SEMI-RIGID URETEROSCOPIC PNEUMATIC LITHOTRIPSY VERSUS HOLMIUM:YAG LASER LITHOTRIPSY FOR THE TREATMENT OF SINGLE URETERAL STONES: A PROSPECTIVE STUDY IN A SINGLE INSTITUTE

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Abstract:

Objective: *To compare the success rates and complications of Lithoclast and holmium laser-assisted ureterorenoscopy (URS) in managing ureteral stones.*

Material and Methods: *We prospectively analyzed the records of 35 patients with ureteral stone who underwent ureteroscopic lithotripsy at our institution from January 2018 to February 2019. In 15 patients (mean stone size 12.6 mm), pneumatic lithotripsy was used; in 20 patients (mean stone size 11.6 mm), laser lithotripsy was performed. Patients were monitored as outpatients at 3 weeks and at 3 months with a kidneys, ureters, and bladder radiograph and ultrasonography. Patients with migrated stones or incomplete clearance underwent an auxiliary procedure such as shockwave lithotripsy (ESWL) or repeated URS.*

Results: *Successful fragmentation included complete stone clearance seen on a KUB radiograph or USG at 3 weeks after URS. This occurred in 11/15 (73.3%) patients in the Lithoclast group and in 18/20 (90%) in the laser group. Auxiliary procedures included ESWL 2 patients in the Lithoclast group and 1 patient in the laser group) or repeated URS (two in the Lithoclast group). Urosepsis after URS occurred in 2/15 (13.3%) patients in the Lithoclast group and 2/20 (10.0%) patients in the laser group.*

Conclusion: *In our study, the fragmentation rates of holmium laser-assisted ureteroscopy were significantly better. The complications and the need for auxiliary procedures were significantly less for holmium laser-assisted ureteroscopy when compared with pneumatic lithotripsy.*

Key words: *Lithotripsy, Ureteroscopic Pneumatic Lithotripsy, Holmium:YAG Laser Lithotripsy, Ureteral Stones.*

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Introduction:

In the course of the last decade up to the present day, the treatment of urinary lithiasis has changed considerably. Traditionally, extracorporeal shock wave lithotripsy (ESWL) was preferred for the treatment of stones located in the kidneys and for less accessible stones located in the proximal ureters [1].

The introduction of smaller flexible and semi-rigid ureteroscopes has led to safer and more efficacious treatment methods [1]. Indeed, ureteroscopy (URS) has become one of the most important techniques in the management of urinary lithiasis. With an increase in efficacy and a reduction in complications, URS is now considered to be an efficient primary choice for the management of ureteral stones.

Different techniques, such as pneumatic lithotripsy (PL) and laser lithotripsy (LL), are available for intracorporeal lithotripsy. PL has many advantages: relatively low cost, easy management and a high stone-free (SF) rate.

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On the other hand, it is associated with a possibility of stone push-up, with a higher chance of stone migration when dealing with proximal ureteral stones than for distal ureteral stones [2].

LL is safe and is able to fragment all stones regardless of their composition. The current generation of flexible, actively-deflectable fiber-optic endoscopes makes virtually every part of the kidney accessible, including the lower pole. This technique produces a shockwave that reduces the likelihood of retropulsion of stones or stone fragments when compared to PL [2–4]. Using LL, calculi are fragmented with a success rate of between 80 and 95% [5].

The aim of this prospective study was to analyze the SF rates between PL and LL for the treatment of single and primary ureteral stones.

Material and Methods

We prospectively analyzed records of 35 patients who had ureteral stones and who underwent ureteroscopic lithotripsy at our institution from January 2018 to February 2019. In 15 patients (mean stone size 12.6 mm, range 7–17 mm) pneumatic lithotripsy was used; in 20 patients (mean stone size 11.6 mm, range 8–18 mm), stones were managed with laser lithotripsy. Age ranged from 22 to 78 years. Male to female ratio was 4:1. Acute ureteric colic was seen in 68.57% (11/13) patients; 17.14% (4/2) presented with vague abdominal symptoms, and 14.29% (3/2) received a diagnosis of ureteral stones incidentally. Duration of symptoms in all patients ranged from 2 to 4 weeks.

A 9 /9.5, 7/8.5F semi rigid ureteroscope was used in all patients with a Nidhi Pneumatic Lithotripter that had 0.8 mm and 1.0 mm probes. The laser used was a

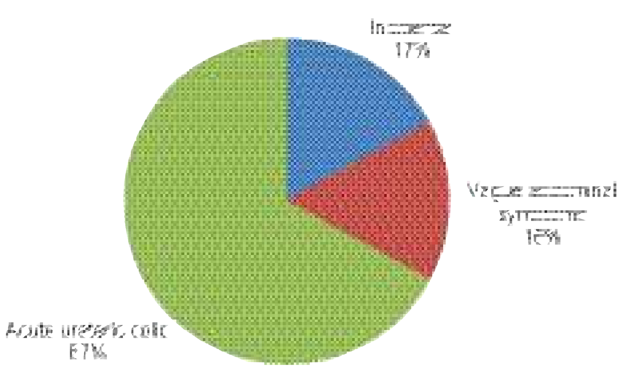

Figure 1: *Clinical Presentation of patients*

The Auriga 30 Holmium Laser. The laser fiber used was 365/550 m, with energy of 0.8–1.5 joules and a frequency of 12 to 20 Hz.

The preoperative workup included urinalysis, a radiograph of kidneys, ureters, and bladder (KUB), ultrasonography (USG), IVU and noncontrast CT scan; as required. Renal parameters were reviewed in all patients. In addition, a blood sugar level was obtained.

Exclusion criteria were: Stone size $\geq$ 20 mm (on KUB radiograph), gross hydroureteronephrosis with parenchymal thinning, anatomical abnormality, signs of urosepsis and pregnancy.

Operative time ranged from 20 to 60 minutes (mean 43.85 min 8.99 SD) for the pneumatic lithotripsy group and 25 to 70 minutes (mean 45.61 min 11.30 SD) for the laser group without significant differences (p = 0.68). At the end, 11/15 patients in the pneumatic lithotripsy group received a Double-J stent. For the laser group, a Double-J stent was inserted in 13/20 patients. Patients were followed as outpatients at 3 weeks and at 3 months with a KUB radiograph and USG. Patients with migrated stones or incomplete clearance underwent an auxiliary procedure such as ESWL or repeated URS. ESWL was performed 3 weeks after URS.

All tests were completed using SPSS version 20.0 software (SPSS, Inc., IBM Corp., Somers, N.Y., USA). Significance was considered as $p < 0.05$ for all statistical comparisons.

Results

Successful fragmentation included complete stone clearance seen on a KUB radiograph or USG at 3 weeks after URS.

In the pneumatic lithotripsy group, 11/15 (73.3%) patients were stone free at 3 weeks. In 4/15 patients, a stone migrated into the kidney. Two patients required ESWL after 3 weeks for residual fragments while two patients had impaction and nonclearance of stone material in the lower ureter because of incomplete fragmentation. These two patients underwent repeated URS after 3 weeks. Signs and symptoms of urosepsis after URS included flank pain, high grade fever, leukocytosis, and bacteruria. Urosepsis occurred in 2/ 15 (13.3%) patients. ESWL was required in 2/15 (13.3%) patients in the lithotripsy group. A Double-J stent was inserted in11/15 (73.3%) patients.

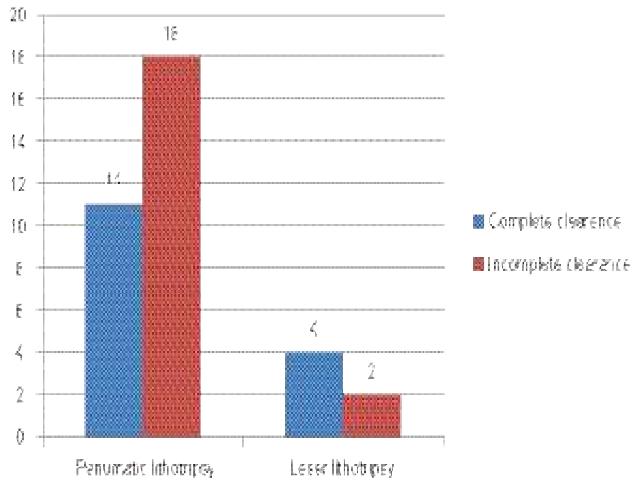

Fig.-2: *Stone clearance at 3 weeks*

In the laser group, 18/20 (90%) patients were stone free at 3 weeks which is significantly higher (p < 0.05) than pneumatic lithotripsy group. In one patient, a stone could not be visualized because of severe edema at the site of stone impaction. A Double-J stent was inserted and URS was performed after 3 week. In one patient, a stone migrated into the kidney and patient required ESWL after 3 weeks. Urosepsis occurred in 2/20 (10.0%) patients. ESWL was required in 1/20 (5.0%) patients in the laser group. A Double-J stent was inserted in13/20 (65%) patients which is significantly lower (p< 0.05) than pneumatic lithotripsy group.

Hospital stay ranged from 24 hours to 72 hours with a mean of 37.32 hours (12.2 SD) in the pneumatic lithotripsy group and 24 to 48 hours with a mean of 31.07 hours (6.10 SD) in the laser group.

Discussion

Pneumatic mechanical devices, such as the pneumatic lithotripsy, are small endoscopic jackhammers that work best when passed through a straight endoscope channel. Clean pressurized air at 0.35 to 0.5 Mpa acts as an energy source to fire the projectile onto a metal rod that is in contact with the stone [6-9].

Aghamirand associates [11] mention an overall fragmentation rate of 88.7% for this modality. Sozen and coworkers [12] describe overall stone-free and fragmentation rates of 94.6% and 96.8%, respectively. These values were 97.1% and 98.5% for stones $\leq$10 mm and 83.7% and 89.1% for stones >10 mm, respectively. Jeon and associates [13] observed immediate stone-free rates of 96.0% for a holmium: yttrium aluminum garnet (YAG) group and 73.1% in a pneumatic lithotripsy group (P<0.05); the 3-month stone-free rates were 96.0% and 84.6%, respectively (P=0.350).

The pneumatic lithotripsy is an efficient and economical means of fragmenting calculi and is particularly useful for large and hard stones. However, pneumatic lithotripsy is associated with a high incidence of proximal stone migration that can necessitate auxiliary procedures such as ESWL for clearance [13]. Also, pneumatic lithotripsy is associated with larger crushed fragments that may require physical removal at the end of the procedure.

Laser lithotripsy was first introduced commercially in the late 1980s with the pulsed-dye laser, which uses 504 nm of light delivered through optical quartz fibers. The 200-mm fiber allows the most endoscopic deflection, but it could deliver only 80 mJ of energy; this frequently was insufficient to fragment calcium oxalate monohydrate calculi. Advances in laser technology led to the development of the holmium: YAG laser, which is a solid state, pulsed laser operating at 2100 nm [14]. The energy is delivered in a pulsatile fashion through low–water density quartz fibers. Johnson and colleagues [16] studied the soft tissue effects of this laser and found that within a water-based medium, the thermal effect of this laser was confined because of a vaporization bubble formed at the tip of the fiber [16].

In 1995, Matsuoka and colleagues [17] presented the first clinical series of patients undergoing endoscopic lithotripsy with this wavelength and found it to be safe and efficient in managing ureteral stones. The energy available at the tip of the holmium laser is not dependent on the diameter of the fiber. The result is photothermal chemical decomposition of the stone, and the stone is virtually vaporized [1].

In our technique of laser lithotripsy, we paint the calculi starting at the periphery that results in formation of fine powdered gravel measuring approximately the size of the laser fiber, which would be in the range of 1 to 2 mm. This powder is easily washed by the side of the scope either during the procedure or afterward. The disparity between the rate of stenting in ureteroscopy with the laser and the pneumatic lithotripsy occurs because of the difference in the size of eventual fragments. With laser lithotripsy, the stone is fragmented into powder whose size is smaller than the laser fiber (350 μ). With the pneumatic lithotripsy, stones are fragmented into slightly larger pieces. Also with the pneumatic lithotripsy, the incidence of proximal migration of stones were higher than with laser lithotripsy. Stent placement was subsequently higher, so that stone passage (with or without SWL) in the subsequent period would be uneventful. Because of the photothermal effect of the laser, there is minimal proximal migration of the calculi. The holmium: YAG laser is an effective instrument for the fragmentation of any kind of ureteral stone; it allows the use of thin or ultrathin instruments and, if manipulated with care, does not damage the ureteral mucosa or the ureteral wall [18]. Contemporary small-caliber ureteroscopes and the holmium laser are the only means of lithotripsy that can safely manage upper-tract urinary calculi in patients with uncorrected bleeding diathesis. In the current study, three patients in the laser group were receiving anticoagulants, and there was no increased incidence of bleeding. Ureteroscopic holmium laser lithotripsy without preoperative correction of hemostatic parameters limits the risk of thromboembolic complications in these patients [19].

In our opinion, laser lithotripsy with slender semi-rigid ureteroscopes is the favored modality for management of ureteral calculi < 2 cm in patients with a short duration of symptoms. The procedure is associated with a high success rate and minimal complications. The role of ureteroscopy for stones <2 cm in the upper ureter has been recently discussed by Chen and coworkers [20]. They reported a stone-free rate after one procedure of 84%; with auxiliary treatment, the total stone free-rate reached 100%.

Recent studies have reported excellent results with the use of stone cones to prevent proximal migration during lithotripsy. This use has not been assessed in this study. A prospective study using stone cones in the pneumatic lithotripsy group would be useful. The learning curve is very short for using the holmium laser as an intracorporeal lithotripter. The cost of holmium laser-assisted ureteroscopy is slightly higher than that for using the pneumatic lithotripsy.

Conclusion

Holmium:YAG laser lithotripsy, is a more efficacious endoscopic technique for the treatment of ureteral stones, allowing a higher stone free rate when compared to pneumatic lithotripsy. The need for auxiliary procedures after holmium laser-assisted URS, is significantly less when compared with pneumatic.

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