Int Urol Nephrol (2011) 43:631–638
DOI 10.1007/s11255-010-9880-y

UROLOGY – ORIGINAL PAPER

Alternative management of complex renal stones

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Received: 13 June 2010 / Accepted: 17 November 2010 / Published online: 12 January 2011

Abstract

Introduction The gold standard for treatment of large and complex renal stones is percutaneous nephrolithotomy (PCNL). However, in patients with significant comorbididties, this option may be suboptimal. We reviewed our experiences with ureterorenoscopy and Holmium laser lithotripsy (UL) for the primary management of large and complex intrarenal calculi.

Materials and methods Forty-three patients with large (2 cm or greater in diameter) renal or staghorn calculi were treated with primary UL. Seven patients were morbidly obese, three had solitary kidneys, two had horseshoe kidneys, three had hepatitis C virus, and three were self-pay and refused admission to the hospital. We calculated the total amount of stone burden, location and composition of calculi, number or ureterorenoscopic procedures necessary, and operative time.

Results In 42/44 renal units (95.5%), complete ureterorenoscopic fragmentation of the stone burden was accomplished. The mean number of procedures necessary to clear all stone burden was 2.07 (range 1–5). The mean stone size was 3.63 cm (range 2–9 cm). The mean operative time was 107.4 min per procedure (range 30–230 min). Two patients were treatment failures and required intervention following ureteroscopy. In both, SWL cleared the remaining stone burden. No patient required PCNL, and one patient was admitted for urosepsis.

Conclusion This series demonstrates that ureterorenoscopy and Holmium laser lithotripsy is an effective and safe primary treatment modality for the treatment of large complex kidney stones. It is an attractive alternative to PCNL, particularly in those with comorbid conditions.

Keywords Ureteroscopy · Holmium laser lithotripsy · Calculi · Staghorn

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Introduction

One of the significant dilemmas facing urologist today is how to approach large renal calculi while maximizing efficacy and minimizing complications. Percutaneous nephrolithotomy (PCNL) and shock wave lithotripsy (SWL) have replaced open nephrolithotomy as the primary treatment for renal calculus with PCNL accepted as the gold standard for large (>2 cm) intrarenal stone burdens [1, 2]. Significant advancements have been made in ureterorenoscopy and laser lithotripsy (UL) that is well recognized as standard therapy for proximal and distal ureteral calculi [1–3].

Previous series have reported stone-free rates of 90% utilizing PCNL for renal calculi regardless of stone size or location [1, 2]. The 2004 AUA Staghorn Guideline Update states that PCNL should be the initial therapy in patients with large renal calculi, especially partial and complete staghorn calculi [4]. However, there are several patient cohorts in which PCNL can be complicated or possible contraindicated. These include patients with upper pole calculi, morbidly obese patients, and patients with bleeding diatheses.

Advances in endourology make possible the retrograde endoscopic approach to the upper urinary tract. UL is attractive in those patients whose comorbidities make PCNL and SWL undesirable. While generally accepted as a treatment option for smaller ureteral calculi, there have been few studies examining the efficacy of UL on larger renal and staghorn calculi [5, 6].

We describe our series of patients undergoing primary UL for large (>2 cm) renal calculi irrespective of size or location of the calculi or of patient comorbidities. We present our success, number of procedures required, stone clearance rates, total time required, and treatment failures.

Materials and methods

Forty-three patients (16 men, 26 women) with large (>2 cm) renal calculi underwent primary UL at one major stone center between May 1999 and December 2007. There were 44 renal units. Inclusion in the study was based on clinically significant or obstructing calculi. All patients had standard radiography, urinalysis, and urine culture prior to their procedures. Patients who had undergone prior SWL or other endoscopic procedures were excluded.

All procedures were done with the patient in the standard lithotomy position under general anesthesia. Two guidewires were inserted into the renal pelvis using rigid cystoscopy under fluoroscopy. The patients' ureters were balloon-dilated if necessary to pass the flexible ureteroscope into the renal pelvis over the working guidewire with the second guidewire secure prior to manipulation. Sterile saline irrigation was used, and 200- and 365-mm holmium: YAG laser fibers were used for laser lithotripsy at 5–10 Hz.

Stone fragmentation was performed in an orderly fashion to minimize migration of fragments. Procedures were concluded once visualization decreased due to stone fragmentation or bleeding after which ureteral stents were typically placed. All patients received prophylactic antibiotics for 3–7 days post-operatively. X-rays were obtained at 4 weeks to exclude residual stone fragments. A success was defined as both complete fragmentation and passage of all stone fragments that remained $\leq$2 mm at 3 months post-treatment. Treatment was considered a failure if the X-rays revealed significant residual stone burden requiring SWL.

Results

Patient characteristics

All patients were treated with UL if they had a stone size >2 cm, irrespective of whether they had comorbidities preventing the safe use of other modalities such as PCNL or SWL. Fourteen patients had comorbidities, including six morbidly obese, three solitary kidneys, two horseshoe kidneys, two patients with hepatitis C virus, and one with hemophilia/HIV/HCV. Three patients refused hospital admission due to self-pay status. There were no long-term complications, and all patients were treated as outpatients (Table 1).

Table 1 Patient characteristics

Number of patients	42
Comorbidities	
None	28
Obesity	6
Solitary kidney	3
Horseshoe kidney	2
Hepatitis C virus	2
Hemophilia/HIV/HCV	1
Complications	
Postoperative urosepsis	1
Long-Term	0

Stone characteristics

The patients' mean stone burden was 3.63 cm/renal unit (range 2–9 cm). This represented patients with a single calculus ($n = 22$), multiple calculi ($n = 6$), partial staghorn calculus ($n = 6$), or complete staghorn calculus ($n = 10$). Partial staghorn calculi were defined as stone in the renal pelvis involving one renal calyx, while complete staghorns involved the renal pelvis and more than one calyx. The stones had mostly unknown composition although calcium oxalate, calcium phosphate, uric acid, and cystine stones were found in 10, 7, 6, and one patient (Table 2).

Overall clearance rates

The overall success rate for stone-free status was 95%. The mean number of UL procedures required to obtain stone-free status was 2.07/renal unit (range 1–5) with 31 and 73% cleared after 1 and 2 procedures. Patients requiring only a single treatment tended to have a smaller mean stone size (2.23 cm) than those requiring 3 and 4 treatments (5.6 cm). Five patients required 4 procedures for complete or partial staghorn calculi, and all had stone burdens greater than 4.5 cm. The two failures represented a 5% failure rate, and these patients underwent subsequent SWL to ensure complete clearance (Table 3).

Table 2 General stone characteristics

Size (cm)	
Mean	3.63
Range	2.0–9.0
Number of stones	
Single	21
Multiple	6
Partial staghorn	6
Complete staghorn	11
No. procedures required	
Mean	2.07
Range	1–5
Stone composition	
Unknown	17
Calcium oxalate	10
Calcium phosphate	7
Uric acid	6
Cystine	1
Ancillary procedures needed	
SWL	2

Clearance rates by number of stones or staghorn stone

Patients with single calculi had a 95% stone-free status after two procedures and 100% after three procedures. Patients with partial and complete staghorns had a stone-free rate of 83 and 18% after a second procedure and an overall clearance of 100 and 91%. There were a higher mean number of procedures required for staghorn calculi (mean 3.45 procedures) when compared to single calculi (mean 1.6 procedures). (Table 4).

Clearance rates by size of stones

The overall success rate was similar across size ranges. The number of procedures required for total clearance increased with the size ranges with mean 1.6 procedures required for stones in the <3.0 cm range and mean 3.3 procedures needed for the largest group (Table 5).

Clearance of lower pole stones

Because of prior reports describing high failure rates of UL in lower pole calculi, we examined this subcohort of patients. The 17 renal units in our series with lower pole calculi had a mean stone size of 3.9 cm (Table 6) and an overall clearance rate of 88%.

Surgical time

The mean operative time was 107.4 min for UL (range 30–230 min). The mean time per procedures for partial and complete staghorns was 78.7 and 122.8 min (Table 3).

Description of treatment failures

The two patients were deemed failures after a postoperative X-ray confirmed persistent stone fragments. Both of these patients underwent SWL to clear the remaining stone burden. Neither of the failures occurred in patients with a single calculus (Table 7).

Table 3 Overall clearance rates

Number of procedures	Number renal units	Size in cm (range)	Cumulative clearance (%)	Time/proc in minutes	Failures
1	14	2.5 (2.0–4.8)	31.8	110.4	0
2	19	3.0 (2.0–6.0)	75	92.5	1
3	4	6.5 (5.0–9.0)	84.1	132.2	1
4	6	4.58 (4.5–6.5)	93.2	115.6	0
5	1	7	95.5	118.6	0

Table 4 Clearance by number of stones/staghorn stones

Number of stones	No. renal units	Mean size in cm (Range)	Mean no. procedures (Range)	Cumulative clearance (%)	Failures
Single	21	2.7 (2.0–5.6)	1.6 (1–3)		
Procedures					
First	10			48	
Second	10			95	
Third	1			100	
Multiple	6	2.4 (2.0–3.0)	1.6 (1–2)		
Procedures					
First	3			43	1
Second	3			86	
P Stag	6	3.9 (2.7–9.0)	2.2 (1–4)		
Procedures					
First	1			17	
Second	4			83	
Fourth	1			100	
Staghorn	11	5.95 (2.5–9.0)	3.45 (1–5)		
Procedures					
First	0			0	
Second	2			18	
Third	3			36	1
Fourth	5			82	
Fifth	1			91	

P Stag Partial staghorn calculus, *Stag* staghorn calculus

Discussion

Large renal calculi represent a significant therapeutic dilemma to urologists. Several treatment modalities exist for the treatment of renal calculi including open nephrolithotomy, PCNL, SWL, and UL. When deciding how to treat these stones, several considerations must be entertained, including the patient's stone burden, the safety and risks and efficacy of each treatment, and the operative time and costs required to clear the calculi.

Shock wave lithotripsy and renal calculi

SWL is desirable because it is easy to use, noninvasive and has minimal morbidity. It has a reported success rate of 70–90% for smaller (<1 cm) renal calculi although clearance rates drop as the stone burden increases [7–9]. Treatment outcomes for SWL can be variable and secondary to multiple factors. Residual fragments have been shown to persist or grow in as many as 60% of patients and become symptomatic or require intervention in as many as 71% [10].

Table 5 Clearance rates by size of stone burden

Stone burden	No. renal units	Mean no. procedures (Range)	Cumulative clearance (%)	Time (min/proc)	Failures
Overall					
3.63 cm	44	2.1	95.6	109.2	2
<3.0 cm	21	1.6 (1–2)		111.2	
Procedures					
First	9		39		
Second	12		96		1
3.0–5.0 cm	11	2.1 (1–4)		98.3	
Procedures					
First	4		36		
Second	4		73		
Third	1		82		
Four	2		100		
>5.0 cm	11	3.3 (1–5)		114.3	1
Procedures					
First	0		0		
Second	3		27		
Third	3		45		
Fourth	4		82		
Fifth	1		91		

Table 6 Lower pole stone characteristics

Number procedures	Number renal units	Size in cm (range)	Cumulative clearance (%)	Time/procedure (minutes)	Failures
LP stones	17	3.8 (2.0–9.0)	88.2		
1	7	2.3 (2.0–3.0)	41.2	111	
2	5	3.1 (2.5–5.1)	64.7	100.7	1
3	2	7.8 (6.5–9.0)	70.6	130.2	1
4	1	6.0 (Ø)	88.2	144.8	

LP Lower pole

Table 7 Treatment failures

Pt. #	Size (cm)	Number	Procedures	Ancillary	Reason
1	2	Multiple	2	SWL	LP
2	9	Staghorn	3	SWL	LB

Stag Staghorn calculus, *SWL* Shock wave lithotripsy, *LP* Lower pole, *LB* Large burden of stone

The 2004 AUA Staghorn Guideline Update reports an overall success rate for SWL of 54% with partial staghorn calculi cleared at a rate of 60% and complete staghorn only at a rate of 42%. It reports that 3.6 procedures were required to achieve the overall clearance rates, with partial and complete staghorns requiring 2.1 and 3.7 procedures [4].

Percutaneous nephrolithotomy

For larger calculi (>2 cm), many series have advocated the PCNL approach with clearance rates up to 90% [2]. This coincides with progress obtained over the past decade in reducing the overall morbidity of percutaneous stone removal. However, these stone clearance rates are influenced by both the volume of stone burden as well as the anatomy of the collecting system. Segura et al. reported results of PCNL-based therapy of patients stratified by stone surface ranged from a 94.4% clearance rate for surface area 0–500 mm [2], to 53.9% for a surface area more than 2,500 mm [2].

The 2004 Update also reports an overall success rate for PCNL of 78%, requiring a mean of 1.9 procedures. Partial staghorn calculi demonstrated 74% clearance and 65% clearance for complete staghorns [4]. A recent series on PCNL reported a stone-free rate approaching that of open extraction, with lower morbidity, shorter operative time, shorter hospital stay, and earlier return to work compared to open surgery [11].

Despite the advancements, PCNL still exposes patients to risks of blood transfusions, partial renal loss and required inpatient hospital stay [12]. Many patients present with comorbidities that preclude the safe use of PCNL.

Contraindications to PCNL and SWL

Morbid obesity and bleeding diatheses are contraindications for PCNL or SWL unless the latter can be corrected, and the presence of upper pole calculi is a relative contraindication to PCNL. Lower pole calculi have also demonstrated sub-optimal clearance rates with SWL and difficult access with UL despite highly deflectable ureteroscopes.

Several factors exist favoring endoscopic approaches over SWL including resilient stone composition and inability to image and localize calculi. The urologist must proceed with more invasive options (PCNL or open extraction) that are less ideal in the general population compared to UL in terms of complications and recovery and especially in patients with comorbidities.

Bleeding diatheses

In patients with bleeding diatheses, complication rates from PCNL and SWL have been shown to be significantly higher than those undergoing UL even when clotting factors are normalized. The length of hospitalization has been shown to be longer in these patients compared to those with no known coagulopathy. In a large series, Linger et al. reported complication rates in patients with coagulopathy to be 33.3% for both PCNL and SWL and 0% for those undergoing UL. While the cost of treatment was higher in coagulopathic patients undergoing UL, it was not as pronounced as the difference in cost of treatment for patients undergoing SWL [13].

Obesity

In obese patients, access to renal calculi with SWL or PCNL is challenging. Obese patients may be too large for the SWL table, and the distance to the stone may be longer than the lithotripter's focal length. Larger patients have demonstrated a decreased chance of success with SWL with body mass index (BMI) as a variable having been found to be an independent predictor of success [14].

PCNL can also be more difficult in obese patients. Longer instruments and sheaths are required to reach the collecting system, and there is increased morbidity in obese patients who require prolonged anesthesia while prone. These patients often have significant comorbidities that accompany their obesity, such as cardiovascular disease and diabetes mellitus. Few studies report any increase in complication rate, transfusion rate, or hospital stay in obese patients compared to those with normal BMI [15].

Upper pole calculi

In patients with upper pole stones, percutaneous lithotripsy often requires supracostal access. This has been associated with a significant complication rate including pneumothorax and hemothorax with rates as high as 10–30% for a supracostal 12th rib approach, and 25–35% with an 11th rib approach [16]. Another possible complication is development of a nephropleural fistula. Ng et al. [17] described their investigation into prone helical CT scans in inspiratory/expiratory phases that shows promise in providing detailed anatomical relationships between the kidney and surrounding structures to help in planning for patients whose stone burden requires upper pole access or those in whom the percutaneous approach is not appropriate.

Ureterorenoscopy and laser lithotripsy

Retrograde UL as a primary therapy for large renal calculi has been described with varying success. Advancements in technology including deflectable ureteroscopes and holmium: YAG lasers have allowed the indications for UL to evolve as a realistic primary option [18, 19]. While Dretler originally reported on eight patients undergoing staged flexible ureteroscopy for staghorn calculi, all required subsequent SWL for residual calculi [20].

Grasso et al. published a series of UL patients, 45 of whom had large (>2 cm), intrarenal calculi. They reported a success rate of 76% after a single session (although only 60% actually underwent a single session since 16% were deemed stone-free after anesthesia and a second look). After two sessions, 91% had successful fragmentation, and after three sessions, 93% had success. They reported three failures overall, all of who underwent PCNL. They reported no long-term complications [6].

Recently, Hyams et al. reported on 120 patients with large (2–3 cm) renal calculi treated with UL. Ninety-four patients (78%) underwent outpatient surgery although 31 (26%) required preoperative stent placement. One hundred and one patients (84%) underwent a single UL. Seventy-six patients (63%) had residual stone burden of 0–2 mm, and 100 (83%) had residual burden of <4 mm. The reoperation rate was only 2.5%, and complications rate was 6.7% [5].

Our mean stone size of 3.63 cm is one of the largest reported. Outpatients required a mean of 2.07 procedures to achieve stone-free status, and none required more than 5 treatments. The overall clearance rate was 31% after one procedure and 73% after two procedures, and ninety-six percentage of patients with stones <3.0 cm and 73% of patients with stones in the 3.0–5.0 cm range were cleared after two procedures. Four procedures were needed to clear 93.2% of patients, and only one patient required a fifth procedure. The two patients who failed did so after the second procedure and both had lower pole calculi and both were cleared with subsequent SWL. The overall success rate of lower pole calculi was 88.2% (15 of 17).

All of these series have established UL as an efficacious treatment modality for larger renal calculi, with results nearing those of more invasive percutaneous techniques and with minimal morbidity. Our series supports these findings and advances the usefulness of UL in patients presenting with significant stone burden in the presence or absence of contraindications to invasive access. All of our patients were candidates for PCNL, 28 of who presented with no comorbidities and 14 of who demonstrated comorbidities although none were absolute contraindications.

We hope that this series will give some additional insight with regard to particular stone burden, including number, size, and location of stones. We did notice that patients with multiple stones and staghorn calculi required more treatment. However, our clearance rate did not decrease as the mean size of the stones increased. A secondary aim of this report would be to guide practitioners to have realistic expectations regarding the number of procedures and time required performing procedures when confronted with a particular patient profile.

Conclusions

Primary UL for large renal calculi is a real treatment option and should be considered in all patients regardless of stone size and location. It is realistic to expect complete success after two UL procedures for most patients, certainly in those with stone size <4.0 cm and even in the majority of those with burden up to 5.0 cm. This compares favorable to PCNL clearance rates and required number of procedures and thus is an excellent option in those patients who present with comorbidities, specifically bleeding diatheses, obesity, or upper pole calculi. For those who do fail primary UL, however, PCNL and SWL do remain as options.

References

1. Segura JW, Patterson DE, LeRoy AJ, Williams HJ, Barrett DM, Benson RC, May GR, Bender CE (1985) Percutaneous removal of kidney Stones: review of 1,000 cases. J Urol 134:1077
2. Albala DM, Assimos DG, Clayman RV et al (2001) Lower pole I: a prospective randomized trial of extracorporeal show wave lithotripsy and percutaneous nephrolithotomy for lower pole nephrolithias—initial results. J Urol 166:2072
3. Wu CF, Shee JJ, Line WY et al (2004) Comparison between extracorporeal shock wave lithotripsy and semi-rigid ureterorenoscope with holmium: YAG laser lithotripsy for treating larger proximal ureteral stones. J Urol 172:1899
4. American Urologic Association Staghorn Guideline Update, March 2004
5. Hyams ES, Munver R, Bird GV et al (2010) Flexible ureterorenoscopy and holmium laser lithotripsy for the management of renal stone burdens that measure 2 to 3 cm: a multi-institutional experience. J Endourol 24:1583
6. Grasso M, Conlin M, Bagley D (1998) Retrograde ureteropyeloscopic treatment of 2 cm or greater upper urinary tract and minor staghorn calculi. J Urol 160:346

7. Renner CH, Rassweiler J (1999) Treatment of renal stones by extracorporeal shock wave lithotripsy. Nephron 81:71
8. Kupeli B, Biri H, Sinik Z et al (1998) Extracorporeal shock wave lithotripsy for lower calyceal calculi. Eur Urol 34:203
9. Lingeman JE, Siegel YI, Steel B et al (1994) Management of lower pole nephrolithiasis: a critical analysis. J Urol 151:663
10. Okeke A, Lam JS, Gupta M (2004) Use of ureteral access sheath to facilitate removal of large stone burden during extracorporeal shock wave lithotripsy. Urology 63(3):574
11. Al-Kohlany KM, Shokeir AA, Mosbah A et al (2005) Treatment of complete staghorn stones: a prospective randomized comparison of open surgery versus percutaneous nephrolithotomy. J Urol 173:469
12. Busby JE, Low RK (2004) Ureteroscopic treatment of renal calculi. Urol Clin North Am 31:1
13. Klingler JC, Kramer G, Lodde M et al (2003) Stone treatment and coagulopathy. Eur Urol 43(1):75
14. Marcovich R, Smith A (2003) Renal pelvic stones: choosing shock wave lithotripsy or percutaneous nephrolithotomy. Int Braz J Urol 29:195
15. Pearle MS, Nakada SY, Womack JS, Kryger JV (1998) Outcomes of contemporary percutaneous nephrostolithotomy in morbidly obese patients. J Urol 160(3 Pt 1):669
16. Lallas CD, Delvecchio FC, Evans BR et al (2004) Management of nephropleural fistula after supracostal percutaneous nephrolithotomy. Urology 64:241
17. Ng CS, Herts BR, Streem SB (2005) Percutaneous access to upper pole renal stones: role of prone 3-dimensional computerized tomography in inspiratory and expiratory phase. J Urol 173:124
18. Preminger GH, Kennedy TJ (1987) Ureteral stone extraction utilizing non-deflectable flexible fiberoptic ureteroscopes. J Endourol 1:31
19. Johnson GB, Grasso M (2004) Exaggerated primary endoscope deflection: initial clinical experience with prototype flexible ureteroscopes. BJU Int 93:109
20. Dretler SP (1994) Ureteroscopic fragmentation followed by extracorporeal shock wave lithotripsy: a treatment alternative for selected large or staghorn calculi. J Urol 151:842