LASER LITHOTRIPSY FOR THE MANAGEMENT OF URETERIC CALCULUS

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ABSTRACT

Urinary calculi are important problem in urology field. Ureteral stones can cause obstructive uropathy and subsequent deterioration of renal function. The minimal invasive approaches become the major source of treatment modalities with the development of lithotripsy technology. A prospective cross sectional hospital study was conducted in the Urology Department of a tertiary care hospital in Kathmandu for a period of one year (September 2022 to August 2023). A total of 118 patients attending Urology OPD and undergoing laser lithotripsy were included in the study. Ureteroscopic procedure was done using a 6.5 Fr (Wolf Inc., Germany) semirigid ureteroscope under direct endoscopic vision and once the stone was visible, fragmentation was done using Ho-YAG laser. The mean age of the patients was 35.36 ± 11.65 years with male preponderance (58.5%). The common presenting symptom was flank pain and ureteric calculus was more common in the left side (49.2%). Upper ureteric calculus (60.2%) and single stone (83.9%) were more common. Stone size <10 mm (54.2%) and density more than 1000 HU (87.3%) were more common. Stone retropulsion was seen in 16.1% cases and 78% had no post operative complications. SFR in Xray KUB was 94.9% and in USG was 78.8%. The association of SFR in Xray KUB and USG among different variables - male and female patients, patients with stone size < and ≥ 10 mm, stone density < and ≥ 1000 HU and sites (upper, middle and lower) was statistically not significant. The laser lithotripsy technique was found to be effective and safe for ureteric calculus with high SFR.

KEYWORDS

Ureteric calculus, laser lithotripsy, retropulsion, Double J stent, Xray KUB, ultrasound, stone free rate

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INTRODUCTION

Urinary calculus is a frequent pathology in urology field. Ureteral calculus can cause obstructive uropathy and subsequent deterioration of renal function.[1-3] There is no clear time threshold for irreversible renal damage hence intervention should be strongly considered in any patient with ureteral obstruction unless close monitoring of renal function is available.[1] There are different treatment modalities for ureteric calculus depending upon various factors like size, density and location of calculus. The available modalities are medical expulsion therapy, open surgery, laparoscopic surgery, endoluminal surgery and Extracorporeal Shock Wave Lithotripsy (ESWL).[2,3] After the invention of Uretero-renoscopy (URS) and ESWL in 1980s, there has been a paradigm shift in the treatment modality of ureteric calculus from open surgery to endoluminal and non-invasive method.[3] The main advantage of URS is fragmentation of calculus under vision.[1,2] There are various modalities for stone fragmentation in URS – electrohydrolic lithotripsy (EHL), pneumatic, ultrasonic, laser and dual energy source (ultrasound+ pneumatic) lithotripsy.[2-4]

There are various types of laser, among which Holmium: Yttrium Aluminium Garnet (Ho:YAG) is commonly used as the tissue penetration of Holmium laser is less than two millimeters (mm).[5,6] Ho:YAG works by creation of microscopic vaporization bubbles and rapid impulsion of the these bubbles at the tip of fibre creates a shock wave that causes breakdown of stones.[1] The diagnosis and management facilities in ureteric calculus show a wide spectrum in different countries.[7] The role of ureteroscopy has dramatically evolved over the past twenty years and has become popular choice for the minimally invasive treatment of urolithiasis. Laser lithotripsy has a wider safety margin than other methods of stone destruction within the ureter because the energy generated in stone fragmentation is dissipated as photo acoustic energy rather than heat.[8] The aim of this study was to find out the laterality, site, number and density of the calculus including the outcome of laser lithotripsy in terms of the rate of stone retropulsion into the kidney and to see the post-surgical complications and stone free rate after the procedure.

MATERIALS AND METHODS

A prospective hospital based observational study was carried out in the Department of Urology of Nepal Medical College Teaching Hospital (NMCTH). The study was conducted for a period of one year (September 2022 to August 2023). Ethical approval was taken from Institutional Review Committee (IRC) of NMCTH. A total of 118 patients attending Urology OPD were included in the study. Inclusion criteria were - patients 18 years and above with ureteric calculus and undergoing laser lithotripsy, patients with negative urine culture, renal function test and computed tomography scan (CT-KUB/CT- IVU). Patients with positive urine culture, renal, pelvic or caliceal stone and uncontrolled coagulopathy were excluded from the study.

A prophylactic intravenous antibiotic was administered before surgery. All the patients were given General / Spinal anesthesia and was placed in lithotomy position. The ureteroscopic procedure was done by urologist and residents using a 6.5 Fr (Wolf Inc., Germany) semirigid ureteroscope under direct endoscopic vision. Ureters were accessed via 0.035 guide wires. Once the stone was visible, fragmentation was done using Ho-YAG laser. The laser fiber (365 µm) was passed through working channel of ureteroscope to the surface of calculi. During the lithotripsy, laser was set to a power of 5–10 W and a frequency of 8-10 Hz. The stone was broken to particles less than 3 mm to increase the likelihood of spontaneous passage. Double J (DJ) stent was inserted routinely after the procedure and post operative IV antibiotics were given for 3 days and patient was discharged, if there was no fever or any other complications. The stent was removed after 4 weeks of the procedure and stone free status was confirmed with ultrasonogram (USG) of abdomen and X ray KUB.

Data was collected after entering all the details in the proforma and was evaluated by SPSS-17. Frequency of demographic and clinical characteristics of ureteric calculus was presented with frequency and percentage. Association between different variables and stone free status was analyzed by chi-square test and P value less than 0.05 was considered statistically significant.

RESULTS

A total of 118 patients were enrolled in the study. The youngest patient was 18 years and the oldest patient was 70 years with mean age of 35.36 ± 11.65 years. There were more male patients (58.5%) than female patients (41.5%). The most common clinical presentation was flank pain (77.1%), which was either right or left depending upon the side of calculus present.

Table 1: Demographic and clinical characteristics of study population (n=118)

Variables	n	%
Gender		
Male	69	58.5
Female	49	41.5
Clinical presentation		
Flank pain	91	77.1
Pain abdomen	27	22.9
Hydronephrosis		
None	23	19.5
Mild	64	54.3
Moderate	28	23.7
Severe	3	2.5
Stone laterality		
Right	51	43.2
Left	58	49.2
Bilateral	9	7.6

Table 2: Ureteric Calculus related characteristics (n=118)

Variables	n	%
Site		
Upper	71	60.2
Middle	14	11.8
Lower	33	28.0
Number		
Single	99	83.9
Multiple	19	16.1
Size (mm)		
< 10	64	54.2
≥ 10	54	45.8
Mean = 9.95 ± 2.75		
Density (HU)		
< 1000	15	12.7
≥ 1000	103	87.3
Mean = 1312.36 ± 324.37		

Table 3: Surgical outcomes among the study population (n=118)

Variables	n	%
Stone retropulsion		
Yes	19	16.1
No	99	83.9
Post operative complications		
Bleeding	12	10.2
Fever	14	11.9
None	92	78.0
Post surgery KUB - residual stone		
Yes	6	5.1
No	112	94.9
Post surgery USG- residual stone		
Yes	16	13.6
No	93	78.8
Not done	9	7.6

The other clinical presentation was generalized abdominal pain (22.9%) and among those with abdominal pain, one patient presented with hematuria and the other with burning micturition. Left ureteric calculus (49.2%) was more common. Bilateral calculi were seen in 7.6% cases (Table 1).

The most common site for calculus was upper ureter (60.2%) and the least common was middle ureter (11.8%). There was predominance of single calculus (83.9%). Size of the stone was divided to two groups considering 10 mm as the cut off. Majority of the cases had smaller ureteric calculi; less than 10 mm (54.2%) and 87.3% cases had calculus with density ≥1000 HU (Table 2). Stone retropulsion was seen 16.1% cases. Post surgery complications was not seen in 78.0% of cases and among those who had, 11.9% had fever and 10.2% had bleeding. Post

Table 4: SFR according to Xray KUB with clinical characteristics (n=118)

Variables	Group	Residual stone-seen, n (%)	Residual stone-not seen, n (%)	P value*
Sex	Male	3 (4.4)	66 (95.7)	0.488
	Female	3 (6.2)	46 (93.9)	
Stone Size (mm)	<10	2 (3.2)	62 (96.9)	0.263
	≥ 10	4 (7.5)	50 (92.6)	
Stone density (HU)	<1000	0 (0)	15 (100)	0.434
	≥ 1000	6 (5.9)	97 (94.2)	
Site	Upper	4 (5.7)	67 (94.4)	0.651
	Middle	0 (0)	14 (100)	
	Lower	2 (6.1)	31 (94)	

*Fisher Exact Test

Table 5: SFR according to USG in relation to clinical characteristics				
		Residual stone- seen, n (%)	Residual stone- not seen, n (%)	P value *
Sex	Male	7 (10.8)	58 (89.3)	0.161
	Female	9 (20.5)	35 (79.6)	
Stone Size (mm)	<10	6 (10.8)	50 (89.3)	0.229
	≥ 10	10 (18.9)	43 (81.2)	
Stone density (HU)	<1000	0 (0)	12 (100)	0.133
	≥ 1000	16 (16.5)	81 (83.6)	
Site	Upper	12 (18.8)	52 (81.3)	0.264
	Middle	2 (15.4)	11 (84.7)	
	Lower	2 (6.3)	30 (93.8)	

*Fisher Exact Test

surgery residual stone was seen in 5.1% cases in KUB and 13.6% cases in USG. 7.6% cases did not do USG (Table 3).

As seen in Table 4 and 5, clinical characteristics such as sex, stone size (≥ 10 mm), stone density (≥1000 HU) and stone site (upper, middle and lower) were not significantly associated with SFR according to both Xray KUB and USG. Majority of the residual stones on USG was ≥10 mm with density ≥1000 HU and was located in the upper ureter.

DISCUSSION

The annual incidence of stone formation in the industrialized world is generally considered to be 1500–2000 cases per million.[7] Ureteric calculi commonly presents as acute abdominal colic typically with intermittent colicky flank pain and lower urinary tract symptoms occur once a stone enters ureter.[9] The stone needs to be actively removed in approximately 25.0% of those affected, and hence such procedures are required in almost 500 patients per million. It has been seen that urolithiasis constitutes 40-50.0% of the urological associated diseases in hospitals.[7]

Ureteroscopy has demonstrated a great efficiency in stone clearance for ureteral stones and superior in treating distal ureteral stones.[8] The development of smaller diameter scopes, increased scope flexibility, improvement of accessories, and holmium laser technology has led more urologists to attempt management of large renal stones with flexible ureteroscopy and laser lithotripsy.[10-12] The mean age of the patient with ureteric calculus undergoing laser lithotripsy was 35.36 ± 11.65 years which is similar to a study done in the eastern rim of Nepal.[3] However, in a study done in southwestern part of Nepal, the mean age of the patients with ureteric calculus was little high (46.74 ± 14.99).[8] Studies done in other parts of the world also show a higher mean age in the patients presenting with ureteric calculi.[4,13,14] There were more male patients (58.5%) than female patients (41.5%) in our study which is very similar to other studies.[3,4,8,9,14]

The most common clinical presentation was flank pain (77.1%), which was either right or left depending upon the side of calculus present. The other clinical presentation was generalized abdominal pain (22.9%) and among those with abdominal pain, one patient presented with hematuria and the other with burning micturition. Pain abdomen was the presenting complaint in a study done in India by Jagannath *et al.*[9] In contrast to these, Jeevaraman *et al*[15] found hematuria as the most common clinical presentation of ureteric calculi. In our study, left ureteric calculus (49.2%) was more common which was similar to study done by Rashid *et al*[16] and Ali *et al.*[17] Right ureteric calculi undergoing laser lithotripsy was slightly more common (60.7%, 50.3% and 51.4%) in studies done by Jagannath *et al*,[9] Abedi *et al*[4] and Koju *et al*[3] respectively. Bilateral calculi were only 7.6% in our study and this finding was similar to other studies.[3,9] There was no hydronephrosis in 19.5% cases and most of the patient with hydronephrosis had mild degree of hydronephrosis (54.3%). Similar to our study, a study done by Zheng *et al*[18] also showed that most of the patient had either no or mild hydronephrosis.

The most common site for calculus was upper ureter (60.2%) which was similar to a study done in china.[18] Contrast to this, lower ureteral involvement was seen in a study done in Iran,

India and Turkey, respectively.[4,9,19] There was predominance of single calculus (83.9%) in our study which was similar to study done in china.[18] The mean size of the calculus was 9.95 ± 2.75 mm and when divided to two groups considering 10 mm as the cut off, 54.2% patients had smaller ureteric calculi i.e. less than 10 mm. Other studies show variation in the size of the calculus undergoing laser lithotripsy, the mean stone size ranging from 7.08 ± 1.66 mm to 14.44 ± 3.56 mm.[4,14,16-19] Stone density also predict stone composition and different stones have different HU but success does not correlate with stone density.[20] The mean density of the calculus in our study was 1312.36 ± 324.37 and 87.3% patients had calculus with density ≥1000 HU. In contrast to this, a study done in India showed that only 28.0% patients had calculus with density ≥1000 HU.[20] The mean density of the calculus was 1043 ± 335.2 HU in a study done by Rashid *et al*[16] which is lesser than our study.

Stone retropulsion was seen 16.1% cases. Contrast to this, other studies showed 2.4% to 6.0% cases of retropulsion in their studies.[8,14] Stone migration was noted with stone larger than 12 mm and retropulsion was seen in only 0.95% cases.[3] Laser lithotripsy has been found to be a safe and effective procedure for ureteric calculus including les stone repulsion rate.[4]

An undeniable advantage of the ureteroscope lies in its small size and the further decrease in the size has taken down the complication rates for URS from 6.6% to 1.5%.[10] Furthermore, after advancement in ureteroscopic technology, the overall complication rates have dropped significantly with major complication rates reported to be <1% to 1.5%.[11] In this study, post-surgery complications was not seen in 78% of cases and among those who had it, 11.9% had fever and 10.2% had bleeding. Other studies also showed very few cases of complications.[7,8,11,17,21,22] Fever was the most common complications seen in post-surgical state after laser lithotripsy.[7,8,11,17] Contrast to this finding, Abedi *et al*[4] found mucosal damage as the common complication in their study. The other post-surgery complication following laser lithotripsy was perforation.[8,11,23]

Post surgery residual stone was seen in 5.1% cases in Xray KUB and 13.6% cases in USG. Succes varies depending on size, number and location of calculi.[7] Studies have shown that the result of stone free rates (SFR) was comparable to those of open surgery (pyelolithotomy/ ureterolithotomy). The SFR of 88% to 96.0% were achieved in patients with large stones.[12-16] SFR of 100.0% was seen in a study done by Ali *et al*[17] where the mean stone size was 18.2 ± 1.5 mm. Study done in Nepal also suggest that laser lithotripsy as a better option in regards to SFR (99%).[3] Many other studies showed SFR of 83.3% to 99%.[9,18,19,21,24,25] It has been seen that laser lithotripsy is successful in treating the patients with ureteric calculus with high SFR and low complications.[7,11]

The association of SFR in Xray KUB and USG among different variables in different groups like - male and female patients, patients with stone size < and ≥10 mm, stone density < and ≥1000 HU and sites (upper, middle and lower) was statistically not significant in our study. Gurcak *et al*[19] also found that there was no association in terms of SFR and other variables like gender, stone size and location.[19] Majority of the residual stone on USG was ≥10 mm with density ≥1000 HU and was located in the upper ureter. Rashid *et al*[16] also showed no statistical significance between stone density and other variables. Similarly, the other two studies also showed that association was statistically not significant in case of SFR and stone density.[20,26] It was seen that SFR in laser lithotripsy is comparable to laparoscopic ureterolithotomy in case of upper ureteral calculi.[17] This reason for the non-significance regarding the association of SFR and different variables of ureteric calculus could be due to the limitations like a single center study and small sample size. Multi center lateral studies with an enlarged sample size may have better results.

In conclusion, laser lithotripsy is a safe and effective way to treat ureteric calculus with high SFR and low complication. In a setting like ours, laser lithotripsy is an ideal and safe treatment procedure.

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REFERENCES

1. Razaghi MR, Razi A, Mazloomfard MM, Mokhtarpour H, Javanmard B, Mohammadi R. Trans-ureteral ureterolithotripsy of ureteral calculi: which is the best; pneumatic or holmium laser technique? *J Lasers Med Sci* 2011; 2: 59-62.
2. Reggio E, Danilovic A, Rubira C, Silvinato A, Bernardo WM. Urinary lithiasis: evaluation of

the use of laser vs pneumatic ureteral lithotripsy. *Rev Assoc Med Bras* 2019; 65: 1329-35.

3. Koju R, Joshi H, Shrestha SM, Karmacharya R, Shalike N. A Comparative study between pneumatic and laser lithotripsy for proximal ureteric calculus. *J Lumbini Med Coll* 2020; 8: 6.
4. Abedi AR, Razzaghi MR, Allameh F, Aliakbari F, Fallah-Karkan M, Ranjbar A. Pneumatic lithotripsy versus laser lithotripsy for ureteral stones. *J Lasers Med Sci* 2018; 9: 233-6.
5. Leijte JA, Oddens JR, Lock TM. Holmium laser lithotripsy for ureteral calculi: predictive factors for complications and success. *J Endourol* 2008; 22: 257-60.
6. Karkan MF, Ghiasy S, Ranjbar A, Javanmard B. Evaluation of 200 mm, 365 mm and 500 mm fibers of Ho:YAG Laser in transurethral lithotripsy of ureteral calculus: A randomize control trial. *J Lasers Med Sci* 2018; 9: 69– 72.
7. Albdaiwi1 DA, Almuanni MA, Shobian MS *et al*. Flexible ureteroscopy and laser lithotripsy intervention for the management of stone disease. *Egyptian J Hospital Med* 2017; 67: 758-64.
8. Shah R, KC RS, Timilsina BR. Laser lithotripsy is safe and effective treatment for ureteral calculi. *J Chitwan Med Coll* 2018; 8: 11- 4.
9. Jagannath K, Gupta AK, Srinivasan N. A Study on ureteric calculi in a rural tertiary care centre. *Int'l Surg J* 2019; 6: 1312-7.
10. Kijvikai K, Haleblian GE, Preminger GM, Rosette J de la. Shock wave lithotripsy or ureteroscopy for the management of proximal ureteral calculi: an old discussion revisited. *J Urol* 2007; 178: 1157-63.
11. Hyams ES, Munver R, Bird VG, Uberoi J, Shah O. Flexible ureteroreno-scopy and holmium laser lithotripsy for the management of renal stone burdens that measure 2 to 3 cm: a multi-institutional experience. *J Endourol* 2010; 24: 1583- 8.
12. Aboumarzouk OM, Monga M, Kata SG, Traxer O, Somani BK. Flexible ureteroscopy and laser lithotripsy for stones > 2 cm: a systematic review and meta-analysis. *J Endourol* 2012; 26: 1257-63.
13. Tangal S, Sanci A, Baklaci U *et al*. What is the optimum lithotripsy method for high density stones during mini- PNL? Laser, ballistic or combination of both. *Lasers Med Sci* 2020; 35: 1765-8.
14. Maghsoudi M, Amjadi M, Norizadeh D, Hassanzadeh H. Treatment of ureteral stones: a prospective randomized controlled trial on comparison of Ho: YAG laser and pneumatic lithotripsy. *Indian J Urol* 2008; 24: 352-4.
15. Jeevaraman S, Selvaraj J, Mohammed Niyamathullah N. A study on ureteric calculi. *Int'l J Contemp Med Res* 2016; 3: 2969-72.
16. Rashid AO, Mahmood SN, Ismaiel M. Impact ofstone density on the total laser time and other surgical outcomes in flexible ureterosopy. *Res Square* 2023; 1: 1-14.
17. Ali AI, Abdel-Karim AM, Abd El Latif AA *et al*. Stone free rate after semirigid ureteroscopy with holmium laser lithotripsy versus laparoscopic ureterolithotomy for upper ureteral calculi: a multicentric study. *Afr J Urol* 2019; 25: 8.
18. Zheng J, Wang Y, Chen B *et al*. Risk factors for ureteroscopic lithotripsy: a case – control study and analysis of 385 cases of holmium laser ureterolithotripsy. *Wideochir Inne Tech Maloinwazyjne* 2020; 15: 185–91.
19. Gurocak S, Onaran M, Tan MO *et al*. Laser or pneumatic lithotripsy in pediatric ureteral stones: which one is more effective? *Gazi Med J* 2015; 26: 1.
20. Gangadharaiah J, Ali NI, Sankhe P. A restrospective analysis of effect of Hounsfield unit of ureteric calculus on outcome of ureteroscopic lithotripsy. *J Evid Based Med Health* 2012; 8: 662-6.
21. Khatana PS, Kumar J, Juneja P. management of ureteric calculi with pneumatic lithotripsy and intracorporeal Holmium: YAG laser: a comparative study. *Int'l J Adv Res* 2018; 6: 408-12.
22. Hofmann R. Ureteroscopy (URS) for ureteric calculi. *Urologe A* 2006; 45: w637-46.
23. Psihramis KE. Laser lithotripsy of the difficult ureteral calculus results in 122 patients. *J Urol* 1992; 147: 1010-12.
24. Devarajan R, Ashraf M, Beck RO, Lemberger RJ, Taylor MC. Holmium: YAG lasertripsy for ureteric calculi: an experience of 300 procedures. *Br J Urol* 1998; 82: 342-7.
25. Vorreuther R, Klotz T, Heidenreich A, Nayal W, Engelmann U. Pneumatic vs electrokinetic lithotripsy in treatment of ureteral stones. *J Endourol* 1998; 12: 233–6.
26. Aksoy SH, Cakiroglu B, Tas T, Yurdaisik I. The effects of stone density on surgical outcomes of retrograde intrarenal stone surgery. *Br J Radiol* 2022; 1: 95: 20220229.