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ORIGINAL RESEARCH

COMPARISON OF INTRACORPOREAL HOLMIUM:YAG LASER WITH PNEUMATIC LITHOTRIPSY IN URETERAL CALCULI FRAGMENTATION.

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Abstract

Aim : To compare ureteroscopic lithotripsy with holmium:YAG laser and pneumatic lithotripter. We also evaluated the results of the two treatment modalities to assess their effectiveness and complications in management of ureteral calculi.

Materials and method: total 50 patients who met inclusion and exclusion criteria were selected and were subsequently randomized into two groups by sealed envelope method. Group 1 was treated with Holmium: YAG laser lithotripsy (Holmium Group) and Group 2 with Pneumatic lithotripsy.

Results : no significant difference was observed between the two groups with respect to age,sex, stone location. 1 case in holmium group had a postoperative complication i.e. Urosepsis, one case each in pneumatic group had postoperative complications i.e. Hematuria and Urosepsis. However, the difference was statistically insignificant ($p>0.05$). Stone Free Rate at 2 weeks, 6 weeks and at 3 months showed no significant difference. One patient required percutaneous nephrolithotomy and 1 patient required repeat ureteroscopy in pneumatic group for stones remaining at 3 months while none of the patients from holmium group required auxiliary procedures. However, this difference was statistically insignificant ($p>0.05$).

Conclusion :This study revealed that Hol:YAG laser lithotripsy is safe and more effective than pneumatic lithotripsy in respect of stenting requirement and has higher stone free rate and less requirement of forceps/baskets.The need for auxiliary procedure after Hol:YAG laser assisted URS is less in comparison with pneumatic lithoclast.

Introduction

The development of minimally invasive techniques has revolutionized the management of ureteral calculi. For stone fragmentation, a variety of lithotriptors can be used, including ultrasonic, electrohydraulic, pneumatic and laser lithotripters.[1] Pneumatic lithotripsy and holmium:YAG lithotripsy have reported favourable outcomes. A rather simple principle of the jackhammer has enabled pneumatic lithotripsy to be a safe and effective method for tone treatment. Thus, the lithoclast has become a widespread tool for fragmentation of urinary stones[2].

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

Similarly holmium:YAG laser has excellent stone fragmenting properties and as a result, it is now a well established modality for intracorporeal lithotripsy. It has successfully fragmented all types of calculi regardless of compositon. Holmium:YAG lithotripsy depends on photothermal mechanism for stone fragmentation, thus the risk of retrograde stone propulsion could be minimized, but it may casue thermal injury to the ureter if used carelessly.[3]

The purpose of the present study was to compare ureteroscopic lithotripsy with holmium:YAG laser and pneumatic lithotripter. We also evaluated the results of the two treatment modalities to assess their effectiveness and complications in management of ureteral calculi.

Method and material

Present study was conducted in the Department of Urology, Dr. Baba Saheb Ambedkar Hospital, Delhi after approval from ethical committee . 50 patients with ureteral calculi of size 6-20 mm suitable for endoscopic treatment were included in the study .

Patients with Stone size >20mm , signs of urosepsis (Fever and Pyuria), pregnant females, with with serum creatinine >2.0mg/dl, Percutaneous Nephrostomy and with urinary tract abnormalities were excluded from the study.

These patients were subsequently randomized into two groups by sealed envelope method. Group 1 was treated with Holmium: YAG laser lithotripsy (Holmium Group) and Group 2 with Pneumatic lithotripsy.

All the patients underwent routine blood investigations, Urinalysis ultrasonography, Excretory urography (IVP) Computed tomography scan of KUB region(for radiolucent stones).

All patients in both groups underwent complete preoperative evaluation from the OPD and were admitted to the hospital one day prior to surgery. All patients were kept nil per orally after midnight before surgery. Part preparation was done from nipple to mid thigh. Informed consent was taken from all the patients. Test dose of Inj. Ceftriaxone was given at 6am on the day of surgery. Randomization was done in operation theatre by a person other than the operating team using sealed envelope. All ureteroscopies were performed under regional anaesthesia as decided by the anaesthetist. Prophylactic antibiotic (Inj. Ceftriaxone 1gm) was administered at the time of induction of anaesthesia.

OPERATIVE PROCEDURE

Parts were painted with 5% povidone iodine solution and draped with complete aseptic technique.

Position of the patient, Operating Team and Equipments

Patients were operated in the lithotomy position. The operating surgeon would stand between the legs of the patient with scrub nurse on his right side and assistant on his left. The video monitor was positioned on the right side of the patient close to the head end of table.

URETEROSCOPY

Ureteroscpy was performed in both the groups using 6/7.5 Fr semi rigid ureteroscopes under fluoroscopic guidance. Direct introduction of the ureteroscope was done after instillation of 2% lignocaine jelly into the urethra. Ureteroscope was advanced under direct vision using continuous irrigation for distension of urethra. The urethra and bladder were thoroughly inspected and ureteric orifices were identified.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

The scope was introduced into the ureter using hydrostatic dilatation or guide wire technique. Ureteric dilataton using soft ureteric dilators was required in two of our cases. Clarity of medium was maintained at all times by continuous irrigation with normal saline. After the visualization of stone, fragmentation was done using the energy source as determined earlier by the sealed envelope method. Baskets were not used to prevent stone upmigration.Fragmentation time from the beginning of lithotripsy till complete stone fragmentation into pieces <2mm was noted by staff nurse/ anaesthetist in all the cases.

HOLMIUM: YAG LASER LITHOTRIPSY

30 watts convergent Holmium YAG laser (Convergent Laser Technologies, Alameda, CA94502, USA) was used with a fiber of 400µm. The laser fiber was placed on the stone surface guided by green tracer light. Clear vision of the fiber tip was maintained at all times. The fibrer tip was kept at least 2mm away from the urothelium to avoid mucosal injury. The laser fiber was extended at least 2mm beyond the tip of ureteroscope to avoid damage to the lens system or the working channel of endoscope. Caution was also exercised in operating the Holmium: YAG laser near a guidewire. The foot pedal was controlled by the operating surgeon at all times. After placing the fiber on stone surface using green tracer light, laser was activated. Lithotripsy was started at low power settings and increased only as necessary. The power of Holmium:YAG laser that was used ranged from 4.8 watt (0.6J at 8Hz) to 14.4 watt (1.2J at 12Hz) though most stones would fragment easily at 9.0 watt (0.9J at 10Hz). After initiation of lithotripsy, a short pause was often required because scattering of minute stone fragments caused “snowstorm effect”, which was cleared by endoscopic irrigation. Fragmentation of stone was carried out from the inside of stone outward to achieve fragments smaller than 2mm.

PNEUMATIC LITHOTRIPSY

Pneumatic lithotripsy was done using Richard wolf pneumatic lithotripter (Richard Wolf, GMBH 75438, Knittligen, Germany). The probe tip was placed against the stone and the lithotripter was activated by a foot pedal only after clear visualization of the stone and identifying the position of probe. The stone was fragmented using either single or continuous pulses and the pressure was set at 2 bars. The goal of lithotripsy was to generate fragments smaller than 2mm that would pass spontaneously. However, in few cases, larger fragments required removal with a basket or grasping device.

A 4.7 Fr/6.0 Fr ureteral stent was placed at the end of procedure in patients with extensive edema, impacted stone, suspicious ureteral injury, narrow ureteral orifice requiring dilatation, and solitary kidney. Intra-operative complications and stone upmigration was noted.

The operative and post operative findings were recorded and data was analysed in spss. Statistical analysis was done using chi square (χ^2) and student “t” tests to study the significance of difference of various parameters and outcomes between the Holmium: YAG laser and Pneumatic lithotripsy groups. Differences were considered statistically significant at p value <0.05.

Results

Table 1 shows comparison between both the groups regarding various variables. According to stone location, 2 patients in each group had upper ureteral stones while 4(16%) cases of holmium group and 6(24%) cases of pneumatic group had middle

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

ureteric stones. While maximum number of cases (72%) i.e. 19(76%) cases in holmium group and 17(68%) cases in pneumatic group had lower ureteral stones. 1 case in holmium group had a postoperative complication i.e. Urosepsis, one case each in pneumatic group had postoperative complications i.e. Hematuria and Urosepsis. However, the difference was statistically insignificant (p>0.05).Table 2 shows Stone Free Rate at 2 weeks, 6 weeks and at 3 months and no significant difference was observed between the two groups. Table 3 shows need for auxiliary procedure One patient required percutaneous nephrolithotomy and 1 patient required repeat ureteroscopy in pneumatic group for stones remaining at 3 months while none of the patients from holmium group required auxiliary procedures. However, this difference was statistically insignificant (p>0.05).

Table 1: comparison between both groups regarding various variables

	Holmium Group	Pneumatic Group	P
Age(years)	34.12±12.16	37.96±12.69	0.280NS
Gender (males)	14(56%)	15(60%)	0.774 NS
Stone Size(mm)	11.48±2.10	10.96±2.07	0.383 NS
Fragmentation Time(min)	11.00±2.31	8.92±1.73	<0.001 S
Stone Up Migration n (%)	0	3(12%)	0.074 NS
Need for Stenting n (%)	8(32%)	18(72%)	<0.05 S
Intra-operative Complications n (%)	0	0	-
Postoperative complication n (%)	1(2%)	2(4%)	0.60(NS)

Table 2: Stone Free Rate

Stone Free Rate		Holmium Group		Pneumatic Group		χ^2	P
		No.	%	No.	%		
2 weeks	Present	1	4.0	4	16.0	2.000	0.157NS
	Absent	24	96	21	84		
6 weeks	Present	0	-	3	12	3.191	0.074
	Absent	25	100	22	88		
3 Months	Present	0	-	2	8	2.083	0.149
	Absent	25	100	23	92		

Table 3: Need for Auxiliary Procedures

Auxiliary Procedure	Holmium Group		Pneumatic Group		Total		p-value
	No.	%	No.	%	No.	%	
Absent	25	100	23	92.0	48	96	0.353
Percutaneous nephrolithotomy	0	-	1	4	1	2	
Repeat Ureteroscopy	0	-	1	4	1	2	
Total	25	100	25	100	50	100	

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

Discussion

The present study was conducted on a group of 50 patients, with ureteral calculi requiring endoscopic treatment, attending the Urology outpatient clinic of Dr. Baba Saheb Ambedkar Hospital, New Delhi.

The majority (64%) of patients were in the age group of 21-40 years. Incidence of ureteral calculi was found to be higher in men (58%) as compared to women (42%) with a male: female ratio of 1.4:1. This is comparable with findings in literature worldwide[4-7]. The two groups were comparable with respect to age (p=0.280) and sex (p=0.774).

The majority of patients (n=36; 72%) had a lower ureteric calculus, while 10 patients (20%) had a middle ureteric calculus and 4 patients (8%) had upper ureteric calculus. The two groups were comparable in respect to distribution of stones in upper, middle and lower ureter (p=0.774).Binbay et al also found that calculi were located in distal ureter in most of patients in both groups they studied (65% in pneumatic group and 52.5% in laser group).[2]

The mean stone size in Holmium:YAG laser group (11.48±2.10) was comparable to pneumatic group (10.96±2.07; p=0.383). Access to the ureter was possible in 100% of our patients. Only 2 patients (5%) required mechanical dilatation of the ureteric orifice whereas in the rest (95%) of patients, hydrostatic dilatation was sufficient to introduce the scope into the ureter.The mean stone fragmentation time was 11.0±2.31min in the Holmium:YAG laser group which was significantly longer than the 8.92±1.73min required for stone fragmentation in the pneumatic group (p=0.001HS).These findings are comparable to those of Garg et al[8] who found the mean lithotripsy time to be 24.03±9.57 min in laser group versus 19.80±4.44 min in pneumatic group (p=0.027).Manohar et al[9] also found a longer fragmentation time (9.82± 7.58min) in Holmium:YAG laser group as compared to lithoclast group (7.86±3.25min) but the difference was not statistically significant (p=0.12).

The longer fragmentation time noted with Holmium:YAG laser lithotripsy seems to arise from the fact that the stone is fragmented into very small particles of size 1-2mm. The Lithoclast on the other hand fragments stone into slightly larger pieces.Three patients had stone upmigration in pneumatic group as compared to none in Holmium:YAG group. Two of these stones were located in upper ureter and one in mid ureter. However the difference between two groups was statistically insignificant (p=0.074). Similar findings were observed by Tipu et al[10] (4% in laser group vs 16% in pneumatic group), Garg et al[8] (0% vs 16%), Jeon et al[11] (4% vs 19.2%) and Binbay et al[2] (2.5% vs 10%).

Bapat et al[12] studied the difference between the two modalities in fragmentation of upper ureteral stones selectively and found significantly more cases of stone upmigration in pneumatic group (13.98%) versus the laser group (1.99%). This difference in the rate of stone upmigration can be attributed to the different mechanism of lithotriptors.

Need for placing a double J stent in the ureter was felt in 18(72%) of patients in pneumatic group which was significantly higher than 8(32%) patients in Holmium:YAG laser group (p=0.005).These findings are comparable to those of Bapat et al[12] (73.05% in pneumatic group versus 29.35% in laser group), Yapanoglu et al[13] (26% vs 10%). Similar findings were observed by Binbay et al[2] who observed the rate of double J stent insertion to be significantly higher in pneumatic group (p=0.01).

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

Bapat et al[12] suggested that the disparity between the rate of stenting in ureteroscopy with the laser and the pneumatic lithoclast occurs because of the difference in the size eventual fragments.

With laser lithotripsy the stone is fragmented into powder whose size is smaller than the laser fiber (365µ). With the Pneumatic lithotripter, stones are fragmented into slightly larger pieces. Also with pneumatic lithotripsy, the incidence of proximal migration of stones was higher than with laser lithotripsy. Stent placement was subsequently higher, so that the stone passage in the subsequent period will be uneventful.

One patient (4%) in each group developed signs and symptoms of urosepsis and one patient (4%) in pneumatic group versus none in Holmium group developed hematuria. These patients were conservatively managed and hematuria resolved within 72 hours of surgery. No patient developed postoperative stricture during the three month follow up period. The difference in postoperative complications between the two groups was not statistically significant (p=0.600).Our findings are comparable to those by Bapat et al1[2] who reported the incidence of urosepsis in postoperative period to be 4.97% in laser group versus 5.69% in pneumatic group. However Manohar et al[9] found significant postoperative hematuria (3.6%) in the laser group versus 8% in lithoclast group (p=0.04) which they presumed to be caused by prolonged contact and excessive heat generation during laser lithotripsy.The very low incidence of both intraoperative and postoperative complications, in both groups, establishes the fact that both Holmium:YAG laser lithotripsy and Pneumatic lithotripsy are very safe methods of ureteroscopic stone fragmentation in experienced hands.

In our study the 2 week stone free rate of Holmium:YAG laser lithotripsy (96%) was superior as compared to pneumatic lithotripsy (84%). However the difference was not statistically significant (p=0.157). The stone free rates at end of 6 weeks (p=0.074) and three months (p=0.149) are also comparable between the two groups.

These results are comparable with the findings of Jeon et al[11,] Bapat et al[12] (97.01% in laser group vs 86.01% in lithoclast group), Binbay et al[2] (97.5% vs 80%, p = 0.03) and Tipu et al[10] (92% vs 82%).

Jeon et al[11] suggested that the main cause of failure in ureteroscopic lithotripsy was the upward migration of stone or fragments. In our study, both the patients in the pneumatic group, who were not rendered stone free at 3 months, had upper ureteral stones at the time of inclusion into the study. Also, upward migration of stones or fragments into the renal pelvis was noted in both the patients at the time of initial procedure. These observations suggest that Pneumatic lithotripsy is more likely to cause upmigration in proximal ureteral stones as compared to Holmium:YAG laser litotripsy, and that this can subsequently lead to treatment failure.

These two patients in the pneumatic group, who still had stones at the end of 3 months, needed auxiliary procedures to achieve complete stone clearance. However the difference between the groups is not statistically significant (p=0.353). One patient, whose stone had again slipped into the ureter after upmigration during the initial procedure, was successfully treated with repeat ureteroscopy. Another patient with stone upmigration was given the option of being referred to a higher centre with facilities for extracorporeal shock wave lithotripsy (ESWL) which was not available at our centre at the time of study. The patient chose to undergo percutaneous nephrolithotomy (PCNL) and was successfully treated.Our findings are comparable to Binbay et al[2], who required auxiliary treatments in 7 patients in pneumatic group,

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 02, 2022

while only 1 patient in laser group needed this treatment (p=0.05). After additional procedures 100% success was achieved in both groups.

Conclusion

This study revealed that Hol:YAG laser lithotripsy is safe and more effective than pneumatic lithotripsy in respect of stenting requirement and has higher stone free rate and less requirementof forceps/baskets.The need for auxiliary procedureafter Hol:YAG laser assisted URS is less in comparison with pneumatic lithoclast.

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