The Effect of Percutaneous Nephrostomy Implementation on The Outcome of Ureteroscopic Stone Treatment

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Purpose: We aimed to investigate the effect of percutaneous nephrostomy (PCN) implementation on the second ureteroscopy (URS) outcomes after a failed URS.

Materials and Methods: The data of four hundred forty-eight patients with an unsuccessful URS history were evaluated. Patients were divided into two groups; patients who underwent PCN before second URS (Group A) and patients who did not (Group B). We compared the stone access rate in the second URS between the two groups according to patient and stone characteristics and operative data. Then, group A was subdivided into two groups according to stone access as; access succeeded (Group A1) and access failed (Group A2). We also compared stone access rates between these two groups in terms of gender, age, body mass index, stone size, side, location, grade of hydronephrosis and PCN duration. All data were available immediately after surgery and obtained from patient files and the outcome assessment was performed during the study period.

Results: Stone access rate was higher in group A than group B (143/196 vs 41/252, $P = .0018$). Mean nephrostomy duration and mean hydronephrosis grade were significantly higher and mean stone size was significantly lower in group A1 than group A2 (18.74 vs 9.62 days, $P < .001$; grade 3.25 vs 1.21, $P = .038$; and 7.286 vs 12.631 mm $P < .001$, respectively).

Conclusion: PCN is a favourable intervention after a failed URS and increases the success rate of the second operation with ease of implementation and minimal morbidity.

Keywords: percutaneous nephrostomy; ureterolithiasis; ureteroscopy; urinary diversion

INTRODUCTION

Ureteroscopy (URS) has begun with Hugh Hampton Young's observation of a child's over-dilated ureter with a posterior urethral valve (PUV) in 1912, using a pediatric cystoscope [1] and has now been widely utilized in ureterolithiasis treatment. The most common indication for URS is a symptomatic ureteral calculus with a very low likelihood of spontaneous passage[2].
Rigid URS has begun to be used in the 1980s for the first time in the treatment of ureteral stones. Despite the wide calibrated URSs (> 10 Fr), high success rates were reported[3]. With the development of new technologies in the past three decades, a new era has started in endourology. Thin and flexible URSs has rapidly changed the endourology practice[4]. However, the flexible URS device is expensive and fibre optics require frequent repair[5] and is not widely available in our country.
Percutaneous nephrostomy (PCN) has been used since 1955 for the treatment of postrenal obstruction or before an endourological intervention with the intent of urinary diversion[6,7]. PCN decompresses the urinary tract in the presence of ureter stone with high success and low complication rates[8]. Indwelling a double j stent (DJS) is another method that is as effective as PCN for decompressing purpose.
It has been shown that the first URS fails and subsequent URS is required in 10-15% of cases[9]. It is a preferred method to indwell a DJS and to treat the stone with a second URS after a while when the urologist cannot access the stone in the first URS. However, sometimes it is not possible to indwell a DJS probably due to the guidewire being unable to pass through an impacted stone. In this case, it is a rational option to decompress the collecting system with a PCN and perform the second URS after a while.
We proposed that the PCN might facilitate the second URS after a failed URS and we aimed to evaluate whether PCN implementation after a failed URS facilitates the second operation in the present study. We hypothesized that PCN would induce a passive dilation in the ureter, decompress the collecting system and facilitate the second ureterorenoscopy by reducing intrapelvic and intraureteral pressures and increasing pelviureteric peristalsis as shown in **Figure 1**.

PATIENTS AND METHODS

Study population

Patients older than 18 years with symptomatic ureteral stones detected by imaging methods (non-contrast computerized tomography [NCCT], ultrasonography [USG], X-ray) and who had a failed URS story were

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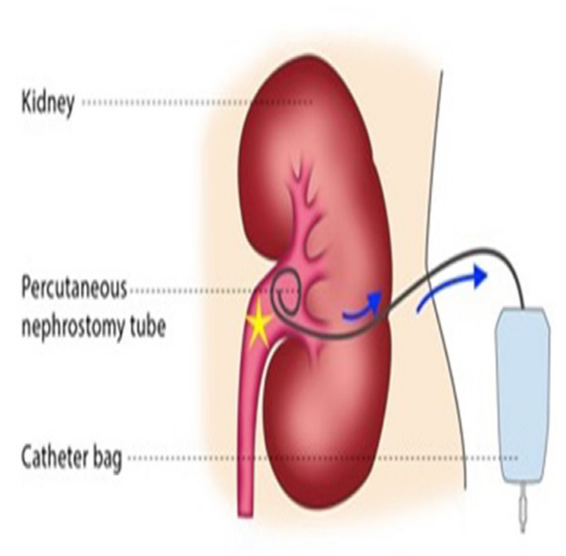

Figure 1. A schematic view of the impact of a percutaneous nephrostomy. The urine in the collecting system is taken out by the catheter bag in the direction of the blue arrows, so that the intrapelvic pressure indicated by the yellow star decreases

included in the study and the data of these patients were analyzed. In the vast majority of patients (398/448, 88.8%), NCCT, which is accepted as the gold standard for the urinary system stone diagnosis, had been used. Additional opaque imaging with CT-Urography had been performed in 22 patients with ureteral stricture suspicion. Intravenous urography (IVU) had not been used in any patient. All patients had surgical indications and did not benefit from medical treatment. Patients with urethral or ureteral stricture, urinary diversion story and pregnancy were not included (n = 28). After the first failed URS, 19 patients who passed the stones spontaneously had not been also included in the study. Informed consent had been obtained at least 48 hours before the operations. All patients had hydronephrosis in varying grades on NCCT. Classification of hydronephrosis was made from grade 1 to 4 according to the system of the Society for Fetal Urology[10]. Since this classification was most often made according to USG findings, all patients included in the study had undergone renal USG.

Study design

This historical cohort study included 448 patients who had undergone a second operation after a failed URS between January 2010 and July 2017. In the same period, a total of 6228 URS operations had been performed in our clinic. First, the patients were divided into two groups; those who underwent PCN (Group A, n = 196) and those who did not undergo PCN (Group B, n = 252). The two groups were compared in terms of stone access rate. Subsequently, the group A was subdivided into two groups: access succeeded (Group A1, n = 143) and access failed (Group A2, n = 53). Antegrade DJS or antegrade flexible URS had been planned for the 53 patients with failed second URS after PCN implementation. In group B, PCN and re-URS had been planned for 211 patients whose stone was inaccessible in the second URS. Factors affecting successful access in the two groups were compared. **Figure 2** shows the study flowchart. The study was conducted in accordance with the Declaration of Helsinki.

Surgical technique

The informed consent form was obtained from the patients and sterile urine culture was provided prior to the ureteroscopy procedure. Intravenous 1 gr cefazolin was administered to patients following spinal anaesthesia. In the lithotomy position, 5% lidocaine gel was applied to the urethra. All the procedures were performed by semirigid ureteroscopes with 8 or 9 Fr distal tip (Storz®, Tuttlingen, Germany). 8 Fr ureteroscope was used in 296 of 448 patients (66.1%) and 9 Fr ureteroscope was used in 152 patients (33.9%). A 0.038 in ×150 cm sized Polytetrafluoroethylene (PTFE) Coated Guidewire (Boston Scientific®, USA) with 3 cm flexible tip was used routinely to guide ureteroscope. A Sensor Dual-Flex PTFE-Nitinol Guidewire with Hydrophilic

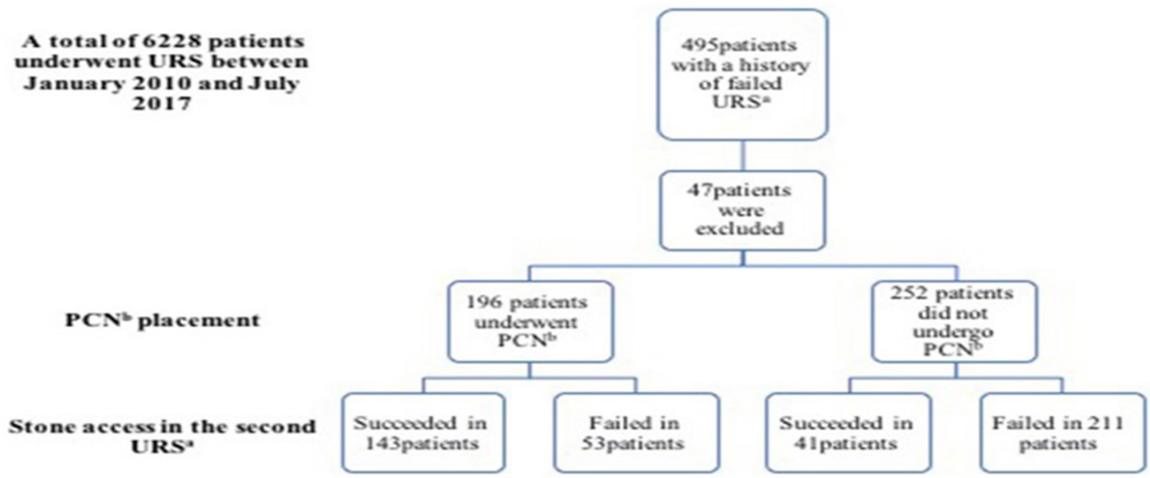

Figure 2. Study flowchart.
[a]Ureteroscopy
[b]Percutaneous nephrostomy

Table 1. Characteristics and clinical data of the patient groups.

	Group A (n = 196)	Group B (n = 252)	*P*-value (mean ± standard)
Age (year)			
Mean	34.97 ± 1.23	35.47 ± 0.65	.663[a]
Range	18-54	19-59	
Gender			
Male	130 (66.7%)	164 (65.4%)	.322[b]
Female	66 (33.3%)	88 (34.6%)	
Body mass index			
Male	23.11 ± 1.44	24.19 ± 1.21	.242[a]
Female	21.96 ± 1.18	22.75 ± 1.03	.319[a]
Laterality			
Right	114 (58.3%)	137 (54.5%)	.653[c]
Left	82 (41.7%)	115 (45.5%)	
Location			
Proximal	73 (37.5%)	100 (40.0%)	
Middle	77 (39.5%)	73 (29.1%)	.451[c]
Distal	46 (22.9%)	79 (30.9%)	
Stone sizea (mm)	8.73 ± 1.18	9.95 ± 1.34	.326
Operation timea (min)	24.45 ± 0.56	23.66 ± 1.22	.524
Hydronephrosis grade[a]	2.23 ± 1.16	2.42 ± 1.05	.128
Time to second ureteroscopya (day)	28.36 ± 0.85	26.66 ± 1.28	.216
Access to stone in the second ureteroscopy	143/196 (72.91%)	41/252 (16.36%)	.0018

Values are given as mean ± standard deviation or number %
[a] Independent-Samples *T*-Test
[b] Fisher's Exact Test
[c] Pearson Chi-Square

Tip (Boston Scientific®, USA) was used as a second alternative when the first guidewire could not pass. All ureteroscopies were performed in a retrograde manner. If stone access achieved, a StoneLight® holmium laser lithotripter was used for stone fragmentation. If the stone could not be accessed, the absence of a ureteral stricture was confirmed by administering a diluted opaque substance with saline solution with low pressure from the lumen of the ureteroscope under the fluoroscopy view. A 16 Fr Foley's catheter was introduced to the bladder with the completion of the operation and was taken on the same day or one day later. The ureteroscopy procedure and instrumentation are shown in **Figure 3**.

After the first URS, 196 patients (Group A) underwent PCN on day 1 postoperatively. Our criteria for implementing a PCN in the postoperative period were the presence of lumbar pain resistant to medical treatment, hydronephrosis at varying grades, and the patient's acceptance of the procedure. Because it is an interventional procedure, the informed consent form was taken from the patients. Eight Fr PCN tube (Rüsch Teleflex®, USA) was inserted by interventional radiology. Five ml of 2% prilocaine was injected into the planned access tract before implementation. The patient was placed in the prone position on the ultrasound table. Then a pillow was placed under the access side to allow the kidney to move upwards. After 10 minutes, PCN was introduced into more dilated renal calyx under ultrasound guidance. A percutaneous nephrostomy view is schematized in **Figure 1**.

Patients had been discharged after a period of observation (in terms of haemorrhage and fever) on the same day following the implementation of PCN. An appointment had been made for the second URS and re-URS had been applied at the date of the appointment. Dates had been determined for second URSs and patients underwent re-URSs on acquisition dates. Patients had been left with PCNs until the second operations. In URS, success had been defined according to stone access. In the third month follow-up, patients had undergone NCCT to assess the residual fragments or strictures. The presence of stones smaller than 4 mm or absence of any residual fragment had been defined as "stone free".

Outcome assessment

Our primary outcome measurement was successful access to the stone in the second URS and comparison of two groups (Group A and B) in terms of patient and stone characteristics.

Secondary outcome measurement was to evaluate factors affecting successful access in group A in terms of gender, age, body mass index (BMI), stone size (mm), side (right or left), location (proximal, middle and distal), grade of hydronephrosis and PCN duration (day). All data were recorded and retrospectively collected from patient files.

Categorical data were examined with the Mann–Whitney U, Chi-square and Ficher's exact tests. Shapiro-Wilk test was performed for the evaluation of the normal distribution of numerical data. Independent two group *T*-tests were used for numerical data as the data were normally distributed. ROC analysis was performed to establish cut-off values predictive for stone access in 75% of the patients. A two-tailed *P* value less than 0.05 was considered statistically significant. All analyses were performed using IBM SPSS® Statistics 23.0.

RESULTS

A total of 448 patients who had undergone a failed URS were enrolled in the study. The reasons for failure in the first URS were as follows; unable to pass the guidewire proximally to the stone in 322 patients, to approach to the stone with ureteroscope allowing efficacious stone fragmentation in 62 patients and displacement of distal located ureteral stone to proximal ureter with the ef-

Table 2. Demographic and clinical data of Group A1 (stone access succeeded) and Group A2 (stone access failed)

	Group A1 n = 143	Group A2 n = 53	*P*-value
Age (year)			
Mean	32.86 ± 1.86	34.45 ± 1.08	.982[a]
Range	18-49	21-54	
Gender			
Male	84 (58.7%)	30 (56.6%)	.170[b]
Female	59 (41.3%)	23 (43.4%)	
Body mass index			
Male	22.81 ± 1.24	23.42 ± 0.89	.121[a]
Female	21.12 ± 1.43	22.81 ± 1.22	
Laterality			
Right	65 (45.4%)	23 (43.4%)	.701[c]
Left	78 (54.6%)	30 (56.6%)	
Location			
Proximal	43 (30.1%)	21 (39.6%)	.669[c]
Middle	51 (35.7%)	19 (35.8%)	
Distal	43 (34.2%)	13 (24.6%)	
Stone size (mm)	7.286 ± 1.02	12.631 ± 0.88	< .001[a]
Nephrostomy duration (day)	18.74 ± 1.14	9.62 ± 0.97	< .001[a]
Hydronephrosis grade	3.25 ± 0.76	1.21 ± 1.09	.038[a]

Values are given as mean ± standard deviation or number %
[a] Independent-Samples *T*-Test
[b] Fisher's Exact Test
[c] Pearson Chi-Square

fect of pressurised saline fluid and failure to proceed proximally with ureteroscope in 64 patients. In the first operation, 38 patients had Grade I (mucosal injury, n = 18; hematuria, n = 20), 51 patients had grade II (urinary tract infections) and 64 patients had grade IIIa (proximal stone migration) complications according to Clavien-Dindo classification. Overall, the mean age of the patients was 35.22 (18-59) years and 66.5% of the patients were male. Stone access rate was significantly higher in Group A (*P* = .0018). In the nephrostomy-implemented group, 72.91% of the stones could be accessed, while only 16.36% of the stones could be accessed in the non-nephrostomy group. In Group A, the second URS had failed in 11 patients, because the guidewire could not be passed proximally to the stone and the stone had been pushed-back to the collecting system in 42 patients. In Grup B, URS had failed in 176 patients, because of being unable to pass the guidewire proximally to the stone and the push back phenomenon in 35 patients. In the second operation, complications were Grade I in 26 patients (mucosal injury, n = 12; hematuria, n = 14), Grade II in 44 patients and Grade IIIa in 77 patients. Demographic and clinical data of the patients are shown in **Table 1**.

Then, we divided the PCN-group (Group A) into two groups; stone access succeeded (Group A1, n = 143) and stone access failed (Group A2, n = 53). We performed a subgroup analysis comparing these two groups in terms of patient and stone characteristics, PCN duration and hydronephrosis grade. Mean hydronephrosis grade was significantly higher in group A1 than group A2 (3.25 ± 0.76 vs 1.21 ± 1.09, *P* = .038). Mean time between PCN implementation and URS was significantly longer in group A1 (18.74 ± 1.14 vs 9.62 ± 0.97, P < .001). There was an inverse relationship between the groups regarding the stone size, as follows, it was significantly larger in group A2 than group A1 (12.631 ± 0.88 vs 7.286 ± 1.02 mm, *P* < .001). Table 2 summarizes the comparison of subgroups of group A (groups A1 and A2).

Since the stone size and PCN duration were important factors affecting stone access in comparison of Group A1 and A2, we performed ROC analysis to determine the predictive values of stone access in 75% of the patients as shown in Table 3. The area under the ROC curve (95% CI) for the prediction of stone access was 0.990 (0.970–1.000) for the stone size. The optimal cut-off value in the prediction of stone access was 9 mm for the stone size, with 91.4% sensitivity and 92.3% specificity. Likewise, the area under the ROC curve (95% CI) for the prediction of stone access was 0.985 (0.956–1.000) for the PCN duration. The optimal cut-off value in the prediction of stone access was 13 days for the PCN duration, with 94.3% sensitivity and 100% specificity. We determined 9 mm and 13 days for stone size and PCN duration, respectively, as predictive values for successful stone access in 75% of patients.

Table 3. ROC analysis of stone size and percutaneous nephrostomy duration for successful stone access in 75% of the patients

	AUC	95% CI	Sensitivity	Specificity	*P*-value
Stone size[a]	0.990	0.970–1.000	91.4%	92.3%	< .001
PCN duration[b]	0.985	0.956–1.000	94.3%	100%	< .001

Abbreviations: AUC, Area under curve; CI, Confidence interval.
a For stone size < 9 mm
b For nephrostomy duration longer than 13 days

DISCUSSION

URS is frequently used in the treatment of ureterolithiasis and provides high success rates. Shield et al. reported a 14.6% failure rate in the initial URS[9]. URS outcomes of high-volume centres were shown to be better than low-volume centres[11]. In our clinic, during the study period, a total of 6228 patients underwent URS due to ureteral stone and 448 URS failed, our failure rate was 7.19%. Normally the PCN requirement rate for DJS failure is < 1%, and PCN is used to treat septic complications and to relieve symptoms of patients. In

Figure 3. Ureteroscopy procedure and instrumentations. **A)** Photograph of semi-rigid ureteroscope used in operations, **B)** Fluoroscopic image of a guidewire pushed forward from the left distal ureter to the proximal ureter, **C)** Fluoroscopic image of a guidewire, which could not be pushed forward to proximal due to an impacted stone in the left ureter, black arrow shows the impacted stone, **D)** Endoscopic view of fragmentation of the stone in the ureter with holmium laser lithotripsy

our series, this rate is quite high (43.8%) because we did not use PCN for therapeutic purposes in these patients, we applied the PCN with the prediction that PCN will facilitate the second URS.

Currently, there are two methods to decompress the renal collecting system: ureteral stents and percutaneous nephrostomy tube. Both methods have similar success rates. PCN placement is a frequently used method in urology practice for both malignant and benign pathologies[12-15]. Kwon et al.[16] evaluated the effectiveness of PCN during URS in the treatment of upper ureteral stones. They divided the subjects into two groups depending on the presence of a PCN at the time of surgery and they found significantly better outcomes in terms of operative time (57.4 minutes vs 68.1 minutes) and success rate (92.9% vs 78.6%) with similar complication rate in the PCN group. In our study, the mean operation time of the two groups was similar, but the success rate was significantly higher in the PCN group comparable to this study. Although the proximal stones were much more than the distal stones (46 vs 40) in group A1, the difference was not significant and we found that stone localization had no effect on success rates.

The same authors assessed the efficacy of PCN during flexible URS in the treatment of renal stones. They enrolled 130 patients and divided them into two groups depending on the presence of PCN during the surgery. They concluded that PCN provided higher stone-free rates in flexible URS treatment without increasing the operation time and complication rates[17].

In the case of sepsis, which is caused by an obstructing stone, urgent decompression of the collecting system is required[18]. The choice between PCN and stent is based on factors such as disease severity, stone size, localization of stone, planned stone treatment method, and the presence of interventional radiology. None of our patients had sepsis or pyonephrosis during the first URS, but all had hydronephrosis at varying grades. Our patients underwent PCN for the purpose of facilitating second URS by decompressing the collecting system, not for emergency intervention. But in this way, we may have prevented the emergency case that the obstructed stone may cause in our patients afterwards.

The quality of life (QoL) of patients undergoing DJS or PCN is also an important issue. Mokhmalji et al. concluded that both methods negatively affect the QoL of patients and this effect has been shown to be similar [19]. While stents lead to mostly lower urinary tract complaints such as irritative voiding symptoms and hematuria, PCN may lead to ergonomic problems such as inconvenience of carrying the nephrostomy tube and bag, poor cosmetic image and perhaps the most important one, easy dislocation of the tube. Although we did not make a detailed inquiry for the inconvenience of PCN in our patients, we observed only mild pain in three of them.

Our centre is a national referral centre for treatment of ureterolithiasis. Flexible URS is also available in our clinic. But when this fragile and expensive device breaks down, the repair process takes a long time since our hospital is a public university hospital and the complicated bureaucratic procedures last long. So, we have to treat the majority of our patients with semi-rigid URS. Also, we do not have a thinner URS with 4 or 6 Fr diameter. We occasionally come across the problem of inaccessibility to the stone during URS treatment in our high case volume clinic. When we can not access the stone and indwell a DJS in initial URS, we prefer to place a PCN expecting to alleviate hydronephrosis, prevent sepsis and facilitate the second URS. The pathophysiology of ureteral colic has not been fully elucidated. But it is an accepted view that ureteral spasm inhibits organized antegrade peristalsis by leading to a significant increase in tonic smooth muscle contraction and two main factors that facilitate the stone passage are the increase of the hydrostatic pressure in the proximal part of the stone and the relaxation of the ureter muscles where the stone is located.

In their experimental studies, Meini et al.[20] have shown that peristalsis can be both antegrade and retrograde route. During ureteral colic, each cell may induce an action potential in response to depolarization and as a result, disorganized peristalsis may occur consequently. Lennon et al.[21] compared the effects of double pigtail ureteric stent and PCN on stone transit and ureteric motility in 12 dogs. They concluded that DJS induces ureteric dilatation, diminishes peristalsis and impairs stone passage and proximal PCN tube drainage can facilitate spontaneous stone passage by preventing ureteral dilation and maintaining antegrade peristalsis. They emphasized that in the initial phase, increasing hydrostatic pressure is probably the most important factor

determining stone passage. In this case, it is proper to express that PCN can facilitate stone passage and access to stones by leading to relaxation in ureteral muscles and preventing ureteral dilatation. The results of these studies and the pathophysiological mechanisms they emphasize, almost clarify the outcome "PCN facilitates the second URS" that we achieved in our study. With the results we have obtained, we also consider that PCN may facilitate the ureteroscopy or allow spontaneous stone passage by providing this effect in the human ureter. Although it is thought that PCN may have a preventive role in the expulsion of the stones by reducing proximal urinary system pressure, this view did not apply to our study. Because we consider that the ureter should be entirely evaluated due to its anatomical and physiological properties. The effect on the proximal as distal as the stone is also important, and we propose that PCN will prevent dilation of the entire ureter and also inhibit ureteral muscle spasm.
Although we found that PCN facilitates the second URS and revealed important parameters affecting the success rate, our study has some limitations; 1) The design of our study was retrospective, 2) URS operations were performed by different urologists. The experience of the surgeon is an important factor affecting the outcome of an operation.

CONCLUSIONS

Our data suggest that decompressing renal collecting system with a PCN is a logical choice to facilitate re-URS when ureteral stone access has failed in an initial URS. The stone size and PCN duration are significant parameters affecting the second URS outcomes.

CONFLICT OF INTEREST

The authors report no conflict of interest.

REFERENCES

1. Meldrum K, Mathews R, Gearhart J. Hugh Hampton Young: a pioneer in pediatric urology. J Urol. 2001;166:1415-7.
2. Alenezi H, Denstedt JD. Flexible ureteroscopy: Technological advancements, current indications and outcomes in the treatment of urolithiasis. Asian J Urol. 2015;2:133-41.
3. Tawfiek ER, Bagley DH. Management of upper urinary tract calculi with ureteroscopic techniques. Urology. 1999;53:25-31.
4. Rassweiler J, Rassweiler M-C, Klein J. New technology in ureteroscopy and percutaneous nephrolithotomy. Curr Opin Urol. 2016;26:95-106.
5. Chew B, Denstedt J. Ureteroscopy and retrograde ureteral access. Campbell-Walsh Urology. 9th ed. Philadelphia: Saunders. 20071508-25.
6. Goodwin WE, Casey WC, Woolf W. Percutaneous trocar (needle) nephrostomy in hydronephrosis. J Am Med Assoc. 1955;157:891-4.
7. Montvilas P, Solvig J, Johansen TEB. Single-centre review of radiologically guided percutaneous nephrostomy using "mixed" technique: success and complication rates. Eur J Radiol. 2011;80:553-8.
8. Lynch MF, Anson KM, Patel U. Percutaneous nephrostomy and ureteric stent insertion for acute renal deobstruction Consensus based guidance. Br J Med Surg Urol. 2008;1:120-5.
9. Shields JM, Bird VG, Graves R, Gómez-Marín O. Impact of preoperative ureteral stenting on outcome of ureteroscopic treatment for urinary lithiasis. J Urol. 2009;182:2768-74.
10. Beetz R, Bökenkamp A, Brandis M, et al. Diagnosis of congenital dilatation of the urinary tract. Consensus Group of the Pediatric Nephrology Working Society in cooperation with the Pediatric Urology Working Group of the German Society of Urology and with the Pediatric Urology Working Society in the Germany Society of Pediatric Surgery. Urologe A. 2001;40:495.
11. Kandasami SV, Mamoulakis C, El-Nahas AR, et al. Impact of case volume on outcomes of ureteroscopy for ureteral stones: the clinical research office of the endourological society ureteroscopy global study. Eur Urol. 2014;66:1046-51.
12. Lee WJ, Patel U, Patel S, Pillari GP. Emergency percutaneous nephrostomy: results and complications. J Vasc Interv Radiol. 1994;5:135-9.
13. Avritscher R, Madoff DC, Ramirez PT, et al. Fistulas of the lower urinary tract: percutaneous approaches for the management of a difficult clinical entity. Radiographics. 2004;24:S217-S36.
14. Kanou T, Fujiyama C, Nishimura K, Tokuda Y, Uozumi J, Masaki Z. Management of extrinsic malignant ureteral obstruction with urinary diversion. Int J Urol. 2007;14:689-92.
15. Nariculam J, Murphy D, Jenner C, et al. Nephrostomy insertion for patients with bilateral ureteric obstruction caused by prostate cancer. Br J Radiol. 2009;82:571-6.
16. Kwon SY, Choi JY, Kim BS, Kim HT, Yoo ES, Park YK. Efficacy of percutaneous nephrostomy tube during ureteroscopy for upper ureter stone management. J Endourol. 2013;27:1209-12.
17. Kwon SY, Kim BS, Kim HT, Park YK. Efficacy of percutaneous nephrostomy during flexible ureteroscopy for renal stone management. Korean J Urol. 2013;54:689-92.
18. Lynch MF, Anson KM, Patel U. Current opinion amongst radiologists and urologists in the UK on percutaneous nephrostomy and ureteric stent insertion for acute renal unobstruction: Results of a postal survey. BJU Int. 2006;98:1143-4.
19. Mokhmalji H, Braun PM, Portillo FJM, Siegsmund M, Alken P, KÖhrmann KU. Percutaneous nephrostomy versus ureteral stents for diversion of hydronephrosis caused

by stones: a prospective, randomized clinical trial. J Urol. 2001;165:1088-92.

20. Meini S, Santicioli P, Maggi CA. Propagation of impulses in the guinea-pig ureter and its blockade by calcitonin gene-related peptide (CGRP). Naunyn Schmiedebergs Arch Pharmacol. 1995;351:79-86.

21. Lennon G, Thornhill J, Grainger R, McDermott T, Butler M. Double pigtail ureteric stent versus percutaneous nephrostomy: effects on stone transit and ureteric motility. Eur Urol. 1997;31:24-9.