Revisiting the Predictive Factors for Intra-Operative Complications of Rigid Ureteroscopy

A 15-Year Experience

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Purpose: To revise the predictive factors for intra-operative complications of rigid ureteroscopy in the treatment of ureteral calculi.

Materials and Methods: During a 15-year period (1993 to 2008), a total of 1496 consecutive patients who had undergone 1660 ureteroscopy procedures were retrospectively reviewed. After exclusion of the cases for diagnostic purposes, diseases other than ureteral calculi, and repeated ureteroscopy procedures, 1189 patients were left as the study population. Those patients were then divided into two groups based on the presence of the complications: complication–positive (group 1, n = 57) and complication–negative (group 2, n = 1132). Both groups were statistically compared regarding patients' age and gender, stone surface area, lateralization and localization of the stone, impaction of the stone, type of the ureteroscope, necessity of ureteral orifice dilation, and use of a catheter during and after the procedure. Furthermore, the effect of leaving the fragmented stones in situ small enough to pass spontaneously (break'n'leave) on occurring of the complications has been investigated.

Results: The complication rate was recorded as 4.7%. Success rate after a single intervention was 86.3%, whereas increased to 94.1% after ancillary procedures. Stone surface area, lateralization, and type of lithotripter used were comparable between the groups, but impacted stones and the stones located at the upper ureters were associated with significantly increased complication rates. Furthermore, significantly less complication has been observed in cases where we performed break'n'leave. Furthermore, multivariate analysis revealed that stone impaction and failure to adhere to the "break'n'leave" principle were the independent predictors of occurring of the complications.

Conclusion: Ureteroscopy is safe and effective in the treatment of ureteral calculi. Careful attention for the patients having a potential for occurrence of the complications and selection of the techniques are of importance for reducing untoward events.

Keywords: ureteroscopy, complications, retrospective studies, ureteral calculi, lithotripsy

INTRODUCTION

Technical advances in the design of ureteroscopes have encouraged urologists for the compact use of ureteroscopy (URS) either for the treatment of ureteral calculi or for some diagnostic approaches. Continuously, evolving fiberoptic visualization, refinements in flexibility, downsizing of the devices, use of fluoroscopy, various baskets and stents, and improvements in the ability of stone fragmentation have broadened the indications of URS and upgraded this procedure almost as the first-line treatment choice for every location of the collecting system of the urinary tract. The competitions among URS, extracorporeal shock wave lithotripsy (SWL), retrograde intrarenal surgery, and percutaneous nephrolithotomy (PNL) for the urinary tract calculi have been the subject of numerous publications in the last decade, maintaining the debate among urologists.[1-3]

Unfortunately, surgical misadventures may still occur, some of which have lasting consequences. The nature of the ureteroscopic complications is well-known, but the predictive factors are still a question that has yet to be clearly elucidated. Careful attention to the selection of the instruments and techniques are of importance for reducing untoward events related to ureteroscopic procedures. Furthermore, the ultimate technologies are still not available in the majority of the urological centers in developing countries that make rigid or semirigid URS the best cost-effective option for the urologists. Frankly, patients having a potential for occurrence of the complications should be well-discriminated and addressed to different treatment modalities, such as SWL, PNL, laparoscopy, or multimodal approaches. Our aim is to report the predictive factors related to the occurrence of intraoperative complications during URS procedures in the treatment of ureteral calculi.

MATERIALS AND METHODS

During a 15-year period (1993 to 2008), a total of 1496 consecutive patients who had undergone 1660 URS procedures were retrospectively analyzed. After exclusion of the cases for diagnostic purposes, diseases other than ureteral calculi, and repeated URS procedures, 1189 patients were left as the study population.

Analysis was focused on intra-operative complications and possible predictive factors. The study population was divided into two groups based on the presence of the complications: Complication–positive (group 1, n = 57) and complication–negative (group 2, n = 1132). Recorded intra-operative complications were mucosal injury, mucosal eversion, ureteral perforation, ureteral avulsion, hematuria, and rupture of the basket catheter inside the ureter (Table 1). Although the adverse events, such as push-back of the stone towards the kidney were included in the analysis of the risk factors for the complications, they were primarily defined as treatment failures and not considered as a complication of the procedure.[4] Mucosal injury was defined as any mucosal tears or false-route without the perforation of the ureter. The presence of visible periureteral fatty tissue and/or contrast extravasation was considered as evidence of complete ureteral perforation. Hematuria was usually minor and occurred in most of the patients, but was only considered as a complication when caused a difficulty in the visibility and necessitated the termination of the procedure.[5]

Comparative parameters were as follows: patients' age and gender, stone surface area, lateralization and localization of the stone, impaction of the stone, type of the ureteroscope, necessity of ureteral orifice dilation, and use of a catheter during and after the procedure. Furthermore, push-back of the stone and adhering to the break'n'leave policy were also evaluated for whether they have an impact on occurring of the complications.

Stones located below the pelvic brim were called as distal or lower and above the pelvic brim were called as proximal or upper. Break'n'leave policy

was defined as fragmentation of the stone small enough (≤ 3 mm) to pass spontaneously, which was named by our department previously.[6] Stone impaction was defined as the stones causing complete ureteral obstruction on excretory urography, causing obstructive anuria, or present at the same site for more than 3 months, or documented to be impacted in the operative details.

Hospital charts, operative notes, and available videos of URS procedures were reviewed in order to determine the stone-free status with the detailed evaluation of radiographic images. Dimension of stones were calculated from the radiographic images pre-operatively. Treatment success was defined as stone-free status after a single intervention. Overall stone-free rate was defined as stone-free status after multimodal intervention in 3 months. Stone-free status was determined either by direct visualization of the involved ureter or by radiographic follow-up imaging.

If possible, extracted calculi were sent for analysis and additional medical therapy was provided for recurrent urolithiasis. Patients with positive urine cultures were treated according to the culture results at least for 3 days prior to the procedure. Antibiotic prophylaxis (third-generation cephalosporin) has been applied for all patients on the day of surgery.

After obtaining signed informed consent, URS was performed under regional or general anesthesia. The patients were placed in the lithotomy position on an endoscopy table allowing the use of fluoroscopy when necessary. Semi-rigid URS (Circon-Acmi: length 41.5 cm, distal diameter 6.9F) or rigid URS (Wolf: length 42 cm, distal diameter 8F) was used depending on the indication of the procedure, patient's characteristics, availability, and individual surgeon preference.

To minimize heat loss during the operation, 0.9% NaCl warmed to 37°C was used as an irrigant. Routine cystoscopy and ureteral dilation were not used and the safety guidewire was inserted under direct vision. The ureteroscope was passed along the urethra, then through the ureteral orifice under video monitoring. A 0.035/0.038-inch standard soft guidewire, a 4F ureteral catheter, or only controlled hydrodilation was used to traverse the intramural ureter.

An electrohydraulic lithotripter was used in the first 38 procedures and replaced with pneumatic lithotripter for the remaining cases. A temporary postoperative 4F ureteral catheter or 4.6 or 4.8F, 10-to-28 cm double-J (DJ) stent was placed in some patients to avoid ureteral damage or in whom were considered for SWL treatment. The decision of stenting was made according to the duration of the procedure and the degree of visible ureteral trauma at the end of the procedure.

Complications were treated with stents, percutaneous nephrostomy, or open surgical repair according to the severity or patient's condition. Patients were discharged within 24 hours unless complications or comorbidity demanded prolonged hospitalization. In patients in whom URS was not possible due to inability to advance the ureteroscope into the ureter, a ureteric stent was placed and URS was performed a few days later (re-URS).

Univariate analyses, including Chi-Square and Student's *t* test, were performed to detect any significant association between each of the variables (NCSS 2007). Multivariate stepwise logistic regression analysis was used to determine the predictive factors affecting intra-operative complications. The values were provided as mean ± standard deviation (SD). A *P* value of less than .05 was considered statistically significant.

RESULTS

Mean age of the patients was 44.89 ± 16.37 years (range, 2 to 90 years) and comparable between the groups 1 and 2 (46.75 ± 14.78 and 44.50 ± 13.89 years, respectively, $P = .363$). No statistical difference was found regarding the male-to-

Table 1. Classification of complications.

Intra-operative Complications	n (%)
Mucosal injury	30 (52.6)
Hematuria	9 (15.7)
Ureteral perforation	13 (22.8)
Ureteral avulsion	2 (3.5)
Mucosal eversion	1 (1.7)
Rupture of the basket catheter	2 (3.5)
Total number	57 (100)

female ratio between the groups (63.20/36.80% and 64.50/35.50%, respectively, $P = .831$).

The groups were comparable regarding the lateralization of the URS (43.90/56.10% and 46.10/53.90% right/left, respectively, $P = .744$). No significant difference was found with respect to stone surface areas (72.04 ± 47.38 and 82.95 ± 87.05 mm², respectively, $P = .757$). Upper location of the ureteral stones was found to be a significant predictor in occurring of the complications in the univariate analysis ($P = .047$; Table 2). The complication rate was 4.7% for all the procedures. The type of the ureteroscope used did not exhibit any impact on the complication rates ($P = .537$).

Of the intra-operative complications, 51 out of 57 (89.4%) were successfully managed by placement of a DJ catheter, whereas remaining 6 procedures required open surgery. The reasons for open surgical approach in these cases were ureteral perforation (n = 2), rupture of the tip of the basket (n = 2), and complete ureteral avulsion (n = 2).

The stone-free rate after a single ureteroscopic intervention (treatment success) was reported as 86.30%. The push-back of the ureteral stone towards the kidney occurred in 99 (8.30%) of the procedures and was mostly encountered in the upper ureter (59.50%). These patients were directed to SWL for further treatment. Furthermore, 25 (2.10%) patients had undergone re-URS due to the inability in advancing the ureteroscope in the first procedure (treatment failure). After secondary procedures, including re-URS, SWL, PNL, and open surgery, the overall stone-free rate was recorded as 94.10% at 3 months.

Pneumatic lithotripsy was the most commonly used method for stone fragmentation (96.81%) followed by electrohydraulic lithotripsy (3.19%). Of the patients who had stones, the break'n'leave policy was performed in 19.30% and 48.30% of the patients in the groups 1 and 2, respectively ($P = .0001$). This factor was found to be a significant predictor for occurring of the complications in univariate analysis. Another predictor in the univariate analysis was the impaction of the stone, which was found to be significantly higher in group 1 compared to group 2 (17.50% and 5.60%, respectively, $P = .0001$).

Balloon dilation of the ureteral orifice was performed in only 16 out of 1189 URSs when the ureteroscope could not be advanced. There was no significant difference again with respect to ureteral orifice dilation ($P = .680$). Ureteral access catheters were used in 47.77% of all procedures to facilitate the advance of the ureteroscope, whereas hydrodilation of the ureteral orifice by a hand-held irrigation pump was enough for ureteral access in the rest of the cases. There was no statistically significant difference between the groups with regards to the rate of using an access catheter ($P = .109$).

In multivariate stepwise logistic regression analysis, the independent predictive factors associated with complications were also evaluated (Table 3). The impaction of the stone was found to be the independent factor for increased complication rates. Furthermore, deeming the stones small enough to pass spontaneously (break'n'leave) was found to be the other predictor decreasing the complication rates.

DISCUSSION

Evaluation of our findings revealed comparable

Table 2. Univariate analysis of risk factors for occurring of the complications.

Categorical factor	Group 1 (n = 57)	Group 2 (n = 1132)	*P*
Age (mean ± SD)*, y	46.75 ± 14.78	44.50 ± 13.89	.363
Gender (male), %	63.20	64.50	.831
Stone surface area (mean ± SD), mm^2	72.04 ± 47.38	82.95 ± 87.05	.757
Lateralization, %			
Right	43.90	46.10	.744
Upper	47.40	31.70	.047
Type of ureteroscope (Wolf), %	66.70	73.20	.537
Ureteral access catheter, %	63.20	47.00	.109
Postoperative ureteral catheter, %	56.10	45.30	.263
Stone impaction, %	17.50	5.60	.0001
Balloon dilation of the ureteral orifice, %	1.75	1.32	.680
Push-back, %	7.01	8.39	.650
Break'n'leave, %	19.30	48.30	.0001

*SD indicates standard deviation.

complication rates (4.7%) with other published studies.[7,8] Success rate after the first procedure was 86.3%, and overall stone-free rate was 94.1% with the auxiliary procedures. In univariate analysis, upper location of the stones, stone impaction, and disrespect to the break'n'leave policy were found to be the significant factors increasing the complication rates. Presence of stone impaction and the break'n'leave policy remained independent predictors at multivariate analyses.

In the last quarter of the 20th century, with the development of small diameter endoscopes and modifications in the techniques, URS has become a widely accepted modality in the treatment of ureteral calculi. Therefore, URS has been a safer and more efficacious modality with growing worldwide experience.[9] However, complications may still occur and the predictive factors should be clearly elucidated to understand the nature of the complications.[7]

In this study, mucosal injury was the most frequently encountered complication (52.60%), which was treated with stent placement and resolved with no further consequences. Parallel to our results, mucosal injury was the most common intra-operative complication over other complications reported up to 62% in the published series.[7,10] Ureteral perforation was second most common complication in our group. Of 13 ureteral perforations, while 11 were treated with DJ stent placement, 2 cases required immediate open surgery due to guidewire slippage and failed DJ placement. Stone extraction and repair of the damaged segment of the ureter were successfully performed in those cases. In other 2 cases, open surgery was required due to the rupture of the tip of the basket catheter inside the ureter, which were both successfully managed with open surgery.

The most tragic complication, however, was the complete ureteral avulsion in two cases. One of them had multiple ureteral stones in the proximal ureter and the other one had proximally located stone with acute kinkings in the mid-ureter. The proximally located stones were fragmented successfully, but with the unbalanced downward

Table 3. Multivariate analysis of risk factors for occurring of the complications.

Independent factor	B*	Exp (B)°	95% Confidence Interval	*P*
Stone impaction	-2.164	0.115	0.036 to 0.365	.0001
Disrespect to break'n'leave	1.959	7.089	1.584 to 1.733	.01
Localization (upper)	-2.892	0.055	0.003 to 0.925	.692

* Regression coefficient
° Relative risk

traction of the ureteroscope, the whole ureter came out in both cases. Primary anastomosis was tried initially, but after a period of follow-up with the ancillary procedures, including ileal neoureter placement, unfortunately both cases had undergone nephrectomy. In a comprehensive review of endoscopic ureteral injuries, complete ureteral avulsion has been reported in 17 out of 5117 (0.3%) procedures in one study.[11] Furthermore, nephrectomy has also been reported as one of the most worrisome complications of URS in other published series.[5,7]

Another technical factor to consider is the success rate of the procedures. The reported overall stone-free rate of URS for ureteral stones is remarkably high ranging between 85% and 100%.[12,13] Our data demonstrated comparable results with the literature, ranging from 86.3% with initial URS to 94.1% with auxiliary procedures at 3 months.

Taking the main goal of ureteroscopic lithotripsy as rendering the patient stone-free without any complication either during or after URS into account, all procedures were classified into two groups according to the presence of complications. Both groups were statistically evaluated for all possible factors that might influence the final outcome.

In univariate analysis, the first factor affecting the complications was stone location. The stones located in the upper portion of the ureters were tended to be complicated. Although some researchers did not find an association between the stone location and complication, in those studies, the number of the procedures was either low, or statistical evaluation was not possible for the independent prediction.[14,15] However, some other reports showed that proximal location of the stone was the predictor for complications using multivariate analyses.[7,12] In the light of our findings, which are also supported by the published series, as for the initial treatment, it would be wiser to refer the patients with proximally located stones to SWL treatment.

After multivariate analysis of all factors, two independent predictors of complications have been identified (Table 3). The first predictor was stone impaction. The edema at the impaction site may easily result in false route and mucosal injury. As outlined by some researchers, the risk for perforation might be increased in impacted stones.[7] We found similar findings and 5 out of 13 (38.4%) ureteral perforations had impacted stones in the ureter. El-Nahas and coworkers also found that stone impaction was the independent predictor for the unfavorable results similar to our series.[12]

Finally, adhering to the break'n'leave policy was found to be the other predictor for decreasing the complication rates. The idea for break'n'leave is that if the left fragments of the stone are small enough to pass down spontaneously (≤ 3 mm), the procedure should be terminated without any other maneuvers. The effort of continuing the fragmentation and/or using a forceps to pull the insignificant fragments down may cause damage to the ureter and prolong the procedure. We found that in the procedures in which break'n'leave were

not performed, the patient has almost seven times higher risk of having a complication. To the best of our knowledge, our study is the first to analyze this factor statistically as a possible predictor of complications.

Some limitations of our study must be taken into account. One of them was insufficient data of the long-term follow-up period. This is because our center is a referral for many hospitals in our region and thus many patients were followed up elsewhere after the procedure. Therefore, the main focus of our study was the prediction of intra-operative complications. Another drawback of our study might be the lack of the use of a laser energy source, which may decrease the rate of push-back ratios, particularly for the proximally located stones. Although laser lithotripsy with flexible ureteroscopes is an effective method with limited complications, because of its high cost it may not be available in many urology departments like ours.[8] Recently, we were equipped with laser system and due to limited number of cases, these patients have not been included into the present study.

CONCLUSION

Ureteroscopy is a safe and highly effective procedure for the treatment of ureteral calculi. Complications are rare and generally can be managed with the placement of a ureteral catheter or with minimally-invasive treatments. Stones located at the upper ureters were associated with significantly increased complication rates. Furthermore, multivariate analysis revealed that stone impaction and failure to adhere to the "break'n'leave" principle were the independent predictors of occurring of the complications. Frankly, careful attention for the patients having a potential for occurrence of the complications and selection of the techniques are of importance for reducing untoward events.

CONFLICT OF INTEREST

None declared.

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