164 TURKISH JOURNAL OF UROLOGY Turk J Urol 2021; 47(2): 164-9 • DOI: 10.5152/tud.2020.20066
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Tubeless PNL can safely be applied to selected patients in pediatric stone disease

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ABSTRACT

Objective: The purpose of this study was to compare the results of tubeless percutaneous nephrolithotomy (TPNL) and standard percutaneous nephrolithotomy (SPNL) for the management of nephrolithiasis in children.

Material and methods: The data for 48 patients aged lesser than 18 years who underwent percutaneous nephrolithotomy (PNL) between January 2010 and June 2018 were reviewed retrospectively. The patients were classified into 2 categories depending on tube placement. A total of 21 patients were treated with TPNL and 27 with SPNL technique. The surgical method employed was selected depending on intraoperative complications. The size of the endoscopic instrument (mini/standard) to be used was decided according to the stone burden and surgeon preference.

Results: A complete stone-free rate (SFR) was achieved in 85.7% (n=18) of the TPNL group and 85.2% (n=23) of the SPNL group (p=0.959). In the TPNL group, two patients with clinically significant stones underwent retrograde intrarenal surgery, and one patient with clinically insignificant residual stone remained under follow-up. In the SPNL group, two patients with clinically significant stones underwent repeat mini-PNL surgery, the stones being fragmented with shock wave lithotripsy in one patient, and 1 one patient with insignificant residual stone remained under follow-up. No significant differences were observed in terms of intraoperative and postoperative complications, mean SFRs, or operative and fluoroscopy times. However, a statistically significant difference was observed in lengths of hospital stay (p<0.001).

Conclusion: TPNL is a safe and effective procedure in children. No significant difference was found between TPNL and SPNL in terms of stone clearance; however, patients undergoing TPNL had significantly shorter hospital stays.

Keywords: Children; nephrolithiasis; percutaneous nephrolithotomy; percutaneous nephrostomy.

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Introduction

The global incidence of pediatric urolithiasis is increasing, although the condition is more endemic in regions such as North Africa, South Asia, and the Middle East. The incidence of urolithiasis can be affected by dietary and environmental factors and obesity.[1] The reported frequency of occurrence in different studies is 2%–3%, with a 55% probability of recurrence within 5 years.[2]

Pediatric kidney stones are treated using shock wave lithotripsy (SWL), with high fragmentation rates and minimal morbidity.[3] However, percutaneous nephrolithotomy (PNL), a well-proven standard procedure, should be considered as the first option for kidney stones exceeding 2 cm, complex stones filling more than one calyx, or staghorn stones.[4] Some studies have reported success rates greater than 90%, with no functional or anatomical damage. PNL also obviates the need for multiple surgical procedures and hospital visits.[5]

Smaller urological endoscopes have been developed in the recent years, and micro-PNL [7–11 French (Fr)], ultra-mini PNL (11–14 Fr), and mini-PNL (14–20 Fr) endoscopes are extensively used today. The use of small endoscopes in children, with their smaller kidneys, narrow calyx infundibula, and less robust calyceal-pelvic system, reduces postoperative morbidity. Different sizes of surgical equipment are also used in different age groups.[6]

A drainage catheter is placed into the collecting system at the end of standard PNL (SPNL). The aim behind using nephrostomy tubes or ureteric stents is to provide adequate kidney drainage.[7] Another reason for nephrostomy placement is to facilitate repeat procedures for residual stones. The European Association of Urology guidelines strongly recommend tubeless (without a nephrostomy tube) or totally tubeless (without a nephrostomy tube or ureteral stent) PNL in uncomplicated cases. The guideline also suggests that TPNL results in a shorter length of hospital stay (LOHS), with no increase in complication rates.[8]

Previous studies have reported inconsistent conclusions about the efficacy of TPNL in children. The purpose of this study was therefore to evaluate and compare TPNL and SPNL for the management of nephrolithiasis in children.

Material and methods

Since all the patients in the study were aged under 18 years, informed consent forms were obtained from the parents. Following receipt of the institutional review board approval (Ankara City Hospital, Approval no: E1-20-966), we reviewed the data from 48 pediatric patients who underwent PNL between January 2010 and June 2018. The patients identified were then classified into two categories according to tube placement. A total of 21 patients had been treated using the TPNL technique and 27 with SPNL. The surgical method (tubeless/standard) employed had been decided on the basis of intraoperative complications. A tubeless procedure had been performed on all patients without bleeding, residual stone, or extravasation at antegrade pyelography at the end of the operation. The size of the endoscopic instrument (mini/standard) was selected on the basis of stone burden and surgeon preference.

Main Points:

- Our observations indicate that the insertion of nephrostomy tubes in pediatric patients is one of the problems arising after surgery. At best, it causes children to be constantly restless and may sometimes result in other problems associated with spontaneous tube withdrawal.
- Grade 4 or 5 parenchymal and even vascular injuries in trauma patients are today treated with observational and supportive procedures. There is therefore no need to fear an iatrogenic non-bleeding grade 3 parenchymal trauma.
- Our results support the idea that total TPNL can be performed safely and effectively. No significant difference was found between TPNL and SPNL in terms of stone clearance.
- Patients who underwent TPNL had a significantly shorter hospital stay.
- Selecting appropriate patients is as important to the success of total TPNL as the surgery itself and is essential to ensure minimal morbidity.

All children were evaluated using medical history, physical examination, complete blood count, coagulation tests, serum biochemistry, urinalysis, urine culture, abdominal ultrasonography, and kidney-ureter-bladder (KUB) radiography. The pediatric nephrology clinic was consulted for further metabolic evaluation in all cases, but no underlying diseases were detected in any patient. Computed tomography (CT) was performed to evaluate the retrorenal colon and surrounding structures around the kidney. The patient data such as age, sex, stone size, stone location, complexity (Guy's stone score), Hounsfield unit, preoperative hemoglobin (Hb) and creatinine levels, history of previous renal/other surgeries, and hydronephrosis were recorded. The patients with positive urine cultures were treated with antibiotics on the basis of antibiogram until the urine culture was ensured to be sterile.

Surgical technique

All procedures were performed under general anesthesia and antibiotic prophylaxis. An open-ended 4- or 5-Fr ureteral catheter was inserted into the kidney through a rigid ureteroscope (9.5 Fr, Karl Storz Endoscopy, Tuttlingen, Germany), in the lithotomy position. The ureteral catheter was fixed to the urethral Foley catheter. The patients were then turned to the prone position. Prone PNL procedures were performed on all the patients. Retrograde pyelography was performed before the puncture through the ureteral catheter. Access to the appropriate calyx was established by a urologist under biplanar fluoroscopic guidance. Once access had been obtained, a hydrophilic guidewire was inserted into the collecting system. Serial dilatations were then performed up to the desired size over the guidewire, 18 Fr for mini-PNL (16–18 Fr, Richard-Wolf GmbH, Knittlingen, Germany via an 18 Fr tract size) and 28/30 Fr for SPNL (26 Fr, Karl Storz Endoscopy, Tuttlingen, Germany). All stones were fragmented with pneumatic lithotriptors (Vibrolith, Elmed Medical Systems, Ankara, Turkey) and Holmium Yag laser (Mega Pulse Tower 30, Richard-Wolf Endoscopy, Germany). Stone fragments were extracted using grasping forceps and irrigation. Only one access was required for all the patients. Fluoroscopic controls were performed at the end of the procedure for evaluating residual stones and antegrade pyelography. In case of extravasation and residual stone greater than 5 mm, a nephrostomy tube and an antegrade indwelling catheter (IC) were inserted under fluoroscopic guidance. Irrespective of tract size, nephrostomy tubes were not inserted in patients with stone-free status at fluoroscopy,

Turk J Urol 2021; 47(2): 164–9
10.5152/tud.2020.20066

with irrigation fluid color not indicating bleeding and not exhibiting extravasation at antegrade pyelography.

Operative time was calculated from passage of the ureterorenoscope through the urethral mea to nephrostomy tube placement and to the removal of the access sheath in the TPNL group. A 14 Fr Foley catheter was used for kidney drainage in the patients in whom a nephrostomy tube had been inserted. Deep mattress skin suturing was performed in the tubeless group, and the tract area was compressed for 2–3 minutes to control subcutaneous bleeding. Patients who underwent TPNL were discharged after removal of the Foley catheter on postoperative day 1. In the SPNL group, nephrostomy tubes were removed on postoperative day 1 if the urine was clear, and the Foley catheters were removed on postoperative day 2. In one patient from the SPNL group, the nephrostomy tube was not removed for 3 days because of persistent hematuria. The tube was eventually removed when the urine became clear on postoperative day 4. The Foley catheter was removed 1 day later, and the patient was discharged. Indwelling stents were removed 3 weeks after surgery under general anesthesia. SWL was planned for residual stones, and stents were maintained in place until stone-free status was achieved.

Follow-up

All the patients were invited to the outpatient clinic for a follow-up visit 10 days after the procedure. KUB radiography, abdominal ultrasound, and urine analyses were performed on all the patients to detect any residual stone, perinephric collection, or infection. The patients were regarded as stone-free if no remaining stones were detected after PNL surgery or if only nonobstructive, asymptomatic, and clinically insignificant residual fragments less than 5 mm in size were observed. CT was not used routinely to avoid radiation exposure.

Statistical analysis

The study data were analyzed using IBM Statistical Package for the Social Sciences version20.0 software (IBM SPSS Corp., Armonk, NY, USA). The variables were expressed as mean, standard deviation, median, and percentages depending on the characteristics of the variable. Student's *t*test (twotailed, independent) or oneway analysis of variance was used, as appropriate, to compare normally distributed continuous variables. The Mann–Whitney U test or Kruskal–Wallis test was used, as appropriate, to compare discrete variables. The chisquare and Fisher's exact tests were used to evaluate parameters on a categorical scale. P values <0.05 were considered statistically significant.

Results

A total of 48 patients undergoing PNL procedures between January 2010 and June 2018 were included in the study. Demographics, preoperative, intraoperative, and postoperative findings; stone composition; and patient-related factors are summarized in Table 1. Complications were observed in four patients, categorized according to the modified Clavien classification system. Postoperative hydro-peritoneum was observed in one patient when the patient turned to the supine position (grade 3a). A drainage catheter was inserted in the peritoneum under ultrasound guidance. The peritoneum was decompressed, and the patient was then evaluated using contrast-enhanced CT. No visceral injury was observed. The drainage catheter was removed 5 days later, and the patient was discharged. A postoperative persistent urine leak was observed in another patient after nephrostomy tube removal. An indwelling ureteral catheter was inserted on postoperative day 5 (grade 3b). Two other patients required postoperative blood transfusion (grade 2) owing to low Hb levels.

A complete stone-free state was achieved in 18 of the 21 patients (85.7%) in the TPNL group at third-month postoperative controls. Clinically significant (n=2) or insignificant (n=1) residual stones were determined in three children. Patients with clinically significant stones underwent retrograde intrarenal surgery (n=2), and the patients with insignificant stones remained under follow-up. Stone-free status was observed in 23 of the 27 patients (85.2%) in the SPNL group at third-month postoperative controls. Clinically significant (n=3) or insignificant (n=1) residual stones were determined in four children. Two of the patients with clinically significant stones underwent repeat mini-PNL surgery (n=2), stones were fragmented with SWL in one patient, and the patient with insignificant residual stones remained under follow-up. No significant differences were determined between the groups in terms of intraoperative and postoperative complications, mean stone-free rates (SFRs), or operative and fluoroscopy times; however, LOHS differed significantly.

Discussion

The first successful standard PNL in a 14-year-old child was reported by Woodside et al.[9] in 1985. A nephrostomy tube was inserted in the kidney of the patient at the end of the surgery. A nephrostomy tube was placed to ensure the drainage of the kidney, to tamponade bleeding along the access site, to prevent urinary extravasation, and to promote healing. The existing nephrostomy tract can also be used for further endoscopic procedures or chemolysis.[10] A secondary PNL is not required in the majority of cases, and leaving a catheter in the kidney may not be beneficial.[11] Pain around the nephrostomy tube is a significant complication after standard PNL. Local anesthetic wound infiltration techniques around the tract have been shown to reduce pain scores and analgesic requirements.[12] However, these also increase morbidity and are not cost effective. Our observations confirm that the insertion of nephrostomy tubes in

Table 1. The preoperative and operative characteristics of patients in both groups

Variable	Tubeless PNL	Standard PNL	p
Number of patients, n (%)	21 (43.8)	27 (56.2)	0.225
Mini/Standard PNL, n (%)	18/3 (85/15)	18/9 (66.7/33.3)	0.131
Age (years), mean (range)	12.48±3.41 (4–17)	11.19±3.75 (5–17)	0.225
Gender (M/F)	10(47.6%)/11(52.4%)	18 (66.7%)/9 (33.3%)	0.184
Previous stone–related surgery	4	2	0.152
Stone size (mm), mean±SD, (min-max)	21.62±2.13 (18–27)	22±1.71 (19–25)	0.495
Hounsfield unit	780.19±229 (450–1,377)	718.93±248 (319–1,154)	0.386
Guy's stone score			0.149
Staghorn stone, n (%)	2 (9%)	7 (26%)	
Multiple calyxes, n (%)	6 (30%)	7 (26%)	
Single stone, n (%)	13 (61%)	13 (48%)	
Hydronephrosis			0.240
No hydronephrosis	5	11	
Grade 1	7	9	
Grade 2	6	4	
Grade 3	1	3	
Stone laterality (R/L)	8 (38.1%)/13 (61.9%)	14 (51.9%)/13 (48.1%)	0.343
Operative time (min), mean±SD (range)	76.19±23.10 (45–124)	75.44±22.34 (41–127)	0.910
Fluoroscopy time (sec)	171.67±51.21 (65–246)	192.22±59.17 (98–317)	0.212
Hospital stay (days), mean±SD (range)	1.81±1.28 (1–7)	3.56±2.53 (1–14)	<0.001*
Stone-free rate, n (%)	18/21 (85.7%)	23/27(85.2%)	0.959

PNL: Percutaneous nephrolithotomy; M/F: Male/Female; R/L: Right/Left; SD: standard deviation; min: minute. *p<0.05 were regarded as statistically significant

pediatric patients is one of the problems requiring resolution after surgery. At best, these tubes cause children to be constantly restless. PNL procedures should therefore be concluded without tube placement unless the case is complicated.

PNL is the standard approach for the treatment of renal stones larger than 1.5 cm in preschool-age patients.[9] A mini-PNL/TPNL technique has also been introduced to reduce SPNL complications with comparable stone clearance rates.[7,13] The use of small endoscopic devices also minimizes patient discomfort by eliminating the use of nephrostomy tubes, thus reducing pain after surgery and shortening LOHS. Tubeless and totally tubeless PNL procedures have been proven to possess more significant advantages in terms of morbidity, postoperative analgesic requirements, LOHS, and cost-effectiveness compared with SPNL.[14-18] Some studies have reported the use of an externalized ureteral catheter removed postoperatively in TPNL.[18,19] This is as feasible as an IC in completely stone-free patients, avoids the need for further procedures to remove the IC, and also eliminates IC-related discomfort. In case of doubt concerning the presence of residual stones, an IC will be more beneficial to facilitate spontaneous passage. Even adult patients find it difficult to cope with both a nephrostomy tube and urethral catheter after surgery, and the difficulty is more marked in children. A ureteral catheter or IC may be optional for these patients.

After the first reported series of 50 TPNLs in 1997,[20] several subsequent reports have supported the use of this technique. A review of randomized studies involving TPNL concluded that outcomes and complication rates were comparable between TPNL and SPNL. The authors also concluded that TPNL is a safe procedure even in the case of a solitary kidney, previous ipsilateral renal surgery, elevated serum creatinine levels, bilateral synchronous PNL, or contralateral endourological stone treatment.[11,12] Grade 4 or 5 parenchymal and even vascular injuries are today treated with observational and supportive procedures in patients with trauma. Only a small proportion of such patients require further procedures. There is therefore no need to fear an iatrogenic non-bleeding grade 3/4 parenchymal trauma, and this should be remembered when inserting a nephrostomy tube.

Turk J Urol 2021; 47(2): 164-9
10.5152/tud.2020.20066

TPNL was found to possess significant advantages in terms of morbidity in a randomized trial involving 202 patients.[21] TPNL (n=101) and SPNL (n=101) were compared in terms of LOHS, postoperative pain, and recovery time. Mean LOHS in the TPNL group was less than 24 hours (21.8± 3.9), significantly shorter than that of the SPNL group (54.2±5 hours) (p<0.01). Khairy Salem et al.[22] noted comparable results in their prospective study, and none of their patients developed major complications. They reported a lower mean pain score and median LOHS in TPNL (pain score 5.5 in SPNL vs. 4.6 in TPNL; LOHS 2.8 days in SPNL vs. 1.7 days in TPNL) in a prospective study.

Beiko et al.[23] reported the first completely tubeless PNL procedure. They used no nephrostomy tube, IC, or ureteral catheter and performed the procedure on an outpatient basis, with the patient going home 4 hours after leaving the operating room. The postoperative course was uneventful. Completely avoiding the use of stents was shown to be successful by Gupta et al.[24] Those authors described IC insertion as a costly procedure, which also required stent removal in another session. Some children are unable to tolerate an IC and complain of persistent discomfort. Externalization of the ureteric catheter, as previously reported by other studies, is therefore preferable.[16,25,26] We believe that the ureteric catheter can be removed along with the Foley catheter on postoperative days 1 or 2 and can also provide the advantage of allowing clearance of residual fragments, without the disadvantages of an IC.[18]

Bilen et al.[25] suggested that TPNL was safer with a shortened LOHS in a study involving 28 renal units in infants and preschool children compared with age-matched controls. The authors also reported their mini-PNL results in which they left only a ureteral catheter in the kidney. A nephrostomy tube was inserted only in cases of significant parenchymal bleeding or significant residual fragments. The authors concluded that patient characteristics and stone burden were similar between the groups with and without percutaneous nephrostomy. SFR was 91.6% in the tubeless group and 78.5% in the SPNL group. A significant decrease was also observed in complication rates, operative and fluoroscopy times, LOHS, and complication rates. In one meta-analysis, Nouralizadeh et al.[26] concluded that there was no significant difference between TPNL and SPNL in terms of stone clearance, operative time, decreased Hb levels, perirenal fluid, postoperative fever, or repeat operation requirements but that the patients who underwent TPNL had a shorter LOHS compared with SPNL (mean difference: –1.57, 95% CI: –3.2 to 0.07, p=0.06), although the difference was not statistically significant. In another study, patients were divided into tubeless, small-bore (16 Fr) tube, and large-bore (22 Fr) tube groups on the basis of nephrostomy tube placement in a retrospective review of 46 pediatric patients undergoing PNL. The authors concluded that the tubeless group experienced fewer complications, with lower LOHS, analgesic requirements, and rates of postoperative fever and urinary leak.[27] Iqbal et al.[28] observed no difference in terms of LOHS, mean operative time, SFR, and post-PNL complications between small-bore nephrostomy tube PNL and TPNL. Only minimal decreases in mean Hb levels were detected in the small-bore PNL group.

The use of adult-size instruments in infants and preschool children has not been observed to result in a difference in SFR or retreatment and complication rates. Different-sized access tracts safely can be used for PNL procedures.[29,30] According to these findings, the use of the same instruments and technique in children as in adults may entail no increased risk of morbidity or blood transfusion requirement. Adult-sized instruments can be safely employed in pediatric patients with significantly decreased LOHS in TPNL.[31]

Bleeding associated with PNL is the leading cause of complications in this type of surgery. Studies comparing TPNL with SPNL have reported no difference in Hb levels and consequently no difference in transfusion requirements in children.[32] None of the patients in the groups experienced bleeding that would require transfusion.

This study shares our experience with PNL in managing pediatric stones and compares TPNL outcomes with those of SPNL. Our study results support the idea that total TPNL can be performed safely and effectively. No significant difference was found between TPNL and SPNL in terms of stone clearance. However, the patients who underwent TPNL had a statistically significantly shorter LOHS. Appropriate patient selection is as important to the success of total TPNL as the surgery and is essential to ensure minimal morbidity.

One limitation of this study is that it was retrospective and consisted of a small number of patient groups. Prospective studies with large patient series are now needed to support our findings. However, our data suggest that tubeless PNL may be feasible in selected patients even in a second-line public hospital. If certain rules are followed, the patients will feel better and treatment costs will be reduced. Every effort made to ensure early recovery will be very valuable, particularly in patients in the pediatric age group.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ankara City Hospital (Date: 2020 Approval no: E1-20-966).

Informed Consent: Written informed consent was obtained from the parents of the patients who participated in this study.

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