ORIGINAL RESEARCH

Single-stage Ureteroscopic Ho:YAG Laser Lithotripsy for Multiple and Bilateral Ureteral Stones

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Multiple and bilateral ureteral stones pose therapeutic challenges to the urologist. The authors we reviewed their experience with single-stage ureteroscopic Ho:YAG intracorporeal laser lithotripsy (ICL) as monotherapy for patients with bilateral obstructive and multiple unilateral ureteral calculi.
Methodology: A retrospective chart review was done on all patients diagnosed with multiple unilateral or bilateral ureteral calculi from July 2009 to May 2012. All stones were diagnosed using a helical unenhanced CT scan. A 9.5Fr semi-rigid ureteroscope (Storz®) was used and intracorporeal lithotripsy was performed using a Ho-YAG laser machine (Sphinx®) by urologists of varying experiences in a single institution. Stone-free status was defined as total stone residual of < 3mm. based on a repeat ultrasound or CT scan.
Results: A total of 63 patients diagnosed with multiple unilateral (45) or bilateral (18) ureteral stones.
The mean stone number per patient was 2.46±1.71 and the mean stone burden was 1.36±0.91cm. The mean operative time was 88.62±75.40mins. The over-all stone-free rate after a single session was 98%. The stone-free rate after a repeat ureteroscopy was 100%. Thirteen patients (21%) developed fever (Clavien 1) and one patient (1%) developed died of uremic complications (Clavien 5).
Conclusion: Ureteroscopic Ho:YAG laser lithotripsy is effective as monotherapy for multiple or bilateral stones with an acceptable low complication rate.

Key words: Holmium YAG laser, ureteroscopy, multiple and bilateral ureterolithiases

Introduction

The management of ureterolithiasis has greatly evolved over the past few years. Previously, open stone surgery was the treatment of choice since the first ureterolithotomy done in 1882. In recent years, the advent of small caliber ureteroscopes and advances in intraureteral lithotripsy has allowed successful and safe endoscopic treatment of ureteral calculi, which paved the way for the steady shift towards minimally invasive surgery. The search for the best energy source for the intracorporeal lithotripsy (ICL) resulted to the development of various energy sources such as pneumatic, ballistic, ultrasonic and other earlier forms of laser to its most recent form, the Holmium:YAG Laser lithotripter (Ho:YAG).[1] This is a laser whose active medium is a crystal of Yttrium, Aluminum, and Garnet doped with Holmium ions.

Ho:YAG laser is considered the preferred energy source for intracorporeal lithotripsy.[2] This

is because neither stone composition nor size alters its ability to disintegrate stones.[4] This ease of stone fragmentation abbreviates the operative time, thus providing a higher safety profile compared to its counterparts.[3] In contrast, both the pneumatic and electrohydraulic energy sources are limited by large stone volume and high stone durility (hardness measured in Hounsfield units).

In May 2009, the National Kidney and Transplant Institute acquired the LISA Sphinx® Ho:YAG laser machine. Its ablative effect is based on the high absorption of the Holmium laser energy in water and in biological tissue containing water. The pulsed energy of the laser radiation is converted into heat within a depth of less than 0.5 mm, making it ideal for use in ablation processes. This technology may be used for all ureterolithiasis regardless of its location, and bladder calculi. Since its acquisition, 575 patients had undergone laser lithotripsy for varying types of urinary tract calculi from May 2009 to December 2011.

There are limited studies reporting the utility ureteroscopic lithotripsy for multiple and bilateral ureteral calculi. The multiplicity and high stone burden may lead to lengthy operative times and potential risk of ureteral injury and may therefore be considered as a relative contraindication to Ho:YAG laser lithotripsy. In these situations, laparoscopic or open ureterolithotomy is considered a viable alternative.

The authors reviewed their experience on a single-stage ureteroscopic Ho:YAG laser lithotripsy for multiple and bilateral ureterolithiasis from May 2009 up to June 2012, analyzing patient and stone demographics including age, gender, stone location, laterality, stone size and number. The clinical outcome parameters included operative time, stone-free rates, intraoperative and postoperative complications, retreatment rates and utility of ureteral stents.

Materials and Methods

A retrospective chart review was done on all patients who were diagnosed with multiple and bilateral ureterolithiasis treated with single-session monotherapy with ureteroscopic Ho:YAG lithotripsy between the study period May 2009 to June 2012, including all patients who were treated either as outpatient or inpatient basis.

The patient demographics included age and gender. Stone characteristics included stone location and laterality, number and size of stone, operative time, stone clearance rates, complication rates, length of hospital stay, and use of ureteral stents. Subsequent postoperative emergency room visits were also noted. Data were statistically treated using incidence ratios and described using a frequency distribution table per gender versus frequency.

Results

There were a total of 63 unique patients (45 multiple unilateral, 18 bilateral) who were included in the study. There were 30 males and 32 females. The mean age was 51.1±27.89 years (Range 20-82). Among the 63 patients, there were 138 cumulative number of stones found in the varied locations. About 43% (59/138) were found in the distal, 42% (58/138) in the proximal and the 15% (21/138) in the middle ureter. In 7 cases, the exact number of stones could not be verified.

Table 1. Summary of stone location and laterality.

Stone Location	Multiple Unilateral	Bilateral	Total
Distal	41	18	59
Middle	15	6	21
Proximal	34	24	58
Grand Total	90	48	138

The mean stone number per patient was 2.46±1.7 (Range:2-7). The mean stone size is 1.36±0.91cms. (Range: 0.3-3.0) (Table 2). The mean operative time was 88.62±75.4mins (Range 30-195). Forty-nine patients (78%) did not have any intraoperative or postoperative complications. Thirteen patients (21%) developed transient low-grade fever which abated with continuous use of intravenous antibiotics. There was one mortality (1%) in a 68-year-old diabetic female with uremia, developed sepsis on the first postoperative day and subsequently succumbed after forty-eight hours. (Table 3).

Table 2. Summary of the number of stones, stone size in relation to operative time.

	Minimum	Maximum	Mean	SD	95% CI
Number of Stones	2	7	2.46	0.87	2.46 ± 1.71
Stone Size	0.3	3	1.36	0.46	1.36 ± 0.91
Operative Time	30	195	88.62	38.47	88.62 ± 75.40

Table 3. Summary of complication rates among patients undergoing ureteroscopic laser lithotripsy.

Complication	Frequency	Percentage
Fever	13	20.6%
Mortality	1	1.6%
None	49	77.8%
Grand Total	63	100.0%

Majority of patients required insertion of an indwelling ureteral stent (84.1%) while the rest had open-ended ureteral catheters (11.1%). All patients with bilateral stones had bilateral stents inserted intraoperatively. Three out of 45 patients (3.2%) with multiple unilateral ureterolithiasis had no indwelling stents upon discharge (Table 4). Eighteen (28.6%) patients underwent the procedure on an outpatient basis while the rest were admitted. About half of admitted patients had a mean length of stay of 2.2±2.25 days. (Table 5).

Discussion

Multiple unilateral or bilateral ureterolithiases present unique therapeutic challenges to the urologist. Multiplicity results to a higher grade of obstruction and when present bilaterally can cause acute renal dysfunction, which may progress to renal failure. Both conditions may also be complicated by infection, which can result to acute pyelonephritis, pyonephrosis, bacteremia and urosepsis.

Table 4. Summary of ureteral drainage techniques after Ho:YAG laser lithotripsy.

Type of ureteral drainage	Frequency	Percentage
Indwelling ureteral catheter	53	84.1%
No indwelling ureteral catheter	3	4.8%
Open-ended ureteral catheter	7	11.1%
Grand Total	63	100.0%

Table 5. Length of hospital stay.

Hospital Stay	Frequency	Percentage
1	15	23.8%
2	16	25.4%
3	7	11.1%
4	5	7.9%
5	2	3.2%
OPD	18	28.6%
Grand Total	63	100.0%

Therapeutic options include extracorporeal shock wave lithotripsy (ESWL), ureteroscopic lithotripsy, percutaneous nephrolithotripsy (PCNL), and laparoscopic or open ureterolithotomy. ESWL is limited when total stone size or burden exceeds 2cm. It requires repetition and therefore may delay relief of obstruction. Its ability to clear stones completely is limited when there is hydronephrosis. PCNL is sometimes applied to upper ureteric stones when attempts at ureteroscopic lithotripsy fail, and when there is retrograde migration of the stones in the kidney. Antegrade access may also be attempted to clear the ureteric stones with flexible ureteroscopy inserted through the Amplatz sheath. In fact, multiple ureteral stones can also be approached in a combined retrograde and antegrade approaches.

Laparoscopic or open ureterolithotomy may be done when all attempts at endoscopic management fail. These last two options are however, seldom necessary when endourologic instrumentation and expertise are available. When done for large volume stones, laparoscopic ureterolithotomy (transabdominal or retroperitoneal) confers the unique advantage of a shorter operative time. However, obstacles may be encountered as a result of difficult intracorporeal suturing.

The authors performed a single-stage ureteroscopic lithotripsy on all their patients. Their

study showed that stone size, stone number and location did not affect stone-free clearance rates. The clearance rate was high (98-100%) even among stones in the proximal ureter. The largest stone size treated was 3 cm and the most number of stones in a single patient was seven. Only 28% of the cases were done as an outpatient procedure while the rest were admitted for 2 days. All of the cases required ureteral drainage with either an indwelling ureteral stent or temporarily with an open-ended ureteral catheter. One case with residual stones required a repeat ureteroscopic procedure because of machine malfunction.

The complication rate was low for both bilateral and multiple ureterolithiasis. Thirteen patients developed low to high-grade fever but all responded to continuous intravenous antibiotic therapy. Neither ureteral perforation nor ureteral avulsion occurred in any of their patients. The single mortality occurred in a 68-year-old diabetic female with bilateral ureteral obstruction with uremic complications. She continued to require dialysis postoperatively and developed urosepsis and septic shock. Indeed, patients with bilateral high-grade ureteral obstruction resulting from multiple large stones in the ureter are high-risk for developing morbidity. These patients are most likely to have azotemia or uremia depending on the degree and length of bilateral obstruction. When other medical co-morbidities are present such as advanced age, diabetes, hypertension, ischemic heart disease, bacteremia, the mortality risk is also increased. For this reason, a staged procedure may be required such a preliminary drainage with either a percutaneous nephrostomy tube or an indwelling ureteral stent. Once renal function is recovered or when the infection is resolved, the ureteroscopic lithotripsy may then be pursued at a later time when the patient is more clinically stable. In fact, this therapeutic strategy could have been applied to the patient who died in this series and it may have even altered her unfortunate outcome. Ureteral stent placement or nephrostomy tube insertion may improve renal recovery until such time that the patient is more clinically stable. Grossi, et al. showed that bilateral synchronous ureteroscopy for bilateral ureteral stones can be performed safely with high stone-free rate. It offers the advantage of single operating room visit, single anesthesia experience and shorter number of hospital days.

The authors believe that treatment for bilateral stones should be individualized and tailored to the patients' needs. Patients with a more serious condition should be treated in a staged manner including preliminary diversion of urine to recover renal function, followed by either a single-staged synchronous ureteroscopic manipulation or bilateral staged ureteroscopic lithotripsy. In the case of multiple unilateral stones, the pressing indication for a staged procedure would be the presence of pyohydronephrosis, bacteremia and urosepsis. In this instance, percutaneous nephrostomy drainage is needed before any ureteroscopic intervention.

Irritative voiding symptoms are commonly seen among patients who have indwelling ureteral stents. In this study, these were experienced by all patients and were in fact, more prominent when the stents were bilateral. Stone-free rate was around 98% for both multiple and bilateral ureterolithiases and 100% on a patient who required a repeat ureteroscopic laser lithotripsy.

Conclusion

Current experience confirmed that indeed multiplicity of ureteral stones in both single and bilateral renal units are not a contraindication to ureteroscopic management and indeed these patients may be treated with a single-stage ureteroscopic lithotripsy, attaining a high stone free rate without increasing the chance of complications.

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