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A Comparative study between pneumatic and holmium laser lithotripsy in treatment of ureteric stones.

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Abstract: Background: Urolithiasis is an important as a general world healthcrisis.In the past 20 years, the treatment of urinary calculi has been changed significantly, although the tolerant application of ureteroscopiclithotripsyis and ESWL, still preferring this methods in the management and treatment of ureteric stones at several hospitals. Aim of Work: To compare between holmium laser and pneumatic lithotripsy in management of ureteric stones as regarding duration of the procedure, stone clearance, incidence of complications and hospital stay. Patients and Methods: Sixty patients complaining from stone ureter were enrolled in the current work over the period from August 2014 to June 2016 in Urology department of National Institute of urology and nephrology. Patients were randomly classified into two groups. Group A (n=30) were managed by holmium YAG laser lithotripsy (LL) while Group B (n=30) were managed by pneumatic lithotripsy (PL) for stone ureter. Different patient data were evaluated and analyzed including, demographics, intraoperative parameters, stone characteristics, and postoperative complications. Results: All 60 patients were evaluated as we had no patients who lost in follow up. No differences between the two groups were observed regarding the baseline demographics and stone characteristics of patients. Group (LL) patients were significantly superior than group (PL) patients regarding the average operative time (29+8.45vs38+11.03 min, p=0.0010) and early stone free rate (93.3%vs86.7%) and incidence of postoperative haematuria which showed statistically significant difference between both groups (6.6%vs56.7%, p=<0.001). While other complications such as migration, perforation and stricture was detected in both groups and compared. Conclusions: Both LL and PL are safe and efficient modalities in treating stones in the ureter with the following advantages of LL for their high efficiency of stone destruction and greater clearance rate of stones with shorter operative time and less incidence of stone migration and postoperative haematuria over PL.

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Key Words: holmium laser lithotripsy, pneumatic lithotripsy, uretroscopy

1. Introduction

Urolithiasis representing an important health crises in most countries. Throughout the previous 20 years, the treatment of calculi in the urinary system are dramatically changed through introduction of advanced tools and instruments. Various end urological therapies are offered for urinary stones. Regardless of the abundant usage of ESWL, ureteroscopiclithotripsyis remain the favorite treatment for controlling stones in the ureter in several health centers and hospitals, due to it is ability for clearance of calculi immediately from the ureters with high percentages than other methods. The global advancement in the manufacturing of advanced instruments and tools in the treatment upper urinary tract stones (urolithiasis), enhanced greatly the success rate and decreased significantly the rate of morbidity among patients ***(1).***

Ureteroscopy combined with intracorporeal lithotripsyis quickly considering a first-line of treatment for proximal ureteral stones. The construction of more forceful flexible equipments, in addition to reliable laser technology and smaller semi-rigid ureteroscopes for ureteroscopic lithotripsy has extended greatly the needs for endoscopic interference ***(2).***

Different kinds and models of lithotripters are used nowadays for destruction and fragmentation of stones throughout ultrasonic, ureteroscopic procedures as electrohydraulic, pneumatic, and laser lithotripters can be used. ***(3).***

The mode of action of pneumatic lithotripters is similar to collision and a bullet; where an energy will transfer many pulses (12 forward and backward pulses) of compressed air through a steel probe for destruction to the stones. The utmost imperative disadvantage of this method (lithotripter) is the backward movement of movable free fragments of stones after destruction into the kidney. ***(4).***

Recent advancements in the design of ureteroscope, in addition to increased using of the holmium yttrium-aluminium-garnet (holmium: YAG) laser which according to many studies led to decline in incidence of complications among patients subjected for fragmentation of calculi by ureteroscope ***(5).***

The characteristics of the holmium: YAG laser are 2100 nm a wavelength, 0.2—0.4 J/pulse a pulse energy and 3.0 and 100W transported power, while the higher powers are not used in stone operation. ***(6).***

To carry out an end urological processes 200—1000_m of laser fibres of are used. The mechanism of action of the holmium: YAG laser due to capability for penetrating tissues at a depth of 0.5mm and the ability for heating of water with high degrees, that, creating microbubbles at the tip of the laser fibres, which finally leads to creation of mechanical forces sufficient for fragmentation and evaporation of urinary tract stones. To minimize the thermal impact of the laser on tissues it is important to supply with high volume of water relieving the overheating released from laser fiber. These steps are believed to accomplish more efficient stone destruction with a minimum risk of inducing trauma and other complications than most other methods of ureteroscopiccalculi fragmentation. ***(7)***.

Aim of the Work:

To compare between holmium laser lithotripsy and pneumatic lithotripsy in the therapy of ureteric calculi as regarding duration of the procedure, stone clearance, incidence of complications and hospital stay.

Patients and Methods:

Between August 2014 and June 2016; a total of 60 patients with stone ureter were included in this study, our study was assigned on a randomized basis and patients underwent either Holmium YAG laser lithotripsy or pneumatic lithotripsy as end urological management for stone ureter. Randomly. We used blocked randomization schedule to allocate patients. After giving written consent, they were randomly divided into two groups. Group A (n=30) were managed by Holmium laser lithotripsy while Group B (n=30) were managed by pneumatic lithotripsy for stone ureter, Patients age ranged from 10 to 60 years. All patients were presented with Stone ureter. Patients were followed up for six months and results were recorded and compared.

The inclusion criteria were:. stone ureter >0.8 mm and < 2 cm, failed medical treatment.

The exclusion criteria were: stones >2 cm and < 0.8 mm, concomitant ureteric stricture, musculoskeletal deformities, urinary tract infection.

Preoperative evaluation:

Full history will be taken from all patients, Imaging assessments for stone size and location by intravenous urogram or non contrast multislice CT urinary tract, Urine analysis and culture will be performed to ensure that the patients have sterile urine before the procedure, Routine preoperative investigations (complete blood count, liver enzymes, kidney function test, bleeding profile and fasting blood sugar), An informed consent will be obtained including counseling on treatment options, procedure and potential complications.

Surgical Technique

All Patients were under spinal anesthesia and placed in lithotomy position, A broad spectrum antibiotic was administered during anesthesia induction, A rigid cystoscope was performed to locate ureteric orifice and advancement of hydrophilic guide wire under fluoroscopic guidance, ureteral orifice was dilated with balloon catheter or axial dilators, a rigid 7.5 f uretroscope was used for uretroscopic lithotripsy, In group A holmium laser lithotripsy was used with fiber 365 um and laser settings were 0.8 _ 1.2 j per pulse and frequency 10 to 15 HZ, In group B pneumatic lithotripsy with swisslithoclast was used with 3 f pneumatic probe and pneumatic setting was 5 bar and frequency 10 HZ, At the end of the procedure Double J stent was placed for 1 month to ensure drainage and prevent obstruction from ureteral oedema.

Postoperative Evaluation

All patients will be evaluated for duration of the procedure, stones clearance rate, hospital stay, incidence and types of complications e.g. (perforation, migration, stricture). On day 1 postoperative radiography KUB was performed routinely to assess the existence of residual fragments as well as the location of Double J stent, while on 4 weeks postoperative the stent will removed in all patients unless there is significant residual or any complications happened at this date or before, finally contrast study done at 3 and 6 months postoperative to evaluate renal function and exclude ureteric stricture.

Results:

Demographic data of the studied cases (total number was 60 cases) the mean age was 37.87 + 12.34 and 40.7+ 8.7 in LL and PL respectively, The main symptom was loin pain presented in 56 patients (93.3%) followed by irritative symptoms in 14 patients (23.3%) with only 3 patients presented with gross haematuria**. (Table 1)**

Urine culture show no growth in all patients while microscopic haematuria present in 43 patients (71.6%), stone parameters (site, size) was evaluated by KUB in radioopaque stone or spiral CT in radiolucent stone, 51 patients (85%) with radioopaque stones while 9 patients with radioloucent stones, the stone size measured by longitudinal axis of the stone.

the stone site was considered in the upper ureter when the stone above the upper border of sacroiliac joint and considered in the lower ureter when below level of lower border of sacroiliac joint while considered in the middle ureter when the stone located between the two borders of sacroiliac joint.

Table 1. Patients demographics and clinical history

	LL	PL	P value
Total patients, n	30	30	
Mean age (years)	37.87 ± 12.34	40.7 ± 8.7	0.31
Loin pain	28 (93.3%)	28 (93.3%)	0.641
Gross hematuria	2 (6.7%)	.1 (3.3%)	1
Irritative $	9 (30%)	5 (16.7%)	0.36
Operative history	6 (20%)	4 (13.3%)	

Table 2. Preoperative workup

	Laser (30)	Pneumatic (30)	P Value
S. Creat (mg/dl)	1.03 ± 0.22	0.94 ± 0.19	0.106
Urine C/S	Negative	Negative	
Microscopic Hematuria	22 (73.3%)	21 (70%)	0.774

		Laser (30)	Pneumatic (30)	
Hydronephrosis	**Mild**	19 (63.3%)	18 (60%)	0.543
	Moderate	7 (23.3%)	10 (33.3%)	
	Severe	4 (13.3%)	2 (6.7)	
Stone Size (cm)		1.33 ± 0.36	1.34 ± 0.37	0.915
Ureteric Stone Site	**Lower**	15 (50%)	20 (66.7%)	0.41
	Mid	9 (30%)	5 (16.7%)	
	Upper	6 (20%)	5 (16.7%)	
Stone Opacity	**Radiolucent**	7 (23.3%)	2 (6.7%)	0.145
	Radioopaque	23 (76.7%)	28 (93.3%)	

Table 3. Perioperative details

		LL	PL	P value
Mean operating time (min)		29 ± 8.45	38 ± 11.03	0.001
Hospital stay		1.2 ± 0.4	1.27 ± 0.45	0.549
Intraoperative complications	***Migration***	0	3(10%)	0.237
	Perforation	0	1(3.3%)	0.91
Postoperative symptoms	***Loin pain***	2(6.67%)	7(23.3%)	0.145
	Irritative $	21(70%)	15(50%)	0.187
	Hematuria	2(6.67%)	17(56.7%)	<0.001

Operative time was estimated in both groups (29+8.45min in L.L and 38+11.03 in PL), this is means that LL takes shorter time than P.L in stone fragmentation, Although the average hospital stay looks similar in both groups. Intraoperative complications were estimated in both groups and stone migration happened in 3 cases in PL only with no cases in LL, this 3 cases which occurred in PL happened in upper ureteric stones which means the more the proximal stone the more chance of stone migration, while intraoperative perforation reported in only 1 case in PL, follow up of the postoperative symptoms showed significant difference in postoperative haematuria between both group with p value (0.001).

Table 4.: Outcome

	Laser (30)	Pneumatic (30)	P Value
Early stone free rate	28 (93.3%)	26 (86.7%)	0.671
1 month stone free rate	29 (96.7%)	27 (90%)	0.85
3 months ureteric stricture (IVP)	2 (6.7%)	0	**0.005**

The early stone free rate was 93.3% in L.L group and 86.7% in PL group, Residual fragments in LL was <4mm in 1 case (clinically insignificant fragment) and >4mm in 1 case (clinically significant fragments), Residual fragment in PL was <4mm in 1 case (clinically insignificant fragment) and >4mm in 3 cases (clinically significant fragments), while delayed stone free rate was (96.7%) in LL group and (90%) in PL group, Postoperative follow up by IVU show only 2 cases developed ureteric stricture following LL with no cases in PL group.

4. Discussion:

Various types and models of lithotripters are used for stone fragmentation during ureteroscopic procedures. In our study, pneumatic and holmium: YAG laser lithotripters were employed. Pneumatic lithotripters work on the same principle as collision with a bullet; on impact, energy transmits compressed air pulses (12 forward and backward pulses) throughout a steel probe to the stones to be destructed. The main significant weakness of this lithotripter is the backward transfer of small movable calculi into the kidney during fragmentation of ureteral stones**. (4)**, Holmium: YAG (yttrium-aluminum-garnet) is the favored laser kind used in management of urolithiasis. This method is characterized by wavelength spectrum of 2140 nm, released from laser pulses, also, having a thermal effect which penetrates to depth of 0.5 mm of soft tissue, and it is employed for the destruction of cysteine, calcium, oxalate and struvite stones. **(8)**.

In our study Fragmentation time was estimated in both groups (29±8.45 min in LL and 38±11.03 min in PL) this is means that LL takes shorter time than PL in stone fragmentation. furthermore another study done by linjin and colleagues 2015, the operative time was 28± 9.2 min in L.L and 41±12.4 in P.L. ***(9)*** Which may be described by the following: In PL the time required for fragmentation of calculi into removable size may be less than LL. Conversely with PL the operator has to handle ureteroscope to hunt for the moving calculi. In addition, pneumatic lithotripter fragments the stones into large numerous fragments that require to be detached or doing extra manipulation to become un sizeable, On the contrary the stone tends to wander fewer with LL permitting the vaporization of the stone without in need to several handling. Also LL vaporizes and debulks the calculi for very small parts even no considerable fragments persist.

Intraopertive complications was reported in both groups, In the present study Stone migration occurred in 3 cases (10%) in PL only, the 3 cases which happened in PL. had occurred in upper ureteric stones (1.5- 2) cm in size, the chance for migration is the more proximal calculi. Furthermore, the stone escaping is more predominate in PL than LL method which may be elucidated by the mode of action of both types of lithotripsy (photothermal in LL versus "jackhammer" effect in PL). It was similar to result done by Ankur and colleagues where stone migration occurred in 2 cases out of 38 in PL only**. (10)**. Intra operative perforation has occurred in P.L in 1 case out of 30 (3.3%) and no cases in L.L (0%) which was controlled by double J stent with no long term problems (stricture) established by ultrasound and IVU after double J removal.

The stone free rate was estimated by KUB or CT at day 1 post operative for early stone free rate and at 1 month post operatively for delayed stone free rate, early stone free rate was higher in L.L (93.3%) than P.L (86.7%), where residual stones are encountered in 2 cases in L.L while in 4 cases in P.L, Though the volume of the fragments was varied, practically fragments less than (<4mm) was considered non-insignificant and was detected in 1 case in each group while clinically significant fragment (>4mm) was present in 1 case in L.L and 3 cases in P.L, delayed stone free rate remain higher in L.L (96.7%) than PL (90%) with only 1 case in LL required additional practice, whereas, 3 patients in PL needed subsidiary steps, by comparing the initial stone free rate to delayed stone free rate it is noted that clinically insignificant fragments passed spontaneously. The stone free rate raised from 93.3% to 96.7% in LL and from 86.7% to 90% in PL group.

In our study, Following the procedure, post operative symptoms were assessed, Post operative gross haematuria was significantly higher in PL than LL group. (6% in LL and 56% in PL), which was also higher in study done by Garg and colleagues 2009, Post operative gross haematuria was higher in PL (28%) than LL (16%) ***(11)***.

In our study post operative follow up after 3 months by IVU done to all patients to evaluate renal function and exclude ureteric stricture, there are only 2 cases out of 30 (6%) in LL group developed ureteric stricture while no cases in PL group (0%), while in Linjin and colleagues 2015, the follow up after 3 months postoperatively by IVU demonstrated higher incidence of ureteric stricture in LL 24 cases (4.9%) than in PL group only 5 cases (1%). ***(Linjin et al, 2015)***, The higher rate of criticism development in laser group could be elucidated by its stronger ablation and coagulation outcome, the area of thermal damage that is accompanied with laser superficial wounding and ablation ranges from 0.5 to 1 mm, which represent a chief role in stricture formation. ***(9)*.**

Conclusion:

In our study Both PL and LL are safe and efficient methods for treating of ureteric calculi. With the following advantages of LL over PL. LL is

techniqually easier than PL, Operation time is shorter in LL than PL, Stone free rate is higher in LL than PL, The stone tends to migrate less in LL than in PL, Post operative haematuria is higher in PL than LL,. on the other hand holmium laser is an expensive modality of lithotripsy compared to other modalities, However Holmium laser can be applied to a variety of procedures such as: prostatic procedures, strictures, urothelial tumors. So we conclude that LL is superior technology compared to PL in term of stone clearance and complications.

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