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Outbreak of Cystoscopy-Related Urinary Tract Infections With *Pseudomonas aeruginosa* in South Korea, 2022: A Case Series

Beomsoo Kim[1], Young-Sin Choi[2], Jun-Koo Kang[3], Yun-Sok Ha[1,4], Seock Hwan Choi[3,4], Bum Soo Kim[1,4], Hyun Tae Kim[1,4], Eun Sang Yoo[1,4], Tae Gyun Kwon[3,4], Jae-Wook Chung[3,4], Tae-Hwan Kim[3,4]

[1]Department of Urology, Kyungpook National University Hospital, Daegu, Korea
[2]Department of Infection Control, Chilgok Kyungpook National University Hospital, Daegu, Korea
[3]Department of Urology, Chilgok Kyungpook National University Hospital, Daegu, Korea
[4]Department of Urology, School of Medicine, Kyungpook National University, Daegu, Korea

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Corresponding author:
Jae-Wook Chung
Department of Urology, Kyungpook National University Hospital, School of Medicine, Kyungpook National University, 807 Hoguk-ro, Buk-gu, Daegu 41404, Korea
Email: jeus119@hanmail.net
https://orcid.org/0000-0002-1055-2357

Co-corresponding author:
Tae-Hwan Kim
Department of Urology, Kyungpook National University Hospital, School of Medicine, Kyungpook National University, 807 Hoguk-ro, Buk-gu, Daegu 41404, Korea
Email: doctork@knu.ac.kr
https://orcid.org/0000-0003-4924-4826

Purpose: This study conducted an epidemiological investigation of *Pseudomonas aeruginosa* urinary tract infections (UTIs) following cystoscopy at Chilgok Kyungpook National University Hospital.

Materials and Methods: From May 16 to July 15, 2022, among 353 patients who underwent cystoscopy, 6 patients reported febrile UTIs following cystoscopy. They were admitted to the urology department of the hospital after visiting the Emergency Department. *P. aeruginosa* was found in the urine cultures of 4 of the 6 hospitalized patients. During the epidemiological investigation, no changes were observed in factors such as the reprocessing procedures for endoscopic equipment. Therefore, microbiological tests were performed using environmental samples derived from the endoscopic equipment and cleaning process.

Results: *P. aeruginosa* was identified in a dual-enzymatic detergent (EmPower) used during the endoscope cleaning process. After changing the disinfectant and cleaning process, no further bacterial growth was observed in subsequent microbiological tests.

Conclusions: This study highlights the potential of cystoscopes to serve as reservoirs for bacteria due to inadequate cleaning during the disinfection process. To minimize the risk of infections following cystoscopy, it is important to pay close attention to the reprocessing and cleaning of cystoscopes.

Keywords: *Pseudomonas aeruginosa*; Urinary tract infections; Cystoscopy

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• **Research Ethics:** This study was approved by the Institutional Review Board (IRB) of Chilgok Kyungpook National University Hospital (IRB No. KNUCH 2024-09-015) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The need for informed consent was waived by the aforementioned IRB due to the retrospective nature of this study.

• **Conflict of Interest:** The authors have nothing to disclose.

HIGHLIGHTS

Over 2 months in 2022, 6 patients undergoing cystoscopy at our hospital complained of febrile urinary tract infections, with *Pseudomonas aeruginosa* found in 4 cases. Contamination was identified in a dual-enzymatic detergent (EmPower) used for cystoscope cleaning. Revising the cleaning process and disinfectant prevented further infections.

INTRODUCTION

Pseudomonas aeruginosa, a gram-negative bacterium commonly encountered in hospital-acquired infections, often exhibits antibiotic resistance [1]. Notably, it forms biofilms, adhering to the surfaces of medical devices or structures, which hinders effective removal during the cleaning process [2]. Biofilms, which serve as protective barriers for bacteria, can reduce the effectiveness of antibiotics or detergents and are particularly common on medical equipment such as endoscopes. Previous studies have reported outbreaks of infections associated with contaminated endoscopes and inadequate disinfection [3-9]. Therefore, *P. aeruginosa* infections warrant special attention, and it is essential to implement appropriate disinfection and infection control procedures [10].

Cystoscopy, one of the most common procedures in urology, requires the careful cleaning of cystoscopes before use on the next patient to prevent infections; accordingly, considerable attention has been directed towards cystoscopy in ongoing research [11-14]. The incidence rate of urinary tract infections (UTIs) after cystoscopy has been reported to range from 2% to 21.2% [11,15]. The most common microorganisms are *Escherichia coli*, enterococci, and staphylococci [16], and *P. aeruginosa* accounts for only 1%–2% of UTIs [17,18].

In this study, we investigated *P. aeruginosa*-related UTIs occurring after cystoscopy at Chilgok Kyungpook National University (Hospital 1) in July 2022.

MATERIALS AND METHODS

At Hospital 1, cystoscopy was performed on an outpatient basis in the cystoscopy room using 2 reusable flexible cystoscopes. In July 2022, with an increase in cases of UTIs following cystoscopy, which led to hospitalizations, the cystoscopy department at Hospital 1 implemented additional passive measures. Previously, only betadine disinfection was conducted before cystoscopy; subsequently, 0.5% hexachlorophene (disinfectant) was added to the betadine disinfection process [19]. However, as the occurrence of UTIs remained an issue, an epidemiological investigation was conducted on July 18, 2022.

1. Participants

From May 16 to July 15, 2022, a total of 353 patients underwent cystoscopy at Hospital 1. Among them, 6 patients developed UTIs with accompanying fever after cystoscopy, leading to hospitalization in the urology department after visiting the Emergency Department (ED) of Hospital 1. Among the 6 hospitalized patients, *P. aeruginosa* was identified in the urine cultures of 4 individuals. The demographic and clinical data of the 6 patients are presented in Table 1.

All 6 patients were male, and they visited the ED within 8 days after undergoing cystoscopy. All patients underwent microbiological tests on the day of their ED visit and were admitted for antibiotic treatment of the infections. After confirmation of negative results in follow-up urine cultures, they were discharged. All 6 patients tested negative for bacteria in blood cultures, with *P. aeruginosa* confirmed in the urine cultures of only 4 of them. However, in the case of patient 2, who showed a negative urine culture result, he had been experiencing fever for 2 days before his ED visit and had been taking oral antibiotics prescribed by a local hospital. As a result, it cannot be ruled out that the negative urine culture result at the time of the ED visit may be attributed to the prescribed oral antibiotics. In the case of patient 6, he underwent cystoscopy the day before visiting the ED. Given the short interval between the procedure and the ED visit, a false-negative result could not be ruled out. Among the 6 patients, only 1 of them (patient 5) was a paraplegic patient requiring cystostomy, and only patient 6 had been hospitalized within 30 days. Patient 6 underwent pelvic mass excision surgery on June 16, 2022 and was hospitalized for postoperative management until June 24. During the surgery, a prophylactic right ureteral stent was inserted. On July 14, 2022, cystoscopy was performed to remove the ureteral stent. However, on the next day, the patient developed right-sided pyelone-

Table 1. Characteristics of patients with *P. aeruginosa* urinary tract infections

Patient	Age (yr)	Sex	Recent hospitalization (within 30 days)	Date of cystoscopy	Date of positive sampling	Delay between cystoscopy and positive sampling (day)	Hospitalization duration (day)	Urine culture	Blood culture
1	87	Male	-	2022.05.27	2022.06.04	8	7	*P. aeruginosa*	NG
2	67	Male	-	2022.05.30	2022.06.05	6	9	NG	NG
3	56	Male	-	2022.07.05	2022.07.13	8	10	*P. aeruginosa*	NG
4	64	Male	-	2022.07.06	2022.07.09	3	21	*P. aeruginosa*	NG
5	58	Male	-	2022.07.13	2022.07.15	2	11	*P. aeruginosa*	NG
6	64	Male	+	2022.07.14	2022.07.15	1	7	NG	NG

P. aeruginosa, *Pseudomonas aeruginosa*; NG, no growth.

phritis and was hospitalized for infection treatment.

2. Laboratory Assessment

It was found that since May 2022, the cystoscopy room has been relocated from a distant area (endoscopy room 7) in the endoscopy cleaning room to an adjacent area. Other than the relocation, there were no changes observed in other factors, including the reprocessing procedures for endoscopic equipment.

Before proceeding with further environmental cultures and investigations, we strengthened the disinfection and cleaning protocols for the cystoscopy room and endoscopic equipment on July 18, 2022. First, to address concerns regarding residual organic matter during the cleaning of the cystoscopy room, ethanol (disinfectant) was incorporated into the cleaning process [20]. Additionally, considering the possibility of urine leakage due to the nature of cystoscopy, we implemented cleaning methods with diluted sodium hypochlorite solution [21]. To address concerns such as biofilm formation on the surface of the sink, caused by pouring sterilized water used for rinsing endoscopic equipment into the sink, we recommended surface disinfection using a combination of an enzymatic cleaner and a disinfectant [22]. The cleaning process after cystoscopy at Hospital 1 is presented in Table 2.

On July 18, 2022, the same day of the report, the first round of environmental microbiological tests was conducted on 2 reusable cystoscopes (Table 3). Samples were collected following the protocol described in a previous study [23]. After collecting a total of 29 samples, microbiological tests were performed.

Table 2. Cleaning process after cystoscopy

1	After cystoscopy, wipe the endoscope with a gauze to remove organic material.
2	Wash with a dual-enzymatic detergent (EmPower), and rinse with tap water in the sink.
3	Immerse in 0.2% peracetic acid (Perasafe) for 10 min.
4	Immerse in 2 L of sterile water in a sterilized tray, then rinse.

EmPower (Metrex Research Corp., Orange, CA, USA), Perasafe (Ecolab Inc., St. Paul, MN, USA).

Table 3. First round of environmental microbiological tests

No.[a]	Specimen[b]	Culture
	After washing with EmPower	
1, 2	Suction tip area	NG
3, 4	Distal end area	NG
5, 6	Liquid passed from the suction tip to distal end	NG
	After immersion in Perasafe	
7, 8	Suction tip area	NG
9, 10	Distal end area	NG
11, 12	Liquid passed from the suction tip to distal end	NG
	After immersion in sterilized water	
13, 14	Suction tip area	NG
15, 16	Distal end area	NG
17, 18	Liquid passed from the suction tip to distal end	NG
19, 20	Water used for rinsing cystoscopes	NG
21	EmPower diluted solution	*P. aeruginosa*[c]
22	Perasafe diluted solution	NG
23	Cleaning brush	*Lactococcus lactis*
24	Sink	*Lactobacillus* spp. & *Candida krusei*
25	Sterilized tray	NG
	Interior of cystoscope storage cabinet	
26	#1 (wall side)	NG
27	#2 (door side)	NG
28	Handle of storage cabinet	NG
29	Treatment cart	NG

NG, no growth; *P. aeruginosa*, *Pseudomonas aeruginosa*.
EmPower (Metrex Research Corp., Orange, CA, USA), Perasafe (Ecolab Inc., St. Paul, MN, USA).
[a]No. 1–20 are samples collected from each of the 2 flexible cystoscopes. [b]The cleaning process is outlined in Table 2. [c]*P. aeruginosa* shows susceptibility to all tested antibiotics, including amikacin, aztreonam, cefepime, ceftazidime, ceftazidime/avibactam, ciprofloxacin, gentamicin, imipenem, levofloxacin, meropenem, and piperacillin/tazobactam.

Table 4. Second round of environmental microbiological tests

Specimen	Culture
EmPower undiluted solution	NG
EmPower subdivided solution[a]	NG
EmPower diluted solution[b]	*P. aeruginosa*[c]
Interior of the EmPower diluted can	
#1	*P. aeruginosa*[d] & *Chryseobacterium indologenes*
#2	*Citrobacter freundii*
Nozzle of the EmPower diluted pump	NG
Sink	
#1 (Handle)	*P. aeruginosa*[e]
#2 (Faucet)	NG
#3 (Surface)	*Citrobacter freundii*

NG, no growth; *P. aeruginosa*, *Pseudomonas aeruginosa*.
EmPower (Metrex Research Corp., Orange, CA, USA).
[a]EmPower undiluted solution dispensed into smaller bottles. [b]EmPower subdivided solution mixed with sterile water. [c]*P. aeruginosa* shows susceptibility to all tested antibiotics. [d]*P. aeruginosa* shows susceptibility to most tested antibiotics but exhibits resistance to gentamicin, imipenem, and meropenem, with intermediate susceptibility to ceftazidime. [e]*P. aeruginosa* shows susceptibility to most tested antibiotics but exhibits resistance to ceftazidime, imipenem, and meropenem.

RESULTS

On July 20, 2022, microbiological tests of 29 samples detected the presence of *P. aeruginosa* in one of the enzymatic detergent samples. Additionally, bacteria were detected in cultures from the cleaning brush (*Lactococcus lactis*) and sink surface (*Lactobacillus* spp. and *Candida krusei*). However, no bacteria were detected in the remaining 26 samples. On the same day the test results were confirmed, the cleaning solution and cleaning method were promptly altered. Previously, cystoscopes were cleaned with a dual-enzymatic detergent (EmPower, Metrex Research Corp., Orange, CA, USA), followed by rinsing with water. This procedure was changed to immerse the cystoscopes in a quad-enzymatic detergent (SaniZyme, Ultra Clean Systems Inc., Oldsmar, FL, USA). Additionally, the cleaning brush was replaced with a single-use brush. Given the issues discovered during the cleaning process, all environmental samples were subjected to a second round of tests on July 20, 2022 (Table 4).

On July 22, 2022, a total of 9 samples were tested for microorganisms. Among them, *P. aeruginosa* was identified in samples from the EmPower diluted solution, interior of the EmPower diluted can #1, and sink handle. Additionally, *Citrobacter freundii* was detected in samples from the interior of the EmPower diluted can #2 and sink surface. No bacteria were detected in the re-

maining 4 samples. Accordingly, all remaining EmPower solution and diluted cans were discarded, and the cleaning frequency in the cleaning room was increased from once daily to twice daily. Additionally, new sink handles were installed, and cystoscopes were promptly cleaned after each procedure to prevent organic residues from solidifying inside the equipment. Furthermore, cystoscopes were not simply stored after cleaning; instead, they were stored in the equipment storage area only after completing the cleaning process. After cleaning and organizing the cleaning room and sink area, a third round of environmental microbiological tests was conducted on July 22, 2022 (Table 5).

On July 25, 2022, a total of 11 samples were cultured, and no bacteria were detected in any of them, effectively ending the outbreak and resolving the issue.

DISCUSSION

From May 16 to July 15, 2022, a total of 353 patients underwent cystoscopy at Hospital 1. Subsequently, 14 patients visited the ED, with 6 of them admitted to the urology department for the treatment of UTIs with fever. During the study, *P. aeruginosa* was identified in the dual-enzymatic detergent (EmPower) during endoscope reprocessing. Therefore, the disinfectant and disinfection methods were changed to resolve the issue.

Table 5. Third round of environmental microbiological tests

Specimen	Culture
Quad-enzymatic detergent (SaniZyme) solution	NG
Sink handle	
#1	NG
#2	NG
Sink surface	
#1	NG
#2	NG
Barcode reader	NG
Computer mouse	NG
Keyboard	NG
Handle of the brush storage cart	NG
Scissors for cutting intravenous bags	NG
Handle for the sink drawer	NG

NG, no growth.
SaniZyme (Ultra Clean Systems Inc., Oldsmar, FL, USA).

In previous studies, outbreaks of *P. aeruginosa* infections following cystoscopy have been reported [17,23]. In these studies, the authors identified contaminated cystoscopes and improper equipment reprocessing methods as the causes of the outbreaks [17,23]. They resolved the outbreaks by implementing proper endoscope reprocessing methods [17,23]. Like previous studies, this study also reports an outbreak of *P. aeruginosa* infections following cystoscopy. However, in the previous studies, the contamination was caused by endoscopic equipment that was contaminated due to improper cleaning methods, whereas in this study, the source of contamination was the cleaning solution used during the endoscope cleaning process. In another study, cystoscopy-related outbreaks were caused by *Carbapenem-resistant Enterobacteriaceae*, and issues were identified in the disinfection and reprocessing processes [24].

This study has some limitations. First, only patients admitted to the ED of Hospital 1 were included in this study. Patients with symptoms of UTIs in outpatient settings or those admitted to other hospitals for UTIs were excluded. For example, 4 patients admitted to rural hospitals for UTIs following cystoscopy during the study period were excluded from this investigation. Second, precystoscopy urine cultures were not conducted for all patients undergoing cystoscopy. In other words, prior to cystoscopy, it was not confirmed that all patients had a negative urine culture result. Therefore, the detection of *P. aeruginosa* in urine cultures performed upon admission to the ED could not definitively confirm whether it was associated with cystoscopy. Third, after cystoscopy, patients typically visit the outpatient department 1–2 weeks later to receive the results of cystoscopy. However, urine cultures were not performed for all patients at their next outpatient visit. As a result, asymptomatic bacteriuria patients were excluded, and patients who did not complain of fever due to UTIs but presented with other symptoms were also excluded. This raises the possibility of underestimating the patient population.

Table 6. Updated cleaning process after cystoscopy

1	Rinse with water after cystoscopy.
2	Immerse in SaniZyme for 5 min.
3	Pass SaniZyme through the biopsy channel entrance using a syringe, and scrub each channel entrance with a brush.
4	Wipe the endoscope with gauze and rinse with water.
5	Immerse in Perasafe for 10 min.
6	Immerse in 2 L of sterile water in a sterilized tray, then rinse.
7	If not used immediately, store in a storage cabinet for drying.

SaniZyme (Ultra Clean Systems Inc., Oldsmar, FL, USA), Perasafe (Ecolab Inc., St. Paul, MN, USA).

Table 7. Environmental management of the cleaning room

Diluted can	Every day after use, immerse in SaniZyme for 5 min, then rinse with water and dry on a drying rack.
Sink	Ethanol disinfection twice daily (before/after cystoscopy).
Brush	Exchange after each use.
SaniZyme	Exchange daily.

SaniZyme (Ultra Clean Systems Inc., Oldsmar, FL, USA).
Cystoscopes are only stored in a storage cabinet after all cleaning steps are completed.
Twice a year, perform culture tests for cystoscopes including cleaning and disinfectant solutions.

Following the study, Hospital 1 established and implemented a cleaning process for cystoscopes and a cleaning room management manual (Tables 6 and 7). When the aforementioned manual and revised cleaning process for cystoscopes were used, there were no further cases of hospitalized patients developing UTIs after cystoscopy.

CONCLUSIONS

Following the occurrence of UTIs in several patients after cystoscopy, an epidemiological investigation was conducted, which revealed that improper cleaning during endoscope sterilization led to the cystoscopes acting as potential reservoirs for bacteria. Therefore, modifications were made to the cleaning process, and a cleaning room management manual was established. This could allow interventions and proactive prevention measures to be taken to prevent similar infection outbreaks from occurring in the future. Close attention must be given to reprocessing and disinfection procedures for endoscopic equipment in order to minimize the risk of infections following cystoscopy.

NOTES

• **Author Contribution:** Conceptualization: BK, YSC, JWC, THK; Data curation: BK, YSC, JKK, YSH, SHC, BSK, HTK, ESY, TGK, JWC, THK; Formal analysis: BK, YSC, JWC, THK; Funding acquisition: JWC, THK; Methodology: BK, YSC, JKK, YSH, SHC, BSK, HTK, ESY, TGK, JWC, THK; Project administration: JWC, THK; Visualization: BK, YSC; Writing - original draft: BK, YSC, JKK, YSH, SHC, BSK, HTK, ESY, TGK, JWC, THK; Writing - review & editing: JWC, THK.

• **ORCID**
Beomsoo Kim: 0009-0007-6399-1744
Young-Sin Choi: 0000-0003-3413-988X
Jun-Koo Kang: 0000-0002-8857-3406
Yun-Sok Ha: 0000-0003-3732-9814
Seock Hwan Choi: 0000-0003-3796-2601
Bum Soo Kim: 0000-0002-4873-3049
Hyun Tae Kim: 0000-0002-4730-3776
Eun Sang Yoo: 0000-0002-7442-6886
Tae Gyun Kwon: 0000-0002-4390-0952
Jae-Wook Chung: 0000-0002-1055-2357
Tae-Hwan Kim: 0000-0003-4924-4826

REFERENCES

1. Nathwani D, Raman G, Sulham K, Gavaghan M, Menon V. Clinical and economic consequences of hospital-acquired resistant and multidrug-resistant Pseudomonas aeruginosa infections: a systematic review and meta-analysis. Antimicrob Resist Infect Control 2014;3:32.
2. Morrison Jr AJ, Wenzel RP. Epidemiology of infections due to Pseudomonas aeruginosa. Rev Infect Dis 1984;6 Suppl 3:S627-42.
3. Qiu L, Zhou Z, Liu Q, Ni Y, Zhao F, Cheng H. Investigating the failure of repeated standard cleaning and disinfection of a Pseudomonas aeruginosa-infected pancreatic and biliary endoscope. Am J Infect Control 2015;43:e43-6.
4. Fernández-Cuenca F, López-Cerero L, Cabot G, Oliver A,

López-Méndez J, Recacha E, et al. Nosocomial outbreak linked to a flexible gastrointestinal endoscope contaminated with an amikacin-resistant ST17 clone of Pseudomonas aeruginosa. Eur J Clin Microbiol Infect Dis 2020;39:1837-44.
5. Srinivasan A, Wolfenden LL, Song X, Mackie K, Hartsell TL, Jones HD, et al. An outbreak of Pseudomonas aeruginosa infections associated with flexible bronchoscopes. New Engl J Med 2003;348:221-7.
6. DiazGranados CA, Jones MY, Kongphet-Tran T, White N, Shapiro M, Wang YF, et al. Outbreak of Pseudomonas aeruginosa infection associated with contamination of a flexible bronchoscope. Infect Control Hosp Epidemiol 2009;30:550-5.
7. Gillespie JL, Arnold KE, Noble-Wang J, Jensen B, Arduino M, Hageman J, et al. Outbreak of Pseudomonas aeruginosa infections after transrectal ultrasound-guided prostate biopsy. Urology 2007;69:912-4.
8. Bou R, Aguilar A, Perpinan J, Ramos P, Peris M, Lorente L, et al. Nosocomial outbreak of Pseudomonas aeruginosa infections related to a flexible bronchoscope. J Hosp Inf 2006;64: 129-35.
9. Kumarage J, Khonyongwa K, Khan A, Desai N, Hoffman P, Taori S. 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;102:89-94.
10. Strand CL, Bryant JK, Morgan JW, Foster JG, McDonald HP, Morganstern SL. Nosocomial Pseudomonas aeruginosa urinary tract infections. JAMA 1982;248:1615-8.
11. Almallah Y, Rennie C, Stone J, Lancashire M. Urinary tract infection and patient satisfaction after flexible cystoscopy and urodynamic evaluation. Urology 2000;56:37-9.
12. Herr HW. The risk of urinary tract infection after flexible cystoscopy in patients with bladder tumor who did not receive prophylactic antibiotics. J Urol 2015;193:548-51.
13. Jørgensen PH, Slotsbjerg T, Westh H, Buitenhuis V, Hermann GG. A microbiological evaluation of level of disinfection for flexible cystoscopes protected by disposable endosheaths. BMC Urol 2013;13:46.
14. McCombie SP, Carmichael JP, Banerjee S, Wood SJ. Urinary tract infection following flexible cystoscopy: a comparison between sterilised cystoscopes and disposable sterile sheaths. J Clin Urol 2013;6:220-4.
15. Burke DM, Shackley DC, O'Reilly PH. The community-based morbidity of flexible cystoscopy. BJU Int 2002;89:347-9.
16. Herr HW. Should antibiotics be given prior to outpatient cystoscopy? A plea to urologists to practice antibiotic stewardship. Eur Urol 2014;65:839-42.
17. Sorbets E, Evrevin M, Jumas-Bilak E, Masnou A, Lotthe A, Thuret R, et al. An outbreak of Pseudomonas aeruginosa urinary tract infections following outpatient flexible cystoscopy. Am J Infect Control 2019;47:1510-2.
18. Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. Nat Rev Microbiol 2015;13:269-84.
19. Dunkerley RC, Cromer MD, Edmiston CE Jr, Dunn GD. Practical technique for adequate cleansing of endoscopes: a bacteriological study of pHisoHex and Betadine. Gastrointest Endosc 1977;23:148-9.
20. Penna TC, Mazzola PG, Silva Martins AM. The efficacy of chemical agents in cleaning and disinfection programs. BMC Infect Dis 2001:1:16.
21. Fukuzaki S. Mechanisms of actions of sodium hypochlorite in cleaning and disinfection processes. Biocontrol Sci 2006;11: 147-57.
22. Augustin M, Ali-Vehmas T, Atroshi F. Assessment of enzymatic cleaning agents and disinfectants against bacterial biofilms. J Pharm Pharm Sci 2004;7:55-64.
23. 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;180:588-92; discussion 592.
24. O'Horo JC, Farrell A, Sohail MR, Safdar N. Carbapenem-resistant Enterobacteriaceae and endoscopy: an evolving threat. Am J Infect Control 2016;44:1032-6.