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Original Article

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Comparison of Holmium: Yttrium Aluminum Garnet laser with pneumatic lithotripsy in the treatment of ureteric stones by semi-rigid ureteroscope

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Abstract

Background: *Ureteric calculi are one of the major causes of attendance at emergency and outpatient department in urology. Miniaturization of endoscopic devices has revolutionized the management of ureteric calculi. Ureteric calculi are effectively managed by semi-rigid URS. Holmium: YAG laser and pneumatic lithotripsy are two most efficacious and widely used intra-corporeal lithotripsy device.*

Objective: *To compare the efficacy of Holmium: YAG laser with pneumatic lithotripsy in the treatment of ureteric stones by semi-rigid ureteroscope.*

Methodology: *A total of 70 adult patients were selected by purposive sampling technique and divided into laser lithotripsy (LL) group and pneumatic lithotripsy (PL) group by lottery. Test of significance was independent sample t-test for quantitative outcome and Chi-square (X2) test or Fisher's exact test for categorical outcome. P- value of less than 0.05 was considered significant and 95% confidence interval was used.*

Result: *Two groups were similar in age, gender, mean size of stones and side of stones. There was a statistical difference in terms of stone clearance, stone migration and mean hospital stay in favor of the LL group (P = 0.035, P = 0.024 and P = 0.002 respectively), and mean operating time in favor of the PL group (P = 0.034). A statistically significant (p=0.044) more post-operative hematuria was found in PL group. There was no significant difference in mucosal injury, ureteral perforation and post-operative fever in both groups.*

Conclusion: *Holmium: YAG laser lithotripsy is more efficacious than pneumatic lithotripsy in terms of rate of stone clearance, complications and post-operative hospital stay while the mean operating time is significantly shorter in PL group.*

Keywords: Ureteral stone, Ureteroscopy, Holmium: YAG laser, Laser lithotripsy, Pneumatic lithotripsy.

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Introduction

Urolithiasis is one of the common disorders of the urinary tract with lifetime prevalence of up to 15%. A significant proportion, about 1/5th of urinary tract stones, is found in the ureter.[1] There are different treatment methods for ureteral calculi such as extra-corporeal shock wave lithotripsy (ESWL), ureteroscopic procedures, percutaneous nephro-lithotomy, laparoscopic ureterolithotomy and open stone surgery.[2] The frequency of spontaneous passage of stone after medical expulsive therapy (MET) is 56% for 8-mm stones, 33% for 9-mm stones, and 27% for stones that were 10-mm or larger in diameter.[3] ESWL and URS are shown to yield overall success rates 86% and 97% with calculus of 10mm or smaller and 74% and 93% with calculus greater than 10-mm respectively.[4] Ureteroscopy has become a powerful diagnostic and therapeutic modality because of the development of small tools for utilization with endoscopes.[5] The main benefit of ureteroscopic surgery is visualization of the ureter that enables detection and treatment of ureteral stones[2]. Different techniques, such as pneumatic lithotripsy (PL) and laser lithotripsy (LL), are available for intra-corporeal lithotripsy.[6] For many years, favorable outcomes were reported with the use of pneumatic lithotripsy (PL), which uses simple principle of the jackhammer that is an effective and safe method for stone treatment.[7] Pneumatic lithotripsy depends on the energy that is generated by the movement of a metal projectile contained within the hand piece when comes in contact with another object.[8] The Ho: YAG is a pulsed source that can work with frequencies of up to 50 Hz and can be used with very fine fibers of up to 200 microns. It can vaporize as well as coagulate the tissues.[9] The thermal effect produced by Ho: YAG laser's pulses are due to formation of plasma bubble.[10] The laser ablation thermal zone ranges between 0.5 to 1.0 mm.[9] This study has been designed to compare the efficacy of Ho: YAG laser lithotripsy (LL) with pneumatic lithotripsy (PL) in the treatment of ureteric stones by semi-rigid ureteroscope.

Methodology

A total of 70 patients with ureteric calculus were included in this study fulfilling the selection criteria at the urology department, NIKDU between July 2020 and June 2022. Exclusion criteria were patients with UTI, uncorrected coagulopathy, bilateral or multiple stones, radiolucent stone, raised s. creatinine (>2mg/dl), pregnancy, abnormal ureteral anatomy, ureteral stricture or growth. Local ethical committee approval was taken for the study. Patients were counseled about the treatment and informed written consent was taken. They were divided into two groups (35 patients in each group) by simple lottery. Laser group was designated as group LL and pneumatic group was designated as group PL. A prophylactic antibiotic was administered intravenously just before the induction of anesthesia. Cystoscopy followed by URS combined with either holmium: YAG laser or pneumatic lithotripsy was performed. A Terumo guide wire (0.035 inch) was negotiated into the ureteric orifice under ureteroscopic vision and fluoroscopic monitoring. Then a semi-rigid ureteroscope of 7 Fr of Karl Storz brand was advanced next to the guide wire. A second guide wire was occasionally needed. As soon as stone was seen, fragmentation was started either by pneumatic lithotripsy or laser lithotripsy. For laser lithotripsy, a Ho: YAG laser of Sphinx Jr brand was used with energies ranging from 0.6 to 1.2 J and pulses from 5-15 Hz with a 200 um fiber. Dusting mode was preferred and stone was fragmented from center to periphery. Swiss lithoclast with 1mm probe was used to break stones in pneumatic groups. The pneumatic setting was 2-5 bars and frequency was 7-10 Hz. Fragments of stone were retrieved by forceps or graspers. A 5 Fr double J stent was placed thereafter. During operative procedure, all patients were closely monitored for any outcome variable (stone clearance, ureteral mucosal injury, ureteral perforation, stone migration etc.). Stone clearance was checked by fluoroscopy and ureteroscopy at the end of the procedure. Per-operative and post-operative complications were managed accordingly. Every patient was followed up during post-operative periods until discharge and after 04 weeks and 12 weeks. Results were analyzed using SPSS 25 (IBM Corp., Armonk, NY, USA). Continuous data was presented as mean ± standard deviation (SD) and categorical data was presented as frequency, percentage. Test of significance was independent sample t-test for quantitative outcome and Chi-square ($X2$) test or Fisher's exact test for categorical outcome. P-value of less than 0.05 was considered significant and 95% confidence interval was used.

Result

Actually we had total 65 patients as 3 patients from LL and 2 patients from PL group were lost during follow-up. The baseline demographics of patients and stone characteristics were similar in two groups (Table 1). Mean operation time was significantly less in PL (39.29±6.11 min) than (42.86±7.68 min) in LL group (p= 0.034)(Table 2). Per-operative stone migration was significantly high (p=0.024) in PL group (27.3%) than in LL group (6.3%). At 04th week, stone clearance of LL group was 29(90.6%) found significantly high (p=0.035) compared to PL group 23(69.7%); while at 12th week, stone clearance was almost similar (p=0.628) (Table II).

Table I: *Demographics and clinical characteristics*

Variable		Group-LL n=32	Group-PL n=33	*p* value
Mean age ± SD(years)		38.89±12.96	39.51±8.91	0.814
Gender	Male	21(65.6%)	20(60.6%)	
	Female	11(34.4%)	13(39.4%)	0.675
Stone parameters				
Laterality	Right ureter	17(53.1%)	19(57.6%)	
	Left ureter	15(46.9%)	14(42.4%)	0.718
Location	Upper	6(18.8%)	5(15.2%)	
	Mid	7(21.9%)	7(21.2%)	
	Lower	19(59.3%)	21(63.6%)	0.916
Mean stone diameter ± SD(mm)		10.19±2.15	10.39±2.13	0.697

Group-LL= patients treated with laser lithotripsy, Group-PL= patients treated with pneumatic lithotripsy. Abbreviation: SD, Standard deviation.

There was no significant difference in mucosal injury, ureteral perforation and post-operative fever in both groups. A statistically significant (p=0.044) more post-operative hematuria was found in PL group. Mean postoperative hospital stay was significantly shorter in LL group (38.37±10.80 vs 44.0±15.56 hours; p=0.002) (Table II).

Table II: *Operative and Post-operative Data*

Variable		Group-LL n=32	Group-PL n=33	*p* value
Complications				
Mucosal injury		4(12.5%)	7(21.2%)	0.349
Ureteral perforation		0(0.0%)	2(6.1%)	0.157
Stone migration		2(6.3%)	9(27.3%)	
	upper	2(100%)	3(33.3%)	
	mid	0(0.0%)	4(44.4%)	0.024
	lower	0(0.0%)	2(22.2%)	
Post-operative hematuria		2 (6.3%)	8 (24.2%)	0.044
Post-operative fever		3 (9.4%)	5 (15.2%)	0.478
MOT±SD(minutes)		42.86±7.68	39.29±6.11	0.034
MHS±SD(hours)		38.37±10.8	44.0±15.56	0.002
Stone clearance	at 4^{th} week	29(90.6%)	23(69.7%)	0.035
	at 12^{th} week	31(96.88%)	30(90.91%)	0.628

Group-LL= patients treated with laser lithotripsy, Group-PL= patients treated with pneumatic lithotripsy. Abbreviation: SD, Standard deviation; MOT, Mean operation time; MHS, Mean hospital stay.

Discussion

Recent improvement in equipment and technologies made great strides in the management of patients with urinary calculi.[2] This study was conducted to compare the efficacy of Holmium: YAG laser with pneumatic lithotripsy for the management of ureteral stones. Age was almost similar in both groups in this study. There was no statistically significant difference in gender distribution in between two groups (p=0.68) in this study. Similar results found in studies done by Cimino et al.[6] Regarding stone location, no significant difference found among the two groups (p=0.92). Similar result was also found in a study done by Akdeniz et al[11] among 157 patients. Mean stone diameter was 10.19+2.15(7-14) mm in LL group which was not significant (p=0.69) in comparison to PL group 10.39+2.13(7-15) mm. This type of similarity was also found in a study of 80 patients (p=0.68) done by Kassem et al.[12]

In this study, at 4th week after ureteroscopic lithotripsy, stone clearance of LL group (90.6%) was found significantly high (p=0.035) compared to PL group (69.7%), while at 12th week stone clearance of both groups (96.88% vs. 90.91%) was found statistically similar (p=0.628). Rahman et al[13] found that 90% patients were stone free at 3 weeks in LL group and 73.3% in PL group which was statistically similar (p< 0.05) to our study.

In our study, the duration of operation among PL group was shorter than Ho: YAG LL group (39.29+ 6.11) vs (42.86+ 7.68) which was statistically significant (p= 0.034). It might be a result of more experience and habituated in working with PL in our center. Rabani et al[14] and Li et al[15] found a significantly (p=0.001) less mean operating time in LL group. Operation time may differ due to patient's stone parameter and surgeon's skill. Per-operative complications such as stone migration, superficial mucosal injury and ureteral perforation are important variables to compare between two groups. In LL group, proximal stone migration occurred in 2 patients (6.3%) during the operation and in PL group, proximal stone migration occurred in 9 patients (27.3%) which was statistically significant (p=0.02). Stone migration occurred in 4 (6.67%) patients of LL group and in 12(21.1%) patients of PL group in a study done by Cimino et al[6] over 117 patients. The result was similar (p=0.03) to this study.

Superficial mucosal injury in ureter occurred in 12.5% cases in LL group and 21.2% in PL group. No statistically significant difference (p=0.349) was observed between two groups in this study. All the patients were managed conservatively by placing a double J stent for 6-12 weeks. Similar results were also found in a study done by Ercil et al[16] over 141 patients (p=0.809). Only 2 cases of ureteral perforation were observed in PL group in this study both were managed by D-J stenting for 8-12 weeks. No case of ureteral perforation was seen in LL group. Post-operative hematuria occurred in 6.3% patient in LL group was significantly lower than 24.2% patient in PL group and the p- value was 0.044. Hematuria occurred in 45.3% LL patient and 54.5% PL patient with no significant difference (p=0.275) in a study conducted by Ercil et al[16] Hematuria results from post obstructive decompression, instrumental injury and post-operative flare up of infection. Different stone parameter, upper tract condition and inclusion-exclusion criteria may be the cause of dissimilar result. In this study, 3(9.4%) patients in LL group developed post-operative fever compared with 5(15.2%) patients in PL group which was statistically not significant (p= 0.478). Abedi et al[2] found similar type of result. Our study shows, the mean duration of post-operative hospital stay in LL group was significantly shorter than PL group and p-value was 0.002. But Li et al[15] showed that there was no significant difference (p=0.62) in mean postoperative hospital stay. Razzaghi et al[17] also showed there was no significant difference (p= 0.89) in mean post-operative hospital stay in between two groups. Post-operative early complications such as hematuria, fever, pain, LUTS were somehow more common in case of pneumatic lithotripsy. This might be the cause of patient's more hospital stay post operatively.

This study has some limitations. It was carried out in a single center, small sample size due to covid-19 pandemic, same surgeon was not involved in all procedures. Large scale, multicenter study & cost benefit ratio between two methods can be incorporate to increase their accuracy.

Conclusion

Holmium: YAG laser lithotripsy is more efficacious than pneumatic lithotripsy in terms of rate of stone clearance, complications and post-operative hospital stay while the mean operating time is significantly shorter in PL group.

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