International Scholars Journals

International Journal of Urology and Nephrology ISSN 2091-1254 Vol. 5 (3), pp. 156-164, March, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Evaluation of ultrasonic ureteral lithotripsy in the management of distal ureteric stones;single center experience

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Accepted 27 January, 2017

To prospectively evaluate the outcome (safety, efficacy and complications) of ultrasonic lithotripsy aided by anti-migration tools and forceps in a management of distal ureteric stones. The study was conducted between October 2014 and October 2016 at urology department Al-Azhar University. A total of 70 patients with distal ureteric stones were selected. The mean Age was 43 (22 to 68) years. All underwent semi rigid ureteroscopy with ultrasonic lithotripsy in stone size ≤1.5 cm. Operative and postoperative data were evaluated and statistically analyzed. Fragmentation time was 85.2±50.2 minutes (fragmentation time was increased in stones with increased HU). Early (day after the operation) and delayed (one month later) stone free rates were estimated. Stone free rates for ureteroscopy using ultrasonic lithotripsy were 67/70 (95.7%). Three cases with residual (4.3 %) were extracted during JJ stent removal. Three stones have retrograde migration into dilated upper urinary tract 4.3% (clinically insignificant). Auxiliary procedure performed 50 cases (71.4 %), stone basket 28 cases (40%) used to clear stones after fragmentations and preventing migration of stones. No significant intraoperative or postoperative complications were encountered. Only minor complications as fever, mucosal abrasions and mild hematuria occurred. Postoperative stenting was JJ stent in 36 cases (51.4 %) and ureteric catheter 34 cases (48.6%). One case required second setting due to probe breakdown. Our study suggests that ultrasonic ureteric lithotripsy is safe and effective without significant complications in management of distal ureteric stones.

Keywords: Ureteric stones, ultrasonic, lithotripsy, intracorpreal, ureteroscopy.

INTRODUCTION

Several devices are available for intracorporeal lithotripsy may be flexible (laser lithotripsy and Electrohydraulic lithotripsy (EHL)) or rigid (ultrasonic and ballistic lithotripsy).1
Mulvaney first reported the use of ultrasound vibration to break renal calculi in 1953. Ultrasonic lithotripsy (UL) was first applied clinically in the early 1970s for treatment of bladder calculi. Hautmann and associates reported good results in the treatment of patients with vesical stones using the ultrasonic lithotripter. The use of ultrasonic lithotripsy in the ureter (UUL) was slower to develop because of the limitations imposed by the diameters of the ultrasonic probe and the ureteroscope. Nevertheless, UUL was the first technique applied for the fragmentation of ureteral stones, as reported by Goodfriend in 1973.2, 3.
With the advent of percutaneous nephrolithotomy, ultrasonic lithotripsy was used as intracorporeal lithotripter because of its unique combination of stone fragmentation and evacuation.4
The ultrasonic probe works by applying electrical energy to excite a piezoceramic plate in the ultrasound transducer. The high frequency generator activated by a foot pedal applies a current to a piezoceramic crystal

within a handpiece. The plate resonates at a specific frequency and generates ultrasonic waves at frequency of approximately 23, 000 to 25, 000 Hz.5

Ultrasound energy is transformed into longitudinal and transverse vibrations of the hollow steel probe, which then transmits the energy to the stone. The probe tip causes the stone to resonate at high frequency and to break: but when the probe is placed on compliant tissue, such as urothelium, damage is minimal because the tissue does not resonate with the vibrational energy.6

Sometimes heat may be developed at the tip of the probe during lithotripsy, it can be reduced by increasing the flow of irrigant fluids with an irrigation rate of 30 mL per minute, the ultrasonic lithotripter system is connected to suction so that small particles are removed continuously with the irrigating fluid during lithotripsy. In addition, the flow of fluid through the hollow probe serves to cool the instrument. Heating of the ultrasound transducer should alert the surgeon to possible occlusion in the probe lumen.7

In general, suction is applied only when the ultrasonic lilhotripter is activated, and suction pressures in the range of 60 to 80 cm H2O are sufficient to maintain adequate flow of irrigant during lithotripsy. Higher suction pressures tend to draw air bubbles into the system, impeding vision. Ultrasonic probes are available at sizes ranging from 2.5 to 12 French. The 2.5 French probe is solid and the only one which has no hollow center for suction. Bending the probe results in energy loss at the convexity of the bend, with the energy being transformed to heat. Stones vary in their susceptibility to destruction with ultrasound. 7

Although the chemical composition of the stone influences the time required for complete disintegration (cystine and calciurn oxalate monohydrate are being the most resistant to fragmentation), the size, density, and surface structure of the calculus appear to be more important. Smaller stones are more rapidly destroyed, as are rough stones. Smooth-surfaced large stones may be more difficult to fragment 8, 9

Currently the Holmium: YAG laser is the most effective **and** versatile intracorporeal lithotripter with good margin of safety. The major drawbacks are the expense of the equipment's acquisition and maintenance as well as the disposable element required limiting its use in many centers 10.

One of the advantages of ultrasonic lithotripsy is their relatively low cost and low maintenance. Although the devices are more expensive than EHL, there are no disposable costs and the probes having an extremely long life span 11

The purpose of this study is to reevaluate the ultrasonic lithotripsy in this new era as regard safety, efficacy and complications.

PATIENTS AND METHODS

A prospective study From October 2014 to October2016 was done on 70 consecutive patients with ureteric stones attending Al Zahraa university hospital.The stones were extracted uretroscopically using UL. Mean age of the patients was 43 (22 to 68) years56 male and 14 female.

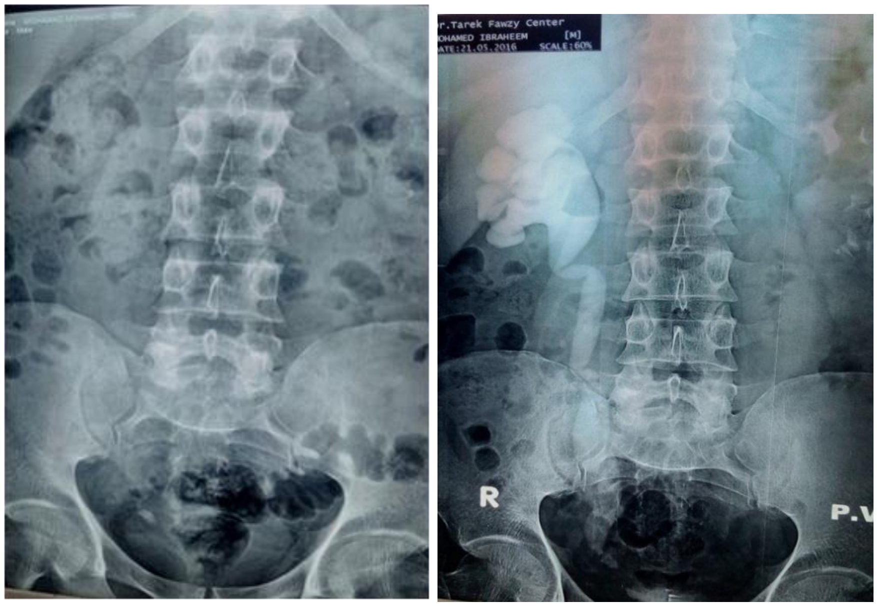
Exclusion criteria

Stone size more than 1.5 cm, untreated urological infection, Pregnancy, sever musculoskeletal deformities, uncorrectable coagulopathy, difficult introduction of ureteroscopy due to stricture or ureteric spasm that may prevent successful retrograde stone management, stone extracted in Toto by stone basket or forceps, Bilateral ureteric stones (one side only attacked),stone upper and middle ureter.

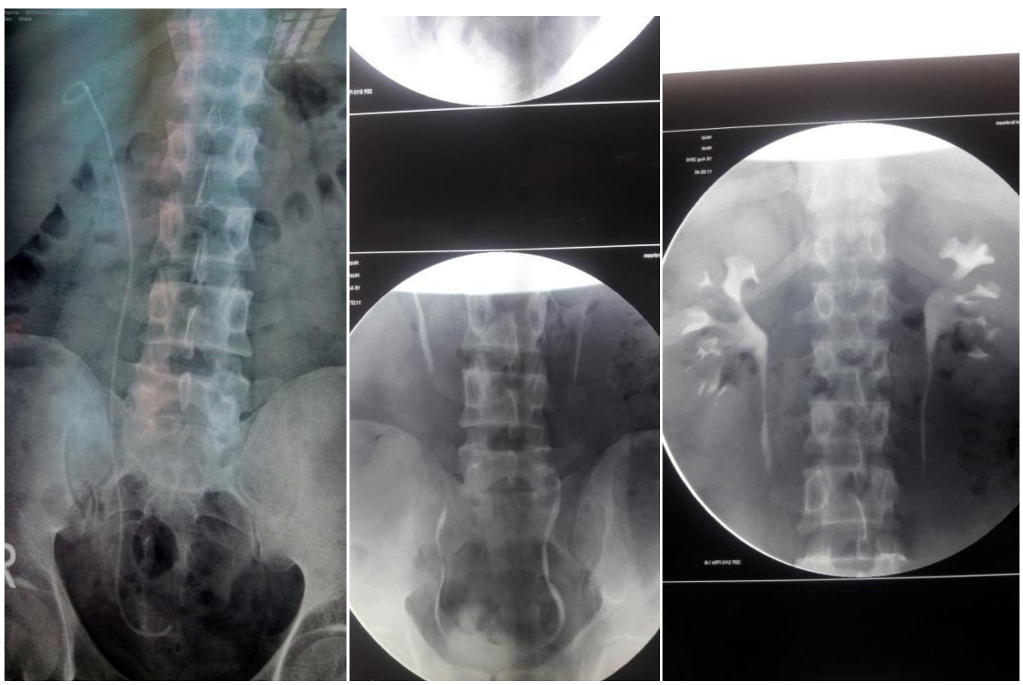
All patients'underwentKUB,ultrasound and spiral CT. IVU was done in limited number of patients. Preoperative urine analysis and culture were obtained. On the day of surgery, a prophylactic antibiotic was administered.Inoperating room Patients were put in lithotomy position with legs supported in stirrups with minimal flex at the hips. The procedure was performed under general or spinal anesthesia.

The equipment included rigid ureteroscopy (semi-rigid ureteroscopy, Karl Storz, Germany), fluoroscopy (C-arm fluoroscopy), stone grasping baskets and forceps, lithoclast (Swiss lithoclast master).(Switzerland with 4 Ch. Probe) and irrigation devices. Retrograde access to the upper urinary tract is usually obtained under endoscopic guidance and imaging. At first guide wire was applied then balloon and/or Teflon dilators were used if necessary. Irrigant fluids were either distilled water or saline maintaining a low-pressure system which is sometimes pumped forcibly to decrease the heat generated by the probe and get a clear field.

The ultrasonic probe is passed through the working channel and placed directly on the stone to prevent stone proximal migration it can be engaged in a stone basket. Stones were fragmented using intracorprealultrasonic lithotripter then either extracted by grasping forceps , baskets or suction which is connected to the ultrasonic hollow probe. After completing the procedure, ureteric catheters were fixed at the end of the procedure but in patients who were at an increased risk of complications (e.g. residual fragments/large residual stone burden bleeding, perforation, ureteral injury or obstruction) ureteral JJ-stents were applied according to surgeon's judgment. Good antibiotic covering gram positive and negative and anaerobic infection. The day after the procedure patients were subjected to KUB film/ultrasonography scanning assessing residual radio-opaque shadows. If non sizable residual (<4 mm), medical expulsive therapy (MET) was described. One month later, patients were reevaluated either to remove stent or to redo ureteroscopy. If there were intraoperative complications of perforation, a migrating/lost stone or avulsion were monitored and repeated separately in the surgical notes. Submucosal tear was observed by direct visualization during the procedure, whereas avulsion or perforation was documented by intraoperative retrograde ureterorenography.



a) Preoperative IVU reveals stone lower right ureter with moderate hydrouretronephrosis.



b) Post-operative follow up with no residual stone. IVU normal after 2months.
Fig 1. Ultrasonicuretericlithotripsyin male patient 63 years old (a&b).

Term of early stone free rate was defined as stone clearance one day after the initial ureteroscopy. Term of delayed stone free rate was defined as stone clearance one month after initial ureteroscopyandmedical expulsive therapy (MET).
Assessment for, vital signs, hematuria and clinical evaluation duringhospital stay were occurred.Radiological follow-up have been tailored to the characteristics of the patients. Success of the procedure was also documented in terms of stone size. Complications were also recorded. All procedures were done by the same surgeon using semirgidureteroscopy and ultrasonic lithotripsy with ureteric hollow probe.
Anti-migration tools like stone basket are used to hold the stone which suspected to migrate up followed by fragmentation of the stone inside. Operative time,hospitalization, complications (hematuria, mucosal injury, perforation postoperative fever, stone free status

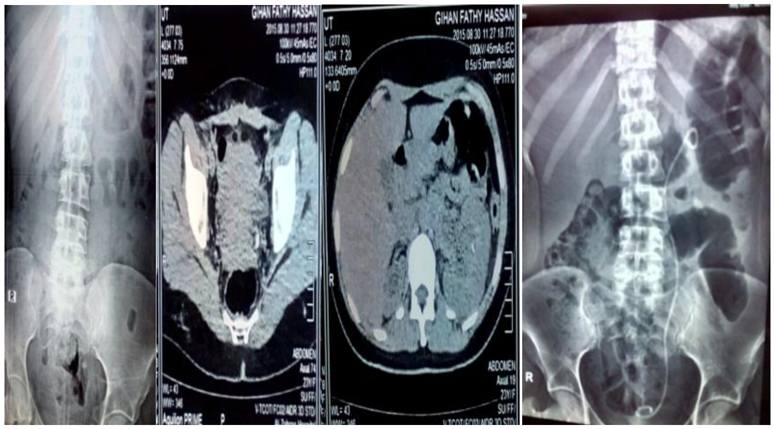
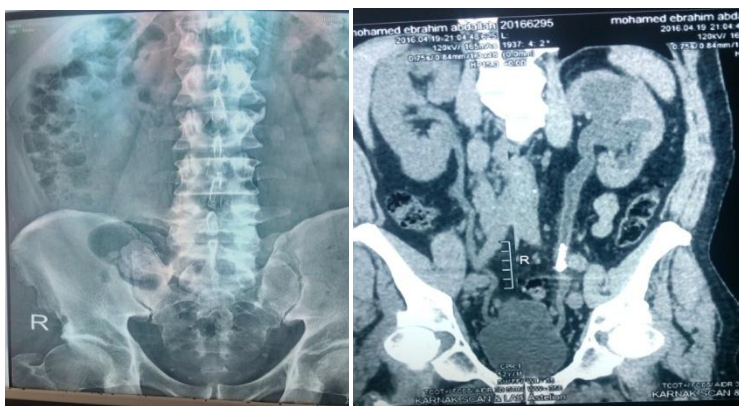
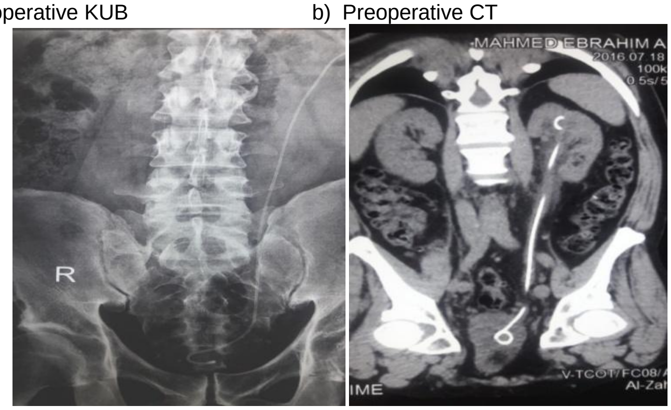


Fig2. Female patient 25 years old presented obstructed solitary left kidney with serum creatinine 7.5 mg /dl. Ultrasound: left mild hydrouretronephrosis and atrophied small right kidney. Plain KUB revealed stone left lower third ureter with left hydrouretronephrosis. Pelviabdomina l CT: atrophied small right kidney and stone left lower third ureter with right hydrouretronephrosis. Patient underwent ultrasonic lithotripsy with DJ insertion. Followup Creatinine: 0.9 mg /dl. Postoperative KUB: free Ultrasound: no back pressure.



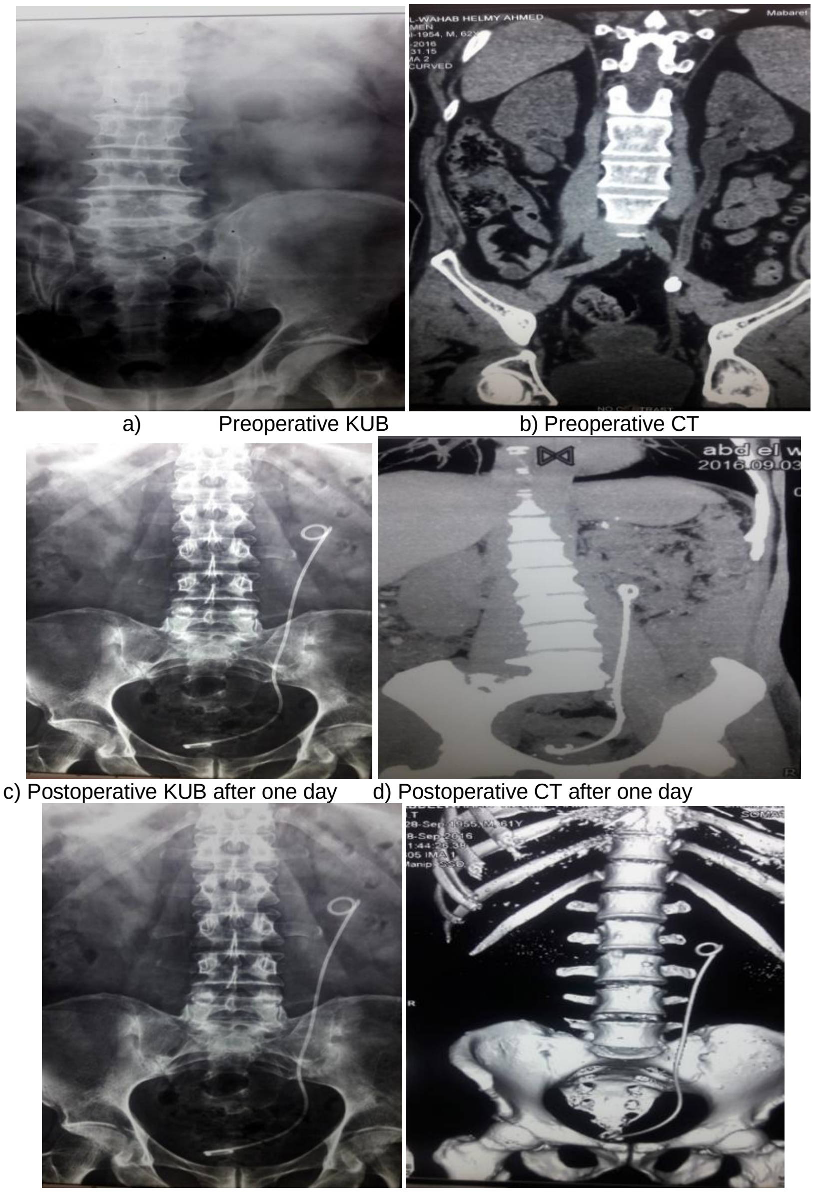
a)Preoperative KUB b) Preoperative CT



c) Postoperative KUB d) Postoperative CT

Fig 3. Male patient 50 years old, Ultrasound: left moderate hydrouretronephrosis. A) Plain KUB revealed stone left lower third ureter. B) Pelviabdominal CT: left hydrouretronephrosis and stone left lower third ureter. Procedure: ultrasonic lithotripsy with DJ insertion. Followup Postoperative. c) KUB: free Ultrasound: mild back pressure. d) CT: stone free.

(fragments<4mm) determined by KUB in radiopaque stones and CT in radiolucent stones.Treatment success was defined as stone free or clinically insignificant residual fragments (residual less than 4mm). Analysis of



a) Preoperative KUB b) Preoperative CT

c) Postoperative KUB after one day d) Postoperative CT after one day

e) Postoperative KUB after one month f) Postoperative CT after one month

Fig 3. Male patient 55 years old. Ultrasound: Left moderate hydrouretronephrosis .a) Plain KUB revealed stone Left distalureter. b) PelviabdominalCT: Left hydrouretronephrosis and stone Left lower third ureter. Procedure: Ultrasonic lithotripsy with DJ insertion Follow up. c) Postoperative KUB after one day: residual stone <4 mm. d) CT: residual stone <4 mm.e) Postoperative KUB after one month: free. f) CT: residual stone after one month: free

Data was performed using SPSS software version 15.An informed consent was taken from all patients.

RESULTS

Among of 70 patients there were 56 male and 14 femalewith mean age 43 (22 to 68) years. Left and right ureteric stones were presented in 42(60%) and 28(40%), respectively. The stone size was measured by longitudinal axis. The size of the stones in treated patients was (0.8-1.5cm). Size of (0.8-1cm) was found in 42(60%) and (1.1-1.5 cm) in 28(40%) (table: 1).All stones are distally located at or below sacroiliac joint. Radiopaque stones were found in 62(88.6%) while radiolucent in 8(11.4%).

The Early stone free rate according to size (0.8-1cm) was 36/42(85.7%). 6 cases with residual fragments <4mm (clinically insignificant) table 2.

The early stone free rate according to size (1.1-1.5cm)was 20/28(71.4%).8 cases with residual fragments

Table 1. Distribution of stone size.

size	**n**
.8-1cm	42(60%)
1.1-1.5 cm	28(40%)

Table 2. Early stone free rate according to size (0.8-1cm).

variables	**n**
number	42
stone free	36(85.7%)
residual	6(14.2%)

Table 3. Early stone free rate according to size (1.1-1.5cm).

Variables	**n**
number	28
stone free	20(71.4%)
residual	8(28.5%)

Table 4. Delayed stone free rate according to stone size (.8-1 cm).

Variables	**n**
number	42
stone free	42(100%)
residual	0(0%)

3 cases with residual>4mm (clinically significant) and5 cases with residual stones (clinically insignificant) table 3. Delayed stone free rate according to size (0.8-1cm) 40/40(100%). Delayed stone free rate according to size (1.1-1.5 cm) was 25/28 (89.8%). The net result of stone free rate for ureteroscopy using ultrasonic lithotripsy 67/70(95.7%) and 3 cases with residual (4.3 %) table 4, 5, 6, 7, and 8.

Table 5. Delayed stone free rate according to stone size (1-1.5 cm).

Variables	**n**
number	28
stone free	25(89.3%)
residual	3(10.7%)

Table 6. Stone free rate for stone size (.8- 1 cm).

Variables	**n**
number	42
early stone free rate	36(85.7%)
delayed stone free rate	42(100%)
residual	0(0%)

The overall fragmentation time was 85.2±50.2 minutes (fragmentation time was increased in stones with increased HU) but all stones were fragmented and no statistical significant correlation between fragmentation and stone density in HU.

The incidence of stone migration was 3 cases and was clinically insignificant (tiny fragments after fragmentation of main bulk of the stone and no need for further intervention.

Table 7. Stone free rate for stone size (1.1 -1.5 cm).

Variables	**n**
number	28
early stone free rate	20(71.4%)
delayed stone free rate	25(89.2%)
residual	3(10.7%)

Table 8. The overall stone free rate and residual stones.

	n
Total	70
Early stone free rate	56(80%)
Delayed stone free rata	67(95.7%)
residual	3(4.3%)

Postoperative stenting was done in total 100% i.e. JJ stent 36 cases (51.4 %) and ureteric catheter 34cases (48.6%).

Sub mucous false passage was in 6 cases and mostly from passage of the guide wire and managed by JJ stent fixation.No incidence of major complications like avulsion or perforation table 9.

Table 9. Intraoperative complications.

Intraoperative complication	**UL**
stone migration	3(4.3%)
sub mucous dissection	6(8.5%)
perforation	0(0%)
avulsion	0(0%)

Post-operativehospitalstay was ranged from 1-7days (2.3±2.064)

One patient underwent second look ureteroscopy due to probe breaking down due to marked bending before gaining the experience.

Auxiliary procedureperformed 50 cases (71.4 %), stone basket 28 cases (40%) used to clear stones after fragmentations and preventing migration of stones. Graspingforceps 50 cases (71.4 %). Follow up of postoperative symptoms show that irritative symptoms were in 36 cases (51.4 %) , loin pain 8 cases (11.4), hematuria 22 cases (31.4%) and fever in 5 cases (7.1 %) managed by proper antibiotic and antipyretics other complications like urgency , frequency , pain in corresponding flank, painful micturiti , heaviness in the perineum was managedsymptomatically.

DISCUSSION

Recently new techniques such as laser using rigid or flexible ureteroscopy are available and has replaced many techniques as ultrasonic and pneumatic lithotripsy but with reviewing the literature no sufficient data for evaluating ultrasonic lithotripsy alone in ureteric stones this is because rapid development of EHL and laser decrease the use of ultrasonic therefore the number of studies that report the results are limited. This instrument was available in our department and we have no experience about its efficacy.in this study we present our experience in this field.

Two types of treatment modalities are more popular for treatment of ureteral stones extracorporeal shock wave lithotripsy and intracorporeal (endoscopic) lithotripsy. The use of extracorporeal shock wave lithotripsy once approved by AUA as treatment modality of choice 12.There is a progressive decline day by day owing to its low success rate and advances and improvements in endoscopic instruments and fiber optics (introcorporeal lithoripsy).13.

There are several intracorporeal lithotripsy alternatives, such as electrohydraulic lithotripsy, ultrasonic lithotripsy, pneumatic lithotripsy and laser lithotripsy.14

Although trend of laser lithotripsy is rising but high treatment cost and ureteral tissue damage seem to be main problems with this technique. Among these treatment options we used ultrasonic lithotripsy forlower ureteric stone.Most studies in recent years compared UL in stone kidney with other intracorporeal lithotripsy modalities or in combination. Few data are available about usage of UL for treatment of ureteric stone.

This study evaluates the results of ULfor ureteric calculi in term of efficacy, safety and complication.70 patients have ureteric calculi were allocatedtoUL. In our study the mean age was43 (22 to 68) years.

Most studies use the UL in combination with most recent technology such as holmium laser or pneumatic lithotripsy (PL) and no sufficient study for evaluation of ultrasonic ureteral lithotripsy alone.

In agreement with our study as regard operative time and hospital stay Gur et al represents his study on 9 cases with mean operative time 84 minutes and hospital stay 3,9 days in patients with steinstrasse following shock wave lithotripsy and calcified JJ stent. All of them are stone freebut the study conducted on small number of patients in comparison with this study.15

All studies on other devicesare (as Laser and pneumatic) carried on stones at different levels. Study published by by Seong and collegue included 51 patientsusing. 43 patients with lower ureteric stones and 4 patients with middle ureteric stones and 4 patients with upper ureteric stones) 16.In a study done by Khan in 2014.The study included 100 patients.60 patients with lower ureteric stones, 12 patients with middle ureteric stones and 18 patients with upper ureteric stones.17

In our study we concentrate on distal ureteric stone with more or less sufficient number of cases but further studies are neededfor evaluation of different levels with good sample size.

In comparison with PL the migration of stones was less in ultrasonic and laser due to jack hammer mechanism of lithoclast probe18,19.

The suction power of UL which decrease the number of uretroscope needed to hunt the small fragments by dormia or forceps in each case.

Less number of hard stone (6 cases with HU >1300) was encountered in this study but all stones are fragmented .Despite small number of hard stone but it did not affect the result because of our limited number of cases so more studies are needed on hard stones .

European Association of Urology (EAU) recommends Ho:YAG laser lithotripsy as the most efficient procedure for ureteroscopic lithotripsy that it can be used both in rigid, and flexible ureteroscopy with its effectiveness against all stone types.20

Ultrasonic energy delivered through hollow steel probes induces transverse and longitudinal vibrations which are transferred to the stone. Because of their inflexible texture, it was some difficulty to use ultrasonic probes in semi rigid ureteroscope still the success rate of ultrasonic lithotripter is over 90 percent which was reported by Vicente et al and Gur et al which were parallel in our study.21,15

Salvado et al. expressed the success rate of laser lithotripsy in the management of distal ureteral stone as 96 percent in evaluation of three lithotripsy devices and show that all of it behaved similarly in terms of the ability to fragment stones, and were equally effective for distal ureteral stones. Adequate fragmentation and fragment removal is mainly dependent on stone size and surgical technique (use of auxiliaryprocedures).22, 23

In study done by Seong and colleague, the fragmentation time was 76± 48 min in PL16. In Nutahara and collegues, the fragmentation time was 90.2 ± 50 min for PL24. In current study no significant changes as the overall fragmentation time was 85.2±50.2 (fragmentation time was increased in stones with increased HU).

Garg and colleagues reported that the stone migration occurred in PL in 8 cases out of 50 (16%).25 In study done by Seong and collegue, the stone migration occurred in PL in 5 cases out of 26(19.2%) 16. In this study stone migrations occurred in 3 cases (4%) and were insignificant due to distal location of all stones and using basket as anti-migration tool in suspected stones also using of auxiliary procedures related to experience with individual variations.

Less complications in our study may be due to using of proper auxiliary procedure at proper time and decreasing the pressure of irrigant fluid when suspected migration in addition suction pressure of hollow probe decrease intrarenal pressure and liability of hematuria and infection which makes ultrasonic ureteral lithotripsy safe and effective modality .

In study done by Seong and colleagues, the ureters were perforated in 2 cases in PL and were managed by DJ stent with no long term sequele16. In Nutahara and colleagues, the ureter was perforated in 1 case in PL and was managed by DJ stent 24.In current study no perforation encountered in agreement with piergiovanno1994.26This may be due to usage of sensor guide wires and retrograde study before any manipulation.

At the end of the procedure ureteric stent was inserted in all cases i.e. JJ stent 36 cases (51.4 %) and ureteric catheter 34 cases (48.6%). Our rational for DJ stent insertion was solitary kidney, submucosal dissection, and difficult procedure with rough manipulation and associated renal stone for ESWL. The stone free rate was estimated by KUB or non-contrastCT one day postoperative for early stone free rate and 1 month post-operative for delayed stone free rate.Early (day after the operation) and delayed (one month later) stone free rate was estimated and the net result of stone free rate for ureteroscopy using ultrasonic lithotripsy 67/70 (95.7%) and 3 cases with residual (4.3 %) which was statistically insignificant but Clinically significant fragments (>4 mm) were encountered and extracted by ureteroscopy during removal of JJ stents. By comparing the early stone free rate to delayed stone free rate it is noted that clinically insignificant fragments passed spontaneously with medical expulsive therapy. The stone free rate raised from 80 % to 96%.

In the current study we noticed that the residual stones are more when stone size increase and when rounded smooth surface stones with high Hounsfield units are included but not statistically significant.

In a study done by Khan in 2014, on PL the delayed stone free rate was 98.3% for distal ureteric stone. In Salman and collegue the stone free rate for distal ureteric stone was 89.2% for (PL). 27.Garg and collegues, reported that the delayed stone free rate was 84% in PL 25.InNutahara and colleagues, the delayed stone free rate was97% 24. Our results of stone free rate for ureteroscopy using UL were 67/70 (95.7%) table 4, 5, 6, 7, 8) which in the same efficacy of pneumatic. Continuous suction decrease risk of infection by decreasing amount of irrigant fluid 19, 21

With our experience during use of ultrasonic in management of ureteric stones be care of bending the probe which may results in energy loss at the convexity of the bend, with the energy being transformed to heat, increase in fragmentation time and impending breakdown of the probe.

Be care of higher suction pressures tend to draw air bubbles into the system so impeding vision.

The limitation of this series include small number of patients; study conducted on distal ureteric stones only so further work up is needed to evaluate its results on upper and mid ureteric stones. More studies are required on hard stones (high HU) and impacted stones.

CONCLUSION

Ultrasonic ureteral lithotripsy isa reliable management modality and is effective as well as laser and pneumatic in management of distal ureteric stones; it is safe, inexpensive in comparison with other modalities andis missedeffective instrument in management of distal ureteric stones with unique advantage of stone fragmentation and removal. Less morbidity with high success rate and should not be neglected.

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