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Percutaneous nephrolithotomy in children: does age matter?

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Abstract

Purpose To compare the outcomes of percutaneous nephrolithotomy (PCNL) in 2 age groups.

Methods Fifty-one renal units (RU) of 45 patients were operated between January 2006 and December 2010. In all patients, PCNL was performed by pediatric nephroscope of 17F size through a 20F Amplatz sheath. Patients were examined in 2 groups (Group1: $\leq$5 years, Group 2: >5 years) and outcomes were compared accordingly.

Results The mean age was 5.95 ± 3.63 years and male-to-female ratio was 23/22. The mean stone burden, operative time, and postoperative hospital stay were 4.24 ± 2.03 cm^2, 94.30 ± 37.28 min, and 5.18 ± 2.97 days, respectively. In the postoperative period, 44 renal units (86.2%) were stone-free. Two age groups were similar regarding the postoperative hospital stay, gender distribution, stone location, stone composition, and complication rates. However, stone burden and number of access was less and stone-free rate was higher in younger age group.

Conclusion The stone-free rate in preschool children is at least as good as older children without an increase in complication rates. The older children (>5 years) have a higher stone burden and need multiple accesses more frequently. The complications are mostly low grade and can be managed conservatively. Our results showed that PCNL in younger children as safe and effective as in the older children and age should not be considered as a limiting factor.

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Introduction

Percutaneous nephrolithotomy (PCNL), since its advent in 1976, has become the first choice of treatment for the kidney stones which requiring surgery [1]. After a 10 years period of adult experience, it was started to be performed in children [2]. Today, PCNL replaced open surgery in surgical treatment of pediatric stone disease patients [3]. First pediatric PCNL series were performed in older children with adult instruments with similar success however with higher complication and transfusion rates [4, 5]. With availability of pediatric size instruments, the complication rates became lesser [6, 7]. The concerns on age of the patients began to disappear with the technological advancement that the operation can be performed without any problem even in the infant period. The presented study aimed to evaluate the outcomes of pediatric PCNL regarding the age groups.

Materials and methods

Between January 2006 and December 2010, 51 renal units (RU) in 45 patients (bilateral in 6 patients) underwent PCNL. Preoperatively, all the patients underwent non-enhanced spiral computed tomography in order to define the renal anatomy and the location of the stones. Preoperative urine cultures were obtained in all patients and patients with preoperative positive urine culture received appropriate antibiotic treatment. Patients underwent preoperative metabolic evaluation by serum and urine (spot and 24-h collection) tests. In all patients, pediatric nephroscope of 17F size and 20F Amplatz sheath was used. Percutaneous access was established under biplanar fluoroscopic guidance. Following the operation, 14F reentry catheter was used in all patients except 2 patients with double j stent only (tubeless PCNL) and 1 patient with double j stent accompanying with re-entry catheter (endopyelotomy case). Previous intervention history did not affect our surgical technique.

The postoperative first visit was done 2–4 weeks after the surgery. Our postoperative follow-up in pediatric PCNL patients included ultrasonography, urinalysis, blood pressure measurement at 3 months intervals for the first year, 6 months interval in the second and then once in a year, X-ray of kidney-ureter-bladder (KUB) at 6 months interval in the first year, and then yearly, renal, and hepatic function tests in serum at 6 months interval if the patient was given a medication. Renal scintigraphy is utilized if any concern on renal function develops and computerized tomography is used if any doubt occurs with the previous imaging modalities.

The patients were compared regarding to 2 groups: Group 1: 5 years or younger, Group 2: older than 5 years. The data has been reviewed retrospectively and the outcomes were analyzed regarding the age groups. Moreover, to evaluate the effect of experience, patients were divided into 2 groups regarding the chronological operation date.

The data of patients were recorded and analyzed by SPSS 13.0 programme. Chi-square test was used for analysis of proportions, evaluation of means were done by Mann–Whitney test and *T* test where appropriate. A P value < 0.05 was considered to be statistically significant.

Results

The mean age was 5.95 ± 3.63 years (11 months–15 years) and male-to-female ratio was 23/22. Seven patients had previous SWL and 2 had open stone surgery history. Operated site was left for 28 and right for 21 RU whereas in 1 patient simultaneous bilateral PCNL was performed. In one patient, bilateral Glenn-Anderson ureteroneocystostomy for bilateral high grade vesicoureteral reflux and in another patient, percutaneous endopyelotomy for ureteropelvic junction obstruction were performed in the same session. There were single stone in 27, multiple in 12, and staghorn in 12 RU. Single access was sufficient in 43 RU whereas more than 1 access was needed in 8 RU (2 accesses in upper pole calyces in 1 patient, 2 accesses in middle and lower pole calyces in 6 patients and 3 accesses in upper, middle, and lower calyces in 1 patient). Three patients needed blood transfusion postoperatively. We experienced one descending colon perforation that was noticed intraoperatively which has been treated conservatively. Postoperative fever was present in 6 patients and prolonged urine leak occurred secondary to a residual ureteral stone in 1 patient. Within a mean follow-up period of 16.3 ± 12.4 months, no long-term surgery-related complication developed.

In the postoperative period, 44 renal units (86.2%) were stone-free. One patient in our series underwent adjuvant shock-wave lithotripsy (SWL) and is still under follow-up with a residual stone. The other patient with significant residual stone was a patient with a previous history of open pyelolithotomy for a staghorn stone and referred to our center with multiple calyceal stones. We have been able to extract all the stones except 2 calyceal stones (7 and 7 mm in size). The stones with a length of ≤3 mm are followed up by imaging modalities and medications if required. With the patients who had clinically insignificant residual fragments (5 RU), the success rate is 96%. The history of previous intervention did not affect either stone-free (chi-square test, $P = 0.432$) or complication (chi-square test, $P = 0.854$) rates. Of 43 patients whose stone analysis were available, 34 (79.1%) had calcium oxalate containing stones whereas 9 (20.9%) had struvite composition.

Mean length and weight of the patients were 113.08 ± 21.86 cm (78–174) and 21.08 ± 8.59 kg (9–45), respectively. The mean stone burden, operative time (including the cystoscopy and ureteral catheterization), and postoperative hospital stay were 4.24 ± 2.03 cm^2 (1.5–10), 94.30 ± 37.28 min (30–195), and 5.18 ± 2.97 days (2–14), respectively. Preoperative hematocrit and serum creatinine levels were 34.93 ± 3.61 and 0.56 ± 0.13 mg/dl whereas the postoperative values were 31.83 ± 4.59 and 0.59 ± 0.15 mg/dl, respectively. The hematocrit drop was significant (Paired samples *T* test, $P < 0.001$) whereas the change in serum creatinine levels was insignificant (Paired samples *T* test, $P = 0.591$). Group 1 and 2 were similar regarding the postoperative hospital stay, gender distribution, stone location, stone composition, and complication rates. However, stone burden and number of access was less and stone-free rate was higher in younger age group (Table 1).

The ROC (receiver operating characteristic) curve analysis revealed that the best cut-off points for predicting stone-free status for age were 7 years (AUC: 0.814, sensitivity: 85.%, specificity: 65.1%, $P = 0.008$) and 4.75 cm^2 for stone burden (AUC: 0.811, sensitivity: 71.4%, specificity: 65.1%, $P = 0.009$). Children younger than 7 years old (93.6% vs. 70.6%, chi-square test, $P = 0.024$) and children with a stone burden lower than 4.75 cm^2 had a higher stone-free rate (92.1% vs. 66.7%, chi-square test, $P = 0.048$). ROC curve analysis was not helpful to find cut-off point for complication status.

Table 1 The comparison of operative parameters regarding the age groups

Parameter	Group 1 (RU, $n = 27$)	Group 2 (RU, $n = 24$)	P
Age (years; mean ± SD)	2.98 ± 1.29	9.16 ± 2.37	<0.001[a]
Weight (kg; mean ± SD)	15.83 ± 5.30	27 ± 7.75	<0.001[b]
Length (cm; mean ± SD)	99.44 ± 14.66	128.43 ± 18.25	<0.001[b]
Stone size (cm^2; mean ± SD)	3.63 ± 1.58	4.89 ± 2.29	0.027[b]
Operative time (minutes; mean ± SD)	86.92 ± 39.62	102.29 ± 33.55	0.150[a]
Postoperative hospital stay (day; mean ± SD)	5.92 ± 3.90	4.37 ± 0.96	0.256[a]
Gender distribution (male/female)	13/14	14/10	0.555[c]
Stone location (single/staghorn/multiple)	15/5/7	12/7/5	0.690[c]
Number of access (single/multiple)	27/0	16/8	<0.001[c]
Postoperative fever (yes/no)	3/24	3/21	0.917[c]
Complication (yes/no)	6/21	4/20	0.728[c]
Stone-free state (yes/CIRF + residue)	27/0 + 0	17/5 + 2	0.012[c]
Stone composition (CaOx/struvite)	18/5	16/4	0.889[c]
Operation date group (first/second)	14/12	12/13	0.571[c]

CaOx calcium oxalate, *RU* renal unit, *SD* standard deviation, *CIRF* clinically insignificant residual fragments

[a] Mann-Whitney *U* test, [b] *T* test, [c] Chi-square test

Discussion

PCNL has become the first treatment choice in children who requires surgery for kidney stone disease [3]. The indications for us to perform PCNL were SWL-resistant upper urinary tract stones and stones larger than 2 cm^2. The two dimensional mean stone size larger than 4 cm^2 reflects our preference and concordance with the literature [5, 8–10].

PCNL in children is a feasible procedure with high success rates regardless of the stone composition and does not prevent the performance of secondary procedures such as ESWL or re-PCNL [5, 8–10]. The stone-free rate in our series was 86.2%. Although, with considering the insignificant residual stones, the success rates increase up to 96%, we have serious concerns on the term "clinically insignificant residual fragments (CIRF)"; therefore, we prefer to give the complete stone-free rate. The residual fragments in children are prone to be a nidus for stone aggregation and a risk factor for recurrence. Afshar et al. showed that fragments in any size are risk factors for postoperative unwanted effects such as recurrence [11].

Our technique of PCNL in children was similar to adults'. We performed the operations in prone position under fluoroscopy guidance. In the adult literature, PCNL in supine position has been described with success and complication rates equivalent to prone position [12]. The supine position PCNL was reported to be advantageous in regards to operative time since no additional time is required for re-positioning. We think that there is no obstacle to perform supine PCNL in pediatric age group. However, neither we have experience nor the literature presents series on this specific issue. The radiation exposure is also another concern in pediatric PCNL. Use of ultrasonography before the surgery or during establishment of access may be a good alternative which has been shown to have high success and low complication rates [13]. However, in case of pediatric cases, to establish the access under ultrasonography guidance before the surgery will require an additional session under anesthesia and in cases who require intraoperative additional access, an interventional radiologist should be ready in the operation room which is not always possible practically. Moreover, if the surgeon would make the ultrasonography guided access, he should be experienced on this technique. There is no specific case-series on the use of ultrasonography guided access in pediatric PCNL series. Therefore, most of the urologists prefer to establish the access by themselves under fluoroscopy. We believe that rational use of fluoroscopy ought to be established to limit the radiation exposure.

One of the main concerns on pediatric PCNL is the possible adverse effects of surgery on the renal parenchyma of a growing child. Although, focal damage is reported in 5% of cases [14], the general belief is that PCNL does not cause adverse renal morphologic or functional alteration [15, 16]. However, the most appropriate sized instruments should be used to minimize this risk.

PCNL is not without complications. As we classify the complications regarding the modified Clavien system [17], we noticed grade 2 complications in 9 (postoperative fever in 6 cases requiring antibiotic treatment and bleeding in 3 cases requiring transfusion), grade 3a in 1 (colonic perforation in 1 case managed conservatively) and grade 3b in 1 (prolonged urinary leak due to a ureteral residue in 1 patient removed with auxillary ureteroscopy) patients. All the complications were managed successfully and patients were discharged without problem. Fever after PCNL was reported between 2 and 49% [4, 5, 8–10, 15, 18–21] and in our series it is about 11%. None of our patients had documented bacteriuria before surgery however the obstruction of the system may prevent the documentation of bacteria from the bladder samples or the stone itself may harbor bacteria inside. Nonetheless, patients who will undergo endoscopic stone surgery should have sterile urine preoperatively and the children with positive urine cultures should have been treated by appropriate antibiotics before surgery. In the pediatric PCNL literature, transfusion rates were reported between 0.4 and 23.9% [4, 5, 8–10, 15, 18–21]. In our series, only 3 (6%) patients needed blood transfusion postoperatively. We believe that forceful manipulations to reach a stone in a difficult location through a single access may cause parenchymal lacerations and bleeding. Instead, establishing a different access may sometimes be less invasive. For practical purposes, we do not hesitate making an additional access to the kidney and in 8 RU, we performed the operation through more than one access. Alternatively, the use of flexible instruments may be a good option for this aim. Prolonged urinary leak mostly occurs secondary to a distal obstruction secondary to a residual stone on the way and sometimes secondary to delayed healing and is reported to occur between 0 and 8% [5, 19]. Residual fragments can be treated endoscopic methods whereas in patients with no residual fragments a temporary double j stent placement will always solve the problem. We experienced this problem in 1 (2%) case which had a residual ureteral fragment which was treated with ureteroscopy. Neighboring organ trauma was never reported previously in the pediatric PCNL literature. This has been attributed to the experienced gained in adults. The colonic perforation was reported between 0.2 and 0.8% in adults and has not been reported in children until 2010 [22, 23]. However, the first colonic perforation in a child was reported by Gedik et al. [24]. In their series of 48 patients, they experienced 1 colonic perforation and in another patient they noticed retrorenal colon preoperatively by computerized tomography. They, therefore, recommended routine preoperative tomography in all PCNL patients. Our single case of colonic perforation was a 5-year-old girl who underwent simultaneous PCNL. In this case, the right side was operated first and the colonic injury happened during the PCNL on the left side. The perforation in the descending colon was noticed during the operation. Following the completion of the PCNL surgery, a controlled colocutaneous fistula over a nelaton catheter was established. The patient was hospitalized for 14 days and was discharged with no problem. This trauma was retroperitoneal and we were able to manage conservatively. In transperitoneal traumas, surgical intervention is mandatory. Therefore, we also recommend a non-enhanced spiral computerized tomography for preoperative evaluation as Gedik et al. did. As a result, most of the complications of PCNL in children are low grade and can be managed conservatively.

At the beginning, PCNL was performed in older children. With the increased experience, younger children were begun to be operated. Today, age is not a limiting factor for PCNL even infants of 3 months of age are being operated [18, 25]. In the present series, more than one-third of the patients are smaller than 3 years old (Fig. 1). In our series, we particularly evaluated the outcomes between preschool and school children. Since the numbers of patients in both groups were similar, our series was ideal to compare the age groups. We noticed that stone burden was larger and need for multiple accesses were more frequent in children older than 5 years old. The need for multiple accesses was probably because of the higher stone burden. However, the stone-free rate was significantly higher in younger children (100% vs. 70.8%). The distributions of gender, stone location, complication rates, postoperative hospital stay, and stone compositions were similar. Also, the distribution of age groups regarding the chronological operation date groups was similar. Thus, gained experience cannot be attributed as a factor for higher stone-free rate in younger children. Although, the number of cases limits making multivariate analysis, the higher stone-free rate in younger children may be due to the lower stone burden. Our results revealed that PCNL in younger children can be performed as safe and effectively as in the older children. However, the ROC curve analysis gave the hint that older children than 7 years and children with a stone burden higher than 4.75 cm^2 have higher risk of having postoperative residual fragments. These findings may be used to inform the parents and prepare the patients for possible further additional treatment modalities.

Age could not be considered as a limiting factor for PCNL in children. In accordance with our findings, recent studies on pediatric cases showed the efficacy of PCNL on different age groups with different sized instruments [6, 7]. These encouraging results and growing experience let

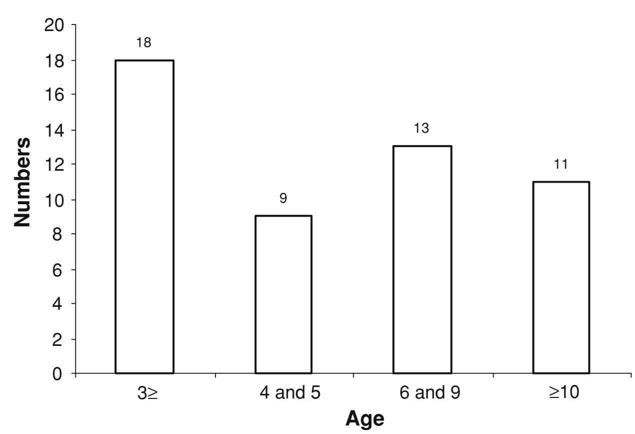

Fig. 1 Number of operated renal units regarding different age groups

authors to report—although with limited numbers—tubeless PCNL [26–28] and bilateral simultaneous PCNL [21]. In our series, we also performed 2 tubeless and 1 bilateral simultaneous PCNL.

Although, the results of our study revealed the safety of PCNL in children, we are aware that it has a retrospective nature and reflects the results of a series with a single instrument type in a single institute. The sample size in our series is not adequate to evaluate the factors which affect the outcomes by multivariate analysis. Therefore, future multicenter studies with a prospective design comparing the outcomes with various sized instruments in different age groups will be better.

Conclusion

PCNL in children is a safe and effective treatment modality. The stone-free rate in preschool children is better than older children without an increase in complication rates. The older children (>5) have a higher stone burden and need multiple accesses more frequently. The complications are mostly low grade and can be managed conservatively. Our results showed that PCNL in younger children as safe and effective as the older children and age should not be considered as a limiting factor.

Conflict of interest statement There is no conflict of interest.

References

1. Fernstrom I, Johannson B (1976) Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 10:257–259
2. Woodside JR, Stevens GF, Stark GL, Borden TA, Ball WS (1985) Percutaneous stone removal in children. J Urol 134: 1166–1167
3. Tekgül S, Riedmiller H, Gerharz E, Hoebeke P, Kocvara R, Nijman R, Radmayr C, Stein R (2008) Guidelines on pediatric urology. EAU guidelines 2008:52–62
4. Zeren S, Satar N, Bayazit Y, Bayazit AK, Payasli K, Ozkeçeli R (2002) Percutaneous nephrolithotomy in the management of pediatric renal calculi. J Endourol 16:75–78
5. Desai MR, Kukreja RA, Patel SH, Bapat SD (2004) Percutaneous nephrolithotomy for complex pediatric renal calculus disease. J Endourol 18:23–27
6. Bilen CY, Koçak B, Kitirci G, Ozkaya O, Sarikaya S (2207) Percutaneous nephrolithotomy in children: lessons learned in 5 years at a single institution. J Urol 177:1867–1871
7. Unsal A, Resorlu B, Kara C, Bozkurt OF, Ozyuvali E (2010) Safety and efficacy of percutaneous nephrolithotomy in infants, preschool age, and older children with different sizes of instruments. Urology 76:247–252
8. Aron M, Yadav R, Goel R, Hemal AK, Gupta NP (2005) Percutaneous nephrolithotomy for complete staghorn calculi in preschool children. J Endourol 19:968–972
9. Salah MA, Toth C, Khan AM, Holman E (2004) Percutaneous nephrolithotomy in children: experience with 138 cases in a developing country. World J Urol 22:277–280
10. Ozden E, Mercimek MN, Yakupoğlu YK, Ozkaya O, Sarikaya S (2011) Modified clavien classification in percutaneous nephrolithotomy: assessment of complications in children. J Urol 185:264–268
11. Afshar K, McLorie G, Papanikolaou F, Malek R, Harvey E, Pippi-Salle JL, Bagli DJ, Khoury AE, Farhat W (2004) Outcome of small residual stone fragments following shock wave lithotripsy in children. J Urol 172:1600–1603
12. Liu L, Zheng S, Xu Y, Wei Q (2010) Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supine versus prone position. J Endourol 24:1941–1946
13. Karami H, Rezaei A, Mohammadhosseini M, Javanmard B, Mazloomfard M, Lotfi B (2010) Ultrasonography-guided percutaneous nephrolithotomy in the flank position versus fluoroscopy-guided percutaneous nephrolithotomy in the prone position: a comparative study. J Endourol 24:1357–1361
14. Samad L, Qureshi S, Zaidi Z (2007) Does percutaneous nephrolithotomy in children cause significant renal scarring? J Pediatr Urol 3:36–39
15. Dawaba MS, Shokeir AA, Hafez AT, Shoma AM, El-Sherbiny MT, Mokhtar A, Eraky I, El-Kenawy M, El-Kappany HA (2004) Percutaneous nephrolithotomy in children: early and late anatomical and functional results. J Urol 172:1078–1081
16. Wadhwa P, Aron M, Bal CS, Dhanpatty B, Gupta NP (2007) Critical prospective appraisal of renal morphology and function in children undergoing shockwave lithotripsy and percutaneous nephrolithotomy. J Endourol 21:961–966
17. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications. A new proposal with evaluation in a Cohort of 6336 patients and results of a survey. Ann Surg 240:205–213
18. Badawy H, Salama A, Eissa M, Kotb E, Moro H, Shoukri I (1999) Percutaneous management of renal calculi: experience with percutaneous nephrolithotomy in 60 children. J Urol 162:1710–1713
19. Holman E, Khan AM, Flasko T, Toth C, Salah MA (2004). Endoscopic management of pediatric urolithiasis in a developing country. Urology 63:159–62, discussion 162
20. Samad L, Aquil S, Zaidi Z (2006) Paediatric percutaneous nephrolithotomy: setting new frontiers. BJU Int 97:359–363
21. Salah MA, Tallai B, Holman E, Khan MA, Toth G, Toth C (2005) Simultaneous bilateral percutaneous nephrolithotomy in children. BJU Int 95:137–139
22. El-Nahas AR, Shokeir AA, El-Assmy AM, Shoma AM, Eraky I, El-Kenawy MR, El-Kappany HA (2006) Colonic perforation during percutaneous nephrolithotomy: study of risk factors. Urology 67:937–941
23. Gerspach JM, Bellman GC, Stoller ML, Fugelso P (1997) Conservative management of colon injury following percutaneous renal surgery. Urology 49:831–836
24. Gedik A, Tutus A, Kayan D, Yılmaz Y, Bircan K (2011) Percutaneous nephrolithotomy in pediatric patients: is computerized tomography a must? Urol Res 39:45–49
25. Guven S, Istanbulluoglu O, Ozturk A, Ozturk B, Piskin M, Cicek T, Kilinc M, Ozkardes H, Arslan M (2010) Percutaneous nephrolithotomy is highly efficient and safe in infants and children under 3 years of age. Urol Int 85:455–460
26. Khairy Salem H, Morsi HA, Omran A, Daw MA (2007) Tubeless percutaneous nephrolithotomy in children. J Pediatr Urol 3:235–238
27. Bilen CY, Gunay M, Ozden E, Inci K, Sarikaya S, Tekgul S (2010) Tubeless minipercutaneous nephrolithotomy in infants and preschool children: a preliminary report. J Urol 184:2498–2502
28. Ozturk A, Guven S, Kilinc M, Topbaş E, Piskin M, Arslan M (2010) Totally tubeless percutaneous nephrolithotomy: is it safe and effective in preschool children? J Endourol 24:1935–1939