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ORIGINAL PAPER

Outcome of Transperitoneal Laparoscopic Ureterolithotomy (TPLU) for proximal ureteral stone > 15 mm: Our experience with 60 cases

Ali Eslahi [1, 2], Faisal Ahmed [3], Mohammad Rahimi [1], Seyed Hamed Jafari [4], Seyyed Hossein Hosseini [1], Saleh Al-wageeh [5], Pegah Mohammad Zadeh Shirazi [1], Khalil Al-naggar [3], Ebrahim Al-shami [3], Mohammad Hossein Taghrir [6]

[1] Department of Urology, School of medicine, Shiraz University of Medical Sciences, Shiraz, Iran;
[2] Shiraz Geriatric Research Center, Shiraz University of Medical Sciences, Shiraz, Iran;
[3] Urology research center, Al-Thora hospital, Department of Urology, Ibb University of Medical Since, Ibb, Yemen;
[4] Medical Imagining Research Center, Shiraz University of Medical Sciences, Shiraz, Iran;
[5] Department of General Surgery, Ibb University of Medical Science, Ibb, Yemen;
[6] Trauma Research Center, Shahid Rajaee (Emtiaz) Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, Iran.

Summary *Purpose: We aim to review our experience of transperitoneal laparoscopic ureterolithotomy (TPLU) for proximal ureteric stone more than 15 mm.*
Patients and methods: Between June 2017 to December 2020, sixty patients with a history of unsuccessful Extracorporeal shock wave lithotripsy (ESWL) and/or failed ureteroscopy for impacted ureteral calculi more than 15 mm who accepted TPLU were enrolled in our study. The patients' demographic information and post-treatment results were gathered and analyzed, retrospectively.
Results: The patients' mean age was 46.25 ± 12.56 years. The mean size of the stone was 20.11 ± 4.76 mm. 37 (61.7%) patients had severe hydronephrosis (HDN) and 46 (76.7%) stones were radio-opaque. Almost all of the patients underwent TPLU by a single urologist. The mean operation time was 72.86 ± 6.07 minutes without intraoperative complication (only 3 stones had upward migration to the pyelocaliceal system). The main operative blood loss was 88.86 ml. The average length of stay in the hospital was 45.8 ± 8.11 hours. The stone free rate (SFR) at discharge was 57 (95%). The overall complication rate was 27 (45%). Regarding early complications, fever was found in 8 (13.3%) patients, and 3 patients (5%) had paralytic ileus. The rate of urine leak was 8.3%, and 8 (13.3%) patients required blood transfusions. In multivariate analysis, the multiple stones, bigger stone in size, incomplete SFR, longer duration of hospital admission, and severe HDN were associated with a high early complication rate (p = 0.05, 0.04, < 001, 0.03, and 0.01, respectively).
Conclusions: TPLU is a harmless option for managing proximal ureteric stone as a primary procedure or salvage procedure with good outcomes and acceptable complication rates.

KEY WORDS: Proximal Ureteral Stones; Laparoscopy; Ureterolithotomy; Transperitoneal approach; Complication.

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INTRODUCTION

Proximal ureteric calculi could be handled in a variety of different ways such as *extracorporeal shock wave lithotripsy* (ESWL), which is really the first option, *percutaneous nephrolithotomy* (PCNL), flexible ureteroscopy, laparoscopic ureterolithotomy, and open ureterolithotomy (1). On the other hand, novel equipment for endoscopic stone fragmentation and improved expertise of many urology surgeons in laparoscopic surgeries have limited the indications for open surgery (2). Where the endoscopic access is impossible or inefficient due to the anatomy of the ureter or size of the stone, the ureterolithotomy laparoscopic technique can be another viable option to open surgery, which may be performed via *retroperitoneal laparoscopic ureterolithotomy* (RLP) or *transperitoneal laparoscopic ureterolithotomy* (TPLU) (3).
Skolarikos et al. attempted to determine the evidence level and recommendation score for the laparoscopic technique for removal of the stone. Laparoscopic ureteral surgery has the greatest degree of evidence. When compared to open ureterolithotomy, it is entirely feasible and has a reduced post-surgical morbidity. It is often used to treat large impacted calculi or when endoscopic ureteral surgery and ESWL have failed (1). TPLU is recommended for the less experienced surgeons; moreover, it provides more workspaces and allows for more accurate recognition of anatomical structures. On the other hand, prior surgery of the abdomen with the high risk of adhesions may be a restrictive factor (4). In this study, we represent our experience of TPLU for proximal ureteric stone in 60 cases.

MATERIALS AND METHODS

Study design

The ethics committees of *Shiraz University of Medical Sciences* approved this project (approval code# IR.SUMS.MED.REC.1399.585), and it was carried out in compliance with the Helsinki Declaration. In a cross-sectional study, which was also conducted retrospectively, the patients who had undergone TPLU for proximal ureteral stone more than 15 mm between June 2017 and

No conflict of interest declared.

December 2020 in our referral centers (*Nemazi Teaching Hospital and Ali-Asghar Teaching Hospital, Shiraz, southern Iran*) were considered for this study. During this period, 60 patients were enrolled in our study.

Inclusion criteria
Patients who accepted TPLU in our center, including those with failed and/or refused ESWL or ureteroscopy, impacted stones, stones larger than 15 mm, and stones located in the proximal ureter (between the ureteropelvic junction and the upper edge of the pelvis).

Exclusion criteria
Patients with stone less than 15 mm, uncorrected coagulopathy, active *urinary tract infection* (UTI), contraindication to general anesthesia, previous surgery in the ureter or abdomen, and urinary tract abnormality.

Data collection
The information about gender, age, size of ureteral stones, laterality, stone opacity, main symptoms, amount of *hydronephrosis* (HDN), operating time, blood loss, *stone-free rate* (SFR), postoperative hospital stay, complications, stone analysis, and data on follow-up, time of follow-up, stone recurrence, and other complications were collected retrospectively. Also, a full *blood count* (CBC) and a renal function test (BUN and creatinine), urine analysis and urine culture were done. Those with positive cultures were treated with proper antibiotic and admitted with sterile urine for operation. All patients were admitted 12 hours before the operation and received parenteral hydration and a single dose of prophylactic antibiotic. They were definitely diagnosed before operation, using the results of plain abdominal X-ray, *ultrasonography* (US), intravenous urography (IVU), and abdominal pelvic *computed tomography* (CT) scan (5). All of them were informed that they would be monitored for three months after the surgery. In a CT scan, the *stone-free rate* (SFR) was identified as the absence of any residual stone. Prolonged drainage was defined as urine leakage requiring drainage for more than 3 days. Also, paralytic ileus was defined as absence of bowel sound lasting for over 36 hours.
In order to figure out what factors could influence the rate of early complications, we evaluated the preoperative factors such as age, gender, *body mass index* (BMI), laterality, stone size, main symptoms, previous surgery (ESWL, URS), serum creatinine, amount of HDN and stone opacity, and operation factors such as the mean operative time, bleeding, SFR and hospital stay; then, we compared them with early complications such as need to a second procedure, blood transfusion, fever, ileus, urinary leakage, and stent migration.

Operative technique
All the procedures were carried out by one skilled urologist (A.E.), who specialized in urologic laparoscopic surgery. After anesthesia induction, the patients were put in flank position while the table of operation was flexed. A pneumoperitoneum of 12-15 mm Hg was obtained by a Veress needle placed into the abdominal cavity through the umbilicus. The operation was carried out through three ports; the first was a 10 mm camera trocar implanted two finger breadths lateral and upper to the umbilicus or lateral umbilical depending on the patient's stature and the other 2 ports were developed at the iliac fossa (10 mm) and subcostal (5 mm) in the mid-clavicular line in cases of the left side, while in the case of the right side, a 5 mm port was placed in the right iliac fossa, and a 10 mm port in the subcostal area in the mid-clavicular line. In certain circumstances, an extra port at the flank was placed for the assistant. In right-side cases, a fourth 5 mm trocar is sometimes implanted for retraction of the liver. The ureter was detected after reflection of the colon, and the stone was found and removed via electrocautery vertical ureterotomy. After that, a 6 F ureteral feeding catheter was implanted as a double J stent, and the ureteral incision was sutured with 5/0 Vicryl sutures. The calculi were removed in a sac via the 10 mm port using a 5 mm scope. A small drain was implanted and removed until the fluid level dropped below 20 ml, and the ureteral catheter was removed 7-10 days later via cystoscopy.

Statistical analysis
The mean ± SD, median, and *Inter-Quartile Range* (IQR) described the quantitative variables, and for qualitative variables, frequency (percent) was used. Non-parametric test was used if data distribution was not standard. Chi-square test was used to assess the potential statistically significant difference. ANOVA was applied to compare the difference of the means between more than two different levels. A P value of 0. 05 or less was considered statistically significant. SPSS version 20 was used to analyze the data.

Results
Table 1 shows the patients' characteristics and perioperative details. The mean age of the patients was 46.25 ± 12.56 years. The mean size of the stone was 20.11 ± 4.76 mm. There were 40 (66.6%) males and 20 (33.4%) females; 36 (60%) ureteral calculi were on the left side and 24 (40%) on the right side. The mean BMI of the patients was 23.66 ± 35.1 kg/m^2 (range 18-35); 31 (51.7%) patients were selected for TPLU as the primary procedure, 21 (35%) patients had failed ESWL, and 8 (13.3%) had failed ureteroscopy (URS). About 37 (61.7%) patients had severe HDN and 46 (76.7%) stones were radiopaque.
The main symptoms at presentation were flank pain which was present in 24 (40%) patients. All procedures were carried out via laparoscopy, with no switch to open ureterotomy. Mean operation time was 72.86 ± 6.07 min (range 60-85 minutes). The overall operative blood loss was 88.86 ml (range 21-200 mL). The hospital stay was 45.8 ± 8.11 hours (range 36-72 hours). The SFR at discharge was 95%.
During the surgery, 3 (5%) patients were reported to have ureteral calculus that had moved to the pyelocaliceal system. Stones were captured in the pyelocaliceal system by passing a semirigid ureteroscope via one of the ports and then via ureteral incision. Then, the stones were removed using non-crushing grasping forceps.
The mean time resuming the oral intake was 24.2 ± 2.8 hours. The mean drain removal time in our study was 3.3 days (range 2-7).

Table 1.
Characteristics of the patients.

Variables	
Gender (male/female)	40/20
Age (year) [a]	46.25 ± 12.56, (22-77)
BMI (kg/m^2) [a]	23.66 ± 35.1, (18-35)
Stone size (mm) [a]	20.11 ± 4.76
History of failed (ESWL/ URS) [b]	21 (35%)/8 (13.3%)
Pre-op hemoglobin (mg/dL) [a]	13.85 ± 0.91, (12-16)
Main symptoms of presentation [b]	
Flank pain	24 (40%)
Vomiting	9 (15%)
Hematuria	8 (13.3%)
Fever	8 (13.3%)
Creatinine rise	7 (11.7%)
Abdominal pain	4 (6.7%)
Indication for laparoscopy [b]	
Primary procedure	31 (51.7%)
History of failed ESWL	21 (35%)
History of failed URS	8 (13.3%)
Laterality (left/right)	36/24
Degree of HDN [b]	
No	2 (3.3%)
Mild	5 (8.3%)
Moderate	16 (26.7%)
Severe	37 (61.7%)
Stone opacity [b]	
Radiopaque	46 (76.7%)
Radiolucent	14 (23.3%)

[a] Data was presented as Mean ± SD, range, and [b] Data was presented as n (%).
BMI; body mass index, ESWL; Extracorporeal shock wave lithotripsy, HDN; hydronephrosis, URS; Ureteroscopy.

Regarding early complication, fever was found in 8 (13.3%) patients who were treated with antipyretic therapy. Three patients (5%) had paralytic ileus which resolved with observational management, and 2 (3.3%) of those patients had UTI which was treated with antibiotic therapy. Stent migration was seen in 6 (10%) patients. Additionally, the rate of urine leak was 8.3%. Eight (13.3%) patients required blood transfusions to restore the hemodynamic state. Regarding late complications, over a mean follow-up period of 10.8 ± 6.6 (range 3-24) months, 2 patients (3.3%) experienced stone recurrence (Table 2).

Table 2.
Intraoperative and postoperative data.

Variables	
Operation time (minutes) [a]	72.86 ± 6.07, (60-85)
Stone free rate [b]	57 (95%)
Hospital admission (hours) [a]	45.8 ± 8.11, (36-72)
Post-op hemoglobin (mg/dL) [a]	13.10 ± 1.04, (10.5-15)
Drain removal (days)	3 (2-7)
Blood loss (mm) [a]	88.86 ± 45.23, (21-200)
Early complications [b]	27 (45%)
Stone migration	3 (5%)
Blood transfusion	8 (13.3%)
Fever/UTI confirmed	8 (13.3%), 2 (3.3%)
Ileus	3 (5%)
Urinary leakage	5 (8.3%)
Late complications [b]	
Recurrence of stone	2 (3.3%)

[a] Data was presented as Mean ± SD, range, and [b] Data was presented as n (%).
UTI; Urinary tract infection.

Table 3.
Preoperative and intraoperative data in patients without/with early complications.

Variable		No (N = 33)	Yes (N = 27)	P value
Age (years) [a]		45.97 ± 12.87 (22-70)	46.84 ± 12.18 (32-77)	0.80
Sex [b]	Male	29	11	0.32
	Female	12	8	
BMI (kg/m^2) [a]		23.53 ± 3.69 (19-35)	23.94 ± 3.17 (18-30)	0.36
Laterality [b]	Left	25	11	0.82
	Right	16	8	
Stone opacity [b]	Radiolucent	12	2	0.11
	Radiopaque	29	17	
Amount of HDN [b]	No	2	0	0.01*
	Mild	1	4	
	Moderate	12	4	
	Severe	28	9	
History of failed URS [b]	No	36	16	0.70
	Yes	5	3	
History of ESWL [b]	No	25	14	0.33
	Yes	16	5	
Stone size (mm) [a]		18.85 ± 3.38 (14-30)	22.31 ± 6.23 (15-35)	0.04*
Number of stones [b]	Single	37	16	0.05*
	Multiple	1	6	
Pre-op hemoglobin (mg/dL) [a]		13.87 ± 0.92 (12-16)	13.81 ± 0.90 (12-15)	0.94
Operation time (minutes) [a]		72.04 ± 5.69 (60-85)	74.63 ± 6.65 (65-85)	0.20
Blood loss (ml) [a]		90 ± 43 (23-200)	86 ± 51 (21-200)	0.57
Hospital admission (hours) b	36	13	4	0.03*
	48	28	12	
	72	0	13	
Stone free rate [b]	Complete	41	16	0.00*
	Non complete	0	3	

P-values < 0.05 were considered significant. [a] mean ± SD (Range), [b] number.
BMI; body mass index, ESWL; Extracorporeal shock wave lithotripsy, HDN; hydronephrosis, URS; Ureteroscopy.

Regarding stone analysis, calcium oxalate stone was seen in 28 (46.7%) patients, uric acid in 11 (18.3%), struvite in 9 (15%), mixed stone in 8 (13.3%), and cystine in 4 (6.7%).

We additionally compared preoperative, operative factors and SFR with early complications and found that multiple stone, large stone, incomplete SFR, longer duration of hospital stay, and severe HDN were associated with a higher early complication rate with a p value of 0.05, 0.04, < 001, 0.03, and 0.01, respectively (Table 3).

Discussion

ESWL, PCNL, RLU and URS are standard treatment options for proximal ureteral calculi (6). However, the ESWL lower stone-free rate, possibility of increasing the risk of hypertension and diabetes mellitus in the long-term, and possible need for multiple treatment sessions are the main limitations of this procedure since complete stone removal is the target (7, 8). After ESWL, re-treatment is needed in up to 36% of cases. Approximately 7% of ureteral stones treated with ureteroscopic therapy required additional operations, and approximately 1-10% required open surgical approach. Many of these additional interventions increased the patient's morbidity. As a result, TPLU is a

viable option for handling these difficult stones (9). Laparoscopic ureteral surgery is progressively replacing the open surgery as the surgeon's experience improves. It is accompanied with reduction in the overall morbidity as well as decrease in hospital stay, and improved cosmetic outcomes with comparable functional outcomes (10). It is a valuable alternative to open ureterolitholithotomy as the first option for proximal ureteric calculi greater than 15 mm in today's world of minimally invasive surgery (3). Furthermore, proximal location of ureteral stone and stone impaction are the primary predictors of unfavorable URS effects (11).

Laparoscopy can be performed with two methods, TPLU or RLU, with the primary determinant of the choice being the surgeon's preference and experience. The disadvantages of the RLU include a small working space, which might cause difficulties with orientation, visualization, organ trapping, trocar spacing, and freeing periureteral inflammatory adhesions due to long impaction time of the stone (12). Furthermore, damage to intraperitoneal organs and hernia can arise following balloon inflation of the extraperitoneal cavity. Complication rate, number of medications for pain relief required, duration of the hospital stay, and time required to resume daily activities after the procedure were similar in transperitoneal and retroperitoneal approaches (9, 10).

The mean age of the patients in our study was 46.25 years with a range of 22 to77 years and male to female ratio of 2:1. The mean age of the patients in the study of *El-Feel et al.* was 39.8 years with a range of 13 to 60 years (13).

The most common indication of TPLU in our study was primary procedure for impacted upper stones in 51.7% of patients, followed by failed ESWL in 35%, and failed URS in 13.3% of cases. Our results are similar to previous papers such as those of *Huan et al.* (14), *El-Moula et al.* (2), and *Nasseh et al.* (15).

In our report, 61.7% of patients had severe HDN. *Hsiao et al.* investigated the effect of HDN on the outcome of ESWL of a single upper ureteral calculus and found that in patients with stone more than 10 mm, the outcome of ESWL was poor if the HDN was moderate or severe. Other procedures like ureteroscopic therapy and laparoscopic surgery can be used as the primary therapy or when a first session of ESWL fails (16).

Therefore, there are not major differences of our study compared with other studies.

In the study by *Wani et al.*, the main symptom was flank pain which presented in 80% of patients and it was followed by burning micturition in 36.6% of patients (17). Similarly, in our study, 40% of patients had flank pain, 15% vomiting, and 13.3% fever.

The mean BMI in our study was 23.66 ± 35.1 kg/m^2 (range 18-35 kg/m^2). Similarly, the mean BMI reported in a previous study was 22.5 ± 2.20 kg/m^2 (range 19.3-27.9 kg/m^2) (14). Mean size of the stone in our study was 20.11 ± 4.76 mm and, similarly, *El-Feel et al.* reported a mean stone size of 1.9 ± 0.7 mm (13).

The operation time of our study was shorter than those of *Al-Sayyad* who reported a mean time of 107 ± 49.5 minutes (4) and of *El-Feel et al.* who reported a mean operation time of 145 ± 42 minutes (13). The shorter operative time may be due to the high number of cases who undergo laparoscopy via TPUL method in our center. Furthermore, the operation was accompanied with reduced operative blood loss, with a mean of 88 ml in our study, which was consistent with previous studies such as that by *El-Feel et al.* (13).

The time of operation gradually reduces with developing of skills and experience. The global issues that affect the time of operation are the time to identify the ureter, identification of the stone location, skillful passage of the catheter stent with antegrade approach, and quick intracorporeal suturing of the ureter.

Identification of the ureter might be difficult and frustrating (18, 19). In our study, we had problematic ureteric identification in some patients. We think that identification of the ureter and stone is not easy in the patients with previous double J stent placement because the amount of HDN is insignificant and the total course of the ureter is dilated. Sweeping in distal to proximal direction should be avoided during dissection since the stone could migrate to the pyelocaliceal system. The easiest method to find the ureter is to identify the psoas muscle and look anteriorly for the ureter. If that's not sufficient, it can be identified in front of the iliac vessels (18). In our report, 3 (5%) patients had ureteral stones that moved to the pyelocaliceal system during the procedure. The stone was chased in the pyelocaliceal system using a semi-rigid ureteroscope which entered via one of the ports and then via the site of ureterotomy. The stones were then extracted using non-crushing grasping forceps (18, 20).

There was no intra-operative complication in this study and all the laparoscopic procedures were completed successfully; none of them had to be converted to open surgery. This can be attributed to careful patient selection and the operative surgeon's expertise. The SFR of 83-100% and a low conversion rate confirmed the safety and efficiency of TPLU performed by experienced surgeons (1). Simforoosh et al published a large-scale study of ureteral laparoscopic surgery on 123 participants; the RLU *vs.* TPLU approach was compared for proximal ureteral stone. The total SFR was 96.7% and the operative time of the TPLU was shorter (137 *vs.* 171 min; p = 0. 02). Minor complications were observed in 11.4% of patients. The migration of the stone necessitated switching to open surgery in one patient (21). Compared with previous series, we had an acceptable SFR of 95%.

In our study the mean removal time of drain was 3.3 days (range 2-7), which was like reported by other articles such as that of *You et al.* which removed the drain after 3.1 ± 1.3 days in the laparoscopy stented group (22). Mean hospital stay in this study was 45.8 ± 8.11 (36-72) hours, which was consistent with *Matias et al.*, who reported a 3.3 days of hospital stay after operation (23).

The overall number of post-op complications in this study was 25 (41%). However, most of our complications were minor and easily managed. The most common complication of TPLU is prolonged urinary leakage which is observed when the site of ureterotomy is not sutured or when stenting of the ureter is not used (1). We did laparoscopic suturing and inserted a ureteral catheter as a stent in all the cases of TPLU. Urine leakage in the present study was seen in 5 (8.3%) patients; in persistent leakage, the position of feeding tube catheter was evalu-

ated, and if it was migrated, it was taken out and the leak was prevented by the insertion of double J stent.
In another study of RLU approach on 50 patients with large ureteric stone (1.5 cm), 20% of the patients experienced urinary leakage, necessitating secondary drainage with a double J stent (24). In the study carried out by *Gaur et al.*, the prolonged leakage of urine (more than 7 days) was seen in 20 out of 101 patients although in 14 of these patients the site of ureterotomy was not sutured and the stenting of the ureter was not used (25).
El-Feel et al. reported about TPUL in 27 patients. They experienced postoperative paralytic ileus in one patient (13). In our study, paralytic ileus was observed in 3 (5%) patients and resolved with observational management in 2-5 days. Colon mobilization, blood and urine spill in the peritoneal cavity, as well as visceral dissection and retraction during the procedure might be the main factors for paralytic ileus.
Keeley et al. reviewed their experience with TPLU in 14 patients; in their study, low grade fever was detected in one patient (26). In the study by *Khalil* and coworkers, postoperative fever was observed in 15.4% of the TPLU group (27). In our study, low grade fever was present in 8 (13.3%) patients which relieved by administration of a suitable antipyretic drug. More non-opaque stones and ileus could explain this higher rate of fever (28). Furthermore, UTI was documented in 2 (3.3%) of those patients, which was treated with suitable antibiotic therapy. Blood transfusion was needed to restore the hemodynamic state in 8 (13.3%) patients. In the study by Khalil and coworkers, the need for blood transfusion in the TPLU group was 15.4% (27).
Chen et al., comparing safety and efficacy between TPLU and RLU for proximal ureteral stones > 10 mm, mentioned that the overall rate of blood transfusion was 2.8% (12). Our explanation for the high rate of blood transfusion might be due to mild anemia in our patients and previous ESWL, which caused extensive adhesions making difficult dissection and obscured anatomy leading to excessive bleeding.
In adjunct to preoperative factors, operative factors and SFR may be associated with early complication rate in our study. We found that multiple stones, larger stone size, non-SFR status, longer duration of hospital stay, and severe HDN were associated with high early complication rate. It is important to mention that the significance of the stone size was due to the total stone size calculated by non-contrast CT scan, and the single large stone did not significantly have an effect on the complication rate.
Sing et al. compared the TPLU and RLU in a prospective randomized study and stated that treating proximal and mid-ureteral stone, larger stone, and impacted stones with TPLU were correlated with additional pain, more tramadol necessity, ileus, and prolonged hospital stays than RLU (29). *El-Feel et al.* reported TPUL in 27 patients and analyzed the factors that may affect the operation time concluding that BMI, laterality, and stone level had no statistically significant effect on the mean operative time (13). According to *Huri et al.,* prolonged hospital stay and operative time can be attributed to larger stones and excessive urinary leakage. However, in their view, the general achievement is that ureteral laparoscopic surgery is a viable and appropriate method, particularly for calculi that cannot be effortlessly treated with endoscopic surgery (30).
The small sample size and retrospective nature of this study were our major limitations together with lack of comparison with other procedures. In fact, SWL and URS are more likely considered for primary treatment of proximal ureteral stone. While TPLU could also produce an acceptable result, its use would be limited due to greater difficulty and trauma. Indeed, given the procedures and practice, as well as the patients' circumstances, the best approach is the safest for patients. Furthermore, we have limited our study to the short-term assessment of TPLU. After all, TPLU damages the natural structure of the ureter. The long-term effects of TPLU are still unknown, and further research is needed to draw definitive conclusions.

Conclusions

Our study supports the results of previous studies, suggesting TPLU as a harmless choice for treating proximal ureteral calculi as a primary procedure or salvage procedure with excellent outcomes and acceptable complications. Additionally, larger stone size, multiple stones, incomplete stone-free rate, longer duration of hospital stay, and severe hydronephrosis were associated with a high rate of early complication.

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Correspondence

Ali Eslahi, MD
alieslahi@yahoo.com

Mohammad Rahimi, MD
mohammadrahimi888@gmail.com

Seyyed Hossein Hosseini, MD
shhosseini_6687@yahoo.com

Pegah Mohammad Zadeh Shirazi, MD
mohammadzadeh.sh6@gmail.com

Department of Urology, School of Medicine, Shiraz University of Medical Sciences, Shiraz (Iran)

Faisal Ahmed, MD (Corresponding Author)
fmaaa2006@yahoo.com
Urology Office, Al-Thora Hospital, Alodine street, Ibb (Yemen)

Seyed Hamed Jafari, MD
hamed338@yahoo.com
Medical Imagining Research Center, Shiraz University of Medical Sciences, Shiraz, (Iran)

Saleh Al-wageeh, MD
alwajihsa78@gmail.com
Department of General Surgery, Ibb University of Medical Science, Ibb (Yemen)

Khalil Al-naggar, MD
Ebrahim Al-shami, MD
Urology Office, Al-Thora General Hospital, Alodine street, Ibb (Yemen)
alshami_ebrahim@yahoo.com

Mohammad Hossein Taghrir, PhD
mhtaghrir@gmail.com
Urology Office, Faghihi Hospital, Zand Blvd., Shiraz (Iran)