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Treatment of renal stones with flexible ureteroscopy in preschool age children

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Abstract The aim of the study is to evaluate the efficacy and safety of retrograde intrarenal surgery (RIRS) to treat renal stones in preschool age (<7 years) children. From September 2005 to May 2013, a total of 65 children (31 boys and 34 girls) with 72 renal stones were treated using RIRS. Patients were considered stone-free when the absence of residual fragments was observed on imaging studies. In the presence of residual calculi >4 mm, a second-stage RIRS was performed. The pre-operative, operative and post-operative data of the patients were retrospectively analyzed. A total of 65 patients with a mean age of 4.31 ± 1.99 years (6 months–7 years) were included in the present study. The mean stone size was 14.66 ± 6.12 mm (7–30 mm). The mean operative time was 46.47 ± 18.27 min. In 5 (7.69 %) patients, the initial procedure failed to reach the renal collecting system and ended with the insertion of a pigtail stent. The stone-free rates were 83.07 and 92.3 % after the first and second procedures, respectively. Complications were observed in 18 (27.7 %) patients and classified according to the Clavien system. Post-operative hematuria (Clavien I) occurred in 6 (9.2 %) patients, post-operative urinary tract infection with fever (Clavien II) was observed in 10 (15.4 %) patients, and ureteral wall injury (Clavien III) was noted in 2 (3 %) patients. RIRS is an effective and safe procedure that can be used to manage renal stones in preschool age children.

Keywords Children · Flexible ureteroscopy · Renal stone

Introduction

Renal stones in pediatric patients are usually caused by an underlying disorder, such as anatomical and metabolic anomalies or recurrent urinary tract infections [1]. Therefore, this age group has high risks of both recurrence and multiple interventions. For years, extracorporeal shock-wave lithotripsy (SWL) and percutaneous nephrolithotomy (PCNL) have been used to treat kidney stones in pediatric populations [2, 3]. However, technological advances, emerge of smaller caliber endoscopes and an increase in

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the application of flexible ureteroscopy (URS) in adult patient populations have made retrograde intrarenal surgery (RIRS) an increasingly suitable alternative treatment modality for pediatric patients. Despite this new popularity, the safety and efficacy of RIRS in pediatric patients under 7 years of age have been poorly investigated. We reviewed our experience using flexible URS to treat 65 children in preschool age with renal stones. To our knowledge, the present study is one of the largest series in the literature in this age group of patients.

Materials and methods

The medical records of 65 preschool age pediatric patients who underwent RIRS for renal stones from September 2005 to May 2013 were retrospectively reviewed. The selection criteria for the procedure included SWL-refractory stones, upon parent's and/or surgeon's preference. Prior to treatment, all patients were evaluated using serum biochemistry, complete blood count and urine culture. Preoperative imaging scans, including a plain abdominal radiograph (KUB), urinary ultrasound (USG), low-dose non-contrast computerized tomography (NCCT) and/or intravenous urogram (IVP) were obtained from all patients. All patients with sterile urine received antibiotic prophylaxis prior to surgery, and those with positive urine cultures were treated according to the antibiogram results. The stone size was taken as the longest diameter measured on CT.

All procedures were performed by one of the three surgeons (BE, TC, or GA) with the patients placed in the flog leg or lithotomy position using 7.5 F flexible ureteroscope (Karl Storz, Tutlingen, Germany). To protect radiation exposure, lead aprons were placed over the patients. Initially, semirigid URS or cystoscopy was performed to place two hydrophilic guidewires into the renal collecting system. In all patients, an attempt was made to advance a ureteral access sheath (UAS) (9.5/11.5 Fr) over the guidewire under fluoroscopic control. If the UAS insertion failed, the flexible ureteroscope was advanced over the hydrophilic guidewire. If the flexible ureteroscope could not be introduced into the renal collecting system, a pigtail stent was placed, and the procedure was repeated 2–4 weeks later. The ureteral orifice dilation was not performed in any of the patients. In all cases, a holmium:yttrium–aluminum-garnet (Ho-YAG) laser was used as a lithotripter. The laser energy and frequency were 0.6–1.0 J and 5–10 Hz, respectively. Stone extraction was not performed routinely, especially fragments smaller than 4 mm were left to pass spontaneously to reduce operative time, but some stone fragments were taken for stone analysis when possible. A pigtail stent (3 or 4 Fr) was placed in selected patients in whom the operative time is >45 min, stone burden >20 mm, in the presence of residual calculi and ureteral wall injury at the end of the procedure. The same technique was performed in all cases during the study period.

All of the patients were evaluated using urinalysis, urine culture, KUB and urinary USG at 1–3 months after the operation. Low-dose NCCT was performed only in the patients with radiolucent stones. Patients were considered stone-free if the absence of residual fragments was observed on imaging studies, which were performed at 3 months following the operation. If residual calculi >4 mm were observed, second-stage RIRS was performed. Patients with residual calculi <4 mm continued to the follow-up. Patients were followed up using urine analysis and urinary USG every 6 months for the first year and once a year thereafter.

SPSS software, version 21.0 (IBM, Armonk, NY) was used to perform statistical analysis. The data were expressed as the mean ± standard deviation or frequency. The normal distribution of the variables was tested using the Kolmogorov–Smirnov test. The Chi squared test was used to analyze the categorical variables, and an unpaired *t* test or the Mann–Whitney *U* test was used to analyze the continuous variables. A p value ≤ 0.05 was considered to be significant.

Results

A total of 65 patients (34 girls and 31 boys) with a mean age of 4.31 ± 1.99 years (6 months–7 years) were included in the present study. The mean stone size was 14.66 ± 6.12 mm (7–30 mm). A total of 17 patients had a history of failed SWL. Table 1 shows the patient and stone characteristics.

The operative outcomes are listed in Table 2. A total of 54 (83.07 %) patients became stone-free after a single procedure. The initial procedure was considered unsuccessful in 11 patients (16.92 %). Of these failures, the initial procedure failed in retrograde access in 5 (7.7 %)

Table 1 Patient and stone characteristics

Mean age (years)	4.31 ± 1.99 (6 months–7 years)
Male/female	31/34
Stone size (mm)	14.66 ± 6.12 (7–30)
Lateralization (R/L)	29/36
Stone location	
Renal pelvis (*n*, %)	22 (30.55 %)
Upper pole calyx (*n*, %)	10 (13.88 %)
Mid pole calyx (*n*, %)	12 (16.66 %)
Lower pole calyx (*n*, %)	28 (38.88 %)

Table 2 Operative and post-operative outcomes

Mean operative time (min)	46.47 ± 18.27 (20–95)
Stone-free rate (after a single procedure) (*n*/total) (%)	54/65 (83.07 %)
Stone-free rate (after a second session) (*n*/total) (%)	60/65 (92.3 %)
Lenght of hospital stay (day)	1.49 ± 1.42 [1–8]
Complication rate (*n*/total) (%)	18 (27.7 %)

patients due to the inadequate ureteral calibration and resulted in the placement of a pigtail stent. In the remaining 6 (9.23 %) patients, clinically significant residual calculi were observed during post-operative imaging studies. Second-stage RIRS was performed in these 11 patients following the failure of the initial procedure. Following the second procedure, 6 patients became stone-free, and the overall SFR reached 92.3 %. The remaining 5 patients had residual calculi that were smaller than 4 mm, and these patients continued to the follow-up.

A UAS was able to be placed in 40 (61.5 %) patients. Of the 25 (38.5 %) patients whose UAS attempt failed, a flexible URS could be placed over the guidewire in 20 (30.8 %) patients. In the remaining 5 (7.7 %) patients, a pigtail stent was placed, and the procedure was postponed for 2–4 weeks.

Complications were observed in 18 (27.7 %) patients and classified according to the Clavien system. Post-operative hematuria (Clavien I) occurred in 6 (9.2 %) patients and was resolved with hydration. Post-operative urinary tract infection with fever (Clavien II) was observed in 10 (15.4 %) patients and treated with antibiotics. Ureteral wall injury (Clavien III) was noted in 2 (3 %) patients and managed successfully with a pigtail stent insertion.

A total of 17 patients had a pigtail stent before the initial procedure. There were no significant differences between the pre-stented and non-stented patients in terms of SFRs, complication rates, operative times and reoperative rates. However, a UAS placement could possible in 94.1 % of the pre-stented patients, but only in 50 % of the non-stented patients ($p = 0.027$) (Table 3).

The SFRs after initial procedure were 28/34 (82.3 %) in female patients and 26/31 (83.8 %) in male patients ($p = 0.90$). The overall SFRs were 31/34 (91.1 %) in female patients and 29/31 (93.5 %) in male patients ($p = 0.78$). 9 (26.4 %) of 34 female patients and 9 (29 %) of 31 male patients experienced any of the complications ($p = 0.82$). There were no significant differences in SFRs after initial procedure, overall SFRs and complication rates between male and female patients.

Stone analysis was available in 39 (60 %) patients. The stone composition was calcium oxalate in 26 (66.6 %) patients, cystine in 6 (15.4 %) patients and magnesium-ammonium phosphate in 7 (17.9 %) patients.

Discussion

The standard procedures to treat renal stones in pediatric populations are similar to those used for adults: SWL, PCNL, RIRS, and laparoscopic surgery. When surgical correction is required, open surgery can also be performed [4].

The first successful use of SWL in a pediatric population was reported by Newman in 1986 [5]. Subsequently, SWL has been considered as a first-line treatment of choice in pediatric renal stone management, especially for stones <20 mm. The SFR of SWL has been reported as 67–93 % in short-term studies and 57–92 % in long-term studies [4]. Despite these high success rates of the procedure, SWL has been associated with a retreatment rate of 13.9–53.9 % and ancillary and/or additional intervention rates of 7–33 % [4]. However, the success of SWL is limited in the treatment of hard stones, such as cystine or calcium oxalate monohydrate, and lower pole stones [6, 7]. In addition, concerns remain regarding the development of diabetes mellitus or hypertension after SWL during long-term follow-up [7, 8].

As in adults, PCNL is recommended as a first-line treatment of choice for renal stones larger than 2 cm in

Table 3 Comparison of outcomes between pre-stented and non-stented patients

	Group 1 (pre-stented, $n = 17$)	Group 2 (non-stented, $n = 48$)	p value
Mean operative time (min)	45.6 ± 16.8 (25–90)	47.7 ± 19.1 (20–95)	0.684
Stone-free rate (after a single procedure) (*n*/total) (%)	14/17 (82.3 %)	40/48 (83.3 %)	0.926
Stone-free rate (after a second session) (*n*/total) (%)	16/17 (94.1 %)	44/48 (91.6 %)	0.814
Reoperative rates (*n*/total) (%)	3/17 (17.6 %)	8/48 (16.7 %)	0.926
Successful UAS placement (*n*/total) (%)	16/17 (94.1 %)	24/48 (50 %)	0.027
Overall complication rates (*n*/total) (%)	5/17 (29.4 %)	13/48 (27.1 %)	0.854

children [4]. Although the SFR after PCNL in children has been reported to be as high as 68–100 %, complications (such as fever, sepsis, renal pelvic perforation, persistent urine leakage, bleeding requiring transfusion, and colonic injury) can occur after the procedure [4, 9, 10]. However, the complication rate was found to be higher when PCNL was performed using adult-size instruments in preschool age children [11]. Specific instruments, such as small-diameter nephroscopes, are needed to perform PCNL in this age group of patients [12].

With the introduction of small flexible URS in clinical use, the ureteroscopic management of renal calculi has become possible even in pediatric patients. The complication rate of pediatric URS ranges from 1.3 to 5.2 % in the literature, whereas the success rates range from 77 to 100 % [13–18]. However, only a limited number of studies have been carried out, and there is a lack of studies examining the efficacy and safety of RIRS in preschool age children. Unsal et al. [16] recently reported the first series of RIRS procedures in the treatment of kidney stones in preschool age children, with a major complication rate of 5.8 % and a success rate of 88 % after a single session. In the present study, the SFR was 83.07 % after a single procedure and 92.3 % after a second procedure, and the major complication rate was 3 %, which was consistent with the literature.

The use of a UAS during RIRS has been associated with reduced intrarenal pressure, decreased operative time and improved SFR in adult patients [19]. The safety and efficacy of the UAS were studied by Singh et al. [20] in 8 patients, whose ages ranged between 4 and 13 years. They reported a 100 % SFR and no complications such as ureteral strictures in 10 months of follow-up. However, Traxer et al. [21] examined the safety of using a UAS during RIRS in adult patients and reported a severe ureteral injury rate of 13.3 %. In our study group, attempts were made to place the UAS in all cases, but it was possible in only 40 of 65 patients (61.5 %) and 2 of them experienced ureteral wall injuries related to the placement of the UAS.

Complications such as ureteral stricture or vesicoureteral reflux may occur after ureteroscopic procedures related to the placement of the UAS and relatively large caliber of ureteroscopes in children. In the present study, all of the patients were followed up with urinary USG and urine analysis at 1 month, 3 months, every 6 months for the first year following the surgery and once a year thereafter, however, we did not observe any hydronephrosis or recurrent urinary infections in any of the patients, which may reflect ureteral stricture or vesicoureteral reflux.

The placement of a ureteral stent prior the URS was found to be associated with decreased cost, decreased operative time, decreased reoperative rates and improved SFR for the URS [22–24]. In addition, Traxer et al. [21] found that the most significant predictor of severe ureteral injury was the absence of a pigtail stent before RIRS during the placement of the UAS. In the present study, 17 patients had a pigtail stent before the surgery. There were no significant differences between the pre-stented and non-stented patients with respect to the SFR, overall complication rates, operative time and reoperative rates. However, placement of the UAS was possible in 94.1 % of pre-stented patients, whereas it was possible in 50 % of non-stented patients. In addition, the 2 patients who presented ureteral wall injury during the UAS placement were in the non-stented group. According to our results, the placement of a ureteral stent before RIRS can be recommended to facilitate the placement of the UAS and reduce major complications such as ureteral wall injury.

Active ureteral orifice dilation via balloon dilators or coaxial dilators can be applied before URS in children to enhance easier access to the ureter. Unsal et al. [16] reported a perforation at the ureterovesical junction after balloon dilation in 1 of 5 preschool age patients, which was managed successfully by placing a pigtail stent. However, in their study, none of the patients who underwent balloon dilation were diagnosed with ureteral stricture or vesicoureteral reflux at a 2-month follow-up [16]. However, it has been suggested by other investigators that active dilation of the ureteral orifice may predispose both ureteral stricture and vesicoureteral reflux [25]. In the present study, active ureteral dilation was not performed in any of the cases to avoid ureteral trauma or bleeding. For the patients in whom the upper urinary tract could not be successfully accessed, we preferred to place a pigtail stent and to repeat the procedure 2–4 weeks later. In the present study, upper urinary tract access was unsuccessful in 5 patients during the initial attempt to URS, resulting in the placement of pigtail stents. In all of these patients, we successfully reached the collecting system in the second session.

In the present study, the selection criteria for the RIRS included SWL-refractory stones, upon parent's and/or surgeon's preference. In patients with hard stones, we preferred RIRS as a first-line treatment of choice because of the limited success of SWL in those patients. In the remaining patients, we provided SWL as a first-line treatment of choice to all parents, however, some of them did not prefer SWL because of the concern about the need of repeated anesthesia during SWL. Similarly, in patients with significant residual stones, we performed second-stage RIRS for the patients to become stone-free and remove pigtail stent in one anesthetic session.

The present study has some limitations. One of these limitations is the retrospective nature of the study and the lack of a randomization procedure for the treatment selection. Second, the stone-free status was determined using KUB and urinary USG in most of the patients.

NCCT, which is known to be the best imaging method to determine SFR after the procedure, was obtained only in patients with non-opaque calculi. All of the operations in the study group were performed by three surgeons, who were experienced in endourology. Although the same technique was performed by these surgeons in this study group, we cannot eliminate the possibility of intersurgeons' differences in success and complication rates. This point can be considered also as a limitation criteria in demonstration of the data. Despite these limitations, the present study is one of the largest series in the literature to show the safety and efficacy of RIRS in this age group of patients.

Conclusions

RIRS is an important treatment of choice in the management of renal stones even in preschool age children with a low complication and high success rate. However, future studies with a prospective design comparing the main treatment modalities are necessary to determine the selection criteria for the treatment of choice.

Conflict of interest None.

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