC)	R ( $\geq 16$ )	R ( $\geq 16$ )	R ( $\geq 16$ )	/	R ( $\geq 16$ )	R ( $\geq 16$ )
Meropenem (MIC)	I (4)	R ( $\geq 16$ )	I (4)	/	I (4)	I (4)
Piperacillin/Tazobactam (MIC)	S ( $\leq 4$ )	R ( $\geq 128$ )	S ( $\leq 4$ )	/	S ( $\leq 4$ )	S (8)
Tobramycin (MIC)	S ( $\leq 1$ )	R (4)	S ( $\leq 1$ )	/	S ( $\leq 1$ )	S ( $\leq 1$ )
Final urine culture	NG	NG	NG	NG	NG	NG
Treatment	Ciprofloxacin (I.V.) Ceftazidime/Abibactam (I.V.)	Tazobactam (I.V.) Ciprofloxacin (I.V.)	Ciprofloxacin (P.O.)	Tazobactam (I.V.) Ciprofloxacin (I.V.)	Tazobactam (I.V.) Ciprofloxacin (I.V.)	Tazobactam (I.V.) Ciprofloxacin (I.V.)
Hospitalization duration	14 days	7 days	0 days	7 days	5 days	
ICU care/ Urosepsis (Y/N)	N/N	N/N	N/N	N/N	N/N	
Outcome	Recovered	Recovered	Recovered	Recovered	Recovered	

Note: Abbreviations: MCI, minimum inhibitory concentration; S, susceptible; I, intermediate; R, resistance; NG, no growth; I.V., intravenous; P.O., per os; ICU, intensive care unit; Y, yes; N, no.

infections. Association with stone surgery was evaluated based on the patient's temporal sequence and the identical AST of urine cultures. Notably, no cases of MDRPA infection occurred in patients treated by other surgeons using s-FUS during the same period. After improvements were made to the reprocessing process, no additional infections occurred for more than six months. Although MDRPA was not directly identified in the r-FURS group from an epidemiological perspective, it is highly likely that the infections were related to r-FURS.

Flexible endoscopes have complex reprocessing requirements and heat-sensitive structures that require skilled and trained personnel. However, inspections revealed that frequent staff turnover resulted in low proficiency levels, and because of a lack of effective communication, chemical HLD was performed solely on r-FURS, with no ETO gas sterilization performed throughout the outbreak period. In response to concerns regarding device-associated

infection outbreaks, the management of r-FURS was intensified, and ETO gas sterilization was implemented by the Infection Control Committee before the commencement of environmental cultures. The possibility that changes in the reprocessing procedures before testing influenced the FURS culture results cannot be excluded. Alternatively, it is possible that these organisms were not detected because of the limitations of culture-based methods, particularly when the bioburden was low. In a study by Cimen et al., during an *Enterobacter* outbreak associated with a duodenoscope, all eight culturing attempts using various methods yielded negative results. However, *Enterobacter* was later isolated from a sample obtained from the forceps elevator component during a duodenoscope dissection, highlighting the challenges of detecting residual contamination using conventional culturing techniques.<sup>17</sup> Uropathogenic infections can result from inadequate reprocessing, particularly due to device damage. However, FURS

integrity was evaluated exclusively by the manufacturer. Due to financial constraints, such assessments were not performed.<sup>8</sup> However, no leakage was detected during the leakage test performed at 27 psi or during visual inspection. Flexion-extension motion tests did not reveal any apparent abnormalities. In a study by Wong et al., recent investigations have explored the use of 4',6-diamidino-2-phenylindole

(DAPI) staining followed by fluorescence microscopy to detect residual bacterial contamination on endoscope surfaces. This technique allows for the visual confirmation of bacterial presence after reprocessing and may provide valuable insights into biofilm persistence. However, its use remains largely experimental because DAPI does not uniformly stain all bacterial species, and the method has not yet been

TABLE 3. Environmental microbiological tests

Variables		Initial round	2nd round	3rd, 4th round	
Device	Flexible ureteroscope	Distal end tip	NG	NG	–
		Instrument channel port	NG	NG	–
		Forcep/irrigation plug	NG	NG	–
		Instrument working channel	NG	NG	–
		ATP test	Negative	–	–
Cleaning room	Sink	Surface #1	<i>Pseudomonas aeruginosa</i> , <i>Stenotrophomonas maltophilia</i>	NG	NG
		Surface #2	<i>Stenotrophomonas maltophilia</i>	NG	NG
		Surface #3	<i>Pseudomonas mosselii</i> , <i>Agrobacterium radiobacter</i>	<i>Paenibacillus glucanolyticus</i>	NG
		Handle #1	<i>Pseudomonas aeruginosa</i>	NG	NG
		Handle #2	<i>Achromobacter species</i>	NG	NG
		Handle #3	<i>Pseudomonas aeruginosa</i> , <i>Sphingomonas paucimobilis</i>	NG	NG
		Channel cleaning	NG	NG	–
	Cleaning brush	Channel opening cleaning	NG	NG	–
		Other	NG	NG	–
		Detergent solution (SaniZyme)	Diluted solution	<i>Achromobacter species</i>	NG
	Diluted solution bottle		<i>Achromobacter species</i> , <i>Paenibacillus timonensis</i>	NG	–
	Ultrasonic cleaner Sedimentation basin	NG	NG	–	–
		NG	NG	–	–

(Continued)

TABLE 3. (Continued)

Variables			Initial round	2nd round	3rd, 4th round
Sterilization room	Sterilizer	#1	NG	NG	–
		#2	<i>Micrococcus luteus, Niattia circulans</i>	NG	–
	Sterilization tray		NG	NG	–
	Storage cart		NG	NG	–
	Disinfection solution (Perasafe)	Diluted solution	NG	NG	–
		Diluted solution bottle	NG	NG	–
Operation room	Operation table		NG	NG	–
	Mouse and keyboard		NG	<i>Streptomyces viridodiataticus</i>	NG
	Operation room switch		NG	NG	–
	Video system		NG	NG	–
	Operation room handle		NG	NG	–

Note: Abbreviations: NG, no growth.

validated for routine surveillance or full-scope applications. Therefore, further research is required to standardize this technique, assess its diagnostic sensitivity and specificity, and determine its feasibility in clinical practice.<sup>18</sup> Unno et al. reported that the use of s-FURS reduced the risk of postoperative UTIs by approximately twofold compared with r-FURS.<sup>19</sup> Higgins et al. recommended the use of s-FURS in patients with compromised immune function or at high risk of sepsis.<sup>20</sup> In the present study, no cases of MDRPA infection were identified in patients who underwent s-FURS during the same period. These findings suggest that s-FURS may be beneficial in situations where reprocessing difficulties are anticipated. However, further studies are required to confirm their effectiveness and cost-effectiveness.

## Conclusions

Recurrent UTIs caused by clinically relevant bacteria after stone surgery should raise the suspicion of infections originating from surgical instruments. In such cases, thorough environmental investigations, including ureteroscopic cultures, reprocessing procedures, and room hygiene, are essential. In our device-related outbreak, the key contributing factors included inadequate reprocessing, absence of ETO

gas sterilization, and insufficient training of personnel responsible for instrument cleaning. To address these issues, the reprocessing protocols were revised, after which no additional cases of infection were reported for more than six months. This suggests the effectiveness of comprehensive infection control measures for preventing device-related outbreaks.

## Acknowledgement

Not applicable.

## Funding Statement

The authors received no specific funding for this study.

## Author Contributions

Conceptualization: Seung-Kwon Choi, Sin Woo Lee; Methodology: Seung-Kwon Choi, Sin Woo Lee; Data collection: Seung-Kwon Choi; Data analysis and interpretation: Sin Woo Lee; Funding acquisition: none; Supervision: Sin Woo Lee; Writing—original

draft: Sin Woo Lee, Seung-Kwon Choi; Writing—review & editing: Sin Woo Lee. All authors reviewed the results and approved the final version of the manuscript.

## Availability of Data and Materials

Due to the nature of this research, participants of this study did not agree to their data being shared publicly, so supporting data is not available.

## Ethics Approval

This study was approved by the Ethics Committee of Seoul Medical Center, Seoul, Korea (IRB No. SMC 2025-07-007), and it was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

## Informed Consent

The need for informed consent was waived by the aforementioned IRB due to the retrospective nature of this study.

## Conflicts of Interest

The authors declare no conflicts of interest to report regarding the present study.

---

## References

1. He M, Dong Y, Cai W et al. Recent advances in the treatment of renal stones using flexible ureteroscopies. *Int J Surg* 2024;110(7):4320–4328.
2. Chen H, Xiao J, Ge J, Liu T. Clinical efficacy analysis of intelligent pressure-controlled ureteroscopy combined with thulium laser in the treatment of isolated upper urinary tract urothelial carcinoma. *Front Oncol* 2024;14:1406031.
3. Food US, Administration Drug. *MedSun Report 2022*. Silver Spring, MD, USA: U.S. Food and Drug Administration; 2022.
4. Ofstead CL, Hopkins KM, Smart AG, Eiland JE, Wetzler HP, Bechis SK. Reprocessing effectiveness for flexible ureteroscopes: a critical look at the evidence. *Urology* 2022;164(4S):25–32.
5. Dolan SK. Current knowledge and future directions in developing strategies to combat *pseudomonas aeruginosa* infection. *J Mol Biol* 2020;432(20):5509–5528.
6. Reynolds D, Kollef M. The epidemiology and pathogenesis and treatment of *pseudomonas aeruginosa* infections: an update. *Drugs* 2021;81(18):2117–2131.
7. Pena C, Dominguez M, Pujol M, Verdaguier R, Gudiol F, Ariza J. An outbreak of carbapenem-resistant *Pseudomonas aeruginosa* in a urology ward. *Clin Microbiol Infect* 2003;9(9):938–943.
8. Wendelboe AM, Baumbach J, Blossom DB, Frank P, Srinivasan A, Sewell CM. Outbreak of cystoscopy related infections with *Pseudomonas aeruginosa*: New Mexico, 2007. *J Urol* 2008;180(2):588–592.
9. Kumarage J, Khonyongwa K, Khan A, Desai N, Hoffman P, Taori SK. Transmission of multi-drug resistant *Pseudomonas aeruginosa* between two flexible ureteroscopes and an outbreak of urinary tract infection: the fragility of endoscope decontamination. *J Hosp Infect* 2019;102(1):89–94.
10. Cindolo L, Castellan P, Scoffone CM et al. Mortality and flexible ureteroscopy: analysis of six cases. *World J Urol* 2016;34(3):305–310.
11. Chang CL, Su LH, Lu CM, Tai FT, Huang YC, Chang KK. Outbreak of ertapenem-resistant *Enterobacter cloacae* urinary tract infections due to a contaminated ureteroscope. *J Hosp Infect* 2013;85(2):118–124.
12. Derickx LAJ, Willemse-Erix D, Van Piggelen A et al. An outbreak of *Pseudomonas aeruginosa* urinary tract infections following cystoscopy traceable to a malfunctioning drying cabinet. *Infect Prev Pract* 2024;6(3):100378.
13. Kim B, Choi Y-S, Kang J-K et al. Outbreak of cystoscopy-related urinary tract infections with *pseudomonas aeruginosa* in South Korea, 2022: a case series. *Urogenital Tract Infect* 2024;19(3):97–103.
14. Legemate JD, Kamphuis GM, Freund JE et al. Pre-use ureteroscope contamination after high level disinfection: reprocessing effectiveness and the relation with cumulative ureteroscope use. *J Urol* 2019;201(6):1144–1151.
15. Ofstead CL, Heymann OL, Quick MR, Johnson EA, Eiland JE, Wetzler HP. The effectiveness of sterilization for flexible ureteroscopes: a real-world study. *Am J Infect Control* 2017;45(8):888–895. doi:10.1016/j.ajic.2017.03.016.
16. Kayabas U, Bayraktar M, Otlu B et al. An outbreak of *Pseudomonas aeruginosa* because of inadequate disinfection procedures in a urology unit: a pulsed-field gel electrophoresis-based epidemiologic study. *Am J Infect Control* 2008;36(1):33–38.
17. Cimen C, Bathoorn E, Loeve AJ et al. Uncovering the spread of drug-resistant bacteria through next-generation sequencing based surveillance: transmission of extended-spectrum  $\beta$ -lactamase-producing *Enterobacterales* by a contaminated duodenoscope. *Antimicrob Resist Infect Control* 2024;13(1):31.
18. Wong M, Wang Y, Wang H et al. Research: fluorescence microscopy-based protocol for detecting residual bacteria on medical devices. *Biomed Instrum Technol* 2020;54(6):397–409.
19. Unno R, Hosier G, Hamouche F, Bayne DB, Stoller ML, Chi T. Single-use ureteroscopes are associated with decreased risk of urinary tract infection after ureteroscopy for urolithiasis compared to reusable ureteroscopes. *J Endourol* 2023;37(2):133–138.
20. Higgins AM, Wolf MJ, Becker REN, Ghani KR. How I Do It: ureteroscopy and high-power holmium laser lithotripsy to treat renal stones. *Can J Urol* 2023;30(3):11574–11582.