UIJ UroToday International Journal®

www.urotodayinternationaljournal.com
Volume 5 - August 2012

A Multi-institutional Study Demonstrating the Safety and Efficacy of Holmium Laser Ureterolithotripsy

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Submitted April 17, 2012 - Accepted for Publication June 17, 2012

ABSTRACT

Purpose: To present the results of a large multi-institutional series of patients treated with ureteroscopic holmium laser lithotripsy (UHLL) for ureteric stones; demonstrating its safety and efficacy in different age groups, stone locations, and other special situations.

Materials and Methods: The medical records of 239 patients with ureteral stones managed by UHLL were reviewed. Patients' medical records were reviewed for age, sex, stone laterality, location, the number and size of stones, the need for ureteral dilation, stenting, and residual fragment extraction.

Results: The 239 patients included 199 males and 40 females. The mean age was 40.6 years (range: 5 to 93 years). Six patients had bilateral ureteric stones that were managed in 1 session. The average stone burden was 9.8 mm (range: 4 to 20 mm). The 239 patients harbored 272 ureteral stones and underwent 255 UHLL sessions. Acute ureteral dilation was performed just prior to ureteroscopy in 73 procedures (28.6%). Stone retrieval was done in 124 (48.6%) of the procedures. Twenty-six patients presented with renal insufficiency and were rendered stone-free with UHLL. Following ureteroscopy, minimal stone clearance was noted on the first postoperative day (20%) but improved to 96% after 3 months. The success rate after a single session was 96.3% and increased to 99% after 2 sessions.

Conclusion: This study demonstrates that the use of holmium laser lithotripsy is a safe and effective modality in the treatment of ureteral stones regardless of sex, age, stone location, or stone size. Good stone clearance was also obtained in patients with renal impairment.

INTRODUCTION

Endoscopes were introduced in urologic surgery in 1806 [1]. The first ureteroscopy was performed with a cystoscope in 1912 by Hugh Hampton Young [2]. By the mid and late 1980s, improvements in design and engineering had resulted in the development and miniaturization of ureteroscopes and a corresponding decrease in ureteral trauma associated with the procedure [3,4].

Stone treatment remains a major indication for both rigid and flexible ureteroscopy. Although some calculi can be removed intact with ureteroscopy, most require fragmentation before safe removal [5]. The advent of small caliber ureteroscopes and

KEYWORDS: Urinary stones, ureteral calculi, lithotripsy, laser, anuria

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CITATION: *UroToday Int J*. 2012 August;5(4):art 34. http://dx.doi.org/10.3834/uij.1944-5784.2012.08.07

UroToday International Journal®
original study
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the advances in intracorporeal lithotripsy have allowed the consistent, successful, and safe management of ureteral stones [6].

A wide range of endoscopic lithotriptors have become available for the fragmentation of urinary calculi, which can be divided broadly into direct contact mechanical lithotriptors, devices that work by means of a shock-wave effect, and laser lithotriptors [7].

Herein we present the results of a large multi-institutional experience demonstrating the safety and efficacy of holmium lasers as an endoscopic lithotrite for the management of ureteric stones considering gender, different age groups, stone locations, the use of ancillary procedures, and the presence of other complex clinical situations.

MATERIALS AND METHODS

The medical records of 239 patients with ureteral stones managed at the University of Arkansas for Medical Sciences, United States, and Assiut University Hospitals, Egypt, were included in this study over a period of 3 years. All patients with symptomatic ureteral stones were included in this study. All patients were evaluated preoperatively with historic, clinical, radiological, and laboratory assessment. They were all managed with ureteroscopic holmium laser lithotripsy (UHLL) on an outpatient basis. All procedures were performed under fluoroscopic guidance.

All patients were given perioperative antibiotics. All patients were treated with ureteroscopy (6.9 F semirigid or flexible ureteroscopes) and a Holmium:YAG laser utilizing a 365 µm laser fiber. A direct fragmentation technique was employed in all procedures. If large fragments were present after stone disintegration, they were retrieved using forceps or basket extraction. No devices were used to guard against stone migration. The success rate was determined by the stone-free status, which was determined at the completion of each endoscopic treatment at 6 weeks and 3 months, postoperatively, and was determined by either endoscopic visualization at the end of the procedure only and/or radiologic evaluation at 6 weeks and 3 months, postoperatively. Earlier in the series, ureteric stents were routinely utilized. Subsequently stent utilization was selective.

RESULTS

The 239 patients included 199 males (83.3%) and 40 females (16.7%). The mean age was 40.6 years (range 5 to 93 years). The 239 patients underwent 255 ureteroscopic laser procedures. They harbored 272 ureteral stones (79 proximal ureteral, 60 middle ureteral, and 133 lower ureteral). There was no significant difference in stone laterality. Six patients with bilateral ureteric stones were managed in 1 session. The average stone burden was 9.8 mm (range: 4 to 20 mm). Main presenting symptoms were renal colic, hematuria, anuria, urinary tract infection, or a combination of these symptoms.

Fifteen children (age range 2 to 15 years) were treated with UHLL. Female patients predominated in this age group (4 males and 11 females).

Ureteral dilation was performed in 73 procedures (28.6%) using balloon or Teflon dilators. Stone retrieval was done in 124 patients (48.6% of the procedures). Of the 239 patients, 26 (10.8%) had renal insufficiency (serum creatinine: 2.1 to 7.6 mg %) or obstructive anuria (6 patients; mean serum creatinine: 22 mg %). All patients were treated definitively by UHLL and rendered stone free. Laser-power use ranged from 2.5 to 16 watts (mean: 9.3 watts). There was no significant difference in stone size or location affecting the success rate.

When radiologic imaging was performed on the first postoperative day, minimal stone clearance was noted (20%), but this increased to 96% after 3 months. The success rate after a single session was 96.3% and it increased to 99% after 2 sessions at 3 months, postoperatively, with an eventual failure rate of 1% (in 2 patients with a stone burden of 20 mm; they were managed by conversion to open ureterolithotomy). Low-grade fever, renal colic, and minimal hematuria were the most common postoperative complications and resolved with conservative treatment. Complications and their rate are noted in Table 1.

DISCUSSION

The Holmium:YAG laser is a pulsing, solid-state laser with a wavelength of 2100 nm and a frequency of 5 to 30 Hz. It is different from other lasers because it does not cause forward scatter (i.e., the effect observed is the only tissue effect achieved), such as the neodymium:YAG, and unlike the CO_2 laser, it can be carried through a flexible fiber [5]. The Holmium laser mechanism of action, with its unique characteristics of longer pulse duration and wavelength, is related to a photothermal mechanism that occurs by direct absorption of the holmium energy by the stone. In other words, the stone is literally melted [8]. Several different patterns of fragmentation can be employed to achieve stone removal, including "drill and core," "ablate and chip," or "direct fragmentation" [9].

UIJ / Vol 5 / Iss 4 / August / http://dx.doi.org/10.3834/uij.1944-5784.2012.08.07
ISSN 1944-5792 (print), ISSN 1944-5784 (online)

Table 1. Complications and their management.
http://dx.doi.org/10.3834/uij.1944-5784.2012.08.07t1

Complication	No. of Patients (%)	Management
Low-grade fever	2	oral antipyretic
Renal colic	1	parenteral antispasmodic
Minimal hematuria	2	IV fluids
Total	5 (2%)	

Several studies, smaller than the present study, have demonstrated the efficacy and safety of Holmium laser lithotripsy in the management of ureteral and renal calculi. Razvi et al. [10] utilized the Holmium:YAG laser for intracorporeal lithotripsy in 75 patients with 79 stones (71 ureteral and 8 calyceal). They achieved complete stone fragmentation without the need for additional procedures in 85% of cases.

In a study by Biyani et al., 48 patients with ureteric stones were treated with the Holmium:YAG laser. All except 1 patient were rendered stone free at 8 weeks. This patient required repeat ureteroscopy and laser lithotripsy. They reported 1 incidence of ureteric perforation while trying to drill multiple holes in a large stone [11].

Grasso and Chalik [12] reported their experience with the Holmium:YAG laser as an endoscopic lithotrite with a 97% success rate in the treatment of 34 ureteral stones.

Yip et al. [13] utilized Holmium laser lithotripsy for ureteral calculi as an outpatient procedure in 69 patients (18 upper, 17 middle, and 34 lower). They reported a success rate of 91%.

In 1999, Tawfiek and Bagley [14] reported their experience with ureteroscopic holmium laser lithotripsy in the management of upper urinary tract calculi in 155 patients. Patients included 59 (38.1%) with renal calculi, 82 (52.9%) with ureteral calculi, and 14 (9%) with both renal and ureteral calculi. All but one of the 82 patients with ureteral calculi (29 proximal, 19 mid, and 34 distal) were successfully cleared of stones after 1 endoscopic procedure. One patient with a proximal ureteral calculus had a 4 mm residual fragment in the kidney.

In an initial experience from Japan for the endoscopic management of upper urinary tract disease in 25 patients, including 19 patients with 20 stones (16 ureteral, 3 lower calyx, and 1 middle calyx), Mugiya and his colleagues [15] used laser lithotripsy in all 16 patients with ureteral calculi, with a reported success rate of 100%.

In a recent study of 205 patients with ureteric stones managed by ureteroscopic Holmium laser lithotripsy, procedure failure was reported in 10 patients (4.9%) due to the inability to introduce the ureterorenoscope. The overall success rate was 95.1%. Ureteral perforation occurred in 3 patients (1.5%) and was managed by double-J stent placement [16].

To our knowledge, this is one of the largest reported series of ureteric stones managed by Holmium laser lithotripsy. Our success rate of 99% after 2 sessions is consistent with other reports. Our experience with the Holmium:YAG laser confirms that it is a safe and effective modality of intracorporeal ureterolithotripsy irrespective of gender, age group, stone location, and stone size. It is also effective and safe in patients with renal impairment.

The overall complication rate related to laser lithotripsy is low in all series. Our complications included brief occurrences of fever, colic, and hematuria, and all issues were resolved with conservative treatment. There were no prolonged or long-term complications noted in our series. The procedure can be performed on an outpatient basis in most patients.

CONCLUSION

Our results confirm the effectiveness and safety of the Holmium laser in the treatment of ureteral stones in males and females of all age groups, regardless of stone size, at all stone locations, and in special clinical situations for renal impairment.

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