

Pneumatic Lithotripsy versus Laser Lithotripsy for Mid-ureteric stone: A Comparative Study in BSMMU, Bangladesh

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ABSTRACT

Introduction: Urolithiasis is a worldwide health problem with significant morbidity. Several modalities are available for fragmentation of mid-ureteric stone. Among them pneumatic and laser lithotripsy (PL & LL) are commonly practiced. Aim of this study was to compare the efficacy and safety between pneumatic and laser lithotripsy (holmium: yttrium-aluminum-garnet) in the treatment of mid-ureteric stone. **Methods:** This experimental study was conducted in the Department of urology at Bangabandhu Sheikh Mujib Medical University (BSMMU) from September, 2020 to August, 2022. A total of 110 patients with large mid-ureteric stone were enrolled purposively and divided into two groups; PL group(60 patients treated with the pneumatic lithotripsy) and LL group(50 patients treated with the laser lithotripsy). Patient demographics, stone characteristics, intraoperative parameters and postoperative complications were compared between two groups. **Results:** The baseline demographics of patients, stone characteristics and duration of mean hospital stay were similar in the two groups. The LL group showed significant benefits compared with the PL group in terms of mean operative time ($p < 0.001$) and early stone-free rate (94% vs 65%, $p < 0.05$), but there was no statistically significant difference at the third month (96% vs 91.6%, $p > 0.05$). Stone migration was significantly higher in PL group (28.3% vs 8%). The other complications, such as ureteric perforation, bleeding, postoperative fever and ureteric mucosal injury, were similar in the two groups. **Conclusion:** Both the PL and LL approaches were effective and safe for mid ureteral stone but LL had short operative time, less stone migration and retreatment rate.

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INTRODUCTION

Ureteric stone is the classic cause of renal colic-type abdominal pain. Mid-ureter is the portion which overlies along the sacroiliac joint and treatment option may vary according location of ureteric stone.¹ Treatments for ureteric calculi has been evolved from open ureterolithotomy to minimally invasive procedures like extracorporeal shock wave lithotripsy (ESWL), ureteroscopic lithotripsy and laparoscopic lithotomy.² The combination of ureteroscopy and intra corporeal lithotripsy has proven to be a viable alternative to ESWL for the management of ureteric calculi.³ Ureteroscopic interventions become the main therapeutic way for large ureteric stones due to high stone-free rate (SFR) and relatively low complications.⁴ There are different modalities of ureteric extracorporeal lithotripsy. For ureteric intracorporeal lithotripsy lasers, pneumatic lithoclast, electrohydraulic lithoclast (EHL) and ultrasonic lithoclast are used.

Several factors influence the selection of an appropriate procedure including stone size, stone composition, the presence of obstruction, anatomy of ureter, surgeon experience, the availability of necessary equipment and financial factors.^{5,6} Ureterorenoscopy (URS) with lithotripsy by either laser (LL) or pneumatic (PL) energy is the most widely accepted first-line treatment option for large (>10 mm) mid-ureteric stone.⁷ Although pneumatic lithotripsy provides high SFR, but there is a considerable incidence of stone migration. Since the introduction of laser lithotripsy, a shift towards its use has been seen, especially for its high SFR, a lower incidence of stone migration and safety in medical conditions like uncorrected coagulopathy. Laser lithotripsy is associated with increase in costs and operative time.^{8,9}

There are only a few studies with variable but conflicting results that compare laser and pneumatic lithotripsy according to their fragmentation, intraoperative parameters, complications and stone-free rates.¹⁰⁻¹³ On the basis of these controversies, this experimental study

was designed to compare the efficacy and safety of PL and LL for the treatment of patients with mid-ureteric stone.

METHODS

This experimental study was carried out in the Department of Urology in Bangabandhu Sheikh Mujib Medical University (BSMMU) during the period of September, 2020 to August, 2022. Study approval was taken from institutional review board (IRB) of BSMMU before data collection. A total of 110 patients were selected by purposive sampling after getting informed consent. Inclusion criteria were patient with unilateral, single stone (size: 1-2 cm) located in the middle part of ureter that had not passed in three weeks with the presence of hydronephrosis. Patients with co-morbidities like diabetes mellitus, hypertension, and renal failure; solitary kidney; ureteral tumor or stricture; who had previous Ureterorenoscopy (URS) or ureteral surgery were excluded from the study. All the patients underwent thorough process of history, examination, and investigations. Imaging examinations including renal ultrasonography, plain radiography of the kidneys-ureters-bladder (KUB), intravenous urography (IVU) or Non-contrast CT were performed according to indication. The laser lithotripsy (LL) group had 50 patients and pneumatic lithotripsy (PL) group had 60 patients. Negative urine cultures were ensured in every patient of both groups. Spinal anesthesia was employed in all patients. A third-generation cephalosporin (ceftriaxone) was administered at induction of anesthesia. Ureteroscopy combined with either holmium: YAG laser or pneumatic lithotripsy was performed by a single urologist using a 7.5 FrStorzsemi rigid ureteroscope. The patients were placed in lithotomy position. The standard technique was employed including cystoscopy with placement of a 0.038-inch floppy tip guide wire past the stone to maintain access and then ureteroscope negotiation. Swiss lithoclast with 1mm probe was used to break the stones in PL group. Elevation of head end of the patients were done to prevent stone migration but use of baskets and ureteric occlusion devices were

avoided. The pneumatic settings were five bar and the frequency 10 Hz. The laser settings were 0.8 to 1.0 J per pulse, and the frequency 10 to 15 Hz. The majority of the patients were treated with a 365 m quartz fiber. Continuous irrigation with normal saline was used to maintain a clear ureteroscopic view when appropriate. In the procedure, all the stones were fragmented, removed completely and ensured no residual stone. A 5-6Fr Double-J stent in retiring all the patients which was left for 3 to 4 weeks and removed on an outpatient basis. KUB radiography was performed routinely on postoperative day 1 to assess residual stone fragments as well as the location of the Double-J stent. Patients were considered stone free when no stone >2 mm was visualized. Postoperative evaluations were made

after discharge from hospital at 1 and 3 months later.

Differences in proportions between the PL group and LL group were assessed by chi-square test. For differences in the continuous variables, Student t test was done. A *p* value <0.05 was considered statistically significant. All statistical analyses were performed by SPSS 20.0 (SPSS, Chicago, IL).

RESULTS

Average age of the patient, male to female ratio, BMI, side of stone, stone size and grading of hydronephrosis were almost similar between the laser and pneumatic lithotripsy groups (Table I).

Table-I: Demographic and Clinical characteristics of study groups

Characteristics	LL Group (N-50)	PL Group (N-60)	<i>p</i> -value
Age in years, (mean± SD)	36.72± 13.31	39.14± 11.22	>0.05
Sex Ratio	M: F 1.9:1	M: F 1.4:1	>0.05
Mean BMI (kg/m ²)	22.5	24.3	>0.05
Side of stone, n/N (%)			
Right	19/50 (38)	27/60 (45)	>0.05
Left	31/50 (62)	33/60 (55)	
Stone size(mm), mean± SD	13.6± 2.43	13.22± 2.81	>0.05
Hydronephrosis n/N (%)			
Mild	13/50 (26)	13/60 (21.6)	>0.05
Moderate	30/50 (60)	35/60 (58.3)	
Severe	07/50 (14)	12/60 (20.0)	

BMI=body mass index; LL=Laser lithotripsy; PL=Pneumatic lithotripsy

The intraoperative and postoperative findings are summarized in Table II. An overall significantly increased operative time was reported in PL compared to LL group; including X-ray exposure time. As can be seen statistically significant differences were found in terms of early SFR, stone migration in favor of the LL group (*P* ≤ 0.05). No significant differences observed between groups in term of mean hospital stay and volume of irrigation fluid. Intraoperative ureteric perforation occurred in two patients (One in PL group and one in LL group), who were treated with insertion of an internal stent in ureter. Eleven patients developed postoperative fever, (7 patients in PL group) that were

managed conservatively with an uneventful course. Five (2 patients in LL group and 3 patients in PL group) patients had persistent gross hematuria for >24 hours postoperatively, which resolved with increased diuresis. Stone migration occurred significantly lower in (four patients) LL group. Three of them were treated with conservative measures as it was partially fragmented to small pieces, while the other required ESWL. On the other hand, stone migration occurred in 14 patients in PL group. Four of them later passed spontaneously but the other 10 patients required retreatment (4 patients require pushback PCNL, 4 require LL and 2 managed by open ureterolithotomy). All

patients in both groups were followed up after discharge, at 1st and 3rd month. The successful fragmentation included complete stone clearance evident on a plain KUB radiograph after URS. The stone-free rates in immediate postoperative period and at the first month were significantly

greater in the LL group than that in the PL group ($P < 0.05$). There was no statistically significant difference regarding stone-free rates between the two groups when it came to the third month (96% vs 91.6%, $p = 0.15$).

Table II: Operative and postoperative findings

Variables	LL Group (N=50)	PL Group (N=60)	p-value
MOT \pm SD, minutes	27.75 \pm 9.02	41 \pm 12.4	<0.001
MHS \pm SD, days	1.4 \pm 2.4	1.6 \pm 3.1	>0.05
X-ray exposure, minutes (mean \pm SD)	3.10 \pm 1.0	3.56 \pm 1.18	<0.05
Irrigation volume, Litre (mean \pm SD)	11.41 \pm 2.32	11.92 \pm 2.89	>0.05
Complications n/N (%)	1/50(2)	2/60(3.3)	>0.05
Ureteric perforation	4/50(8)	7/60(11.7)	>0.05
Postoperative fever	2/50(4)	4/60(6.7)	>0.05
Mucosal injury	4/50(8)	17/60(28.3)	<0.05
Stone migration	2/50(4)	3/60(5)	>0.05
Gross hematuria			
Immediate SFR, n/N (%)	47/50(94)	39/60(65)	<0.05
SFR, n/N (%)			
1-month	47/50(94)	48/60(80)	<0.05
3-months	48/50(96)	55/60(91.6)	>0.05

N.B.: MOT (Mean operation time); MHS (Mean hospital stay); SFR (Stone free rate)

DISCUSSION

Improvement in technology of intra corporeal stone fragmentation has made it possible to successfully access and treat virtually any stone within the ureter in a relatively atraumatic fashion. Ureterorenoscopy (URS) with lithotripsy is the preferred treatment for large mid-ureteric stone. Despite the availability of several techniques, pneumatic and laser energy are preferred for their high stone free rates (SFR)⁹ and lower morbidity rates.^{14,15} The holmium: YAG laser can be used to fragment stones of all composition with semi-rigid ureteroscopy, with a fragmentation rate of 90-100%.¹⁶

There were no statistically significant differences in demographic and clinical characteristics in both groups in this study. Operative time was significantly longer in PL group, which is dissimilar with other studies.^{17,18} This difference probably related to the combined fragmentation and dusting technique used in LL reducing the need for fragment retrieval in comparison to PL in which additional time is required for grasping of

relatively larger stone fragments. As operative time was longer in PL, radiation exposure was also significantly higher in this group which correlates with the study conducted by Nour et al.⁷

In this study, immediate stone free rate in LL group was significantly high (94%). At 3-month follow-up, however, the success rate for PL increased to 91.6%, comparable to that of the LL group. This discrepancy of stone free rate could be the result of the length of follow-up. With a longer follow-up, more spontaneous stone passage occurred and greater stone-free rate could be achieved in both groups. In term of efficacy of lithotripsy, Laser has significant advantages over the other techniques.¹⁹ Although some investigators held a viewpoint that patients without a stent were not at a higher risk for complications and had fewer postoperative symptoms than those with a stent,²⁰ a 5/6Fr DJ stent was preferred to be inserted to avoid postoperative ureteric obstruction by stone fragments or blood clots in this study.

Migration of a ureteric stone is a common complication when using a pneumatic energy source.^{1,18,21} In this study, there was also significant stone migration in PL group favoring the argument of use of laser lithotripsy. Contrary to this finding, no difference was observed in the rate of stone migration between PL and LL in some studies and a meta-analysis.^{4,7,9} Elevation of head end of the patients were done to prevent stone migration but use of baskets and ureteric occlusion devices were avoided in this study due to the risk of ureteric mucosal injury. PL group also required higher re-treatment than LL which coincides with the observation of Tipu et al.¹

Although LL had fewer complications, no significant differences found in present study regarding ureteric perforation, postoperative fever, mucosal injury, gross hematuria in comparison to PL which is supported by most of the studies.^{4,9,15,22,23} Discordant to our observations, two studies reported a significantly lower complication rate in patients undergoing laser lithotripsy.^{1,24} In a meta-analysis, postoperative ureteral stricture rate was significantly higher in LL than PL but this comparison was not investigated in this study.^{4,9}

This study conducted in a single center only and may not be generalizable to other regions of the world. Surgical procedures were performed by several surgeons that might lead to bias in our results. A randomized study with larger number of patients is needed to confirm the results. Furthermore, cost analysis of the techniques and re-treatment sessions was not evaluated.

CONCLUSION

This study concluded that, both the Pneumatic and Laser Lithotripsy (PL & LL) approaches were effective and safe for the treatment of mid ureteric stone. LL method had several advantages, especially in shorter mean operative time, lower risk of radiation hazard and lower stone migration rate.

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Conflict of interest: None

REFERENCES

1. Tipu SA, Malik HA, Mohhayuddin N, Sultan G, Hussain M, Hashmi A, et al. Treatment of ureteric calculi-use of Holmium: YAG laser lithotripsy versus pneumatic lithoclast. JPMA. 2007; 57: 440-443.
2. Khaladkar S, Modi J, Bhansali M, Dobhada S, Patankar S. Which is the best option to treat large (> 1.5 cm) midureteric calculi? JLAST. 2009; 19(4): 501-504.
3. Segura JW, Preminger GM, Assimos DG, Dretler SP, Kahn RI, Lingeman JE, et al. Ureteral stones clinical guidelines panel summary report on the management of ureteral calculi. J Urol. 1997; 158(5): 1915-1921.
4. Chen S, Zhou L, Wei T, Luo D, Jin T, Li H, et al. Comparison of holmium: YAG laser and pneumatic lithotripsy in the treatment of ureteral stones: an update meta-analysis. Uro Int. 2017; 98(2): 125-133.
5. Geraghty RM, Jones P, Somani BK. Worldwide trends of urinary stone disease treatment over the last two decades: a systematic review. J Endure. 2017; 31(6): 547-556.
6. Doizi S, Raynal G, Traxer O. Evolution of urolithiasis treatment over 30 years in a French academic institution. Progress Urol. 2015; 25(9): 543-548.
7. Nour HH, Kamel AI, Elmansy H, Badawy MH, Shabana W, Abdelwahab A et al. Pneumatic vs. laser lithotripsy for mid-ureteric stones: Clinical and cost effectiveness results of a prospective trial in a developing country. AJU. 2020; 18(3): 181-186.
8. Pietropaolo A, Proietti S, Geraghty R, Skolarikos A, Papatsoris A, Liatsikos E, et al. Trends of 'urolithiasis: interventions, simulation, and laser technology' over the last 16 years (2000–2015) as published in the literature (PubMed): a systematic review from European section of Uro-technology (ESUT). World J. Urol. 2017; 35(11): 1651-1658.
9. 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 Endure. 2015; 29(8): 883-887.

10. Kitano H, Shimmied S, Goriki A, Iwamoto H, Hayashi T, Mutaguchi K. Comparison of pneumatic lithotripter and Holmium YAG laser in transureteral lithotripsy (TUL). *Nihon Hinyokika Gakkaizasshi. Jpn J Urol.* 2013; 104(3): 513-520.
11. Sun Y, Wang L, Liao G, Xu C, Gao X, Yang Q, et al. Pneumatic lithotripsy versus laser lithotripsy in the endoscopic treatment of ureteral calculi. *J Endure.* 2001; 15(6): 587-590.
12. Li XC, Liu Y, Yang JG, Zhang DH. Comparative study of pneumatic lithotripsy and holmium laser lithotripsy for ureteral stones. *J Cent South Unit (MedSci).* 2005; 30(5): 601-603.
13. Cimino S, Favilla V, Russo GI, Saita A, Sortino G, Castelli T, et al. Pneumatic lithotripsy versus holmium: YAG laser lithotripsy for the treatment of single ureteral stones: a prospective, single-blinded study. *Uro Int.* 2014; 92(4): 468-472.
14. Sancak EB, Kılınc MF, Yücebaş SC. Evaluation with decision trees of efficacy and safety of semirigid ureteroscopy in the treatment of proximal ureteral calculi. *Uro Int.* 2017; 99(3): 320-325.
15. Freer B, Şen V, Erbatu O, Yıldız A, Ongün Ş, Çınar Ö, et al. Comparison of efficacy and complications of holmium laser and pneumatic lithotripters used in the ureterorenoscopic treatment of proximal ureter stones, a multi-center study of society of urological surgery aegean study group. *J Urol Surg.* 2018; 5(3): 158-163.
16. Zheng W, Denstedt JD. Intracorporeal lithotripsy: update on technology. *Urol Clin.* 2000; 27(2): 301-313.
17. Khofer WY, Bader M, Stroke R, Stief C, Waidelich R. Efficacy and safety of Ho: YAG laser lithotripsy for ureteroscopic removal of proximal and distal ureteral calculi. *BMC urology.* 2014; 14(1): 1-7.
18. Abedi AR, Razzaghi MR, Allameh F, Aliakbari F, FallahKarkan M, Ranjbar A. Pneumatic lithotripsy versus laser lithotripsy for ureteral stones. *JLMS.* 2018; 9(4): 233-236.
19. Dogan HS, Tekgul S, Akdogan B, Keskin MS, Sahin A. Use of the holmium: YAG laser for ureterolithotripsy in children. *BJU Int.* 2004; 94(1): 131-133.
20. Mendez-Probst CE, Goneau LW, MacDonald KW, Nott L, Seney S, Elwood CN, et al. The use of triclosan eluting stents effectively reduces ureteral stent symptoms: a prospective randomized trial. *BJU Int.* 2012; 110(5): 749-754.
21. Sen H, Bayrak O, Erturhan S, Urgun G, Kul S, Erbagci A, et al. Comparing of different methods for prevention stone migration during ureteroscopic lithotripsy. *Uro Int.* 2014; 92(3): 334-338.
22. Seong SJ, Ji-Hwan H, Kyu SL. A comparison of holmium: YAG laser with lithoclast lithotripsy in ureteral calculi fragmentation. *IJU.* 2005; 12(6): 544-547.
23. Kassem A, Elfayoumy H, Elsaied W, Elgammal M, Bedair A. Laser and pneumatic lithotripsy in the endoscopic management of large ureteric stones: a comparative study. *Uro Int.* 2012; 88(3): 311-315.
24. Bapat SS, Pai KV, Purnapatre SS, Yadav PB, Padye AS. Comparison of holmium laser and pneumatic lithotripsy in managing upper-ureteral stones. *J Endure.* 2007; 21(12): 1425-1428.