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HO:YAG LASER VS PNEUMATIC LITHOTRIPSY WITH SEMI RIGID URETEROSCOPE FOR PROXIMAL URETERAL CALCULI : OUR INSTITUTIONAL EXPERIENCE

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ABSTRACT **Introduction & objectives:** Different modalities are available for proximal ureteric stone fragmentation. From them pneumatic and holmium: yttrium-aluminum-garnet lithotripsy has favorable outcomes. In our randomized study, we included 100 patients who underwent semi rigid ureteroscopic pneumatic lithotripsy or laser lithotripsy. This study aims to compare the outcome of PL and LL in the management of upper ureteric calculi. **Materials & methods:** 100 patients were admitted in Govt Kilpauk medical college and hospital between January 2021 to June 2022 & randomized 50 cases of URS with pneumatic lithotripter and 50 cases of URS with laser lithotripter were enrolled. Patients with urinary tract infection, radiolucent stones, loss of follow-up, concurrent middle or lower third ureteral stones or acute renal failure were excluded. All patients underwent semi-rigid URS with Ho:YAG laser or pneumatic lithotripsy followed by DJ stenting. The aim of this study to compare the stone-free rate, assess the complications, duration of surgery and assess the need for second procedure , if retropulsion of calculus occurred following PL and LL. **Results:** Demographically, no statistical different in both groups in view of age, gender, mean size of stones ($P > 0.05$). Retropulsion occurred in 16% of the PL group ($P < 0.05$) and required auxillary procedure. There was a statistical difference in terms of stone free rate of stone in favor of LL group ($p \leq 0.05$) and mean operative time in favor of the PL group ($p \leq 0.05$). **Conclusions:** In both techniques, acceptable results were achieved. We found that both the PL and LL approaches were effective and safe for proximal ureteric calculi. LL method had advantages in more stone free rate, lower retropulsion rate but longer procedure duration compare to the PL method.

KEYWORDS : Ureteric stone – Ho: YAG laser – Pneumatic lithotripsy – rigid ureteroscope

INTRODUCTION

Urolithiasis is a common disease worldwide. Shock wave lithotripsy (SWL), ureteroscopy (URS), and percutaneous nephrolithotomy are the three main interventions for the management of urolithiasis. The choice of treatment is determined by patient and stone characteristics. [1] The spontaneous passage of stone is 72% in patients with stone size less than 7mm. While spontaneous passage is very low (5%) when the stone size is more than 7mm. According to the location, size and other factors, there are many treatment options for the removal of stone from the ureter like conservative medical expulsion therapy, extracorporeal shock wave therapy (ESWL), stone fragmentation through retrograde ureteroscopy (URS), laparoscopy and open ureterolithotomy.[2.]

Ureteroscopy occupies an important place in the treatment of ureteric calculi as increasing technological advancements and miniature of scope size allow easier access to stones in all parts of the kidney and ureter. As a result, complication rate, most notably the ureteral perforation rate, have been reduced to less than 5%, and long term complications such as stricture formation occur with an incidence of 2% or less. Overall, the stone-free rate is remarkably high at 81% to 94% depending on stone location and size, with the vast majority of patients rendered stone-free in a single procedure.3

Laser is an acronym for light amplification by *s*timulated emission of radiation. The holmium: yttrium, aluminum, Garnet laser (holmium: YAG laser) was developed in the early 1990s. The holmium laser is a solid-state laser system that operates at a wavelength of 2140 nm in the pulsed mode with a pulse duration range of 250 to 350 microseconds. Its growing success is a result of its excellent performance as both a lithotripter and a surgical laser. It can vaporize as well as coagulate the tissues. It has a wide range of endoscopic applications and has demonstrated effectiveness in clearing stones of all compositions. The holmium: YAG laser is transmittable via flexible fibres. The thermal effect produced by holmium: YAG laser's pulses are due to the formation of a plasma bubble. The zone of thermal injury associated with laser ablation ranges from 0.5 to 1.0 mm^4. Holmium laser lithotripsy occurs primarily through a photothermal mechanism, as pulse duration produces an elongated cavitation bubble that generates only a weak shock wave which causes stone vaporization. Ureteroscopy with laser lithotripsy occupies an important place in treating ureteric calculi as the holmium laser is one of the safest, most effective, and most versatile intracorporeal lithotripters.[5]

Pneumatic (Ballistic) lithotripsy relies on energy generated by the movement of a projectile. Once the projectile is in contact with another object, the ballistic energy is transferred to the object. The Swiss Litho Clast, introduced in the early 1990s, was the first ballistic lithotrite. The metal projectile in the hand piece of the Litho-Clast is propelled by measured bursts of compressed air against the head of a metal probe at a frequency of 12 cycles per second. The probe tip is placed against the stone, and the Litho Clast is activated by a foot pedal when it is in contact with inflexible objects, such as stone, fragments on impact (jackhammer effect). The advantages of ballistic lithotrites are their relatively low cost and low maintenance. Disadvantages of ballistic devices include the rigid nature of the technology, which requires ureteroscopes or nephroscope with straight working channels. In addition, ballistic lithotripsy is associated with a relatively high rate of stone retropulsion.[6]

AIMS AND OBJECTIVES

1.To evaluate the efficacy of holmium: YAG laser and pneumatic (Ballistic) lithotripter in treating upper ureteric calculi with regards to stone-free rate (SFR), safety, morbidity, feasibility, complications, retropulsion and further need of an additional procedure to achieve complete stone clearance.

2. To evaluate pneumatic lithotripter (PL) and laser lithotripter (LL) efficacy in the management of upper ureteric calculi

METHODS

This is a prospective, randomized study of 100 cases (50 cases of URS with PL and 50 cases of URS with LL between January 2021 to June 2022. Inclusion criteria are all cases of upper ureteric calculi located above transverse process of L4 vertebral level on CT scan. Exclusion criteria are presence of urinary sepsis, paediatric age group patients, multiple stones, bleeding disorders, pregnancy. All the patients were to undergo preoperative routine blood investigations, urine analysis and radiological evaluation using USG KUB, X-Ray KUB, NCCT KUB. Informed and written consent was obtained from all the patients.

In the laser lithotripsy group, holmium: YAG laser frequency was usually set between 5 to 12 Hz at a power setting of 0.5to 1.5 J. Using 420-micron fibre and 6/7.5Fr semi-rigid ureteroscope. In the pneumatic lithotripsy group, 6/7.5 fr and 8/9.8 fr semirigid ureteroscope with 3-5 fr size lithoclast probe used, which works by

propelling measured bursts of compressed air against the head of metal probe at 3 atm pressure and 12Hz frequency (12 cycles per second). In all the procedures, a double J stent (5Fr) was placed after the procedure, followed by catheterization. Check ultrasonography and plain X-ray KUB was done in all the patients on the second postoperative day to look for any residual stone. Foleys catheter was removed the following day. Double J stent was removed after 15 days. Patients were discharged on the third postoperative day, given uneventful recovery. Only one patient of the PL group who had a ureteric perforation stent was removed after four weeks, and at the same time stone was cleared with URS using a Pneumatic lithotripsy device with a repeat stent placed for two weeks. To check for the complications during the hospital stay, patients were individually checked by the investigator on a twice-daily basis. While after discharge, the patients were called on the 15th day of discharge and check X-ray KUB and USG KUB was done to see stone clearance in patients with residual stone. Stone size, location, duration of surgery, duration of lithotripsy, clearance of stone, intra-operative complications (mucosal injury, ureteric perforation, avulsion, haematuria) and causes of failure of procedure like retro propulsion, retained stone and need for an alternative procedure like PCNL/ESWL was recorded along with its outcomes.

STATISTICALANALYSIS

For statistical evaluation Statistical Package of Social Sciences 15 (SPSS 15) program was used. Descriptive statistics (mean ± standard deviation) and Student's t test was used to show and analyze the quantitative outcomes. The p values less than 0.05 were considered statistically significant.

RESULTS

In our study, youngest patient was 20 years old, and the oldest was 68 years old. 78% patients between 20-40 years of life, with an average age of 34.5 years in the PL group and 35.5 years in the LL group. Total 52 male and 48 female were enrolled in this study, among them 26 male and 24 female patients were included in each study group. Statistically, there was no significant difference in patient's age and gender among both study groups (p>0.07) (Table 1).

Table 1: Age and gender distribution among study group.

Age (years)	Female		Male	
	PL	LL	PL	LL
12-20	00	02	00	00
21-30	12	02	10	16
31-40	08	12	14	04
41-50	02	06	02	04
51-60	00	02	00	02
>61	02	00	00	00
Total	24	24	26	26

In the PL group, the maximum size of calculi is 16 mm, and the minimum size is 8.7 mm, with an average stone size is 10.6mm in studied patients. In the LL group, the maximum calculi size is 17 mm and minimum 9 mm, with an average size of 13 mm in studied patients. There is no statistically significant difference in stone size among the two study groups (p>0.006). The average lithotripsy time for fragmentation during ureteroscopic removal of calculi (with or without the use of dormia basket depending upon need) is 24.6 minutes in the PL group and 31.16 minutes in the LL group. Statistically, there was no significant difference between the study groups in mean Lithotripsy time (p>0.08).

The average operating time in the PL group is 52.3 minutes, and in the LL group is 68.5 minutes, with the shortest operating time of 32 minutes & 44 minutes and longest operating time of 74 minutes & 86 minutes in the PL and LL group, respectively (p<0.05). Among 50 patients with proximal ureteric calculi in the PL group, retropulsion occurred in 8 cases, thus average stone retropulsion rate of 16% (8/50). Other side 50 patients with proximal ureteric calculi in the LL group, retropulsion occurred among 2 cases with an average retropulsion rate of 4% (2/50). There was statistically significant difference in retropulsion rate among both the groups (p<0.05). Among the PL study group during the procedure, eight calculi migrated to the kidney, 84% of patients were stone free in a single sitting and 16% (8/50) patients required second procedure to achieve 100% stone-free rate in the form of PCNL, ESWL and repeat URS. Among the LL group, 48/50 subjects (96%) stone clearance using URS laser lithotripsy in a single sitting, and retropulsion occurred in 2/50 patients (4%), which cleared with either PCNL or ESWL, depending on stone characteristics and renal anatomy (p<0.05) showed a statistically significant difference in stone clearance while managing proximal ureteric calculi, clearly showing that laser lithotripsy is a better and effective lithotripter in managing proximal ureteric calculus.

In the PL study group, one ureteric perforation occurred during procedure and stone migrated, so patient stented and procedure abandoned, which later on cleared with RIRS after four weeks. In addition, minor complications like mucosal injury occurred in 4 patients, and haematuria and low-grade fever observed among 8 patients. In the LL study group, no major complication like ureteric perforation, avulsion & sepsis encountered. However, minor complications like low-grade fever observed in 2 patients and hematuria observed in 2 patients. 5Fr, 26 cm size DJ stent placed under C-arm guidance in all patients. After the procedure, stent-related complications in frequency, dysurea, urgency and dull aching flank pain were observed in 8 (16%) patients in each study group. There was no statistically significant difference in stents related symptoms among study groups. At the four-week follow-up period, all patients included in the study underwent plain x-ray KUB and USG- KUB. Stone free rate in PL group is 84% (42/50) and in LL study group 96% SFR (48/50) noted after 1st procedure.

DISCUSSION

Stones in the ureter are managed with as minimally invasive a procedure as possible. Stone fragmentation through URS and ESWL is the frequently used procedures for ureteric stones.[2,3] ESWL is no doubt a non-invasive procedure, but there are many factors like the site, size and composition of the stone, degree of impaction in the ureteric walls, presence of bones and bowel loops intervening between the stone and the lithotripter, obesity, other causes of ureteric obstruction like stricture, which reduces the efficacy of ESWL.[7]

Bilateral ESWL in one sitting is not advised, while bilateral URS is feasible.[8] Ureteroscopy (URS) with pneumatic lithotripsy was developed in 1990 and was reported to be the most effective procedure to treat ureteral stones. URS is a safe method, particularly in calculus obstruction or non- opaque stones.[8]

The AUA/EAU ureteral stones guideline panel reported that the stone-free rate for both SWL and ureteroscopy (URS) when treating proximal ureteral stones is around 81%. However, the rate for stones >10 mm decreased to 68% and 79% if they were treated by SWL and URS, respectively.[3] The holmium: YAG laser has a long pulse duration with a pear-shaped bubble, and fragmentation occurs through a 'photothermal mechanism'. The net result of this modality is smaller fragmentation and, thereby, slower lithotripsy. However, the overriding significant advantage is its ability to fragment all stone compositions.[9] Pneumatic lithotripter: Originally developed at the university teaching hospital in Lausanne, Switzerland, it is based on a jackhammer principle.[10] A projectile in the hand-piece is propelled by compressed air through the probe. The compressed air originates from a small generator that is connected to a dry, clean air supply. The ballistic energy produced is conveyed to the probe base at 12 Hz. In pneumatic lithotripsy, probe tip continue impact against stone. When tensile forces of stone are overcome, then the stone start to break.[11]

Mahmood et al [(12)] performed a comparative study between PL and LL outcomes in the management of 100 patients of upper ureteric calculi and randomized in two groups of 50 patients each. They noticed that the stone clearance rate in the PL group was 94% and in the LL group 98% with a mean operative time of 60±40 min and 40±26 min respectively. They noticed complications like a ureteric perforation in two patients in the PL study group (8%) and found no significant difference in minor complications. Our study found a stone clearance rate of 84% in the PL group and 92% in the LL group, with a mean operative time of 52.3 min in the PL group and 68.5 min in the LL group, respectively with statistical significance between both the groups. Ureteric perforation occurred in one patient (4%), mucosal injury in four patients (8%) of the PL group; however, no such events observed in the LL group. Postoperative minor complications like fever, mild haematuria, and stent symptoms were the same among both groups. The final clearance rate of 100% is achieved using second auxiliary procedures like PCNL and ESWL, depending on the need of the situation. The main reason for the failure of the procedure was retropulsion of stone to the kidney, which occurred in 16% of patients of the PL group and 4% of patients in the LL group and ureteric

perforation in 2% of patients of the PL group. However, the stone clearance rate was slightly lower than the previous study but is still comparable.

Manohar et al [13] found a stone clearance rate of 88% with pneumatic lithotripsy and 82% with laser lithotripsy for proximal ureteric calculus with an overall complication rate of 16% in the PL group and 24% in the LL group, in our study we found better clearance rate with less complication in LL group than PL group, but still, it is comparable (Table 2). Bapat et al [14]noticed 86.01% and 97.01% clearance rate in PL and LL group with an average complication rate of 13.98% and 1.99%, respectively, which clearly shows that laser device is far better than pneumatic in management of proximal ureteric calculi with the semi-rigid ureteroscope.[15] In our study we also noticed the same and comparable findings (Table 2).

Razagi M et al [15]conducted study to compare two types of a lithotripter, including holmium: YAG laser and pneumatic one in transurethral ureterolithotripsy (TUL) to manage ureteral calculi ≥1 cm. 112 patients with ureteral calculi more than 1 cm were selected in randomized order for pneumatic or holmium: YAG laser transurethral ureterolithotripsy (56 patients in each group). The success rate was 85.7% in the pneumatic group and 100% in the holmium: YAG laser group (p=0.003). Stone migration up in the pelvicalyceal system was observed only in 8 cases of the pneumatic group. No statically differences were observed regarding patients' age, hospital stay, and complications between the two groups. The conclusion is that Holmium: YAG Laser lithotripsy is more superior technology than pneumatic lithoclast in terms of rate of stone clearance and complications.

Table 2: Comparison of previous studies with our study

	Clearance rate		Complications	
	PL (%)	LL (%)	PL(%)	LL (%)
Mahmood et al [12] (J Endourol 2016)	94	98	8	4
Manohar T, et al (J Endourol 2005).[13]	88	84	16	24
Bapat SS (J Endourol 2007).[14]	86.01	97.01	13.98	1.99
Razagi MR, et al (Urol J 2013).[15]	87	100	8	0
Sarwar Noori Mohamood, et al (J Endourol 2016).[17]	94	98	32	8
Our study (2021-2022)	84	92	16	8

Our study also found a significant difference in stone clearance rate, which is far better in the LL group with very minimal complications and less need for additional procedures to achieve a 100% clearance rate than the PL group.

CONCLUSION

According to our results, by using both techniques, acceptable results were achieved. However, in the pneumatic group, the duration of operation was shorter and the cost was less than LL. Holmium: YAG laser lithotripsy is a superior technology than pneumatic lithotripsy in terms of rate of stone clearance, complications and secondary procedure rate especially in upper ureteric stones with the semi-rigid ureteroscope. There was no major complication with any statistically significant differences between the 2 groups.

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