

Endourology/Urolithiasis

Reliability of Percutaneous Nephrolithotomy in Pediatric Patients: Comparison of Complications With Those in Adults

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Purpose: To assess the reliability of percutaneous nephrolithotomy (PNL) in pediatric patients by comparing complications between pediatric patients and adults by use of the modified Clavien grading system.

Materials and Methods: The data of 74 pediatric (0 to 16 years) and 535 adult (17 years and older) patients who underwent PNL owing to kidney stone disease between January 2005 and December 2011 were analyzed retrospectively. The complications in the pediatric and adult patients were classified in five grades according to the modified Clavien system.

Results: The most frequent cause of grade I complications was fever requiring anti-pyretics, which was seen in 4 pediatric patients (5.4%) and 30 adult patients (5.6%). Grade II complications (blood transfusions, < 12 hours urinary leakage) were observed in 11 pediatric patients (14.8%) and 80 adult patients (14.9%). Grade III complications were also seen in 6 pediatric patients (8.1%) (grade IIIb; D-J catheter implantation under general anesthesia) and 78 adult patients (14.5%) (grade IIIa; D-J catheter implantation and angio-embolization under local anesthesia). There was no statistically significant difference between the two groups in terms of grade I, II, or III complications ($p > 0.05$). Colonic injury occurred in one patient (1.3%) in the pediatric group (grade IVa). In the adult group, one patient (0.2%) died as the result of myocardial infarction (grade V).

Conclusions: Thanks to technological developments and minimalization of the equipment used, when indicated, pediatric patients can be safely treated with PNL with low complication rates similar to those in adult patients.

Keywords: Complications; Nephrolithiasis; Percutaneous nephrolithotomy

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Article History:

received 13 December, 2012

accepted 12 February, 2013

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INTRODUCTION

Endoscopic kidney stone surgery is one of the greatest and most important developments in urology practice over the past 50 years. These surgical developments began with the description of endoscopic procedural methods that cause the least damage to the kidney. Percutaneous nephrolithotomy (PNL) is the most important and commonly used of these endoscopic procedural methods [1]. A success rate as high as 90% has been reported for PNL. Thanks to technical advances, next to the increased efficiency, there has also been a decrease in morbidity [2-4].

PNL was first used for the pediatric population in 1985. There were hesitations about its use for pediatric stone disease at first, but it has now become a routine surgical method and has replaced open surgery [5]. Although PNL is a method with a high success rate in the treatment of pediatric and adult stone disease, it is possible to encounter serious complications during and after the procedure. Standardization is needed in terms of grading the complications. The Clavien classification is often used for this purpose. The Clavien classification was defined in 1992 and modified in 2004 after being validated in a cohort of 6,336 patients [6,7]. This classification was first used in urological

applications such as retroperitoneoscopy, laparoscopic live donor nephrectomy, and laparoscopic radical prostatectomy [8-10].

In our study, we used the Clavien classification to compare the complications that occurred in pediatric and adult patients undergoing PNL. The goal of this study was to assess the reliability of PNL in pediatric patients from a different angle.

MATERIALS AND METHODS

In this study, the data of 74 pediatric and 535 adult patients who underwent PNL owing to kidney stone disease between January 2005 and December 2011 were analyzed retrospectively from our medical records. The patients were divided into pediatric cases (0 to 16 years) and adults (17 years and older).

Urine culture was obtained from all patients before the operation. Treatment with antibiotics was started for patients with urinary infections, depending on their culture results, and procedures were planned after the sterilization of their urine. All patients underwent metabolic evaluation that included urine pH, serum calcium, phosphorus, and uric acid determination. Measurement of 24-h urinary calcium, phosphorus, uric acid, creatinine, and electrolytes was also performed. Kidney-ureter-bladder radiography and intravenous pyelography or noncontrast abdomen computed tomography was performed. The stone load was calculated in millimeters squared (mm^2) through the multiplication of the length by the width of the stone as seen in the preoperative kidney-ureter-bladder radiography.

The localization of the stone, the number of renal accesses, the type of lithotripsy, stone-free rates, blood transfusion in the preoperative-postoperative period, duration of hospitalization, and complications during the PNL procedure were recorded. The complications in pediatric and adult patients were classified in five grades according to the modified Clavien system [7].

All patients were evaluated with kidney-ureter-bladder radiography or noncontrast computed tomography (those with nonopaque stones) in the early postoperative period regarding residual stone existence.

1. PNL technique

The patients were anesthetized in the supine position. In the lithotomy position, an open-ended ureter catheter was placed in the ureter orifice where the stone was located. Then, the patient was put into the prone position. The pelvic caliceal system was monitored under C-arm fluoroscopy (Philips BV 29, Philips Medical Systems, Best, The Netherlands) by injecting radio-opaque material or air from the ureter catheter. A suitable calyx was inserted by using a 19-gauge percutaneous input needle under a fluoroscope. A guide wire (Sensor Guide Wire, 0.038 inches) was put forward through the inside of the needle. The entry point of the kidney was widened by gradually passing

the dilator set materials (Amplatz Renal Dilatator Set, Marflow AG, Zürich, Switzerland) over the guide wire. A 26-Fr (Karl Storz, Tuttlingen, Germany) rigid nephroscope was used in adult patients, 24-Fr (Richard Wolf GmbH, Knittlingen, Germany) rigid nephrosopes were used in older pediatric patients, and 15.5-Fr (Richard Wolf GmbH) rigid nephrosopes were used in preschool children for endoscopic monitoring of the kidney. According to its size, the stone was only extracted by stone grasping forceps (Grasping Forceps, Karl Storz) or removed with forceps by breaking the stone with a pneumatic, ultrasonic, or combined lithotripter (Swiss Lithoclast, EMS, Nyon, Switzerland). A Foley catheter was placed into the cover of the nephrostomy after completion of the operation and the nephrostomy site was checked by injecting opaque material from the Foley catheter.

The nephrostomy tube was removed after an antegrade nephrostogram was performed. D-J implantation was performed for a patient with a PNL application in the case of persistent urinary leakage (>24 hours) from the nephrostomy tract, after the nephrostomy was removed in the postoperative period.

2. Statistical methods

SPSS ver. 11.5 (SPSS Inc., Chicago, IL, USA) was used for the analysis and p-values less than 0.05 were accepted as significant. The Mann Whitney U-Test was used to compare the two groups. For categorical data, a chi-square test was performed.

RESULTS

There were 74 patients (12.15%) in the pediatric group and 535 patients (87.85%) in the adult group. The mean age was 9.81 ± 4.25 years in the pediatric patients and 40.94 ± 13.33 years in the adult patients. The mean stone surface area was $329.45 \pm 175.91 \text{ mm}^2$ (range, 100 to 900 mm^2) in the pediatric patients and $716.01 \pm 449.60 \text{ mm}^2$ (range, 100 to $3,000 \text{ mm}^2$) in the adult patients (Table 1).

There was no statistically significant difference between the two groups in terms of laterality, number of access sites (minimum, 1 vs. maximum, 3), location of the stone (upper

TABLE 1. Demographic data of patients and operations

Demographic	Pediatric	Adult	p-value
Patient	74 (12.15)	535 (87.85)	-
Age (y)	9.81 ± 4.25	40.94 ± 13.33	-
Stone surface area (mm^2)	329.45 ± 175.91	716.01 ± 449.60	-
Range	100-900	100-3,000	
Stone-free rates	68 (91.89)	487 (91.03)	$p > 0.05$
Patients requiring ESWL	5 (6.76)	23 (4.30)	$p > 0.05$
Hospital stay (d)	2.36 ± 0.48	3.11 ± 0.86	$p < 0.05$

Values are presented as number (%) or mean \pm standard deviation. ESWL, extracorporeal shock wave lithotripsy.

pole, lower pole, pelvis, staghorn), or the methods of crushing (pneumatic, ultrasonic, or combined) ($p > 0.05$).

Regarding the results of the treatment, 68 patients (91.89%) in pediatric group and 487 patients (91.03%) in the adult group were stone-free. Extracorporeal shock wave lithotripsy was required in 5 patients (6.76%) in the pediatric group and 23 patients (4.30%) in the adult group for residual stones. There was no statistically significant difference between the two groups in terms of stone-free rates ($p > 0.05$) (Table 1).

The most frequent cause of grade I complications was fever requiring antipyretics, and it was seen in 4 pediatric (5.4%) and 30 adult patients (5.6%). Grade II complications in pediatric patients were blood transfusions in 6 patients (8.1%) and < 12 hours of urinary leakage in 5 patients (6.7%), with an overall grade II complication rate of 14.8%. In the adult group, blood transfusions were required in 54 patients (10%) and < 12 hours of urinary leakage occurred in 26 patients (4.9%), resulting in an overall grade II complication rate of 14.9%. There was no statistically significant difference between the two groups in terms of grade I and grade II complications ($p > 0.05$) (Table 2).

When both groups were evaluated in terms of grade III complications, in 6 pediatric patients, D-J implantation was performed after PNL under general anesthesia owing to urinary leakage lasting longer than 24 hours after removal of the nephrostomy tube (group IIIb). In the adult group, 74 patients (13.8%) had a prolonged drainage, 2 patients (0.4%) had hematoma, one patient (0.2%) underwent D-J catheter implantation under local anesthesia owing to postoperative urinoma, and one patient (0.2%) underwent angio-embolization owing to persistent hematuria. In the adult group, the overall grade IIIa complication rate was 14.57%. There was no statistically significant difference between the two groups in terms of grade III complications

($p > 0.05$) (Table 2).

Colonic injury occurred in one patient (1.3%) in the pediatric group. The case of colonic injury was diagnosed intraoperatively. Intraoperative consultation was done with a pediatric surgeon. The pediatric surgeon advised primary repair. The patient became stone-free and was discharged on the fourth day postoperatively without any additional complications (grade IVa). In the adult group, one patient (0.2%) died owing to myocardial infarction (grade V).

The average hospital stay was 2.36 ± 0.48 days for the pediatric patients and 3.11 ± 0.86 days for the adults. Pediatric patients were discharged significantly earlier ($p < 0.05$).

DISCUSSION

The goal of treatment in urinary system stone diseases is to obtain a rapid and high level of success through a treatment that is minimally damaging to the kidney. To this end, PNL has now replaced open surgery because it offers short-term hospitalization and low cost of treatment, provides patients with the opportunity to reduce work loss in the postoperative period, requires a minimal surgical excision, and does not cause cosmetic deformity with incision scars [11].

Although PNL is a surgical method with high success rates, it must not be forgotten that complications can occur during and after the procedure. The most frequently encountered complications of PNL are extravasation (7.2%), bleeding necessitating blood transfusions (11.2% to 17.5%), and high fever (21% to 32.1%). Septicemia (0.3% to 4.7%), colon injury (0.2% to 4.8%), and pleural lacerations (0% to 3.1%) are seen less often [12].

The Clavien classification has been used in urological

TABLE 2. Comparison of complications between the pediatric and adult group

Grade	Pediatric		Adult		p-value
	Complication	n (%)	Complication	n (%)	
Grade I	Fever requiring antipyretics	4 (5.4)	Fever requiring antipyretics	30 (5.6)	$p > 0.05$
Grade II	Blood transfusion	6 (8.1)	Blood transfusion	54 (10.0)	$p > 0.05$
	Urine leakage < 12 h	5 (6.7)	Urine leakage < 12 h	26 (4.9)	
Grade III	-	6 (8.1)	Double-J stent placement for urine leakage > 24 h	74 (13.8)	$p > 0.05$
			Double-J stent placement for hematoma	2 (0.4)	
			Double-J stent placement for urinoma	1 (0.2)	
			Angio-embolisation	1 (0.2)	
			IIIb	Double-J stent placement for urine leakage > 24 h	
Grade IV					NA
IVa	Colon perforation	1 (1.3)	-		
IVb	-		-		
Grade V	-		Myocardial infarction (exitus)	1 (0.2)	NA

NA, not available.

studies for the classification and grading of complications after PNL. It provides standardization in the classification of complications, which is helpful in informing patients [6,7]. In the present study, we compared complications between the pediatric and the adult groups by use of this classification.

De la Rosette et al. [13] reported complications in a series of 5,803 patients as follows: grade I, 11.1%; grade II, 5.3%; grade IIIa, 2.3%; grade IVa, 0.3%; grade IVb, 0.2%; and grade V, 0.03% according to the Clavien classification. They pointed out the low major complication rates of PNL, which makes it an efficient and reliable method. Labate et al. [14] showed in a their series of 5,724 patients that the most commonly encountered complications are grade I, which constitute 54% of all complications. They also reported that the rate of major complications is low.

Güven et al. [15] reported in a study of 130 PNL procedures in pediatric patients the complications classified according to Clavien classification as follows: grade I, 17 patients; grade II, 4 patients; grade IIIa, 11 patients; grade IIIb, 7 patients; and no grade IV and V complications. They proved the efficacy and usability of PNL in children of all ages with low complication rates. In our study, a grade IV complication was seen in only one pediatric patient with colon perforation (1.3%) and a grade V complication occurred in only one adult patient with myocardial infarction and death (0.2%). The low major complication rates of PNL in pediatric patients, similar to the case in adults, indicates that PNL can be safely performed in pediatric patients as well as in adults.

In a study by Tefekli et al. [16] with 811 patients, post-operative complications classified according to the Clavien classification were as follows: grade I, 4%; grade II, 16.3%; grade IIIa, 6.6%; grade IIIb, 2.8%; grade IVa, 1.1%; grade IVb, 0.3%; and grade V, 0.1%. The most frequently reported complications were bleeding and urinary leakage. This was similar to our results. We also noted bleeding and urinary leakage as the most commonly encountered complications. In our study, there was no statistically significant difference between the pediatric and the adult groups in terms of grade I, II, and III complications (Table 3; The percentages of complications by Clavien grade are seen in different studies.).

However, when the details of grade III complications

were studied, we found that grade IIIb complications were encountered more frequently in the adult patients, whereas grade IIIa complications were seen more commonly in the pediatric group. This difference was due to the necessity for the treatment of complications in children under general anesthesia, whereas adults are treated under local anesthesia. This situation forms a small handicap peculiar to children.

Performing PNL in pediatric cases is relatively more difficult than in adults because of the difficulty in accessing the organ. The kidney is smaller and mobile, has limited movement, and is less tolerant towards hemodynamic and hypothermic changes. Despite these difficulties, PNL has been performed safely and efficiently in pediatric stone disease. Dogan et al. [19] stated that PNL can be applied to children of all ages both efficiently and reliably. Güven et al. [20] stated in a similar study that PNL can even reliably be applied to children below the age of 3 y with stone disease. Therefore, in this study, PNL was applied to children of all ages and high ratios of cases with no stones were achieved. Kumar et al. [21] stated that PNL can be applied for staghorn stones reliably and efficiently. Also, DeMarco [22] stated in a review that PNL has become a standard therapy for pediatric patients with large stones in the past two decades owing to the development of percutaneous entry techniques, miniaturization of instruments, and technological developments in the field of energy sources to break stones. We also showed that the complication rates in the pediatric patients were similar to those in the adults according to the Clavien grading. In both groups, the complication rates were low and there was no statistically significant difference. This is evidence for the reliability of PNL. Furthermore, the similar stone-free rates in both groups (pediatric, 91.89%; adult, 91.03%) prove the efficiency of PNL in renal stone surgery.

CONCLUSIONS

Thanks to technological developments and minimalization of the equipment, when indicated, stone disease in children can be safely treated with PNL. PNL can be performed safely and efficiently in pediatric patients, with high stone-free rates and low complication rates similar to those of adults.

TABLE 3. Percentage of complications by Clavien grade

Study	No.	Grade I	Grade II	Grade IIIa	Grade IIIb	Grade IVa	Grade IVb	Grade V
Tefekli et al. [16]	811	4	16.3	6.6	2.8	1.1	0.3	0.1
De la Rosette et al. [17]	244	25.8	16.8	0.4	0.4	0.4	0	0
De la Rosette et al. [13]	5,803	11.1	5.3	2.3	1.3	0.3	0.2	0.03
Shin et al. [18]	698	12.6	20.8	4.4	0.7	0.9	0.6	0.4
Güven et al. [15]	130	17	4	11	7	0	0	0
Our pediatric group	74	5.4	14.8	0	8.1	1.3	0	0
Our adult group	535	5.6	14.9	14.5	0	0	0	0.2

Values are presented as (%) unless otherwise indicated.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ACKNOWLEDGMENTS

This study was supported by the Gaziantep University.

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