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Laparoscopic Ureterolithotomy vs Ureteroscopic Lithotripsy for Large Ureteral Stones

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ABSTRACT

Background and Objectives: The purpose of this study was to compare two methods (transperitoneal laparoscopic ureterolithotomy [TLU] and a combination of ureteroscopic lithotripsy [UL] with retrograde intrarenal surgery [RIRS]) designed for the treatment of large proximal ureteral calculi so that their associated complications and stone-free rates could be assessed.

Methods: A total of 100 patients from three different hospitals who were diagnosed with large upper ureteral stones (≥15 mm) were treated via TLU (n = 48) or UL-RIRS (n = 52). They were treated between March 2012 and May 2014. The study compared the complications, success rate, patient characteristics, and the operation time between the two groups.

Results: The immediate stone clearance rate after a single session was higher in the TLU group than in the UL-RIRS group (100% vs 73.1%, $P = .005$). However, there was no significant difference in the stone-free rates between the two groups three months after the last procedure was performed (100% vs 96.1%, $P = .655$). Regarding patients with a history of early-failure extracorporeal shock-wave lithotripsy, there was no significant difference in the stone-free rate between the two groups three months after the last procedure (100% vs 94.4%, $P > .05$). Further, overall complication rates between the groups were not statistically different ($P = .261$).

Conclusion: This study demonstrates that TLU is an effective and safe procedure to treat large impacted upper ureteral stones. When compared to UL-RIRS, TLU showed equivalent efficacy and safety, though there were failed first-line treatments.

Key Words: Transperitoneal laparoscopic ureterolithotomy, Ureteroscopic lithotripsy, Retrograde intrarenal surgery, Proximal ureteral stones.

INTRODUCTION

There is uncertainty as to which treatment option is superior for managing upper ureteral stones. Recently, laser lithotripsy and flexible ureteroscopy were both proven efficacious compared to shock-wave lithotripsy (SWL) in treating large ureteral stones and in causing less retreatment.[1,2] Indications for ureteroscopic lithotripsy (UL) have been extended because of recent technical developments, such as a new generation of flexible ureteroscopes, anti-retropulsion devices, and laser technology.[2] However, different outcomes with regard to ureteroscopic management of large impacted upper ureteral calculi have been reported with stone clearance rates ranging between 33% and 93%.[3] In spite of the fact that the laser-based flexible ureteroscope can treat ureteral calculi with successful stone clearance rates of up to 97%, these instruments require additional costs and more treatment sessions. As a result, their global utilization has been somewhat limited.[3]

Laparoscopic ureterolithotomy (LU) has recently proven itself as an advanced option for the treatment of large proximal ureteral stones. Indications have been confined to select cases, and this technique is considered a final surgical modality for cases of previous SWL or endoscopic failure, large impacted stones, anatomic anomalies, etc.,[4] Currently, LU seems to be primarily indicated for large impacted stones and demonstrates successful stone clearance rates of nearly 100%.[5–6]

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However, in the absence of comparative data, clinicians feel hesitant in declaring an optimal choice for the treatment of proximal large ureteral stones. Therefore, a prospective, nonrandomized comparative study is presented here to assess the safety and effectiveness of the two procedures (i.e., transperitoneal laparoscopic ureterolithotomy [TLU] and UL in combination with Retrograde Intrarenal Surgery [RIRS]), which are designed to treat proximal ureteral stones larger than 15 mm.

MATERIALS AND METHODS

Between March 2012 and April 2014, data were prospectively collected from 100 patients who underwent TLU or UL combined with RIRS (UL-RIRS) for impacted upper ureteral stones greater than 15 mm. These surgeries occurred at three separate hospitals in Korea and were conducted by a total of three skilled urologic surgeons (one per hospital). The hospitals treated 30 cases (16 TLU, 14 UL-RIRS), 42 cases (18 TLU, 24 UL-RIRS), and 28 cases (14 TLU, 14 UL-RIRS), respectively. The institutional review boards at all three hospitals approved of this study. Also, informed consent for this study was obtained from all patients prior to the investigation.

The inclusion criteria called for patients who were diagnosed with a single-impacted upper ureteral (below the ureteropelvic junction to the superior aspect of the sacroiliac joint) large stone (>15 mm at the longest diameter) observed on a plain abdominal film of the kidney, ureter, and bladder or through noncontrast computed tomography. Those patients with a history of SWL or UL for the same ureter stone were also included. Patients with a history of active infection, pregnancy, coagulopathy, or ureter stricture caused by malignancy, a nonfunctioning kidney, or distal ureteral calculi were excluded.

For each patient, the operative method was chosen based on a joint decision made by the patient and the surgeon. The patients were segregated into two groups based on the primary treatment procedure: a TLU group and a UL-RIRS group. Prior to the procedure, the patient was educated on the surgical procedure and the complications associated with it. The patient was assessed through urinalysis and culture, complete blood count, a renal function test, and radiological imaging such as noncontrast abdominopelvic spiral computed tomography or plain kidney, ureter, and bladder radiological film. The impacted ureteral stones were defined as stones that are attached to the ureteral wall as per the diagnosis of intraoperative ureteroscopy or laparoscopy. The procedure was recorded as successful when the stone was completely cleared or if the residual fragments were clinically insignificant (<2 mm) according to postoperative radiological imaging performed after removal of the double-J (DJ) stent. Using noncontrast computerized tomography, the residual stone status was assessed after the removal of the DJ stent. Patients who needed additional treatment for residual fragments were further assessed in the 3 months following the procedure.

TLU Operative Technique

Through cystoscopy, the ureteral catheterization was performed prior to TLU under general anesthesia. According to the patient, this step was omitted. The patients were then placed in the lateral decubitus position (kidney) with a bridge at the flank.

We favored the flank position with 30° lateral inclination. After the open port placement for the camera (10 mm), two closed ports of 12 mm and 5 mm were present. At 12 mm Hg, the CO_2 pneumoperitoneum was preserved. The researchers also used 12-mm trocar (at the operator's right-hand) and a 5-mm trocar (at the operator's left hand). These trocars were placed at 6–8 cm in a lateral position from the first trocar in the anterior axillary line to create an isosceles triangle. Once the laparoscope was introduced into the operative field, the ureter was identified at the anterior position of the psoas muscle and traced to the calculus. A ureteral bulge indicated the location of the ureteral stone, which was confirmed with an atraumatic grasper. The surgeons performed a longitudinal ureterotomy over the lower portion of the stone using a cold knife. The ureterotomy was then extended using scissors, and the stone was extracted using a nontraumatic grasper and placed into a bag. Once the DJ stent was inserted, the ureterotomy was sealed with a 3–0 running Vicryl suture. In the peri-ureteral space, the surgeon placed a hemovac drain. The DJ stent was removed 1 month after the operation.

UL and RIRS

Under general anesthesia, the patient was placed in the lithotomy position. The surgeon used a 7.5- or 8.5-Fr semirigid ureterorenoscope (R. Wolf™; Knittlingen, Germany) to perform the ureteroscopy and a flexible ureteroscope (Karl Storz Flex-X2™; Karl Storz, Tuttlingen, Germany) when necessary. Once the guidewire was inserted under fluoroscopic imaging, the semirigid double-lumen 7.5- or 8.5-Fr ureterorenoscope was inserted into the ureter. The ureterorenoscope was moved toward the stone's location with the help of visual and fluoroscopic images.

The stone was fragmented using holmium laser lithotripsy. The stones (<2 mm) were fragmented and small fragments were left undisturbed so that they would pass via urination. This was followed by the indwelling of a DJ stent, which was removed after 2–4 weeks.

If the retropulsion of large fragments (i.e., >5 mm) into the renal pelvis or calyx occurred during the operation, a ureteral access sheath (11-Fr/13-Fr or 12-Fr/14-Fr) was passed along the guidewire and a flexible ureteroscope (7.5-Fr Storz Flex-X2) was advanced through the ureteral access sheath. The stone was disintegrated using dusting technique with the help of a 200-μm holmium YAG (yttrium aluminum garnet) laser fiber set at 0.5–1.5 J and 8–20 Hz. For this procedure, there was no continuous stone grasping and removal. Some of the residual fragments underwent stone analysis with the help of tipless nitinol baskets. Finally, based on the sole discretion of the surgeon, a DJ stent was indwelled into the patient.

All statistical analyses were performed with SAS software (SAS Institute, Cary, NC). Normally distributed variables were expressed in the form of mean ± standard deviation and compared with student *t*-test. For nonparametric continuous data, the researcher used the Mann-Whitney *U* test. The χ^2 test or Fisher's exact test was used for categorical variables. *P* values <.05 were considered statistically significant.

RESULTS

One hundred patients who met the inclusion criteria were involved in the study. Of those, 48 were placed into a TLU group and 52 were placed into a UL-RIRS group. **Table 1** shows the demographic characteristics of the patients who underwent the study. The patients' mean age was 57.5 ± 12.3 years. Sixty-four (64.0%) patients were male and 36 were female (36.0%). Among the study patients, 36 (36.0%) were diagnosed with ureter calculi on their right side and 64 (64.0%) on their left side. There was no difference between the TLU and UL-RIRS groups with respect to age, sex, body mass index, and side where the stone was located (**Table 1**). There was also no significant difference in stone size between the two groups ($P = .163$) (**Table 1**).

The mean operation times in Groups I and II were 128.5 ± 5.7 and 49.7 ± 2.2 minutes, respectively ($P < .001$). The stone-free rate after a single procedure was 100% in Group I and 73.1% in Group II ($P < .01$). Fourteen patients (26.9%) in Group II were not stone-free after a single procedure. Of those, SWL was performed as an additional procedure on four patients; the other 10 received no additional treatment, allowing residual stones to pass via urination. Three months after the last procedure, the stone-free rate was 96.1% in Group II. An additional UL procedure was conducted in one patient, and further SWL was needed in another

Table 1.
Patient Demographic Data and Stone Characteristics

	TLU Group	UL with RIRS Group	*P* Value
No. of cases (%)	48 (48.0)	52 (52.0)	
Age, years	57.9 ± 1.9	57.0 ± 1.5	.448
Sex			
Male, n (%)	26 (54.2)	32 (61.5)	.293
Female, n (%)	22 (45.8)	20 (38.5)	
BMI (kg/m^2)	23.9 ± 0.5	24.8 ± 0.6	.227
Stone size, cm	2.1 ± 0.0	2.2 ± 0.0	.163
Laterality			
Right, n (%)	14 (29.2)	22 (42.3)	.123
Left, n (%)	34 (70.8)	30 (57.7)	
Radiopacity (radiopaque), n (%)	39 (81.3)	42 (80.8)	.557
Previous failed SWL history, n (%)	14 (29.2)	18 (34.6)	.357
Previous UL failure	1	—	—

BMI, body mass index; RIRS, retrograde intrarenal surgery; SWL, extracorporeal shock wave lithotripsy; TLU, transperitoneal laparoscopic ureterolithotomy; UL, ureteroscopic lithotripsy.

patient. Although TLU had a higher stone-free rate after the primary procedure ($P = .005$), after 3 months, no significant differences in stone-free rates were detected between TLU and UL-RIRS groups (100% vs. 96.1%, $P = .655$) (**Table 2**). The mean duration of hospitalization was significantly different among the groups: the TLU group showed 6.7 ± 0.4 days and the UL-RIRS group showed 4.9 ± 0.6 days ($P < .001$) (**Table 2**). The mean estimated blood loss was 70.6 ± 3.0 mL in the TLU group. DJ stent indwelling time was significantly longer in the TLU group when compared with the UL-RIRS group (4.6 ± 0.1 weeks vs. 2.6 ± 0.1 weeks, $P < .001$) (**Table 2**).

There were no severe complications related to surgery for either group. In the TLU group, six complications were found: transfusion was needed in one case due to bleeding, two cases presented fever because of urosepsis, two patients had prolonged urine leakage (modified Clavien grade 3a), and ureteral stricture occurred in one case. In the UL-RIRS group, 10 complications occurred: one case of ureteral perforation, one transfusion was needed due to bleeding, six cases of infection, one case of urine leakage, and one instance of ureteral stricture. Bleeding to the extent that a transfusion is required and urine leakage are extremely rare complications after RIRS. In this study, one patient experienced bleeding requiring a transfusion, which was caused by a perirenal hematoma, and one patient experienced a perirenal urinoma after RIRS. These were possibly due to high irrigation flow and increased renal pelvic pressure during surgery. The patient with urine leakage was successfully managed using a percutaneous nephrostomy catheter. All cases of ureteral stricture were found within 3 months after the last procedure was conducted and all required a prolonged DJ catheterization. No patient had more than a modified Clavien grade 4 complication in any of the groups (**Table 3**).

Regarding patients with a previously failed SWL, no patient differences were observed between those in the TLU and UL-RIRS groups with respect to age, body mass index, stone laterality, and stone size (**Table 4**). A significant difference in the stone-free rate after a single procedure was found between the two groups (100% vs 72.2%, $P = .043$). However, 3 months after the last procedure, no differences in stone-free rates were noticed between the groups (100% vs 94.4%, $P > .05$). In addition, no significant difference in the total complication rate was found between the UL-RIRS and TLU groups (0 vs 11.1%, $P = .205$) (**Table 4**).

DISCUSSION

LU holds many advantages over open surgery, such as reduced hospitalization, absence of cosmetic damage, reduced analgesia, and rapid convalescence[7] while also maintaining a stone removal rate comparable to open surgery. As a result, the acceptance of LU as an alternative to open surgical techniques to treat large proximal ureteral stones has increased.

In spite of the fact that a number of impacted ureteral stones can be managed well by UL or SWL, LU seems to be the best alternative when removing impacted ureteral stones larger than 15 mm.[8–9] When comparing SWL, UL, and LU, the LU technique seems to be free from any hindrances such as access difficulty and stone burden. In fact, one can almost achieve a 100% stone-free rate in a

Table 2.
Comparison of Perioperative Data

Variables	TLU Group	UL with RIRS Group	*P* Value
Operation time (min)	128.5 ± 5.7	49.7 ± 2.2	<.001
Hospital stay (days)	6.7 ± 0.4	4.9 ± 0.6	<.001
D-J stent duration (weeks)	4.6 ± 0.1	2.6 ± 0.1	<.001
EBL (mL)	70.6 ± 3.0	—	—
Stone-free rate at 1 month, n (%)	48 (100)	38 (73.1)	.005
Stone-free rate 3 months after the last procedure, n (%)	48 (100)	50 (96.1)	.655
Lithotriptor (laser), n (%)	—	34 (65.4)	—

EBL, estimated blood loss; RIRS, retrograde intrarenal surgery; TLU, transperitoneal laparoscopic ureterolithotomy; UL, ureteroscopic lithotripsy.

Table 3.
Complications According to the Clavien Grading System

	TLU Group	UL with RIRS Group	*P* Value
Grade I			
Ureteral perforation	—	1	
Renal colic	—	—	
Ileus	—	—	
Transfusion	1	1	
Grade II			
Infection/fever	2	6	
Grade IIIa			
Urine leakage	2	1	
Grade IIIb			
Ureteral stricture	1	1	
Grade IV			
Sepsis	—	—	
Total complication, n (%)	6 (12.5)	10 (19.2)	.261

RIRS, retrograde intrarenal surgery; TLU, transperitoneal laparoscopic ureterolithotomy; UL, ureteroscopic lithotripsy.

single LU session.[9–11] Thus, LU is the favorable solution for most cases of large, impacted, or multiple ureteral stones when flexible ureteroscopy remains unavailable.[10]

There have been tremendous improvements regarding SWL, and its success rate is purely dependent on the stone size, its location, and the degree of ureteral obstruction. A recent study reported an 84% stone-free rate after one session of SWL for ureteral stones, although this rate dropped to 42% if the stone size was >1 cm.[12] When compared with UL, SWL is a costly option even for treating ureteral stones smaller than 15 mm.[13] Further, when repeated SWL sessions are conducted, they may result in damage of renal tissues as well as renal atrophy.[14] Thus, in modern practice, SWL is not preferable when treating large ureteral stones.

Several studies have shown a high success rate (i.e., 86%–100%) with percutaneous nephrolithotomy (PNL).[15–17] Long et al.[19] conducted a study in which they assessed the efficacy and safety of mini-PNL when treating large proximal ureteral stones. They achieved a 95.7% stone-free rate after the initial round of the procedure.[18] Though PNL exhibits a high success rate, it may result in other serious complications including severe bleeding, urine leakage, injury of the surrounding organs, and sepsis. In some studies, the complication rates were as high as 83%.[19]

Kaygisiz et al.[6] recently reported similar 3-month stone-free rates with UL when compared to LU for large upper and midureteral stones (96.6% vs. 100%, $P = .483$).[5] However, they included slightly fewer upper ureteral stones cases in the UL group than in the LU group (51.7% vs. 77.4%). Furthermore, the mean stone diameter in the UL group was smaller than the mean stone diameter in the LU group (15 mm vs 20 mm, $P = .005$). In a randomized controlled trial, Wang et al.[21] assessed the efficacy and safety of three procedures (mini-PNL, UL, and retroperitoneal LU) in treating impacted upper ureteral stones larger than 15 mm.[20] They revealed that retroperitoneal LU and mini-PNL provided a higher stone-free rate (100% vs. 96% vs. 72%) with a similar complication rate among the three groups ($P > .05$) 1 month after the procedure. Also, 15 patients required auxiliary SWL post-UL whereas only three patients required auxiliary SWL after mini-PNL, and there was no such case reported after retroperitoneal LU. Further, Kumar et al.[1] prospectively evaluated LU versus UL for proximal ureteral stones larger than 2 cm in size and demonstrated that LU had a higher stone-free rate, comparable operating time, reduced need for auxiliary procedures, and lower complication rate compared with UL.[21] These results are similar to our findings.

We combined UL-RIRS in order to increase the stone-free rate and decrease the need for further auxiliary procedures. Although this combined method showed a higher clearance rate and a lower complication rate than has been reported by previous studies, further auxiliary procedures were still required in some cases.

The current study demonstrates that TLU exhibits high stone-free and low re-treatment rates compared to UL-RIRS after the first attempt. After the first attempt with LU and UL-RIRS, success rates were 100% and 73.1%, respectively. And though there was a high success rate in the TLU group, with longer operation and hospitalization times when compared to the UL-RIRS group, both treatments exhibited satisfactory results with low morbidity rates. Even in patients with previously failed SWL, both procedures showed comparable stone-free and complication rates in the treatment of large impacted upper ureteral stones. In the UL-RIRS group, there was an unusual complication of bleeding, which required a transfusion. It was caused by a perirenal hematoma after surgery, and it was managed conservatively. With regard to hospital stay duration, our results indicated slightly longer durations than those reported in other studies.[6,7] This could be due to differences in healthcare systems and cultural backgrounds. For instance, Korean patients usually remain in the hospital until the surgical suture is removed.

Table 4.
Comparison of Perioperative Outcomes in Patients with a Previously Failed ESWL History

	TLU (n = 14)	UL with RIRS (n = 18)	*P* Value
Age (years)	52.7 ± 3.6	53.7 ± 2.8	1.000
BMI (kg/m^2)	24.2 ± 0.8	25.1 ± 1.6	.970
Laterality (right), n (%)	4 (28.6)	7 (38.9)	.410
Stone size (cm)	2.0 ± 0.1	2.1 ± 0.0	.129
Operative time (min)	116.5 ± 10.0	50.9 ± 1.7	<.001
Hospital stay (days)	5.7 ± 0.3	5.7 ± 1.2	.133
Stent duration (weeks)	4.5 ± 0.2	3.2 ± 0.3	.002
Stone-free rate at 1 month, n (%)	14 (100)	13 (72.2)	.043
Stone-free rate 3 months after the last procedure, n (%)	14 (100)	17 (94.4)	.318
Urine leak, n (%)	0	0	—
Stricture, n (%)	0	1 (5.6)	.378
Other complications, n (%)	0	1 (5.6)	.378
Total complications, n (%)	0	2 (11.1)	.205

BMI, body mass index; RIRS, retrograde intrarenal surgery; TLU, transperitoneal laparoscopic ureterolithotomy; UL, ureteroscopic lithotripsy.

The present study has several limitations. First, this was a prospective, multi-institutional study involving multiple surgeons using different sets of equipment; therefore, the results presented here are vulnerable to inherent biases. Second, this study was not randomized and selection bias may be present; but, this aspect was beyond our control due to the broad geographic distribution of the hospitals and the different specialties of the participating surgeons. However, the above limitations may have been balanced by the routine use of noncontrast computed tomography scanning as the standard examination for postoperative stone-free evaluation. Limitations may have also been balanced by the multi-institutional nature of the study. Further randomized trials with a higher number of patients may provide additional evidence to the aspects that were not addressed in the present study.

CONCLUSION

From this study, it can be concluded that TLU is a safe and effective option for treating large impacted upper ureteral stones after unsuccessful front-line treatments. Even though TLU resulted in longer operation times, longer hospital stays, and longer ureteral stent indwelling durations compared with UL-RIRS, TLU still achieves a higher stone clearance rate than UL-RIRS without auxiliary procedures.

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