BANGLADESH JOURNAL OF
UROLOGY
Bangladesh J. Urol. 2022; 25(2): 93-97
www.banglajol.info/index.php/BJU
DOI: https://doi.org/10.3329/bju.v25i2.68588

Original Article
ISSN : 2304 - 8514 (Print)
ISSN : 2304 - 8522 (Online)

Efficacy and Safety of Treatment Options for Large Upper Ureteral Stone

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Received: 27 - 01 - 2022
Accepted: 21 - 01 - 2022
Conflicts of interest: None

Abstract

Background: *There are three minimally invasive methods for the treatment of large (>1 cm) upper ureteral stones: ureteroscopic lithotripsy (URSL), percutaneous nephrolithotomy (PCNL) and laparoscopic ureterolithotomy (LUL). With multiple surgical options, the controversy of choosing the best option for a given patient lies.*

Objective: *To compare efficacy and safety between URSL, PCNL and LUL to determine the best choice.*

Methodology: *This study was conducted from March 2020 to February 2022 with 120 patients who had upper ureteral stones admitted at NIKDU. They were randomized into 3 equal URSL, PCNL & LUL groups, 40 patients in each group. The primary outcome was a stone-free rate after 1 month of surgery, and the secondary outcomes were the duration of surgery, length of hospital stay, and complication rate post-operatively.*

Result: *Eight patients needed auxiliary PCNL after URSL and 1 patient after LUL, but none after PCNL. The stone-free rate was 78.1% (25/32) in the URSL group, 95% (38/40) in the PCNL group and 100% (39/39) in the LUL group. Operation time was the shortest with URSL and the longest with LUL (all* $p < 0.05$*). Hospital stay was shorter in the URSL group compared with PCNL & LUL group (*$p = 0.0001$*). Operation-related complications were almost similar among the three groups.*

Conclusion: *Laparoscopic ureterolithotomy followed by PCNL is the most efficacious modality for treating large upper ureteral stones with a superior stone-free rate and lesser need for auxiliary treatments compared to URSL.*

Keywords: Ureteral calculi, Ureteroscopy, Percutaneous, Nephrolithotomy, Laparoscopy.

Introduction

Urinary lithiasis forms in the urinary system and is a common problem for more than 12% of the population[1]. Stone in the upper ureter can cause pain, hydronephrosis, urinary tract infections, loss of renal function, ureteral polyps and stricture in the stone site[2,3]. Therefore, the stone requires interventions for their removal. Treatment options for large (>1cm) upper ureteral stones are conservative measures & surgery. Conservative measures include hydration, analgesic, and alpha-blockers, and minimally invasive surgical options are ureteroscopic lithotripsy (URSL),

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percutaneous nephrolithotomy (PCNL), laparoscopic ureterolithotomy (LUL) to open surgery[4]. The latest European Association of Urology (EAU) guideline recommend URSL as the first-line option for stone larger than 10 mm[5]. Antegrade mini-PCNL is used for large stones, impacted stones, simultaneous renal stones, failed URS or SWL and inability to obtain retrograde access (urinary diversions or ureteric strictures). LUL is an option for treating large and impacted stones. With multiple surgical options, there lies the controversy of choosing the best option for a given patient. So, the selection of a particular treatment option depends on patient factors (fitness for anaesthesia, acceptability to invasive or less invasive options or acceptability to low stone-free rate), surgeon factors (skills and experience), stone factors (size, location, impaction) and anatomical factors (solitary kidney, unavailability of retrograde access). So, this study has been designed to compare the safety and efficacy of three minimally invasive methods: URSL, PCNL, and LUL to manage large (> 1 cm) upper ureteral stones.

Methodology

This prospective study was conducted in the Department of Urology, NIKDU, between March 2020 and February 2022. 120 patients with large upper ureteral stones were selected after informed consent of the treatment options and the risks & benefits of each treatment modality. Inclusion criteria were patients with single, large (>1 cm) upper ureteral stones. Exclusion criteria were patients age <18 years, radiolucent stone, need for additional procedures, previous intervention on the same side, active infection, urinary tract abnormality, coagulopathy, and pregnancy. Full history taking, general physical examination and Laboratory investigations, including ultrasonography of KUB, serum creatinine, excretory urography or non-contrast CT scan of KUB, urine for routine and microscopic examination, urine for C/S, coagulation profile, complete blood count was carried out before admission.

Patients were randomized by lottery and allocated into 3 equal groups. Ureteroscopic lithotripsy was done in lithotomy position with a 6 Fr semirigid ureteroscope under general anaesthesia using a 30W Holmium laser. Access was provided with retrograde insertion of a 0.035-inch floppy tip guidewire without dilating the ureteral orifice. A 6 Fr DJ stent was inserted at the end of the procedure. Percutaneous nephrolithotomy was done under general anaesthesia. Under fluoroscopy guidance, an external 5 or 6 Fr ureteral catheter was inserted in the lithotomy position through a cystoscope. Then after Foley catheterization patient was rotated to a prone position, and calyceal access was gained with a fluoroscopy-guided puncture of the desired calyx. A floppy tip 0.035-inch guidewire was inserted across the ureter into the urinary bladder. The percutaneous tract was dilated with a single-step metallic dilator and secured the tract with a 17.5 Fr Amplatz sheath in all cases. Surgery was performed with a 12 Fr rigid nephroscope. Stones were fragmented with pneumatic lithoclast. A 6 Fr DJ stent was inserted. 14Fr nephrostomy tube was used at the procedure's end and removed the next morning. Transperitoneal laparoscopic ureterolithotomy was done under general anaesthesia. The patient was placed in a flank position, and 3 ports were made. A 10 mm camera port was inserted 2 fingerbreadths lateral & superior to the umbilicus, and 2 additional 5 mm working ports were inserted a handbreadths superior & inferior to the camera port along the midclavicular line. A fourth 5 mm port is occasionally used on the right side for liver retraction. After reflection of the colon, the ureter was identified, and the stone was located and extracted using vertical ureterotomy. A 6 Fr DJ stent was inserted, and ureterotomy was closed with 4/0 vicryl suture. A drain was inserted through a 5 mm port.

The study's primary outcome was stone-free rate after 1 month of surgery, and secondary outcomes were duration of surgery, length of hospital stay, and complication rate post-operatively. Successful treatment was defined as the complete removal of the stone or the presence of a small insignificant residual stone (<4 mm in diameter)[6]. Auxiliary treatment was undertaken if the residual stone diameter was >4 mm. One month after surgery, the patient returned to the hospital to be re-examined with x-ray KUB film and the stone clearance rate was calculated. Stone clearance was defined as the absence of stone debris on the KUB film.

Continuous data were presented as mean ± standard deviation (SD), and categorical data were presented as frequency and percentage. For normally distributed continuous variables, analysis of variance (ANOVA) was used to detect differences among the groups. Variables in the contingency table were analyzed by the Chi-square test (or the Fisher exact test). $P < 0.05$ indicated statistical significance.

Result

Among 120 patients, there were 73 males & 47 females. There were no statistically significant differences in age, sex, side of stone & stone size (p>0.05) among the three groups (Table 1).

Eight patients failed to undergo URSL because the ureteroscope could not reach the location of the stone. They underwent mini PCNL. One patient failed to undergo LUL because the stone returned to the calyx that was removed with mini PCNL. Failed 9 cases should have been included in the statistics data.

The success rate was 80% in the URSL group, 100% in the PCNL group and 97.5% in the LUL group. Stone-free rate after 1 month was 78.1%, 95% & 100%, respectively. There were statistically significant differences between the URSL group and PCNL & LUL group but no difference between the PCNL group and the LUL group. Mean operation time and post-operative hospital stay were statistically significant among the 3 groups (Table 2).

There were no severe post-operative complications in any patient. The main complications in the URSL group were pain & fever that resolved with analgesics and antibiotics. Pain, fever, UTI & bleeding were the main complications in the PCNL group that subsided with analgesics, antibiotics, and blood transfusion. There was no urosepsis. In the LUL group, urine leakage occurred in 2 patients that resolved with conservative management. There were no statistically significant differences between the 3 groups regarding post-operative complications (p>0.05).

Table 1: Baseline characteristics of the patients.

Variable	URSL group n=40	PCNL group n=40	LUL group n=40	*p* value	*p* value	*p* value[s]
Age (years)	38±12	40±14	42±13	0.49	0.16	0.51
Male/female	23/17	26/14	24/16	0.49	0.82	0.64
Side (right/left)	21/19	24/16	23/17	0.5	0.65	0.82
Stone size (mm)	12.2±1.4	12.5±1.2	12.8±1.9	0.31	0.11	0.40

aURSL vs. PCNL; bURSL vs. LUL; cPCNL vs. LUL

Table 2: *Patient outcomes after the procedure.*

Variable	URSL group n=40	PCNL group n=40	LUL group n=40	*p* value	*p* value	*p* value[s]
Success rate	32/40 (80%)	40/40 (100%)	39/40 (97.5%)	0.003*	0.01*	0.31
Mean operation time (min)	62.6±21.8	75.1±22.3	126±28.5	0.01*	0.0001*	0.0001*
Post-operative hospital stays (days)	1.8±0.7	4.5±1.3	3.3±1.1	0.0001*	0.0001*	0.0001*
Stone-free rate after 1 month	25/32 (78.1%)	38/40 (95%)	39/39 (100%)	0.03*	0.002*	0.13

aURSL vs. PCNL; bURSL vs. LUL; cPCNL vs. LUL

Table 3: *Post-operative complications.*

Variable	URSL group n=32	PCNL group n=40	LUL group n=39	*p* value	*p* value	*p* value[s]
Pain	5	7	9	0.83	0.43	0.54
Fever	4	5	1	1.00	0.10	0.09
Urine leakage	0	0	2	NS	0.19	0.19
Pelvic/ureter perforation	1	0	0	0.26	0.26	NS
Urinary tract infection	1	2	0	0.69	0.27	0.16
Blood transfusion	0	4	0	0.07	NS	0.04*

aURSL vs. PCNL; bURSL vs. LUL; cPCNL vs. LUL

Discussion

SWL, URSL, PCNL and LUL are the modalities for treating upper ureteral stones, each having different success rates and complications. According to various guidelines, URSL & SWL are recommended treatment modalities for upper ureteral stones>1 cm[7]. Both modalities have acceptable stone clearance rates with minimal morbidity.

URSL is less effective than PCNL & LUL for large upper ureteral stones. Disadvantages are low stone clearance rate, retropulsion of stone in the renal pelvis, and need for an auxiliary procedure. PCNL is a more invasive procedure with a risk of bleeding, so it is not considered a first-line approach. However, PCNL is preferred in case of large impacted ureteral stones, concomitant renal stones, failed URSL, stones in transplanted kidneys, and patients with urinary diversion. LUL has the best stone clearance rates among all the surgical modalities after a single procedure. As it is a more invasive procedure, its use is limited for upper ureteral stones. Even the guidelines considered LUL an optional treatment modality when other treatment options have failed or are unlikely to succeed[8].

In this study success rate was 80%, and the stone clearance rate was 78.1% one month after URSL. The success rate was reported by Lee et al. and Mugiya et al. to be 35–87%[9,10]. Operation time (62.6±21.8 min) and post-operative hospital stay (1.8±0.7 days) are short in URSL than PCNL (75.1±22.3 min & 4.5±1.3 days) & LUL (126±28.5 min & 3.3±1.1 days) groups respectively. A similar result was found by Wang et al. in which mean operation time was (55.7 ± 23.9 min & 125.6 ± 41.2 min) and post-operative hospital stay was (2.5 ± 1.3 days & 6.8 ± 2.6 days) in PCNL & LUL group respectively[11].

The stone clearance rate was 95% one month after PCNL in this study. Karami and colleagues compared URSL and PCNL in 70 cases of upper ureteral stones >1 cm[12]. They showed that the stone clearance rate was 96% in the PCNL group, and stones of 32% of patients in the URSL group returned to the renal pelvis and needed an auxiliary procedure after URSL. A similar conclusion was drawn in another study of 53 patients. The stone-free rate at 1 month was 95.4% in the PCNL group and 58% in the URSL group, and eight patients had upward migrating stones during the URSL procedure[13].

The stone-free rate was 100% after LUL in this study. There was no significant difference between the PCNL & LUL groups in terms of operation time & duration of post-operative hospital stay. A meta-analysis by Torricelli et al. showed that the outcomes of LUL were more favourable than for semi-rigid ureteroscopic lithotripsy, making it the treatment of choice when flexible ureteroscopy is not available[14].

This study has some limitations. It was carried out in a single centre; post-operative CT examination was not done 1 month after the operation when the stone clearance rate was calculated, and follow-up was not given after 1 month, so we cannot compare stricture rate or long-term complications between the groups. SWL was not included to compare with other modalities because of its limited availability.

Conclusion

Laparoscopic ureterolithotomy followed by PCNL is the most efficacious modality for treating large upper ureteral stones with a superior stone-free rate and lesser need for auxiliary treatments than URSL. A large-scale, multicenter, randomized controlled trial should be conducted to establish the best treatment option among three modalities for large upper ureteral stones.

Acknowledgements

We acknowledge all the NIKDU, Dhaka staff who supported conducting this study. No formal funding for this study.

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