

Management of Large Proximal Ureteral Calculi: A Three-year Multicenter Experience of Simultaneous Supine Percutaneous Nephrolithotomy and Retrograde Ureterolithotripsy

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Purpose: To share our multicenter experience using a safe and effective method for treating large proximal ureteral calculus by simultaneous supine percutaneous nephrolithotomy (sPCNL) and retrograde ureterolithotripsy (URSL) in the Galdakao-modified supine Valdivia position.

Materials and Methods: Between December 2014 and August 2017, all patients with large proximal ureteral stones (> 15 mm) who underwent simultaneous sPCNL and retrograde URSL at three medical centers were retrospectively reported. The ureter stone was pushed back (retrograde) with the ureteroscope and was retrieved using forceps with a nephroscope through an Amplatz sheath. Surgical methods and outcomes were described to improve our experience and management of large proximal ureteral calculi.

Results: A total of 31 patients underwent simultaneous sPCNL and retrograde URSL. The mean patient age, stone size, operating time, and postoperative hospital stay were 57 years (range, 32–74 years), 20.1 mm (range, 15.0–37.9 mm), 81 minutes (range, 30–150), and 3.2 days (range, 2–7 days), respectively. There were 10 modified Clavien grade I and five grade II complications. No blood transfusions were necessary in this series. All patients were treated with double-J stents without a nephrostomy tube. Only one patient did not achieve stone-free status because of the strict stone impaction into the ureteral wall. This patient received auxiliary URSL after two months. Thereafter, the overall stone-clearance rate at three months was 100%.

Conclusion: Our preliminary data showed that this modified method is safe and effective for treating large proximal ureteral stones.

Keywords: endoscopes; percutaneous nephroscopy; supine position; upper ureteral stone; ureteroscopic lithotripsy

INTRODUCTION

Ureteroscopic lithotripsy (URSL) and extracorporeal shock wave lithotripsy (ESWL) were proposed by the latest American Urological Association (AUA) guidelines as first-line treatments for managing proximal ureteral calculi⁽¹⁾. However, ESWL has a poor stone-free outcome rate and requires multiple sessions in cases of upper ureteral stones > 10 mm⁽²⁾. Rigid URSL, when approaching large proximal ureter stones, is often associated with a long operative time, the migration of stones or fragments, and further auxiliary procedures such as flexible URSL and ESWL. According to the 2016 European Association of Urology (EAU) guidelines, percutaneous nephrolithotomy (PCNL) can be considered in cases of large (> 10 mm) impacted proximal ureteral calculi⁽³⁾, but bleeding is generally commonly reported with an overall 7% need

for transfusion⁽⁴⁾.

Since each technique has its own limitations, large proximal ureteral stones are challenging to treat with minimally invasive techniques and the optimal management of large proximal ureteral stones (> 15 mm) has yet to be defined. Here we report a multicenter experience describing a safe and effective method of treating large proximal ureteral calculi by simultaneous supine PCNL (sPCNL) and retrograde semi-rigid URSL in the Galdakao-modified supine Valdivia (GMSV) position.

PATIENTS AND METHODS

Study population and study design

Between December 2014 and August 2017, all patients who underwent simultaneous sPCNL and URSL for a large proximal ureteral calculus at the Kaohsiung Medical University Hospital, Kaohsiung Municipal Siaogang Hospital, and Kaohsiung Municipal Ta-Tung

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Table 1. Patient demographics and clinical data

Patient characteristics ^a	Number of patients (N = 31)
Sex, male/female, n	23/8
Median age, year (range)	57 ± 8.7 (32–74)
Body mass index, kg/m ² (range)	27 ± 4.4 (21.2–41.7)
BUN, mg/dL (range)	20.2 ± 18.1 (11.1–109)
Creatinine, mg/dL (range)	1.11 ± 0.35 (0.58–2.41)
eGFR, mL/min/1.73m ² (range)	74.7 ± 23.8 (29–119)
Stone laterality, right/left, n	17/14
Stone size length, mm (range)	20.1 ± 6.3 (15–37.9)
Stone burden, mm ² (range)	205 ± 94.9 (57.8–403)

Abbreviations: BUN, blood urea nitrogen; eGFR, estimated glomerular filtration rate.

^a Data presented as number or mean ± standard deviation

Hospital were retrospectively reviewed.

Inclusion and exclusion criteria

The inclusion criteria were the presence of a large proximal ureteral calculus, length on standard imaging ≥ 15 mm, and ureteral stone located between the ureteropelvic junction and the lower border of the fourth lumbar vertebra. Patients with a large proximal ureteral calculus combined with other ureteral, renal, or bladder stones were excluded. Patients with untreated urinary tract infections who were pregnant or had an abnormal interposition of visceral organs (retrorenal colon), a potential malignant renal tumor, or a bleeding tendency were excluded from the study. Patients who could not be placed in the GMSV position because of bone deformity or muscle contracture were also excluded⁽⁵⁾. This study was approved by the institutional review board of the Kaohsiung Medical University Hospital (ID: KMUHIRB-E(I)-20170273). Informed consent was obtained from all patients, after educating them about the residual stones and double J stent placement.

Preoperative preparation

All patients underwent preoperative urine culture; serum biochemistry and routine blood tests; radiographic



Figure 1. Lateral-frontal view of the patient with a left proximal ureter stone placed in the Galdakao-modified supine Valdivia (GMSV) position with the left leg in extension and the other in flexion. The C-arm and fluoroscopic instrument were placed contra-laterally to the left ureteral stone.

examination of the kidneys, ureters, and bladder (KUB); and computerized tomography urography (CTU) evaluation⁽⁶⁾. Stone size was determined by measuring the length and the width during preoperative radiologic investigations. The stone surface area was calculated using the formula described by Tiselius and Anderson (length \times width $\times 3.14 \times 0.25$)⁽⁷⁾. All patients were administered intravenous preoperative antibiotics, and urine culture was performed before administration of prophylactic antibiotics.

Patients were admitted to our urology ward two days before the operation for preoperative and anesthetic assessment according to the hospital protocols and health insurance indications in Taiwan. Under local anesthesia with intramuscular injection of pethidine, patients were placed in the prone position. Renal puncture was performed with an 18G Chiba biopsy needle and Radifocus® hydrophilic guidewire was introduced into the targeted calyx under fluoroscopic guidance by a radiologist on the day before the operation. An antegrade pyelogram delineating the pelvicalyceal system was used to confirm the position of stone, guidewire, and percutaneous nephrostomy pigtail.

Surgical technique

On the day of the operation, the patient was placed in the GMSV position (**Figure 1**), with one leg ipsilateral to the stone in extension and the other in flexion. Two surgeons performed the sPCNL and retrograde semi-rigid URSL, simultaneously. After tract dilatation with an Ultraxx™ nephrostomy balloon through the Radifocus® hydrophilic guidewire, a 30 French (Fr) Amplatz sheath was introduced. One surgeon placed a 24 Fr nephroscope (Richard Wolf, Knittlingen, Germany) at the ureteropelvic junction and waited for the other surgeon to approach in a retrograde manner the proximal ureteral stone with a 6 Fr semi-rigid ureteroscope (Richard Wolf, Knittlingen, Germany). Although the main length of the ureteral stone required for inclusion in the study was ≥ 15 mm, patients were further separated into two groups based on the width of ureteral stones measured on radiologic images. Stones with width < 10 mm were pushed back in a retrograde manner with the ureteroscope and retrieved using forceps with the nephroscope through the Amplatz sheath. The 30 Fr Amplatz sheath allows the passage of the stones with width < 10 mm (**Figure 3**). Stones with a width > 10 mm were disintegrated by a holmium: YAG laser and then pushed retrograde and removed in an antegrade manner by forceps through an Amplatz sheath. Baskets were unnecessary during all procedures. At the end of the operation, a double-J stent was positioned in retrograde fashion, which was subsequently removed as an outpatient procedure 2–4 weeks postoperatively depending on the outcome of stone clearance.

Outcome assessment and postoperative care

The primary outcome of interest was stone-free clearance, which was defined as the absence of fragments or a single fragment of ≤ 4 mm on standard radiography at the 1- and 3-month follow-up examinations⁽⁸⁾. Secondary outcomes included operating time, hospital stay, and complications, which were graded according to the modified Clavien classification⁽⁹⁾.

The operating time was defined as the time between the PCN tract dilatation and the end of the operation (Foley insertion), which excluded the time required for anesthesia and patient's positioning. Postoperative labora-

Table 2. Intraoperative parameters and postoperative outcomes

Intraoperative results^a	
Operating time, minutes (range)	81 ± 28 (30–150)
Postoperative outcomes^a	
Postoperative hospital stay, days (range)	3.2 ± 1.3 (2–7)
Postoperative stone-free status, n (%)	30/31 (97)
Stone clearance at 3 months, n (%)	31/31 (100)
Complications:	
Modified Clavien classification grade I, n (%)	10/31 (32)
Hematuria	9
Flank pain	5
Urethral pain	2
Modified Clavien classification grade II, n (%)	5/31 (16)
Postoperative fever more than 38.0 with antibiotics	5
Further treatment, n (%):	1/31 (3)
Auxiliary ESWL	1

^aData presented as mean ± standard deviation or number (%)

Abbreviations: ESWL, extracorporeal shock wave lithotripsy.

tory data were collected to investigate for active bleeding. Continuous bladder irrigation was administered for one night if gross hematuria was present, and the Foley catheter was removed if there was no evidence of hematuria. KUB radiography was arranged to confirm the postoperative stone clearance. We discharged the patient if there was no evidence of fever, anemia, or persistent pain. All patients were under urologic outpatient clinic follow-up after discharge.

RESULTS

A total of 31 consecutive patients (23 men, 8 women) with a single large proximal ureteral calculus underwent simultaneous sPCNL and URSL. Percutaneous lithotomy tract provided access mainly through the lower calyx in 16 cases, while in the remaining 15 cases, access was achieved through the middle calyx. Patient demographics and stone characteristics are described in **Table 1**. The mean stone length on standard imaging was 20.1 mm (range, 15.0–37.9 mm); the stones were > 20 mm in 15 patients and 15–20 mm in 16 patients. Intraoperative and postoperative findings are reported in **Table 2**. The mean operating time was 81 minutes (range, 30–150 minutes). Ureteral stents without a nephrostomy tube (tubeless method) were used in all cas-

es. There were 16 patients who experienced modified Clavien class I and five patients who experienced class II postoperative complications. Among class I complications, nine patients had transient gross hematuria, five patients experienced flank pain, and two patients experienced urethral pain. Overall, five patients developed a postoperative fever (class II complication), which was controlled with appropriate antibiotics and supportive treatment. Notably, no blood transfusion was needed in this series, and no urinary tract perforation or adjacent organ injury occurred during the procedures.

We discontinued bladder irrigation in 22 patients within six hours after the operation; however, for nine patients, bladder irrigation continued beyond this time due to postoperative gross hematuria. In these nine cases, bladder irrigation was discontinued one day after the operation due to improved hematuria.

The postoperative stone stone-free rate at 1-month follow-up was 96.8%, with one patient not achieving stone-free status; this patient had a small (5 mm) residual stone revealed by postoperative follow-up KUB due to severe angulation and strict stone impaction into the ureteral wall. This patient received URSL two months after the simultaneous sPCNL and URSL (a double J stent was placed following the simultaneous

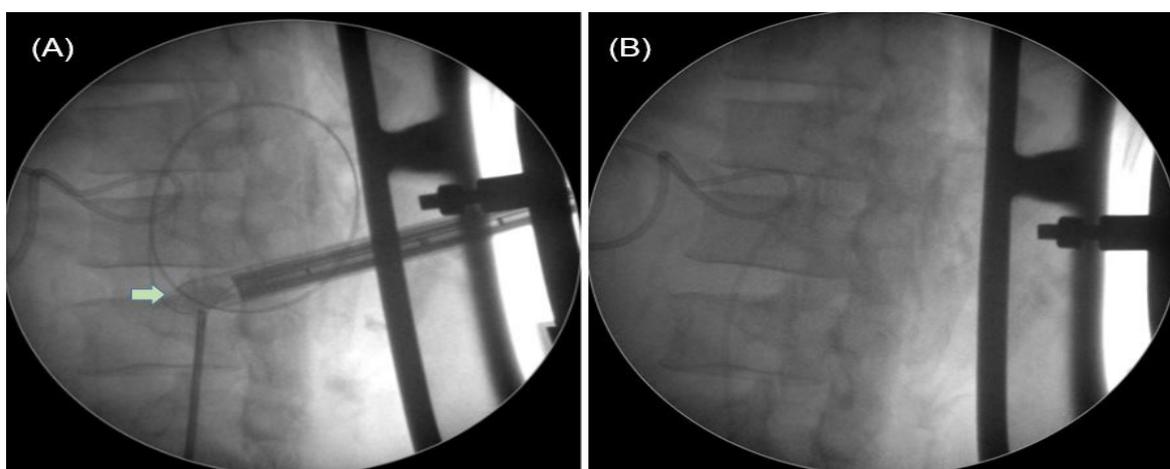


Figure 2. Fluoroscopic images under C-arm showing the (A) right upper ureter stone (arrow) simultaneously approached by antegrade nephroscope and retrograde ureteroscope; and the left percutaneous nephrostomy in situ with the (B) right double-J stent without residual stones postoperatively.

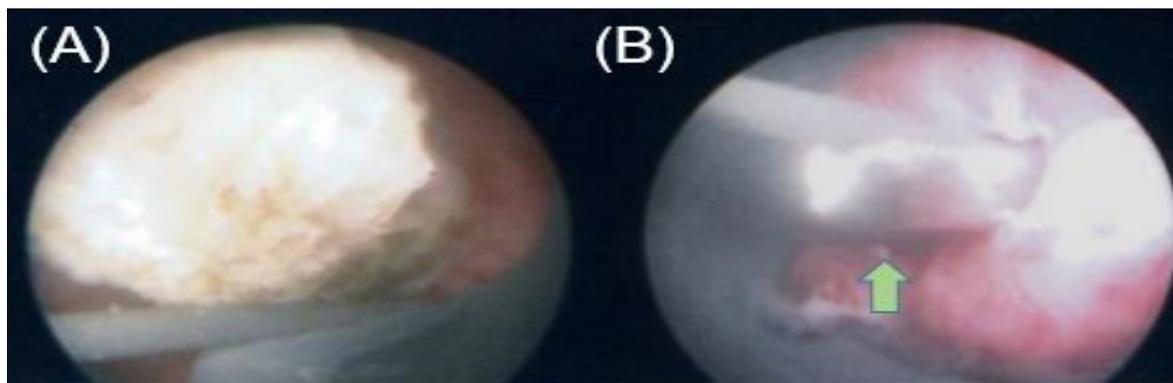


Figure 3. Views under nephroscopy revealed (A) a ureter stone pushed back to ureteropelvic junction by the retrograde ureteroscope (B) after retrieving the stone in an antegrade manner; the ureteroscope is visible at the ureteropelvic junction (arrow).

sPCNL and URSL for two months). Postoperatively radiographic imaging revealed no residual stone after the second operation. The overall stone-clearance rate at three months was 100%.

DISCUSSION

Before the 1980s, ureteral stones were managed by open ureterolithotomy. With the advent of ESWL, small-caliber semi-rigid ureteroscopes with holmium lasers, flexible ureterorenoscopes, and laparoscopic procedures, the management of ureteral calculi has changed dramatically. ESWL, URSL, PCNL, laparoscopic ureterolithotomy, and open surgery are methods currently available for the treatment of proximal ureteral calculi. Most upper ureteral stones, especially those < 10 mm in length, can be managed with a minimally invasive approach with excellent surgical outcomes. However, large impacted upper ureteral stones remain challenging to manage, and the optimal treatment for large proximal ureteral calculi located between the ureteropelvic junction and the lower border of the fourth lumbar vertebra is controversial.

According to the 2016 EAU guidelines for urolithiasis, ESWL and URSL are the first-line treatment modalities for the management of proximal ureteral stones⁽¹⁾. However, each technique has limitations. ESWL requires multiple sessions and has a dramatically decreased stone-free rate for stones > 10 mm^(2,10). Retrograde URSL also requires several passages with the ureteroscope to remove all the stone fragments after intracorporeal lithotripsy, which has been reported to be associated with an increased risk of ureteral perforation. Moreover, continuous high-pressure irrigation may also result in stone migration back into the renal pelvis or calyx with a reported incidence of 28–60%⁽¹¹⁾, furthermore, the stone may become unreachable and require further use of a rigid or semi-rigid ureteroscope. Although some studies have used an anti-retropulsion device such as a basket during rigid URSL, there is no space available for passage of the device wire when managing large impacted stones⁽¹²⁾. Moreover, the procedure could be converted to PCNL, laparoscopic, or open ureterolithotomy in some cases such as a tortuous ureter or unusual ureter angulation. A flexible ureteroscope (fURS) is considered a new trend and was suggested by the 2016 American Urological Association

(AUA) guidelines for the surgical management of stones, which indicate the use of URS for proximal ureteral stones⁽¹⁾. However, fURS is not commonly available worldwide because of its high costs, skill-dependence, and long operative time.

Therefore, according to the 2016 EAU guidelines, PCNL is to be considered for managing large proximal ureteral stones (> 10 mm)⁽³⁾. Since the 1980s, PCNL has been gradually widely used as a minimally invasive treatment for large proximal ureteral stones because of its high stone-free rate. A meta-analysis performed in 2017 reported that PCNL was superior to URSL for stone clearance and but showed no significant difference in pain or ureterostenosis despite PCNL being more invasive⁽¹³⁾. PCNL produced its advantages via an antegrade tract, which could avoid stone migration by acting as an effective anti-reputation device. However, PCNL was commonly associated with a high risk of bleeding requiring blood transfusion (0–23%), adjacent organ injury (0.4%), and infectious complications (33%)^(14,15). Laparoscopic ureterolithotomy has been recommended by some randomized controlled studies due to its excellent stone-free rates, especially for proximal ureteral stones > 15 mm when compared to URSL^(16–18). Nonetheless, laparoscopic ureterolithotomy is relatively invasive. There are two entry points for laparoscopic ureterolithotomy. Transperitoneal entry has been associated with postoperative ileus and the possible risk of damaging intraperitoneal structures, thus contributing to the morbidity rates⁽¹⁹⁾; retroperitoneal entry has been associated with fewer intraperitoneal complications, but steeper surgical learning curves. Thus, it remains to be seen which treatment modality is ideal for patients with large proximal ureteral stones.

A new approach to PCNL using a modified lithotomy position called the GMSV position has recently been proposed⁽⁵⁾. The GMSV position is more comfortable for the anesthetist, especially in cases of obese or high-risk anesthesia patients and supports a versatile antero-retrograde approach to the upper urinary tract, which opens the possibility of endoscopic combined intrarenal surgery (ECIRS)^(20,21). ECIRS in the GMSV position is a synergic and a single step approach combining PCNL and retrograde intrarenal surgery using fURS⁽²²⁾. However, fURS is not currently available in many hospitals in developing countries due the high equipment costs.

Therefore, surgeons prefer to use semi-rigid ureteroscopes because of their durability and affordable price. Hence, herein we propose a new technique using simultaneous supine PCNL and retrograde semi-rigid URSL in the GMSV position for large proximal ureteric calculi.

In this study, the postoperative stone-free rate was approximately 97%. Due to the strict stone impaction into the ureteral wall, one patient did not reach stone-free status as a small fragment remained positioned along the upper ureter. This patient received URSL two months after the simultaneous sPCNL and URSL procedure and achieved stone-free status postoperatively. Overall, the stone-clearance rate at 3 months was 100%. Also in our study, percutaneous lithotomy tract was achieved mainly through the lower calyx (N = 16) and middle calyx (N = 15). Large-scale studies are warranted to better examine the optimal calyx for puncture; however, our current experience suggests that the middle and lower-calyx renal accesses represent safe and easy approaches to the creation of a correct tract to the collecting system.

The results of our study suggest that simultaneous sPCNL and URSL may be a new strategy worth exploring for the safe and effective treatment of upper tract urolithiasis. This approach creates an open low-pressure system that reduces the absorption of irrigation fluid into the circulation. If needed, the stone can be disintegrated first and then pushed back, or directly pushed back to the renal pelvis by retrograde ureteroscopy and then retrieved via forceps with a nephroscope through an Amplatz sheath, in a single procedure without the need for baskets, thus reducing the risk of ureteral injury and bleeding. In the case of a stone width of < 10 mm, the operation time was extremely short due to the use of an Amplatz sheath, which allows the removal of stone fragments of up to 10 mm. The sPCNL and URSL procedures were performed by two surgeons simultaneously, and once the ureteroscope approached the upper ureteral stone, the operation was finalized within seconds, easily and efficaciously after stone removal using an antegrade renolescope. Our study also demonstrated less intraoperative blood loss with none of the patients requiring a blood transfusion. The cause of reduced bleeding was probably due to the shorter operative time required. We also believe that given the shorter operation time and the reduced blood loss, patients return to their daily activities much sooner. In addition, during withdrawal of the ureteroscope, the ureter and bladder can be reevaluated for any residual stone fragments, bleeding, or blood clots. Moreover, this approach also offers the possibility of treating concurrent ipsilateral renal stones with the same percutaneous access during the same session.

Our study has some limitations. First, a small number of cases were included in the study and our design was retrospectively descriptive rather than comparative. However, our multicenter results of simultaneous sPCNL and URSL seem promising for treating large proximal ureteral stones. Second, due to the limitations placed by our hospital protocols and health insurance system in Taiwan, all patients were admitted 2 days before operation for preoperative laboratory studies and preoperative anesthesia assessment to be performed on the first day of hospitalization, and renal access puncture was performed by interventional radiologists on the second

day. Thus, in accordance with our hospital protocols, all patients underwent two-stage PCNL (renal access was done by radiologists), rather than a single-stage procedure in one session.

CONCLUSIONS

Simultaneous sPCNL and URSL represents significant progress in the treatment of large proximal ureteral stones. Based on the low blood transfusion rate, no major complications, a high stone-free rate, and short postoperative stay duration, we believe that simultaneous supine PCNL and retrograde URSL is a safe and effective treatment. It is likely that, with more experience using this method, this approach will gain increasing acceptance among urologists in the coming years. However, more clinical trials are required to confirm the outcomes of the present study.

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CONFLICT OF INTEREST

The authors have no competing interests.

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