Research Article

Semi-rigid Ureteroscopy in Children Using Pneumatic Lithotripsy: Safety and Efficacy

Hosam M. Mahmoud, Ahmed Z. Mohamed, Ahmed H. Abd-elgawad, and Ehab R. Tawfiek.
Department of Urology, Faculty of Medicine, Minia University.

Abstract
Introduction: The first-line treatment of ureteric stones is done using (URS) and (ESWL). Pneumatic, electro-hydraulic, ultrasonic, and laser devices have been used for URS treatment . Small caliber ureteroscopes with laser lithotripsy are the traditional management for pediatric ureteral stones and have provided a more safe management with lower complication rates. **Aim of the work:** The aim of our study was to demonstrate the safety and efficacy of pneumatic lithotripsy in the management of ureteral stones in pediatric cases. **Patients and Methods:** Our prospective clinical study at Nephrology and Urology Minia University Hospital, involved semi-rigid ureteroscopy using pneumatic lithotripsy in 20 child with ureteric stones. All children (2-16 years old) attended at our outpatient clinic diagnosed with ureteric stones (< 15 mm in size) and indicated for surgery underwent URS. Upper ureteric stones will excluded in our study. **Results**: In the current research, the outcome of 20 children underwent ureteroscopy with the use of a semirigid ureteroscope for middle and lower ureteric stones have been described. Our stone-free rate was 90%, all the complications were noted in our study at the start. We have not experienced any case of ureteral avulsion, there had been a single case of intraoperative ureteric perforation with extravasation. Regarding post-operative residual hydronephrosis , in our study 70 % of cases had no postoperative hydronephrosis on 1-month follow up US, while 100% of cases showed no hydronephrosis on 3-6 month follow up.
Key Words: URS: ureteroscopy, ESWL: extracorporeal shock wave lithotripsy.

Introduction
Pediatric urolithiasis with an overall incidence of around 2-3% is relatively rare. Excluding the endemic areas, ureteric stones constitute a small proportion of the overall stone load. (Schwarz and Dwyer, 2006)

Pediatric stones constitute 1-5% of all urinary system stones in developed countries, and their incidence is approximately 30% in developing countries. (HULBERT et al., 1985). The first-line treatment of ureteric stones is done using ureteroscopy (URS) and extracorporeal shock wave lithotripsy (ESWL). (El-Assmy et al., 2006).

Pneumatic, electro-hydraulic, ultrasonic, and laser devices have been used for URS treatment. Small caliber ureteroscopes with laser lithotripsy are the traditional management for pediatric ureteral stones and have provided a more safe management with lower complication rates . (Koura et al., 2007, Bapat et al., 2007).

Patients and Methods
Study Design:
Our study was prospective clinical study at Nephrology and Urology Minia University Hospital, involving semi-rigid ureteroscopy using pneumatic lithotripsy in 20 child with ureteric stones.

Study population:
All children diagnosed with ureteric stones attended at our outpatient clinic of Urology department at Minia university, Nephrology and Urology hospital and needed surgery for ureteral stones with upper and lower urinary tract symptoms.

Inclusion criteria:
a- Children at age between 2-16years with symptomatic ureteric stones and indicated for surgical intervention.
b- Middle and lower third ureteric stones.
c- The size of ureteral calculi is equal to or smaller than 15 mm.

Exclusion criteria:

a. Upper third ureteric stones.
b. Stones larger than 15 mm.
c. Associated ureteral congenital anomalies.
d. Children younger than 2 years old.

Methodology

Patients were assessed on the baseline of complete ureteric stone diagnosis, evaluation of prior management lines if present, confirmation of surgical indication and fitness for surgery, and a consent was signed by the parent explaining potential outcome and possible complications of the procedure for all children, then admitted patients were assigned to certain hospital number.

***All patients were evaluated at baseline as follows*:**

- **Personal history**: including age, sex, family history.
- **Medical history**: detailed medical history with a special emphasis on lower urinary tract symptoms (LUTS) and loin pain, pervious medical treatment if present.
- **Surgical history**: whether open or endoscopic surgery.
- **Metabolic workup**: in children with recurrent ,or multiple stones.
- **Physical examination**; general and local abdominal examination for size of urethral meatus, size of the penis, palpable abdominal swelling, scars and evaluation of the spine for dimples or other defects.
- **Laboratory investigation**: Urine analysis, urine culture, complete blood count (CBC), Renal function tests, coagulation profile
- **Imaging**: Pelvi-abdominal ultrasound, Plain X-ray K.U.B, CT KUB, IVU (if needed)

❖ ***Surgical technique:***

All the endoscopies were done in dorsal lithotomy position under general anesthesia and all cases received routine preoperative antibiotic prophylaxis.

All cases underwent initial cystoscopy using 11 F pediatric cystoscope to insert guidewire to the kidney or up to the impacted stone.
Ureteroscopy was performed with a 9 F (Karl Storz semirigid ureteroscope).

The ureteroscope was inserted into urethra, avoiding injury to the penile urethra. Uretero-vesical junction (UVJ) dilatation was avoided in all cases.

We used 8FR Karl Storz semi-rigid ureteroscope for entry into the UVJ and raised irrigation pressure to open the intra-mural ureter, this was assisted by a safety guide wire, and we could turn the ureteroscope 90–180° so that the scope beak could easily pass through the ureteric orifice. The ureteroscope was advanced with fine movement of the surgeon's hand through the ureter.
The stones were scattered using a single or continuous end-fire probe with a pneumatic lithotripter (BOSTON SCIENTIFIC EMS Microvasive Swiss Lithoclast). Air pressure and pneumatic lithotripter frequency were set at 3 bars and 12 Hz, respectively, during procedure.

The process of fragmentation continued until all stones were broken to particles of 2-3 mm. Stone extraction tools were not used . In all cases, ureteric stents were routinely used after procedure, choosing stent depending on the degree of manipulation throughout ureteroscopy or the presence of considerable residual ureteric fragments. One Patients had a ureteric catheter attached to a Foley catheter that was removed after 48 hours, while other 19 patients had JJ stents inserted that were removed within 4 weeks.
During the operation, temperature was monitored regularly and precautions were taken to avoid hypothermia through the use of blanket and pre-warm irrigation fluid.

❖ **All patients were assessed during post-operative period as follows**:

- The patients were followed postoperatively for any complications as urinary tract infection, fever, or pain.
- Patients who did not develop any immediate post-procedure complications were discharged after 24 h of monitoring and after doing plain X-Ray KUB film to exclude the presence of residual fragments and to check the position of the ureteric stent.
- after 48h non self-retaining ureteric catheters were removed .
- Within 2- 4 weeks after the procedure the JJ stents were removed.

All patients were evaluated 1, 3, and 6 months postoperatively by, plain X-ray KUB, US, CT KUB (if needed). IVU was done in 2 cases at a mean of 3.8 months after treatment and VCUG was done in 2 cases at a mean of 3.8 months after treatment.

Results

Total number of children cases was 20 child who had ureteric stones and included in our study. All cases had ureteroscopy and litho-tripsy using a pneumatic lithotripter. Mean of patient age is 8.4 ± 3.59 years, ranged from 2-15 years with range 13 years**. (Table 1)**

About 95% of cases had stone in lower third ureter, Most of cases 80% had solitary stone. Stone size in half of cases was 0.5-1 cm. Regarding laterality 55% of stones were left sided vs. 45% in right side. **(Table 2)**

Table (1): age of children in the study group:

	Mean ± SD	Minimum	Maximum	Range
Age (years)	8.4 ± 3.59	2	15	13

Table (2) :Stone characteristics in study group:

Variable	Value N (%) T=20 (100%)
Stone site	
Middle third	1 (5%)
Lower third	19 (95%)
Stone number	
Solitary	16 (80%)
multiple	4 (20%)
Stone size	
<0.5 cm	1 (5%)
0.5-1cm	10 (50%)
1-1.5 cm	9 (45%)
Stone laterality	
Right	9 (45%)
Left	11 (55%)

25% of cases had postoperative fever, two cases 10% had post-operative residual stones. 30% of cases had postoperative renal colic. 15% of cases had postoperative hematuria and 5% had postoperative UTI .The difference is statistically significant. **(table 3)**

Table (3): Postoperative data for all cases:

Complication	Incidence, Total=20(100%)		
	Yes	No	Significance
Post-operative fever	5(25%)	15(75%)	P=0.002* Z=3.16
Post-operative residual stones	2(10%)	18 (90%)	P=0.0001* Z=5.69
Postoperative renal colic	6(30%)	14(70%)	P=0.01* Z=2.53
Postoperative transient hematuria	3(15%)	17(85%)	P=0.0001* Z=4.43
Postoperative UTI	1(5%)	19(95%)	P=0.0001* Z=4.43

In our study about 22.2% of patients with stone size > 1 cm had post-opeartive residual stones . While 8.3 of patients had residual stones when the stone density was between 400-100 HU . **(Table 4)**

Table (4): Univariate analysis showing relation between postoperative residual stones and different variables.

	Post-operative residual stones			Significance
	Yes	No	Total	
Sex				
Male	1(12.5%)	7(87.5%)	8(100%)	**P =0.21**
Female	0(0%)	12(100%)	12(100%)	**$\chi 2$ =1.58**
Stone site				
Middle third	0(0%)	1(100%)	1(100%)	**P =0.81**
Lower third	1(5.3%)	18(94.7%)	19(100%)	**$\chi 2$ =0.06**
Stone size				
Less than 0.5 cm	0(0%)	1(100%)	1(100%)	**P =0.53**
0.5-1 cm	0(0%)	10(100%)	10(100%)	**$\chi 2$ =1.29**
1-1.5 cm	2(22.2%)	7(77.8%)	9(100%)	
Stone number				
Solitary	1(6.3%)	15(93.8%)	16(100%)	**P =0.61**
Multiple	0(0%)	4(100%)	4(100%)	**$\chi 2$ =0.26**
Stone laterality				
Right	1(11.1%)	8(88.9%)	9(100%)	**P =0.26**
Left	0(0%)	11(100%)	11(100%)	**$\chi 2$ =1.29**
Stone density				
<400 HU	1(16.7%)	5(83.3%)	6(100%)	**P =0.76**
400-1000HU	1(8.3%)	11(91.7%)	12(100%)	**$\chi 2$ =0.56**
>1000HU	0(0%)	2(100%)	2(100%)	
Degree of hydronephrosis				
Minimal	0(0%)	1(100%)	1(100%)	
Mild	3(37.5%)	5(62.5%)	8(100%)	**P =0.64**
Moderate	2(22.2%)	7(77.8%)	9(100%)	**$\chi 2$ =1.7**
Severe	0(0%)	2(100%)	2(100%)	
Post-operative residual hydronephrosis				
No hydronephrosis	1(7.1%)	13(92.9%)	14(100%)	**P =0.51**
Minimal	1(25%)	3(75%)	4(100%)	**$\chi 2$ =1.35**
Mild	0(0%)	2(100%)	2(100%)	

Table (5): Preoperative and postoperative hydronephrosis:

	Preoperative hydronephrosis				Significance
	Minimal	Mild	Moderate	Severe	
No hydronephrosis	1(100%)	6(75%)	7(77.8%)	0(0%)	
Minimal	0(0%)	1(12.5%)	2(22.2%)	1(50%)	**P =0.3** **$\chi 2$ =7.23**
Mild	0(0%)	1(12.5%)	0(0%)	1(50%)	
Total	1(100%)	8(100%)	9(100%)	2(100%)	

70 % of cases had no postoperative hydronephrosis at one-month follow up .

Discussion

The lower rate of calcular disease in children, the higher clearance rate of post-shock wave lithotripsy and problem with the use of large ureteroscopes in small ureters have caused ureteroscopy for children stone disease to lag behind that of adults. (Gofrit et al., 2001)

Ureteroscopy has become a more appealing treatment choice for pediatric ureteric stones after development of small caliber semi-rigid ureteroscopes and auxiliary tools. The successful treatment of lower ureteric stones has increased its usefulness for managing of upper urinary tract stones.(Bassiri et al., 2002).

Abdominal pain (60%), followed by hematuria (30%), was the most common symptom in our research. In preschool age (less than six years) hematuria was most prevalent, while in elderly children, abdominal pain was more common. The distribution of symptoms in the age groups in Azili et al., (Azili et al., 2014), was UTI in 1–4 years age group, and abdominal pain in children 5–14 years.

Because of the availability of smaller endoscopic equipment and a wide variety of accessories (6.9 Fr semi-rigid ureteroscope), balloon dilation was not included in our study. After 3 months of follow-up, no cases had ureteric stricture. In 38 percent of 66 patients, Bassiri et al., (Bassiri et al., 2002) did dilatation and on 3 months follow-up there was no stenosis or stricture .

Erturhan et al., (Erturhan et al., 2007), which used a 9.5 Fr semi-rigid ureteroscope, reported a ureteral dilatation in 41% of their cases. In 70% of their cases, Smaldone et al., (Smaldone et al., 2007) reported ureteral dilatation; this high rate of ureteral dilatation was due to the large number of upper ureteric stones in their series (42 percent) and their stone and gravel removal policy after disintegration that was not done in our study; Lesani and Palmer (Lesani and Palmer, 2006), didn't do ureteral dilation and reported their successful pediatric ureteroscope.

The role in the current study was to avoid using extraction tools to clear as much as possible stone fragments, as it had many benefits. The first benefit is that the delicate pediatric urethra and ureter did not necessitate multiple entries. Secondly, although the stone was small, it was slightly larger than our expectations, so it may injure the ureter or the urethra during its removal. Third, multiple entries for the removal of gravels may render the visual field hematuric and unclear. The last benefit was that before the ureteroscopy there is no need for ureteric orifice dilatation, because we did not wish to remove all gravels.

In the current research, the outcome of 20 children underwent ureteroscopy with the use of a semirigid ureteroscope for middle and lower ureteric stones have been described. Our stone-free rate was 90%, comparable to data from 24 studies reviewed by Basiri et al., which recorded overall success rates of 93.2% (range, 81% – 100%) and 74.4% (range, 20% – 100%) for lower and upper ureteric stones, respectively. (Basiri et al., 2008).

Kurzrock and coworkers (Kurzrock et al., 1996) indicated that it was necessary to place a stent in all cases, with just 29% requiring it, and it was removed after a limited period of time. In all patients postoperatively, Thomas et al., (Thomas et al., 1993) placed ureteric stents. However, Herndon et al., (Herndon et al., 2006) reported that postoperative stents were not necessary in all patients, but only inserted in 17.6% of their cases. In the current study, ureteric stent insertion at the end of the operation has been our practice in all patients despite no ureteric orifice dilatation, complete fragmentation of stones, use of small caliber ureteroscope, no multiple ureteric entries and no ureteric trauma except in one case.

In the current research, stent insertion in children had resulted in discomfort (the "stent syndrome" of frequency, urgency, abdominal pain), but its placement was helpful in allowing stone fragments to pass and preventing ureteral obstruction. Stenting allows improved healing and relief of local edema, and avoids postoperative discomfort and potential secondary infectious complications.

One research also reported no intraoperative complications in their series; although, in one case they recorded early post-endoscopy

complications in the form of UTI, and in another case as stent migration, which required a second ureteroscopy for removal. (Straub et al., 2010). Another study. Reported a ureteral perforation rate of 1.4 percent in 221 pediatric cases underwent ureteroscopy for ureteral sone. (Fuchs and Yurkanin, 2003) Minevich et al., (Minevich et al., 2005) revealed no intra-operative complications but one patient developed a late postoperative ureteral stricture that was successfully endoscopically managed.

This was mainly because of the high ureteral balloon dilatation rate in their series, which was approximately 30%. Azili et al., reported a 4.2 per cent overall major complication rate (Azili et al., 2014). Bassiri et al., implemented an open reimplantation in 2 cases with severe ureterovesical damage, and another for a case with ureteric stenosis. They reported the risk factors for developing stricture being an impacted stone, ureteral perforation, and large sized instrumentation causing mucosal damage. Many of the early postoperative complications were naturally due to infections. In the research the reported incidence of pyelonephritis was 0-4%. (Bassiri et al., 2002)

All the complications were noted in our study at the start. We have not experienced any case of ureteral avulsion, there has been a single case of intraoperative ureteric perforation with extravasation. The stone was impacted at that case, and it has been managed by cessation of disintegration and stent placement.

On the day following operation patient developed fever and transient hematuria that was managed conservatively, after 1 month a secondary URS was done for residual stone on follow up US after 3 months from stent removal there was no residual hydronephrosis and no residual stones on KUB film.

In cuurent series there were five cases with early postoperative fever and 3 cases with transient hematuria and all cases were managed conservatively. Also, there was only one case of urinary tract infection presented postoperatively by fever and high WBC count, and the case was manged conservatively. In our series there was no incidence of stent migration.

Regarding post-operative residual hydronephrosis, in our study 70% of cases had no postoperative hydronephrosis on 1-month follow up US. For those who had residual hydronephrosis 33% of them had preoperative severe hydronephrosis which became minimal and 33% showed residual stones and had secondary URS. 100% of cases showed no hydronephrosis on 3-6 month follow up. Ascending cystogram was done for 2 cases and revealed no Vesico-ureteric reflux, while IVU was done for 2 cases and showed no ureteric stricture.

Conclusion & Recommendation

1. Ureteroscopic lithotripsy is a reasonably practical and efficient for ureteric calculi clearance in children.
2. Prior to ureteroscopy, preoperative stenting is not required in all cases and must be case-specific.
3. Semi-rigid ureteroscopy and pneumatic lithotripsy are safe and effective methods when performed by skilled hands without ureteric dilation.
4. In current series the stone free rate after one session of semi-rigid URS was 90%.

So, we recommend The use of laser lithotripter, flexible and smaller caliber scopes which will make ureteroscopy in pediatrics faster and more effective.

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