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Ultrasound-guided minimally invasive percutaneous nephrolithotomy in the treatment of pediatric patients <6 years

A single-center 10 years' experience

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Abstract

Owing to the fragile kidney and relative small collecting system of pediatric patients, urologists were always reluctant to treat pediatric urolithiasis with PCNL. Here we conduct a study to assess the effectiveness and safety of pediatric patients with renal calculi <6 years.

A total of 88 pediatric patients (99 kidney units) <6 years underwent the ultrasound (US)-guided minimally invasive percutaneous nephrolithotomy in our institute from March 2006 to April 2016. The mean age was 30.9 months (range, 7–72 months). The mean stone size was 19.5 mm (range, 10–50 mm). The group included single stone in 35 kidney units, upper ureteral stone in 12 kidney units, multiple stone in 43 kidney units, and staghorn stone in 9 kidney units. The procedure of puncture and dilation were guided by US solely.

The mean operation time was 52.3 minutes (range, 15–140 minutes). The mean postoperative length of stay was 6.0 days (3–16 days). Besides, the initial stone free rate (SFR) was 90.9% (90/99) and the final SFR was 96.0% (95/99). The mean hemoglobin drop was 10.9 g/L (range, 1–25 g/L). Postoperative complications occurred in 12 patients including fever in 11 cases and active pleural effusion in 1 case.

The US-guided MPCNL is an effective and safety procedure to treat pediatric patients with stone <6 years.

Abbreviations: CT = computed tomography, EAU = the European Association of Urology, ESWL = extracorporeal shock wave lithotripsy, KUB = kidney–ureter–bladder plain, MPCNL = minimally invasive percutaneous nephrolithotomy, PCNL = percutaneous nephrolithotomy, PUJ-O = pelvi-ureteric junction obstruction, SFR = stone free rate, URS = ureteroscopy, US = ultrasound.

Keywords: pediatric urolithiasis, percutaneous nephrolithotomy, postoperative complications, stone free rate

1. Introduction

Anatomic abnormalities, metabolic disturbances, and infection are associated with pediatric urolithiasis.[1] The recurrence rate of urolithiasis in children is greater than in adult. Therefore, minimally invasive treatments have an important role in pediatric urolithiasis than in adult. PCNL is an effective and safety procedure to deal with kidney stone and has a high stone free rate (SFR) and high complications.[2] The most complications are associated with the size of the tract and instruments.[3] Owing to the fragile kidney and relative small collecting system of pediatric patients, urologists were always reluctant to treat pediatric urolithiasis with PCNL. Recently, the minimally invasive percutaneous nephrolithotomy (MPCNL) has been successfully performed in pediatric urolithiasis with similar SFR and lower hemoglobin drop and blood transfusion rates.[4,5]

However, the reports on ultrasound (US)-guided minimally invasive PCNL are still few. In this study, our objective was to assess the efficacy and safety of treating pediatric patients with US-guided MPCNL. This study is the largest single-center series report of MPCNL in the treatment of pediatric urolithiasis <6 years from China.

2. Materials and methods

A total of 88 pediatric patients (99 kidney units) <6 years who underwent the US-guided MPCNL from March 2006 to April 2016 were reviewed. The indications of MPCNL included cystine stone, extracorporeal shock wave lithotripsy (ESWL) refractory stone, ≥10 mm lower calyx stone, or anatomic abnormality of urinary tract. All patients were informed that the clinical and laboratory data would be used for scientific research and written consent was obtained before the MPCNL. The research was approved by Ethics Committee of Peking University People's Hospital and informed consent was obtained from all participants.

The mean age of pediatric patients was 30.9 months (range, 7–72 months). There were 11 patients with bilateral renal stone. The mean stone size was 19.5 mm (range, 10–50 mm) which was measured by preoperative radiographs and determined by the largest diameter. To the multiple stones of kidney unit, the stone

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Table 1

The preoperative characteristics of the pediatric patients.

Parameters	No. (%)	Mean (range)
Patients	88	
Sex male/female	59 (67.0)/29 (33.0)	
Age, mo		30.9 (7–72)
Stone size, mm		19.5 (10–50)
kidney left/right	52 (52.5)/47 (47.5)	
Location		
Upper ureteral	12 (12.1)	
Pelvis	49 (49.5)	
Upper pole	4 (4.0)	
Middle pole	1 (1.0)	
Lower pole	11 (11.1)	
Multiple locations	22 (22.2)	
Stone type		
Upper ureteral	12 (12.1)	
Single	35 (35.4)	
Multiple	43 (43.4)	
staghorn	9 (9.1)	
Hydronephrosis	70 (70.7)	

size was calculated by adding the longest diameter of each stone. A total of 70 (70.7%) patients were presented with mild hydronephrosis. Besides, 7 patients had hyperuricemia and 5 had cystinuria. All pediatric patients were conducted preoperative evaluation, including complete blood count, serum biochemistry, urine analysis, abdominal US, radiography, and computed tomography (CT). To avoid postoperative sepsis and ensure the sterile urine during the procedure, we managed the patients of urinary tract infection with antibiotics. The preoperative data of the pediatric urolithiasis were presented in Table 1.

2.1. Surgical technique

All MPCNLs were done during induction of general anesthesia. Ureteric catheter was placed using 3 Fr ureteral catheter in the lithotomy position to fill with collecting system. Then a 10 Fr Foley catheter was inserted and the patients were positioned prone. The 17.5 gauge needle was introduced into desired calyx under 3.5 MHz US guidance. And a J-shaped guide-wire was then inserted into collecting system through the needle after observing the urine reflux. The access was dilated by serial facial dilators through the guide-wire. A 14 to 16 Fr renal access was established. Nephroscopy was performed using an 8/9.8 Fr rigid ureteroscope. Lithotripsy was performed using pneumatic or holmium laser and the stone fragments were extracted by grasping forceps or flushed out by pulsed perfusion pump. The need to establish an additional tract depends on whether there is a residual stone for removal. Stone clearance was confirmed by US at the end of procedure by nephroscopy. Then we inserted a 4.7 Fr double-J stent and placed a 14 Fr nephrostomy tube after MPCNL in most young children.

Postoperative serum biochemistry and complete blood count testing were performed immediately. According to the results of urine culture and antibacterial spectrum, the prophylactic antibiotics were used. To assess the results, CT or kidney–ureter–bladder plain (KUB) was performed at the time of 24 to 48 hours after the procedure (Fig. 1). A patient was defined clinically residual fragments when the residual stones were ≥4 mm in diameter. Most of double-J stent was removed 4 weeks postoperative. The initial SFR was calculated at hospital discharge. The final SFR was calculated at 3 months later.

2.2. Statistical analysis

Mean ± standard deviation and median were performed on numerical data. Student t test for continuous variable and statistical significant test were made when $P < .05$.

3. Results

All MPCNLs were performed under US guidance. The middle posterior pole (72 renal units, 72.7%) was the most commonly access. Fifteen renal units (15.2%) in the upper pole and 12 (12.1%) renal units in the lower pole. A total of 70 patients (age ≥36 months) established the channel size of 14 or 16 Fr and 12 Fr

Figure 1. (A) Preoperative plain X-ray of patient with left kidney stone; (B) postoperative plain X-ray of kidney, ureter, and bladder of the same patient. The plain X-ray of patient showing stone in the left kidney was successfully removed by MPCNL, and nephrostomy drainage tubes were placed.

Table 2

The postoperative outcome of minimal invasive percuntaneous nephrolithotomy.

Parameters	No. (%)	Mean (range)
Operative time, min		52.3 (15–140)
Nephrotomy tube removed, d		3.8 (1–9)
Postoperative hospital time, d		6.0 (3–16)
Postoperative hemoglobin drop, g/L		10.9 (1–25)
Preoperative creatine, μmol/L		31.9 (7–289)
Postoperative creatine, μmol/L		35.7 (13–89)
P = .187		
Puncture site		
Upper pole	15 (15.2)	
Middle pole	72 (72.7)	
Lower pole	12 (12.1)	
Initial SFR	90.9	
Final SFR	96.0	
Major complications		
Fever (>38.5°C)	11 (12.5)	
Reactive pleural effusion	1 (1.1)	

MPCNL = minimal invasive percuntaneous nephrolithotomy, SFR = stone free rate.

in 18 cases. Seventy-seven (87.5%) cases performed a single session, whereas 11 (12.5%) cases performed 2 sessions. The mean operation time was 52.3 minutes (15–140 minutes). Besides, the hemoglobin concentration of 73 patients (83.0%) was decreased after the procedure and the mean hemoglobin drop was 10.9 g/L (range, 1–25 g/L). The mean postoperative hospital stay time was 6.0 days (range, 3–16 days). The initial SFR was 90.9%. There was no significant difference between preoperative and postoperative creatine ($P > .05$). The final SFR was 96.0%. The postoperative complications occurred in 12 (13.6%) patients including 11 patients with fever (>38.5°C) and 1 patient with active pleural effusion (Table 2). All patients were managed with conservative treatment. There was no patients received blood transfusion in our study. No sepsis, kidney loss, and adjacent organ injury were observed.

Stone analysis was available in 58 patients by infrared spectrophotometry. Results showed calcium oxalate stone in 34 cases, mixed composition stones in 8 cases, struvite stones in 6 cases, uric acid stones in 6 cases, and cystine stones in 4 cases.

4. Discussion

Pediatric urolithiasis shows a wide geographic variation. ESWL remains the ideal procedure for the treatment of pediatric urolithiasis with a diameter of ≤20 mm with few complications. Children can pass the stone fragments more quickly than adult after performing ESWL.[6,7] But ESWL often requires repeated sessions under general anesthesia due to the lower SFR. Urologists have hesitation on performing ESWL due to the risk of general anesthesia in China. Therefore, ESWL was not commonly done in pediatric patients at our center.

Previous studies have proved that PCNL has a higher SFR and lower need for ancillary procedures as monotherapy.[3,8] The European Association of Urology (EAU) guidelines recommend that PCNL is the primary treatment option in children with kidney stones >2 and >1 cm lower pole calyx stones.[9] But the adult size instrument may be not suitable for pediatric patients due to their fragile kidneys and small collecting system. Miniperc is PCNL performed with sheath size ≤20 Fr and the tract size ranges from 12 to 20 Fr. Numerous studies show that miniperc has the similar SFR with less complications associated with hemorrhage.[9]

The most PCNL procedures in the treatment of pediatric urolithiasis were reported under fluoroscopic guidance.[3,10,11] The US-guided MPCNL in the treatment of pediatric urolithiasis has some advantages in the prevention of exposure in the radiation and the real time clear visible of kidney adjacent tissue and vessels during procedures compared with previous reports under fluoroscopic guidance. Besides, US-guided MPCNL also can deal with nonopaque stones such as uric acid stone and cystine stone. The most frequently reported complications of PCNL in young children is bleeding, postoperative fever, or infection and persistent urinary leakage.[12] The blood transfusion rate is <10% in the modern series.[13] Postoperative infectious complications including fever with or without UTI were reported as <15%.[13–15] All procedures were successfully performed under US guidance in this study. There was no severe complications occurred, including blood transfusion, sepsis, and adjacent organ injure. And the rate of fever is 12.5% in this series. The concentration of hemoglobin was decreased in 73 patients (83%) with the mean hemoglobin drop of 10.9 g/L. The result confirmed the low incidence of MPCNL-related vessel injury under US guidance.

The SFR of PCNL in the treatment of pediatric urolithiasis varies from 86.9% to 98.5% with single session in recent studies.[5] SFR was increased with adjunctive treatments, including second-look PCNL, ESWL, and ureteroscopy (URS).[16] The SFR of 89% was achieved in complete staghorn patients.[17,18] The initial SFR of this study was 90.9%, and the final SFR was improved up to 96.0% with adjunctive treatments including second-look PCNL or ESWL.

The study is limited by the retrospective method, without control group, for lack of metabolic evaluation, relative short follow-up time, and single-center experience. Nevertheless, this study is the largest series report to evaluate the US-guided PCNL in the treatment of pediatric urolithiasis <6 years.

Author contributions

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