Original Research Article

Semi-rigid Ureteroscopy and Pneumatic Lithotripsy for upper ureteric stones

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Abstract

Background: The urinary stone disease is the 3rd highest among all urinary problems. These stones may grow and enlarge in the kidney or may enter into the ureter.
Objective: This study aimed to know the Outcome of semi-rigid Ureteroscopy with Pneumatic Lithotripsy in Upper Ureteric Stones and to study the stone-free rate, complications, cause of failure of the procedure, rate of retro propulsion into the kidney and rate for conversion to PCNL/ESWL.
Materials and methods: This was a prospective observational study of 100 Patients who came with upper ureteric stones to our institute. They were subjected to semi-rigid ureteroscopy and pneumatic lithotripsy over two years after inclusion and exclusion criteria. Ureterolithotripsy was performed with a 6/7.5 Fr semi-rigid ureteroscope (Richard Wolf) and the Swiss lithoclast (Electro Medical Systems, Switzerland) using single or multiple fires to break the stone into small pieces.
Results: Division by the stone size, Group 1 with stone size 6-14 mm and group 2 with stone size 15-20 mm. 57 (89%) patients in group 1 were cleared of stone out of 64 patients, while only 24 (66.7%) patients in group 2 were cleared of stone out of 36 patients with statistical significance. Another division is by the location of the stone, Group 1 with stone located at or below the level of the transverse process of the third lumbar vertebra (≤L3) and group 2 with stone located above the level of the transverse process of the third lumbar vertebra (>L3). 42 (97.7%) patients with stone located ≤L3 were cleared of stone out of a total of 43 patients, while 39 (68.4%) patients with stone located >L3 were cleared of stone out of a total of 57 patients with statistically significance. The mean duration of surgery in 81 patients who were cleared of stones was 30.56 ± 12.25 minutes. Mean duration (minutes) to clear the stone in group 1 (stone size 6-14mm) was 27.81±11.06 while in group

2(stone size 15-25 mm) was 37.08 ± 12.68. The mean duration (minutes) to clear the stone present at or below the level of the transverse process of the third lumbar vertebra (≤L3) was 26.43 ± 10.89 while >L3 was 35 ± 12.19 with statistically significance. Retropropulsion was noted in 9% of the patients. Another causes of failure were narrow ureter (3%), ureteric avulsion (1%), retained stone (4%) and kinked ureter (2%). Patient with ureteric avulsion was subjected to open repair with stone removal and stenting.

Conclusion: Semi-rigid ureteroscopy with pneumatic lithotripsy is a safe and effective modality to manage upper ureteric stones. The overall stone clearance rate is good. Stone clearance rate and duration of surgery can be predicted from stone size and location. The complication rate is very low, <5%.

Key words

Ureteroscopy, Pneumatic, Lithotripsy, Ureter.

Introduction

The urinary stone disease is the 3rd highest among all urinary problems [1]. These stones may grow and enlarge in the kidney or may enter into the ureter. The spontaneous passage of stones is 68% in patients with stone size less than 5mm, and spontaneous passage is very low (5%) when the stone size is more than 6mm. When the size of the stone in the ureter becomes more than 6-7 mm, it needs active manipulation for the stone removal [2]. According to the site, size and other factors, many treatment options are there for the removal of the stone from the ureter like conservative, Extracorporeal Shock Wave Lithotripsy (ESWL), stone fragmentation through antegrade or retrograde Ureteroscopy (URS), Laparoscopic and open Ureterolithotomy [3, 4].

Ureteroscopy (URS) has traditionally constituted the favoured surgical treatment of mid and distal ureteral stones, while ESWL has been preferred for the less accessible proximal ureteral stones. The EAU Ureteral Stones Guideline Panel reported that the stone-free rate for ESWL and ureteroscopy (URS) when treating upper ureteral stones is around 81%. The rate of clearance for stones >10 mm decreases to 68% and 79% if they were treated by ESWL and URS, respectively.

With the development of smaller calibre semi-rigid and flexible ureteroscopes and the introduction of improved instrumentation, developing the holmium: YAG laser, URS has evolved into a safer and more effective modality for treating stones in the all locations in the ureter with increasing experience worldwide [5, 6]. Complication like ureteric perforation have been reduced to less than 5%, and long-term complications such as stricture formation occur with an incidence of less than 2%. Overall stone-free rates are remarkably high at 81% to 94% depending on stone location, with the majority of patients rendered stone-free in a single procedure. Moreover, impacted ureteral calculi are more challenging to fragment with ESWL because of the lack of expansion space for the stones in the ureter. This leads to better management by ureteroscopy [7-9]. Advances in endoscope design and the institution of intracorporeal lithotripsy devices such as the Swiss lithoclast and Holmium: YAG laser made the treatment of any ureteral stone easier [10].

Pneumatic lithotripter (Swiss Lithoclast) is simple to use, no disposable parts, economic and has no thermal sequelae [11]. So In this study, we evaluated the stone-free rate, safety, morbidity, feasibility and complications of semi-rigid ureteroscopy with pneumatic lithotripsy in treating upper ureteric stones.

Objective

The objective of this study as to know the Outcome of semi-rigid Ureteroscopy with

Pneumatic Lithotripsy in Upper Ureter Stones and to study the stone-free rate, complications during the procedure, cause of failure of the procedure, study the rate of retro propulsion into the kidney, rate for conversion to PCNL/ESWL, postoperative Complications

Materials and methods

This was a prospective observational study of 100 Patients who came with upper ureter stones to our institute.

They were subjected to semi-rigid ureteroscopy and pneumatic lithotripsy over two years. Inclusion Criteria were Stone size 6 mm - 20 mm, Stones in upper ureter, No associated renal stone, Patients of 16 years or above age, Hemodynamically stable patients. Exclusion criteria were Coagulopathies, Very high-risk patients (co-morbidities like a severe cardiopulmonary disease), Patients with calculus <6mm and >25 mm (largest diameter), Associated renal stone requiring removal, bilateral stone or recurrent ureteric stone cases, Pediatric patients < 16 years age, Pregnant patients.

Methodology

Informed written consent of all patients of upper ureter stones planned for URSL was taken before being made part of the study. The size of the stone was calculated by calibrated computer software on CT KUB. All patients had undergone hematological, biochemical and urine examinations preoperatively. All patients were given prophylactic antibiotics (Cefaperazone + sulbactam 1.5 gm IV stat) 30 minutes before the procedure. After spinal anesthesia, the patient was placed in the lithotomy position. After confirming the side of the stone on CT KUB, a 6/7.5 Fr semi-rigid ureteroscope (Richard Wolf) was introduced into the ureter transurethrally depending upon the calibre of the ureter and ease of passing the scope under the guidance of a 150 cm, 0.038-inch flexible guide wire. Pneumatic lithotripsy (PL) was performed with the Swiss lithoclast (Electro Medical Systems, Switzerland) using single or multiple fires to break the stone into small pieces. Pieces were removed with forceps or dormia basket. A high chance of retro propulsion was suspected; Dormia basket held the stone in position during lithotripsy. A 5Fr DJ stent was placed after the procedure in every case, followed by catheterization. Postoperatively, patients were managed with intravenous antibiotics, analgesics and intravenous fluids in the ward.

Check ultrasonography and plain X-ray KUB was done in all the patients on the second postoperative day to look for any residual stone. Foleys catheter was removed the following day. The double-J internal stent was removed after four weeks. A standard Proforma was assigned for every patient and filled during the hospital stay and on subsequent follow-up. Patients were discharged on the third postoperative day, given uneventful recovery.

To check for complications during the hospital course, the investigator individually reviewed patients daily. While after discharge, the patient was called on the 10^{th} day of discharge and a check X-ray KUB and USG KUB was done to see stone clearance in patients with residual stone. Stone size, location, duration of surgery, clearance of stone, intraoperative complications (mucosal injury, ureter perforation, ureter avulsion, hematuria), use of any additional instrument like Dormia basket, causes of failure of procedure like retro propulsion, retained stone, need for an alternative procedure like ESWL/PCNL were recorded.

Results

The youngest patient in the series being 18 years old and the oldest being 66 years old. It was observed that the majority (73%) of the patients belonged to the 3^{rd} and 4^{th} decade of life (**Table – 1**).

The male to female ratio understudy was 2:1. 53 (79%) male patients were cleared of stone out of 67 male patients under study, while 28 (84%)

female patients were cleared of stone out of 33 female patients under study. Although a slightly higher clearance rate was observed in female patients, no significant difference was found (p = 0.245) (**Table – 2**).

Table - 1: Age and gender distribution.

Age in years	Female	Male
0-20	1	2
21-30	12	19
31-40	14	28
41-50	4	13
51-60	1	5
61 and above	1	0
Total	33	67

43 (81%) patients with right side upper ureter stone were cleared of stone out of a total of 53 cases of suitable side stone, while 38 (80.8%) patients with left side upper ureter stone were cleared of stone out of total 47 cases of left side stone. No statistically significant difference was found in stone clearance concerning side operated. (p=0.484).

We divided the patients into two groups according to the stone size operated. Group 1 with stone size 6-14mm and group 2 with stone size 15-20 mm. 57 (89%) patients in group 1 were cleared of stone out of 64 patients, while only 24 (66.7%) patients in group 2 were cleared of stone out of 36 patients. A significantly higher stone clearance rate was noted in group 1 than group 2 (p=0.003) (**Table – 3**).

Table - 2: Gender vs stone clearance.

	Total	Cleared	Not cleared	p- value	Remark
Male	67	53(79%)	14	0.245	Not significant
Female	33	28(84%)	5		

Table - 3: Stone size vs stone clearance.

	Total	Cleared	Not cleared	p-value	Remark
Group 1 (6 mm - 14 mm)	64	57(89%)	7		
Group 2 (15 mm – 20 mm)	36	24(66.7%)	12	0.003	Significant

Table - 4: Stone location vs stone clearance.

	Total	Cleared	Not cleared	p-value	Remark
≤L3	43	42	1		
>L3	57	39	18	0.0001	Significant

Table - 5: Duration of surgery vs stone size and location.

Character		Mean duration in minutes	Standard Deviation	p-value	Remarks
Stone size	6-14 mm	27.81	11.06		
	15-25 mm	37.08	12.68	0.007	Significant
Location	≤L3	26.43	10.89		
	>L3	35	12.19	0.006	Significant

We divided the patients into two groups according to stone location. Group 1 with stone located at or below the level of the transverse process of the third lumbar vertebra (≤L3) and group 2 with stone located above the level of the transverse process of the third lumbar vertebra (>L3). 42 (97.7%) patients with stone located ≤L3 were cleared of stone out of a total of 43 patients, while 39(68.4%) patients with stone located >L3 were cleared of stone out of a total of 57 patients. We found a significantly higher

stone clearance rate ≤L3 as compare to >L3 (p=0.0001) (**Table – 4**).

The mean duration of surgery in 81 patients who were cleared of stones was 30.56 ± 12.25 minutes. Mean duration (minutes) to clear the stone in group 1 (stone size 6-14 mm) was 27.81±11.06 while in group 2 (stone size 15-25 mm) was 37.08 ± 12.68. The mean duration (minutes) to clear the stone present at or below the level of the transverse process of the third lumbar vertebra (≤L3) was 26.43 ± 10.89 while >L3 was 35 ± 12.19. We found a significantly higher time to clear the stone in group 1(stone size 15-25 mm) and if the stone is located >L3 (**Table – 5**).

Table - 6: Causes of failure of procedure.

Cause of failure	No. of cases	Percentage	Additional procedure: Cases
Retropropulsion	9	9%	ESWL/PCNL : 3/6
Narrow ureter	3	3%	ESWL/PCNL:1/2
Kinked ureter	2	2%	PCNL
Ureteric avulsion	1	1%	OPEN REPAIR
Residual stone	4	4%	ESWL

Failure of the procedure was noted in 19% of the cases due to various causes. Failure was considered if a patient needed additional procedure (like ESWL or PCNL) in the same sitting to clear the stone or large residual fragments (>4 mm) not cleared in follow up period and needed additional procedure. The most common cause was retro propulsion. Retropropulsion was noted in 9% of the patients. Another causes of failure were narrow ureter (3%), ureteric avulsion (1%), retained stone (4%) and kinked ureter (2%). Patient with ureteric avulsion was subjected to open repair with stone removal and stenting. At the same time, all others were subjected to either ESWL or PCNL depending on stone size and feasibility of clearance (**Table – 6**).

Table - 7: Complications of procedure.

Complication	% of patients
Ureter avulsion	1
Ureter perforation	1
Mucosal avulsion	1
Mild fever	3
Sepsis	0
Significant hematuria	0
Blood transfusion	0

Major Complications were noted in 3% of patients. Ueteric avulsion, mucosal avulsion and ureter perforation were noted in 1% each. Mild fever was reported in 3% of patients, relieved during hospital stay without any profound Sepsis. Mild hematuria was present in all cases, but significant hematuria requiring blood transfusion or termination of procedure was not seen in any of the patients. No blood transfusion was given to any patient (**Table – 7**).

Discussion

Ureteroscopy (URS) with pneumatic lithotripsy was developed in 1990 and was reported to be the most effective procedure to treat ureteral stones. URS is a safe method, particularly in the presence of calculus obstruction or non-opaque stones [12].

It is established that pneumatic lithotripter has merits of safety and cost-effectiveness. Pneumatic lithotripter is very effective on all stone composition, including calcium oxalate monohydrate and cystine stones [13], and it is rarely traumatic to tissue and has a low complication rate. Ikram Ullah, et al. reported a stone-free rate of 72.72% in 22 cases of upper ureter stone. They noticed a 27.27% retro propulsion rate [14]. They did not use any stone trapping device to reduce the retro propulsion rate. At the same time, we noticed only a 9 % retro propulsion rate, and we used basket in 13%

of cases to reduce the risk of retro propulsion. Stone retro propulsion during the breakdown of upper ureteral calculi can occur even when using Holmium laser. In a study of 208 cases of ureteral stones, 55 of them in the upper ureter, Gupta, et al. reported a 3.3% failure rate due to retro propulsion using Holmium laser [15].

Fasihuddin Q, et al. treated 125 patients with ureteroscopy. There was technical failure to negotiate through the ureteric orifice in 6.1% of the patients. The overall stone clearance rate at all locations in the ureter was 93.8% [16]. In our study, failure to negotiate the ureter was found in 10% of cases. The most common cause was narrow ureter (8%). These 5% were cleared off in the second sitting after double J stenting to dilate the ureter for two weeks. In 3% while trying to stent the ureter, the stone was pushed back into the kidney, so the stone was cleared by the alternative procedure in the same sitting. In 2%, there was a kink in the ureter, which didn't allow to reach up to stone by ureteroscope so push back PCNL was done.

Harbans et al. noticed a stone fragmentation rate of 83.93% while a stone-free rate of 71.4%. They had a ureteric perforation rate of 2% [177]. Rajpar, et al. studied 30 cases and found a stone-free rate of 86.7% [18]. Bapat SS, et al. noticed a success rate of 86.01% with a ureter perforation rate of 4% [19]. In our study overall success rate achieved was 81%. However, the success rate was slightly lower than that reported in previous studies but is comparable.

In our study, the stone-free rate in female patients was slightly more than that in male patients; this is due to the short female urethra, hence the easiness of introducing the ureteroscope and access to the stones, especially those high up in the upper ureter near the ureteropelvic junction.

Khaled Mursi, et al. found a success rate of 85%. They found more failure in stone size >15mm and stone located close to renal pelvis [20]. YK Hong studied 61 cases of upper ureter stone. They had an 80.3% success rate and failure in 19.7%. They reported stone migration in 16.4%, ureter perforation in 4.9% and gross hematuria in 11.4%. They found a stone-free rate of 90.9% in female while 74.4% in male but no statistically significant difference. They found decrease in stone clearance with increasing stone size (100% in <5 mm, 89.5% in 5-10 mm, 61.9% in >10 mm) [22].

Table - 8: Comparison of previous studies with our study.

Study	Clearance rate	Complications
Harbans Singh [18]	71.4%	Ureter perforation 2%
Tunc L [23]	SFR 60%, Fragmentation rate 84%	Retropropulsion 7.1%, Sepsis 4.5%, Perforation 1.3%
Bapat SS [20]	86.01%	Perforation 4%
Hong YK [22]	80.3%	Ureter perforation 4.9%
Ikram Ullah [24]	72.72%	Retropropulsion 27.27%
M Khalid [25]	85%, More failure if stone size >15 mm and location near renal pelvis	Mucosal injury 7.3% Retropropulsion 7.4%
Ihsanullah Khan [26]	92.8%	Retropropulsion 4% Sepsis 2%
Our study (2018-2020)	81%, Single stage clearance 76%, <15 mm - 89%, >15 mm - 66.7%, <L3-97.7%, >L3-68.4%	Ureter avulsion 1% Mucosal injury 1% Ureter perforation 1% Retopropulsion 14%

In our study we noticed comparatively more clearance rate in stone size <15mm (89%) than >15 mm (66.7%) size and comparatively more clearance in stone located ≤L3 (97.7%) than >L3 (68.4%).

Complication rates, notably ureteric perforation rates, have been reduced to less than 5%, and long-term complications such as ureteric stricture formation occur with an incidence of 2% or less. In our study, we found a complication rate of 3%. Ureter avulsion occurred in 1 patient who needed open repair. 2 cases of ureter perforation and mucosal avulsion was managed with a double J stent. No stricture was noted during follow up of these patients.

Comparative studies with our study are mentioned in **Table - 8**.

Conclusion

Semi-rigid ureteroscopy with pneumatic lithotripsy is a safe and effective modality to manage upper ureter stones. The overall stone clearance rate is good. Stone clearance rate and duration of surgery can be predicted from stone size and location. The complication rate is very low, <5%. The only disadvantage of retro propulsion can be overcome by using stone trapping devices like dormia basket or stone cone.

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