

Outcome, Efficacy and Safety of Ureteroscopic Pneumatic Lithotripsy In Management of Lower and Mid Ureteric Calculi

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الخلاصة

الهدف من الدراسة:

لتحديد كفاءة وامن جهاز تكسير الحصى الهوائي لعلاج الحصى في المنطقة الوسطى والسفلى من الحالب.

الطريقة:

شملت الدراسة 100 مريض مصاب بحصى في الحالب تم علاجهم بجهاز تكسير الحصى الهوائي خلال سنة واحدة من عام 2014 ولغاية عام 2015 في مستشفى الديوانية التعليمي. كانت الحصى موجودة في منتصف الحالب لدى 25 مريضا وفي اسفل الحالب لدى 75 مريضا.

تم تعريف معدل النجاح باختفاء الاعراض وعدم وجود بقايا حصى صغيرة اكبر من 2 ملمترا.

التخدير العام استخدم لجميع المرضى

النتائج:

معدل النجاح كان 90% بالمئة, معدل النجاح في حصى منتصف واسفل الحالب كان 82 و 92 بالمئه على التوالي. في سنة من المرضى تحركت الحصى الى داخل الكلية واخضع المريض بعد ذلك الى تفتيت الحصى باستخدام الموجات الصدمية, تم ملاحظة المضاعفات في 11 بالمئه من الحالات وتم علاجها تحفظيا. فترة الرقود في المستشفى كانت من 24 الى 48 ساعة.

الاستنتاج:

جهاز التفتيت الهوائي هو طريقه موثوقة وعالية الفعالية, سريعة وامينة وغير مكلفه لعلاج حصى الحالب مع حدوث حالات مضاعفات بسيطة.

ABSTRACT:

OBJECTIVE: To determine the efficacy and safety of pneumatic lithotripsy in the treatment of mid and lower ureteric calculi.

DESIGN: prospective study.

DURATION: From 2014 to 2015

SETTING: Department of Urology, AL-Diwaniya teaching Hospital.

PATIENTS & METHODS:

Over a period of one year, one hundred (100) patients of ureteric stones were treated with pneumatic lithoclast. Twenty five (25) Stones were located in mid ureter, Seventy five (75) stones were located in lower ureter. Success rate was defined as symptom free, no residual stones larger than 2mm. General anesthesia was given to all patients.

RESULTS:

Over all success rate was 90%. Success rate in middle and lower ureteric stones were 82%, 92% respectively. Completely fragmented stones cleared spontaneously within two weeks in 95% of cases and all patients were free of stones one month after the procedure. In six (6) patients stone was migrated, later on submitted for ESWL and successful. Complications were encountered in 11% of cases and were managed conservatively.

Hospital stay was 24 to 48 hours.

CONCLUSION:

Pneumatic lithotripsy is reliable, highly effective rapid, safe and cost effective treatment modality for ureteric stones with negligible incidence of complications.

KEY WORDS: Ureteric Stone, Lithoclast, General Anaesthesia.

Introduction

Ureteroscopy was first described by Young and McKay in 1929 but not until the late 1970 as its clinical use demonstrated. Currently, advances in ureteroscope design, including fiber-optic visualization, flexibility and downsizing, and improvements in calculus fragmentation ability, balloon dilation, and various baskets, stents and wires, have broadened ureteroscopic diagnostic and therapeutic capabilities.⁽¹⁾

Dramatic advances in ureteroscopic design have occurred within the last decade. Smaller caliber flexible steerable ureteroscopes permit the endourologist to maneuver into previously inaccessible recesses of the collecting system.⁽²⁾

The indications for ureteroscopy fall into two categories; diagnostic and therapeutic. Diagnostic indications include evaluating a patient with a radiological filling defect, hematuria, or positive cytology of the upper tract, or surveillance of patients with upper tract malignancies that have been treated endoscopically. Therapeutic indications include removing upper tract stones or other foreign bodies, treating upper tract malignancies, or treating strictures or areas of obstruction.⁽³⁾

The Ureteric divisions are: the lower third of the ureter is the portion below the level at which the ureter crosses the bifurcation of the common iliac artery. The upper third of the ureter is usually taken to be that portion of the ureter lying above the sacro-iliac joint and the middle third is the portion between them. However, in the report from the 'Ureteral Stones Clinical Guidelines Panel' from the AUA, analysis of treatment outcomes was considered on the basis of the proximal and distal ureter, the proximal ureter that was taken to include the proximal and middle thirds as described above.⁽⁴⁾

Rigid ureteroscopes range from 4 F to 13.5 F at the tip and use channels for instruments and/or irrigation ranging from 2.3 F to 5.4 F. Advantages of the rigid scope includes the large working channel, greater durability, and excellent visualization. The disadvantages include its rigidity and size, which become apparent while trying to traverse the ureter over the pelvic brim.⁽³⁾

Four methods of intracorporeal lithotripsy are available. Stones can be disintegrated by ultrasound using a long thin rigid probe, but the inner diameter of the hollow probe to which suction is applied is small. Probes with an outer diameter of 2 F are available for electrohydraulic lithotripsy (EHL). A pneumatic lithotripter was introduced in 1992 and has proved popular and successful.⁽⁴⁾

In an experimental study, the safety of the Ho: YAG, CdL, EHL and pneumatic disintegrator were compared. The tip of each probe was positioned 0.5 mm from the ureteric wall and then discharged. The length of time before ureteric perforation occurred was recorded. The Ho: YAG perforated after 2 s, the EHL after 24 s, the CdL after 257 s and the pneumatic device had not perforated the wall after 6 min. The clinical implications of the study are very clear. Not only the ureteric wall was at risk but the distal lens of the ureteroscope was also more vulnerable to be damaged by Ho: YAG and EHL than from other intracorporeal lithotripters.⁽⁴⁾

There are many and various stone-retrieval devices; the baskets that are most commonly used are the flat-wire basket and the Nitinol tip-less basket. For retrieval of tissue, grasping forceps, cold-cup and alligator-toothed biopsy forceps, and retractable biopsy brushes are available.⁽³⁾

The goal of surgical management of ureteral calculi is to achieve complete stone clearance with minimal morbidity to the patient. Shock-wave lithotripsy, rigid and flexible ureteroscopes, powerful compact lithotrites, and new stone retrieval devices have greatly improved the urologist's ability to treat ureteral stones, regardless of size or location in the ureter. Most ureteral calculi are 4 mm or smaller and pass spontaneously, although not without discomfort and expense to the patient. ⁽⁵⁾

Ureteral calculi of any size are often associated with renal obstruction, and care must be taken to prevent irreversible damage to the kidney, whether choosing expectant or active treatment. The challenge facing the urologist treating upper tract urinary calculi is to select the optimal treatment modality based on the patient's stone characteristics.(i.e., to choose between the two most frequently used modalities in ureteral stone treatment—ESWL and ureteroscopy). ⁽⁵⁾

The indications for intervention in the management of ureteral calculi are intolerable/intractable symptoms, infection, obstruction, and a stone that is unlikely to pass spontaneously. ⁽⁵⁾

Ureteroscopy can be used to treat upper urinary calculi. Successful treatment depends on access to the stone and effective retrieval and/or fragmentation. Technical advances in the instruments used have been responsible for improving ease and success of ureteroscopic treatment. Small-diameter, rigid and flexible ureteroscopes can reach nearly any part of the ureter or intrarenal collecting system with relatively little need for dilation and with fewer traumas to the ureter than seen with earlier generations of endoscopes. The holmium laser capability of lithotripsy with an ablative effect removes stone volume and makes it particularly

effective through small-diameter endoscopes. ⁽⁶⁾

Placing a ureteric stent after ureteroscopy with stone extraction is a routine, to prevent possible stenosis or to decrease secondary pain caused by mucosal edema. A stent is routinely placed after ureteroscopic lithotripsy; if there are particular complications, a stent may be necessary to prevent late complications, e.g. ureteric stricture. However, routinely placing a stent to prevent late complications or to relieve flank pain from a ureteric stricture or mucosal edema after surgery is questionable. Indeed, stents may cause complications, e.g. haematuria, painful urination, urgency, flank pain, lower abdominal pain, bacteriuria, infection, or it may migrate; these symptoms can last for 3 days after removing the stent. Moreover, if a stent is placed for a long time it can cause stone formation or denudation of the stent. ⁽⁸⁾

PATIENTS AND METHODS

From October 2014 to October 2015, 100 patients (65 male and 35 female) with ureteral stones were admitted to Al-Diwaniya teaching hospital, urology unit and enrolled in this study, their age range from 20 to 60 years with a mean age of 39 ± 3 years.

All patients were evaluated by history, physical examination and laboratory investigation (including urinalysis, full blood count and renal function tests). The stone size, location, opacity and degree of obstruction were assessed by preoperative radiographic imaging studies, including KUB, ultrasound and computerized tomography (CT scan).

For all patients treatment was by intracorporeal lithotripsy with pneumatic lithoclast through a semirigid ureteroscope. This treatment option chosen either from the beginning (for stones more than 7mm

in size) or after failure of expectant treatment.

Active UTI treated with broad spectrum antibiotics preoperatively. Preliminary JJ stent insertion was needed in 10 patients in whom the ureter was difficult to be negotiated because of narrow orifice and URS was done 2 weeks later.

A morning KUB was obtained in all patients. All patients received single preoperative broad spectrum parenteral antibiotic at the time of induction of anesthesia. All the patients were operated under general anesthesia, in lithotomy position.

Our equipment was basically the Swiss lithoclast, and 9.5 F semirigid ureteroscope with 5mm working channel, 6⁰ lens and with the aid of hand pump for the irrigation fluid to improve the view.

Unfortunately, all ureteroscopic procedures were done without the aid of fluoroscopy (not available). Introduction of ureteroscope into the ureter was aided by a guidewire (Polytetrafluoroethylene (PTFE) coated guidewire) in most of patients. Once the stone visualized, the lithoclast metal probe was introduced via the ureteroscope and the stone fragmented with multiple transmitted shocks, the goal was to break the stone into 2-3mm fragments which can pass spontaneously. Stone gravel usually passed down along the flow of irrigant solution. Few pieces sometimes required removal with grasper. After completion of the procedure the retrieved stone fragments/particles were analyzed to know the chemical composition of the stone. For all patients, procedure time was determined (the time from the start of the ureteroscopy to the end of the procedure).

Cases of failure of introduction of the ureteroscope or those with small stones retrieved by only grasper were excluded from the study.

Requirement for other procedures, because of failure of fragmentation of stone or proximal migration of stone, was considered failure. Post URS JJ stent placement was done only in cases of long time procedure, residual fragments, bleeding or ureteral injury.

Parenteral antibiotic was continued for 2 days, and then oral antibiotics and analgesics were prescribed for 3- 5 days. Residual fragments were followed by KUB and ultrasound on the first postoperative day, the 7th postoperative day and on the 3rd week.

Majority of the patients were discharged on the first postoperative day. JJ stent was removed in 3 weeks time. Final results regarding clearance and complications were assessed at 3 weeks postoperatively.

Results

A total of 100 patients were treated by ureteroscopy and intracorporeal pneumatic lithotripsy for distal & mid ureteric calculi. They were 65 males and 35 females (table 3). Their age ranged from 20 to 60 years with a mean age of 39 ± 3 years (table 3).

Sixty three patients had calculi in right ureter, and 37 in left (table 4). Seventy five patients (75%) had lower ureteric and 25 patients (25%) had mid ureteric calculi (table 4). Mean calculus size was 11.6 ± 2.88 mm (range 7-20mm) (table 4).

Ten stones (10%) were radiolucent and 90 stones (90%) were Radiopaque. Preliminary JJ ureteric stenting was done in 10(10%) patients. Introduction of ureteroscope into the ureter was aided by a guidewire in 90(90%) patients (table 5).

Fragmentation rate was 90%. Treatment failure occur in 10(10%)patients: two (2%)calculi were failed to be fragmented with pneumatic lithotripsy and treated by open ureterolithotomy, and 6(6%)calculi migrated from the ureter up into the kidney during the procedure was regarded as treatment failure and later treated with ESWL (figure 1). Two patients (2%) required two sessions of lithoclast for incomplete fragmentation.

The early stone-free rate at the end of the operation (Complete clearance of calculi at the end of the procedure) was 70(70%). Residual calculi fragments were present 20 (20%) patients, which were followed post operatively with X-ray KUB film and ultrasound which was performed on the first postoperative day and another on the 7th postoperative day and at third postoperative week were the final result assessed (Figure 2).

At the end of the operation ureter was stented with 6Fr JJ stent in 25(25%) patients. This ureteric stent was removed

Age and gender of patients

	NO.	%
20-30	28	28%
31-40	32	32%
41-50	27	27%
51-60	13	13%
Mean±SD(range)	39±3	
Gender		
Male	65	65%
Female	35	35%
total	100	100%

Parameters of the treated stones (size, site, and opacity)

	NO.	%
Size in mm: =<10 mm	46	46%
> 10 mm	54	54%
Mean±SD (Range)	11.6±2.88	

endoscopically under local anesthesia after 3 weeks postoperatively (Table 5).

Procedure time with ureterorenoscopic lithotripsy in those 100 patients ranged between 10 minutes to 60 minutes with a mean of 36.51±10.05minutes. Hospital stay ranged from 24 hours to 48 hours.

The main complications encountered were: (1) ureteric perforation observed in four patient (4%) who was treated with JJ stenting,

(2) hematuria occurs in 16(16%)patients which resolved within the first 48hr postoperatively (Figure 3).

Overall success rate (stone free rate at the end of 3 weeks follow up) was 90%. Whereas success rate in, middle and lower ureter were 82% and 92% respectively.

Results of our study (fragmentation, stone clearance, and complications) were correlated to stone parameters: size, site in tables 7, 8, and 9 respectively. The results were significant when we correlate stone size with stone clearance, complications and time of procedure.

Side:	Left	<u>37</u>	<u>37%</u>
	Right	<u>63</u>	<u>63%</u>
Ureter site:	Mid	<u>25</u>	<u>25%</u>
	Lower	<u>75</u>	<u>75%</u>
Stone opacity:		<u>10</u>	<u>10%</u>
	Radiolucent		
	Radioopaque	<u>90</u>	<u>90%</u>

The need of JJ stents, guide wires and auxiliary procedures

	<u>NO.</u>	<u>%</u>
Preliminary JJ stent: Yes	<u>10</u>	<u>10%</u>
No	<u>90</u>	<u>90%</u>
Guide wire use: Yes	<u>90</u>	<u>90%</u>
No	<u>10%</u>	<u>10%</u>
Postoperative JJ stent: Yes	<u>25</u>	<u>25%</u>
No	<u>75</u>	<u>75%</u>
Auxillary procedures: ESWL	<u>6</u>	<u>6%</u>
Open ureterolithotom	<u>2</u>	<u>2%</u>
Another session	<u>2</u>	<u>2%</u>
No	<u>90</u>	<u>90%</u>

Discussion

The management of ureteral calculi represents one of the complex problems in urological practice. In planning to treat ureteral calculi, several factors are to be considered simultaneously, including stone size, chemical composition, location of the stone, anatomy of the urinary tract and the impact on the renal function, which are all depend on the availability of modern efficient radiological investigation. On the other

hand available treatment modalities should also considered and need to be evaluated for their efficacy, cost and morbidity. All these considerations make the management of ureteral calculi uniquely challenging.⁽⁸⁾ Fortunately, during the past two decades, a variety of new therapeutic modalities have been developed with the aim of providing effective treatment and at the same time minimizing the unpleasant effects of therapy. Accordingly, ureteric calculi are

primarily approached by ESWL or ureteroscopy and several devices are available for achieving intracorporeal stone destruction which includes electrohydraulic lithotripsy (EHL), laser lithotripsy, ultrasonic lithotripsy and pneumatic (ballistic) lithotripsy.⁽⁹⁾

In this study we evaluate the efficacy and safety of treatment with ureteroscopic pneumatic lithotripsy, which is the primary treatment modality used in our hospitals in the last few years.

Most of patients in our study were young adults with age range from 20-60 years with mean age of 39.3 years. Other studies conducted for the management of ureteric stones reveal an age range between 16-70 years with a mean age of 46.8 years.⁽¹⁰⁾

Male to Female ratio in our study was 3: 1 which was comparable to other studies in which male to female ratio was 2: 1 and reflect that men are affected two

to three times more frequently than women.^(11,12)

The procedure time with ureteroscopy and intracorporeal lithotripsy recorded in our study was between 10 minutes to 60 minutes with a mean 36.51 ± 10.05 . Lower ureteric stones and stones less than 10mm required less procedure time than mid ureteric stones and those more than 10 mm respectively with a statistically significant differences (P value <0.051 and <0.012 respectively), which is a logical result and comparable to other studies.^(13,14)

Since most of the stones treated in our series were lower ureteric stones (75%) and equal or less than 10mm in size (63%), this explain why our mean procedure time was shorter than other studies.^(13,14)

Our overall success rate (stone free rate at the end of third week) was 90% which is within the reasonable range achieved by other studies 69.5% to 98.99%.^(10,15,16)

We achieved a higher stone clearance rate and a less complication rate with stones equal or less than 10 mm than stones larger than 10 mm; which were again statistically significant (P value <0.0001).

These higher complication rates for larger ureteral stones were stones explained by the expected more difficulty and time consuming for the access and efficient fragmentation of the stones as mentioned in many studies.^(15,16)

Nevertheless the complications encountered in our study were in General equal to or less and easily managed than in other studies, there was four ureteric perforation (4%) while the rates observed in other studies ranged 1%-6.9%^(17,18), and 16 cases of hematuria (16%), all subsided spontaneously within 48 hours. Proximal migration of stones into the kidney happened in 6 of our

patients (6 %), which inspite of being a treatment failure in our protocol; all patients were treated successfully with ESWL. This drawback in pneumatic lithotripsy described in many studies with rates of 2%- 17%.^(17,18)

We also compared our successful fragmentation for mid and lower ureteral stones (treated by ureteroscopic pneumatic lithotripsy) with the successful fragmentation rates achieved by ESWL and mentioned in 2 large Iraqi studies.^(10,11) Success rates with pneumatic lithotripsy were 81.8% and 91.4% for mid and lower ureteral respectively, while those in ESWL were 76.9% and 77.5%.^(10,11)

From these results we noticed that ureteroscopic pneumatic lithotripsy was more efficient in the treatment of mid and lower ureteral stones than ESWL, with best results achieved for lower ureteral stones.

The Swiss lithoclast is a unique device that adds to the currently available devices for performing intracorporeal lithotripsy. Advantages of this device include its simplicity, reliability, and ease of use for the urologist and other nursing personnel. In addition, no disposable elements are required, which adds to the cost effective aspect of this device. There is no heat generated during activation, making it a safer treatment modality.^(19,20)

Conclusions

1. Ureteroscopy and intracorporeal lithotripsy is a good alternative in treating ureteral stones especially when the patient asks for "single shot" treatment.
2. Pneumatic lithotripsy is a minimally invasive, highly effective, easy to use, cost effective

- with a high safety profile method of treatment for ureteral stones.
3. Using the pneumatic lithotripsy , the success rate is significantly better in lower than mid ureter stones and in stones equal or less than 10mm than those larger than 10mm in size; and it was effective in all stone types with no significant difference related to chemical composition.
 4. Ureteroscopic pneumatic lithotripsy is more efficient than ESWL in managing mid and lower ureteral stones, and it should be considered the primary treatment option for impacted lower ureteral stones.

Recommendations

1. We hope in the future , that our hospitals could be supplied with the new generation advanced pneumatic lithoclast with the suction device, and the special flexible nitinol probes that could be used in smaller sizes ureteroscopes and even in flexible ureteroscopes; which will definitely improve the success rate (stone free rate), and decrease complications.
2. To conduct a comparison studies for different types of intracorporeal lithotripsy especially with laser lithotripsy which we hope that some of our hospital will be equipped with in the future.
1. We recommend further studies with larger sample size for more accurate results.

References

1. **William J., Peter D., Michael L., David E. and Joseph W.** Ureteroscopy: current practice and long-term complications. *J Urol* 1997; 157, 28-32.
2. **George K., David E., Michael L. and Joseph W.** Ureteroscopy: effect of technology and technique on clinical practice. *J Urol* 2003; 170, 99–102.
3. **Carter Q. and Joseph W.** Surgical Atlas Ureterorenoscopy. *BJU Int* 2006; 9 8: 235 – 245.
4. **Whitfield H.** The management of ureteric stones. Part II: therapy. *BJU Int* 1999; 84, 916–921.
5. **Patrick C., Alan B., E. Darracott Jr., and Alan J.** Campbell's urology textbook. Eighth edition 2002.
6. **Brent K., Timothy G., Gary J., and J. Stuart Jr.** comparison of outcomes of ureteroscopy for ureteral calculi located above and below the pelvic brim. *Urology* 2001; 58(3), 351-355.
7. **Jeong H. , Kwak C. and Lee S.E.** Ureteric stenting after ureteroscopy for ureteric stones: a prospective randomized study assessing symptoms and complications. *BJU Int* 2004; 93, 1032-1035.
8. Delvecchio FC, Kuo RL, Preminger GM.: Clinical efficacy of combined lithoclast and lithovac stone removal during ureteroscopy. *J Urol*, 164: 40-42, 2000.
9. Akhtar MS and Akhtar FK.: Utility of the lithoclast in the treatment of upper, middle and lower ureteric calculi. *Surg JR Coll Surg Edinb Irel*, 144-148, 2003.
10. Al-Azzawi-I-S.: Impacted lower ureteric stones: the treatment options currently available. *Iraqi J of community medicine*, 17(4): 400-404, 2004.
11. Al-Azzawi-I-S. : Treatment of ureteric stones by in .situ ESWL. *Iraqi postgraduate medical J.*, 2(1): 63-66, 2002.
12. Ullah S, Kamran T, Zaheer K, et al: Pneumatic lithotripsy for the management of ureteric calculi. *J Coll. Physicians. Surg-Pak.*; 13 (2): 101-3, 2003 Feb.
13. Asghar A, Saleem M, Jamil M, et al: Our experience with 100 cases of ureteric stones. Comparison of different methods of treatment. *The Professional*, 7 (3): 331-7, July-Aug-Sept 2000.
14. O'Toole Gc, Khan SM, Kelly DG, et al: The management of ureteric calculi without extracorporeal shock wave lithotripsy. *Ir J Med Sci.*; 169 (2): 119-21, 2000.
15. Fashuddin Q, Hassan AT: Ureteroscopy (URS); an effective interventional and diagnosis modality. *J Pak Med Assoc.*; 52 (11): 510-2, 2002.
16. Zhong W, Zeng G, Cai Y, et al: Treatment of lower ureteric calculi

- with extracorporeal shock wave lithotripsy and pneumatic ureteroscopic lithotripsy: a comparison of effectiveness and complications. Chin Med J (Engl).; 116 (7): 1001-3, 2003.
17. Chen QS, Ren YC, and Liao JX: Pneumatic lithotripsy for ureterolithiasis: Clinical analysis of 512 cases. Di-Yi-Jun-Yi-Da-Xue-Xue-Bao.; 23 (7): 750-1, 2003.
18. Puppo P, Riccio HiG, Bozzo W, et al: Primary endoscopic treatment of ureteric calculi. A review of 378 cases. Eur Urol.; 36 (1): 48-52, 1999.
19. Taylor AL, Oakley N, Das S, et al. Day case ureteroscopy: an observational study. BJU-Int.; 89 (3): 181-5, 2002.
20. Silinkas T et al: Review and results of our first uretero-scopy experience at Klaipeda hospital. Medicina-(Kau-nas), 38 Suppli1: 8-12, 2002.