Evaluation of Holmium: YAG Laser Versus Pneumatic Lithotripsy for the Intra Corporeal Lithotripsy of the Ureteric Stones

Saad Dakhil Farhan

ABSTRACT:

BACKGROUND :

Ureteroscopy (URS) is a precise, minimally invasive surgical intervention that can assess the entire collecting system to treat a stone using intracorporeal lithotripsy.The implication of laser technology in the development of lithotripter fibres has revolutionised intracorporeal lithotripsy.

OBJECTIVE:

To compare the efficacy and safety of Holmium: YAG laser and pneumatic lithoclast in treating ureteric calculi.

METHODS:

The study included total of 65 patients divided into two groups of laser lithotripsy **(LL)** (25 patients) and pneumatic lithoclast (PL)(40 patients). Inclusion criteria were patients with a single ureteric stone of size 0.7cm-2.0 cm. Stone size was determined with pre op CT scan. A 8 French rigid ureteroscope was used for all cases. Holmium: YAG laser with 600 µm wide fiber size was employed in laser group and frequency was set at 8 Hz at a power of 1.2 joule.Pneumotic lithoclast with used in PL group. Postoperatively patients underwent radiography and helical CT as required to asses stone clearance.

RESULTS:

The mean patient age , the male to female ratio , stone size and site were similar between the two groups. Mean operative time in LL group was 35.5 minutes as compared to 25.7 minutes in PL group, the Stone migration up in pelvicalyceal system occurred in one patients(4%) of LL group while in nine patients(22.5%) of PL group. Double J (DJ) Stent was placed in 9 (36%) patients in LL group where as 17(42%) patients required it in PL group. Stone free rate at 4 weeks was 84% in LL group as compared to 72.5% in PL group.

CONCLUSION:

Holmium: YAG laser lithotripsy is a superior technology compared to pneumatic lithoclast in terms of rate of stone clearance and complications especially in upper ureteric stones. .

KEYWARDS: intracorporeal lithotripsy,laser lithotripsy,pneumotic lithotripsy, ureteric stone .

INTRODUCTION :

Ureteroscopy occupy an essential place in the treatment of ureteric calculi as increasing technologic advancements allow easier access to stones in all parts of the kidney and ureter.In particular, improvements in ureteroscopic equipment emphasize the need for appropriate and effective miniaturized intracorporeal lithotripsy devices [1,2].

Laser is an acronym for light amplification by stimulated emission of radiation, The Holmium: Yttrium, Aluminum, Garnet laser(holmium:YAG laser) was developed in early 1990s [3]. The holmium laser is a solid-state laser system that operates at a wavelength of 2140 nm in the pulsed mode[4]. 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 [5]. It has a wide range of endoscopic applications, and has demonstrated effectiveness in clearing stones of all compositions [6]. The holmium: YAG laser is transmittable via flexible fibers. The thermal effect produced by holmium: YAG laser's pulses

College of Medicine , Baghdad University.

are due to formation of plasma bubble[7].The zone of thermal injury associated with laser ablation ranges from 0.5 to 1.0 mm [8].holmium laser lithotripsy occurs primarily through a photothermal mechanism that causes stone vaporization, The holmium laser is one of the safest, most effective, and most versatile intracorporeal lithotripters [9,10].

Pneumotic(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 [11]. The Swiss LithoClast, introduced in the early 1990s, was the first ballistic lithotrite. The metal projectile in the handpiece 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 LithoClast is activated by a foot pedale . The advantages of ballistic lithotrites is their relatively low cost and low maintenance [12]. Disadvantages of ballistic devices include the rigid nature of the technology, which requires ureteroscopes or nephroscopes with straight working channels. In addition, ballistic lithotripsy is associated with a relatively high rate of stone retropulsion [13].

The aim of this study is to compare the efficacy of holmium: YAG laser and pneumatic(Ballistic) lithoclast in treating ureteric calculi.

MATERIAL AND METHODS:

This is a prospective study was carried out in the Urology department of Al Shaheed Gazi Al hareri Surgical Specialties hospital , from January 2011 and June 2012 . Sixty Five patients were selected after informed consent . Patients with single ureteric stone of size 7mm-20mm were selected. Patients with co morbidities like renal failure ,Patients with multiple stones or those with technically difficult in passing the ureteroscopy were excluded from the study. All the patients underwent thorough process of history, examination, and investigations. Radiological evaluation with ultrasonography, IVP and CT scan were preoperatively performed , stone size was assessed with CT scan. Operative time was defined as the duration between insertion of the ureteroscope into the urethera and placement the folys catheter at the end of the procedure. Two groups were made, the laser lithotripsy (LL) group (25 patients) and pneumatic lithotripsy (PL) group(45Patients) . All patients received tamsulosine (0.4 mg) as a single daily dose for at least one weak before the procedure. Negative urine cultures were mandatory in every patient of both groups. Ureteroscopy combined with either holmium: YAG laser or pneumatic lithotripsy was performed by a single Urologist using a 8 French rigid ureteroscope. For ureteroscopic laser lithotripsy a Holmium :YAG laser which operates at a wavelength of 2100 nm was used. All the patients were treated with a 600 µ m quartz end fiber. It is recommended that treatment be begun with low-pulse energy (e.g. 1.2 J) with a pulse rate of 8 Hz and that pulse frequency be increased as needed to speed fragmentation (Figure 1&2).To maximize lithotripsy efficiency, We move the laser fiber over the stone surface in a “painting” fashion, vaporizing the stone rather than fragmenting it . The laser fiber should extend at least 2 mm beyond the tip of the endoscope to avoid destroying the lens system or the working channel of the endoscope. The laser fiber should be kept at least 1 mm from the urothelium, and lithotripsy should proceed until the stone fragments are powdering or become small enough to be passed spontaneously .

Swiss Pnumotic lithoclast with 1mm probe was used to break the stones in PL group. Stones were fragmented by using single or multiple fire technique and lithotripsy should proceed until the stone fragments are small enough to be passed spontaneously or can be safely retrieved with grasping device.

DJ Stents were used in cases of impacted stones , and when there is perforation of the ureter or migration of the stones. . Postoperatively; patients underwent radiography for X-ray KUB and helical CT as required to asses stone clearance . Treatment outcomes were defined as complete disappearance of the stones.

Statistical comparison of two independent percentages was done and p value of less than 0.001 is considered statistically significant.

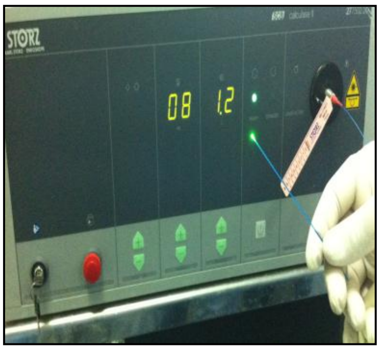

Figure 1: The setting of laser lithotriptor

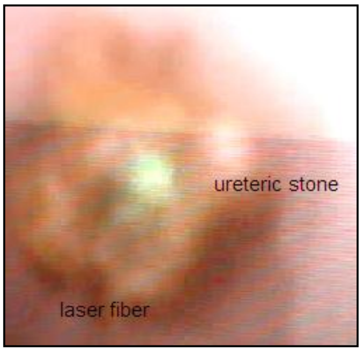

Figure 2:Intracorporeal laser lithotripsy.

RESULTS:

Average patient age, the male to female ratio , stone size and stone site were similar between the groups (Tables 1&2).

The median stone size was 11-15 mm in both groups with a range of 7mm to 20 mm (p=0.17 NS) .(table 2).

As far as location is concerned, we divided the ureter into proximal, mid and distal portions as per standard anatomical landmarks. In LL group 3 (12%) stones were located in proximal ureter, 12 (48%) in mid ureter and 10 (40%) in distal ureter while 4 (10%) were in proximal part of ureter , 12 (35%) in mid ureter and 22 (55%) in distal ureter in PL group.(p=0.45 NS) (table 2).

Mean operative time in LL group was 35.5 minutes , as compared to 25.7 minutes in PL group (p<0.001) .(Table 3).

In one (4%) patients treated with laser, we came across stone migration up in the pelvicalyceal system required . On the other hand stone migration occurred in nine(22.5%) patients in PL group.

Ureteral perforation ocurs only in two patients(5%) with PL group but not in LL group

The total percentage of Migration / perforation complication was more common in PL group (27.5%) than LL(4%) (P=0.018)(table 4).

We were not very generous in the use of DJ stent. In LL group, 9 (36%) required DJ stenting and 17 (42%) were subjected to DJ stenting in PL group (p=0.6).(Table 5).

Short duration of hospitalization (Less than 12 hours) were more in LL group (52%) than PL (42.5%)(P=0.45)(Table 6). Complete Stone clearance rate was better in LL (84 %) as compared to PL(72.5 %) (P=0.26) (Table7).

As shown in (Table 8) , laser lithotripsy significantly increases the risk of having a complete stone clearance by 6.6 times compared to standard pneumatic procedure, after adjusting for stone size and site.

An upper third ureteric position of stone is associated with a 7.1 times improvement of outcome with LL (OR=1.4) .

Having a bigger stone (16+ mm) is expected to reduce the risk of complete stone clearance by compared to smaller stone(OR=0.13) .

Table 1: Average patient age, the male to female ratio.

	Method used				
	Pneumatic lithotripsy		Laser lithotripsy		
	N	%	N	%	P
Age group (years)					0.95[NS]
15-20	1	2.5	1	4.0	
20-30	13	32.5	10	40.0	
30-40	21	52.5	8	32.0	
40-50	3	7.5	4	16.0	
50-60	2	5.0	2	8.0	
60-70	0	0.0	0	0.0	
Total	40	100.0	25	100.0	
Median	(30-40) years of age		(30-40) years of age		
Mean rank	33.1		32.8		
Gender					0.36[NS]
Female	21	52.5	16	64.0	
Male	19	47.5	9	36.0	
Total	40	100.0	25	100.0	

Table 2: Stone size and stone site.

	Method used				
	Pneumatic lithotripsy		Laser lithotripsy		
	N	%	N	%	P
Site of ureteric stone					0.49[NS]
Lower third	22	55.0	10	40.0	
Middle third	14	35.0	12	48.0	
Upper third	4	10.0	3	12.0	
Total	40	100.0	25	100.0	
Size of stone (mm)					0.17[NS]
7-10	9	22.5	10	40.0	
11-15	22	55.0	11	44.0	
16-20	9	22.5	4	16.0	
Total	40	100.0	25	100.0	
Median	(11-15) mm		(11-15) mm		
Mean rank	35.3		29.3		

Table 3: Duration of the` procedure.

	Method used				
Duration of the procedure (min)	Pneumatic lithotripsy		Laser lithotripsy		
	N	%	N	%	P
20-30	20	50.0	2	8.0	
31-40	15	37.5	10	40.0	<0.001
41-50	5	12.5	9	36.0	
51-60	0	0.0	4	16.0	
Total	40	100.0	25	100.0	
Median	(20-30) min		(31-40) min		
Mean rank	25.7		35.5		

Table 4: Complications of both procedures.

		Complications					
Method used		None	Migration / perforation	Total	RR	95% CI of RR	P value
Pneumatic lithotripsy	N	29	11	40	6.9	(0.9 - 50.1)	0.018
	%	72.5	27.5	100			
Laser lithotripsy	N	24	1	25	Reference		
	%	96	4	100			

Table 5: Need for DJ (Double J ureteric catheter)

		Need for DJ					
Method used		Not needed	Required / used	Total	RR	95% CI of RR	P value
Pneumatic lithotripsy	N	23	17	40	1.2	(0.6 - 2.2)	0.6[NS]
	%	57.5	42.5	100			
Laser lithotripsy	N	16	9	25	Reference		
	%	64	36	100			

Table 6: Duration of hospitalization.

		Short duration of hospitalization (<12 hours)					
Method used		12-24	<12 hours	Total	RR	95% CI of RR	P value
Pneumatic lithotripsy	N	23	17	40	Reference		
	%	57.5	42.5	100			
Laser lithotripsy	N	12	13	25	1.2	(0.7 - 2)	0.45[NS]
	%	48	52	100			

Table 7: Stone clearance rate

		Complete stone clearance (100%)					
Method used		Incomplete	Complete	Total	RR	95% CI of RR	P value
Pneumatic lithotripsy	N	11	29	40	Reference		
	%	37.5	72.5	100			
Laser lithotripsy	N	4	21	25	1.6	(0.7 - 3.5)	0.26[NS]
	%	24	84	100			

Table 8 : Multiple logistic regression with the risk of complete stone clearance as the dependent (response) variable and type of lithotripsy procedure as the independent (explanatory) variable after adjusting for site and size of ureteric stone.

	partial OR	P
Laser lithotripsy compared to Pneumatic lithotripsy	6.6	0.002
Upper third compared to Lower / middle third of ureter	1.4	0.13
Bigger stone size (16+ mm) compared to smaller size	0.13	0.022

P (Model)<0.001

Overall prediction accuracy = 83.1%

DISCUSSION :

Technology has made it possible to successfully access and treat virtually any stone within the ureter in a relatively a traumatic fashion. The holmium: YAG laser is a solid state system which can be used to fragment stones of all composition with a fragmentation rate of 90-100%. [14] . Laser lithotripsy has significant advantages over the other lithotripsy techniques ; The probes for laser lithotripters are more suitable for smaller caliber instruments [15].The long holmium:YAG pulse duration produces an elongated cavitation bubble that generates only a weak shockwave [16]. This explain the low rate of stone retropulsion with laser lithotripsy (4%) compared with pneumotic lithotripsy (22.5%) . Holmium laser lithotripsy work primarily through a photothermal mechanism that causes stone vaporization and had the ability to fragment all stones regardless of composition [9]. This explain the higher rate of stone clearance with laser lithotripsy (84%) compared with pneumotic lithotripsy(72.5%). The depth of thermal injury to the urethelium is only 0.5-1 mm and this explain The very low incidence of perforation of the ureter with LL [15]. We use DJ stent in cases of migration of stones or ureteral perforation,The use of DJ stents post operativly was lower with LL group because low incidance of residual stones and stone migration with LL group compared with PL group .The only disadvantage of this energy source seems to be the cost of the device and the requirement for eye protection [5].

The Swiss Pneumotic lithoclast was developed in Switzerland in 1989 and clinical results of its use in fragmenting urinary stones were published in the early 1990s [17]. Our results show that this modality is also an effective way of fragmenting stones. We have achieved an overall stone clearance rate of 72.5 % at 4 weeks, which is comparable to international published data. The disadvantage being stone migration up, because of jack hammer mechanism of lithoclast probe[18]. Most of the migrations occurred in proximal ureteric stones. We also tried elevated head end of the table to prevent stone migration but we avoided the use of baskets due to the risk of ureteric mucosal injury. Al Beer et al. [19]. Used lidocain jelly for preventing stone displacement during pneumatic lithotripsy for ureteral calculi . The mean operative time was shorter with PL compared with LL and this because the difference in the mechanism of stone fragmentation and this comparable with other studies [20] . According to Peh O H et al holmium: YAG laser lithotripsy is both effective and safe[21].In another study conducted by James D et al holmium: YAG laser is even safer in patients with bleeding diathesis[22]. A comparison of holmium: YAG laser with pneumatic lithotripsy in ureteral calculi fragmentation was done by Seong Soo Jeon etal. in Korea[23] . This study revealed that laser is better than lithoclast in terms of stone free rates as well complication rates . This study also give similar results. A prospective randomized controlled trial comparing nonstented versus stented ureteroscopic lithotripsy by John D et al . [24] . Had given the observation that routine stenting after ureteroscopic intra corporeal lithotripsy with the holmium laser is not required as long as the procedure is uncomplicated. We also used stents only, when required.

CONCLUSION:

Holmium: YAG laser lithotripsy is a superior technology than pneumatic lithoclast in terms of rate of stone clearance and complications, especially in upper ureteric stones. Since this is a single centre study, a multi centre study at a larger scale is required.

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