Clinical characteristics of postoperative febrile urinary tract infections after ureteroscopic lithotripsy

Jin Woo Kim¹, You Jin Lee¹, Jae-Wook Chung², Yun-Sok Ha¹, Jun Nyung Lee²,³, Eun Sang Yoo¹,³, Tae Gyun Kwon²,³, Bum Soo Kim¹,³

¹Department of Urology, Kyungpook National University Hospital, ²Department of Urology, Kyungpook National University Chilgok Hospital, ³Department of Urology, School of Medicine, Kyungpook National University, Daegu, Korea

Purpose: Ureteroscopic lithotripsy (URS) is gaining popularity for the management of ureteral stones and even renal stones, with high efficacy and minimal invasiveness. Although this procedure is known to be safe and to have a low complication rate, febrile urinary tract infection (UTI) after URS is not rare. Therefore, we aimed to analyze the risk factors and causative pathogens of febrile UTI after URS.

Materials and Methods: Between January 2013 and June 2015, 304 patients underwent URS for ureteral or renal stones. The rate of postoperative febrile UTI and the causative pathogens were verified, and the risk factors for postoperative febrile UTI were analyzed using logistic regression analysis.

Results: Of 304 patients, postoperative febrile UTI occurred in 43 patients (14.1%). Of them, pathogens were cultured in blood or urine in 19 patients (44.2%), and definite pathogens were not identified in 24 patients (55.8%). In patients with an identified pathogen, Pseudomonas aeruginosa had the highest incidence. Multivariate analysis showed that the operation time (p<0.001) was an independent risk factor for febrile UTI after URS. The cut-off value of operation time for increased risk of febrile UTI was 70 minutes.

Conclusions: Overall, febrile UTI after URS occurred in 14.1% of patients, and the operation time was an independent predictive factor for this complication. Considering that more than 83.7% of febrile UTIs after URS were not controlled with fluoroquinolones, it may be more appropriate to use higher-level antibiotics for treatment, even in cases with unidentified pathogens.

Keywords: Lithotripsy; Ureteroscopy; Urinary tract infection

INTRODUCTION

Technology has brought many advantages to ureteroscopy for the treatment of urinary stones, including decreased procedural invasiveness and a high success rate. In recent times, ureteroscopic lithotripsy (URS) is widely used, not only for ureteral stones, but also for renal stones. The first flexible ureteroscopic procedures were introduced in the 1960s [1-3]. With the development of a smaller diameter, increased flexibility, and digital ureteroscopes, flexible URS has become one of the standard procedures for the management of small or mid-sized renal stones. It has shown
Although urinary tract infections (UTIs), ureteral injuries, hematuria, and postoperative renal colic have been reported as common complications of ureteroscopic procedures, UTI is one of the most frequent complications [5-7,10,11]. To prevent procedure-related infection, prophylactic antibiotics are routinely administered, even in endoscopic surgery. Traditionally, fluoroquinolones have been used as prophylactic antibiotics for URS; however, febrile UTI following the procedure is not rare even with prophylactic antibiotics. However, only a few clinical studies researching the pathogens of febrile UTI after URS have been conducted, and the overall understanding of postoperative febrile UTI and appropriate antibiotic therapy is limited. Therefore, this study aimed to analyze the characteristics and risk factors of febrile UTI after URS and endeavored to seek the most effective prevention and management methods.

**MATERIALS AND METHODS**

The Institutional Review Board of the Kyungpook National University Hospital approved the study protocol based on the Declaration of Helsinki (approval number: KNUH 2018-03-014). Between January 2013 and June 2015, 304 patients who underwent URS for the management of ureteral and/or renal stones were included in this retrospective study. Preoperative urine cultures were performed, and patients with preoperative UTI (pyuria or bacteriuria) were excluded from this study. Perioperative clinical information included: age, gender, body mass index, underlying diseases (hypertension, diabetes mellitus, chronic renal failure), previous stone history (primary or recurrent), stone characteristics (number of stones, stone size, multiplicity, laterality, location), methods of URS (semi-rigid/flexible/combined), presence of hydronephrosis on preoperative image, preoperative ureteral stent, preoperative percutaneous nephrostomy, and operation time. All patients underwent a non-contrast computed tomography scan to evaluate the stone characteristics. In case of multiple stones, the stone size was calculated as the sum of the diameters of each stone.

A fluoroquinolone was prophylactically administered 1 hour before surgery, and oral antibiotics were administered for 5 days postoperatively. URS was performed with a semi-rigid ureteroscope (8.5-Fr; Karl Storz, Tuttingen, Germany) and/or a flexible ureteroscope (8.2-Fr, URF-P5; Olympus, Tokyo, Japan). After cystoscopy, a hydrophilic guidewire was advanced vertically inside the ureter under fluoroscopy guidance. In cases of flexible URS, a ureteral access sheath (12/14-Fr; Cook Urological Inc., Bloomington, IN, USA) was inserted along the guidewire up to the proximal ureter. Stones were fragmented using a 200-µm holmium laser lithotripter (Lumenis Inc., Tel Aviv, Israel). After the procedure, large fragments of calculi were removed with a 1.9-Fr nitinol stone basket (Zero-tip; Boston Scientific, Marlborough, MA, USA), whereas small fragments (less than 2 mm in diameter) were left for natural drainage. At the end of the procedure, a 6-Fr double-J ureteral stent was inserted in all patients to reduce postoperative flank pain.

Procedural success was defined as no obvious stones or stones less than 2 mm according to simple X-ray of the kidney, ureter, and bladder or ultrasound examination at 2 weeks after the URS. A postoperative febrile UTI was defined as the occurrence of a fever higher than 38°C combined with pyuria within 1 week of surgery and without any infectious signs in other organs. The postoperative febrile UTI incidence and the causative pathogens were verified, and risk factors were analyzed with logistic regression analysis. Multivariate analysis was used to identify the risk factors of postoperative febrile UTI. Statistical analyses were performed using PASW Statistics ver. 18.0 software (IBM Co., Armonk, NY, USA), and p-value <0.05 was considered statistically significant.

**RESULTS**

The overall incidence of febrile UTI was 14.1% (43/304 patients). Table 1 shows the patients' demographics and stone characteristics. The mean patient age was 56.9±13.1 years, and the mean stone size was 10.0±4.1 mm. Of the 304 patients, 207 patients (68.1%) were male and 97 patients (31.9%) were female. The underlying diseases included hypertension (42.8%), diabetes mellitus (23.7%), and chronic kidney disease (5.3%). The mean body mass index was 25.1±3.8 kg/m². A total of 48 patients (15.8%) had a history of stone surgery, and 148 patients (48.7%) had preoperative hydronephrosis. Three patients (1.0%) had preoperative ureteral stents, and 55 patients (18.1%) had percutaneous nephrostomies. The mean operation time was 67.1±27.9 minutes.

Table 2 shows the comparison of clinical information between the febrile UTI group and the non-febrile UTI group. Univariate analysis showed that the stone size (p=0.026) and the operation time (p<0.001) were significantly different between the febrile UTI and non-febrile UTI groups.
Infectious complications after URS

between the two groups. In this study, 146 patients underwent URS, 105 patients underwent retrograde intrarenal surgery (RIRS), and 53 patients underwent URS with RIRS. No difference in the incidence of postoperative UTI was detected according to surgical modality (p=0.921). In the multivariate logistic model, only the operation time was independently correlated with postoperative febrile UTI (odds ratio, 1.023; 95% confidence interval, 1.010–1.039; p<0.001). Receiver operating curve analysis showed that the cut-off value of the operation time that could predict a high risk of febrile UTI after URS was 70 minutes (sensitivity: 58.1%, specificity: 61.7%).

Of 43 patients with a febrile UTI, true pathogens were cultured in blood or urine in 19 patients (44.2%), and definite pathogens were not cultured in 24 patients (55.8%). *Pseudomonas aeruginosa* was the most commonly cultured in 11 patients (25.6%), and *Escherichia coli*, *Staphylococcus capitis*, *S. epidermidis*, *Proteus mirabilis*, *Enterococcus faecalis*, *Enterobacter cloacae*, *Citrobacter amalonaticus*, and *Achromobacter xylosoxidans* were cultured in 1 patient (2.3%) each.

Fig. 1 shows the algorithm of administered antibiotics.

### Table 1. Baseline characteristics of patients

| Characteristic                  | Value  |
|--------------------------------|--------|
| No. of patient                 | 304    |
| Mean age (y)                   | 56.9   |
| Gender                         |        |
| Male                           | 207 (68.1) |
| Female                         | 97 (31.9) |
| Body mass index (kg/m²)        | 25.1   |
| Risk factor                    |        |
| Hypertension                   | 130 (42.8) |
| Diabetes mellitus              | 72 (23.7) |
| Chronic renal failure          | 16 (5.3) |
| Ureteral stent                 | 3 (1.0) |
| Nephrostomy                    | 55 (18.1) |
| History of stone operation     | 48 (15.8) |
| Hydronephrosis                 | 148 (48.7) |

Values are presented as number only, mean only, or number (%).

### Table 2. Univariate and multivariate logistic regression analyses of febrile UTIs after ureteroscopic lithotripsy

| Variable                              | Postoperative febrile UTI | p-value | Odds ratio | 95% confidence interval |
|---------------------------------------|---------------------------|---------|------------|-------------------------|
| No. of patient                        | 43 (14.1)                 | 261 (85.9) |            |                         |
| Mean age (y)                          | 56.8                      | 56.9    | 0.961      | 0.997                   | 0.997                   | 0.966–1.028            |
| Gender                                |                           |         | 0.189      | 0.510                   | 0.752                   | 0.323–1.754            |
| Male                                  | 33 (76.7)                 | 174 (66.7) |            |                         |
| Female                                | 10 (23.3)                 | 87 (33.3)  |            |                         |
| Hypertension                          | 21 (48.8)                 | 109 (41.8) | 0.385      | 0.439                   | 1.347                   | 0.633–2.864            |
| Diabetes mellitus                     | 13 (30.2)                 | 59 (22.6)  | 0.276      | 0.605                   | 1.238                   | 0.552–2.776            |
| Chronic renal failure                 | 4 (9.3)                   | 12 (4.6)   | 0.200      | 0.251                   | 2.191                   | 0.574–8.369            |
| Body mass index (kg/m²)               | 26.23                     | 25.1     | 0.077      | 0.059                   | 1.078                   | 0.992–1.174            |
| History of stone operation            | 9 (20.9)                  | 39 (14.9)  | 0.318      | 0.333                   | 1.553                   | 0.637–3.791            |
| Stone location                         |                           |         | 0.921      | 0.269                   | 0.722                   | 0.406–1.286            |
| Ureter                                | 20 (46.5)                 | 126 (48.3) |            |                         |
| Kidney                                | 16 (37.2)                 | 89 (34.1)  |            |                         |
| Combined                              | 7 (16.3)                  | 46 (17.6)  |            |                         |
| Preoperative ureteral stent           | 1 (2.3)                   | 2 (0.8)   | 0.327      | 0.349                   | 3.626                   | 0.245–53.754           |
| Preoperative nephrostomy              | 8 (18.6)                  | 47 (18.0)  | 0.925      | 0.727                   | 0.844                   | 0.326–2.184            |
| Preoperative hydrounephrosis          | 20 (46.5)                 | 128 (49.0) | 0.869      | 0.866                   | 1.112                   | 0.051–2.244            |
| No. of stone                          |                           |         | 0.876      | 0.567                   | 0.789                   | 0.350–1.776            |
| Single                                | 24 (55.8)                 | 149 (57.1) |            |                         |
| Multiple                              | 19 (44.2)                 | 112 (42.9) |            |                         |
| Stone size (mm)                       | 11.30                     | 9.79     | 0.026      | 0.686                   | 1.018                   | 0.935–1.108            |
| Operation time (min)                  | 82.77                     | 64.54    | <0.001     | <0.001                  | 1.023                   | 1.010–1.039            |

Values are presented as number (%) or mean only.

UTI, urinary tract infection.
In all 43 patients with a febrile UTI, fluoroquinolones were initially administered until pathogens were cultured. Of 19 patients with a trigger pathogen identified in their blood and/or urine culture, antibiotics were changed to piperacillin/tazobactam in 7 patients, a 3rd generation cephalosporin in 5 patients, and a carbapenem in 6 patients, while 1 patient remained on fluoroquinolones. Of the 24 patients without an identified causative pathogen in their blood and/or urine culture, 11 were managed with piperacillin/tazobactam, 7 patients received a 3rd generation cephalosporin, and 6 patients were maintained on fluoroquinolones. After appropriate antibiotics administration, the condition of all the patients improved.

**DISCUSSION**

Prophylactic antibiotics are commonly used to prevent infection in urological procedures performed for conventional diagnostic and therapeutic purposes. Many studies have been conducted to investigate the use of prophylactic antibiotics for URS, and their use has been proven to reduce the occurrence of postoperative fever and UTI. According to the European Association of Urology Guidelines, fluoroquinolones are recommended as prophylactic antibiotics for diagnostic ureteroscopy and URS. The American Urological Association Best Practice Guidelines [12] also suggest that all patients undergoing URS should receive a prophylactic fluoroquinolone drug or trimethoprim-sulfamethoxazole. Knopf et al. [13] conducted a randomized study to compare single dose oral levofloxacin (250 mg) to no prophylactic antibiotics in URS. Their primary measurement was bacteriuria, which resulted in an incidence of 1.8% vs. 12.5%, respectively, a significantly lower incidence in the prophylactic antibiotics group.

In our study, the prophylactic antibiotics administered were fluoroquinolones. However, despite this, postoperative febrile UTI after URS was not rare, occurring in 14.1% of the patients at Kyungpook National University Hospital. Mitsuzuka et al. [14] analyzed 153 patients who underwent URS for renal and/or ureteral stones between 2011 and 2013, and reported that febrile UTI occurred in 18.3% of the patients. The major difference between our study and that of Mitsuzuka et al. [14] is the inclusion criteria. They included patients with preoperative pyuria, and this may be a reason for the higher incidence of febrile UTI. The study suggested that preoperative pyuria is a risk factor for febrile UTI. Sohn et al. [15] analyzed 531 patients who underwent diagnostic ureteroscopy or URS and reported that 38% of patients had infectious complications. This study showed a lower incidence of febrile UTI when compared to our
study, which may be related to the inclusion of diagnostic 
ureteroscopy, which carries lower risk of infectious 
complications than the lithotripsy does. Our study showed 
that trigger pathogens were identified in only 19 of 43 
patients with postoperative febrile UTI, which means that 
many patients did not have bacteremia or bacteriuria. Since 
most causative pathogens of nosocomial UTI are *E. coli*, 
Enterobacter spp., and *P. aeruginosa* [16], fluoroquinolones 
were empirically administered as the initial antibiotics 
until the pathogens were identified. If the pathogens were 
identified and the results of antimicrobial susceptibility 
were revealed through blood or urine culture, it was not 
difficult to determine the next therapeutic regimen.

According to clinical practice guidelines for the antibiotic 
treatment of community-acquired urinary tract infections 
[17], *E. coli* is the most common causative bacterium in 
UTI in Korea. In Korea, fluoroquinolones are mainly 
recommended as the primary antibiotic for UTIs. However, 
since the resistance to fluoroquinolones of causative bacteria 
of UTIs in Korea is higher than that reported in the United 
States and Europe, the failure rate of fluoroquinolone 
treatments is high. In 2006, the antibiotic resistance of *E. coli* 
isolated from cystitis to ciprofloxacin was 24.6% in Seoul, 
40.0% in Gyeongsang Province, 47.7% in Gyeonggi Province, 
and 32.1% in Chungcheong Jeolla Province [18]. Therefore, 
the selection of empirical antibiotics should be based on 
data from different time periods and regions. However, 
*E. coli*, which induces UTIs in Korea, is highly resistant 
to ciprofloxacin, ampicillin/sulbactam, and gentamicin. Thus, 
for UTIs accompanied by sepsis or recurrent UTIs, 
piperacillin/tazobactam, third- or fourth-generation 
cephalosporin, amikacin, and carbapenem are recommended 
as a priority. Some experts recommend antipseudomonal 
antibiotics in the early stage of severe infections suspected 
as sepsis or healthcare-associated infections. After beginning 
early empirical treatment using broad-spectrum antibiotics, 
the treatment should be readjusted according to obtained 
culture results [17]. In these patients, we gradually stepped 
up the antibiotic regimen. If the infection was well-controlled 
using fluoroquinolones and no definite pathogens were 
identified, patients received intravenous fluoroquinolone 
drugs until pyuria was rarely seen and inflammatory 
serum markers, such as leukocytosis and elevated C-reactive 
protein level, were normalized. However, if these patients 
showed persistent fever and uncontrolled UTI symptoms, we 
changed the antibiotics to a 3rd generation cephalosporin. 
Then, if the UTI was under control, the patients were 
maintained on these antibiotics; however, if the symptoms 
of UTI did not improve over 2 or 3 days, the antibiotics were 
changed to piperacillin/tazobactam.

In this study, the most frequent causative pathogen of febrile UTI was *P. aeruginosa*, which was identified in 
11 patients (25.6%). This suggests that in the event of a 
postoperative febrile UTI, the possibility of infection by *Pseudomonas* should be considered, despite the use of 
prophylactic antibiotics, such as fluoroquinolones. Currently, 
the rate of fluoroquinolone-resistant *P. aeruginosa* in 
hospitals is increasing [19]. Therefore, if a postoperative 
febrile UTI is not well-controlled under the regimen of 
prophylactic antibiotics, an early step-up of antibiotics 
should be considered even before the results of culture and 
antimicrobial susceptibility are reported.

Several studies assessed the risk factors of febrile 
UTI after URS. Mitsuzuka et al. [14] demonstrated that 
preoperative pyuria and pyelonephritis were significant 
risk factors for postoperative febrile UTI. Sohn et al. [15] 
reported that bacteriuria and previous catheterization were 
the strongest risk factors of febrile complications. Grabe 
et al. [20] suggested that bacteriuria, preoperative ureteral 
stents, and percutaneous nephrostomy were the risk factors 
of febrile complications. Previous pyuria was excluded, and 
preoperative ureteral stenting was not common in our study. 
Although cases of percutaneous nephrostomy were included 
in our study due to previous pyelonephritis, all cases were 
managed for UTI before surgery.

Thirty-three of 207 male patients in this study had 
febrile UTI. Preoperative digital rectal examination was 
performed in all male patients and acute prostatitis was not 
suspected in any patient. In addition, all 33 patients who had 
febrile UTI did not have prostatitis-related lower urinary 
tract symptoms after surgery.

Our study revealed that the operation time was the only 
risk factor for postoperative febrile UTI. We observed that 
a long operation time requires massive irrigation, and this 
can be one of the reasons for the high incidence of UTI, 
although we did not measure the volume of irrigation fluid. 
The irrigation flow rate and the irrigation volume were 
previously reported as independent risk factors for UTI 
after URS. The high pressure in the renal pelvis, and reflux 
systemic absorption of irrigation fluid containing bacteria 
or toxins have been proven to contribute to the incidence of 
febrile UTI after URS [21-25]. If the stone size is large, the 
operation time could be longer, but the stone size was not 
significantly correlated with the incidence of febrile UTI in 
our study. We also postulate that the composition (hardness) 
of the stones, rather than their size might contribute to a 
longer operation time.

This study has several limitations. First, this was a
retrospective study with a small sample size. Second, because our institute is a tertiary hospital for lithotripsy, several patients in this study had complicated conditions, such as large or impacted stones and a comorbid status, which could increase the risk of postoperative UTI. Third, we did not analyze the effects of irrigation pressure or volume as potential risk factors for postoperative febrile UTI, as the irrigation flow rate and renal pelvic pressure were not measured in our study because manual irrigation was used during URS and RIRS, which made measurement of irrigation flow pressure impossible. This is one of the major limitations of this study. However, we have used a ureteral access sheath with a wide diameter (12/14-Fr) for RIRS during the study period in an effort to reduce irrigation flow pressure. Fourth, stone analysis was not routinely performed in this study, because dusting only without stone retrieval was performed in many cases. Among the cases in which stone analysis was performed, uric acid stone was the most common. Finally, this study was conducted in a single center, and as the resistance of pathogens to antibiotics can be different at each center, a further multi-center based study will be needed.

CONCLUSIONS

Despite adequate prophylactic antibiotics, postoperative febrile UTI after URS developed in 14.1% of patients at our institution. Although not all causative pathogens were identified, *P. aeruginosa* was the most frequently reported pathogen, which was isolated in more than half of the patients with a febrile UTI. In addition, most of the identified microorganisms were resistant to fluoroquinolones, which are routinely used as prophylactic antibiotics. Therefore, when a postoperative UTI is not well-controlled using prophylactic antibiotics, more potent antibiotics should be considered, even before the confirmation of pathogens. Moreover, to prevent postoperative UTI, it will be necessary to try to reduce the operation time.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP) (NRF-2015R1C1A1A01053009), (2016R1C1B1011180). Additional funding was provided by the Ministry of Education (2015R1D1A3A03020378) and the Ministry of Science, ICT & Future Planning (NRF-2014M3A9D3034164).

REFERENCES

1. Marshall VF. Fiber optics in urology. J Urol 1964;91:110-4.
2. Takagi T, Go T, Takayasu H, Aso Y. Fiberoptic pyloureteroscopy. Surgery 1971;70:661-3.
3. Bush IM, Goldberg E, Javadpour N, Chakrobortty H, Morelli F. Ureteroscopy and renoscopy: a preliminary report. Chic Med Sch Q 1970;30:46-9.
4. Aboumarzouk OM, Monga M, Kata SG, Traxer O, Somani BK. Flexible ureteroscopy and laser lithotripsy for stones >2 cm: a systematic review and meta-analysis. J Endourol 2012;26:1257-63.
5. Stav K, Cooper A, Zisman A, Leibovici D, Lindner A, Siegel YI. Retrograde intrarenal lithotripsy outcome after failure of shock wave lithotripsy. J Urol 2003;170:2198-201.
6. Fabrizio MD, Behari A, Bagley DH. Ureteroscopic management of intrarenal calculi. J Urol 1998;159:1139-43.
7. Volkin D, Shah O. Complications of ureteroscopy for stone disease. Minerva Urol Nefrol 2016;68:570-85.
8. Geavlete P, Georgescu D, Niţă G, Mirciulescu V, Cauni V. Complications of 2735 retrograde semirigid ureteroscopy procedures: a single-center experience. J Endourol 2006;20:179-85.
9. Skolarikos A, Mitsogiannis H, Deliveliotis C. Indications, prediction of success and methods to improve outcome of shock wave lithotripsy of renal and upper ureteral calculi. Arch Ital Urol Androl 2010;82:56-63.
10. Breda A, Ogunyemi O, Leppert JT, Schulam PG. Flexible ureteroscopy and laser lithotripsy for multiple unilateral intrarenal stones. Eur Urol 2009;55:1190-6.
11. Cindolo L, Castellan P, Scoffone CM, Cracco CM, Celia A, Paccadusco A, et al. Mortality and flexible ureteroscopy: analysis of six cases. World J Urol 2016;34:305-10.
12. Wolf JS, Bennett CJ, Dmochowski RR, Hollenbeck BK, Pearle MS, Schaeffer AJ. Best practice policy statement on urologic surgery antimicrobial prophylaxis. J Urol 2008;179:1379-90.
13. Knopf HJ, Graff HJ, Schulze H. Perioperative antibiotic prophylaxis in ureteroscopic stone removal. Eur Urol 2003;44:115-8.
14. Mitsuzuka K, Nakano O, Takahashi N, Satoh M. Identification of factors associated with postoperative febrile urinary tract infection after ureteroscopy for urinary stones. Urolithiasis 2016;44:257-62.
15. Sohn DW, Kim SW, Hong CG, Yoon BI, Ha US, Cho YH. Risk factors of infectious complication after ureteroscopic...
procedures of the upper urinary tract. J Infect Chemother 2013;19:1102-8.

16. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. Infect Control Hosp Epidemiol 2013;34:1-14.

17. Kang CI, Kim J, Park DW, Kim BN, Ha US, Lee SJ, et al. Clinical practice guidelines for the antibiotic treatment of community-acquired urinary tract infections. Infect Chemother 2018;50:67-100.

18. Kim ME, Ha US, Cho YH. Prevalence of antimicrobial resistance among uropathogens causing acute uncomplicated cystitis in female outpatients in South Korea: a multicentre study in 2006. Int J Antimicrob Agents 2008;31 Suppl 1:S15-8.

19. Polk RE, Johnson CK, McClish D, Wenzel RP, Edmond MB. Predicting hospital rates of fluoroquinolone-resistant Pseudomonas aeruginosa from fluoroquinolone use in US hospitals and their surrounding communities. Clin Infect Dis 2004;39:497-503.

20. Grabe M, Botto H, Cek M, Tenke P, Wagenlehner FM, Naber KG, et al. Preoperative assessment of the patient and risk factors for infectious complications and tentative classification of surgical field contamination of urological procedures. World J Urol 2012;30:39-50.

21. Tuzel E, Aktepe OC, Akdogan B. Prospective comparative study of two protocols of antibiotic prophylaxis in percutaneous nephrolithotomy. J Endourol 2013;27:172-6.

22. Singla M, Srivastava A, Kapoor R, Gupta N, Ansari MS, Dubey D, et al. Aggressive approach to staghorn calculi-safety and efficacy of multiple tracts percutaneous nephrolithotomy. Urology 2008;71:1039-42.

23. Oster PJ. Risks of flexible ureterorenoscopy: pathophysiology and prevention. Urolithiasis 2018;46:59-67.

24. Lildal SK, Andreassen KH, Christiansen FE, Jung H, Pedersen MR, Oster PJ. Pharmacological relaxation of the ureter when using ureteral access sheaths during ureterorenoscopy: a randomized feasibility study in a porcine model. Adv Urol 2016 Oct 20 [Epub]. http://doi.org/10.1155/2016/8064648.

25. Oster PJ, Pedersen KV, Lildal SK, Pless MS, Andreassen KH, Oster SS, et al. Pathophysiological aspects of ureterorenoscopic management of upper urinary tract calculi. Curr Opin Urol 2016;26:63-9.