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Ultrasonography-Guided Percutaneous Nephrolithotomy for the Treatment of Urolithiasis in Patients with Scoliosis

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We examined the surgical outcomes of minimally invasive percutaneous nephrolithotomy (MPCNL) in scoliotic patients with complicating urolithiasis. Two patients with scoliosis were hospitalized for MPNCL due to upper tract urolithiasis. Calyx puncture was performed in the prone position under ultrasonographic guidance. The renal access route was established using a set of 8F to 16F dilators, and a transpyelic ballistic lithotriptor was used to fragment the calculi. The stone burdens in the 2 patients were 410 mm^2 and 500 mm^2. The entire operative time was 40 to 70 minutes, and the mean time of establishing percutaneous access was 20 minutes. The calculi were completely removed by single-session pneumatic lithotripsy. The 2 patients recovered from MPCNL uneventfully, and the follow-up radiologic examinations identified no stone residual or recurrence. MPCNL is a minimally invasive modality that is effective and safe for the treatment of urolithiasis in patients with scoliosis.

Key words: Urolithiasis – Scoliosis – Percutaneous nephrolithotomy – Minimally invasive – Effectiveness – Safety

Upper tract urolithiasis (UTUL) or upper urinary calculosis is a common urologic disorder that is rapidly increasing in the Chinese population. Surgical intervention is usually required in serious or complicated cases; however, the conventional open procedure imparts a heavy burden on the patient physiologically, psychologically and financially. In many patients minimally invasive surgery has been successfully used to treat UTUL. Multiple methods exist, including extracorporeal shock wave lithotripsy (ESWL), antegrade/retrograde ureteroscopy, percutaneous nephrolithotomy (PCNL), and laparoscopy.[1] In patients with larger calculi (diameter, >2 cm), neither ESWL nor antegrade/retrograde ureteroscopy

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is adequate and associated with a greater risk of morbidity.[2] PCNL has become the standard treatment of care for complicated UTUL due to its high success rate and low complication rate.[3] In addition, PCNL has been successful in treating patients with failed open surgery or ESWL, kidney transplantation, and urinary deformity or diversion.[4–7]

PCNL is contraindicated for patients with obesity, pelvic kidney, or spinal deformities, such as scoliosis, kyphosis, and lordosis.[2] These pre-existing conditions will result in movement of anatomic landmarks and consequently increase the frequency of procedural complications in establishing percutaneous renal access. Furthermore, patients with scoliosis may suffer from more serious urolithiasis, probably in association with the underlying congenital anomalies or secondary variations in the urinary tract.[8] Kara *et al*[9] reported successful treatment of a small series of previously treated patients with scoliosis suffering from large renal stones in a single center by applying PCNL and auxiliary ureteroscopy. Their experience suggests that PCNL may be suitable for patients with scoliosis.

In 1992, Wu *et al*[10] developed a modified PCNL, termed minimally invasive PCNL (MPCNL), that has been found valuable for treating urinary calculosis. This technique has been well recognized in urologic practice because of its low morbidity rate and broad indications. However, it has not been reported whether MPCNL can replace conventional PCNL for the treatment of urolithiasis in patients with scoliosis. In the present study, we examined the feasibility, effectiveness, and safety of MPCNL for the treatment of refractory UTUL in patients with concomitant congenital scoliosis. We used percutaneous ultrasonography to guide this interventional procedure, and the use of pneumatic lithotripsy was effective in removing calculus. To our knowledge, this is the first study to report the use of MPCNL to treat urolithiasis in patients with complicating scoliosis.

Methods

Patients and assessments

Two patients with scoliosis were referred to our urology center because of radiologically diagnosed UTUL and aggravated symptoms between February 2010 and March 2011. Both patients were middle-aged women with a known history of congenital lumbar scoliosis. The predominant complaint/symptom was intermittent flank pain in both patients. Neither patient received surgical or interventional treatment before the referral due to concern of procedural risks associated with pre-existing scoliosis.

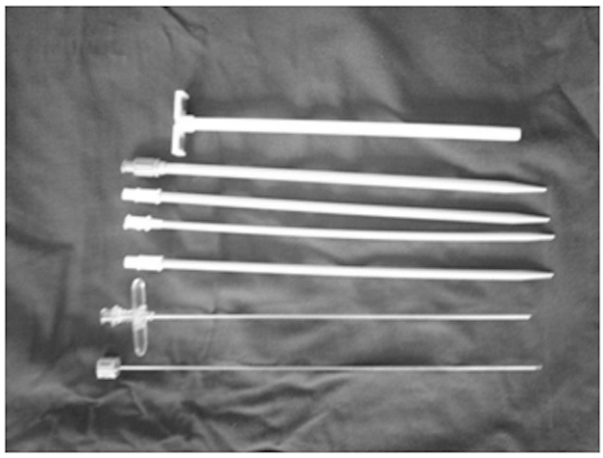

Fig. 1 Fascial dilators in sizes 8F to 16F that were used to establish the renal access tract.

Preoperative radiologic assessments consisted of kidney-ureter-bladder (KUB) radiography, abdominal noncontrast-enhanced computed tomography (CT), and intravenous urography. In the first patient (patient 1), a retrograde urography (Fig. 1G) was ordered to further characterize the urinary tract obstruction, as the collect duct system was poorly visualized on intravenous urography. Despite having mild urosepsis indicated by urinalysis, the urine cultures were negative. However, as a preventative measure, preoperative wide spectrum antibiotics were empirically given to alleviate any underlying urinary tract infections.

Ultrasonography-guided MPCNL

The 2 patients gave informed consent before undergoing MPCNL. The same attending urologist performed the 2 procedures and was assisted by an assigned team of assistant surgeons, anesthesiologists, and surgical nurses. The patients were intubated and positioned in the lithotomy position under combined intravenous-inhalational general anesthesia. A 5F ureteral access catheter was introduced into the diseased ureter with the assistance of ureteroscopy (uroVision GmbH, Bad Aibling, Germany), and the distal end of the ureteral catheter was secured to an 18F Foley bladder catheter. The patients were turned to the prone position, with the abdomen cushioned and the waist elevated.

In the case of less serious pelvic dilation, sterile saline was infused through the 5F ureteral catheter into the renal pelvis to establish the artificial

Table 1 Clinical and surgical characteristics of patients with scoliosis undergoing MPCNL

	Patient 1	Patient 2
Age (year)	51	48
Height (cm)	156	140
Body mass (kg)	50	35
Body mass index (kg/m^2)	20.5	17.9
History of flank pain (month)	1	24
Duration of aggravation	3 days	2 months
Calculus burden (mm^2)	410	500
Location of calculi	Right renal pelvis and upper ureteral segment (L3 level)	Left renal pelvis
Direction of spinal curvature	Left	Left
Cobb angle (°)	51	58
Operative time (min)	70	40
Length of hospital stay (day)	10	9
Stone analysis	Calcium oxalate mixed with calcium phosphate	Calcium oxalate

MPCNL, minimally invasive percutaneous nephrolithotomy.

hydronephrosis (patient 2). An 18-gauge access needle (uroVision) was inserted percutaneously through the intersection of the 11th intercostal space and the scapular line into the target (middle) major calyx under ultrasonographic guidance (Siemens Healthcare, Munich, Germany). The puncture was deemed successful based on the outflow of urine upon the withdrawal of the core needle. A 0.035-inch zebra guidewire (uroVision) was inserted through the needle sheath. Using a dagger knife, a small incision was made in the skin and subcutaneous fascia to retract the needle sheath. An introducer set (uroVision) was used to dilate the renal access tract from 8F to 16F (Fig. 1). The dilator was withdrawn, and the Peel-away sheath (uroVision) was maintained in the access route. A 9.8F dual-channel ureteroscope (Richard Wolf Medical Instruments Corporation, Vernon Hills, Illinois) was advanced into the renal pelvis and upper ureteral segment. A transpyelic ballistic lithotriptor (Electro Medical Systems, Nyon, Switzerland) was used to fragment the calculi in a stepwise fashion, and the stone fragments were completely removed by the combination of grasping and flushing. A double-J ureteral stent (uroVision) was placed antegrade, and a percutaneous nephrostomy tube was placed.

Postoperative care and follow-up

Follow-up KUB radiography was performed on postoperative day (POD) 4, and the nephrostomy tube was removed on POD 5 if the double-J stent was appropriately positioned and no stone remnants were present. The urethral catheter was maintained until PODs 7–8 to minimize the occurrence of ureteral reflux and ascending urosepsis caused by postoperative urinary retention, and the patients were discharged in the absence of fever or other discomfort. Patients were instructed to drink a set amount of water and modify their diets based on the stone analysis results. The double-J stent was removed using ureteroscopy 7 weeks after the MPCNL. KUB, intravenous urography, and noncontrast CT radiographs were ordered at 3-month intervals.

Results

Patient characteristics

The past history and physical examination of the 2 patients were normal except for the pre-existing lumbar scoliosis. The routine preoperative laboratory, including hematology, biochemistry, coagulation test, chest X-ray, electrocardiography, and pulmonary function test, showed no significant clinically abnormalities. Demographic and clinical data for both patients are presented in Table 1. The Cobb angle, a measure used to describe the coronal plane deformity on anteroposterior plain radiographs in the classification of scoliosis, was determined to be 51 degrees in patient 1 and 58 degrees in patient 2. The stone burdens were 410 mm^2 and 500 mm^2, respectively. Patient 1 exhibited 2 ureteral stones (minimum dimension, $>$1.5 cm) that were located at the L3 level and ipsilateral to the spinal curvature, as well as mild hydronephrosis (Fig. 2, left panel). In contrast, patient 2 exhibited a urolithic kidney that was contralateral to the spinal curvature, and the renal pelvic calculi were complicated with severe hydronephrosis and multiple ureteral calculi (maximum dimension, $<$1.5 cm) (Fig. 2, right panel). The preoperative metabolic workup did not identify any clinically significant metabolic abnormalities. The stone analyses indicated the presence of calcium oxalate mixed with calcium phosphate in patient 1 and only calcium oxalate in patient 2.

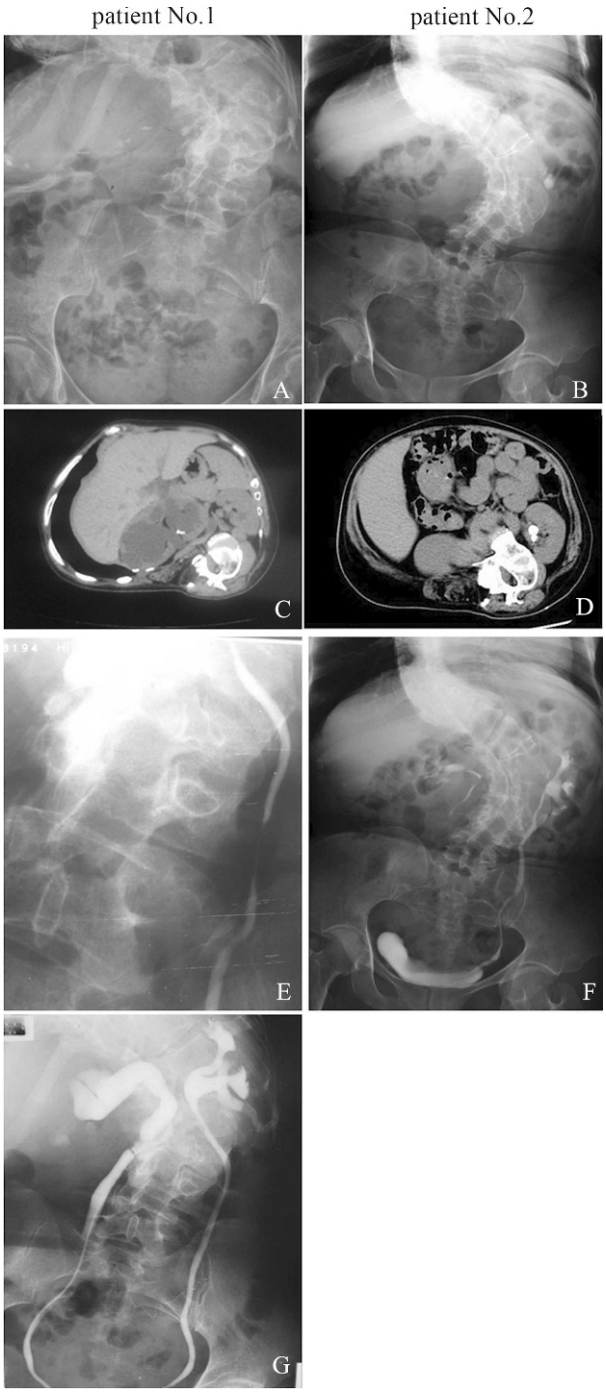

Fig. 2 Preoperative radiologic assessment of 2 scoliotic patients with urolithiasis: KUB radiograph (A and B) revealed the scoliotic curvature of the spinal column and the presence of urinary calculi; upper abdominal CT scan (C and D) showed the anatomy of the diseased kidney in relation to the surrounding organs; and intravenous urography (E and F) and retrograde urography (G) characterized the excretory function of the diseased kidney and the location of urinary obstruction.

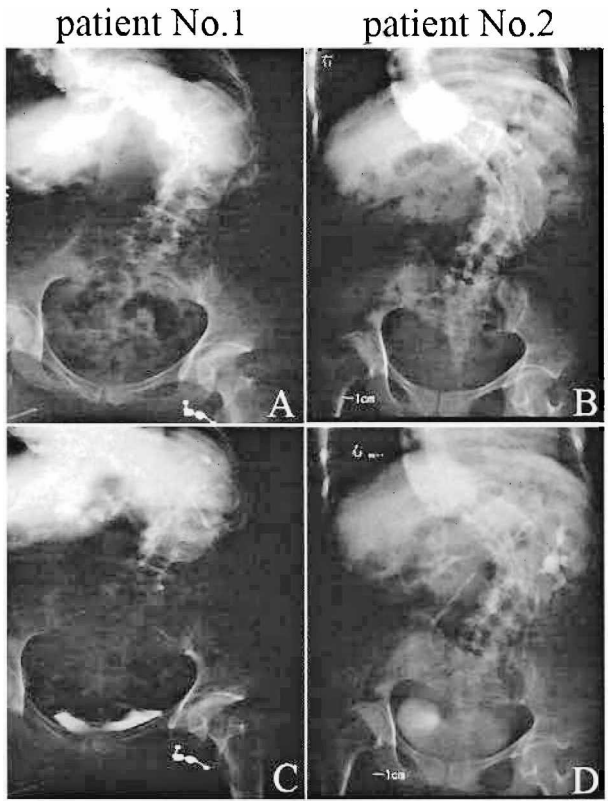

Fig. 3 Follow-up radiographs at 3 months after MPCNL. KUB radiograph (A and B) and intravenous urography (C and D) revealed a calculus-free urinary tract.

Surgical outcomes

A single tract was required in the 2 patients. Percutaneous renal access was successfully established using ultrasonographic guidance. The entire surgery lasted 40 to 70 minutes, and the time for establishing percutaneous access was 25 minutes in patient 1 and 15 minutes in patient 2. The urinary calculi were completely removed in 1 session of pneumatic lithotripsy along with stone grasping and flushing. The double-J stent was appropriately indwelled in both patients. No urinary tract bleeding or perforation occurred in MPCNL.

Postoperative progress and follow-up

The 2 patients had a successful recovery from MPCNL. The patients resumed oral intake on POD 2 and started off-bed activities on POD 3. There was no need for prolonged placement of the nephrostomy tube or the double-J stent. The follow-up radiographs indicated that the urinary tract was calculus-free in both patients (Fig. 3). Thus, neither

patient required a second MPCNL or any other auxiliary intervention. The 2 patients had stable renal function throughout the hospitalization and follow-up period.

Discussion

ESWL is considered the least invasive modality for the treatment of urinary calculosis, but it has a higher incidence of lower stone recurrence compared with RUS or MPCNL.[11] ESWL is preferred for the lithotripsy of renal calculi between 4 and 20 mm in diameter, and is less successful for fragmented ureteral stones.[12] MPCNL is a modified version of PCNL that has been used extensively in China during the past 2 decades.[15] The popularity of MPCNL lies in its reported favorable procedural safety; however, it has limited indications due to the small percutaneous tract (11–20F versus 26–34F).[13] As such, MPCNL is primarily used in pediatric patients or adult patients with small stones or as a secondary technique used to supplement conventional PCNL.[14] Advancements in MPCNL equipment and techniques have helped broaden the indication of MPCNL to any UTUL requiring PCNL intervention, as suggested by Guangzhou and colleagues.[15] Using multiple tracts, MPCNL allows for the removal of staghorn calculi or complex renal calculi.[16]

The appropriate choice of the interventional modality depends primarily on the stone burden, stone location, and presence of concomitant anomalies such as scoliosis.[9] Scoliosis is a rare medical condition that is characterized by the abnormal lateral curvature of the spinal column. It is typically classified as congenital, idiopathic, or neuromuscular. Idiopathic scoliosis accounts for most cases (70%), and the prevalence is higher in women (M/F, 1:4).[17] Congenital scoliosis is frequently associated with syndromes and anomalies of other systems, including neurologic, cardiovascular, and genitourinary. Severe scoliosis may compromise a patient's cardiopulmonary function and consequently increase the surgical risks of nonorthopedic procedures.[18] Urinary morbidity can occur secondary to scoliosis, including urinary deviation, urosepsis, calculosis, and renal impairment. The prophylactic use of wide spectrum antibiotics is recommended, even in the case of culture-negative urosepsis. ESWL is less useful in patients with scoliosis as it is technically challenging to localize urinary calculi.

In our study, 2 patients were treated successfully and all stones were removed using 1 session-single tract MPCNL. At present, our follow-up examinations have identified no residual stone or recurrent calculosis in the 2 patients. The renal and/or upper ureteral calculi were fragmented by the application of pneumatic pressure, and removed by pulsating and pressurized irrigation rather than by grasping with delicate forceps used in MPCNL. However, this forceful pulse flow raises a safety concern that the high intrapelvic pressure in MPCNL may cause backflow into the collecting system by vascular, lymphatic, and mesenchymal routes, and further subject patients to a higher risk of urosepsis.[16] Some investigators suggest that MPCNL is safe, as the renal pelvic pressure remains lower than 30 mmHg, a pressure that usually leads to backflow.[17] Multiple tracts can be used to minimize backflow, thus reducing intrapelvic pressure.[18] The multitract technique shortens the procedure duration, improves stone clearance, and facilitates the flushing out of fragmented stones by irrigation.[19] Although the use of MPCNL has broadened, it not suitable for the removal of stones more than 30 mm in diameter, as it has a high risk of leaving residual particles.

The presence of musculoskeletal deformities inevitably complicates the endourologic procedure.[9,20] As in any other minimally invasive surgical technique, MPCNL requires the operators to have a good knowledge of local anatomy. The appropriate puncture into the collecting system is the most crucial for a successful MPCNL and the greatest risk occurs during percutaneous manipulation.[15] However, the spinal curvature alters the location and relationship of major visceral organs and vessels, especially kidneys and renal vessels ipsilateral to the spinal curvature, in a three-dimensional manner. Although this does occur, it is uncommon for urologists or endourologists to encounter patients with an abnormal posture, such as seen in scoliosis. It is technically challenging to establish the nephrolithotomy access in patients with scoliosis, especially in those with a larger lateral spinal curvature. The stones located in the upper major calyx are relatively less accessible than those located in the pelvis or the ureter. The percutaneous puncture into the stone-bearing major calyx or pelvis located ipsilateral to the spinal curvature is relatively easier compared to that contralateral, as this access is less likely to involve intestines or other intraperitoneal organs. A thorough preoperative radiologic assessment can characterize the anatomy of the diseased kidney in relation to the surrounding organs, and help minimize the occurrence of iatrogenic injuries. An abdominal contrast-enhanced CT scan is recommended to minimize the risk of colonic penetration.[21] Using

ultrasonographic guidance, the calyx puncture was completed with a single attempt in the 2 patients. In contrast, Kara *et al*[9] positioned the puncture site using retrograde contrast fluoroscopy, and although this procedure is less convenient and more invasive, they reported no adverse event. However, the technical difficulty depends on the severity of complicating hydronephrosis rather than the location of stones. In patient 2, we also created an artificial hydronephrosis to facilitate ultrasonographic localization of target calyx and reduced the likelihood of urinary perforation or bleeding. In addition, the 2 patients underwent MPCNL in the routine lithotomy to prone position, whereas the urinary calculi were properly located using preoperative ultrasonography when the patients were in the routine prone position.

Despite MPCNL's minimally invasive advantages, it is subject to some complications.[15] The primary complications of MPCNL consist of visceral injury, renal vascular injury, urinary tract perforation/leakage, urosepsis, and hydrothorax caused by the percutaneous puncture at the 11th intercostal space. As reported by Kara *et al*[9] the most common and serious complication after PCNL is renal hemorrhage, which requires blood transfusions in severe cases. The operator's experience is thought to be the most significant predictor of urinary tract bleeding.[9]

Scoliosis-complicating urolithiasis is a rare condition encountered in urologic practice. The optimization of therapeutic modality depends on an appropriate algorithm, including the burden and location of stone, concomitant upper ureteral calculus, preoperative medical and radiologic assessment, and the experience of the urologist. Our results show that MPCNL is an effective and safe minimally invasive modality for the treatment of urolithiasis in patients with scoliosis. Ultrasonographic guidance will not only improve MPCNL performance, but also reduce the procedural risks. Other minimally invasive surgical approaches, such as ESWL and ureteroscopy, might be attempted or used as adjuvants to MPCNL. Medical conditions that could affect the spinal anatomy should be evaluated before MPCNL to maximize the therapeutic effectiveness and minimize the risk of residual stones and recurrence.

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