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Retrograde Ureteroscopic Management of Large Renal Calculi: A Single Institutional Experience and Concise Literature Review

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Abstract

Introduction: Advances in flexible ureteroscope design and accessory instrumentation have allowed for more challenging cases to be treated ureteroscopically. Here, we evaluate our experience with ureteroscopy (URS) for the management of large renal calculi (≥2 cm) and provide a concise review of recent reports.
Methods: A retrospective review was undertaken of all URS cases between 2004 and 2014 performed by the endourologic team at a single academic tertiary care institution. We identified patients with at least one stone ≥2 cm managed with retrograde URS. Stone size was defined as the largest linear diameter of the index stone. Small diameter flexible ureteroscopes were used primarily with holmium laser. Patient demographics, intraoperative data, and postoperative outcomes were evaluated.
Results: We evaluated 167 consecutive patients who underwent URS for large renal stones ≥2 cm. The initial reason for choosing URS included patient preference (29.5%), failure of other therapies (8.2%), anatomic considerations/body habitus (30.3%), and comorbidities (28.8%). Mean patient age was 55.5 years (22–84). The mean stone size was 2.75 cm with mean number of procedures per patient of 1.65 (1–6). The single session stone-free rate was 57.1%, two-stage procedure stone-free rate was 90.2% and three-stage stone-free rate was 94.0%. Access sheaths were used in 47% of patients. An association was identified between stone size and patient outcomes; smaller stones correlated with decreased number of procedures. Postoperative complications were minor.
Conclusions: Single or multi-stage retrograde ureteroscopic lithotripsy is a safe and effective mode of surgical management of large renal calculi. Total stone burden is a reliable predictor of the need for a staged procedure and of stone-free rate.

Keywords: ureteroscopy, nephrolithiasis, lithotripsy

Introduction

Renal calculi greater than 2 cm in diameter have historically been treated with percutaneous nephrolithotomy (PCNL), which continues to be recommended as per American Urologic Association (AUA) guidelines.[1] PCNL clearance rates for these large stones range from 83% to 90%.[2] However, PCNL remains largely an inpatient procedure associated with complications such as blood loss requiring transfusion, extravasation, and less commonly, sepsis and pleural or colonic injury.[2,3] Comorbidities such as obesity, renal insufficiency, and chronic obstructive pulmonary disease (COPD) may be associated with an increased risk for these complications. Patients with bleeding diatheses or on strict anticoagulation may experience significant blood loss with this surgery, making them poor candidates for PCNL while others would simply prefer less invasive treatment options. Although technological modifications have led to the advent of the ''mini-PCNL'' with smaller access tracts (14–20F), complication rates have remained significant with up to 2% of patients requiring transfusions and longer operative times when compared to standard PCNL.[4]

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Since the advent of the semirigid fiberoptic ureteroscope and deflectable flexible ureteropyeloscope, retrograde lithotripsy has long been described as a viable option for treatment of upper tract calculi.[5,6] In recent years, flexible ureteroscopy (URS) with holmium laser lithotripsy has become a favorable management option for large renal calculi as the technology of flexible ureteroscopes and endoscopic surgical technique have continued to improve. Smaller endoscopes, increased endoscope flexibility, and holmium laser technology have made retrograde management of large renal calculi an increasingly appealing option for urologists and patients alike. Indications for retrograde ureteroscopic treatment of these stones include failed prior percutaneous therapy, hypermetabolic syndrome, morbid obesity, chronic anticoagulation, anatomic factors, and patient preference. In this study, we present a single institutional experience with retrograde URS with laser lithotripsy for the management of large (>2 cm) renal stones.

Patients and Methods

An Institutional Review Board approved retrospective analysis was performed of electronic medical records, operative notes, and anesthesia reports investigating patients presenting to this institution with large renal calculi over a 10-year period from 2004 to 2014. A total of 167 patients with at least one stone with diameter >2 cm were treated during this time. Stone size was determined using the largest diameter on coronal or axial view on computed tomography (CT) of the abdomen and pelvis. The method of assigning size based on cumulative diameter of all stones was not used in this study.

Patients were administered perioperative intravenous antibiotics. Cystoscopy was performed under general anesthesia. Fluoroscopy and safety guidewires were used. A flexible ureteroscope was advanced to the renal pelvis and lithotripsy was performed using a Holmium laser fiber of size 200 or 365 μm depending on stone location. Holmium laser lithotripsy was used in every case. Electrohydraulic lithotripsy (EHL) was performed in an adjunctive fashion in a minority of cases. A 12/14F ureteral access sheath was used when deemed appropriate. Stone manipulation was undertaken using nitinol stone retrieval baskets. Calculus fragments were sent for analysis and ureteral stents were placed routinely. Patients were considered to be stone free if a single fragment smaller than 3 mm remained after lithotripsy. Clearance was confirmed visually in the operating room or with CT. If CT was not performed, follow-up kidney, ureter, and bladder radiograph (KUB) and ultrasound were completed as an outpatient with residual stone size measured using the KUB.

The patient data were evaluated for patient demographics, intraoperative data, stone parameters, and patient outcomes. Operative time was recorded as time from beginning to end of anesthesia. Fisher's exact test of independence with a two-tailed p-value was performed to determine patient outcomes.

Results

Patient risk factors for undergoing URS for management of large renal stones included obesity, bilateral nephrolithiasis, cystinuria, and COPD. Reasons for choosing URS are documented in Table 1.

TABLE 1. INDICATIONS FOR URETEROSCOPIC MANAGEMENT OF LARGE RENAL CALCULI

Reason for ureteroscopy	*No. of patients*	*% of patients (n = 167)*
Anatomic considerations/body habitus	20	12.0
Comorbidities[a]	19	11.4
Patient preference	17	10.2
Failure of other therapies	10	6.0
Other[b]	3	1.8
None indicated	99	59.3

[a]Including bleeding diatheses, chronic anticoagulation.
[b]Included concern for urothelial malignancy, encrusted stent distally attached to a bladder stone, and recent subcapsular hematoma.

Evaluation of patient demographics revealed that 58.1% of patients were female (Table 2). There was no apparent difference in the presentation of patients with left-sided *vs* right-sided calculi. Mean stone size was 2.75 cm. The number of procedures required for stone clearance was evaluated based on stone size (Table 3). Stones that were 3 cm in diameter or

TABLE 2. PATIENT AND STONE DEMOGRAPHICS

Demographics	
Age (mean, years)	55.5
Gender	
Female	97 (58.1%)
Male	70 (41.9%)
Laterality	
Right	83 (49.7%)
Left	80 (47.9%)
Bilateral	4 (2.4%)
Stone size	
Mean (cm)	2.75
Median (cm)	2.5
Stone location	
Renal pelvis	72 (42.1%)
Staghorn/multiple	60 (35.1%)
Poles	
Lower pole	22 (12.9%)
Upper pole	12 (7.0%)
Mid pole	5 (2.9%)
Stone composition[a]	
Mixed	45 (32.3%)
Uric acid	24 (17.3%)
Calcium oxalate monohydrate (COM)	22 (15.8%)
Apatite	22 (15.8%)
Calcium oxalate dihydrate (COD)	9 (6.5%)
Cystine	7 (5.0%)
Struvite	6 (4.3%)
Brushite	4 (2.9%)
Access sheath used	128 (47%[b])
Laser energy used (mean, kJ)	21.88

[a]Stone composition only available for 139/167 patients.
[b]One hundred twenty-eight procedures of 271 total stages had documented use of ureteral access sheaths.

Table 3. Outcome Evaluation Based on Stone Size

Stone size (cm)	*Number of patients*[a]	*Number of procedures needed for clearance*		
		1	*2*	*≥3*
2–2.9	80	52	25	3
≥3	66	30	23	13

[a]Remaining patients did not completely clear their stone burden (see section ‘‘Discussion’’).

larger required a greater number of procedures for stone clearance compared to stones that were <3 cm. This finding was determined to be significant; patients with stone size >3 cm were more likely to undergo more than one operative procedure than those with stones of 2.9 cm or smaller ($p = 0.03$). Investigation of stone location revealed that the majority of these stones were found in the renal pelvis (42.1%). Outcomes were evaluated based on stone location (Table 4). Lower pole and staghorn stones had the lowest stone-free rates. Most stones were mixed in origin, being composed of two or more stone types. However, calcium oxalate monohydrate (15.8%), apatite (15.8%), and uric acid (17.3%) were the most common materials found in patients with stones of a single predominant type (Table 2).

The mean number of procedures per patient was 1.65 (range 1–6). A total of 133 patients were treated to clearance. Stone-free status was attained in 59.4% of these patients after a single session procedure, 90.2% for a two-stage procedure, and 94.0% for a three-stage procedure. Mean operative time was 243.9 minutes. Ureteral access sheaths were used in 47% of patients. A total of eight patients (4.8%) experienced complications all of which were Clavien-Dindo grade II or below.[7] Complications included postoperative urinary tract infections, pyelonephritis, and bacteremia.

Discussion

Patients presenting with large renal calculi have traditionally been recommended for management with PCNL.[1,8] PCNL is an invasive procedure that often requires a multiple day hospital stay. The advent of the mini PCNL has resulted in potentially shorter stays in centers where this procedure has been adopted. However, both procedures continue to be associated with a risk of bleeding and the potential need for blood transfusion.[4,9] Consequently, PCNL is contraindicated in patients with bleeding diathesis or on chronic anticoagulation, while there is a relative contraindication for patients with certain spinal abnormalities. Other complications include extravasation and potential for injury to colon, lung, liver, and spleen. Thus, for those patients for whom the use of PCNL may pose a serious risk or in patients who prefer to undergo a less invasive but still effective modality for large stone management, URS is an ideal alternative.

The recent AUA guidelines on surgical management of stones recommend PCNL for renal calculi >2 cm in diameter in adults.[1] However, URS is rapidly becoming an attractive alternative. Recent studies have demonstrated that URS with holmium laser lithotripsy can be an effective alternative treatment option for these patients with reported clearance rates ranging from 83% to 93% after an average of 1–2.4 procedures.[10–14] Reported complication rates are low and most typically consist of postoperative fever, pain, and urinary tract infection. A recent meta-analysis by Aboumarzouk and colleagues reported an overall complication rate of 10.1%, with major complications developing in 5.3% of patients.[15] Other advantages of URS include decreased hospital stay and decreased anesthesia exposure and cost. We maintain that, in the hands of experienced endourologists and using small caliber ureteroscopic equipment along with the appropriate safety wires and stents, the risk of serious complications is greatly diminished compared to PCNL. Only eight patients had documented complications in this series, none of which were above Clavien-Dindo II. Similarly, others have documented predominantly minor complications after ureteroscopic management of large renal calculi.[11,15] Surprisingly, many of the complications in this series occurred in patients in whom ureteral access sheaths had been placed. This is likely because access sheaths were very often placed in patients with a recent history of urinary tract infection, pyelonephritis, or sepsis thought to be associated with their infected stone burden or with suspicion for a postoperative septic event due to a prior history of infectious stone. Patients with ureteral access sheaths also had decreased stone-free rates compared to those without (Supplementary Table S1; Supplementary Data are available online at www.liebertpub.com/end), likely because sheaths were used in patients with larger stone burdens.

Due to remarkable advancements in ureteroscope technology and accessories,[16] the practice of URS has become standard and urologist comfort with the procedure has led to several groups successfully managing large calculi with this technique (Table 5). This current series is the largest cohort study of its nature to date. We argue for an increasing role for URS in the management of large renal calculi in the appropriate patients. Among the first to show the results of this technique in a report was Grasso and colleagues in 1998.[17] Other groups have since demonstrated similar success in utilizing URS with laser lithotripsy to definitively manage large renal calculi (Table 5). With advances in URS, these groups and others were able to demonstrate successful treatment of ever larger patient cohorts. One report of interest

Table 4. Comparison of Results Based on Stone Location

	Renal pelvis	*Staghorn/multiple poles*	*Lower pole*	*Upper pole*	*Mid pole*
Total no. of patients	72	60	22	12	5
1-Stage stone-free rate (%)	69.6	23.3	72.7	83.3	100
2-Stage stone-free rate (%)	90.3	70.6	86.4	100	n/a
≥3-Stage stone-free rate (%)	92.8	81.7	None[a]	n/a	n/a

[a]Some patients did not completely clear their stone burden (see section ‘‘Discussion’’).
n/a = not applicable.

Table 5. Comparison of Stone Parameters and Outcomes

Reference	No. of patients	No. of calculi	Mean stone size	Stone-free rate (%) 1	2	3	Final	Mean no. of procedures	Operative time (minutes)
Cohen et al.[10]	145	164	2.9				87	1.6	ND
Hyams et al.[11]	120	ND	2.4				83[a]	ND	102.7
Riley et al.[13]	22	ND	3.0				91	1.82	72
Mariani[14]	59	63	4.4				95	1.7	79
Karakoyunlu et al.[18]	30	ND	2.7	30	87	100		1.83	114.5
Geraghty et al.[16]	43	ND	2.9				84	1.58	75.2
Al-Qahtani et al.[19]	120	123	206	59	87	97		1.6	89
Wilhelm et al.[20]	25	ND	1.9				96	1.28	98.5
Takazawa et al.[21]	20	20	3.1	65	85	90		1.4	114
Breda et al.[12]	15	15	2.2	60	87	93		2.3	83.3
Scotland	167	171[b]	2.8	57	90	94		1.65	243.9

[a]Residual stone <4 mm.
[b]Only calculi with diameter ≥2 cm counted.
ND = not documented.

is by Mariani[14] who presented patient outcomes after stone management using a combination of EHL and holmium laser as the means of fragmentation. Most other reports have exclusively utilized the holmium laser. More recent work[11] has presented multi-institutional experiences and systematic reviews[15] have provided data to support the use of ureterscopic stone management as an alternative to PCNL for the treatment of large renal stones. A prospective randomized report by Karakoyunlu and colleagues[18] now adds more rigorously collected data in support of this practice.

We and others have now demonstrated that the use of URS results in acceptable stone-free rates. Our secondary stone-free rate was 90.2%. This is comparable to recently published data by other groups and to those achieved with PCNL.[2,18] A total of 34 patients were not clear at the conclusion of one or more stages but did not return for further management. Reasons for this included patient decision to attempt trial of passage and to return to their home urologists for clearance of residual stone.

Here, renal calculus size did affect the ability of the urologist to achieve complete clearance of stone burden with the use of URS and laser lithotripsy (Table 3). Smaller stones correlated with decreased number of procedures. Stones that were at least 3 cm in diameter were more likely to require multiple stage procedures than those 2–2.9 cm in diameter. At least 54.5% of patients with 3 cm stones (36/66) underwent more than one procedure for clearance *vs* 35% (28/80) of patients with stones smaller than 3 cm (Table 3). These findings support the contention that very large stones will require multiple stage procedures. Patients electing to undergo URS for management of their large stone burdens should be counseled accordingly. While we have shown clearance of stone throughout the kidney, including the lower pole, stone-free rates were indeed found to be influenced by calculus location (Table 4). As has been proposed previously,[22] single location stone-free rates were found to be lowest in the lower pole. Also in this series, 60 patients with staghorn or multiple location calculi were treated with URS (Table 4). These patients were more likely to require staged procedures for clearance; single-stage stone-free rate was 23.3%, which improved to 81.7% with three-stage procedures. Of the eight patients with complications, four were treated for staghorn calculi. The complications in all four patients were postoperative infections.

Our operative times as presented are significantly longer than those of other studies that range from 72 to 114.5 minutes (Table 5) and are comparable to PCNL times.[18] However, the documented times at this institution reflect total anesthesia time, which includes the time taken for the procedure. Additionally, for the majority of the time period included in this study our institutional practice was to focus on the use of baskets to remove every stone fragment. This accounted for >50% of the operative time (S.H., unpublished data). Given the data by several other groups documenting stone-free rates comparable to those presented here while allowing patients to pass fragments postoperatively (Table 5), we have since adjusted our practice pattern accordingly to minimize operative times. We argue that the operative times achieved for URS of large stones have resulted in no significant complication or adverse effect on patients, which has allowed stone treatment to be an outpatient procedure even in patients with staghorn calculi.

The primary limitation of this study is that it is retrospective. Another drawback is the relatively small number of patients, precluding powered statistics. There is also limited follow-up data for some patients. These data were generated at a tertiary referral center. Hence, while many of our patients may present to us for this phenomenon, they often will return to their home urologists for follow-up care after the initial postoperative visit. However, the aim of this study was to evaluate the ureteroscopic treatment of these patients and initial results without necessarily following the long-term outcomes.

Conclusions

We have demonstrated that single or multi-stage retrograde ureteroscopic lithotripsy is a safe and effective mode of surgical management of large renal calculi. The total stone burden is a reliable predictor of the need for a staged procedure. Stone size is also a significant predictor of stone-free rate. Stone-free rates are comparable to published series and to those achieved with PCNL.

Author Disclosure Statement

D.H.B. is a consultant for Bard Medical, Olympus, and Cook. All other authors have nothing to disclose.

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Abbreviations Used

AUA = American Urologic Association
COPD = chronic obstructive pulmonary disease
CT = computed tomography
EHL = electrohydraulic lithotripsy
KUB = kidney, ureter, and bladder radiograph
PCNL = percutaneous nephrolithotomy
UAS = ureteral access sheath
URS = ureteroscopy