Direct Comparison of Pneumatic and Laser Lithotripsy in the Management of Lower Ureteric Stone, in Ibn Sina hospital and Omdurman military hospital

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Abstract

Background: A variety of treatment are available for ureteral calculi, including ureteroscopic lithotripsy, shock- wave lithotripsy, laparoscopic lithotomy, and percutaneous nephrolithotomy. **Aim**: Direct comparison of pneumatic and laser lithotripsy in the management of lower ureteric stone, in Ibn Sina hospital and Omdurman military hospital. **Methods**: This was analytic across-sectional hospital based multicenter study, conducted in Ibn Sina and Omdurman military hospital within the period from July up to December 2022. A hundred patients who presented with lower ureteric stone, during study period were included. Direct interviewing questionnaire was utilized. **Results:** The majority of patients (76%) had stone size between 11-15 mm and 24% with stone size between 7-10 mm. There was a higher proportion of stone free rate intraoperatively in uretroscope laser (90%) compared to uretroscope pneumatic (84%) however this was not statistically significant. The odds of stone free rate intraoperativewas increased by 1.7 folds in uretroscope laser management option (OR=.17; 95% CI (.5-5.6). Significantly less operation pain was found in uretroscope pneumatic 76% versus 92% in uretroscope laser. The probability of post-operative pain was reduced by 3.6 times (OR=3.6, 95% CI (1.1-12.2)) in uretroscope pneumatic. Also, significantly less post- operative fever was found in URS pneumatic 70% versus 88% in uretroscope laser. The risk of reduced post-operative fever in URS pneumatic was 3.1 folds (Or=3.1; 95% CI (1.1-8.9)).

There was highly significant association between duration of operation and management options, p=.001 Less than one-hour duration time of operation was significantly achieved in URS pneumatic 80% versus 16% in URS laser management option. **Conclusion**: The study concluded that both URS laser and URS Pneumatic laser are effective and safe modalities in treating lower ureteric stones, URS pneumatic is superior in reducing complications in terms of pain and fever in addition to less duration time of operation (less than one hour), therefore it is recommended.

Keywords: ***Pneumatic lithotripsy, Laser Lithotripsy, Lower Ureteric Stone, Ibn Sina hospital, Omdurman military hospital***

Introduction

Ureteric stones are a common presentation in urological practice. In recent years, progressive miniaturization and technical improvements of ureteroscopes and auxiliary devices have revolutionized their management. Stone free rates well above 90% can, thus, be achieved [1]. Ureteroscopy is one of the most commonly performed procedures by the general urologist. The advancement of ureteroscopy and related working instruments to manipulate or fragment ureteral calculi has significantly increased treatment options. A variety of lithotripters can be used for stone fragmentation, including ultrasonic, electrohydraulic, pneumatic, and laser lithotripters. For many years, favorable outcomes were reported with the use of pneumatic lithotripsy (PL), which uses the simple principle of the jackhammer that is an effective and safe method for stone treatment [2]. Thus, the Lithoclast has become a widespread tool for fragmentation of urinary stones all over the world. Holmium: YAG lithotripsy employs photothermal energy for stone fragmentation [3]. The holmium: YAG laser is now a well-established modality of intracorporeal lithotripsy with an increasing popularity due to its excellent stone-fragmenting properties [4]. Impacted ureter stones present a challenge to the Urologist as the best modality of treatment is still controversial. Impacted stones are defined as calculi that have remained in the same position for at least 2 months [5], failure to pass a guide wire by the side of the stone, failure to visualize contrast medium beyond the stone [6]. Extracorporeal shockwave lithotripsy (SWL) is a non-invasive modality but the stone-free rate falls dramatically for impacted calculi [7, 8] because of lack of natural expansion space around the stone [9, 10]. With the development of smaller caliber semi-rigid and flexible ureterorenoscopes and the introduction of improved instrumentation, including the holmium: yttrium–aluminum–garnet (Ho: YAG) laser, ureteroscopy has evolved into a safer and more efficacious modality for treatment of impacted stones in all locations of the ureter. Ureteroscopic intracorporeal lithotripsy has now become the first-line therapy for chronically impacted stones [11]. Although flexible ureteroscopy is associated with improved access to the proximal ureter and superior stone-free rates, there are many papers advocating that semi rigid ureteroscope is safe and successful treatment modality even for proximal ureteral stones [12, 13]. In recent years, there have been studies comparing the effectiveness of various lithotripters and other minimal invasive methods (e.g., percutaneous antegrade removal) in the

management of impacted upper ureteral stones [14–15]. These studies have only evaluated upper ureteral stones; in addition, they have not presented long-term follow-up results.

Although both, laser and pneumatic lithotripsy, have stood the test of time, laser lithotripsy is significantly costlier, not only because of the necessary initial capital investment for a laser machine but also because of the need to constantly procure replacement laser fibers, whether disposable or with a limited reuse option. Because of these associated costs and its high efficacy and low maintenance, many urologists do prefer the pneumatic lithotripter. Its inflexibility and a higher risk of retro-pulsion may make it slightly less suitable for stones higher up the ureter. However, for stones in the distal ureter, both treatment options can be regarded as almost equal, except for the costs. Pneumatic lithotripsy being the less cost-effective option, at least in our setting, the question remains whether both options, given our limited resources, are equally effective and beneficial to our patients in our healthcare setting and whether switching to a more economical solution would affect the outcomes.

This study aimed to direct comparison of pneumatic and laser lithotripsy in the management of Lower Ureteric Stone, in Ibn Sina hospital and Omdurman military hospital. (Effectiveness of each other in management of LUS outcomes and complications).

Materials and Method

Study Population and Design: Was conducted analytic cross-sectional hospital based multicenter study, conducted in Ibn Sina and Omdurman military hospital within the period from July up to December 2022.

Inclusion and Exclusion Criteria: Patients who presented with lower ureteric stone, during study period, distal ureter stone between 7 and 20 mm, Patient age >18 years, No anatomical abnormalities, and A previous attempt of medical expulsive therapy in uncomplicated stones less than 1cm

Any patient outside the above criteria, Pregnancy, Signs of urinary infection, and Elevated Cr >2 mg/dL was excluded from this study.

Sample Size, Data Collection and Analysis:

Hundred patients, 50 patients underwent URS laser and 50 patients underwent pneumatic URS. Direct interviewing questionnaire was used to collect data. Data entered, cleaned, and analyzed using Statistical Package of Social Science (SPSS) computer program, version 24.0. Descriptive statistics in term of frequency tables with percentages and graphs. Means and standard deviations, presented with relevant graphical representation for quantitative data. Chi squire test was used to test the relationship between the variables, P value was considered significant if $p \leq 0.05$ (CI 95%).

Ethical considerations: Written ethical clearance and approval for conducting this research was obtained from Sudan Medical Specialization Board Ethical Committee, written permission was obtained from the administrative authority of Ibn Sina hospital and Omdurman military hospital, and written consent was obtained from all participants. Confidentiality was considered intentionally, data was used anonymously by using identity numbers instead of names in order to protect participants' identity and keep securely, and information will be used for research purpose only. No reference to any individual participant was made in study reports.

Results:

Personal characteristics of patients:

Regarding the age groups, most of patients were aged 18-30 years (58%), 25% aged between 46-65 years, 13% aged between more than 70 years and only 4% aged less than 31–45-year-old. Male patients dominated study population as they constituted 61% of patients with a male to female ratio of 1:1.6). Regarding the studied anthropometric measures, 58% of patients weighed 61-80 kg, 24% weighed 41-60 kg, 14% weighed more than 80 kg and only 4% weighed less than 40 kg. Height of 48% of patients was between 101-150 cm, and another 48% ranged between 151-200 cm while only 4% were less than 100 cm. (Table1).

Personal characteristics		Percentage %	p.value
Age	18-30 year 31-45 year 46-70 year More than 70 years	58 4 25 13	p ≤ 0.05 (CI 95%).
Gender	Male Female	61 39	
Weight	Less than 40 kg 41-60 kg 61-80 kg More than 80 kg	4 24 58 14	
Height	Less than 100 cm 101-150 cm 151-200 cm	4 48 48	
Total	100		

Table. 1. Personal characteristics of Lower Ureteric Stone patients Ibn Sina hospital and Omdurman military hospital (n=100)

Stone characteristics:

The majority of patients (76%) stone size ranged between 11-15 mm and reminder had stone size between 7-10 mm. Number of stones at time of diagnosis, it was almost equal in cases of solitary or two stones

with the percentages of 45% and 46% respectively, and only 9% had more than two stones. On looking to stone density on CT KUB, more than two thirds of patients (66%) had stone density of 500-1000 HU, 33% more than 1000 HU and only 1% less than 500 HU.

Management

Equal number of patients were managed by URS laser and URS pneumatic. The intra-operative proportion of stone free rate intraoperative was 87%. (Table 2)

			Option of management						
			URS laser	URS pneumatic	Total	P value	OR	95% CI	
								Lower	Upper
Stone Free Rate intraoperative	Yes	n	45	42	87	.277	1.7	.5	5.6
		%	90.0%	84.0%	87.0%				
	No	n	5	8	13				
		%	10.0%	16.0%	13.0%				
Total		n	50	50	100				
		%	100.0%	100.0%	100.0%				

Table 2. Association between patients stone free rate intraoperative and management options

In half of the patient, operation lasted 1-2 hours, in 48% less than one hour and only 2% of patients lasted more than 2hours and 78% of them required DJS insertion.

Comparison between URS laser and URS pneumatic

The intraoperative stone free rate was higher in URS laser as it reached 90% compared to 84% in URS however this was not statistically significant (p=.277). The odds of stone free rate intraoperatively were increased by 1.7 folds in URS laser management option (OR=.17; 95% CI (.5-5.6). Taking into account operative complications, there was significantly less intra-operative pain (p=.027) and, postoperative fever in patients treated with URS pneumatic (p=.024) in, but there was no significant association between complications in terms of post-operative urgency, (p=.079) and post-operative hematuria (p=.210) between the two management options. The probability of post-operative pain was reduced by 3.6 times (OR=3.6, 95% CI (1.1-12.2)) in URS pneumatic and the risk of reduced post-operative fever in URS pneumatic was 3.1 folds (Or=3.1; 95% CI (1.1-8.9)**. (Table 3)**

Complications			Option of management		Total	P-value	OR	95% CI	
			URS laser	URS pneumatic				Lower	Upper
Post-Operative pain	yes	N	46	38	84	.027*	3.6	1.1	12.2
		%	92.0%	76.0%	84.0%				
	no	N	4	12	16				
		%	8.0%	24.0%	16.0%				
Total		N	50	50	100				
		%	100.0%	100.0%	100.0%				
	yes	N	44	35	79				

Post-Operative fever		%	88.0%	70.0%	79.0%	.024*	3.1	1.1	8.9
	no	N	6	15	21				
		%	12.0%	30.0%	21.0%				
Total		N	50	50	100				
		%	100.0%	100.0%	100.0%				
Post-Operative urgency	yes	N	26	18	44	.079	1.926	.865	4.290
		%	52.0%	36.0%	44.0%				
	no	N	24	32	56				
		%	48.0%	64.0%	56.0%				
Total		N	50	50	100				
		%	100.0%	100.0%	100.0%				
Post-Operative haemoturia	yes	N	31	26	57	.210	1.506	.679	3.339
		%	62.0%	52.0%	57.0%				
	no	N	19	24	43				
		%	38.0%	48.0%	43.0%				
Total		N	50	50	100				
		%	100.0%	100.0%	100.0%				

*****Significant

Table 3. Association between complications and management options

Duration of surgery was significantly less in patients who underwent URS pneumatic (p=.000) as in 80% of patients their procedure lasted in less than one hour compared to only 16% in URS laser.

The post-operative day 1 stone free rate by KUB was significantly higher in URS laser patients (p=.004) as 84% of patients were stone free vs only 54% in URS pneumatic patients. The probability of post-operative day 1 stone free rate by KUB was increased by 3.8 times (OR=3.8; 95% CI (1.5-9.7)) among patients with URS laser.

There was no statistically significant difference between the two management modalities in terms of number of stones and intra-operative stone free rate (p=.335). The risk of stone free rate intraoperative was increased by .971 folds (OR=.971; 95% CI (.2-.9)) among patients with two stones in URS pneumatic patients versus URS laser (85% vs.84.6%). (Table 4). Furthermore, there was no significant association between density on CT KUB, duration of operation and management options (p=.338). (Table 5)

Number of Stone				Option of management		Total	P-value	OR	95% CI	
				URS laser	URS pneumatic				Lower	Upper
Single	Stone Free Rate intraoperative	yes	N	14	25	39	.335	2.8	.3	26.4
			%	93.3%	83.3%	86.7%				
		no	N	1	5	6				
			%	6.7%	16.7%	13.3%				
	Total		N	15	30	45				
			%	100.0%	100.0%	100.0%				
Twice	Stone Free Rate intraoperative	yes	N	22	17	39	.650	.971	.2	4.9
			%	84.6%	85.0%	84.8%				
		no	N	4	3	7				
			%	15.4%	15.0%	15.2%				
		Tota l	N	26	20	46				
			%	100.0%	100.0%	100.0%				
More than Two	Stone Free Rate intraoperative	yes	N	9	0	9	NSC			
			%	100.0%	0.0%	100.0%				

		Total	**N**	**9**	**0**	**9**				
			%	**100.0%**	**0.0%**	**100.0%**				

Table 4. Associations between numbers of stones, stone free rate intraoperative and management options

Again, there was no significant association between post-operative pain, DJ insertion and management option. The post-operative pain was not significantly high among DJ insertion in URS pneumatic (81.6%) with probability of .8 times (OR=.8; 95% CI (.3-2.4)). (Table 10) There was no significant association between post- operative fever, DJ insertion and management option. The post-operative fever was not significantly high among DJ insertion in URS pneumatic (85.7%) with probability of .6 times (OR=.6; 95% CI (.2-1.8)).

With regard to post-operative complications, there was no significant association between post-operative urgency, DJ insertion and management option. The post-operative urgency was not significantly high among DJ insertion in URS laser (92.3%) with probability of 1.5 times (OR=1.5; 95% CI (.2-11.8)). Moreover, there was no significant association between post-operative haematuria, DJ insertion and management option. The post- operative haematuria was not significantly high among DJ insertion in URS laser (90.3%) with probability of 2.8 times (OR=2.8; 95% CI (.612.5)).

Discussion

Data from the Urologic Diseases in America project show that rates of URS have risen among Medicare beneficiaries and privately insured individuals over time. [18] A study examining stone management in Australia shows similar findings; the proportion of stones treated with URS has doubled in the past decade. [19] Additionally, it has been shown that physicians who have recently entered practice or recently completed training are more likely to use URS. [20, 21]**.**

The present work aimed to make a direct comparison of Pneumatic and Laser Lithotripsy in the management of Lower Ureteric Stone, in Ibn Sina hospital and Omdurman military hospital. Our study showed that there was no significant association between stone free rate intraoperative and management options (p=.277). The intraoperative stone free rate was higher in URS laser as it reached 90% compared to 84% in URS however this was not statistically significant (p=.277). The odds of stone free rate

intraoperatively were increased by 1.7 folds in URS laser management option (OR=.17; 95% CI (.5-5.6). This finding is in line with the statements that Laser and pneumatic are the most dependent lithotripters [22,23]. Also, in accordance of Degirmenci *et al*. compare laser and pneumatic lithotripsy for treating impacted ureteric stones and reported a distal ureteral stone-free rate of 96.8% and 91.7% for laser and pneumatic, respectively [24].

Duration of surgery was significantly less in patients who underwent URS pneumatic (p=.001) as in 80% of patients their procedure lasted in less than one hour compared to only 16% in URS laser. Many authors reported shorter lithotripsy time of pneumatic relative to laser; however, regarding the operative time [25, 26]. Taking into account operative complications, there was significantly less intra-operative pain (p=.027) and, postoperative fever in patients treated with URS pneumatic (p=.024) in, but there was no significant association between

complications in terms of post-operative urgency, (p=.079) and post-operative haemoturia (p=.210) between the two management options. The probability of post-operative pain was reduced by 3.6 times (OR=3.6, 95% CI (1.1- 12.2)) in URS pneumatic and the risk of reduced post-operative fever in URS pneumatic was 3.1 folds (Or=3.1; 95% CI (1.1-8.9)). The operative complications were higher in the laser versus the combined group, 11.11% vs. 4.4%, respectively, which is statistically significant ($p \geq 0.05$); this is may reflect the safety of the heatless mechanism of pneumatic lithotripsy device when the working filed is narrow due to stone impaction. [17]. The operative complication rate is comparably not well with that reported in the literature which ranged widely from 4 to 28.4% [27, 28]. However, in other studies the most common complications of stone surgery are pain and infection, followed by organ injury (urethra, bladder, ureter or kidney) and bleeding [29]. This study, showed that URS pneumatic is treatment of choice in reducing complications in terms of pain and fever in addition to less duration time of operation (less than one hour). In contrast to our study findings a previous study showed that both groups did not show statistically significant differences in patient stone size, operation time, complications, and stone-free rates ($p > 0.05$) [22]. In concordance with our study many studies showed that both PL and LL are effective and safe modalities in treating large ureteric stones with minor insignificant differences. [16]

Regarding the post-operative day 1 stone free rate by KUB, it was significantly higher in URS laser patients (p=.004) as 84% of patients were stone free vs only 54% in URS pneumatic patients. The probability of post- operative day 1 stone free rate by KUB was increased by 3.8 times (OR=3.8; 95% CI (1.5-9.7)) among patients with URS laser. This agreed with the fact that the radiation dosage for a CT-KUB has been sharply reduced, and control CT-KUB even more (≈1.5 mGy, absorbed dose≈ 0.7-08 mSv, this is a low dose) with maintained and sometimes even better results [30].

In our study there was no significant association between density on CT KUB, duration of operation and management options, p=. 338.Also, there was no significant associations between stone size, density on CT KUB and gender, p=.091 for density of CT KUB between 500-1000 HU and density of CT KUB more than 1000 HU, P=.321. Massoud *et al*. [31] stated that in patients who have stones of 500 to1000 HU, factors such as body mass index of more than 30 kg/m2 and a lower calyceal location make them less suitable for SWL. On the other hand, the study showed that the majority of patients (76%) with stone size between 11-15 mm and 24% with stone size between 7-10 mm. The success rate (stone free rate) of URS has been around 80% in the proximal ureter. It is seen in literature that URS has a higher stone-free rate for stones smaller than or equal to 10 mm in the distal ureter and stones bigger larger than 10 mm in the proximal ureter. [32]. However, Stone size is a significant factor affecting the stone-free state following any intervention for the treatment of ureteral stones. [33]

CONCLUSION

The study concluded that both URS laser and URS Pneumatic are effective and safe modalities in treating lower Ureteric Stone, in Ibn Sina hospital and Omdurman military hospital but the URS pneumatic is better in reducing complications in such as pain and post-operative fever in addition to less operative time (less than one hour).

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 online ISSN 1858-6279 ISSN 1858-**6155**