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MINIREVIEWS

Percutaneous nephrolithotomy in pediatric age group: Assessment of effectiveness and complications

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Abstract

Management of kidney stone disease in pediatric population is a challenging condition in urology practice. While the incidence of kidney stone is increasing in those group, technological innovations have conrtibuted to the development of minimally invasive treatment of urinary stone disease such as mini-percutenous nephrolitotomy (mini-PCNL), micro-PCNL, ultra mini-PCNL. In this review we tried to evaluate the effect of new teratment techniques on pediatric kidney stones.

Key words: Percutaneous nephrolithotomy; Pediatric; Kidney stone; Urolithiasis

Core tip: In this article, minimally invasive treatment options of pediatric kidney stone disease are examined. Also, the effectiveness and complication rates of these techniques were reviewed in the light of recent publications.

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INTRODUCTION

The incidence of kidney stones in pediatric population is increasing and is reported that 50 cases per 100000 children[1]. The majority of kidney stones contain calcium. Most consist of calcium-oxalate but to a lesser extent calcium phosphate. Much less commonly kidney stones consist of urate, cysteine or struvite. Unlike adults, urinary stone disease in pediatric population is associated with genetic, metabolic and anatomical causes. Children with urolithiasis are considered high

risk for recurrent stone formation, and it is crucial for children to receive a treatment method that will provide them stone free[2].

Most pediatric urinary stones can be managed effectively by minimaly invasive treatment modalities such as extracoporeal shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), retrograde intrarenal surgery (RIRS)[3]. However, PCNL can have a significant role in cases involving large and/or SWL resistant stones. Acording to the European Association of Urology guidelines, PCNL is recommended as primary treatment option for large renal stones (> 20 mm) and also for > 10 mm stones of the lower renal pole[4].

The surgical management of pediatric kidney stones with PCNL has been developed due to improvement of endoruologic devices and acquired experiences. Standard PCNL required 24-30 F nephrostomy sheath for renal access. But this method is associated with complications such as hemoglobin drop, blood transfusion, damage of renal parenchyma, and postoperative analgesic requirement. In order to decrease morbidity associated with PCNL in pediatric patients small size instruments have been used. Thus, PCNL is performed with small size endoscopes *via* smaller percutaneous tract in diameters ranging from 11 F to 20 F and this was named as Miniperc or Mini-PCNL[5]. Recently, Micro-PCNL or microperc has been described as another minimally invazive PCNL technique that is performed through a 4.8 F all-seeing needle[6].

The literature was reviewed for success and complication rates regarding recent PCNL techniques in pediatric age group.

MINI-PCNL: SURGICAL TECHNİQUE, SUCCESS AND COMPLICATION RATES

The first pediatric PCNL was described using a 15 F peel-away sheat and 10 F pediatric cystoscope by Helal *et al*[7] in 1977. Yet, this technique was developed using an 11 F access sheat by Jackman *et al*[8] in pediaric patients. Since then, the new form of PCNL has become a treatment option for adults as well[9,10]. The first 12 F nephroscope was presented to perform mini-PCNL in 2001[9]. The new device consisted of 15 F and 18 F sheats, a system of continuous low pressure irrigation, and a 6 F working channel. In time, this technique has developed and also accumulated in the pediatric patients for the treatment of renal stones regardless of the size of the stone. There is no common consensus as to exact size that is used for mini-PCNL, but usually access sheats below 20 F is accepted[11].

Mini-PCNL is performed under general anesthesia. After introduction of anethesia with the patient in the lithotomy position, retrograde ureteral catheterization is performed with 3-5 F ureteral catheter to fill the collecting system during percutaneous access. Then, the patient is repositioned in the prone posistion with a 30°-45° upward tilt of the affected site. Adequate padding of the pressure points should be done to prevent pressure induced injuries and neuropraxias[12,13]. Prone position is the most preferred technique but it has been reported that supine position *vs* prone position has equal safety and effectiveness[14]. Percutaneous renal access is achieved under the fluoroscopic and/or ultrasonic guidance. A lower pole posterior calyx access is preferred, but site of renal puncture may vary depending on localization and burden of stone and renal anatomy. Puncture tract dilatation is performed with dilators, followed by placement of the sheath. According to the endsocopic equipment used in mini-PCNL different sheath size has been reported in literature. Although most preferred one is 16 F sheath, 15 F, 16 F, 18 F or 20 F sheaths have been used. Also, the most common endoscopes used are 9 F, 5 F ureteroscope, 12 F and 15 F mini-nephroscopes[15,16]. Acording to the localization of the stone 7 F, 9 F and 14 F flexible ureteroscopes can be used. Stone disintegration is usually performed with laser and/or pneumotic lithotripsy that vary according to the surgeon preference[17].

PCNL is a challenging procedure in pediatric population because of the small kidney and the low tolerance to blood loss. The use of the mini-PCNL technique is becomig increasinly popular in the teratment of kindey stones in pediatric patients.

In the first publications, standart PCNL technique was performed for the treatment of kidney stone in children and stone-free rate (SFR) has been reported to be 47%-98%[18,19]. Adult instruments were used with minimal complications. Badway *et al*[19] reported their results of 60 children using a 26 F and 28 F Amplatz sheat. SFR was reported approximately 84% with PCNL monotherapy, with only one procedure being abandoned due to intraoperative bleeding. Samad *et al*[18] performed 188 PCNLs using a 17 F or 26 F nephroscope in children aged 6-16 years. SFR was reported 47% after PCNL momotherapy and transfusion rate was 3%. Bilen *et al*[20] compared the use of 26 F, 20 F and 14 F Mini-PCNL. The mean patient age of the children in each group was 13.2 years, 5.9 years and 6.3 years, respectively. The stone burden, previous surgery and the mean haemoglobin drop postoperatively did not change between the groups; however, the blood transfusion rate was higher in the 26 F and 20 F Amplatz sheath groups. The SFR was highest in the Mini-PCNL group, at 90%, compared to 69.5% in the 26 F and 80% in the 20 F group.

There is no consensus on definition of SFR. It is usually considered as stone fragments smaller than 3 or 4 mm. But untreated residual fragments can cause a stone related events. Due to the fact that pediatric patients have a risk for stone recurrence. It is important to achieve complete stone clearance by selected treatment methods in the treatment of kidney stones in pediatrics[21].

Wang *et al*[22] reported their results of 247 renal units with calculi in 234 patients who underwent mini-PCNL aged under 3 years. All procedure were performed by

Table 1 Mini- percutenous nephrolitotomy

Ref.	Year	Renal unit	Mean age	Stone size (mean)	Tract	Mean operative time (min)	Initial SFR %	Complications (%, overall)
Ozden *et al*[24]	2010	100	9.5 yr	507.5 mm²	20.8 F (mean)	79.1	85	25
Zeng *et al*[25]	2012	20	20.6 mo	2.2 cm	14-16 F	77.5	95	NR
Resorlu *et al*[26]	2012	106	9.6 yr	23.7 mm	12-22 F	76.3	85.8	17
Yan *et al*[27]	2012	27	42.6 mo	1.85 cm	14-16 F	86.5	85.2	15
Wah *et al*[28]	2013	23	4.76 yr	3.44 cm²	16 F	109.4	83.6	14
Onal *et al*[29]	2013	1205	8.8 yr	4.09 cm²	Cutoff size 20 F	93.5	81.6	27.7
Elderwy *et al*[30]	2014	47	8 (median) yr	2.3 cm (median)	20-24 F	90	91.4	10.6
Desoky *et al*[31]	2015	22	9.5 yr	2.4 cm	20 F	65.1	90.9	36.3
Brodie *et al*[15]	2015	46	7.3 yr	NM	16 F	NR	76	NR

NR: Non reported; NM: Not measured; SFR: Stone-free rate.

Table 2 Modified clavien classification

Grade Ⅰ	Any deviation from the normal postoperative course without the need for treatment
Grade Ⅱ	Requiring pharmacological treatment with drugs Blood transfusions and total parenteral nutrition are also included
Grade Ⅲ	Requiring surgical, endoscopic or radiological intervention
Grade Ⅲa	Intervention not under general anesthesia
Grade Ⅲb	Intervention under general anesthesia
Grade Ⅳ	Life-threatening complication requiring IC/ICU management
Grade Ⅳa	Single organ dysfunction (including dialysis)
Grade Ⅳb	Multiorgan dysfunction
Grade Ⅴ	Death of a patient

ICU: Intensive care unit.

single tract, including 245 14 F tracts, 1 16 F tract and 1 12 F tract, respectively. 191 cases had stone burden 1-2 cm² and 30 cases stone burden > 2 cm², 26 cases < 1 cm². Mean operating time was 32.5 min (range 21-62 min). Complete stone free rate has been reported as 240 renal unit (97.2%). In another mini-PCNL study SFR rates has been reported as 90.8% in stone burden < 20 mm, but 76.3% in stone burden > 20 mm[23]. In Table 1, there is an overwiew of the recent published data of mini-PCNL.

Due to the minimally invasive nature of mini-PCNL in the case of providing complete stone clearance and a clear nephrostomy tract makes the procedure in tubeless manner. Bilen *et al*[32] evaluated result of tubeless (ureteral catheter but no nephrostomy drainage tube) *vs* conventinal mini-PCNL (nephrostomy drainage tube) in infants and preschool children. In this study with 28 renal unit in 26 patients, the tubeles mini-PCNL group had significantly shorter surgery and fluoroscopy times. Complications rates were higher and duration of hospitalization were longer in the nephrostomy group. Stone-free rates were reported as 91.6% and 78.5% in tubeless and nephrostomy group, respectively.

The aim of the minimally invasive PCNL is to reduce complications such as blood loss, intraoperative -postoperative pain and hospital stay. On the other hand it is believed that a smal calibre tract is less injurious to nephrons. But many authors have reported that 24-26 F dilataion does not cause significant morbidity in children, it has been reported that there is no advantage in using a small access based on renal scaring alone[33]. The caliber and number of tracts are associated with intraoperative hemorrhage during PCNL in children[34]. Complication rates have significantly reduced with the development of the smallest and least traumatic endoscopic appliances. Moreover, it is reported that there is a significant correlation of intraoperative bleeding with duration of surgery, stone burden and sheath size[35]. In additon that it is stated that operative time, sheat size, mid calyceal puncture and partial staghorn formation are independet predictors of complications[29].

It is important that using a common definition in the expression of complication to determine the risk factors for complications. Recently, the modified Clavien system for classifying surgical complications has been used for this purpose[36]. But complications are not always reported according to this system in recent publications (Table 2). Modified Clavien Classification has been shown.

The fist time, Ozden *et al*[24] indicated perioperative complications of PCNL in pediatric patients using the modified Clavien grading system. Transient fever (grade I) is one of the most frequent complication. But it is not always microbial in origin[37]. It is determined that transient fever rate is 31% in 188 PCNLs. However, postoperative infection is reported in approximately 6% of pediatric patients[20,38].

Bleeding is a serious complication during intraoperative and postoperative period in pediatric patients which is associated with sheath size, stone burden, number of tracts and operative time. Hemoglobin drop requiring transfusion (gare Ⅱ) is reported in 0.4%-24% of patients[39,40]. In another study higher hemoglobin drop

Table 3 Complication rates of mini- percutenous nephrolitotomy accoring to modified clavien classification

Ref.	Year	Renal unit	Overall complication rate (%)	Grade Ⅰ-Ⅱ (%)	Grade Ⅲ (%)	Grade Ⅳ-Ⅴ (%)
Ozden *et al*[24]	2010	100	25	21	4	-
Resorlu *et al*[26]	2012	106	17	17	-	-
Yan *et al*[27]	2012	27	15	15	-	-
Wah *et al*[28]	2013	23	14	13.6	0.4	-
Onal *et al*[29]	2013	1205	27.7	23.04	3.46	1.2
Pan *et al*[42]	2013	59	11.9	11.9	-	-
Elderwy *et al*[30]	2014	47	10.6	8.5	2.1	-
Desoky *et al*[31]	2015	22	36.3	22.7	13.6	

has been determined in pediatric patients performed PCNL when size of the tract dilataion exceeded 22 F[34].

There is a debate on the classification of grade Ⅲ complication, is that auxillary procedures such as RIRS, SWL and second look PCNL. It is recommended to considered them as part of treatment strategy. However, such as hydrothorax requiring chest tube or urine leakage requiring urinary diversion can be classified as Clavien grade Ⅲ complication[24]. It is said that grade Ⅲ, Ⅳ, Ⅴ complications should be quite rare and more likely associated with surgical techniques and expereince[41]. Complication rates have been shown in literature in Table 3.

ULTRA-MINI PCNL: SURGICAL TECHNIQUE AND NEW REPORTS

In 2013, the new PCNL technique was described by Desai *et al*[34] using of a novel 6 F mini nephroscope through an 11-13 F metal sheath to perform holmium: YAG laser lithotripsy. The new procedure was performed in 36 patients with a mean stone size 14.9 mm. Two patient were preschool children. It was reported that mean operative time, stone free rate at postoperative 1st day and 1st month were 59.8%, 88.9%, and 97.2%, respectively. Complication rate were reported as 16.% in 6 patients, according to Clavien classification, including 2 sepsis, 1 urinary extravasation, and 3 fever. The authors determined that there was no needed blood transfusion[43]. In another study results of 62 patients were reported using a 3.5 F nephroscope. Nephrostomy tract was dilatated up to 13 F. Only four of the 62 patients were children. Mean stone size was 16.8 mm, stone free rate at the 1st month was reported approximately 87%[44]. There is no sufficient data available to compare this new technique with other methods which use for the treatment of pediatric urinary stones. The new technique's effectiviness and safety remain to be seeen in larger prospective studies in pediatric patients.

MICRO-PCNL: SRUGICAL TECHNIQUES

Recently, Micro-PCNL or microperc has been described as another minimally invasive PCNL technique that is performed through a 4.85 F all-seeing needle. A three-way connector is attached to the latter, which admits a saline irrigation tube, 0.9 or a 0.6 mm-diameter micro-optic, a 272 μm laser fiber. The outher diameter of this modified needle is 1.6 mm (4.85 F). The first time this new technique were used in 15 adults. Mean stone size, operation time was 30.4 mm, 101.4 min, respectively. Postoperative complete stone clearance achieved in 11 patients[45]. Since then this method has addopted to the tretamnet of pediatric kidney stones. In a study, 24 infant treated with micro-PCNL. The mean age, stone size, operation time were 15.8 mo, 13.5 mm, 53.7 min, respectively. There is no major complication and hemoglobine drop requiring blood transfusion reported[46]. More experience and more knowledge is needed for the effectiveness of this method.

CONCLUSION

Technological innovations have contributed to the development of minimally invasive treatment of urinary stone disease. It can be said that to increase the efficacy and reduce complications is the main objective of physcians. In this manner new teratment methods which use for minimally invasive management of kindey stones in pediatric population has offered various treatment alternatives to the surgens. However, level of experience and new publications can contribte us to provide complete stone clearance and to reduce complication rates.

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