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Original Research Paper

Urology

URERTEROSCOPIC LASER LITHOTRIPSY IS BETTER THAN PNEUMATIC LITHOTRIPSY FOR URETRIC STONES

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ABSTRACT

Background: Among various intra-corporeal lithotripters, pneumatic lithotripter has become the widely used tool for the treatment of urinary stones. Recently the holmium: YAG laser has been used with a wide range of potential urological applications, including intra-corporeal lithotripsy of urinary calculi. **Aims and objective:** Compare the effectiveness and complications of treatment for ureteric stones between holmium laser lithotripsy and pneumatic lithotripsy. Material and Methods: Comparison of 100 patients presented with ureteric stones, group one (50) of whom were treated with pneumatic lithotripsy and group two (50) with holmium laser was done and the effectiveness and complications of both were analyzed. **Results:** There was no difference in patient age, sex, stone size and location of stones between the two groups. The immediate stone free rates were 86% in the holmium: YAG group and 64% in the pneumatic lithotripsy group ($p = 0.011$).. The mean operative time in the holmium: YAG group (35.7 ± 3.2) was shorter than those with pneumatic lithotripsy group (50.2 ± 5.3). Postoperative stay in hospital was less than 24 hours in holmium: YAG group (74%) and shorter than those for pneumatic group (36%) ($p < 0.002$). Post treatment complications such as ureteral perforation were encountered in only three patients who underwent pneumatic lithotripsy. Other complications, such as mucosal injury, ureteral perforation and postoperative fever; there was no statistically significant difference between the two groups. While light hematuria was found more frequently in the pneumatic group (10%) in comparison to laser group (4%) ($p = 0.045$). On the other hand, the overall complication rates between the two groups was statistically significant (10%) laser group vs. (36%) pneumatic group ($p = 0.002$). **Conclusions:** Holmium: YAG laser lithotripsy was associated with shorter operation time and postoperative hospitalization period. We believe that Holmium: YAG laser lithotripsy is an excellent treatment modality for managing ureteral calculi in central Rajasthan where stone formation rate is quite high. Drawback of holmium laser lithotripsy is its cost and maintainance.

KEYWORDS : Ureteral Calculus, Ureteroscopy, Lithotripsy, Laser

Introduction

Technical advancement in endoscope design and miniaturization have allowed surgeons to access calculi throughout the collecting system and regards as a gold standard for management of ureteral stones [1]. Stone disintegration through a rigid ureteroscope can be achieved with in situ lithotripsy. The spectrum of lithotripters includes: Ultrasonic lithotripsy, electrohydrolic lithotripsy, pneumatic lithotripsy and laser lithotripsy [2]. Pneumatic and holmium: YAG laser lithotripsies are commonly used in majority of urology centers and both reported favorable outcomes [3]. Impacted ureteral calculi (IUC) are difficult to remove because they are surrounded by edematous ureteral mucosa or polyps, accompanied by moderate hydronephrosis or stones staying in the same position for more than 2 months[4–6] An optimal outcome of treatment for ureteric stone depends upon number of factors like character, size and location of stone, clinical severity and patient expectations, anatomical conditions, available technical facilities and expertise. Other than conservative management for smaller stones less than 5 mm size, contemporary treatment options for lower ureteric stones are Extracorporeal Shock Wave Lithotripsy (ESWL), Ureteroscopic Lithotripsy (URSL by using LASER/ Pneumatic/ Ultrasonic), stenting alone, medical expulsive therapy and open ureterolithotomy[.7,8] Most frequently used contemporary options for intra-corporeal endoscopic ureteral stone management are Pneumatic and LASER lithotripters[9-11] The zone of thermal injury associated with laser ablation ranges from 0.5 - 1.0 mm [12]. Therefore subsequent injury of the ureter is unlikely to happen as long as the lithotripsy is performed under direct vision. Using laser lithotripters the trauma to the urothelial mucosa is usually less compared to the other lithotripters [13]. The lithoclast lithotripsy fragments calculi with a mechanism similar to that of a pneumatic jackhammer. Compressed air propels a small projectile against the probe, causing the probe to oscillate back and forth at frequency of 12 cycles per second. Fragmentation occurs as the probe tips repeatedly impact the stone

[14] [15]. The advantages of ballistic lithotripsy are their relatively low cost and low maintenance. The disadvantages of ballistic devices include the rigid nature of the technology, which requires ureteroscopes or nephroscopes with straight working channels, with a relatively high rate of stone retropulsion[16]. Furthermore, lithoclast lithotripsy fragments the calculi into multiple chunks that need to be basketed and removed [17].

AIM AND OBJECTIVE:-Aim of this study is to show the effectiveness of Holmium laser better than Pneumatic lithotripsy in ureteral stones.

MATERIAL AND METHODS:-

A prospective study including a total of one hundred patients presented with ureteral stones, who were candidate for transuretral lithotripsy, they were assigned into two groups (50 patients in each group) using a prospectivecomparative study in a period between may 2022 and december 2022 at urology department JLN Medical college ajmer in central Rajasthan.

Patients in both groups (group one and group two) underwent transuretral lithotripsy using pneumatic and Holmium: YAG laser, respectively. Informed consents were obtained from all the patients. Patients were included when they had single or multiple ureteric stones of different sizes (7 - 20 mm), presence of moderate or severe hydronephrosis, failed medical conservative treatment, symptomatic patient with ureteric stones. Patients with renal anomalies, pelvic or caliceal stones, pregnancy, severe musculoskeletal deformity and history of uncontrolled coagulopathy were excluded from the study. Before the procedure, urine cultures were obtained, and if positive, antibiotics were administered. All of the subjects

should have negative urine cultures preoperatively. Patients were assessed by ultrasonography and plain abdominal X-ray (kidney-ureter and bladder), excretory urography before performing transuretral lithotripsy to evaluate stone size and location, non-contrast CT-scan was done when indicated in selected cases to document stone size and location. All the procedures were done by an 8 Fr semi-rigid Karl storz ureteroscope in both groups, under general or spinal anesthesia after receiving a single shot of prophylactic antibiotic. In laser lithotripsy, holmium: YAG laser power ranged from 2.5 watt (0.5 J at 5 Hz) to 15 watts (1.0 J at 15 Hz) stones were dusted and left for spontaneous clearance. For lithoclast (pneumatic) lithotripsy, 1.0 mm probe was used to fragment the stone with both single and continuous pulses and pressure was set at 2 bars, large stone fragments were removed using Dormia basket and small one left for spontaneous clearance. In order to maintain a clear ureteroscopic view, irrigation was pumped manually and intermittently during the procedure. After stone fragmentation, final ureteroscopy was performed under direct vision to detect any residual stone or injury to the ureteral wall or adjacent organs. Indwelling ureteral double J stent of 5-6Fr was placed when indicated and removed after 4weeks. Urethral catheter (if inserted) was removed 48 hours postoperatively. All the patients were re-evaluated by abdominal ultrasonography and plain abdominal X-ray (Kidney-ureter and bladder) after two weeks and four weeks postoperatively. Demographic characteristics, operation time, lithotripsy time (from the first fire to the stone to the last fire), immediate stone-free rate, after four weeks stone-free rate, hospitalization, and postoperative complication such as, mucosal injury, ureteral perforation and fever (>38); were compared between the two groups. Stone-free status (residual stone fragments <2mm) and the stone pushing back were determined intra-operatively.A *p* valueless than 0.05 were considered statistically as significant.

RESULTS:

A total of one hundred patients who underwent transuretral lithotripsy were analyzed. The group one patients were managed with pneumatic lithotripsy and group two patients were managed with Holmium: YAG laser in urology department JLN Medical college Ajmer in central Rajasthan .Patient demographics and clinical characteristics are shown in Table 1.

Table 1.

Variable	LASER (n = 50)	Pneumatic (n = 50)	*P*-value
Mean age, y	41.6±5.3	44.2±6.7	0.76 (NS)
Male, n (%)	28 (56.0%)	26 (52.0%)	0.344 (NS)
Female, n (%)	22(44.0%)	24 (48.0%)	0.689(NS)
Previous history of URS, n (%)	4 (8.0%)	9 (18.0%)	0.136(NS)
Stone laterality			
Right side, n (%)	24(48.0%)	27 (54.0%)	0.548 (NS)
Left side, n (%)	26 (52.0%)	23 (46.0%)	0.548 (NS)
Stone size diameter average (mm))	12.5±1.7	10.5±0.9	0.30(NS)
Stone location			
Proximal, n (%)	16 (32.0%)	14 (28.0%)	0.659 (NS)
Middle, n (%)	11 (22.0%)	12 (24.0%)	0.810 (NS)
Distal, n (%)	23(46.0%)	24(48.0%)	0.841 (NS)

Mean patients' age, male to female ratio, and stone size were similar between the two groups.

Table 2 summarizes operative characteristics, outcomes and complications in both groups.

Variable	LASER (n = 50)	Pneumatic (n = 50)	*P*-value
Complications:			
Hematuria, n (%)	2 (4.0%)	8 (16.0%)	0.045 (S)
Mucosal damage, n (%)	1 (2.0%)	3 (6.0%)	0.543 (NS)
Ureteral perforation, n (%)	0 (0.0%)	3 (6.0%)	0.078 (NS)
Postoperative fever, n (%)	2 (4.0%)	5 (10.0%)	0.238 (NS)
Overall complications rate n (%)	5 (10.0%)	18 (36.0%)	0.002 (S)
Migration of stone, n (%)	2 (4.0%)	8 (16.0%)	0.045 (S)
Mean operation time (min) approx	35.7±3.2	50.2±5.3	0.02(S)
Mean lithotripsy time(min) approx	15.2±2.6	8.7±1.8	0.04(S)
Hospital stays < 24 hr, n (%)	37(74%)	18 (36%)	<0.002 (S)
Immediate stone-free status, n (%)	43 (86.0%)	32 (64.0%)	.011 (S)
Stone location, SFR			
Proximal, n (%)	17/18 (94.4%)	15/16 (93.7%)	0.456 (NS)
Middle, n (%)	8/10 (80.0%)	9/13 (69.2%)	0.308 (NS)
Distal, n (%)	19/22 (86.4%)	7/21 (33.3%)	0.002 (S)
Dormia basket need, n (%)	3(6.0%)	9 (18.0%)	0.065 (NS)
Impacted stone, n (%)	9 (18.0%)	6 (12.0%)	0.400 (NS)

The mean of the duration of lithotripsy was 15.2±2.6 minutes in laser group in comparison to 8.7±1.8 minutes in pneumatic group and this was statistically significant ($p = 0.04$). On the other hand, the mean operative time was shorter in the laser group (35.7±3.2 minutes) in comparison to the pneumatic group (50.2±5.3 minutes), a result was statistically significant ($p = 0.02$). Moreover, the majority of patients in the laser group stay in hospital <24 hours (37 patients 74%) in comparison to only 18 patients in the pneumatic group (36%) a finding was statistically significant ($p < 0.002$) . Likewise, the immediate stone-free rate was found in 43 patients (86.0%) in laser group compared to 32 patients (64.0%) in pneumatic group, again a finding which was statistically significant ($p = 0.011$). Migration of Stones occurred only in 8 patients (16.0%) in pneumatic group. While, there was only 2 patients (4%) with stone migration in laser group. A finding was statistically significant ($p = 0.011$). In regard to the stone free rate, patients in the laser group had significantly higher stone-free rate for the proximal ureteral stones 17/18 (94.4%) in comparison to thepneumatic group15/16 (93.7) ($p = 0.456$). In term of complications, such as, mucosal injury, ureteral perforation and postoperative fever, there was no statistical significance difference between the two groups ($p = 0.543$, $p = 0.078$, $p = 0.238$) respectively. While light macroscopic hematuria was found more frequently in the pneumatic group patients (16%) in comparison to laser group patients (4%), a finding was statistically significant ($p = 0.045$). On the other hand, the

overall complications rate between the two groups was statistically significant (10.0% VS 36.0%) $p = 0.002$ as shown in Table 2.

Discussion

Developments in endourology have dramatically changed the approach to ureteral calculi and transureteric endoscopic management emerged as the procedure of choice. The invention of advanced ureteroscopes, lithotripsy devices, and other instruments has made the use of open surgery very rare [18].

A variety of lithotripters can be used through ureteroscope, pneumatic and holmium: YAG laser lithotripsies are commonly used in majority of urological centers [3]. In this study the mean duration of lithotripsy for stone fragmentations into small and removable size was shorter in pneumatic group (8.7±1.8min) compared to the laser group (15.2±2.6 min). On the other hand, the holmium: YAG laser lithotripsy had more advantages from the aspect of operation time as our results shows that the mean operative time was shorter for laser group (35.7±3.2 min) in comparison to pneumatic group (50.2±5.3 min). These results are inconsistent with results reported by Jeon et al., 2005; Rozzaghi et al., 2013 and Rozzaghi et al., 2011 [3] [19] [20]. These findings could be best explained by the fact that in pneumatic lithotripsy the time for stone fragmentation into removable size may be shorter than holmium: YAG lithotripsy, however, the operator has to manipulate the ureteroscope to hunt for moving stones and hence needs more time. Furthermore, pneumatic lithotripsy fragment calculi into multiple chunks that need to be basketed and removed [3]. In contrary, holmium: YAG lithotripsy vaporizes and de bulks the stone until one or only a few fragments remain which may be basketed easily [3]. In our study, majority of patients in the laser group stayed in hospital less than (24 hours) (37 patients 74%) in comparison to only 18 patients in the pneumatic group (36%) a finding was statistically significant ($p < 0.002$). This is in agreement with studies reported by Jeon et al., 2005; Rozzaghi et al., 2013 and Rozzaghi et al., 2011 [3]

[19] [20]. The shorter operative time required in laser lithotripsy, less expected complications, higher immediate stone free rate, may all contribute to the fact that majority of patients in the laser group needed less hospitalization. In the present study, the immediate stone free rate of holmium: YAG laser lithotripsy was superior to that of pneumatic lithotripsy (86% VS 64%) respectively. While this result was in disagreement with a study conducted by Bhandri & Basnet, 2011 in which figures of (92% VS 94%) for laser and pneumatic lithotripsy was reported respectively [21]. The underlying mechanism of stone fragmentation inlaser lithotripters in which most calculi can be fragmented into either extractable fragments or into small sand-like particles which don't require removal is the main cause of this superiority in the immediate stone free rate in comparison to the pneumatic lithotripters [22]. Noticeably, however, we reported a lower immediate stone free rate for both laser and pneumatic group in comparison to other studies [20]-[22]. In the current study, upward migration of Stones occurred in five patients (16%) in pneumatic group. While, there was only two patients (4%) with upward stone migration in laser group. A finding was statistically significant ($p = 0.045$). This finding was reported by other researchers in which retrograde stone migration occurred in 10% of pneumatic group and in 6% of laser group [21]. This could be explained by the different mechanism of lithotripter that could affect the rate of stone migration and constitutes the mechanism of failure in ureteroscopic lithotripsy. In lithoclast lithotripsy calculi are fragmented with a mechanism similar to that of pneumatic jackhammer While the mechanism of holmium: YAG energy which heats the stones to a critical thermal threshold at which the stone composition is altered yielding a stone crater and small fragments. Therefore undesired upward migration of stones or fragments can be minimized [23] [24]. Moreover, to minimize unwanted upward migration, in majority of our cases we have applied energy in a single pulse as we observed that it was more powerful in breaking stones and more helpful in preventing the stones from going upwards into the kidneys. In addition, we tried to elevate head end of the table to prevent stone up-migration. . In term of complications, such as, mucosal injury, ureteral perforation and postoperative fever, there was no statistically significance difference between the two groups ($p = 0.543$, $p = 0.078$, $p = 0.238$) respectively. This in accordance with results reported by Razhahe, 2011 and Bhandari & Basnet, 2011 [20] [21]. While hematuria was found more frequently in the pneumatic group patients (16%) in comparison to laser group patients (4%), a finding was statistically significant ($p = 0.045$). On the other hand, the overall complications rate between the two groups was statistically significant (10.0% VS 36.0%) in laser and pneumatic group respectively $p = 0.0.002$. This finding is in agreement with result reported by Joen et al., 2005 and Tipu et al., 2007 [10] [25]. Lithoclast lithotripsy fragmented calculi into more fragments than holmium: YAG laser lithotripsy. The increased number of fragments, basketing and manipulation of ureteroscopy seemed to increase mucosal injury, bleeding and impaired vision especially in the case of stone impaction [26]. Even though holmium: YAG fiber tips should be kept in contact with the stone and off the mucosa with the aid of tracer light [27]. The depth of thermal injury to the urothelium is only (0.5 - 1) mm [28] and this explains no incidence of perforation of the ureter with laser lithotripsy (0.0%) compared with pneumatic lithotripsy group (6.0%).

Conclusions

Holmium: YAG laser lithotripsy was associated with shorter operation time and postoperative hospitalization period. We believe that Holmium: YAG laser lithotripsy is an excellent treatment modality for managing ureteral calculi in central Rajasthan where stone formation rate is quite high. Drawback of holmium laser lithotripsy is its cost and maintainance.

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