Bilateral Single-session PCNL with Minimally Invasive Technique in Pediatric Nephrolithiasis

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Purpose: To assess outcomes of bilateral single-session percutaneous nephrolithotomy (PCNL) with minimally invasive techniques in pediatric population.

Materials and Methods: From August 2015 to July 2021, 45 children (including 12 infants) were treated with bilateral single-session PCNL, which included miniPCNL (12-16-Fr) and Microperc (4.8-Fr). Patient, stone and operation-related characteristics, stone-free rate (SFR) and complication rate (CR) were compared using ANOVA. Independent predictors were determined using multivariate linear regression.

Results: The mean stone burden was 3.2 cm in sum diameter for both kidneys. For bilateral kidneys, the mean operative time was 61.6min and SFR was 93.3%; CR was 53.3%, of which complications of Clavien grade 1 and 2 accounted for 46.7%. Bilateral Microperc, bilateral miniPCNL and Microperc plus miniPCNL was performed in 19, 14 and 12 children respectively. Both irrigation volume and postoperative stay were less in groups with Microperc. Both SFRs and CRs were satisfactory for the three groups. Self-limiting hematuria represented the most common complication of all cases (33.3%), especially in groups with miniPCNL. The stone burden was the only independent predictor for operative time ($P < .001$) and the postoperative complication ($P = .008$). Children with older age ($P = .009$), higher body mass index ($P = .016$) or a higher stone burden ($P < .001$) received larger irrigated fluid volume. Microperc was associated with less irrigated fluid volume ($P = .001$). Children with Clavien grade 3 complications ($P = .004$) spent prolonged postoperative hospital stay.

Conclusion: With favourable SFR and acceptable CR, bilateral single-session PCNL with minimally invasive techniques might be an effective and safe procedure for pediatric nephrolithiasis.

Keywords: bilateral single-session surgical procedures; minimally invasive surgical procedures; nephrolithiasis; nephrolithotomy, percutaneous; pediatrics

INTRODUCTION

Over the past few decades, there has been a significant increase in the prevalence of pediatric nephrolithiasis [1,2]. Children often suffer from recurrent stones, multiple surgical interventions and progressive impairment of renal function, which would undermine their physical and mental health as well as place financial burdens on their families[3]. In a long-term follow-up study, percutaneous nephrolithotomy (PCNL) was found to be a more effective procedure for safely managing pediatric nephrolithiasis[4].

With the miniaturization of urological endoscopes, minimally invasive PCNL has become a viable option for both adults and children in a single session, with acceptable operative time, similar stone-free rates (SFR) and decreased complication rates (CR)[5,6]. Comparative studies and systematic reviews have extensively validated the feasibility, safety and effectiveness of bilateral single-session PCNL in adults[7]. The advantages of a single procedure include single anesthesia, reduced hospital stay and cost savings[8]. However, bilateral single-session PCNL with minimally invasive techniques as an option for pediatric nephrolithiasis has not yet been investigated. The aim of this study is to evaluate the feasibility, efficacy, and safety of minimally invasive bilateral single-session PCNL in treating pediatric nephrolithiasis.

MATERIALS AND METHODS

Study Design

This article was designed as a descriptive study. We retrospectively reviewed our prospectively maintained database containing consecutive patients who received endourological procedures from August 2015 to July 2021. Patients who underwent bilateral single-session minimally invasive PCNL at the age $\leq$ 14 years (yr) met inclusion criteria (n = 50). Selection criteria for bilateral single-session PCNL in our center were (1) bilateral nephrolithiasis; (2) the stone burden with a sum diameter larger than 1.0cm in each kidney; (3) infants' kidney stones larger than 3mm in diameter (Microperc); (4) no contraindications for anesthesia and surgery. Five cases with incomplete data were excluded. Finally, 45 children were included in our study. This study was ap-

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Table 1. Clinical data of children with bilateral nephrolithiasis

Variable		
No. patient/ renal unit, N	45/90	
No. infants, % (N)		26.7 (12)
Gender, male/female, N		28/17
Age [a], year		4.0 (1.4, 5.7), 4.2, .4-12.0
BMI [a], kg/m^2		16.3 (15.0, 16.9), 16.3, 13.2-25.5
Symptom, % (N)		
Hematuria		35.6 (16)
Urinary tract infection		35.6 (16)
Anuria		8.9 (4)
Adverse emotional reactions		17.8 (8)
Abdominal or flank pain		42.2 (19)
Stone burden [a], cm		
Unilateral		1.5 (1.0, 2.0), 1.6, 0.3-4.0
Bilateral		3.0 (2.0, 4.0), 3.2, 1.1-6.0
Hydronephrosis, % (N)		
Unilateral		20.0 (9)
Bilateral		55.6 (25)
Positive urine culture, % (N)		37.8 (17)
PCNL techniques, % (N)		
Bilateral MicroPerc		42.2 (19)
Bilateral mini-PCNL		31.1 (14)
MicroPerc + mini-PCNL		26.7 (12)
Operative time [a], min		60 (36, 90), 62, 20-180
Irrigated fluid volume [a], ml		1200 (2000, 4000), 3140, 100-15000
Stone free rate, % (N)		
per patient		93.3(42/45)
per renal unit		96.7(87/90)
Postoperative complications (Clavien classification), % (N)		53.3(24/45)
Grade I		31.1(14/45)
Fever		11.1(5/45)
Hematuria		33.3(15/45)
Intestinal obstruction		11.1(5/45)
Grade II		15.6(7/45)
Fever		17.8(8/45)
Blood transfusion		0
Fever (Grade I + II)		28.9(13/45)
Grade I + II		46.7(21/45)
Grade III		6.7(3/45)
Hemoglobin drop [a], g/l		7.0 (-.5, 11.0), 4.9, -15.0-20.0
Serum creatinine elevation [a], μmol/l range		5.4 (-2.0, 12.0), 4.7, -8.0-19.0
Postoperative hospital stay a, day		3.0 (2.0, 4.0), 3.4,1.0-10.0
Hospital stay a, day		6.0 (4.0, 8.0), 6.4, 3.0-15.0

Abbreviations: BMI, Body Mass Index; PCNL, percutaneous nephrolithotomy [a], Continuous variables were shown in median (P25, P75), mean, and range.

proved by the Institutional Review Board, and all children's parents signed informed consent that they understood the choice they made and possible complications. All children completed standard preoperative evaluation including medical history inquiry, physical examination, laboratory tests (blood and urine) and imaging. The collection of data based on a prepared standard data sheet was conducted by the same investigator (ZJ) in our team and checked by another designated investigator (PY). Imaging incorporated ultrasound (US) and low-dose non-contrast computed tomography (NCCT) to determine stone burdens, hydronephrosis and anatomical abnormalities. Children with severe hydronephrosis, sepsis or anuria first received retrograde stenting or percutaneous nephrostomy; then they underwent bilateral single-session PCNL after 2-4 weeks. Children with positive urine cultures were treated under the guidance of drug sensitivity tests, while children with negative ones were prescribed prophylactic broad-spectrum antibiotics, usually cephalosporins. PCNL procedures would be deferred for children with positive urine cultures until the urine culture is negative.

The stone burden was estimated by adding the maximum diameter of each stone on NCCT. Operative time was defined as the duration from insertion of puncture needles to skin sutures. Stone-free status was determined as all residual fragments < 2.0 mm in diameter on NCCT at 1 month after surgery. Complications were classified using the modified Clavien grading system for PCNL[9].

Surgical Techniques

Definitions, indications and qualification. Minimally invasive PCNL was recommended for children with kidney stones larger than 1cm in sum diameter in our center, which included miniPCNL (12-16-Fr, Richard-Wolf GmbH, Knittlingen, Germany) and Microperc (4.8-Fr, PolyDiagnost, Pfaffenhofen, Germany) in this study. Children underwent bilateral Microperc, bilateral miniPCNL, or a combination of Microperc on one side and miniPCNL on the other side (Microperc+miniPCNL). Microperc would be considered under the following circumstances: 1) younger children, especially < 3 years old; 2) kidneys with lower stone burdens, especially < 1.5cm; 3) kidneys without hydronephrosis. The side with lower stone burden was usually treated first and the other side was treated subsequently. The contralateral procedure would not be attempted unless PCNL was successful on the first side without intraoperative complications (severe hematuria with hemoglobin drop > 10g/l or other adverse anesthetic event) and prolonged operative time (> 120min). Otherwise, the single-session procedure must be suspended and staged PCNL would be considered. Our center performs more than 2000 surgeries of endoscopic lithotripsy per year and minimally invasive PCNL is a standard practice. All procedures were carried out by JL who had pediatric PCNL experience of about 100 cases per year to ensure the uniform level of experience and skills.

Positioning and retrograde catheterization. General anesthesia was provided through a laryngeal mask or tracheal intubation, a thermal insulation blanket was used to avoid hypothermia. Children first received placement of double-J stents (4.7-Fr/12-18 cm, Cook, Bloomington, IN, USA) with ureteroscopes (8/9.8-Fr, Richard-Wolf GmbH, Knittlingen, Germany) and a bladder catheter in the lithotomy position under general anesthesia (**Figure 1A**). Children with bilateral pre-stenting were directly placed in a prone position (**Figure 1B**). Therefore, saline infusion could be performed through the bladder catheter and the stents if artificial hydronephrosis was needed.

MiniPCNL. A 4.8-Fr all-seeing needle (PolyDiagnost, Pfaffenhofen, Germany) was used for puncturing under US guidance (**Figure 2A**). After reaching the target calyx, usually the intermediate or lower pole calyx, the inner puncture shaft was removed and then a 0.035-inch ultra-stiff guidewire was inserted into renal pelvis. In children who already had a nephrostomy tube (Figure 1B), the guidewire could be directedly inserted into renal pelvis through the tube. Guided by the wire, tract dilation was achieved to 12-16-Fr using Amplatz dilators (**Figure 2B**). The laser fiber was inserted through nephroscopes and irrigation fluid was instilled into renal pelvis by gravity (**Figure 2C**).

Microperc. As for Microperc, a threepath connector was applied to the outer tip of the shaft after puncturing. A laser fiber was then placed through the connector and irrigation fluid was injected manually with a syringe by an assistant (**Figure 2D**).

Table 2. Clinical data of children with bilateral nephrolithiasis stratified by PCNL techniquse

Variable	Bilateral Microperc (N = 19)	Bilateral MiniPCNL (N = 14)	*P*-value
Age a, year	2.7 ± 2.2	6.0 ± 3.5	-
BMI a, kg/m^2	16.5 ± 2.4	16.7 ± 2.7	.649
Stone burden [a], cm			
Unilateral	1.2 ± .5	2.0 ± .9	-
Bilateral	2.4 ±. 9	4.1 ± 1.5	-
Hydronephrosis, % (N)			
Unilateral	26.3 (5)	14.3 (2)	-
Bilateral	36.8 (7)	78.6 (11)	-
Operative time [a], min			
Unilateral	27.0 ± 14.4	37.5 ± 20.6	.018
Bilateral	54.0 ± 27.0	75.0 ± 38.6	.077
Irrigated fluid volume a, ml			
Unilateral	158 ± 92	3357 ± 2257	< .001
Bilateral	316 ± 173	6714 ± 4497	< .001
Stone free rate, % (N)			
Unilateral	94.7 (36/38)	96.4 (27/28)	1.000
Bilateral	89.5 (17/19)	92.9 (13/14)	1.000
Postoperative complication, % (N)	36.8 (7)	78.6 (11)	.033
Grade I	10.5 (2)	57.1 (8)	.007
Fever	10.5 (2)	14.3 (2)	1.000
Hematuria	10.5 (2)	57.1 (8)	.007
Intestinal obstruction	0	21.4 (3)	.067
Grade II	21.1 (4)	14.3 (2)	1.000
Fever	21.1 (4)	3 (21.4)	1.000
Blood transfusion	0	0	-
Fever (Grade I + II)	31.6 (6)	35.7 (5)	1.000
Grade I + II	31.6 (6)	71.4 (10)	.037
Grade III	5.3 (1)	7.1 (1)	1.000
Hemoglobin drop [a], g/l	4.3 ± 7.8	4.6 ± 8.5	.881
Serum creatinine elevation [a], µmol/l	4.6 ± 8.5	5.5 ± 8.4	.552
Postoperative hospital stay [a], day	3.1 ± 1.9	4.3 ± 2.9	.276
Hospital stay [a], day	6.1 ± 2.1	7.4 ± 3.9	.461

Abbreviations: BMI, body mass index; PCNL, percutaneous nephrolithotomy; SD, standard deviation;
[a], Continuous variables were shown in mean ± SD

Lithotripsy, nephrostomy tubes and ureteric stents. The 272-µm holmium-YAG laser was used for lithotripsy. High frequency (20-30 Hz) and low energy (0.6-0.8 J) was set for Microperc, so that stones were dusted rather than fragmentated so as to facilitate the spontaneous passage of residual stones. After the lithotripsy process, bilateral nephrostomy tubes were placed and skin was sutured in miniPCNL (**Figure 2E**), while Microperc were tubeless (**Figure 2F**). Intravenous antibiotics were given for 1-2 days postoperatively. The nephrostomy tube was retained for 1-2 days and removed. Double-J stent removal was performed at 1 month (mo) after surgery.

Statistical analysis

Normality of distribution was checked using Shapiro-Wilk tests. Student *t* tests and Mann-Whitney U tests were applied for continuous variables to determine the significance of each variable between groups. Chi-square tests and Fisher's precision probability tests were used for categorical variables. Multivariate linear regression was performed to identify independent pre-

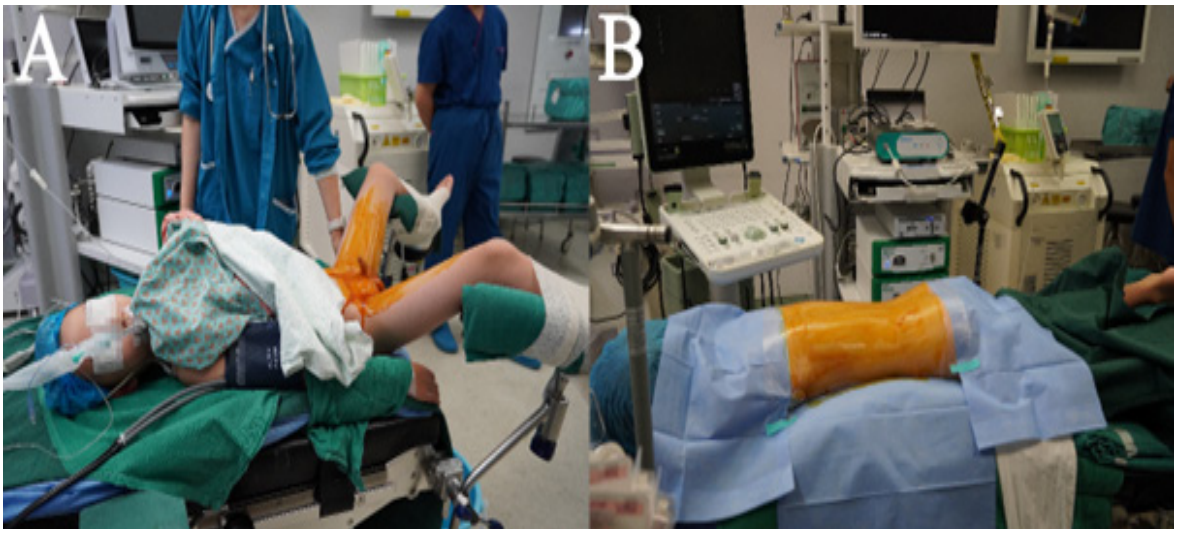

Figure 1. Positioning of bilateral single-session percutaneous nephrolithotomy with minimally invasive technique. **A,** lithotomy position for retrograde catheterization; **B,** prone position for following lithotripsy

Table 3. Multivariate regression analysis of operative parameters, irrigated fluid volume, postoperative hospital stay and postoperative complication.

Variable	Operative Time		Irrigated Fluid Volume		Postoperative Hospital Stay		Postoperative Complication [b]	
	β	*P*-value	β	*P*-value	β	*P*-value	OR (95% CI)	*P*-value
Age (> 3 vs. ≤ 3 [a])	-	.243	.24	.009	-	.674	-	.419
Gender (male vs. female [a])	-	.075	-	.779	-	.361	-	.845
BMI	-	.470	.20	.016	-	.640	-	.362
Stone burden	.51	< .001	.48	< .001	-	.489	2.314 (1.243, 4.305)	.008
Hydronephrosis	-	.102	-	.569	-	.856	-	.141
(bilateral vs. unilateral vs. none [a])	-	.371	-	.354	-	.223	-	.973
Urine culture (positive vs. negative [a])								
PCNL technique	-	.955	-.34	.001	-	.871	-	.300
(bilateral Microperc vs. Microperc + miniPCNL vs. bilateral miniPCNL [a])								
Operative time		-	-	-	-	-	.923	-	.653
Irrigated fluid volume		-	-	-	-	-	.437	-	.524
Postoperative complication		-	-	-	-	.56	< .001	-	-
(with vs. without [a])								
Grade I			-	.847	-	-			
Grade II			-	.847	-	-			
Grade III		-	-	-	-	.34	.004	-	-

Abbreviations: β, standardized coefficient; BMI, body mass index; CI, confidence interval; OR, odds ratio; PCNL, percutaneous nephrolithotomy
[a] reference for each categorical variable;
[b] patients with postoperative complications versus patients without postoperative complications;

dictors for operative time, irrigated fluid volume, and postoperative hospital stay with β(standardized coefficient) respectively. The predictive factors of postoperative complications were determined by logistic regression analysis, and the odds ratio of each variable was calculated. Tests were 2 sided and $P = .05$ was the threshold for statistical significance. All statistical tests were performed using SPSS (version 24.0).

RESULTS

Our study included children from 4 mo to 12 yr, among whom infants accounted for 26.7% (12/45) and children aged < 3 years accounted for 46.7% (21/45). The male-to-female ratio was nearly 1.5:1 (28:17). Pain, hematuria and urinary tract infection were the most common symptoms when nephrolithiasis was diagnosed. Younger children (< 3 years) mainly presented as hematuria ($P = .005$), urinary tract infection ($P < .001$) and adverse emotional reactions and crying ($P = .003$), while the main clinical manifestations of older children (> 3 years) were abdominal or flank pain ($P < .001$) (not shown). No child presented with fever or elevated serum creatinine at the day of surgery. The unilateral and bilateral mean stone burden were 1.6 cm and 3.2 cm respectively. Bilateral hydronephrosis was mostly presented. Positive urine culture was found in 37.8% of children. Mean operative time was 61.6min and SFR was 93.3%; CR was 53.3%, of which complications of Clavien grade 1 and 2 accounted for 46.7%. Hematuria represented the most common complication (33.3%), while no children needed blood transfusion. Hemoglobin and serum creatinine were both stable after bilateral PCNL. The mean postoperative hospital stay and hospital stay were 3.4 and 6.4 days respectively. (**Table 1**) All surgeries were performed as scheduled without staged procedures. Bilateral Microperc, bilateral miniPCNL and Microperc plus miniPCNL were performed in 19, 14 and 12 children respectively. The operative time of bilateral-Microperc (54 min) was shorter than that of bilateral-miniPCNL (75 min), however, the difference was not statistically significant ($P = .077$). When comparing operative time between these two groups in

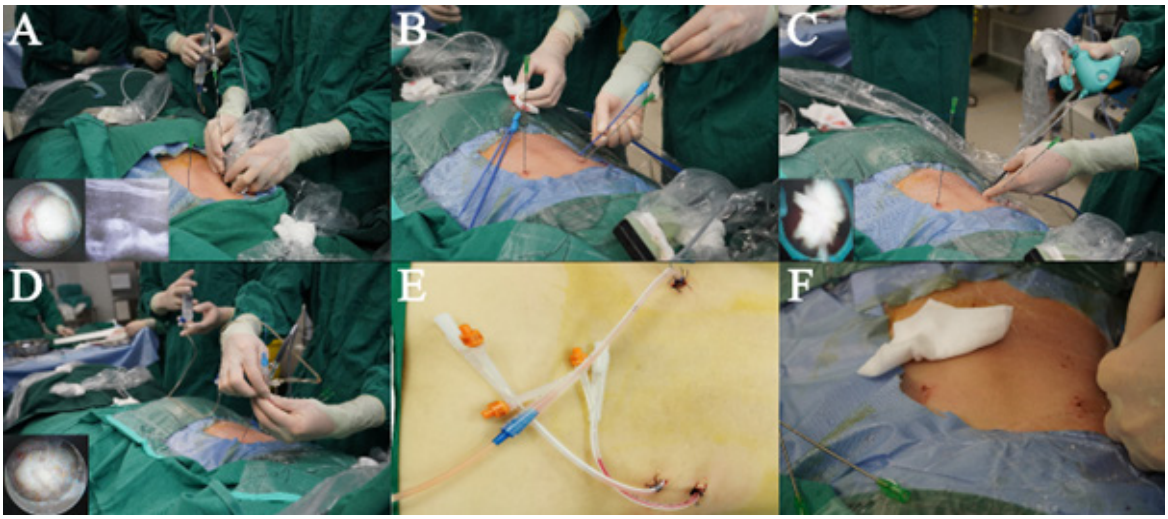

Figure 2. Procedures of bilateral single-session percutaneous nephrolithotomy with minimally invasive technique. **A**, puncturing; **B,** dilation of miniPCNL; **C,** fragmentation with 12 Fr nephroscopes; **D**, fragmentation with 4.8 Fr Microperc; **E**, placement of nephrostomy tubes in bilateral miniPCNL; **F**, tubeless bilateral Microper

a unilateral manner, we found that bilateral-Microperc was significantly different from bilateral-miniPCNL (P = .018). Irrigated fluid volume was significantly lower for bilateral-Microperc (316 mL) than bilateral-miniPCNL (6714 mL) ($P < .001$). One 12-year-old girl suffered from postoperative pneumonia and sepsis (Clavien grade 3), which were treated with supportive therapies and enhanced monitoring in ICU. Two infants underwent a second lithotripsy with ureteroscopes due to steinstrasse (Clavien grade 3). No difference in SFR was found between bilateral-Microperc and bilateral-miniPCNL ($P > .05$); however, fewer complications especially Grade I+II complications were found in bilateral-Microperc than bilateral-miniPCNL ($P < .05$). Fever was the most common complication after bilateral-Microperc (31.6%), while hematuria was the most common complication after bilateral-miniPCNL (57.1%). Microperc group was significantly different from miniPCNL group in the rate of hematuria ($P = .007$). There was no significant difference in hemoglobin drop and serum creatinine elevation between groups ($P > .05$). (**Table 2**)

Stone burden was the only independent predictor for operative time ($\beta = .51$, $P < .001$) as well as postoperative complication (OR = 2.314, 95% CI: 1.243-4.305, $P = .008$); High stone burden was associated with prolonged operative time and more complications. Children with an older age ($\beta = .24$, $P = .009$), higher body mass index (BMI) ($\beta = .20$, $P = .016$) or higher stone burden ($\beta = .48$, $P < .001$) received larger irrigated fluid volume; however, Microperc was related with less irrigated fluid volume ($\beta = -.34$, $P = .001$). We also discovered that children with more complications ($\beta = .56$, $P < .001$), especially Clavien grade 3 complications ($\beta = .34$, $P = .004$) spent prolonged postoperative hospital stay. (**Table 3**)

DISCUSSION

With the availability of smaller size instruments, miniaturized PCNL have become possible, with decreased severe complications. Compared to extracorporeal shockwave lithotripsy for renal pelvic and lower calyceal stones > 1cm, miniPCNL has significantly higher stone-free rates with a lower retreatment rate and without a significant increase in complications[10]. The surgical characteristics and outcomes for Microperc and retrograde intrarenal surgery in treating young children with 1-2 cm renal stones were similar, however, Microperc allowed lower anesthesia sessions[11]. In children with a larger stone burden, the SFR of miniPCNL was significantly higher than that of flexible ureteroscopy, and CR was similar between the groups[12]. Our study also demonstrated that minimally invasive PCNL could be a feasible and safe procedure as a monotherapy for younger children with nephrolithiasis, especially in a bilateral single-session manner; in addition, minimally invasive bilateral single-session PCNL could become an alternative to extracorporeal shockwave lithotripsy and retrograde intrarenal surgery, and even the preferred treatment modality.

Purkait et al.[13] performed a retrospective analysis to assess outcomes of staged PCNL for bilateral staghorn stones in pediatric patients > 3 yr. Initial SFR was 76.47% which was lower than 95.8% for children > 3 yr in our study (not shown in Results); however, their final SFR after any auxiliary procedures (second look PCNL or postoperative ESWL) was up to 95% and their low initial SFR was mainly due to a great stone burden. In our study, five children with bilateral complete or partial staghorn stones were rendered stone-free in one session, which demonstrated that bilateral single-session PCNL was as effective as staged PCNL. In Purkait's study, complications were noted in 47 % of patients and most complications were minor (Clavien grade 1+2 accounting for 39%). In our study, the CR (54.2%) for children > 3 yr resembled the rate of theirs and the skew toward minor complications (Clavien grade 1+2 accounting for 50.0%) was also similar (not shown in Results). Therefore, bilateral single-session PCNL was also a safe procedure which was comparable to staged PCNL.

The findings of a study conducted on adult patients indicated that bilateral single-session PCNL had significantly shorter operative time, shorter hospital stay and higher hemoglobin loss than staged PCNL; however, the stone-free rate and complication rate were comparable between bilateral single-session PCNL and staged PCNL[14]. In our study, we found that both hemoglobin and serum creatinine were stable in postoperative period of bilateral single-session PCNL for children. These findings were consistent with those observed in studies involving unilateral PCNL[15,16]. However, it needs to be verified if the kidney function was stable after bilateral single-session PCNL in a long-term follow-up. Compared to staged PCNL, bilateral single-session PCNL has been reported to offer other advantages over the use of single anesthesia, reduced surgical and psychological stress, decreased medication delivery (such as antibiotics and anesthetics) and significant cost savings [14]. Even in the absence of previous studies exploring these benefits in pediatric patients undergoing bilateral single-session PCNL, the skew toward cost savings, reduced medication use, and alleviation of both mental and physical stress aligns with our common sense, which would be validated in further studies.

Salah et al.[17] reported favorable outcomes in 13 children aged three to fourteen who underwent bilateral single-session PCNL (26-Fr), with all children rendered stone-free and no occurrence of severe bleeding or other major complications. The outcomes of our study were comparable to theirs: with the exception of one child, all 24 children > 3 yr achieved a stone-free status, and only one female patient suffered from postoperative pneumonia (Clavien grade 3). With minimally invasive nephroscopes, the mean operative time of two sides was 70.9 min (range 20-180 min) which was comparable with that of Salah's study (not shown in Results). When calculated per renal unit, the mean operative time (32.8 min) was much shorter. Furthermore, the postoperative hospital stay of our study (3.4 days) was shorter than 4-5 days of Salah's (not shown in the Results section). Therefore, in conclusion, the minimally invasive bilateral single-session PCNL may offer advantages of shorter operative time and hospital stay for pediatric patients.

A recent systematic review[18] concluded that SFRs ranged from 80%-100% and 85%-100% for Microperc and miniPCNL (11-14-Fr) respectively in pediatric unilateral nephrolithiasis. Our results extended previous studies and provided additional evidence that minimally invasive bilateral single-session PCNL was also a feasible procedure for dealing with bilateral stones in one

session. The pooled CRs for Microperc and miniPCNL (9% and 14%) were lower than 36.8% and 78.6% in our study respectively. However, the pooled rate of Clavien grade 3 complications was 2.4% which was comparable with 6.7% in our study. The main reason would be our strict adherence to the modified Clavien grading system for PCNL. It has been demonstrated that urologists tended to have a lower rate of agreement for grading minor complications than for severe complications[9]. Most of the previous studies did not regard spontaneously resolving hematuria as a minor complication, while hematuria was exactly the most common complication of our study. The mean operative times per renal unit for bilateral-Microperc and bilateral-miniPCNL were 27.0 min and 37.5 min respectively in our study, which were respectively shorter than 37.2 min and 56.0 min in two studies with comparable stone burden[19,20]. Mean hospital stay per renal unit was 3.0 days and 3.7 days for bilateral-Microperc and bilateral-miniPCNL respectively in our study, which were comparable with those (2.5 days and 3.2 days) in the systematic review. Our study revealed that the stone burden was an independent predictor for operative time. This finding was consistent with Kareem's studies, which demonstrated that operative time was significantly prolonged in increased stone size as well as multiple stones and calyceal stones in infants and preschool children[21]. The information regarding the number and location of stones was not available in our study, nevertheless, we are convinced that complicated stones would result in a prolonged operative time. The stone burden was an independent predictor for complications, which was also found in the study designed for unilateral standard PCNL in adults[22]. With a lower stone burden, children could suffer fewer potential operation-related complications, particularly in bilateral procedures. With increased irrigated fluid volume, more fluid absorption into the blood was observed[23], which was associated with complications such as perforation, bleeding, hypothermia and cardiovascular changes in adults[24,25]. Fluid absorption leading to fluid overload may be more detrimental to pediatric patients. Our study found that the stone burden was an independent predictor for irrigated fluid volume, and therefore the control of operative time as well as irrigated fluid volume was crucial in order to decrease complications. We also found that children with an older age or higher BMI received larger irrigated fluid volume, which reminded us of their overload risk. A previous study showed that postoperative stay increased with the Clavien grade in adults [9]. In our study, we found evidence that complications were predictive for postoperative hospital stay, which was unaffected by demographics, stone or operative characteristics. As shown in our results, only Clavien grade 3 complications were associated with prolonged postoperative hospital stay. Since Clavien grade 3 complications were uncommon, we concluded that bilateral single-session PCNL was a safe procedure without long postoperative hospital stay.

Our study certainly presents some limitations. Firstly, this study was the first step towards enhancing our understanding of minimally invasive bilateral single-session PCNL in pediatric stone formers. Thus, another comparative study would be necessitated to further elucidate parallels and differences between bilateral single-session PCNL and staged or unilateral PCNL. Secondly, another limitation lies in the retrospective nature, though the database was constructed prospectively. Thirdly, single- institution and single- surgeon experience could limit the extent to which the results can be generalized.

CONCLUSIONS

Compared to miniPCNL, Microperc was a preferred option for children with a young age and for the renal unit with a low stone burden. MiniPCNL can achieve similar operative time and SFR with Microperc, but it is accompanied with more self-limited hematuria. With favourable SFR and acceptable CR, bilateral single-session PCNL with minimally invasive techniques might be a feasible, effective and safe procedure for pediatric nephrolithiasis. Bilateral single-session PCNL with minimally invasive techniques should be a surgical option for experienced urologists.

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CONFLICT ON INTEREST

We confirm that there are no known conflicts of interest associated with this publication; We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed.

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