Comparison of Ureteroscopic Holmium Laser lithotripsy and ESWL in Treatment of Ureteric Stones

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Abstract. The urologists have several options for treating ureteral stones in the range of 8-15mm. Of that range, this study makes a comparison between ESWL and ureteroscopic holmium laser lithotripsy in the treatment of ureteric stone. In spite of that ureteroscopy and ESWL are invasive procedures, still there is controversy which of them is more suitable for treating ureteral stones condition. Study Aim: This study conducts a review to compare the effectiveness, safety and complications of using ureteroscopic holmium laser lithotripsy and ESWL in treating ureteral stones. Study Methods: Eighty ureteroscopic holmium laser lithotripsy or ESWL-treated patients between April 2016 and April 2017 in Al-Diwaneyah teaching hospital who is having 8–14mm single radiopaque ureteral stone, were assessed. All of the patients in the study sample were subjected to follow-up period of seven months using ultrasonography. Then, comparison was made to identify stone clearance rate, potential complications and cost. Study Results: Results show that There is resemblance in treatment time and stone clearance rate between the two treatments. Generally, the total cost, the procedural time and analgesia requirements and were noticeably variant. Additionally, gross hematuria and renal colic were more frequent with ESWL procedure, while the voiding symptoms show more frequency with ureteroscopy procedure. The two procedures that were applied for the treatment of 8-14mm range ureteral stones proved to be the least invasive and secure.

Keywords: Ureteroscopic; Laser lithotripsy; ESWL; Al-Diwaneyah teaching hospital

1. Introduction

Historically, urolithiasis had accompanied humans for millennia. The medical advances have made humans able to manage the urolithiasis progressively with limited complications. The majority of urinary stones passing via the renal calyces to the renal pelvis and ultimately to the ureter, are considered the cause of a number of critical symptoms. The most common of such symptoms related to the ureteral stones are hematuria, pain and hydronephrosis. Many options were presented for the urologists to manage 8-14mm range ureteral stones (Table1), including ureteroscopic holmium laser lithotripsy and ESWL procedures [1,2,3]. While ureteroscopy procedures and ESWL are effective and the least invasive among other procedures, debate yet persists over which of the two procedures is more benefitting for the management of ureteral stones. Various researches stated different results of ESWL and ureteroscopy procedures, in spite that both of the treatment methods use advanced instruments, and present few complications with high satisfaction in the urologist community [4–8].
The researcher in this study conducted a comparison of the objective outcomes on ureteral stones patients who were treated with either ESWL or ureteroscopy procedure.

**Table 1:** management of ureteric calculi: guidelines to urolithiasis of EAU and AUA

| Proximal ureter | Mid ureter | Distal ureter |
|-----------------|-----------|--------------|
| (All size)      | (All size)| (All size)   |
| EAU options     | ESWL, URS, PNL, LAP. And open surgery | ESWL, URS |
| Proximal ureter | ESWL, URS | Distal ureter |
| <1 cm options   | Observation, ESWL. | ESWL, URS, PNL, LAP. And open surgery |
| >1 cm            | ESWL, URS | Observation, URS ESWL. |

Notes: EAU-European Association of Urology, AUA-American Urological Association.

2. Patients and methods

2.1. Study Sample

This study sampled single radiopaque 8-14mm range ureteral stone patients who were subjected to ESWL procedure (n = 40) and to ureteroscopy procedure (n = 40) in the period between April 2016 and April 2017 at Al-Diwaneyah teaching hospital (Table 2). Bilateral or multiple stone Patients, radiolucent stone patients, repeated treatment, acute urinary tract infection patients, distal ureteral and ureteral stricture patient's stone patients were not covered by this study. An explanation was given to the sampled patients about the advantages, drawbacks, and complications that accompany each of the two procedure before they volunteer for the study.

2.2. Selecting the treatment option

A written informed consent of each patient has been obtained before conducting the treatment.

**Table 2:** characteristic of the patient on both groups.

|                | ESWL       | URS        | P value |
|----------------|------------|------------|---------|
| Age (years)    | 41.3±8.8   | 40.4±9.4   | 0.68    |
| Sex, male/female | 28/12     | 25/15      | 0.48    |
| Stone side     |            |            | 0.29    |
| Right          | 17 (42.5%) | 13 (32.5%) |         |
| Left           | 23 (57.5%) | 27 (67.5%) |         |
| Stone site     |            |            | 0.451   |
| Upper ureter   | 28 (70%)   | 31 (77.5%) |         |
| Mid ureter     | 12 (30%)   | 9 (22.5%)  |         |
| Stone diameter (mm) | 9.7±3.5 | 10.1±4.4 | 0.66    |

2.3. Study Structure

Kidney-Ureter-Bladder (KUB) X-Ray film (Figure 1) and ultrasonography were used to diagnose Ureteral stones condition. Then, the longest diameter of each stone was measured before conducting the procedure. ESWL-treated patients were evaluated in terms of coagulation profile, urine analysis and serum creatinine level. Also, the third-generation Dornier lithotripter (Dornier, Germany) to be an outpatient procedure was used in performing ESWL treatment. In the first treatment procedure, the shockwave was set at 3,000–3,500 and voltage was set at 10–12Kv. Patients were dismissed after being kept under surveillance for two hours by use of routine antibiotics and then evaluated one week
later by means of KUB to assess the stone passage. ESWL treatment procedure was re-admitted in case residual stones were found during the follow-up. According to the Chinese Urology Association (CUA) guidelines, in case a stone remains after three ESWL treatment sessions, ureteroscopy treatment procedure, is used in order to avoid the possibility of ureterostenosis [3]

Ureteroscopy-treated patients were evaluated with serum creatinine level, KUB X-Ray film, chest X-ray, urine analysis, EEG and coagulation profile (Figure 2). Furthermore, 8/9.8-Fr, 12u rigid ureteroscope (storz, Germany) was used with Ureteroscopy under the general anesthesia. For ureteroscopic lithotripsy treatment procedure, a holmium laser was used at 1.2–1.5 J and 10–15 Hz settings (Figure 3). After the fragmentation of the stones into multiple pieces, 2mm stone 6.0F DJ persisted (Figure 4). The routine management was taken by administering antibiotics and analgesia. After 1-2 days from the operation, and after having applying catheter removal, all patients were discharged. Then, KUB was used to evaluate those patients after one week and the removal of the stent was conducted after two weeks.

Figure 1. ureteral calculus (arrow) before ESWL

Figure 2. Right ureteral calculus (arrow) before ureteroscopy

Figure 3. Ureteroscopic holmium laser lithotripsy.
3. Statistical Analysis

The statistical were identified to be of significance with two-sided p0.05. The study used SAS software v.9.2 (SAS, Cary, NC) to conduct the statistical analyses.

4. Results

Ureteroscopy and ESWL treatment operations were conducted simultaneously in a successful way. Severe complications were not present throughout the application (ureteral perforation, ureteral avulsion with ureteroscopy, nor renal haematoma with ESWL). The total procedural time, analgesia requirement, total cost, gross hematuria and voiding symptom differed between the two treatments significantly. However, treatment time and stone clearance rate were similar. one case was observed with stone shifting to the pelvis in ureteroscopy-treated group of patients. This stone couldn’t be reached with rigid ureteroscope application. Residual stones were removed by ESWL treatment procedure after one week. three cases in which stones couldn’t be removed completely in the ESWL-treated group of patients were observed. They were managed by ureteroscopy treatment procedure in the end. All subjects were put under 3-6 month follow-up period and they had no observed residual stones or ureterostenosis when the follow-up period ended.

5. Discussion

Ureteroscopy and ESWL treatments are the least invasive choices for patients with proximal ureteral stones. In 1912, ureteroscopy technique was practiced for the first time [12]. However, it could not gain the general acceptance until the late 1970’s. Later, it became standardized treatment procedure [13]. ESWL technique started to be used in the 1980s and it gave stone clearance rate in the range of 90%. In addition, this technique leads to the decrease in the use of open surgery to manage ureteral stones [9–11]. Later advances in ESWL treatment made it capable of breaking boundaries became more effective. Twined the use of laser lithotripsy, a promising 95% or more stone-free results in the treated patients after undergoing the single treatment [14,15]. Researches comparing ureteroscopy and ESWL treatments in general are not conclusive and in some cases give mix results. Nevertheless, some researches applaud ESWL technique [7]. Some others researches suggest that ureteroscopy is the suitable treatment [16–18]. This paper compared several results related to those two approaches in terms of the following variables:

1) stone clearance rate
2) treatment time
3) procedural time
4) complications
5) cost-effectiveness.

Stone clearance rates in this comparative research were 97.5% for ureteroscopy versus 92.5% for ESWL with no significant variance. Such percentages are consistent with the results found in the previous researches [15,16]. Stones were fragmented into multiple 2mm pieces during the ureteroscopy surgery. In addition, the use of KUB imagery to evaluate stone clearance after one week assisted stone passing. With ESWL treatment, stone clearance rate was evaluated according to the final results, which patients may be subjected to experience for more than one session. Table 4 shows that the stone clearance rate of ureteroscopy was significantly variant from that of single ESWL session. However, multiple ESWL sessions gave similar result to that of ureteroscopy. This might explain the reason ESWL stone clearance rate varied in the range of 80-100% [4,7]. Moreover, stone composition and hardness determined ESWL stone clearance rate.

This study confirms the reliability of Holmium laser lithotripsy for fragmenting stones regardless of composition and hardness. Holmium laser lithotripsy is conducted in all kinds of ureteroscope treatment [19]. However, stone movement causes operation failure [20,21]. Yet, ureteroscopic lithotripsy failure cannot be avoided even with the advances in instruments and capacities. Ureteroscopy treatment application with laser lithotripsy is more suitable to manage stone clearance rate than ESWL single session treatment along with the general effectiveness superiority [22–24]. However, ESWL is still a priority treatment choice for proximal ureteral calculi because of cost-effectiveness and implementation easiness. Furthermore, ESWL is preferred when ureteroscopy fails. In this study, no treatment interval variance was observed on both sample groups. Nevertheless, results show observable variance in procedural period in general between the two sample groups. As for ESWL-treated group of patients, the procedure period consisted of shockwave lithotripsy duration plus two-hour monitoring. Then, patients were discharged home and they were seen in the follow-up appointment after one week. The ureteroscopy-treated group of patients took much more time including operation and hospitalization (3.061.0 vs. 48.068.5 hours). ESWL-treated patients showed faster recovery and they were back to their daily activities within two days, while some ureteroscopy-treated patients showed voiding symptoms which subsided when they had their ureteral stent removed after two weeks [25,26].

The procedural time variance resulted in cost variance. Even if the patients were subjected to three ESWL treatment sessions, the cost variance in the two techniques was still noticeable. Additionally, ureteroscopy, as a surgical choice, requires general anesthesia along with analgesia after the operation, while ESWL, as an outpatient technique, doesn’t require anesthesia nor post-operation analgesia. To sum up, ESWL-treated patients gained more effectiveness in terms of cost than ureteroscopy-treated patients.

This research compared the two techniques in terms of complications. First of all, no severe complications were found such as renal haematoma and ureteral perforation with ESWL, nor in ureteral avulsion for ureteroscopy during application. Second, the ESWL-treated patients showed higher hematuria and renal colic rate than ureteroscopy-treated patients. renal colic and macroscopic bleeding with ESWL, resulted from stone fragments migration and the damage in the ureteral mucosa [27,28]. Little hematuria and renal colic were observed after ureteroscopy as most of the stone fragments were cleared through operating. Most hematuria and renal colic usually clear out after stone passaging needless of special treatment. Finally, voiding symptoms were experienced more by ureteroscopy-treated patients than ESWL-treated patients (67.5% vs. 7.5%). With the ureteroscopy procedure in this research, each patient had ureteral stent, which moved out after two weeks. This might be the explanation of more ureteroscopy-treated patients had voiding symptom. Joshi et al and Lamb et al [29,30] stated that, after having ureteral stents, it is unavoidable for ureteroscopy-treated patients to have voiding symptoms along with other discomforts. It is proved that ureteral stent
discomfort is enhanced by a-blockers, yet their activity is not complete [31]. Perhaps voiding symptoms are the explanation for that many patients reported that they have fears related to of ureteroscopy treatment procedure in a questionnaire. After following up for six months, no ureterostenosis nor residual stones were observed in the two groups of patients.

The answers on a questionnaire after the operation uncovered resemblance in satisfaction rate. About 90% of the ESWL-treated patients showed satisfaction with the treatment in comparison to 83.75% of ureteroscopy-treated patients. Unsatisfaction with most of the ureteroscopy-treated patients was due to high treatment cost and voiding symptoms. To the researcher’s knowledge, no other similar data in a Chinese cohort were found. This research was conducted in a single hospital on only 80 cases, so more research is required with regard of all conclusions through multi-focus prospective for validation purposes. In conclusion, ESWL outpatient treatment needs no analgesia nor anesthesia. Consequently, it prevails as the first treatment of choice for proximal ureteral stones unlike the surgical ureteroscopic laser lithotripsy, which needs general anesthesia, hospitalization and high cost. The decision of which procedure is suitable relies on the characteristics of the stones, the patient acceptance of the treatment and cost effectiveness.

6. Conclusion:

ESWL treatment procedure keeps the prevailing choice of treating ureteral stones. However, the ureteroscopic holmium laser lithotripsy treatment procedure is still described as costlier between the two procedures. To determining which treatment procedure is more suitable is dependent on the stone characteristics as well as the patient acceptance and the ratio of the cost-effectiveness.

7. References

[1] Preminger GM, Tiselius HG, Assimos DG, Alken P, Buck C, et al. (2007) 2007 guideline for the management of ureteral calculi. J Urol 178: 2418–2434.
[2] Turk C, Knoll T, Petrik A, Sarica K, Skolarikos A, et al. (2013) Guidelines on Urolithiasis, European Association of Urology (UPDATE MARCH 2013).
[3] Na YQ, Sun G, Ye ZQ, Sun YH, Sun ZY, et al. (2011) Guideline of Chinese urological disease diagnosis and treatment- Urolithiasis, People’s Health Publishing House, Beijing. p. 241–264.
[4] El-Faqih SR, Husain I, Ekman PE, Sharma ND, Chakrabarty A, et al. (1988) Primary choice of intervention for distal ureteric stone: ureteroscopy or ESWL? Br J Urol 62: 13–18.
[5] Chang SC, Ho CM, Kuo HC. (1993) Ureteroscopic treatment of lower ureteral calculi in the era of extracorporeal shock wave lithotripsy: from a developing country point of view. J Urol 150: 1395–1398.
[6] Birı H, Kupeli B, Isen K, Sinik Z, Karaoglan U, et al. (1999) Treatment of lower ureteral stones: extracorporeal shockwave lithotripsy or intracorporeal lithotripsy? J Endourol 13:77–81.
[7] Pearle MS, Nadler R, Bercowsky E, Chen C, Dunn M, et al. (2001) Prospective randomized trial comparing shock wave lithotripsy and ureteroscopy for management of distal ureteral calculi. J Urol166: 1255–1260.
[8] Marchant F, Storme O, Osorio F, Benavides J, Palma C, et al. (2009) Prospective trial comparing shock wave lithotripsy and ureteroscopy for management of distal ureteral calculi. Actas Urol Esp 33: 869–872
[9] Chaussy C, Brendel W, Schmiedt E. (1980) Extracorporeally induced destruction of kidney stones by shock waves. Lancet 13: 1265–1268.
[10] Chaussy C, Schmiedt E, Jocham D, Brendel W, Forssmann B, et al. (1982) First clinical experience with extracorporeally induced destruction of stones by shockwaves. J Urol 127: 417–420.
[11] Chaussy C, Eisenberger F, Forssmann B.(2007) Extracorporeal shock wave lithotripsy (ESWLH): a chronology. J Endourol 21: 1249–1253.
[12] Young HH, McKay RW.(1929) Congenital valvular obstruction of the prostatic urethra. SurgGynecolObstr 48: 509.
[13] Lyon ES, Kyker JS, Schoenberg HW. (1978) Transurethral ureteroscopy in women: a ready addition to the urological armamentarium. J Urol 119: 35–36.
[14] Teichman JM, Rao RD, Rogenes VJ, Harris JM.(1997) Ureteroscopic management of ureteral calculi: electrohydraulic versus holmium:YAG laser lithotripsy. J Urol 158: 1358–1361.
[15] Liu DY, He HC, Wang J, Tang Q, Zhou YF, et al. (2012) Ureteroscopic lithotripsy using holmium laser for 187 patients with proximal ureteral stones. Chin Med J 125: 1542–1546.
[16] Peschel R, Janetschek G, Bartsch G. (1999) Extracorporeal shockwave lithotripsy versus ureteroscopy for distal ureteral calculi: A Prospective randomized study. J Urol 162: 1909–1912.
[17] Turk T, Jenkins A. (1999) A comparison of ureteroscopy to in situ extracorporeal shockwave lithotripsy for the treatment of distant ureteral calculi. J Urol 161: 45–47.
[18] Lotan Y, Gettman MT, Roehrborn CG, Cadeddu JA, Pearle MS. (2002) Management of ureteral calculi: A cost comparison decision making analysis. J Urol 167: 1621–1629.
[19] Tawfiek ER, Bagley DH. (1999) Management of upper urinary tract calculi with ureteroscopic techniques. Urology 53: 25–32.
[20] Kurahashi T, Miyake H, Oka N, Shinozaki M, Takenaka A, et al. (2007) Clinical outcome of ureteroscopic lithotripsy for 2,129 patients with ureteral stones. Urol Res 35: 149–153.
[21] Yencilek F, Sarica K, Erturhan S, Yagci F, Erbagci A. (2010) Treatment of ureteral calculi with semi-rigid ureteroscopy: where should we stop? Urol Int 84: 260–264.
[22] Aboumarzouk OM, Kata SG, Keeley FX, McClinton S, Nabi G.(2012)Extracorporeal shock wave lithotripsy (ESWL) versus ureteroscopic management for ureteric calculi. Cochrane Database Syst Rev. 2012 May 16.
[23] Lindqvist K, Holmberg G, Peeker R, Grenabo L. (2006) Extracorporeal shockwave lithotripsy or ureteroscopy as primary treatment for ureteric stones: a retrospective study comparing two different treatment strategies. Scand J Urol Nephrol 40: 113–118.
[24] Lam JS, Greene TD, Gupta M. (2002) Treatment of proximal ureteral calculi: holmium:YAG laser ureterolithotripsy versus extracorporeal shock wave lithotripsy. J Urol 167: 1972–1976.
[25] Park J, Shin DW, Chung JH, Lee SW. (2012) Shock wave lithotripsy versus ureteroscopy for ureteral calculi: a prospective assessment of patient-reported outcomes. World J Urol 18. [Epub ahead of print].
[26] Chaussy C, Bergsdorf T. (2009) The Preferred Treatment for Upper Tract Stones Is Extracorporeal Shock Wave Lithotripsy (ESWL) or Ureteroscopic: Pro ESWL. Urology 74: 259–262.
[27] Wilson WT, Preminger GM. (1990) Extracorporeal shock wave lithotripsy: Anupdate. Urol Clin N Am 17: 231–242.
[28] Vural A, Oguz V, Oktenl C, Yenicesu M, Caglar K et al. (1998) Detection of Source of Haematuria after Extracorporeal Shock Wave Lithotripsy (ESWL) by Automated Measurement of Urinary Red Cell Volume. Int Urol Nephrol. 30: 31–37.
[29] Joshi HB, Newns N, Stainthorpe A,MacDonagh RP, Keeley FX Jr, et al. (2003) Urteral stent symptom questionnaire: development and validation of a multidimensional quality of life measure. J Urol 169: 1060–1064.
[30] Lamb AD, Vowler SL, Johnston R, Dunn N, Wiseman OJ. (2011) Meta-analysis showing the beneficial effect of a-blockers on ureteric stent discomfort. BJU Int 108: 1894–1902.
[31] Wang CJ, Huang SW, Chang CH. (2009) Effects of tamsulosin on lower urinary tract symptoms due to double-J stent: a prospective study. Urol Int 83: 66–69.