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Safety and efficacy of mini-percutaneous nephrolithotomy in management of renal stones in pediatric age group

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Abstract

Background Currently, kidney stones are frequently observed in children and teens.

Objectives To evaluate the safety and efficacy of mini-percutaneous nephrolithotomy (MPCNL) in managing renal stones in pediatric patients.

Patients and methods This retrospective case series study included 115 consecutive patients aged < 11 years old who underwent MPCNL at Sulaimani Teaching Hospital and Mercy Medical City, Sulaimaniyah, Iraq, from January 2016 to March 2021. MPCNL was done on all patients through 16–20 Fr tracts. The stone-free rate, perioperative complications, tract number, operative time, postoperative hemoglobin change, and hospitalization time were assessed.

Results The mean patients' age was 6.53 ± 1.3 years, and the mean stone burden was 2.073 ± 1.03 cm^2. After a single session of MPCNL, 93.25% of patients attained a complete stone clearance through a single tract in 109 patients (94%) and two tracts in 6 patients (5.2%). Hospitalization time, operative time, postoperative hemoglobin drop, and perioperative complications were 2.23 ± 0.93 days, 39.26 ± 8.22 min, 0.51 ± 0.34 g/dL, and 25.21%, respectively. No major complications (Clavien grade III and IV) were found. Most complications were minor, including Clavien grade I ($n = 18$, 15.6%) and II ($n = 11$, 9.56%), which were managed conservatively.

Conclusions MPCNL is an effective and potentially safe procedure for treating complex renal stones in pediatric patients aged < 11 years, yielding an excellent stone-free rate and acceptable complications.

Keywords Pediatric age group, Renal stone, Nephrolithotomy, Clavien grade

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Introduction

Urolithiasis is a common issue affecting pediatric age groups [1], and its prevalence is rising among both children and infants. The incidence of pediatric urolithiasis has rapidly increased, with an estimated adjusted annual increase of 10.6%, especially in developed countries [2]. Therefore, urolithiasis should be considered a lifestyle ailment [3]. The incidence of renal stones in children may differ geographically, and gender influences stone formation, with a higher incidence of males than females for the first decade of life and female predominance in the second decade [4]. Regarding the overall management of pediatric urolithiasis, girls have the most stone treatment than boys [2]. Developing countries like the Middle East and Far Eastern nations have a higher prevalence of renal stones than Western countries [5].

Also, kidney stone formation is influenced by climate, diet, profession, fluid intake, genetic predisposition, urinary tract infections and malformations. Therefore, dietary factors are considered causative factors, as in those areas, uric acid stones and ammonium acid urate predominate strongly [6]. Consequently, poor lifestyles, increased salt intake from processed and preservative foods and decreased water intake play a significant role in the global rise of pediatric urolithiasis worldwide [7].

Children need metabolic evaluation and efficient and regular follow-up because of their high recurrence rate and the most common metabolic disturbances were hypocitraturia and hypercalciuria [8]. Pediatric may have other risk factors like anatomical abnormalities, genetic defects in epithelial transportation, and repeated urinary tract infections. Genetic abnormalities play a more significant factor in younger populations. Environment and lifestyle, like unhealthy diet and dehydration, may cause metabolic abnormalities [9].

Percutaneous nephrolithotomy (PCNL) has become the first choice of treatment for kidney stones that require surgery, and ten years after PCNL emergence, pediatric cases were initiated. First, pediatric PCNL series were performed in older children in which adult instruments were used with similar success; however, with higher complication and transfusion rates [10]. With the advancement and availability of smaller-size instruments, MPCNL became a single-stage, most effective treatment with stone clearance rates of > 90% and fewer complications [11]. Shock wave lithotripsy (SWL) and interventional treatment for renal stones in children often necessitate general anesthesia or intravenous sedation; hence, stone relief in a single session is of high priority. Although SWL can be done in children for kidney stones of < 1.5–2.0 cm, concerns include the necessity of further shock treatments, low stone-free rates after single-session monotherapy, frequent retreatment sessions, and increased risk of postoperative obstruction [12]. SWL can be used safely and effectively for most renal stones in children; however, when the stones are more significant, challenging or more complex and unaffected by SWL, the surgical management decision can be made [13]. The ideal management of pediatric stone disease is still demanding. Surgical procedures should not affect the growth and diminish the function of the small young kidneys. Surgical management aims to reach total stone clearance with minimal morbidity to the patient regarding the duration of surgery and hospital stays with a reduction in blood loss and other complications [14].

According to European Association of Urology (EAU) guidelines, PCNL is the first line option in children with kidney stones of > 2.0 cm at lower pole calyx. The stone-free rate can range from 73 to 96% with PCNL [14]. Despite these advances and refinement in surgical instruments and decades of improvement in the procedure, PCNL remains a demanding procedure with associated morbidity. Postoperative sepsis (2.0%), fever (10–16%), blood transfusion (3.0–6.0%), significant bleeding (8.0%), and perforation of adjacent organs (0.4%) are still essential complications after PCNL [15]. Thus, this study aimed to evaluate the safety and feasibility of MPCNL in the first decade of life (pediatric age group) and assess perioperative complications and stone clearance rate.

Patients and methods

Study setting and design

This retrospective case series study included 115 consecutive patients aged < 11 years old who underwent MPCNL at Sulaimani Teaching Hospital and Mercy Medical City, Sulaimaniyah, Iraq, from January 2016 to March 2021.

Inclusion criteria

Patients with confirmed renal stones aged < 11 years, regardless of gender, nationality, and residency.

Exclusion criteria

Patients with other diseases, such as renal failure, liver failure, cancer, diabetes, hypertension, and those on chemotherapy and chronic medications were excluded from the study.

Patient Preparation and surgical technique

The pre-operative evaluations included urinalysis, urine culture, renal function testing, abdominal ultrasonography (USG), and kidney, ureter, and bladder (KUB) radiography. Intravenous urography and non-contrast computed tomography (CT) were performed. Then, patients were treated by MPCNL using pediatric instruments (16–20 Fr tract). Under general anaesthesia and rescue endotracheal tube (ETT), intravenous prophylactic antibiotics (3rd generation cephalosporins) were given

just before induction. Then, in the lithotomy position, a ureteric catheter (4Fr) was inserted by a pediatric cystoscope (8Fr). After that, in a prone position under fluoroscopic and contrast guidance, an experienced urologist did a needle puncture to the chosen calyx and the tract was dilated with serial coaxial amplatz dilators, then sheaths (16–20 Fr) and a 12-Fr mini-nephroscope (Karl Storz, Tuttlingen, Germany). A pneumatic lithotripter was used with a holmium laser to disintegrate the stones (Calculus II holmium laser system, Karl Storz, Tuttlingen, Germany). All calyces were routinely checked at the end of the procedure using a rigid nephroscope and a 15-Fr flexible nephroscope (Karl Storz, Tuttlingen, Germany) to examine and remove stone fragments. The operation was completed when the stone-free status was committed, and residual pieces were unavailable using fluoroscopy and endoscopy. Intraoperative flexible nephroscopy was performed for all patients, which was very helpful in confirming free stones or non-significant residuals, and then a JJ stent was inserted. The Foley catheter (12 or 14 Fr) was inserted as a nephrostomy tube removed once the urine was clear, usually after one day. The ureteric stent was removed after 2 weeks from operation.

The patients were discharged home when comfortable, afebrile, and had no urine leakage from the nephrostomy site. The stone burden was measured by multiplying the two most significant dimensions on pre-operative radiography, and the stone complexity was classified according to Guy's stone score.

Follow-up

The first follow-up visit was scheduled two weeks after the operation, presumably for JJ stent removal (in the case of an uneventful procedure). Consequent assessments were performed at six weeks, and a second assessment was conducted at three months with renal USG supplemented with X-ray KUB. The stone-free rate was calculated three months postoperatively. It was classified as completely stone-free (absence of residual stone fragments) or residual stones (residual stones of any size by imaging).

Table 1 Patients' sociodemographics and preoperative characteristics

Variable	Number (%)
Gender	
Female	46 (40)
Male	69 (60)
Previous stone surgery	
Yes	32 (27.82)
No	83 (72.18)
SWL	
Yes	16 (13.9)
No	99 (86.1)
Stone complexity	
GSS 1	46 (40)
GSS 2	53 (46.08)
GSS 3	8.0 (6.95)
GSS 4	8.0 (6.95)
Total	115 (100)

GSS: Guy's stone score, SWL: Shock wave lithotripsy

Statistical analysis

Data were analyzed using the Statistical Package for Social Science (IBM-SPSS, USA, Version 25). The normally distributed data were presented as numbers (Percentages) or mean ± standard deviation (SD).

Results

The mean age of patients who underwent MPCNL for renal stones was 6.65 ± 1.3 years, with an age range of 7 months to 10 years. The mean stone burden was 2.073 ± 1.03 cm^2. Most patients were males (n = 69, 60%), had no previous stone surgery (n = 83, 72.18%), and only 16 patients (13.9%) had CT for stone diagnosis. Regarding the stone complexity, most patients had Guy score II (GSS 2, n = 53, 46.08%), followed by GSS1 (n = 46, 40%), then GSS3/GSS4 (n = 8.0, 6.95% each; a complete staghorn stone) (Table 1).

After a single session of MPCNL, 93.25% of patients achieved complete stone clearance and the calculus was cleared through a single tract in 109 (94.7%) cases, while 6.0 (5.3%) patients required two tracts. Most patients had JJ stent (n = 88, 76.52%), while 27 (23.48%) did not. The mean operative time was 39.26 ± 8.22 min (calculated from puncture till nephrostomy tube insertion), the mean hospitalization stay was 2.23 ± 0.93 days, and the mean postoperative hemoglobin change (drop) was 0.51 ± 0.34 g/dL. Regarding the complications, 29 (25.21%) patients had perioperative (operative and postoperative) complications, most of which were minor. Based on the Clavien grading system, 18 children (15.6%) had grade I, and 11 children (9.56%) had grade II complications that were managed conservatively. However, no one had major complications (grade III and IV); fever was found in 18 (15.65%) patients. Four patients (3.47%) required postoperative blood transfusion, and postoperative urinary tract infection (UTI) was developed in 7.0 (6.08%) cases. Interestingly, no cases of prolonged urine leakage (> 24 h), pleural effusion, extravasation, colonic injury, sepsis, mortality, and urinoma were reported (Table 2).

Discussion

PCNL has high stone-free rates and has proven highly effective as monotherapy or in combination with SWL [16].

Table 2 Operative and postoperative characteristics

Variable	Number (%)
Tract	
1 Tract	109 (94.7)
2 Tract	6.0 (5.3)
JJ stent insertion	
Yes	88 (76.52)
No	27 (23.48)
Complication	
Perioperative complication	29 (25.21)
Postoperative fever	18 (15.65)
Blood transfusion	4.0 (3.47)
Urinary tract infection	7.0 (6.08)
Prolonged urine leakage (> 24 hours)	0
Pleural effusion	0
Extravasation	0
Colonic injury	0
Sepsis	0
Mortality	0
Urinoma	0
Surgical complications grade	
Grade I	18 (15.6)
Grade II	11 (9.56)
Grade III	0
Grade IV	0

MPCNL: Mini-percutaneous nephrolithotomy

The aim of renal stone treatment is complete stone clearance and prevention of recurrence. Pediatric urolithiasis has a higher recurrence rate than adults, so the main goal is decreasing renal injury using less invasive procedures [17].

In this study, a 93.25% clearance rate was reached with a single session of MPCNL. This result is higher than those published studies over the past years, such as Gunset et al. [18], Unsal et al. [19], and Mahmood et al. [14], who achieved 70%, 83%, and 89.5% stone-free rates, respectively. Gained endourological experience and advancement techniques with the availability of instruments explain the good results of this study.

Also, in this study, only 8.0 patients (6.95%) had complete staghorn, and only 6.0 patients (5.2%) experienced a multitrack procedure, which might explain the difference in the stone-free rate with other studies. These outcomes are contrary to those of other studies, which had mostly complete staghorn with a single-track procedure in most cases [14, 18, 19].

Although MPCNL had a high success rate, perioperative complications still happened, including this study (25.21%), which is less than those reported by Özden et al. (42%) [20], Goyal et al. (39.2%) [21], and Guven et al. (29.1%) [22]. Thus, modification and improvement of the Clavien score are crucial for precise and efficient assessment of each possible MPCNL complication to decrease flaws and inter-observer variability [20]. The most common complications in this study were fever (16.65%) and blood transfusion (3.47%). These outcomes are less than that reported by Nouralizadeh et al., who found postoperative fever in 31% and blood transfusion in 23.9% of pediatric cases with renal stones [23].

Smaller surgical tools didn't significantly prolong operative time but achieved the same stone clearance as adult standard-size instruments [24]. Bleeding is one of the anticipated and crucial complications of PCNL that can lessen vision and cause blood loss and subsequent hypovolemic shock if not recognized and managed at an early stage. It can result in early termination of the procedure and prevent reaching stone clearance goals. In this study, 4.0 cases (3.47%) with severe bleeding had three staghorn calculi and one partial staghorn stone that necessitated blood transfusion and the end of the procedure. Bleeding needing transfusion was associated with stone burden, sheath size, number of tracts and operative time documented from 0.4 to 24% [21]. The use of a gentle technique, the correct placing of the first tract, avoidance of improper manipulations, such as extracting the nephroscope, and increased surgical experience together, and a wholly equipped surgical theatre with the availability of instruments are essential factors to avoid bleeding [25].

Conclusions

MPCNL is an effective and potentially safe procedure for treating different types of renal stones in the pediatric age group (< 11 years old) with an excellent stone-free rate and acceptable complications.

Abbreviations

CT	Computed tomography
ETT	Endotracheal tube
Fr	Fourteen French
KUB	Kidney ureter and bladder
GSS	Guy score
MPCNL	Mini-percutaneous nephrolithotomy
PCNL	Percutaneous nephrolithotomy
SD	Standard deviation
SPSS	Statistical Package for Social Science
SWL	Shock wave lithotripsy
UoS	University of Sulaimani
UTI	Urinary tract infection
USG	Ultrasonography

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Author contributions

SNM: Conceptualization, methodology, data collection, writing the original manuscriptSHAS: Supervision, methodology, study registration, writing the original manuscriptROM: Methodology, data analysis, writing the original manuscriptMSJ: Data curation, study administration, edition of the final draft All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Scientific and Ethical Committees of the College of Medicine, University of Sulaimani, Sulaimaniyah, Iraq (No. 50/07/2016/UoS). Also, permission was granted by the Sulaimani Directorate of Health. All procedures were done according to the Declaration of Helsinki. Written informed consent was obtained from patients' legal guardians, and the study's aims were explained to them.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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