Original Research Article

Comparison of Pneumatic Vs Holmium Yag Laser in Proximal Ureteral Stones-A Retrospective Observational Study

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Abstract

Introduction: Global prevalence of urolithiasis is approximately 14%, which varies depending upon age, gender, geographical location, and ethnicity.Upper urinary tract constitutes majority of stone burden, only 5% of stones are found within the bladder.Urolithiasis presents a significant economic burden on the healthcare systems across the world.**Materials and Methods:** A retrospective observational study was conducted at Department of Urology and Renal Transplantation, Sri Ramachandra Institute of Higher Education and Research (SRIHER), Chennai,India Demographic details of patients, history and physical examination findings, biochemical evaluation (serum creatinine, blood urea nitrogen), urinalysis, and urine culture sensitivity test results, duration of surgery, duration of hospital stay, stone migration, stone recurrence, and complication were recorded from the case files.**Results:** mean age of the patients in pneumatic lithotripsy group was 41.58±12.66 and in laser Lithotripsy group was 45.12±11.16. Independent-t-test was computed to find the significant mean difference between the groups. It revealed that there is no statistically significant mean difference found between the both groups regarding age. Hence both groups were similar. The mean operation time(minutes) of the patients in pneumatic lithotripsy group was 24.00±7.56 and in laser Lithotripsy group was 23.73±6.39. Independent-t-test was computed to find the significant mean difference between the groups. It revealed there is no statistically significant mean difference found between the both groups regarding operation time (minutes).**Conclusion:** Holmium laser is costly, less commonly available while pneumatic is cheap and widely used. Our study, establishes the supremacy of HO:YAG laser over pneumatic lithotripsy in proximal ureteric calculi and should be preferred modality, if it is available and economically feasible.

Keywords: Urolithiasis, Lithotripsy, Holmium laser, HO:YAG.

Introduction

Global prevalence of urolithiasis is approximately 14%, which varies depending upon age, gender, geographical location, and ethnicity[1]. Upper urinary tract constitutes majority of stone burden, only 5% of stones are found within the bladder[2].Urolithiasis presents a significant economic burden on the healthcare systems across the world [3]. Ureteral calculi constitute about 66% of all Urolithiasis in which 17% in proximal ureter, 11% in middle and 72% in distal ureter[4].The proximal part of ureter starts from the pelvic ureteric junction till the superior border of the sacrum, the middle part starts the superior border of sacrum till the inferior border of the sacrum, and the distal part of the ureter extends from the lower border of sacrum till bladder[5].There are various treatment modalities (i.e. conservative, medical expulsive therapy, endoluminal surgery, open, laparoscopy, and robotic) available for ureteral calculus, depending upon a wide number of factors, which include: size, location, and density of calculi.Open surgery was the mainstay of treatment for ureteral stones, till the early 1980's. With the introduction of the small caliber ureteroscope and ESWL open surgery of ureteral stone has decreased significantly[6].Ureteroscopic surgery has the benefit of endoscopically visualizing the ureter. This also helps in the detection and management of ureteral stones[7].Since 1990's; flexible and rigid ureteroscopy are being extensively used as a mainstay of treatment modality for ureteral calculi[8]. Holmium: yttrium-aluminum-garnet(HO:YAG)is the most commonly used laser[13]. It is a solid- state pulse laser, having a wavelength of 2100nm, highly absorbed by water, and less tissue penetration (0.5mm)[14]HO:YAG laser lithotripsy produces a thermal effect, due to the formation of microscopic bubbles. These bubbles are formed at the tip of fiber leading to their rapid implosion and thus creating a shock wave that eventually breaks the stones[15]The present study aimed to compare overall safety, efficacy between Laser and Pneumatic lithotripsy; in proximal ureteric calculi.

Aims of the Study

1. To evaluate and compare the efficacy of Pneumatic vs. Holmium YAG laser in Proximal Ureteral Stones with the relevant outcome variables i.e. stone-free rate (SFR), duration

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of surgery, duration of hospital stay, stone migration, auxiliary procedures.

2. To evaluate and compare the safety of Pneumatic vs. Holmium YAG laser i.e. duration of hospital stay and complications.

Materials and Methods

Site of Study: Department of Urology and Renal Transplantation, Sri Ramachandra Institute of Higher Education and Research (SRIHER), Chennai,India

Type of Study: a retrospective observational study

Period of Study: Two years (October 2018 to October 2020)

Sample size:120(60 in each group)according to the patient admission and operative statistics during the study period (Oct 2018-2020)

Inclusion criteria: All patients >18 years of age with proximal ureteral stone who had undergone ureterorenoscopic lithotripsy (Pneumatic vs Laser) during the study period were included.

Exclusion criteria:

- Patients with the renal anomaly
- pelvic or calyceal stone
- severe musculoskeletal deformity
- urethral and ureteral stricture disease
- coagulopathy
- severe medical comorbidities
- pregnant patients

Method: All data to be collected retrospectively.

Demographic details of patients, history and physical examination findings, biochemical evaluation(serum creatinine,blood urea nitrogen),urinalysis, and urine culture sensitivity test results, duration of surgery, duration of hospital stay, stone migration, stone recurrence, and complication were recorded from the case files.

Urine culture was done, before the procedure, and accordingly antibiotic regimen was given. Only after sterile culture of urine, the patients were operated. All patients were treated with appropriate perioperative antibiotics two doses of injection cefoperazone (500 mg) ± sulbactam (500 mg), one at the time of induction of anesthesia and a second dose 12 h later. All patients underwent Non-contrast CT Scan (NCCT) KUB before the procedure. Stone parameters included stone size in millimeters defined as the maximum transverse diameter of stone, stone location, and stone burden.

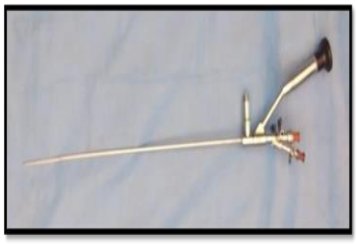

Fig 1: Ureteroscope

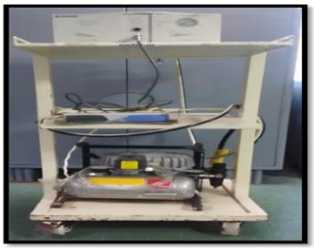

Fig 2 : Swiss Litho Clast Luamenis

URSL procedure was performed in standard lithotomy position under regional anesthesia with a 6/7.5 Fr Karl Storz™ semirigid ureteroscope with 30° telescope lens.

Fig 3: Holmium Laser

Laser or pneumatic lithotripter was used to fragment the calculus. Settings for Ho: YAG laser lithotripsy with a 365 µ–mm fiber was energy 0.8–1.2 J and frequency 10–15 Hz. The energy setting for pneumatic lithotripsy (Swiss Litho Clast Master™) was 4 bar and the frequency was 5-10Hz. After completing the procedure, 26cm double pigtail stent (6 Fr size) and as per urethral catheter were placed. Postoperative X- ray KUB was routinely obtained. The ureteral stent was removed after 02 weeks. NCCT KUB after 04 weeks of stent removal for residual stone.For this study, stone-free‖ state was defined as an absence of any residual fragment of size less than 3mm. Any auxiliary procedure such as repeat URSL or SWL performed for residual calculi and complications (ureteral injury, bleeding, sepsis, and stricture) were noted.Duration of surgery was defined as the time starting from the introduction of the cystoscope till the insertion of the urethral catheter, after finishing the procedure.

Results

Analysis and Interpretation

Comparison of demographic and clinical characteristics between pneumatic and laser lithotripsy in patients with ureteral calculus

Table 1: Mean distribution of patients with ureteral calculus based on age between pneumatic and laser lithotripsy groups. (N=120)

Sample characteristics	Pneumatic Lithotripsy(n=60)	Laser Lithotripsy(n=60)	Independent t-test	*p* value
Age in years	Mean±SD	Mean±SD	t=1.61	0.10 (NS)
	41.58±12.66	45.12±11.16		

(p<0.05: Significant level, NS: Non-significant)

Table 1 shows the mean age of the patients in pneumatic lithotripsy group was 41.58±12.66 and in laser Lithotripsy group was 45.12± 11.16. Independent-t-test was computed to find the significant mean difference between the groups. It revealed that there is no statistically significant mean difference found between the both groups regarding age. Hence both groups were similar. (p>0.05)

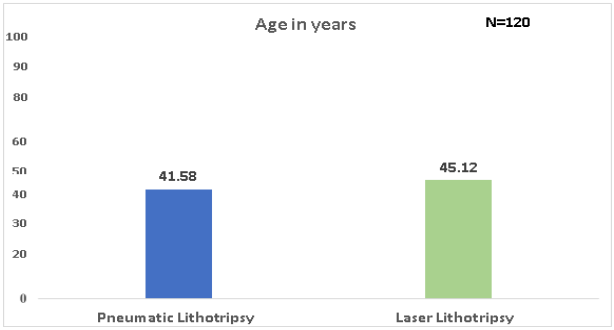

Fig 3:Bar graph showing comparison of mean distribution of patients with ureteral calculus based on age in years between pneumatic and laser lithotripsy group.

Table 2:Frequency and percentage distribution of patients with ureteral calculus based on gender between pneumatic and laser lithotripsy groups. (N=120)

Samplecharacteristics		Pneumatic Lithotripsy(n=60)	LaserLithotripsy(n=60)	Chi-square test	*p* value
		Frequency (%)	Frequency (%)		
Gender	Male	44(73.3)	47(78.3)	χ^2=0.14 df=1	0.47(NS)
	Female	16(26.7)	13(21.7)		

(p<0.05: Significant level, NS: Non-significant)

Table 2 shows that, majority of the patients in both groups were males i.e. 73.3% in the pneumatic lithotripsy group and 78.3% in the laser lithotripsy group. Around 26.7% of the patients in the pneumatic lithotripsy group were and 21.7% of the patients in the laser lithotripsy group were females. Chi-square test was computed to find the significant difference between the groups. It revealed there is no statistically significant difference found between the groups regarding gender. Hence, both groups were similar. (p>0.05)

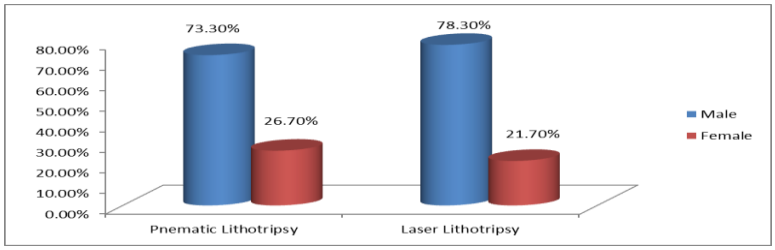

Fig 4: Bar graph showing percentage distributions of patients with ureteral calculus based on gender between pneumatic and laser lithotripsy group

Table 3: Frequency and percentage distribution of patients with ureteral calculus based on stone laterality between pneumatic and laser lithotripsy groups (N=120)

Sample characteristics		Pneumatic Lithotripsy(n=60)	Laser Lithotripsy(n=60)	Chi-square test	*p* value
		Frequency (%)	Frequency(%)		
Stone laterality	Right	28(46.7)	29(48.3)	χ^2=56.1 df=1	0.69(NS)
	Left	32(53.3)	31(51.7)		

(p<0.05: Significant level, NS: Non-significant)

Table 3 shows that, majority of the patients in both groups had left side stone laterality i.e. 53.3% in the pneumatic lithotripsy group and 51.7% in the laser lithotripsy group. Around 46.7% of the patients in the pneumatic lithotripsy group and 48.3% of the patients in the laser lithotripsy group had right side stone laterality. Chi-square test was computed to find the significant difference between the groups. It revealed there is no statistically significant difference found between the groups regarding stone laterality. Hence both groups were similar. (p>0.05)

Fig 5: Bar graph showing percentage distribution of patients with ureteral calculus based on stone laterality between pneumatic and laser lithotripsy groups

Table 4: Mean distribution of patients with ureteral calculus based on stone size between pneumatic and laser lithotripsy groups.(N=120)

Sample characteristics	Pneumatic Lithotripsy (n=60)	Laser Lithotripsy (n=60)	Independent t-test	*p* value
Stone size (mm)	Mean±SD	Mean±SD	t=1.71	0.08 (NS)
	8.55±2.80	9.43±2.81		

(p<0.05: Significant level, NS: Non-significant)

Table 4 shows the mean stone size (mm) the patients in pneumatic lithotripsy group were 8.55±2.80 and in laser Lithotripsy group was 9.43±2.81. Independent-t-test was computed to find the significant mean difference between the groups. It revealed there is no statistically significant mean difference found between the both groups regarding stone size. Hence both groups were similar. (p>0.05)

Fig 6: **Bar graph showing comparison of mean distribution of patients with ureteral calculus based on stone size (mm) between pneumatic and laser lithotripsy groups.**

Table 5: Frequency and percentage distribution of patients with ureteral calculus based on multiple stones between pneumatic and laser lithotripsy groups. (N=120)

Parameters		Pneumatic Lithotripsy (n=60)	Laser Lithotripsy (n=60)	Chi-square test	*p* value
		Frequency (%)	Frequency (%)		
Multiple stones	Yes	2(3.3)	3(5.0)	χ^2=39.31 df=1	0.06(NS)
	No	58(96.7)	57(95.0)		

(p<0.05: Significant level, NS: Non-Significant)

Table 5shows that, majority of the patients in both groups had no multiple stones i.e. 96.7% in the pneumatic lithotripsy group and 95.0% in the laser lithotripsy group. Around 3.3% of the patients in the pneumatic lithotripsy group and 5.0% of the patients in the laser lithotripsy group had multiple stones. Chi-square test was computed to find the significant difference between the groups. It revealed there is no statistically significant (p>0.05) difference found between the groups regarding multiple stones

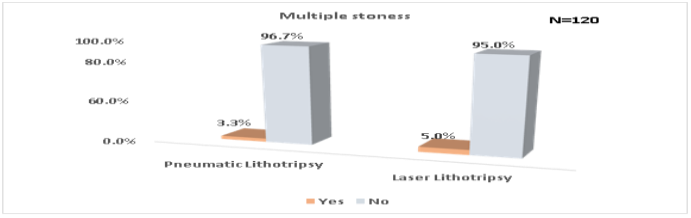

Fig 7: Bar graph showing percentage distribution of patients with ureteral calculus based on multiple stones between pneumatic and laser lithotripsy groups.

Comparison of operative and postoperative parameters between laser and pneumatic lithotripsy in patients with ureteral calculus

Table 6: Mean distributions of patients with ureteral calculus based on operation time between pneumatic and laser lithotripsy groups. (N=120)

Sample characteristics	Pneumatic Lithotripsy(n=60)	Laser Lithotripsy (n=60)	Independent t-test	*p* value
Operation time (Minutes)	Mean±SD	Mean±SD	t=0.20	0.83 (NS)
	24.00±7.56	23.73±6.39		

(p<0.05: Significant level, NS: Non-significant)

Table 6 shows the mean operation time (minutes) of the patients in pneumatic lithotripsy group was 24.00±7.56 and in laser Lithotripsy group was 23.73±6.39. Independent-t-test was computed to find the significant mean difference between the groups. It revealed there is no statistically significant mean difference found between the both groups regarding operation time (minutes).

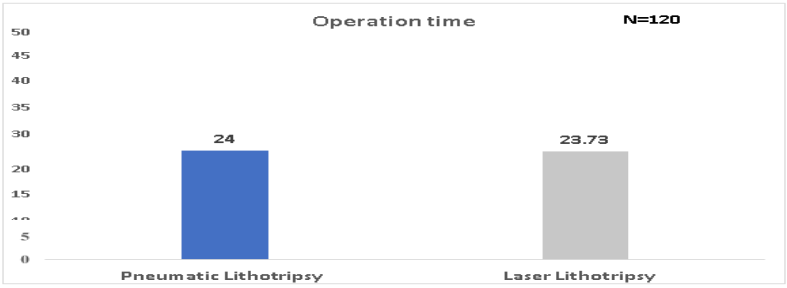

Fig 8: Bar graph showing comparison of mean distribution of patients with ureteral calculus based on operation time (minutes) between pneumatic and laser lithotripsy groups

Table 7: Mean distributions of patients with ureteral calculus based on hospital stay between pneumatic and laser lithotripsy groups. (N=120)

Sample characteristics	Pneumatic Lithotripsy (n=60)	Laser Lithotripsy (n=60)	Independent t-test	*p* value
Hospital stay (Days)	**Mean±SD**	**Mean±SD**	t=1.93	0.05 (NS)
	1.95±0.89	2.32±0.91		

(p<0.05: Significant level, NS: Non-significant)

Table 7 shows the mean hospital stay (days) of the patients in pneumatic lithotripsy group was 1.95±0.89 and in laser Lithotripsy group was 2.32±0.91. Independent-t-test was computed to find the significant mean difference between the groups. It revealed there is no statistically significant mean difference found between the both groups regarding hospital stay days.

Fig 9: Bar graph showing comparison of mean distribution of patients with ureteral calculus based on hospital stay days between pneumatic and laser lithotripsy groups

Table 8: Frequency and percentage distribution of patients with ureteral calculus based on stone migration between pneumatic and laser lithotripsy groups. (N=120)

Parameters		Pneumatic Lithotripsy (n=60)	Laser Lithotripsy (n=60)	Chi-square test	*p* value
		Frequency (%)	**Frequency (%)**		
Stone migration	Yes	5(8.3)	2(3.2)	χ^2=0.71 df=1	0.003(S)
	No	55(91.7)	58(96.7)		

(p<0.05: Significant level, S: Significant.

Table 8 shows that, majority of the patients in both groups had no stone migration i.e. 91.7% in the pneumatic lithotripsy group and 96.7% in the laser lithotripsy group. Around 8.3% of the patients in the pneumatic lithotripsy group and 3.2% of the patients in the laser lithotripsy group had stone migration. Chi-square test was computed to find the significant difference between the groups. It revealed there is a statistically significant (p<0.05) difference found between the groups regarding stone migration.

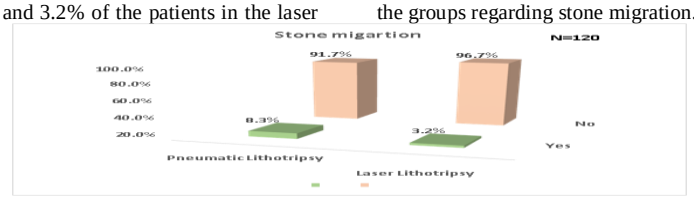

Fig 10: Bar graph showing percentage distribution of patients with ureteral calculus based on stone migration between pneumatic and laser lithotripsy group.

Table 9: Frequency and percentage distribution of patients with ureteral calculus based on stone free rate between pneumatic and laser lithotripsy groups. (N=120)

Parameters		Pneumatic Lithotripsy(n=60)	LaserLithotripsy(n=60)	Chi-square test	*p* value
		Frequency (%)	**Frequency (%)**		
Stone free rate	Yes	16(26.6)	6 (10.0)	χ^2=20.00 df=1	0.001(S)
	No	44(73.4)	54 (90.0)		

(p<0.05: Significant level, S: Significant)

Table 9 shows that, majority of the patients in both groups had no stone free rate i.e. 73.4% in the pneumatic lithotripsy group and 90.0% in the laser lithotripsy group. Around 26.6% of the patients in the pneumatic lithotripsy group and 10.0% of the patients in the laser lithotripsy group had stone free rate. Chi-square test was computed to find the significant difference between the groups. It revealed there is a statistically significant (p<0.05) difference found between the groups regarding stone free rate.

Table 10: **Frequency and percentage distribution of patients with ureteral calculus based on complications between pneumatic and laser lithotripsy groups. (N=120)**

Parameters		Pneumatic Lithotripsy (n=60)	Laser Lithotripsy (n=60)	Chi-square test	*p* value
		Frequency (%)	Frequency (%)		
Complications	Yes	5(8.3)	2(3.3)	χ^2=22.75 df=1	0.006(S)
	No	55(91.7)	58(96.7)		

(p<0.05: Significant level, S: Significant)

Table 10 shows that, majority of the patients in both groups had no complications i.e. 91.7% in the pneumatic lithotripsy group and 96.7% in the laser lithotripsy group. Around 8.3% of the patients in the pneumatic lithotripsy group and 3.3% of the patients in the laser lithotripsy group had complications. Chi-square test was computed to find the significant difference between the groups. It revealed there is a statistically significant (p<0.05) difference found between the groups regarding complications.

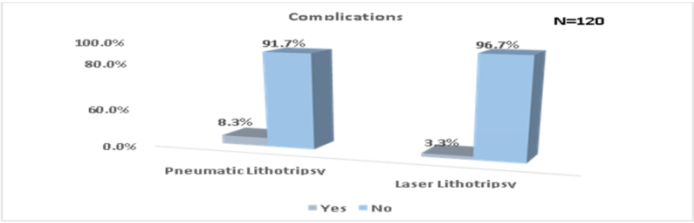

Fig 11: **Bar graph showing percentage distributions of patients with ureteral calculus based on complications between pneumatic and laser lithotripsy groups.**

Table 11: Frequency and percentage distribution of patients with ureteral calculus based on auxiliary procedure between pneumatic and laser lithotripsy groups. (N=120)

Parameters		Pneumatic Lithotripsy (n=60)	LaserLithotripsy(n=60)	Chi-square test	*p* value
		Frequency (%)	Frequency (%)		
Auxiliary procedure	Relook	11 (18.4)	4(6.6)	χ^2=0.18 df=3	0.03(S)
	PCNL	4(6.6)	0(0)		
	RIRS	1(1.6)	2(3.4)		
	No	44(73.4)	54(90.0)		

(p<0.05: Significant level, S: Significant)

Table 11 shows that, majority of the patients in both groups didn't underwent for auxiliary procedures i.e. 73.4% in the pneumatic lithotripsy group and 90.0% in the laser lithotripsy group. About 18.4% of the patients in the pneumatic lithotripsy group had relook and 6.6% in the laser lithotripsy group had relook. Around 6.6% of the patients in the pneumatic lithotripsy group underwent for PCNL and none (0%) of the patients in the laser lithotripsy group underwent for PCNL. About 1.6% of the patients in the pneumatic lithotripsy group underwent for RIRS and 3.4% of the patients in the laser lithotripsy group underwent for RIRS. Chi-square test was computed to find the significant difference between the groups. It revealed there is a statististatistically significant (p<0.05) difference found between the groups regarding auxiliary procedures.

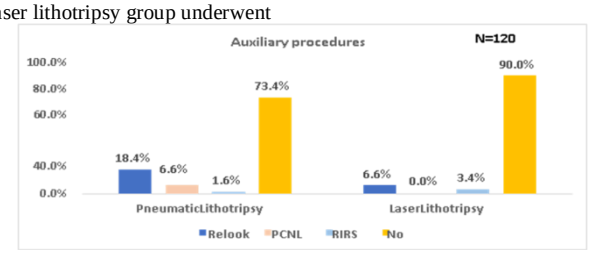

Fig 12: Bar graph showing percentage distributions of patients with ureteral calculus based on auxiliary procedures between pneumatic and laser lithotripsy groups.

Discussion

Urinary calculus is one of the commonly problem presented to urology outpatient department. Recent improvement in equipment and technology made a great progress in management of patient's with urinary calculi.In the recent times, minimal invasive interventions are preferred. Pneumatic lithotripsy is minimal invasive procedure with advantage of being less expensive and relatively safe. This is being widely used all over the world. This intervention is having higher chances of stone migration in proximal ureteral calculi[13]HO: YAG laser is the other minimal invasive approach, which is the most effective, very safe and can be used through all types of ureteroscope. It generates a weak shock wave which is less likely to cause migration of stone or stone fragments[3].

Holmium:YAG laser is effective, irrespective of hardness of stone and its composition[1]In the present study, total 120 patients were included of which 60 underwent Holmium laser and rest PL. Comparison between HO:YAG laser and lithotripsy revealed that in terms of stone free

rate,stone migration HO:YAG laser performed better than PL. complications relook URS and auxiliary procedures were also found less in Holmium laser group.In the present study, mean age of presentation was 41.58 years for PL, and 45.12 years for LL. The difference was not statistically significant ($p<0.05$). Ureteric calculi are more commonly found in male. It was also evident in our study where, the male to female ratio in PL (Male: 73.3%, Female: 26.7%) and in LL is (Male: 78.3%, Female: 21.7%).The difference which was statistically not significant ($p>0.05$).In EkremAkdeniz et al study, male to female ratio (PL, Male: 68.8%, Female: 31.2% and in LL Male: 70.1%, Female: 29.9%) which is comparable to our study.Stone sizes in Amir abedi et al study (PL 9.2+/-2.1mm, LL-9.6+/-2.4mm), Bapat et al (PL- 12.3 mm, LL-11.5 mm), and Rajan Kazu et al (PL-9.53+/-1.86 mm, LL-9.50+/-1.64 mm) were found. Our study stone sizes PL (8.55+/-2.80 mm), LL (9.43+/- 2.81mm) were comparable. Multiple stones in PL arm (3.3%, N=2), LL arm (5%, N=3) are comparable.Mean operation time in our study was 24+/-7.56 minutes for PL and 23.7+/-6.39 minutes for LL which are lower than Ekram Adkinez (PL-30.31+/-15.03 minutes, LL- 34.30+/-19.7 minutes), and Rabeni et al (PL-25.47+/-8.5 minutes, LL-34.6+/10.25 minutes). Rajan Kazu et al (PL-14.7+/-4.77 minutes, LL-13.31+/-3.24 minutes) had lower operating time.Mean hospital stay in our study (PL-1.95+/-0.89 days, LL-2.32+/-0.91days) was found comparable in PL and LL group, Akram et al reports mean hospital stay PL(2.08+/-0.7 days),LL(1.53+/-0.89 days) which is comparable to our study.In our study, stone migration rate in PL arm (8.3%) and in LL arm (3.2%), this is statistically significant. Garg et al. reported high stone migration in PL arm (16%). Akramkesin et al. (PL 9.1%, LL7.65%), Ahmed Ismail et al. (PL13.5%,LL0%) and Rajankazu et al.(PL23.84%, LL0.95%) also reported high migration in PL arm in comparison to LL arm. These studies are in accordance to our findings, while Akram et al. reported no significant difference in stone migration between PL (9.1%) and LL (7.65%).Knispel[6] and Hong reported lower success rates for proximal ureteral stones in comparison to the stones in the mid and distal ureteral stones. Devarajan et al reported a 90% success rate in laser lithotripsy (N=300).Stone free rate in our study was significantly more in LL(90%) as compared to PL(73.4%). Razaghi et al. Reported more SFR in LL (100%, N=12), than PL (42.9%, N=14), p=0.001.Bapat et al. Reported more SFR in LL than PL. these findings are in accordance to our study. Jeon et al reported higher SFR in Ho: YAG laser arm (96%) than lithoclast arm (37.1%) ($p< 0.05$). Akdeniz et al. reported comparable SFR in PL (89.9%, N=109) and LL (87.9%, N=107).In present study we found significantly more complications in PL arm (8.3%, N= 5) versus LL arm (3.3% N=2). 2 patients in PL arm suffered mucosal injuries while 3 developed urosepsis. In LL arm, 1 patient had mucosal injury and other had urosepsis.

Conclusion

Demographic distribution between the groups was comparable. Size of the stone, mean operation time and mean hospital stay were comparable. Holmium laser has distinct advantage over the Pneumatic Lithotripsy with lesser incidence of stone migration and auxiliary procedures.Holmium laser is costly, less commonly available while pneumatic is cheap and widely used. Our study, establishes the supremacy of HO: YAG laser over pneumatic lithotripsy in proximal ureteric calculi and should be preferred modality, if it is available and economically feasible.

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