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Original Research Article

EFFICACY OF HOLMIUM LASER (LL) WITH PNEUMATIC LITHOTRIPSY (PL) IN PATIENTS WITH PROXIMAL URETERAL STONES

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Abstract: *The present study aimed to compare the success rate of holmium laser (LL) with pneumatic lithotripsy (PL) in patients with proximal ureteral stones. A randomized controlled trial was carried out in the Department of Urology at the Liaquat National Hospital in Karachi between December 2020 and June 2021. Included were 124 patients who had ureteric stones in their proximal ureters. Pneumatic lithotripsy and holmium laser groups were created for the patients. The complete removal of the stones, as determined by kidney, ureter, and bladder computed tomography (CT-KUB), was the definition of the treatment's success. Stratification was carried out, and descriptive statistics were calculated. The post-stratification Chi-square test was used, and a P-value of less than 0.05 was deemed significant. The average length of time a stone was present was 10.54 ± 2.65 days in group A and 10.43 ± 2.68 days in group B. The average stone size in group A was 1.58 ± 0.22 cm, whereas in group B, it was 1.54 ± 0.22 cm. 93.5% of group A and 69.4% of group B were stone-free. The study groups showed a noteworthy correlation about their stone-free condition. For proximal ureteral stones with a size up to 2 cm, comparing pneumatic lithotripsy 1.9 to holmium laser, which has a higher success rate, is the recommended method.*

Keywords: Success Rate, Holmium Laser, Pneumatic Lithotripsy, Proximal Ureteral Stones

Introduction

Urolithiasis is a globally significant health issue. Pakistan lies within the geographical region known as the Afro-Asian Stone Belt, extending from Egypt in the west to Iran, India, Thailand, and Indonesia in the east. Open surgery is becoming obsolete with the introduction of ongoing improvements to minimally invasive procedures (Tipu et al., 2007). Ureteral stones and consequent obstructive uropathy can impair renal function. Numerous research findings indicate that ureteroscopy is the primary treatment option for ureteral stones, mainly focusing on flexible ureteroscopic lithotripsy. This approach utilizes various lithotripters such as ultrasonic, electrohydraulic, pneumatic, and laser lithotripters (Razzaghi et al., 2013). Usually, proximal ureteral calculi result in blockage, which triggers hydronephrosis and subsequent decline in renal function (Zhu et al., 2010). While there are several ways to treat ureteric calculi, there is an increasing trend to use minimally invasive surgical techniques (Tipu et al., 2007). When the stone obstructs the urinary tract or produces substantial pain resistant to medical treatment, minimally invasive procedures are carried out (Razaghi and Razi, 2001). Ureteroscopy (URS) is the main form of therapy for lower and middle ureteral stones, as well as the majority of upper ureteral stones (Bapat et al., 2007; Khalil, 2013).

Ureteroscopic lithotripsy has traditionally been the favored surgical approach for mid- and distant ureteral stones. Advances in ureteroscopy involve the development of small-caliber semi-rigid ureteroscopes and lithotripsy methods such as holmium :(Ho: YAG) yttrium-aluminum-garnet. The success rates of laser lithotripsy (LL) and pneumatic lithotripsy (PL) have increased while complications have dropped (Degirmenci et al., 2014; Wu et al., 2005).

In a study, 100 patients with size 1-2 cm ureteric stones were split into two equally matched groups of Holmium: YAG laser lithotripsy (LL) and pneumatic lithoclast (PL). The result reported that in the proximal ureter, the stone-free rate was 90.9% in the laser group compared to 71.4% in the pneumatic lithoclast group (Tipu et al., 2007). In a different research investigation 2, individuals diagnosed with upper ureteral stones exceeding 1 cm in size were randomly split into two groups. Medication was given to one group using a pneumatic lithoclast, while the other underwent treatment with a holmium laser. The study results showed that the immediate success rate in eliminating the stones was 100% in the holmium laser group, whereas it was 42.9% in the pneumatic lithoclast group (Razaghi and Razi, 2001). This research aimed to assess the efficacy of pneumatic lithotripsy compared to holmium laser treatment in managing proximal ureteral stones. The primary objective was to eliminate the stones and achieve a stone-free condition for the patients involved in the study. This would help patients with proximal ureteral stones be treated using the method that will provide a higher success rate.

Methodology

A randomized controlled trial was undertaken at the Urology Department of Liaquat National Hospital, Karachi, between 21 January 2019 and 20 June 2020. Ethical approval was obtained before the data acquisition. A non-

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randomized convenience sampling technique was utilized to recruit participants in the study.

By taking the proportion of success rate in holmium laser (LL) and pneumatic lithoclast (PL) in proximal ureteric stone using P1 = 90.9%1 and P2 = 71.4%1, 1-β = 80%, the calculated sample size was 62 patients in each group with the help of WHO software for sample size calculation taking 95% confidence level. Patients with ureteric stones of size up to 2 cm in the proximal ureter, aged between 20 to 50 years of age, with a negative urine culture and normal Renal function (Serum Creatinine between 0.5-1.5 mg/dl) were eligible to participate in the study. Patients excluded from the study encompassed those with stones located in the pelvic area or the calyx, as well as those found in the mid or lower sections of the ureter, ongoing urinary tract infections (UTI), multiple stones, prior ureter surgeries or endoscopic ureter maneuvers, a history of previous shock wave lithotripsy (SWL) targeting a stone in the duplicate ureter, congenital urinary abnormalities, and coagulopathy. This investigation was undertaken after approval of the College of Physicians and surgeons Pakistan (CPSP). The patients with ureteric stones of size up to 2 cm in the proximal ureter visited the emergency room (ER) or Urology outpatient department (OPD) at Liaquat National Hospital, Karachi, and satisfied the study's inclusion requirements. The principal investigator took the patient's clinical history. Patients were allocated by lottery method (patients were divided into two groups, namely pneumatic lithotripsy (PL) and holmium laser (LL), based on what slip they chose from the box). A negative urine culture was mandatory for every patient in both groups. An 8 fr semi-rigid ureteroscope was used on both groups. Holmium-YAG lasers are made at the Institute of LASER Science and Technology, associated with Iran's Atomic Energy Organisation. The pneumatic lithoclast originates from Switzerland. Computed tomography of kidneys, ureters, and bladder (CT-KUB) (Kidney Ureter Bladder) was performed before surgery. CT-KUB was interpreted by a 5-year experienced radiologist with a Fellow of College of Physicians and Surgeons Pakistan (FCPS) radiology degree. Complete stone clearance as determined by CT-KUB following treatment was the definition of treatment outcome.

Version 21 of SPSS was utilized to organize and evaluate the patient's data. Both proportion and incidence were measured for qualitative variables like gender, occupation, residence, stone's location, clearance of stone, and stone-free status. For quantitative data, such as age, stone duration, and stone size, mean ± standard deviation was computed. The chi-square test was used to stratify based on age, gender, occupation, residency, length of the stone, stone size, and stone location to determine the impact of these variables on the result. A p value of less than or below 0.05 was deemed statistically significant.

Results

Table 1 presents sociodemographic and clinical parameters for patients undergoing holmium laser lithotripsy (LL) and pneumatic lithotripsy (PL) for proximal ureteral stones. Age, duration of stone presence, and stone size show slight differences between the two groups but remain relatively similar overall, indicating comparable baseline characteristics. The gender distribution shows a higher proportion of males in the LL group than in the PL group. Regarding residence, more patients in the PL group come from urban areas than the LL group. Occupation-wise, distributions are similar across both groups with slight variations. The duration and size of the stones are distributed nearly evenly between the two groups, suggesting that the treatments were applied to patients with similar stone profiles.

Table 1. Sociodemographic and clinical parameters of study participants

Parameters	mean ± Std.	
	LL	PL
Age (Years)	36.53 ± 9.22	38.98 ± 7.18
Duration of STONE (Days)	10.54 ± 2.65	10.43 ± 2.68
Size of STONE (cm)	1.58 ± 0.22	1.54 ± 0.22
n (%)		
Gender		
Male	53 (85.5%)	45 (72.6%)
Female	9 (14.5%)	17 (27.4%)
Residence		
Urban	37 (59.7%)	44 (71.0%)
Rural	25 (40.3%)	18 (29.0%)
Occupation		
Unemployed	16 (25.8%)	16 (25.8%)
Student	5 (8.1%)	2 (3.2%)
Private Job	27 (43.5%)	26 (41.9%)
Business Man	10 (16.1%)	13 (21%)
Govt. Job	4 (6.5%)	5 (8.1%)
Duration of Stone		
≤10 days	30 (48.39%)	32 (51.61%)
>10 days	32 (51.61%)	30 (48.39%)
Size of Stone		
≤1.5 cm	27 (43.55%)	24 (38.71%)
>1.5 cm	35 (56.45%)	38 (61.29%)
LL: laser lithotripsy; PL: pneumatic lithotripsy		

The success rates of the two groups receiving distinct treatments for proximal ureteral stones—the Pneumatic Lithotripsy (PL) group and the Holmium Laser Lithotripsy (LL) group—are compared in Table 2. In the LL group, a high success rate was observed, with 93.5% (58 out of 62 patients) achieving success in stone removal, compared to a significantly lower success rate of 69.4% (43 out of 62 patients) in the PL group. The statistical analysis yielded a p-value of 0.0001, indicating that the difference in success rates between the two groups is highly significant. This suggests that Holmium Laser Lithotripsy is more effective than Pneumatic Lithotripsy in treating patients with proximal ureteral stones.

Table 2. Comparison of the success rate of the laser lithotripsy group in comparison to the pneumatic lithotripsy group (n=124)

Success	STUDY GROUP		*p-value*
	LL	PL	
Yes	58(93.5%)	43(69.4%)	0.0001
No	4(6.5%)	19(30.6%)	
LL: laser lithotripsy; PL: pneumatic lithotripsy			

Discussion

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In the surgical treatment of ureteral stones, numerous options are available, including Extracorporeal shock wave lithotripsy (ESWL), ureteroscopy, percutaneous antegrade ureteroscopy, laparoscopic surgery, and open surgery (Türk et al., 2016). Many urologists favor the pneumatic lithotripter (PL) due to its lower price, ease of setup, and greater success rate (Sun et al., 2001). Higher rates of stone movement, however, are a drawback (Knispel et al., 1998). Pneumatic lithotripter is less expensive than laser lithotripter (LL) while being more successful in treating impacted stones and proximal ureter stones (Yiu et al., 1996). Regarding safety, effectiveness, and risks in the endoscopic treatment of stones in the ureter, numerous research has contrasted PL with LL, apart from studies emphasizing commonalities between the two groups (Kassem et al., 2012; Manohar et al., 2008; Salvadó et al., 2012). Some indicated that LL is more efficient and has fewer complications (Atar et al., 2013; Bapat et al., 2007; Yin et al., 2013). Our study results showed that the mean duration of stone was 10.54 ± 2.65 days for the Holmium Laser (LL) group and 10.43 ± 2.68 days for the Pneumatic Lithoclast (PL) group. The mean stone size in the LL group was 1.58 ± 0.22 cm, while the PL group was 1.54 ± 0.22 cm. A high rate of stone-free status was found for the LL group, i.e., 93.5% and 69.4% in the PL group. In group A, this difference was statistically significant ($p = 0.001$). The stated success rate of pneumatic lithotripters treating ureteral stones is between 95 and 100 percent (Khan et al., 2011; Zhu et al., 2014). Sozen et al. evaluated 500 patients who underwent semi-rigid ureteroscopic stone retrieval using a pneumatic lithotripter, revealing an overall stone-free rate of 94.6%. Similarly, Gunlusoy et al. discovered success rates for pneumatic lithotripsy in treating upper, middle, and lower ureteral stones to be 90.5%, 93.1%, and 98.8%, respectively, in a study involving 1296 patients (Gunlusoy et al., 2008). Also, the average stone fragmentation time for the Ho-Yag and pneumatic groups was 13.7 minutes and 7.9 minutes, with a stone-free percentage of 100% and 42.9%, respectively. In research by Jeon et al., individuals who received ureterorenoscopy (URS) with laser and pneumatic lithotripters were evaluated. The proportion of stone-free samples was 84.6% and 96.0%, correspondingly. In the laser group, the mean operating time was 49.9 minutes, whereas it was 76.9 minutes in the non-laser group (Jeon et al., 2005). Similar to the existing studies, our laser group's operating time was much reduced. Numerous studies demonstrate a negative association between stone size and treatment efficacy. However, some studies find no correlation between stone size and treatment success (Ather et al., 2009). In our investigation, we observed no noteworthy contrast in the rates of achieving a stone-free status between the two groups. However, we identified a notable dissimilarity in complication rates, indicating that patients undergoing pneumatic lithotripsy were more inclined to require open surgery. Stones must be crushed between the probe and the mucosa during pneumatic lithotripsy. This is the most prevalent reason for ureteral perforation. Due to the semi-contact fragmentation that occurs during laser lithotripsy treatment, this issue arises infrequently. Razzaghi et al. reported no distinction in complication rates among the pneumatic and laser lithotripsy groups (Razzaghi et al., 2013). Jeon observed that the incidence of complications in the pneumatic lithotripsy group in his study was 7.7%, but in the laser lithotripsy group, no complications were reported (Jeon et al., 2005). In a study published by Binbay et al., pneumatic and laser lithotripsy for impacted ureteral stones were compared. The reported stone-free rates were 80% and 97.5%, respectively. The laser lithotripsy group had a much shorter mean operating time than the other group, 48 minutes compared to 30 minutes (Binbay et al., 2011). The results of this study showed that independent of the location of the stone, the use of Ho: YAG as an intracorporeal lithotripter while ureteroscopic therapy of impacted ureteral stones is highly effective.

One limitation of our study was that men dominated it. Consequently, extending our findings to women should be done with caution. Another limitation of this study is that one cannot prove the cause and effect of complications. The study was conducted on a small scale in an urban area, so it's probable that the findings can't be extrapolated to larger populations.

Conclusion

Treatment of proximal ureteral stones with pneumatic and holmium laser lithotripsy is successful. Proximal impacted ureteral stones can be treated with either semirigid ureteroscopy techniques; however, holmium laser lithotripsy with flexible ureteroscopes is superior for intrarenal migrated stones. In the proximal ureteral stones, the fragmentation rates of the holmium laser are significantly better compared with those using the pneumatic lithotripsy. In conclusion, according to our experience, for proximal ureteral stones with a size up to 2 cm, lithotripsy with the high success rate of holmium laser makes it the preferable method; on the other hand, the high retropulsion rate of pneumatic lithotripsy makes it less successful.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

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Approved by the department Concerned.

Consent for publication
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Conflict of interest

The authors declared absence of conflict of interest.

Author Contribution

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Study Design, Review of Literature.
Conception of Study, Development of Research Methodology Design, Study Design,, Review of manuscript, final approval of manuscript.
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Coordination of collaborative efforts.
Conception of Study, Final approval of manuscript.

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