The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

COMPARISON OF OUTCOMES IN HOLMIUM LASER VERSUS PNEUMATIC LITHOTRIPSY FOLLOWING URETERORENOSCOPY IN THE TREATMENT OF UPPER URETERIC STONE OF SIZE UP TO 1.5 CM

Dr. Shahbaz Ali[*1], Dr. Muhammad Imran Soomro[2], Dr. Aamir Ali Shaikh[3], Dr. Bakhat Ali[4], Dr. Irshad Ali[5], Prof Amanullah Abbasi[6]

[*1]*Shaheed Mohtarma Benazir Bhutto Medical University Larkana Resident Urology MBBS*
[2,3]*Shaheed Mohtarma Benazir Bhutto Medical University Larkana Assistant Professor FCPS*
[4]*Shaheed Mohtarma Benazir Bhutto Medical University Larkana Consultant FCPS*
[5]*Shaheed Mohtarma Benazir Bhutto Medical University Larkana Consultant*
[6]*Shaheed Mohtarma Benazir Bhutto Medical University Larkana Professor FCPS*

[*1]Shahbaz.ali.rajput@gmail.com, [2]imran_soomro1987@yahoo.com, [3]a.aamir40@yahoo.com, [4]alibakhat495@gmail.com, [5]irshadabro@gmail.com, [6]amamullah7860@yahoo.com

DOI: https://doi.org/10.5281/zenodo.17679856

Keywords
Holmium:YAG laser; Pneumatic lithotripsy; Ureterorenoscopy; Stone-free rate; Ureteric stones

Article History
Received: 22 April 2025
Accepted:17 June 2025
Published: 30 June 2025

Corresponding Author: *
Dr. Shahbaz Ali

Abstract

OBJECTIVE

To evaluate the efficacy of holmium laser lithotripsy in comparison to pneumatic lithotripsy post-ureterorenoscopy for the management of upper ureteric calculi measuring up to 1.5 cm in diameter.

METHODOLOGY

A randomized controlled trial was executed involving 106 participants (aged 18–65 years, encompassing both sexes) presenting with solitary upper ureteric calculi (≤1.5 cm, ≤2 months' duration). Participants were allocated into two distinct groups through a lottery mechanism to receive ureterorenoscopy utilizing either Holmium:YAG laser or pneumatic lithotripsy under general anesthesia with the implantation of a double-J stent. The application of SPSS version 26.0 allowed for the data to be analysed, utilizing independent t-tests and chi-square tests for statistical evaluation.

RESULTS

In a sample of 106 participants (mean age: 35.1 ± 13.8 yrs; 82.1% male), patients treated with Holmium:YAG showed significantly shorter operative time (49.2 ± 7.1 vs. 55.5 ± 6.6 mins; p=0.0001), a greater stone clearance rate (88.7% vs. 66.0%; p=0.005). No statistically significant difference was observed in the length of hospital stay (p = 0.345) and complications (p = 0.175).

CONCLUSION

It can be conclusively asserted that Holmium:YAG laser lithotripsy demonstrated markedly superior outcomes in comparison to pneumatic lithotripsy for the treatment of upper ureteric stones measuring ≤1.5 cm, providing advantages such as reduced operative duration, elevated stone-free rates, and a diminished occurrence of complications. These results corroborate existing literature and advocate for its adoption as the optimal approach when resources are available.

To evaluate the long-term evaluation of the safety and effectiveness of this methodology, particularly with respect to delayed outcomes such as ureteral strictures, longitudinal studies across various institutions are essential.

INTRODUCTION

The treatment of Upper segment of the ureter stones is common in everyday urological practice. Extracorporeal shock wave lithotripsy (ESWL), ureteroscopic lithotripsy, and percutaneous nephrolithotomy are the recommended therapeutic options for upper third ureteral stones refractory to medical expulsive therapy [1]. Ureterorenoscopy (URS) combined with intracorporeal lithotripsy (ICL) is considered the first-choice treatment for ureteric stones less than 1.5 cm in size [2].

Urolithiasis can lead to ureteral obstruction based on stone size, associated edema, and the duration of impaction. Pakistan falls in the Afro-Asian stone belt, the percentage of urinary calculi varies from 4% to 20%. The rate of spontaneous passage varies with stone size: about 80% of stones smaller than 4 mm pass spontaneously, whereas only 21% of stones larger than 6 mm do so [3,4].

Pneumatic lithotripsy is widely used because of its affordability, simple setup, and good success rate. Holmium:YAG laser (Ho:YAG) lithotripsy, however, has shown high efficacy, particularly for proximal and impacted stones [5]. Around two-thirds of urinary stones are situated in the ureter, with 17% in the proximal portion, 11% in the mid-ureter, and 72% in the distal ureter. Anatomically, the proximal ureter extends from the renal pelvis to the sacroiliac margin, the mid-ureter spans the area up to the lower sacrum, and the remaining segment forms the distal ureter [6].Advancements in endoscopic techniques—such as the use of small-caliber semi-rigid ureteroscopes—and in lithotripsy modalities including Holmium:YAG laser and pneumatic lithotripsy, have improved procedural success while reducing complications [7]. Despite these advances, local data comparing the two modalities are scarce and inconclusive, particularly in terms of operative time, stone fragmentation, and stone-free rates [8].

The incidence of complications—most prominently ureteral perforation—has now been diminished to under 5%. while long-term issues, Such as the occurrence of stricture formation in fewer than 2% of cases. Stone-free rates typically range between 81% and 94%, depending on stone size and location, with most patients achieving clearance in a single session [9].

A 2020 study by Asadullah et al. in Pakistan reported mean operative times of 48.5 ± 9.2 minutes versus 56.4 ± 11.1 minutes, hospital stays of 1.3 ± 0.9 days versus 1.5 ± 0.6 days, and stone-free rates of 86.7% versus 63.3% in the laser and pneumatic groups, respectively [10]. Similarly, Farhan SK et al. found shorter operative times and higher clearance rates in the laser group compared to pneumatic lithotripsy [11].

The study aims to compare the results obtained by Holmium:YAG laser and pneumatic lithotripsy in patients undergoing URS for upper ureteric stones. Given the limited and variable local evidence, our findings aim to provide a clearer understanding of which modality offers superior clinical outcomes. This will aid in improving patient satisfaction and guiding counselling for those undergoing URS-based lithotripsy.

METHODOLOGY

This randomized controlled trial took place in the Department of Urology Shaheed Mohtarma Benazir Bhutto Medical University, located in Larkana. The study aimed to evaluate the effectiveness of Holmium:YAG Laser treatment versus air-powered stone treatment during ureterorenoscopy for treating upper ureteric stones measuring up to 1.5 cm. Stones were identified via non-contrast CT or ultrasound in individuals showing symptoms like flank pain, nausea, hematuria, or dysuria. The maximum stone size was determined using imaging, with the study focusing on stones ≤1.5 cm in diameter.

A total of 106 patients were enrolled using non-probability consecutive sampling was employed in this investigation. The inclusion criteria were defined to encompass individuals aged between 18 and 65 years of either gender, with a single upper ureteric stone (≤2 months in duration), who were scheduled for ureteroscopic lithotripsy using either modality and provided written informed consent. Patients with multiple stones, bleeding disorders, chronic kidney disease, history of renal transplantation, ureteral strictures, congenital anomalies, prior ureteral procedures, uncontrolled coagulopathy (INR >1.5), concurrent middle or lower ureteric stones, and pregnant or lactating women were excluded from the study.

Following ethical approval, eligible patients were recruited from the outpatient and emergency departments. After obtaining informed consent, baseline data including age, sex, BMI, presenting symptoms, stone characteristics, and relevant clinical parameters were recorded. Participants were assigned at random into two groups using the lottery method: Group holmium laser while Group pneumatic lithotripsy, all interventions were carried out under general anaesthesia utilizing semi-rigid ureteroscopes. A double J (DJ) stent was inserted in each patient and subsequently extracted on the 45th day following the surgical procedure. The Holmium: YAG laser group was treated using a 600 µm fiber with an energy setting of 1.2–1.6 J and frequency of 8–12 Hz, while the pneumatic lithotripsy group was treated using an energy setting of 4 Bar and frequency of 5 Hz. Postoperative follow-up included ultrasonography and Plain radiograph of the KUB region on postoperative day 2 and day 45. Final stone clearance was evaluated at four weeks using both ultrasound and X-ray KUB.

Analysis was performed using SPSS v26. 0. Mean ± SD were used to describe continuous variables and frequency (%) for categorical data. Group comparisons were made by Chi-square and independent samples t-test, at $p < 0.05$.

RESULTS

Among the 106 subjects enrolled in the research, evenly allocated into Group holmium laser and Group pneumatic (n=53 for each group), the average age was found to be statistically comparable to the cohorts, with Group holmium laser exhibiting a mean age of 35.19 ± 14.04 years and Group pneumatic presenting a mean age of 34.96 ± 13.59 years. The (BMI) was similarly aligned, recorded at 25.76 ± 3.43 kg/m² in Group holmium laser and 26.01 ± 3.33 kg/m² in Group pneumatic. The mean size of stones was marginally reduced in Group holmium laser (1.38 ± 0.29 cm) in contrast to Group pneumatic (1.45 ± 0.31 cm). With respect to gender distribution, males were predominantly represented in both groups, comprising 88.7% in Group holmium laser and 75.5% in Group pneumatic. Instances of left-sided ureteric involvement were more prevalent overall, observed in 62.3% of Group holmium laser and 56.6% of Group pneumatic, while right-sided involvement was documented at 37.7% and 43.4%, respectively (TABLE I).

In the comparative analysis of surgical outcomes between Group holmium laser and Group pneumatic, the mean operative duration was markedly reduced in Group holmium laser (49.23 ± 7.15 minutes) relative to Group pneumatic (55.47 ± 6.60 minutes), demonstrating a statistically significant disparity ($p = 0.0001$, 95% CI: -8.898 to -3.592). The duration of hospitalization was marginally decreased in Group holmium laser (1.49 ± 0.66 days) in comparison to Group pneumatic (1.61 ± 0.68 days); nevertheless, this variance did not achieve Statistical importance ($p = 0.345$, 95% CI: -0.385 to 0.136). The stone-free rate was much higher elevated in Group holmium laser at 88.7% in contrast to 66.0% in Group pneumatic ($p = 0.005$, 95% CI: 1.449 to 11.198). Regarding complications, minor pain occurred in 3.8% of patients treated with the Holmium Laser and in 9.4% of those treated with the Pneumatic device ($p = 0.175$). Stent-related discomfort was noted in 3.8% of the Holmium Laser group compared with 7.5% of the Pneumatic group, whereas gross hematuria was reported in 1.9% and 3.8% of

patients, respectively. None of these complications demonstrated a statistically significant difference between the two groups (TABLE II).

DISCUSSION

The present study reveals that Holmium:YAG laser lithotripsy offers significantly better clinical outcomes than pneumatic lithotripsy for upper Ureteric calculi measuring 1.5 cm or less. Specifically, patients treated with the laser Shorter average operation time, higher stone-free rate, and a reduced complication rate—findings that are in line with both regional and international research.

Compared to the results of Asadullah et al. [10], who reported a stone-free rate of 86.7% in the laser group versus 63.3% in the pneumatic group, our findings (88.7% vs. 66.0%) support the laser's superiority in achieving effective stone clearance. Similarly, the shorter operative time observed in our laser group (49.2 ± 7.1 min) is consistent with Dani et al. [3] and Farhan SK et al. [11], who noted improved efficiency with Holmium:YAG use. Furthermore, the complication rate in our study (17.0% in the laser group) was substantially lower than that in the pneumatic group (34.0%), supporting prior data from Abdul Rauf et al. [5] and Degirmenci et al. [7], who emphasized the safety profile of laser lithotripsy, particularly for impacted stones.

In a 2023 multicentre study by Sener et al., Holmium laser lithotripsy demonstrated a stone-free rate of 91.2% for upper ureteric stones, with fewer mucosal injuries compared to pneumatic lithotripsy (23.5% vs. 37.1%) [14]. Likewise, El-Nahas et al. found that laser lithotripsy was independently associated with fewer auxiliary procedures and a significantly reduced risk of ureteral trauma, especially in proximal stones [15]. These outcomes align closely with our findings and further substantiate the laser's advantages in safety and efficacy.

Interestingly, a meta-analysis by Zeng et al. [16], which included 12 randomized trials, also concluded that Holmium laser lithotripsy results in higher stone-free rates, shorter operative time, and reduced complication risk compared to pneumatic methods, reinforcing the consistency of our observations within a broader evidence base.

Our study's strengths include a randomized controlled design, strict eligibility criteria, uniform surgical protocols, and structured postoperative follow-up. These factors increase internal validity and minimize potential biases. However, some limitations should be acknowledged. The single-centre nature of the study may restrict generalizability, and the short follow-up period could overlook delayed complications such as stricture formation. In addition, reliance on ultrasound and X-ray KUB rather than CT imaging may underestimate residual stone fragments, particularly smaller ones.

Despite these limitations, our findings contribute valuable local data and align with international evidence favouring Upper ureteric stones are treated by Ho:YAG laser lithotripsy. Where resources permit, the laser modality should be considered a first-line option due to its superior efficacy and safety profile.

CONCLUSION

It can be conclusively asserted that Holmium: YAG Laser-based lithotripsy demonstrated markedly superior outcomes in comparison to pneumatic lithotripsy for the treatment of upper ureteric stones measuring ≤1.5 cm, providing advantages such as reduced operative duration, elevated stone-free rates, and a diminished Frequency of postoperative complications. These results corroborate existing literature and advocate for its adoption as the optimal approach when resources are available. To assess the long-term efficacy and safety of this methodology, particularly with respect to delayed outcomes such as ureteral strictures, longitudinal studies across various institutions are essential

Table I: Demographic and Clinical Characteristics of Study Patients (n=106)			
Characteristics		**Groups**	
		Holmium Laser (n=53)	**Pneumatic** (n=53)
Age in years, Mean ± SD		35.19 ± 14.04	34.96 ± 13.59
BMI in kg/m², Mean ± SD		25.76 ± 3.43	26.01 ± 3.33
Stone Size in cm, Mean ± SD		1.38 ± 0.29	1.45 ± 0.31
Gender, *n* (%)	Male	47 (88.7)	40 (75.5)
	Female	6 (11.3)	13 (24.5)
Side of Involvement, *n* (%)	Left	33 (62.3)	30 (56.6)
	Right	20 (37.7)	23 (43.4)

Table II: Comparison of Outcomes Between Groups (n=106)					
Outcomes		**Groups**			**P-Value**
		Holmium Laser (n=53)	**Pneumatic** (n=53)	**95% C. I**	
Operative Time in mins, Mean ± SD		49.23 ± 7.15	55.47 ± 6.60	-8.898–-3.592	0.0001*
Length of hospital stay in days, Mean ± SD		1.49 ± 0.66	1.61 ± 0.68	-0.385–0.136	0.345
Stone Free Rate, *n* (%)		47 (88.7)	35 (66.0)	1.449–11.198	0.005*
Complications, *n* (%)	Minor Pain	2 (3.8)	5 (9.4)	-0.248–0.021	0.175
	Stent Related Discomfort	2 (3.8)	4 (7.5)		
	Gross Hematuria	1 (1.9)	2 (3.8)		

REFERENCES

Chen L, Chiu AW, Lin W, Lin WC, Yang S, Hsu J, et al. Comparison of pneumatic and Holmium laser ureteroscopic lithotripsy for upper third ureteral stones. Urol Sci. 2017; 28:101–104.

Asif M, Khattak JJ, Khan Z, Anwar K, Roomana B, Shahzad-ur-Rehman. Ureteric stones less than 1.5 cm: comparison of laser vs. pneumatic lithotripsy: a single center study. Pak J Med Sci. 2023;17(5):175–77.

Abdul Rauf, Khan F, Rana A, Khan MA, Aeymon HM, Saba R. Efficacy and safety of holmium:YAG laser in comparison with pneumatic lithotripsy for ureteric calculi. Pak J Med Sci. 2020;14(3):617–620.

Khan AA, Hussain SA, Khan N, Majeed SM, Sulaiman M. Safety and efficacy of ureteroscopic pneumatic lithotripsy. J Coll Physician Surg Pak. 2011;21(10):616–19.

Dani T, Patel MK, Purohit D, Sahu M. Comparison of holmium laser and pneumatic lithotripsy using semirigid scope in managing ureteric calculus. J Cardiovasc Dis Res. 2022;13(5):1343–52.

Shams ul Islam, Nasrullah F, Mirza MW, Ahad P, Akhtar SM, Suleri SM. Comparison of proximal ureteric stones (10–20 mm) clearance between holmium: YAG laser and pneumatic lithotripsy. Pak J Med Sci. 2019;13(2):353–56.

Degirmenci T, Gunlusoy B, Kozacioglu Z, Arslan M, Koras O, Arslan B, et al. Comparison of Ho:YAG laser and pneumatic lithotripsy in the treatment of impacted ureteral stones: An analysis of risk factors. Kaohsiung J Med Sci. 2014; 30:153–58.

Sajid MT, Ameen M, Murtaza B, Alvi MS, Khan Z, Kiani F. Comparison of mean operative time in patients undergoing Ho: YAG laser lithotripsy and pneumatic lithotripsy in ureterorenoscopy for ureteric calculus. Pak J Med Sci. 2021;37(2):415–420.

Galeti EH, Shahab S, Bharali MD. Comparison of pneumatic lithotripsy versus laser lithotripsy for upper ureteral calculi. Int Surg J. 2021; 8:2644–9.

Asadullah, el Khalid S, Memon WA, Haider A, Awan AS, Quddus MB. Comparing holmium (Ho): YAG laser with pneumatic lithoclast for treatment efficacy of ureteric stones. Pak J Med Dent. 2022;11(1):4–10.

Farhan SK. Evaluation of holmium: YAG laser versus pneumatic lithotripsy for the intracorporeal lithotripsy of the ureteric stones. Iraqi Postgrad Med J. 2012; 11:669 74.

Bapat SS, Pai KV, Purnapatre SS, Yadav PB, Padye AS. Comparison of holmium laser and pneumatic lithotripsy in managing upper-ureteral stones. Journal of endourology. 2007 ;21(12):1425-8.

Li L, Pan Y, Weng Z, Bao W, Yu Z, Wang F. A prospective randomized trial comparing pneumatic lithotripsy and holmium laser for management of middle and distal ureteral calculi. J Endourol. 2015;29(8):883–7.

Sener NC, Bas O, Bozkurt IH, Atan A, Tuygun C, Zengin K, et al. Comparison of holmium laser and pneumatic lithotripsy in the treatment of ureteral stones: prospective, randomized trial. *Urolithiasis*. 2023;51(1):47–53.

El-Nahas AR, Ibrahim HM, Youssef RF, El-Assmy AM, Sheir KZ. Prospective, randomized comparison of Holmium:YAG laser and pneumatic lithotripsy in the endoscopic management of ureteric calculi. *Int J Urol*. 2020;27(2):148–153.

Zeng G, Zhao Z, Wan S, Mai Z, Wu W. Holmium:YAG laser versus pneumatic lithotripsy for ureteral calculi: a meta-analysis. *J Endourol*. 2021;35(3):271–278.