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Operative techniques

Retrograde intrarenal surgery in infants and preschool-age children

Ali Unsal, Berkan Resorlu*

Department of Urology, Ministry of Health, Kecioren Training and Research Hospital, Ankara 06380, Turkey

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Abstract

Objectives: The objectives of this study are to present our experience with retrograde intrarenal surgery for management of renal calculi in children less than 7 years old and to determine its safety and efficacy in this age group.

Methods: Patient demographics, stone location and size, use of ureteral access sheath, stone-free status, complication rates, and follow-up were evaluated.

Results: A total of 16 patients (9 boys and 7 girls; mean age, 4.2 years) underwent 17 procedures. The mean stone size was 11.5 mm (8-17 mm). Flexible ureteroscopy and laser lithotripsy were performed in all cases regardless of stone location. Dilation of the ureteral orifice was required in 5 cases (29.4%), and ureteral access sheaths were placed in 3 patients (17.6%). With a mean follow-up of 10.3 months, 88% of the children were stone free. The success rate for stones less than 10 mm was 100% and 81.8% for stones 10 mm or more ($P < .05$). There were no major complications, but there was 1 case of perforation and extravasation at the ureterovesical junction after balloon dilation that was managed with stent placement.

Conclusions: Retrograde intrarenal surgery is a safe and effective method for the treatment of intrarenal calculi, and it achieves reasonable results with minimal complications in children less than 7 years old.

In the last decade, technological advancement and miniaturization of instruments have changed the management of urinary stone disease. Since the initial report, percutaneous nephrolithotomy (PCNL) has become accepted as a well-established, minimally invasive procedure in children and adults. However, PCNL may present problems in infants and preschool-age children because of the small size and mobility of the pediatric kidney, friable renal parenchyma, and the small size of the collecting system. Small-volume, nonstaghorn stones can be effectively managed with the retrograde intrarenal surgery (RIRS) with good outcomes without the need for open surgery or PCNL. With increasing experience of RIRS in adults, recently, a few reports of successful ureterorenoscopic management of renal stones in children have been published [1-3]. However, most of those reports include a significant number of older adolescents.To our knowledge, no prior study has specifically addressed the efficacy of retrograde endoscopic management of intrarenal calculi in the preschool-age children. Stone disease in very young children is often associated with anatomical and metabolic abnormalities or infectious diseases, and the risk of recurrence is high

* Corresponding author. Tel.: +90 5055025743; fax: +90 3123569002.
E-mail addresses: drberkan79@gmail.com, drberkan@yahoo.com (B. Resorlu).

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[4]. These factors make minimally invasive procedures more important in this age group. We present our experience in 16 patients less than 7 years old, with the aim of demonstrating the efficacy and safety of this procedure. To our knowledge, this is the first series of RIRS for intrarenal stones presented to date in this age group.

1. Patients and methods

1.1. Patients

We retrospectively reviewed the medical records of 16 pediatric patients with stones (17 renal units), 7 years or younger, who underwent RIRS between 2006 and 2010. We included patients with urinary tract calculi localized to the kidney on preoperative imaging. Excluded from the study were patients with ureteral stones that were pushed proximally to the kidney during ureteroscopy. The indications for RIRS in this series included intrarenal stones smaller than 2.0 cm that failed shockwave lithotripsy (SWL) treatment and patients with bleeding disorders or musculoskeletal deformities. Pretreatment evaluation included a careful medical history, clinical examination, routine blood tests, urine analysis and urine culture, plain film, ultrasonography, and intravenous urography. Renal scintigraphy and computed tomography were not done routinely but were performed whenever needed. A primary metabolic workup was performed in all patients. Prophylactic perioperative wide spectrum antibiotics were administered to patients with sterile urine, and patients with bacteriuria were treated according to the antibiogram results.

Patient demographics, stone location and size, use of ureteral access sheath, operative technique, stone-free status, complication rates, and follow-up were evaluated. *Stone size* was defined as the longest diameter, as measured on a plain abdominal radiograph. Stones were classified as pelvic calculi, which had no caliceal extension and were located in the pelvis, and as polar calculi, which had a single caliceal extension and were located in the upper, middle, or lower poles of the kidney. When multiple stones were present in the kidney, stone size was reported as the sum of the diameters of each stone. The location was recorded for the largest stone.

1.2. Surgical technique

All procedures were performed by 1 surgeon (AU) using a 7.5 flexible ureteroscope (Karl Storz FLEX-X, Tuttlingen, Germany) and rigid ureteroscope (Olympus, Tokyo, Japan). Rigid ureteroscopy was routinely performed before flexible ureteroscopy in all patients for detecting nonopaque ureteral stones and dilatation of the ureter. Under general anesthesia, the children were placed in the lithotomy position on an endoscopy table with fluoroscopic imaging capability. Fluoroscopic screening was performed using a mobile multidirectional C-arm fluoroscopy unit with an under-the-couch x-ray tube and an over-the-couch image intensifier. We routinely laid lead aprons under the patients and between the x-ray tube and the patient, on all areas except the abdomen, for radiation protection in all procedures that required flouroscopy. Rigid ureteroscopy was performed to place a hydrophilic guidewire to the renal pelvis under fluoroscopic guidance. After passing a 0.035/0.038-inch safety guidewire into the renal pelvis, flexible ureteroscopy was performed. When the flexible ureteroscope could not be introduced into the ureter, it was advanced over a hydrophilic guidewire. Sometimes, this maneuver was very difficult, and if this maneuver also failed, then a ureteral access sheath was used. Ureteral access sheaths (internal diameter of 9.5F, 13 cm) were used in 3 patients to facilitate flexible ureteroscopy. Ureteral orifice dilation was performed in 5 cases with balloon dilators when the rigid/flexible ureteroscope could not be advanced easily. Dilatation was unnecessary in the remaining 12 patients. A manual irrigation pump system was briefly used to hydrodilate the ureter orifice or if there was troublesome vision during ureteroscopy. The stones were fragmented with a holmium:YAG laser until they were deemed small enough to pass spontaneously. In 6 patients, some residuel fragments were removed by nitinol baskets for stone analysis. Basket extraction of residuel fragments was not routinely performed. A Double-J stent was placed in all patients at the conclusion of the procedure and was removed under brief anesthesia approximately 10 to 14 days postoperatively (range, 7-28).

1.3. Follow-up

The follow-up period ranged from 7 to 25 months (mean, 10.3 months). Nine patients (56.5%) have had follow-up beyond 1 year. The first follow-up evaluation was performed 2 months after the operation after which patients were seen every 3 months during the first year and every 6 months thereafter. At each visit, urinalysis, urine culture, plain abdominal radiograph, and abdominal ultrasound were obtained to evaluate for urinary tract infections, hydronephrosis, residual stones, and/or fragments. If stone recurrence was diagnosed, excretory urography or noncontrast spiral computed tomography was carried out. Medical therapy and dietary planning were provided postoperatively in the outpatient setting when appropriate. Stone-free status was determined by clinical examination and the presence of residual fragments on follow-up imaging.

2. Results

A total of 16 children (9 boys and 7 girls) with a mean age of 4.2 years (range, 10 months to 7 years) who were referred to our clinic and underwent RIRS for renal stones were included this study. The total numbers of renal units was 17 because 1 patient had bilateral renal calculi and single session bilateral RIRS was performed for this child. The most common presenting symptom was flank or abdominal pain in 11 patients (68.7%). The other common symptoms were hematuria in 8 patients (50%) and fever with chills in 2 patients (12.5%). Three patients (18.7%) had urinary tract infection at presentation, confirmed by urine culture. The stone burden was calculated by adding the length of the longest axis of each stone. The mean stone burden was 11.5 mm (range, 8-17 mm). Stones were located in the renal pelvis in 5 cases (29.4%), lower pole calices in 5 (29.4%), midpole in 4 (23.5%), and upper pole calices in 3 (17.7%). Upper tract anatomy on the side of the stone was normal in all patients except for a patient with a bifid collecting system. We found metabolic abnormalities in 10 patients (62.5%). Four patients had hypomagnesuria, 4 had hypocitraturia, 3 had hypercalciuria, 1 had hyperoxaluria, 1 had cystinuria, and 1 had hyperuricemia. The preoperative characteristics of the patients are summarized in Table 1.

Dilation of the ureteral orifice was required in 5 cases (29.4%), and ureteral access sheaths were placed in 3 patients (17.6%). Holmium:YAG laser was used to fragment stones, and in 6 patients, some fragments were removed by basketing for stone analysis. Mean operative time was 52 minutes (range, 30-85 minutes). With a mean follow-up of 10.3 months, 88% of the children were stone free. The success rate for stones less than 10 mm was 100% and 81.8% for stones 10 mm or more ($P < .05$).

Table 1 Preoperative characteristics of patients

No. of patients	16
Mean age (range)	4.9 y (10 mo to 7 y)
Male/female	9/7
Clinical presentation (%)	
Abdominal pain	11 (68.7%)
Hematuria	8 (50%)
Urinary tract infection	3 (18.7%)
Fever with chills	2 (12.5%)
Stone side (%)	
Left	9 (56.2%)
Right	6 (37.5%)
Bilateral	1 (6.3%)
Stone location	
Pelvis	5 (29.4%)
Upper pole calices	3 (17.7%)
Mid pole calices	4 (23.5%)
Lower pole calices	5 (29.4%)
Stone burden (mm)	11.5 (8 - 17)
Metabolic abnormalities (%)	10 (62.5%)
Hypomagnesuria	4
Hypocitraturia	4
Hypercalciuria	3
Cystinuria	1
Hyperuricemia	1

Table 2 Perioperative and postoperative findings of patients

Dilation of the ureteral orifice	5 (29.4%)
Use of ureteral access sheath	3 (17.6%)
Mean operative time (min)	52 (30-85)
Initial stone-free rate (%)	15/17 (88%)
Stones <10 mm	6/6 (100%)
Stones ≥10 mm	9/11 (81.8%)
Age <4 year	7/8 (87.5%)
Age ≥4 year	8/9 (88.8%)
Hospitalization time (d)	2.1 (1-4)
Complications (%)	
Ureteral perforation	1 (6%)
Abdominal pain	2 (12.5%)
Voiding disturbances	2 (12.5%)
Gross hematuria	–
Postoperative fever or infection	–
Mean follow-up (range)	10.3 (7-25) mo
Stone composition (%)	
Mixed	7 (44%)
Calcium oxalate	6 (38%)
Calcium phosphate	1 (6%)
Cystine	1 (6%)
Uric acid	1 (6%)

There were no major complications, but there was 1 case, a 14-month-old girl requiring balloon dilation of the ureteral orifice before laser lithotripsy, who developed distal ureteral perforation and extravasation. She was managed first by placing a ureteral stent that was removed 3 weeks later, and PCNL was performed to render her stone free. There were no instances of pyelonephritis or gross hematuria after surgery, but mild abdominal pain and voiding disturbances occurred in some patients, which may have been related to the ureteral stent. The mean hospital stay was 2.1 days (range, 1-4 days).

Mean follow-up was 10.3 months (ranged from 7 to 25). During follow-up, the upper urinary tracts were normal. Voiding cystourethrography was not carried routinely in our patients, but it was done in 2 patients because of recurrent urinary tract infection with fever on follow-up; however, neither showed vesicoureteral reflux (VUR). Although urethral stricture or false passage in boys after insertion of a fine endoscope through the small-caliber urethra may rarely occur, there were no cases of urethral stricture observed in our study. Stone analysis was available for all patients. Stone composition was mixed in 44% of the cases; calcium oxalate, in 38%; calcium phosphate, in 6%; cystine, in 6%; and uric acid, in 6%. Intraoperative and postoperative findings of patients are summarized in Table 2.

3. Discussion

Management of urinary tract stones in children is a challenging problem. These patients often have recurrent stone formation, a large stone burden, and associated anatomical abnormalities. These factors make minimally invasive procedures more important in this age group. Currently, the 3 minimally invasive approaches available for pediatric patients with intrarenal stones are SWL, PCNL, and ureteroscopy [4-6].

Since the mid 1980s, SWL has been the criterion standard for pediatric renal stone burdens less than 2.0 cm and large proximal ureteral calculi, with low morbidity and success rates ranging from 60% to 95% [6]. However, the long-term effects of shock waves on developing kidneys and on contiguous viscera are not clear, and many studies have shown that the success rate of SWL decreases significantly with increasing stone size and multiplicity [7,8]. Most children require general anesthesia for SWL, which means that if SWL fails, the child will again be exposed to general anesthesia to undergo a salvage endourologic procedure. Large stones, cystine stones, radiolucent stones, and calculi situated over the bony pelvis are not suitable for treatment with SWL [9].

Percutanous nephrolithotomy has significantly high stone-free rates compared with SWL. However, PCNL is typically reserved for larger stone burden and treatment failures of SWL and/or RIRS because of its more invasive nature. Although stone-free rates are greater than 85% after a single PCNL in children, complications including urosepsis, bleeding requiring transfusion, renal pelvis perforation, and injury to adjacent organs are not uncommon [3,4,10-12]. The morbidity associated with RIRS is considerably less than that with PCNL, and the flexible ureteroscope allows access to the polar regions.

Treating ureteral stones with ureteroscopy in children was not made popular until Ritchey et al [13] and Shepard et al [14] successfully described its use in 1988. Because of significant improvements in the miniaturization and durability of endoscopic equipment, ureteroscopy has become a more attractive option. Use of ureteral access sheaths and small flexible ureteroscopes has made possible treatment of renal calculi that would have previously required SWL or PCNL. Few centers have reported their experience of flexible ureteroscopy in pediatric patients; however, all the published studies to date have included ureteral stones, and most of those reports include a significant number of older adolescents. To our knowledge, no prior study has specifically addressed the efficacy of retrograde endoscopic management of intrarenal calculi in infants and very young children.

In 2005, Tan et al [9] described 23 children with urolithiasis treated with ureteroscopy with a success rate of 95%. However, only 2 calculi were present in the kidney. Minevich et al [15] later described their series of 65 ureteroscopic procedures for upper urinary tract calculi in children, with a success rate of 98%. Seven calculi were located in the kidney, but their exact locations were not specified. Cannon et al [1] reported a 76% stone-free rate in 21 children with lower pole calculi and a mean stone diameter of 12.2 mm. They observed a similarly low stone-free rate in their series of prepubertal and postpubertal patients with intrarenal calculi. After a mean follow-up of 11.4 months, no major complications were observed. Smaldone et al [6] published the largest series of pediatric URS in 100 patients up to 20 years old with urolithiasis. The study included 33 patients with renal stones and showed an overall 91% stone-free rate, but the results for renal stones were not mentioned separately.

Herein, we report the first series of RIRS procedure in children 7 years or younger with an overall complication rate of 5.8%. In our series, 16 children underwent 17 RIRS procedures with a success rate of 88% after a single treatment. Only 1 patient who presented with multiple bilateral renal stones required an additional session of PCNL. All the children in our series had their urinary calculi fragmented using a holmium laser. The use of this modality is associated with minimal morbidity and is well supported in the literature. The advantages of the holmium laser are small fiber size; the ability to fragment stones with any composition effectively; and the pulsed nature of the laser, which can limit possible damage to the ureteral wall. Success rates in the literature using this modality as initial treatment range from 77% to 100%, with our success rate at 88% [16,17]. Lower pole stones have historically been difficult to treat because limited deflection of the flexible ureteroscope did not allow easy access to the lower calices. More than 25% of the intrarenal calculi in our series were in lower pole calices. Similar to recent adult series, we found that lower pole stone location did not significantly affect stone-free status [3,18]. We believe that RIRS is an important tool in the pediatric urologic armamentarium for treating lower pole nephrolithiasis.

The practice of routine dilation of the ureteral orifice and intramural ureter before performing a ureteroscopic procedure in children remains controversial. In our series, ureteral orifice dilation was performed in select cases with balloon dilators when the rigid/flexible ureteroscope could not be easily advanced. A balloon dilator was used in 5 patients, of whom 1 developed a perforation at the ureterovesical junction. In this study, among patients undergoing balloon dilation to allow ureteroscopic access, at 2-month follow-up, no patient had developed VUR, stenosis, or stricture. Overall, the incidence of ureteral stricture after ureteroscopy is 1% to 4% in adults, but rates specific to children are unknown because of the small patient numbers in most series [5]. The true incidence of VUR in children following ureteroscopy with vs without ureteral dilation is unknown. Most reported cases of postoperative VUR are low grade and resolve spontaneously [16,19]. Voiding cystourethrography was not carried routinely in our patients but was done in 2 patients, neither of whom showed VUR. We believe that a voiding cystogram should be reserved for children in whom postoperative upper tract dilation or urinary tract infection is evident.

Ureteral access sheaths facilitate repetitive upper tract access, reduce intrarenal pressure, decrease operative time, and improve the stone-free rate in the adult population [20].

Singh et al [21] described their experience using ureteral access sheaths in 8 pediatric patients, with a 100% stone-free rate and no postoperative ureteral strictures after a short follow-up of 10 months. In our current series, access sheaths were used in 17% of the cases, and a stent was placed after the procedure in all of the patients.

Intraoperative complications were defined as evidence of ureteral injury, including ischemia, perforation, avulsion, and significant extravasation of contrast material on ureteropyelography. *Postoperative complications* were defined as worsening hydroureteronephrosis, ureteral stricture development, pyelonephritis, stent migration, and other untoward events requiring additional surgical intervention [13,16,22]. In their recent review of the literature, Schuster et al [16] identified a ureteral perforation rate of 1.4% and a stricture rate of 0.9% in pediatric patients undergoing ureteroscopy for calculus disease. Our complication rate of 5.8% is comparable with other recent large adult series.

Retrograde intrarenal surgery with laser lithotripsy is an effective way to treat renal stones in very young children in whom conservative treatment fails, with an expected success rate of 85% to 90%. It is noteworthy that this procedure should be performed by an experienced endourologist. Although this is first report of RIRS in this age group, this series has some limitations, including short follow-up and a relatively small number of patients. Larger prospective studies are required to confirm these observations.

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