



Comparative Study Between Holmium Laser Versus Pneumatic Lithotripsy for the Treatment of Lower Ureteric Calculi

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Received: 07 - 10 - 2021
Accepted: 18 - 12 - 2021
Conflicts of interest: None

Abstract:

Objective: To compare the efficacy of Holmium laser and pneumatic lithotripsy for the treatment of lower ureteric calculi.

Methods: The study included total of 218 patients divided into two groups of laser lithotripsy (LL) and pneumatic lithotripsy (PL). Study was conducted between October 2014 and September 2018. Inclusion criteria were patients with a lower ureteric single stone of size 0.8 to 1 cm and negative urine culture. An x-ray KUB and USG of KUB was mandatory. IVU also done when required. Procedures were done under spinal anesthesia. A 9.5 Fr. semi rigid ureteroscope was used for ureteroscopy in all cases. Holmium laser with 550 μ m fiber was employed in laser group and frequency was set between 20-30 Hz at energy of 0.5 to 1 Joule. Storz lithotripter was used in PL group. Postoperatively patients underwent radiography at 4th week of follow up to assess stone clearance.

Results: The mean patient age in LL and PL group was 38.8 ± 9.1 (15-58) and 41.2 ± 10.3 (16-62) years, male to female ratio 1.75:1 and 1.57:1 and stone size 8.94 ± 0.98 and 8.94 ± 0.91 mm respectively. Stone free rate at 4 weeks was 96.36 % in LL group as compared to 88.83 % in PL group ($p=0.033$). Stone migration up in pelvicalyceal system occurred in one (0.90%) patients of LL group while in five (4.63%) patients of PL group ($p=0.0929$). DJ Stent was placed in 43 (39.09%) patients in LL group whereas 64 (59.25%) patients required it in PL group ($p=0.0030$). Complication rate was 18.18% (20) in LL group whereas it was 38.88% (42) in PL group ($p=0.0038$)

Keywords: Lower ureteral calculi, Uretero-rensoscopy (URS), Pneumatic lithotripsy (PL), Laser Lithotripsy (LL).

Conclusion: Holmium laser lithotripsy is a superior technology compared to pneumatic lithotripsy in terms of rate of stone clearance and complications for lower ureteric stones.

Introduction

Urinary stone disease is a major health care problem due to its high prevalence and incidence.¹ There are different therapeutic approaches for ureteral stones depending on stone size, location and anatomical variations of the urogenital tract. Ureteroscopy has

changed our perception and eventually our treatment strategies of ureteral stones. Common methods of intracorporeal ureteroscopic lithotripsy include pneumatic, electrohydraulic, and Holmium:YAG (Ho:YAG) laser.² Holmium Laser lithotripsy now gained popularity and is established as standard

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modality.³HO: YAG laser lithotripsy works according to photothermal mechanism.⁴ It is transmittable via flexible fibers which vary in diameter from 200 to 550 μ m. The thermal effect produced by holmium: YAG laser's pulses are due to formation of plasma bubble which acts on stone without retropulsion.³The zone of thermal injury associated with laser ablation ranges from 0.5 - 1.0 mm.⁵Therefore subsequent injury of the ureter is unlikely to happen as long as the lithotripsy is performed under direct vision. Using laser lithotripters the trauma to the urothelial mucosa is usually less compared to the other lithotripters.⁶

Pneumatic lithotripter functions in a similar manner as pneumatic jackhammer.⁴ Compressed air pushes a small projectile which in turn makes the probe oscillate at the frequency of 12 cycles per second. Fragmentation occurs as a result of the repetitive impact of probe tip against the stone.^{4,7}The aim of this study is to evaluate the effectiveness and safety of treatment for lower ureteral stones with pneumatic lithotripsy compared to holmium: yttrium-aluminum-garnet (HO: YAG) laser therapy.

Materials & Methods:

This prospective study was carried out in the department of urology, Rangpur Medical College and Hospital between October 2014 and September 2018. A total of 218 patients with lower ureteric calculi were selected after informed consent of the available therapeutic options, and the risks and benefits associated with each treatment modality. Patients with a lower ureteric stone of size 0.8 to 1 cm and negative urine culture were selected. Stone size was determined based on the preoperative plain abdominal x-ray. Patient with multiple stones, bilateral stones and renal failure were excluded from study. All the patients underwent thorough process of history, examination and investigations. An x-ray KUB and USG of KUB was mandatory in all cases. IVU also done when required.

The patients were randomized and allotted into 2 groups, the laser lithotripsy (LL) group and pneumatic lithotripsy (PL) group. All the procedures were done by a 9.5 Fr semi-rigid Karl Storz ureteroscope in both groups, under spinal anesthesia in the lithotomy position after receiving a single shot of prophylactic antibiotic. A pre-operative plain film of the KUB was obtained to confirm the lower ureteric stone. Retrograde access to the ureter was obtained with ureteroscope

alongside a 0.035-inch safety guide wire. In laser group, the stone was identified and fragmented by laser lithotripsy. Holmium: YAG laser with 550 μ m fiber was employed in laser group until the stone was disintegrated into <3 mm fragments to avoid the need for basket extraction and frequency was set between 20-30 Hz at energy of 0.5 to 1 Joule. Storz lithotripter was used in PL group. For pneumatic lithotripsy 1.0 mm probe was used to fragment the stone with both single and continuous pulses and pressure was set at 2 bars. Large stone fragments was retrieved with a grasper and small one left for spontaneous clearance. In order to maintain a clear ureteroscopic view, irrigation was pumped manually and intermittently during the procedure. Double-J (DJ) stent was placed based on following criteria; prolonged procedures (>60 minutes), large amount of stone debris or evident ureteral edema/trauma.

Patients were followed up postoperatively with x-ray KUB at 4th week. Treatment outcomes included stone free and complication rates were compared between the two groups. Stone-free status has been defined as an asymptomatic patient with no stone or stone fragment \leq 3 mm on digital x-ray KUB. This was considered to be too small to extract and was liable to pass spontaneously. Patients requiring re-procedures during follow-up were considered as treatment failure. Data were compiled and statistical analysis was done with 't' test. Statistical comparison of two independent percentages was done and p value of 0.05 considered statistically significant.

Results:

A total of 218 patients (female, n=82 and male, n=136; pneumatic group (PL), n=108 and laser group (LL), n=110) were included in this study. Mean ages of the patients in the PL, and LL groups were 41.2 \pm 10.3, and 38.8 \pm 9.1 years, respectively (p=0.0695). The male to female ratio were 1.57:1 and 1.75:1 for PL and LL group respectively. The stones were localized in the right, n=93 and left ureter n=125. Mean stone size was 8.94 \pm 0.98 in PL and 8.94 \pm 0.91 mm in LL group respectively. A statistically significant intergroup difference was not detected as for patients' ages, gender, laterality and stone size. In regard to the overall stone free rate, patients in the LL group had significantly higher stone-free rate 106/110 (96.36%) in comparison to the PL group 97/108 (88.83%), (p = 0.0338).

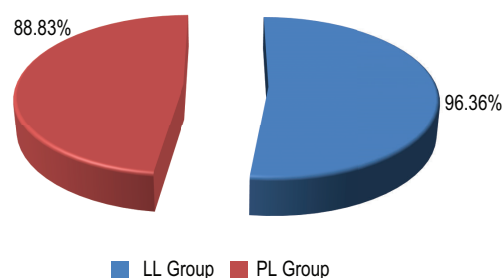
Table I: Baseline characteristics of patients in both groups.

Parameters	Pneumatic Lithotripsy (PL)	Laser Lithotripsy (LL)	<i>p</i> value
No of patients	108	110	
Mean Age±SD	41.2±10.3	38.8±9.1	0.0695
Male/Female ratio	1.57:1	1.75:1	
Laterality			
Right ureter	45 (41.66%)	48(43.64%)	0.8311
Left Ureter	63 (58.34%)	62 (56.36%)	0.7681
Stone size (mm)	8.94±0.98	8.94±0.91	1.0000

Mean operative time was shorter in the LL group (46.12± 26.3minutes) in comparison to the PL group (58.32± 34.12minutes), a result was statistically significant ($p = 0.003$). Moreover, 43 patients in the LL group (39.09%) required DJ stent versus 64 patients (59.25%) in PL group, which was statistically significant ($p=0.003$). Migration of Stones occurred only in 5 patients (4.63%) in PL group while in only one patient (0.90%) in LL group and was statistically significant ($p = 0.039$).

In terms of procedure-related complications, comparison between the groups shows mild hematuria that 21(19.95%) in PL group and 6(5.45%) in LL group, ($p=0.0014$); Mucosal injury of ureter 07(46.48%) in PL group and 1(0.90%) in LL group;

($P=0.028$). In case of post-operative fever, there was no significant difference between PL and LL group; 7(7.40%) & 9 (8.18%); $p=0.9555$. Overall complication rate was 18.18 % (20) in LL group whereas 38.88 % (42) in PL group ($p=0.0038$).

**Fig-1.** Stone clearance in LL and PL Group**Table II.** Operative characteristics, outcomes and complications.

Parameters	Pneumatic Lithotripsy (PL)	Laser Lithotripsy (LL)	<i>p</i> value
Total operative time in (min)	58.32± 34.12	46.12± 26.3	0.0034
Double J stent	64(59.25%)	43(39.09%)	0.0030
Overall Stone free rate	96(88.83%)	106 (96.36%)	0.0338
Stone migration	05(4.63%)	01(0.90%)	0.0929
Mild hematuria	21(19.95%)	06(5.45%)	0.0014
Ureteric injury(mucosal)	07(46.48%)	01(0.90%)	0.0287
Postoperative fever	07(7.40%)	09(8.19%)	0.9555
Overall complications rate	42(38.88%)	20(18.18%)	0.0007

Discussion

Ureteroscopic lithotripsy has become the method of choice for the management of distal ureteric calculi in many centers worldwide.⁸ Nowadays some authors recommend URS Lithotripsy for distal ureteral calculi as a first-line treatment since it provides higher success rates and quick stone clearance with minimal complications.^{9,10} The meta-analysis of the EAU/AUA nephrolithiasis guideline panel demonstrated that URS yields significantly greater stone-free rates for the majority of stone stratifications.¹¹ A variety of lithotripters can be used through ureteroscope, pneumatic and holmium: YAG laser lithotripsies are commonly used in majority of urological centers.¹²

In the present study stone-free rate for lower ureteric calculus with holmium laser was 96.36% and 88.83% with pneumatic lithotripsy respectively ($p=0.033$). These findings approach results reported by Seon et al., 2005 and Tipu et al., 2007 in which figures of 96% for laser lithotripsy versus 71% for pneumatic lithotripsy were reported.^{12,13} While this result was in disagreement with a study conducted by Bhandri & Basnet, 2011 in which figures of (92% VS 94%) for laser and pneumatic lithotripsy was reported respectively.^{14,15} Reddy et al. 2016 obtained a success rate at a level of 90.9% after a single ureteroscopic lithotripsy procedure. The highest, almost 100%, effectiveness was obtained in the case of stones smaller than 10 mm in diameter, located within the lower ureter. Effectiveness decreased alongside with the increase of the stone diameter, its location within the upper sections of the ureter, longer period within the ureter.⁸

Holmium: YAG laser lithotripsy had more advantages from the aspect of operation time as this study shows that the mean operative time was shorter for laser group in comparison to pneumatic group; (46.12 ± 26.3 Vs 58.32 ± 34.12 min); $p=0.0034$. These findings are comparable to other studies.^{12,16,17,18}

In the present study, upward migration of stones occurred 4.63 % (5) in pneumatic group. While, there was only one patient (0.90%) in laser group. A finding was statistically significant ($p = 0.039$). The most important disadvantage of pneumatic lithotripsy is migration of the stone into renal collecting system. Razzaghi et al.¹⁸ detected incidence of stone migration into renal collecting system as 17.9% in the PL group but, without such a complication (0%) in the laser group. This finding was reported by other researchers in which retrograde stone migration occurred in 10% of

pneumatic group and in 6% of laser group.¹⁴ This could be explained by the different mechanism of lithotripter that could affect the rate of stone migration and constitutes the mechanism of failure in ureteroscopic lithotripsy. In pneumatic lithotripsy calculi are fragmented with a mechanism similar to that of pneumatic jackhammer.²⁰ While the mechanism of holmium: YAG energy which heats the stones to a critical thermal threshold at which the stone composition is altered yielding a stone crater and small fragments.²¹ Even though stone migration is an unwanted adverse event, it can be seen in both techniques, and with advanced technology, improvements in the design of ureteroscopes, and also auxiliary instruments its rates are decreasing. Moreover, to minimize unwanted upward migration, applying energy in a single pulse leads in breaking stones and more helpful in preventing the stones from going upwards into the kidneys.¹⁷ In addition, elevation of head end of the table to prevent stone up-migration.

In present study, patients in the laser group 39.09 % required DJ stent versus 59.25% in pneumatic group, which was statistically significant ($p=0.003$). These findings are comparable to so many studies done in the past.^{4,11,19} The practice of ureteric stent placement after uncomplicated ureteroscopy is common, although is largely unsupported by the available literature.^{21,22,23} In many cases, the added morbidity, cost and time associated with stent placement can be safely avoided.²³

In term of complications, such as, hematuria 21 (19.95%) Vs 6 (5.45%) and mucosal injury 07 (46.48%) Vs 1 (0.90%) between PL & LL groups. There was statistically significance difference ($p = 0.016$, $p = 0.028$) respectively. But post-operative fever was found less frequently in the pneumatic group patients (7.40 %) in comparison to laser group patients (8.18 %), a finding was not statistically significant ($p = 0.95$). On the other hand, the overall complications rate between the two groups was statistically significant (38.38 % VS 18.18 %) in pneumatic and laser group respectively ($p=0.0007$). These complications are commonly documented in other studies but with a variety of definitions and frequencies.^{12,13} Complications in the ureteroscopic lithotripsy group were frequent but minor, were managed conservatively. The depth of thermal injury to the urothelium is only (0.5 - 1) mm²⁴ and this explains no incidence of major injury of the ureter with laser lithotripsy. Pneumatic lithotripsy fragmented calculi into more fragments than holmium: YAG laser

lithotripsy. The increased number of fragments, basketing, removing of stone and manipulation of ureteroscopy seemed to increase mucosal injury, bleeding and impaired vision especially in the case of stone impaction.²³ Holmium: YAG laser lithotripsy is a superior technology than pneumatic lithotripsy in terms of rate of stone clearance and complications in lower ureteric stones. Since this is a single centre study, a multi centre study at a larger scale is required.

Conclusion:

Holmium laser lithotripsy is a superior technology compared to pneumatic lithotripsy in terms of rate of stone clearance and complications for lower ureteric stones.

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