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ORIGINAL PAPER

Minimal invasive percutaneous nephrolithotomy (Mini-PCNL) in children: Ultrasound versus fluoroscopic guidance

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Summary

Background: *Miniaturization of endoscopic instruments in percutaneous nephrolithotomy (PCNL) allowed less invasive procedures with low complication rates, especially in children. This study was conducted to evaluate the safety and efficacy of ultrasonography-guided (USG) versus fluoroscopy-guided (FG) mini-PCNL in children.*

Materials and methods: *This is a retrospective comparative study conducted from June 2015 to June 2020. The sample included 70 children (35 pateints underwent USG mini-PCNL and 35 pateints underwent FG mini-PCNL). They were compared mainly by the patients' demographic characteristics, procedural information, and post-treatment outcomes. In the USG mini-PCNL group, puncturing was performed using a 3.5 MHz US probe, whereas fluoroscopy was utilized in the FG mini-PCNL group.*

Results: *Both groups were comparable in terms of gender, previous history of failed ESWL, and hydronephrosis grade.*
The mean stone burden was 15.94 ± 3.69 mm and 19.20 ± 7.41 mm in USG and FG groups, respectively (p = 0.024). The stone-free rate (SFR) was 97.1% in the USG group and 94.3% in the FG group, which was not statistically significant (p = 0.16).
Mean operative time in the USG group and FG group was 69.00 ± 13.33 minutes and 63.48 ± 16.90 minutes, respectively.
Four (11.4%) patients in the FG group required blood transfusions to restore the hemodynamic state (p = 0.039). Fever was detected in 4 (11.4%) patients in the USG group and 15 (31.4%) patients in the FG group (p = 0.041).

Conclusions: *In children, mini PCNL under USG is safe and as effective as fluoroscopy.*

KEY WORDS: *Fluoroscopy; Minimal invasive; Nephrolithotomy; Percutaneous; Ultrasonography.*

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INTRODUCTION

Epidemiologic studies have confirmed the continually growing rate of urinary stone disease in the pediatric population over the past years. Due to stone sizes and higher recurrence rate, while being less common than adults, pediatric urinary tract stones require much more difficult management (1). For the treatment of the upper tract urinary stones in the pediatric population, *extracorporeal shock wave lithotripsy* (ESWL) is still the first-line management option. However, the unpredictable outcome and lower *stone-free rates* (SFR) are the main disadvantages of this approach (2). On the other hand, using a *retrograde intrarenal surgery* (RIRS) in children might cause vesicoureteral reflux and ureteral strictures and require a longer general anesthesia duration (2). Several studies demonstrated acceptable SFR using mini-PCNL in the pediatric population (2, 3). Short hospitalization and decreased incidence of bleeding are the main advantages of the mini-PCNL procedure. In contrast, there are some downsides, including prolonged operation time and the need for miniature-sized instruments. An ideal mini-PCNL tract size in children is the smallest tract possible, as long as it provides enough space for removing the stone fragments. This decrease in the tract size results in a decreased risk of bleeding (3). When performing access to the *pyelocaliceal system* (PCS) system, for guidance, the surgeon might choose fluoroscopy or *ultrasonography* (US), based on his/her experience with these devices, their availability in the operation room, and the patient's calyceal anatomy. Advantages of using the US as guidance is decreased exposure to radiation and overall cost, decreased rate of visceral injury due to better visualization of adjacent organs, safety in pregnancy, real-time visualization of the PCS and renal parenchyma, better differentiation of the anterior and posterior calyx, detection of radiolucent stones, and the potential to avoid vascular injury by adding Doppler flow imaging (3, 4). Critical appraisal of mini-PCNL techniques and evaluation of their outcomes in children remain under-reported. Therefore, we evaluated the safety and efficacy of USG *versus* FG mini-PCNL in children in our center.

MATERIALS AND METHODS

This study was approved by the ethics committees of *Shiraz University of Medical Sciences* (Approval code#

No conflict of interest declared.

IR.sums.med.rec.1399.638). All pediatric patients who had undergone Ultrasound and Fluoroscopy-guided mini-PCNL in our referral centers (*Namazi Teaching Hospital and Ali-Asghar Teaching Hospital, Shiraz, southern Iran*) from June 2015 to June 2020 were enrolled in our study. We gathered the patients' preoperative data, including age and gender, US finding, previous history of ESWL failure, stone characteristics such as radiopacity, location, and size. We also gathered perioperative clinical lab data, including *complete blood count* (CBC), renal function test [*blood urea nitrogen* (BUN) and creatinine], and urine culture. Positive cultures were treated with proper antibiotics and admitted with sterile urine for operation. Operation and post-operation data including the length of operation, SFR, and hospitalization period were also gathered. Using the Modified Clavien grading system (5), we classified the post-operative complications into five grades. This grading system describes fever as grade I; blood transfusion need, urine leakage, and urinary tract infection as grade II; double-J placement for urine leakage, ureteroscopy, and need to an axillary procedure as grade III; urosepsis and neighboring organ injury as grade IV; and death as grade V. The inclusion criteria were age under 18 years, normal renal function, renal stones more than 10 mm, and/or history of previous ESWL failure. The exclusion criteria were all cases with active *urinary tract infection* (UTI), uncorrected coagulopathy, congenital abnormalities, and those patients who had undergone transplant or urinary diversion.

Surgical procedure

All patients were admitted 6 hours before the operation and received parenteral hydration and a single prophylactic antibiotic dose. The procedure was done under general anesthesia. In supine position with abducted thigh position, a ureteral catheter 3 Fr or 4 Fr was inserted into the kidney and taped to a fixed urethral Foley catheter (8-12 Fr depending on the patients' age and size). Then, the patient was switched into the prone position. After proper padding of the chest, abdomen, knee, and ankle, the patient was draped with sterile coverage. Considering the children's increased risk of hypothermia, the patients were kept warm throughout the procedure.

In ultrasound guidance group

By performing Color-Doppler US guidance with a 3.5-MHz probe (*BK Medical*), the PCS was visualized. Based on the child's age and degree of hydronephrosis, the optimal tract length was chosen. Using a one-shot dilatation technique, we passed an 18-gauge access needle into the target calyx using a curved US probe. Afterward, its stylet was removed, and 0.035-inch J- tipped guidewire was introduced into the targeted calyx. The skin was incised, and an 8 Fr polyurethane dilator first dilated the nephrostomy tract and was then removed. Alken was then inserted to guide 18 Fr Amplatz dilator into the PCS. Using the length of the measured tract and Amplatz shadow for precise placement, we passed the Amplatz sheath into the PCS. After confirmation of the Amplatz sheet optimal position, both Amplatz dilator and Alken were removed, leaving the Amplatz sheath and guidewire in place. Using a 15 Fr rigid nephroscope, we performed the nephroscopy to pinpoint the stones' site and then crush them with a pneumatic lithoclast. All stone particles were removed by forceps. All steps, including SFR status, were monitored under the guidance of the US without using FG.

In fluoroscopic guidance group

For better visualization of the PCS, the contrast was injected through the ureteral catheter. Then, under the FG, an 18-gauge needle was passed into the system. Next, a safety guidewire was introduced into the PCS. The rest of the procedure was the same as described in the USG group; yet, it was carried out under FG.

The tubeless procedure was only performed in those patients with single tract access, minimal bleeding, no significant perforation injuries or residual stones, and no secondary procedure requirement.

Post-surgery, after 12 to 24 hours, urethral Foley and ureteral stent catheter were removed. Nephrostomy tubes were removed on the second day after the operation. A plain abdominal film (*KUB x-ray*) and the US was done on the day after the operation, and residual stones, if presented, were followed at least eight weeks for spontaneous passage of fragments less than 4-5 mm.

Statistical analysis

The mean ± SD, median, and *Inter-Quartile Range* (IQR) described the quantitative variables, and for qualitative variables, frequency (percent) was used. Nonparametric test was used if data distribution was not standard.

Chi-square test was used to assess the potential statistically significant difference. ANOVA was applied to compare the difference of the means between more than two different levels. A P-value of less than 0.05 was considered statistically significant. All data were analyzed using SPSS version 20 software.

RESULTS

Demographic characteristics of the patients and the stone of the two groups are shown in Table 1. The total number of patients in each group was 35 patients. In the USG group, the mean age was 5.68 ± 3.05 years, and in the FG group, it was 7.47 ± 3.75 years (p = 0.032).

The mean stone size was 15.94 ± 3.69 mm (range15-40 mm) and 19.20 ± 7.41 mm (range15-40 mm) in the USG and FG groups, respectively (p = 0.024). Successful access to the target calyx and collecting system was 100% in both groups. The mean length of the tract was 3.17 ± 0.35 mm in the USG group and 3.19 ± 0.37 mm in the FG group. The mean access time to the PCS in the USG group was 1.60 ± 0.70 minutes, while it was 1.56 ± 0.56 minutes in the FG group. Mean operative time in the USG group was 69.00 ± 13.33 minutes, and in the FG group, it was 63.48 ± 16.90 minutes. The initial stone-free rate was 94.3% in the USG group and 94.3% in the FG group. However, the final stone-free rate was 97.1% in the USG group and 94.3% in the FG group. The hospital stay was 45.94 ± 4.58 hours and 46.40 ± 5.15 hours in the USG and FG groups. Post-operative nephrostomy insertion was performed in 5 (14.3%) patients in the USG group and 11 (31.4%) patients in the

Table 1.
Demographic and clinical characteristics of the patients.

Variable	Fluoroscopic group (35)	Ultrasonographic group (35)	p value
Age (years) [a]	7.47 ± 3.75	5.68 ± 3.05	0.032
Gender [b]			
Male	23 (65.7%)	25 (71.4%)	0.607
Female	12 (34.3%)	10 (28.6%)	
Size of stone (mm) [a]	19.20 ± 7.41	15.94 ± 3.69	0.024
History of failed ESWL [b]	8 (22.9%)	11 (31.4%)	0.420
Previous PCNL [b]	10 (28.6%)	9 (25.7%)	0.788
Single kidney [b]	8 (22.9%)	0 (0.0%)	0.003
History of UTI [b]	11 (31.4%)	5 (14.3%)	0.088
Stone opacity [b]			
Radiopaque	26 (74.3%)	35 (100.0%)	0.001
Radiolucent	9 (25.7%)	0 (0.0%)	
Hydronephrosis Grade [b]			
Mild	18 (51.4%)	20 (57.1%)	0.855
Moderate	13 (37.1%)	12 (34.3%)	
Sever	4 (11.4%)	3 (8.6%)	
Laterality [b]			
Right	8 (22.9%)	22 (62.9%)	0.001
Left	27 (77.1%)	13 (37.1%)	

P-values of < 0.05 were considered significant. [a] Data was presented as Mean ± SD; [b] Data was presented as n (%). ESWL = Extracorporeal shock wave lithotripsy; PCNL = Percutaneous nephrolithotomy; UTI = Urinary tract infection.

FG group (p = 0.088). According to modified Clavien classification, Grade 1 complications [Fever (axillary temperature more than 38° C)] was 31.4% in the FG group *versus* 11.4% in the USG group (p = 0.041).
All patients were treated with suitable antipyretics and antibiotics. Regarding Grade 2 complications, 4 (11.4%) patients in the FG group experienced intraoperative bleeding, which required transfusions to restore the hemodynamic state (p = 0.039), while the rate of Grade 3 complications (need for additional surgery, ESWL) was 5.7% in the FG group *versus* 2.9% in the USG group. The rate of Grade 4 complications (*Urosepsis*) was 2.9% in the FG group. Other significant complications were not detected (Table 2).

Table 2.
Intraoperative and postoperative data.

Variable	Fluoroscopic group (35)	Ultrasonographic group (35)	p value
Fluoroscopy screening time (minutes) [a]	0.60 ± -0.46	-	0.0001
Length of tract (mm) [a]	3.19 ± 0.37	3.17 ± 0.35	0.845
Access time (minutes) [a]	1.56 ± 0.56	1.60 ± 0.70	0.780
Hemoglobin drop (mg/dL) [a]	2.21 ± 2.59	0.74 ± 0.29	0.002
Residual stone > 5 mm [b]	2 (5.7%)	1 (2.9%)	1.00
Hospital stays (hours) [a]	46.40 ± 5.15	45.94 ± 4.58	0.696
Operation time (minutes) [a]	63.48 ± 16.90	69.00 ± 13.33	0.134
Post op nephrostomy [b]	11 (31.4%)	5 (14.3%)	0.088
Initial success rate [b]	33 (94.3%)	33 (94.3%)	1.000
Final success rate [b]	33 (94.3%)	34 (97.1%)	0.574
*Complications Grade 1 Fever [b]	15 (31.4%)	4 (11.4%)	0.041
Complications Grade 2 Blood transfusion [b]	4 (11.4%)	0 (0.00%)	0.039
Complications Grade 3 2nd-look ESWL [b]	2 (5.7%)	1 (2.9%)	0.931

P-values of < 0.05 were considered significant. [a] Data was presented as Mean ± SD; [b] Data was presented as n (%).
**Complication rate according to Clavien-Dindo score and types. ESWL = Extracorporeal shock wave lithotripsy.*

Discussion

We have suggested US-guided mini-PCNL as a harmless choice for managing pediatric renal calculi with excellent outcomes and little complications in the present study. Abnormalities in the urinary tract anatomy, metabolic disorders, and infections are the most common causes of urinary tract stone formation, especially in pediatric cases (3). In the upper tract calculi, ESWL, PCNL, and RIRS are standard treatment options in children. We preferred to treat the stones with the least invasive options since the stone recurrence rate is high. Thus, ESWL is the preferred option for stones less than 20 mm in diameter. However, ESWL lower stone free rate, the possibility of increasing hypertension and diabetes mellitus in the long-term and the possible need for multiple treatment sessions are main limitations of this procedure since complete stone removal is the target (6, 7).
The technology of miniaturization of the access sheath has progressed recently, and the miniaturized PCNL has recently been categorized into mini-PCNL (≤ 22Fr), Chinese mini-PCNL (14-20Fr), super-mini-PCNL (10-14 Fr), ultra-mini-PCNL (11-13Fr), micro-PCNL (4.8Fr), and mini-micro-PCNL (8 Fr) (8).
Several studies have investigated the outcome and safety of mini-PCNL and reported that mini-PCNL was associated with less bleeding and postoperative pain, similar SFR, and lower complication rates than the standard PCNL (9-11).
USG mini-PCNL has many advantages, such as an ongoing monitoring of the surrounding tissues and vessels during the procedure, increased accuracy in access to the stone, less staff exposure to radiation, and no need for contrast injection (12). Since the tract to the collecting system is shorter in the pediatric population than adults, the US makes it easier for safer tract dilation and precise placement of the needle to the collecting system (13).
It was recommended that when used by experienced hands, USG could be a safe and effective alternative to fluoroscopy as guidance (4, 6). Despite all the mentioned benefits of using the US in mini-PCNL, it has one major limitation. As an operator-dependent modality, the experience of a surgeon with the US is a major key factor. An additional limiting factor is the low echogenicity of Amplatz dilatator and Amplatz sheath (14).
With a decent residency training program, we can improve the speed of the learning curve. It is suggested that this method should be initially performed in adult patients with simple calculi and it should be performed in younger children with larger complex stones only when the surgeon is fully experienced (13).
Tian et al. studied the feasibility and safety of ambulatory mini-PCNL on the upper urinary tract calculi; based on the results, the age and stone size showed no effect on the surgery outcome (15). Like our study, the mean age and stone size were not statistically equal between the groups. In our study, the average stone size was 15.9 mm in the USG group and 19.2 mm in the FG group. Since managing larger stones requires a well-experienced surgeon in order to avoid the need for a second-look-PCNl, this may explain the tendency in surgeons to choose the standard PCNL technique in patients with larger stones. *Resorlu et al.* studied the effect of previous

open renal surgery and failed ESWL on the outcomes of PCNL and reported no significant increase in the risk of PCNL complication (16). Likewise, in our study, a history of failed ESWL, previous renal surgery, or PCNL, the grade of hydronephrosis and stone location were not statistically significant between the FG and USG groups.
For an ideal PCNL outcome, optimal percutaneous access to the PCS is a must. This is achieved under fluoroscopy, US, or CT guidance with a success rate between 86.7-100% (4, 17). In our study, we have a 100% access success rate in both groups. Whether using FG or USG, the success rate was the same for accessing the PCS.
In the present study, all stones were opaque in the USG group. At the same time, 74% of the FG group patients had opaque stone (p = 0.001). In previous studies, it has been suggested that the incidence of non-opaque stones is accompanied by longer operative times and increased complications, which was noticed in our article (18).
Zhu et al. reported SFR according to different stone sizes and complexities. In this study, PCNL SFR of US guidance was similar to PCNL with fluoroscopy guidance when treating simple kidney stones (STONE scores of 5-6), but PCNL with fluoroscopy guidance was more effective when stone complexity was higher (STONE scores of 7-8). The final SFR was 69.8% for PCNL with US guidance vs. 89.4% for PCNL with fluoroscopy guidance (19). In a systematic review including 14 studies, mini-PCNL, and Ultra mini-PCNL, the SFR was 80%-100% (3). Similar to the others, our study showed a stone-free rate of 94.3% *vs.* 97.1% in the FG and USG groups, respectively, without any statistically significant difference (p = 0.57).
Our study showed no significant differences in the operative time (63.48 *vs.* 69.00) in minutes between US-guided and fluoroscopy-guided groups.
In another study, the mean operation time in the USG and FG groups was reported to be 88.92 and 79.28 minutes, respectively (20).
In our studies, gaining access to the PCS under US guidance was similar to the fluoroscopic-guided access.
The mean access time was 1.56 ± 0.56 minutes in the USG group *vs.* 1.60 ± 0.70 minutes in the FG group. In another study by *Falahatkar et al.*, the duration of access to the target calyx was 14.36 ± 14.84 seconds in the USG group vs.14.78 ± 25.54 seconds in the FG group (14). The mean access time to PCS and mean operative time is similar to other studies with no statistically significant difference (12, 21, 22). Additionally, the USG had zero radiation exposure.
In a systemic review, less than 1% of the patients had a nephrostomy tube placed (3). In our study, nephrostomy drainage time was higher in the FG group, which defies the result of the previously published article (14). This might be due to better visualization of PCS in the USG group and larger stone size in the FG group.
The hospital stay was 45.94 ± 4.58 hours in the USG and 46.40 ± 5.15 hours in the FG group (range 2-4 days) in our study, while other studies reported 2.7 to 4.1 days (4, 23). Therefore, there was no significant difference in the hospital stay, similar to previous studies.
Using the Clavien-Dindo grading system, we found that the overall operative complication rates were not similar. We noticed a relatively higher postoperative fever rate in the FG group [11.4% *versus* 31.4%, (p = 0.041)].
A higher positive preoperative urine culture in the FG group, an essential prognostic factor for postoperative infectious complications, more nonopaque stones in the FG groups, and shorter time in USG to access the collecting system could explain this higher rate in the FG groups (19). In the present study, four patients in the FG group experienced intraoperative bleeding, which required blood transfusions with patients' successful recovery. This finding is in the same line with *Andonian et al.'s* findings (24). However, a systematic review revealed no significant difference between USG and FG regarding bleeding (22). Our explanation was better visualization of the vital organ in the US group and US ability to provide information on the surrounding viscera and the depth of needle penetration and to provide distinguishing images to identify the posterior and anterior calyces (25).
Two patients needed an axillary procedure (ESWL) in the FG group, while one patient needed it in the USG group. Additionally, one patient developed urosepsis in the FG group, which was treated with proper antibiotics. In the study by Guven et al., which included 107 children aged less than14 years, ureteroscopy was needed in two patients and second-look PCNL in nine patients (26). In another multicentric study on 1205 children, there was one death case due to septic shock (27). No significant complications such as pneumothorax or hydrothorax, colon damage, or any adjacent injuries occurred in both groups, almost similar to previous articles (3). The retrospective nature of this study and the small sample size was our significant limitations. Randomization was not done in our study, and we detected the heterogenicity of the stone size and age between our groups. We performed all mini-PCNLs in the prone position, and post-procedure imaging was almost limited to plain XR or US. The prone positioning was performed in all of the patients during the procedures. Stone composition analysis data were also unavailable. No specific information was available about the operators' experience or the number of surgeons operating on children. Therefore, further investigations of the long-term effects in a large sample size with one endourologist are recommended.

Conclusions

Our study supports the results of previous studies, suggesting US-guided mini-PCNL as a harmless choice for managing pediatric renal calculi with excellent outcomes and little complications.

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References

1. Ward JB, Feinstein L, Pierce C, et al. Pediatric Urinary Stone Disease in the United States: The Urologic Diseases in America Project. Urology. 2019; 129:180.

2. Srisubat A, Potisat S, Lojanapiwat B, et al. Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones.Cochrane Database Syst Rev. 2014:Cd007044.

3. Jones P, Bennett G, Aboumarzouk OM, et al. Role of Minimally Invasive Percutaneous Nephrolithotomy Techniques-Micro and Ultra-Mini PCNL (<15F) in the Pediatric Population: A Systematic Review. J Endourol. 2017; 31:816.

4. Basiri A, Ziaee SA, Nasseh H, et al. Totally ultrasonography-guided percutaneous nephrolithotomy in the flank position. J Endourol. 2008; 22:1453.

5. Tefekli A, Karadag MA, Tepeler K, et al. Classification of percutaneous nephrolithotomy complications using the modified clavien grading system: looking for a standard. Eur Urol. 2008; 53:184.

6. Hong Y, Ye H, Yang B, et al. Ultrasound-guided minimally invasive percutaneous nephrolithotomy is effective in the management of pediatric upper ureteral and renal stones. J Invest Surg. 2020:1.

7. Ahmed F, Askarpour M-R, Eslahi A, et al. The role of ultrasonography in detecting urinary tract calculi compared to CT scan. Res Rep Urol. 2018; 10:199.

8. Zeng G, Zhu W, Lam W. Miniaturised percutaneous nephrolithotomy: its role in the treatment of urolithiasis and our experience. Asian J Urol. 2018; 5:295.

9. Haghighi R, Zeraati H, Ghorban Zade M. Ultra-mini-percutaneous nephrolithotomy (PCNL) versus standard PCNL: A randomised clinical trial. Arab J Urol. 2017; 15:294.

10. ElSheemy MS, Elmarakbi AA, Hytham M, et al. Mini vs standard percutaneous nephrolithotomy for renal stones: a comparative study. Urolithiasis. 2019; 47:207.

11. Izol V, Satar N, Bayazit Y, et al. Which factors affect the success of pediatric PCNL? Single center experience over 20 years. Arch Ital Urol Androl. 2020; 92:345-9.

12. Agarwal M, Agrawal MS, Jaiswal A, et al. Safety and efficacy of ultrasonography as an adjunct to fluoroscopy for renal access in percutaneous nephrolithotomy (PCNL). BJU Int. 2011; 108:1346.

13. Desai M. Ultrasonography-guided punctures-with and without puncture guide. J Endourol. 2009; 23:1641.

14. Falahatkar S, Allahkhah A, Kazemzadeh M, et al. Complete supine PCNL: ultrasound vs. fluoroscopic guided: a randomized clinical trial. Int Braz J Urol. 2016; 42:710.

15. Tian Y, Yang X, Luo G, et al. Initial prospective study of ambulatory mPCNL on upper urinary tract calculi. Urol J. 2020; 17:14.

16. Resorlu B, Kara C, Senocak C, et al. Effect of previous open renal surgery and failed extracorporeal shockwave lithotripsy on the performance and outcomes of percutaneous nephrolithotomy. J Endourol. 2010; 24:13.

17. Basiri A, Ziaee AM, Kianian HR, et al. Ultrasonographic versus fluoroscopic access for percutaneous nephrolithotomy: a randomized clinical trial. J Endourol. 2008; 22:281.

18. Maghsoudi R, Etemadian M, Kashi AH, Ranjbaran A. The association of stone opacity in plain radiography with percutaneous nephrolithotomy outcomes and complications. Urol J. 2016; 13:2899.

19. Zhu W, Li J, Yuan J, et al. A prospective and randomised trial comparing fluoroscopic, total ultrasonographic, and combined guidance for renal access in mini-percutaneous nephrolithotomy. BJU Int. 2017; 119:612.

20. Osman M, Wendt-Nordahl G, Heger K, et al. Percutaneous nephrolithotomy with ultrasonography-guided renal access: experience from over 300 cases. BJU Int. 2005; 96:875.

21. Abed SM, Alhamdani N. Ultrasonographic guidance versus fluoroscopic guidance for renal access in percutaneous nephrolithotomy (PCNL): a comparative study.Iraqi J Med Sci. 2019; 18:335.

22. Corrales M, Doizi S, Barghouthy Y, et al. Ultrasound or fluoroscopy for percutaneous nephrolithotomy access, is there really a difference? A review of literature. J Endourol. 2021; 35:241-248.

23. Karami H, Rezaei A, Mohammadhosseini M, et al. Ultrasonography-guided percutaneous nephrolithotomy in the flank position versus fluoroscopy-guided percutaneous nephrolithotomy in the prone position: a comparative study. J Endourol. 2010; 24:1357.

24. Andonian S, Scoffone CM, Louie MK, et al. Does imaging modality used for percutaneous renal access make a difference? A matched case analysis. J Endourol. 2013; 27:24.

25. Lojanapiwat B. The ideal puncture approach for PCNL: Fluoroscopy, ultrasound or endoscopy?. Indian J Urol. 2013; 29:208.

26. Guven S, Frattini A, Onal B, et al. Percutaneous nephrolithotomy in children in different age groups: data from the Clinical Research Office of the Endourological Society (CROES) Percutaneous Nephrolithotomy Global Study. BJU Int. 2013; 111:148.

27. Onal B, Dogan HS, Satar N, et al. Factors affecting complication rates of percutaneous nephrolithotomy in children: results of a multi-institutional retrospective analysis by the Turkish pediatric urology society. J Urol. 2014; 191:777.

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