Improved effectiveness and safety of flexible ureteroscopy for renal calculi (<2 cm): A retrospective study

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Abstract

Introduction: We discuss the efficacy and safety of flexible ureteroscopy for renal calculi with a burden of <2 cm, as well as the prevention and treatment of complications.
Methods: A total of 108 renal calculi with flexible ureteroscopy and holmium laser treatment were retrospectively analyzed. The stone-free rate was evaluated. The effectiveness, safety, surgical technique, incidence of complications, and relevant treatments were analyzed.
Results: All patients underwent only one lithotripsy procedure. The success rate of flexible ureteroscopy was 97.2% (105/108). Among the 105 cases, the total lithotripsy success rate was 97.1% (101/105). The total stone-free rate after 8 weeks post-operation was 94.3% (99/105), the stone-free rate of the lower calyx was 85.7% (30/35); it was 98.6% (69/70) in the middle–upper calyceal and renal pelvis. The incidence of complications was 12.9% (14/108). None of the patients had serious adverse outcomes.
Conclusion: Flexible ureteroscopy represents an optimal treatment option for selected renal calculi with burden of <2 cm. The effectiveness and safety of flexible ureteroscopy can be further improved through reasonable preoperative evaluation and advances in surgical techniques, as well as a better understanding of the inducement and treatment of complications.

Introduction

Flexible ureteroscopy is an important method for treating renal and ureteral calculi. This relatively new technique is particularly beneficial for patients who are unsuitable for extracorporeal shock wave lithotripsy (ESWL) or percutaneous nephrolithotripsy (PCNL), patients with repetitive ESWL failure, obesity, hemorrhagic disease, lower calyceal calculi, or calyceal diverticular calculi, and patients who require multiple ESWL.

Marshall first reported the application of flexible ureteroscopy for clinical diagnosis in 1964.[1] Advances in the past 20 years have made flexible ureteroscopy an efficient and safe treatment for renal or upper ureteral calculi. The stone-free rate of ESWL is influenced by the calculi burden, position, composition of calculi, and the anatomical structure of the collection system. The stone-free rate clearly decreased for patients with multiple calculi, lower calyceal calculi, or harder calculi.[2,3] Moreover, computed tomography (CT) or magnetic resonance imaging (MRI) confirmed that 63% to 85% of patients suffered from renal injury after ESWL.[2]

The preoperative evaluation, selection of appropriate cases, and the prevention of complications are currently the new focus of research to improve further the effectiveness and safety of flexible ureteroscopy. In the present study, we discuss these issues of flexible ureteroscopy to treat patients with renal calculi of with a burden of <2 cm.

Methods

A retrospective review was conducted for the 108 procedures performed at our institution to treat renal calculi <2 cm in size from July 2013 to July 2014. All patients underwent a preoperative intravenous pyelography (IVP) or CT to determine the collecting system anatomy and the total calculi burden.

The inclusion criteria were single or multiple renal calculi, upper ureteral calculi, and repetitive failure of ESWL, with calculi burden <2 cm. The exclusion criteria included severe hydronephrosis, ureterostenosis, and an included angle less than 45° between the pelvis ureter and funnel of lower calyceal.

Patients were placed in the dorsal lithotomy position under general anesthesia. A F8/9.8 rigid ureteroscope was inserted from the ureter to the renal pelvis to dilate the ureter. All the flexible ureteroscopy procedures were ureteral sheath-assisted to allow for optimal visualization, to maintain low intra-pelvic pressure, and to facilitate extraction of stone fragments. A double-J stent was placed for patients suffering from ectopic kidney, solitary kidney calculi, or ureteral calculi, as well as cases where we encountered difficulty in placing a ureteral sheath. Subsequently, flexible ureteroscopy and holmium laser lithotripsy were conducted after 14 days.

After rigid ureteroscopy, a guide wire (0.038 mm) was directly placed into renal pelvis. The ureteroscope was then pulled out, and an F14 ureteral sheath was inserted. After the outflow of urine from the ureteral sheath, the guide wire was pulled out. A F8.5 flexible ureteroscope (we used the same flexible ureteroscope for every intervention) and a 220-μm holmium laser fibre were subsequently used for treatment. Dynamic B ultrasonic scanning was combined to localize the calculi in patients with severe hydronephrosis, lower calyceal calculi, or calyceal diverticular calculi. For patients with calyceal diverticular calculi, the atresic diverticulum mucosa was incised by a holmium laser under monitoring of dynamic B ultrasonic scanning (Fig. 1). The holmium laser was set at a low energy level (0.6J–0.8J) and a high rate (10Hz–25Hz) to pulverize the calculi in a worm-eaten pattern. Sustained low pressure flushing allowed us to optimally visualize and maintain low intra-pelvic pressure. If the lithotripsy process was influenced by breathing, intermittent apnea was adopted. Basketing was performed on the fragments larger than 2 mm. Following the lithotripsy, a F6 double-J stent was placed. In the absence of fever or bacteremia, the catheter was removed on the first day post-operation. Common broad-spectrum antibiotics were used for 2 days after the operation. X-rays of the kidneys, ureters, and bladder (KUB) or CT was performed at 30 and 60 days post-operation to assess the effects of surgery. We defined a stone-free status as calculi fragments in kidney <2 mm.

Results

Based on the retrospective analysis, the demographics of patients and calculi are shown in Table 1. We considered a total of 108 cases, including 7 cases of calyceal diverticular calculi, 1 case of calculus in pelvic ectopic kidney, and 2 cases of calculi in solitary kidney. The outcomes of operation are presented in Table 2.

Calculi was not found in 12 patients, including 2 cases with severe hydonephrosis, 4 cases of lower calyceal calculi, and 6 cases of calyceal diverticular calculi. Subsequently, dynamic B ultrasonic assisted scanning was successfully used to find these calculi in 10 patients (83.3%, 10/12).

A total of 14 (12.9%) perioperative complications were encountered (Table 3). Transfusion and conservative therapy were conducted in a severe hemorrhage patient without surgical treatment. One patient with septic shock was characterized by a light coma and serious septicemia symptoms at 2 hours postoperatively. Anti-shock and anti-infection (with imipenem/cilastatin) treatments were routinely given, and septicemia symptoms improved after 2 days. The acute renal failure (ARF) patient showed renal colic, oliguria, and increased serum creatinine (564 μmol/L) on the first 3 days postoperatively. Serum creatinine levels began to decrease by the fourth day and returned to the preoperative level on the sixth day postoperatively. Two patients with ureteral injury had a double-J stent in place for 6 weeks without ureterostenosis. Steinstrasse patients underwent ureteroscopy to remove calculi in the distal ureter.

Discussion

The use of flexible ureteroscopy for renal calculi has been reported in the literature. However, only a limited number of

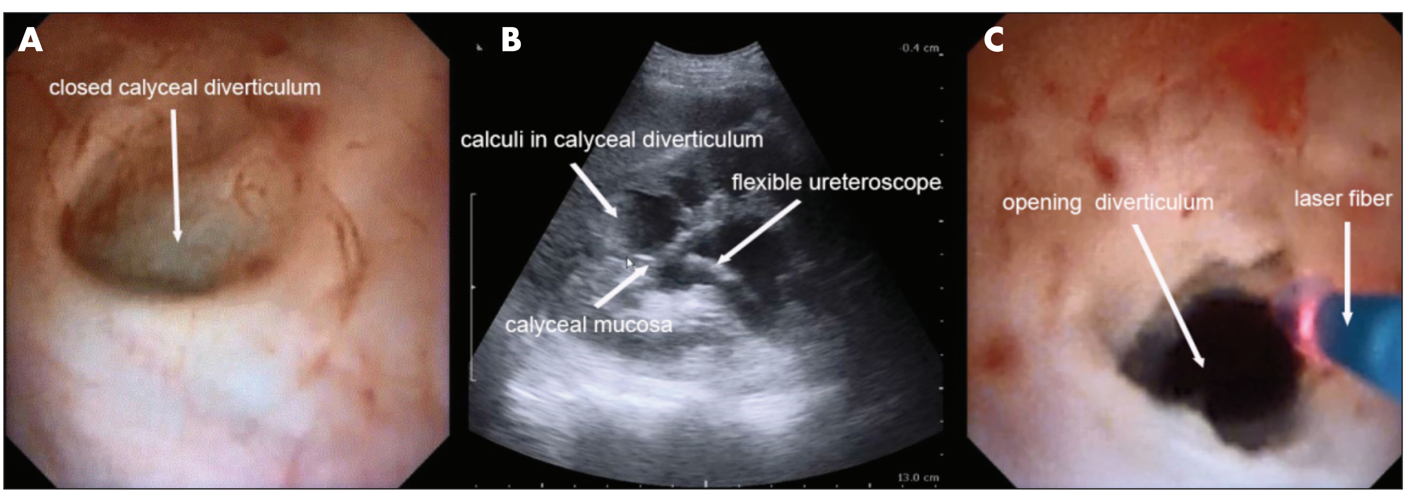

Fig. 1. Dynamic B ultrasonic scanning assisted calculi localization. A: Closed calyceal diverticulum with thin calyceal mucosa. B: Dynamical ultrasonography to determine the relative position between the flexible ureteroscope and calculi. C: Incision the thin calyceal mucosa with a holmium laser.

Table 1. Demographics of patients and calculi

Gender	
Male	68
Female	40
Age, years	38 ± 21
Calculus size, cm	1.37 ± 0.43 (0.9–2.0)
Position of calculus	
Middle-upper calyceal and pelvis	73
Lower calyceal	35
Hydronephrosis	
≥3 cm	4
1–3cm	25
No	79
Previous ESWL (%)	17.6

ESWL: extracorporeal shock wave lithotripsy.

Table 2. Operation outcomes

No. lithotripsy procedures	1
Operation time (min)	56.4 ± 18.5
Hospital stay (days)	3.7 ± 1.4
Success rate of FURS	97.2% (105/108)
Lithotripsy success rate	97.1% (101/105)
Lower calyceal	91.4% (32/35)
Middle-upper calyceal and pelvis	98.6% (69/70)
SFR 4th week postoperative	88.6% (93/105)
Lower calyceal	77.1% (27/35)
Middle-upper calyx and pelvis	94.3% (66/70)
SFR 8th week postoperative	94.3% (99/105)
Lower calyceal	85.7% (30/35)
Middle-upper calyceal and pelvis	98.6% (69/70)

FURS: flexible ureteroscopy; SFR: stone-free rate.

reports can be found on the preoperative evaluation, surgical technique, and the prevention of complications. The safety and prevention of complications are crucial for the advance of flexible ureteroscopy. Our study emphasized the selection of appropriate cases, improvement of surgical techniques, and avoidance of complications.

The ureteral sheath was placed to ensure the circulation of flushing water, to allow for optimal visualization, and to provide less resistance for the rotation of ureteroscope. This sheath favours the basketing of calculi and facilitates the extraction of fine calculi fragments. As an additional benefit, the sheath protects the ureter from repeated insertion and removal of the flexible ureteroscope. The absence of a ureteral sheath in the pelvis can prolong the operation time or cause retrograde infection, even bacteremia or septic shock.[4,5] In our study, the septic shock case was likely due to failure placement of the ureteral sheath in the pelvis, which led to high intra-pelvic pressure. Reports indicate that 86% of flexible ureteroscopy were ureteral sheath-assisted.[6] The relative safety of flexible ureteroscopy without ureteral sheath needs to be further investigated. We recommend that the ureteral sheath should be used in all flexible ureteroscopy. For cases when the ureteral sheath is difficult to place, flexible ureteroscopy was abandoned.

The stone-free rate of lower calyceal calculi by ESWL was lower than 50%.[7] Flexible ureteroscopy can effectively manage lower calyceal calculi. However, the outcome of flexible ureteroscopy is affected by the anatomical structure of the lower calyceal to a large extent. When the included angle between the pelvis ureter and funnel of the lower calyx was less than 30°, the lithotripsy success rate was extremely low.[8-10] The success rate of flexible ureteroscopy has been reported as 83% to 86.3% for lower calyceal calculi of 1 to 2 cm.[11,12] In our analysis, the success rate was 91.4%. IVP or CT urography can be used for the preoperative evaluation of intra-pelvis anatomical structures, especially the included angle, to select appropriate cases for flexible ureteroscopy. Flexible ureteroscopy was only performed for the lower calyceal calculi with an included angle that was greater than or equal to 45°. The small visual field of a flexible ureteroscope makes it difficult to find the calculi in cases of severe hydronephrosis, and requires repeated localization during lithotripsy. Therefore flexible ureteroscopy is not the optimal choice for renal calculi with severe hydronephrosis or for lower calyceal calculi with included angles less than 45°.

The localization of calculi was extremely difficult in some cases with hydronephrosis, lower calyceal calculi, or calyceal diverticulum calculi. For the first time in these cases, we applied dynamic B ultrasound-assisted calculi localization to confirm the relative position between the flexible ureteroscope and calculi. Subsequently, the atresic calyceal diverticulum can be incised by a holmium laser, then a flexible ureteroscope could be placed into the diverticulum to accomplish lithotripsy without injury or hemorrhage.

The selection of the holmium laser energy is important for lithotripsy effects and stone-free rates. Power over 1.0J may easily damage the 220 μm fibre.[13] The initial power was 0.6J, which would then be adjusted according to the lithotripsy effect. The calculi fragments should be less than 2 mm to ensure the passage into the ureter easily without steinstrasse. If the calculi are difficult to pulverize, a stone basket can be used to remove calculi over 2 mm to prevent steinstrasse and shorten the time of extraction. For patients

Table 3. Peroperative complications

Complication	N (%)
Severe hemorrhage	1 (0.9)
Septic shock	1 (0.9)
Steinstrasse	2 (1.9)
ARF accompanied by hematuresis	1 (0.9)
Bacteremia	1 (0.9)
Fever	6 (5.6)
Ureteral injury	2 (1.9)
Ureterostenosis	0 (0)
Ureteral rupture or avulsion	0 (0)
Total	**14 (12.9)**

ARF: acute renal failure.

with steinstrasse, ureteroscopy to relieve obstruction is necessary. The overall stone-free rate is 94.3% 8 weeks postoperatively. The stone-free rate of the lower calyceal is up to 85.7%. However, excessive pulverization is unnecessary as it prolongs operation time.

The complications of flexible ureteroscopy deserve attention. The overall complication rates were 6.8% to 16%.[5,6,14-16] The complication rate increases with the size of the calculi.[6] Major complications include serious infection, ureteral rupture or avulsion, hemorrhage, and steinstrasse, which have an incidence of about 5.3%. Other complications include ARF, ureterostenosis, perforation, hematuresis, and urinary tract infection, which have an incidence of about 4.8%. Hematuresis, infection, and injury are the most common complications.

The literature review revealed that the percentage of infective complications was 3.0%, which accounts for 30% of the total complications.[6] Septic shock is associated with uncontrolled preoperative infection and high intra-pelvic pressure. The infection should be completely treated before the operation, especially for the infection-induced or upper ureteral calculi. For the upper ureteral calculi, we recommend that the double-J stent be placed 2 weeks before the flexible ureteroscopy procedure. The intra-pelvic pressure should also be decreased by maintaining continuous drainage. Treatment of septic shock is based on the principle of early detection and treatment. Severe cases should be transferred to the intensive care unit.

Hemorrhage is mainly related to damage caused by the ureteral sheath, laser injury, or renal calyceal avulsion. Moreover, the rupture of renal parenchyma under the high pressure of flushing may lead to hemorrhage. For renal hemorrhage without injury to the renal parenchyma, transfusion and conservative therapy are recommended. Interventional therapy or nephrectomy should be administered in cases with uncontrolled hemorrhage. Ureteral rupture or avulsion is associated with inflammation or the violent placement and removal of the ureteral sheath under insufficient anesthesia.

The effect of flexible ureteroscopy on renal function is usually reversible. High intra-pelvic pressure may be the major reason for ARF. When the intra-pelvic pressure exceeds 300 mmHg, the injury is obviously aggravated. Other reasons include the mechanical injuries caused by ureteroscope and lithotripter.[17] The use of flexible ureteroscopy for bilateral kidneys was reported at a single clinic. None of the patients had acute postoperative azotemia or statistically significant elevation of serum creatinine.[15,18] However, flexible ureteroscopy should be cautiously used for solitary kidneys. A double-J stent should be placed before and after flexible ureteroscopy. Postoperative AFR can be prevented by avoiding high intra-pelvic pressure, prolonged operation time, traumatic hemorrhage, and steinstrasse. For ARF, conservative therapy is usually adopted, such as the maintenance of unobstructed drainage, avoidance of nephrotoxic drugs, and the treatment of infection.

Conclusion

Flexible ureteroscopy and holmium laser treatment can be an optimal approach for selected renal calculi with a burden of <2 cm, especially in patients with repetitive ESWL failures, obesity, and hemorrhagic disease or for lower calyceal and calyceal diverticular calculi. The selection of these cases is based on the collecting system anatomy and calculi position, as well as the patient's physical condition, accompanying diseases and wishes, in addition to the surgeon's experience. The effectiveness and safety of the procedure are closely related to the preoperative evaluation and surgical technique, as well as a better understanding of the inducement and treatment of complications.

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