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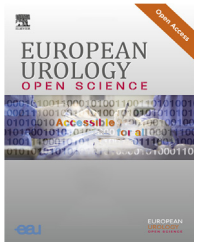

European Association of Urology

Stone Disease

Is Mini Percutaneous Nephrolithotomy a Game Changer for the Treatment of Renal Stones in Children?

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Abstract

Background: Mini percutaneous nephrolithotomy (MPCNL) is a newer surgical procedure that has changed the management of paediatric renal stones.
Objective: To evaluate MPCNL morbidity and success rates for renal stones as a function of patient age in a paediatric cohort.
Design, setting, and participants: This was a retrospective case series that included 143 consecutive patients younger than 17 yr who underwent MPCNL at our institution between January 2016 and November 2020. The patients were categorised into three different age groups: <6 yr (n = 71, 49.7%), 6–11 yr (n = 44, 30.8%), and 12–17 yr (n = 28, 19.6%). MPCNL was performed in all patients through 16–20Fr tracts.
Outcome measurements and statistical analysis: The stone-free rate, perioperative complications, tract number, operative time, postoperative haemoglobin change, and hospitalisation time were evaluated for each age group.
Results and limitations: MPCNL was performed in 143 paediatric patients (88 boys and 55 girls; mean age 6.53 yr). The mean stone burden (± standard deviation) was 2.096 ± 1.01 cm in group one, 2.05 ± 1.05 cm in group two, and 3.46 ± 19.94 cm in group three; group three was significantly larger (p = 0.001). After a single MPCNL session, 92.42% of patients experienced complete stone clearance. All age groups were similar in terms of stone-free rate (p = 0.82), hospitalisation time (p = 0.94), postoperative haemoglobin change (p = 0.06), and perioperative complications (p = 0.62). However, stone size (p = 0.009), stone complexity (p = 0.001), number of access points (p = 0.03), and operative time (p = 0.009) were higher in the group aged 12–17 yr.
Conclusions: MPCNL is an effective and safe procedure in younger as well as older children. Age should not be considered a limiting factor for MPCNL in children, and MPCNL should be considered the primary option for treating paediatric renal stones when PCNL is indicated.

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Patient summary: Our results show that surgical removal of kidney stones through an incision in the skin and using miniaturised instruments is an effective and safe procedure for children.

1. Introduction

Urolithiasis in children is rare but the incidence is rising worldwide in all paediatric age groups. The condition is challenging to manage in paediatric cases because of the small size of the urinary tract and high recurrence rates [1,2].

Technological advances have changed the renal stone management approach in children from open surgery to a minimally invasive approach [3]. Percutaneous nephrolithotomy (PCNL) has become a standard procedure for treating renal stones and offers a high stone-free rate with no long-term adverse effects on the renal parenchyma of the developing kidneys of a growing child [4–8].

Attempts to reduce perioperative morbidity using miniaturised PCNL (MPCNL) has become popular for treating renal stones in various paediatric age groups using smaller tracts ranging in size from 11Fr to 20Fr with less harm to the renal parenchyma; consequently, there is lower associated morbidity without a decrease in therapeutic efficacy [9–15]. Concerns regarding the age of the patient has begun to wane, and MPCNL can now be performed even in infancy [16–18]. Here we compare the success rates and perioperative morbidity among different age groups of children undergoing MPCNL.

2. Patients and methods

We performed a retrospective case review of 143 consecutive patients younger than 17 yr who underwent MPCNL at our tertiary referral institution between January 2016 and November 2020. The patients were categorised into three different age groups: <6 yr (n = 71, 49.7%); 6–11 yr (n = 44, 30.8%); and 12–17 yr (n = 28, 19.6%). PCNL was performed on all patients through 16–20Fr tracts.

All patients were evaluated using preoperative renal function tests, urinalysis, and urine culture. Preoperative imaging methods included kidney, ureter, and bladder (KUB) radiography and ultrasonography (USG); nonenhanced computed tomography (CT) was performed in all patients to evaluate the renal anatomy, the location of the stone, and the relation of the colon and surrounding structures to the kidney.

Preoperative factors included age, gender, stone side, stone burden (cm^2), stone complexity (using Guy's stone score [19]), and previous stone-related treatments. The operative and postoperative factors were number of tracts, operative time (minutes), stone-free status, intraoperative and postoperative complications (according to the modified Clavien classification [20]), postoperative haemoglobin change (g/dl), and hospitalisation time (days).

2.1. Surgical technique

All procedures were performed in the prone position after administration of prophylactic antibiotics. Renal access was obtained under fluoroscopic guidance by a urologist, and the tract was dilated with serial coaxial Amplatz dilators, followed by insertion of Amplatz sheaths (16–20Fr) and a 12Fr mini-nephroscope (RZ Medizintechnik GmbH, Tuttlingen, Germany). A pneumatic lithotripter was used with a holmium laser when necessary to disintegrate stones (cyber Ho 60 holmium laser system, Quanta System, Milan, Italy).

The operation was deemed complete when stone-free status was confirmed and residual fragments were not detected using both fluoroscopy and endoscopic examination (rigid and flexible nephroscope).

After completion of the procedure, a 12–14Fr Foley catheter was inserted as a nephrostomy tube in all patients. Double-J (JJ) stents were inserted routinely. The nephrostomy tube and urethral catheter were removed when the urine was clear on postoperative day 1. Patients were discharged home when they were comfortable, afebrile, and had no urine leakage from the nephrostomy site.

2.2. Follow-up

The first follow-up visit was scheduled for 2 wk after the procedure for JJ stent removal, and the JJ stent was removed in the case of an uneventful procedure. Subsequent assessments were performed at 6 wk, and a second assessment at 3 mo (chance of spontaneous clearance of stone fragments) with renal USG supplemented with KUB X-rays. CT scans were not used to minimise costs and radiation exposure.

The overall stone-free rate was calculated at 3 month postoperatively and was classified as either completely stone-free (defined as the absence of residual stone fragments) or residual stones (detection of a residual stone of any size on imaging).

2.3. Statistical analysis

Data were analysed using SPSS v24. A χ^2 test was used for analysis of proportions, and mean values were compared using a Mann-Whitney test or a t test, as appropriate. A p value of <0.05 was considered statistically significant.

3. Results

A total of 143 children (88 boys and 55 girls; mean age 6.53 yr; range 7 mo–16 yr) underwent MPCNL for renal stones and were included in the study. Patients were categorised into three age groups: group 1, <6 yr (n = 71, 49.7%; mean age 3.1 ± 1.2 yr); group 2, 6–11 yr (n = 44, 30.8%; mean age 7.1 ± 1.4 yr); and group 3, 12–17 yr (n = 28, 19.6%; mean age 14.4 ± 2.7 yr). The mean stone burden was 2.096 ± 1.01 cm in group 1, 2.05 ± 1.05 cm in group 2, and 3.46 ± 19.94 cm (p < 0.001) in group 3. The female/male ratio was 28/43 in group 1, 18/26 in group 2, and 9/19 in group 3. There were 18 patients with a complete staghorn stone (Guy's stone score IV), of whom five (7%) were in group 1, three (6.8%) were in group 2, and ten (37%) were in group 3 (p < 0.001; Table 2).

Fifty-five patients (38.4%) had undergone previous stone related surgery, of whom 20 (28.2%) were in group 1, 12 (13.6%) were in group 2, and 13 (44.4%) were in group 3.

Table 1 – Patient demographics and preoperative characteristics

Parameter [a]	Age <6 yr (*n* = 71)	Age 6–11 yr (*n* = 44)	Age >11 yr (*n* = 28)	*p* value
Age (yr)	3.1 ±1.2	7.1± 1.4	14.4 ± 2.7	0.001 [b]
Gender, *n* (%)				
Female	28 (39.4)	18 (40.9)	9 (32.1)	0.004[d]
Male	43 (60.6)	26 (59.1)	19 (67.9)	
Previous stone surgery, *n* (%)				0.403 [d]
Yes	20 (28.2)	12 (13.6)	13 (44.4)	
No	51 (71.8)	16 (86.4)	15 (53.6)	
Extracorporeal shockwave lithotripsy, *n* (%)				0.69 [d]
Yes	10 (14.1)	6 (13.6%)	5 (17.9)	
No	61 (85.9)	38 (86.4%)	23 (82.1)	
Stone size (cm)	2.096 ± 1.01	2.05 ± 1.05	3.46 ± 19.94	0.001 [c]
Stone complexity, *n* (%)				0.001 [d]
Guy's stone score 1	27 (38)	19 (43.2)	7 (25.9)	
Guy's stone score 2	33 (46.5)	20 (45.5)	4 (14.8)	
Guy's stone score 3	6 (8.5)	2 (4.5)	6 (22.2)	
Guy's stone score 4	5 (7)	3 (6.8)	10 (37)	

[a] For continuous variables, results are presented as the mean ± standard deviation.
[b] Mann-Whitney U test.
[c] *t* test.
[d] χ^2 test.

Table 2 – Operative and postoperative characteristics

Variable [a]	Age <6 yr	Age 6–11 yr	Age >11 yr	*p* value
Stone-free rate after single MPCNL session (%)	93 ± 0.25	93.5 ± 0.46	89.3 ± 0.315	0.82 [c]
Operative duration (min)	39.92 ± 9.53	38.6 ± 6.92	48.04 ± 22.29	0.009 [b]
Number of tracts, *n* (%)				0.03 [c]
1 tract	67 (94.4)	42 (95.5)	20 (71.4)	
2 tracts	4 (5.6)	2 (4.5)	4 (14.3)	
3 tracts	0	0	4 (14.3)	
JJ stent insertion (%)				0.768 [c]
Yes	78.9	75	82.1	
No	21.1	25	7.2	
Postoperative haemoglobin drop (g/l)	0.53 ± 0.32	0.49 ± 0.36	0.48 ± 0.428	0.94 [c]
Hospital stay (d)	2.31 ± 1.16	2.16 ± 0.71	1.6 ± 0.39	0.06 [b]
Operative and postoperative complications, *n* (%)				
Postoperative fever	19 (26)	10 (24)	7 (25)	0.623 [c]
Blood transfusion	11 (18.3)	7 (15.9)	3 (10.8)	0.106 [c]
Urinary tract infection	3 (4.20)	1 (2.3)	2 (7.2)	0.537
Prolonged urine leakage (>24 h)	5 (7)	2 (4.5)	2 (7.2)	0.935
Pleural effusion	0	0	0	–
Extravasation	0	0	0	–
Colonic injury	0	0	0	–
Sepsis	0	0	0	–
Mortality	0	0	0	–
Urinoma	0	0	0	–
Surgical complications, *n* (%) [d]	0	0	0	–
Grade I	11 (18.3)	7 (15.9)	3 (10.8)	0.089 [c]
Grade II	5 (11.2)	3 (6.8)	4 (14.4)	0.078
Grade III	0	0	0	–
Grade IV	0	0	0	–

MPCNL = mini percutaneous nephrolithotomy.
[a] For continuous variables, results are presented as the mean ± standard deviation.
[b] Mann-Whitney U test.
[c] χ^2 test.
[d] Modified Clavien grading system.

The preoperative characteristics of the groups are listed in Table 1. After a single MPCNL session, 92.42% of patients achieved complete stone clearance; the rate was 93%, 93.5%, and 89.3% for groups 1, 2, and 3, respectively (p = 0.82). Of the 143 MPCNL cases, the calculus was cleared through a single tract in 129 cases (90%); ten patients (7%) required two tracts and four (3%) required three tracts.

The stone-free rate (p = 0.82), hospitalisation time (p = 0.94), postoperative haemoglobin change (p = 0.06), and perioperative complications (p = 0.62) were similar

between the groups. However, stone size (p = 0.009), stone complexity (p = 0.001), number of tracts (p = 0.03), and operative time (p = 0.009) were higher in the group aged 12–17 yr (Tables 1 and 2).

Some patients experienced complications: 21 (14.6%) were Clavien grade I and 12 (8.4%) were Clavien grade II. No major complications (Clavien grade III and higher) were observed. There was no significant difference in complication rates between the age groups, and most complications were minor (Clavien grade I or II). All were managed conservatively.

Six patients (4.1%) required a postoperative blood transfusion, and a postoperative UTI occurred in nine cases (6.2%), which were treated with appropriate parenteral antibiotics. There were no significant differences in postoperative UTI rates (p = 0.53) and blood transfusion rates (p = 0.93) between the groups (Table 2).

4. Discussion

The incidence of kidney stones has increased worldwide in all paediatric age groups. It is an enormous challenge, especially in light of the small size of the urinary tract and the high recurrence rates [1,2]. PCNL is the standard procedure in children who require surgery for kidney stone disease, even in infants [4–8]. MPCNL has become very popular for treating renal stones in different paediatric age groups and can lower perioperative morbidity without compromising therapeutic adequacy [9–15].

The stone-free rate of our paediatric series was 92.42% (89.3–93.5%) after MPCNL monotherapy, with no significant difference between the age groups (p = 0.82). The groups had stone clearance rates within the previously reported range of 50–98% [21–24].

MPCNL monotherapy is also used to treat paediatric renal stones, with stone clearance rates of 82% [25], 85.2% [26], 89.5% [12], 86.2% [18], and 91% [14] reported. Jones et al [15] published a systematic review of MPCNL in the management of paediatric stone disease and found an overall stone-free rate of 87.9% (range 76–97.5%).

Despite the high success rates, PCNL is a highly invasive procedure with the potential for serious complications. The complication rate was 24–26% in our series according to the modified Clavien classification, which is similar to rates reported in the literature [12,15,17,27,28]. All of our complications were grade II and were managed conservatively.

The proportion of patients who developed a postoperative UTI was 4.5–7.2% and 2.3–7% needed a blood transfusion. These rates are in agreement with reported postoperative UTI rates of 3.5–6% and blood transfusion rates of 3.1–18% [12,17,23,26]. There were no significant differences between the age groups in UTI and blood transfusion rates.

For complete clearance of stones, intraoperative percutaneous calyceal irrigation was performed to flush out stone fragments with saline and to reach inaccessible calyces through a rigid nephroscope. A flexible nephroscope was used to examine and remove stones to avoid additional punctures; multiple tracts were used when required [29].

The frequency of larger stones requiring multiple tracts was higher among children older than 11 yr (n = 8; 28.4%). However, the stone-free and perioperative complication rates were no different than in the other two age groups.

There were no differences between the age groups in stone-free rate, hospitalisation time, postoperative haemoglobin change, or perioperative complications. These findings suggest that MPCNL can be safely performed in any age group, and age should not be considered a limiting factor for MPCNL in children.

5. Conclusions

MPCNL is an effective and safe procedure in both younger and older children. It can be used to treat simple and complex renal stones with excellent stone clearance and complication risk. Age should not be considered a limiting factor for MPCNL in children, and MPCNL should be considered the primary option for treating paediatric renal stones when PCNL is indicated.

Author contributions: Sarwar Noori Mahmood had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Mahmood.
Acquisition of data: Falah.
Analysis and interpretation of data: Falah, Ahmed, Tawfeeq.
Drafting of the manuscript: Fakhralddin, Tawfeeq.
Critical revision of the manuscript for important intellectual content: Mahmood.
Statistical analysis: Ahmed.
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