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RESEARCH ARTICLE

SAFETY AND EFFICACY OF RETROGRADE INTRARENAL SURGERY IN PEDIATRIC STONE DISEASE

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ABSTRACT

Objectives: To evaluate the safety and efficacy of flexible ureteroscopic (FURS) lithotripsy for intrarenal stones in children younger than 12 years.
Methods: From January 2004 to March 2013, 44 patients (29 males and 15 females) with a mean age of 5.8 ± 1.6 years (range 0.5 to 12) underwent flexible ureteroscopic laser lithotripsy for the treatment of kidney stones. The baseline characteristics, findings of metabolic assessement, perioperative data and complications were recorded. Evaluation of outcomes were assessed at 2, 12 and 24 weeks postoperatively with urine analysis and ultrasonography.
Results: Mean age was 5.8 ± 1.6 (range 0.5 to 12). Mean stone size was 12 ± 2.1 mm (range 8 to 25). The overall stone-free rate after a single procedure was found 84% at 2 week and 93.1% at 3 month. A secondary treatment (SWL, PNL or re-FURS) was not required in any patients. Failure of initial ureteral access (6.8%), urinary tract infection (13.6%), acute pyelonephritis (2.2%), hematuria (2.2%) and acute urinary retention early postoperatively (6.8%) were recorded as surgery related specific complications.
Conclusions: FURS seems to be a safe and effective procedure and could play an important role in the management of pediatric kidney stones.

Key Words: Renal stone, Flexible ureteroscopy, Children, Holmium, YAG laser.

INTRODUCTION

Renal stone disease remains a significant health problem in the adult population with the incidence of urolithiasis estimated to be as high as 12% (Seftel and Resnick, 1990). While the exact incidence of kidney stone disease in children is unknown, in the United States, stones are the reason for 1 out of every 1000-7500 pediatric hospital admissions (Walther *et al.,* 1980; Millner and Murphy, 1993). Extracorporeal shockwave lithotripsy (SWL) has traditionally been the first-line option for most of the upper urinary tract stones smaller than 10 mm in diameter. However for larger stones or in SWL-refractory cases percutaneous nephrolitotomy (PNL) has been considered a well established first-line theraphy which may present some problems in prepubertal pediatric population. Recent series showed that with the advancement and miniaturization of flexible ureteroscopes, retrograde intrarenal surgery (RIRS) has also becoming an important treatment modality in pediatric stone disease (Unsal and Resorlu, 2011). We reviewed our experience with flexible ureteroscopy (FURS) in treating 44 children with intrarenal stones younger than 12 years old.

MATERIALS AND METHODS

Between January 2004 and March 2013, we retrospectively reviewed the records of all children with kidney stones younger than 12 years who underwent flexible ureteroscopic holmium laser lithotripsy at our institution. The patients' hospital records were comprehensively reviewed to obtain patient demographics, presence of associated anatomic or metabolic abnormalities, stone size and location, operative technique, use of ureteral access sheath, operation time, type of endoscopic equipment used, surgical outcomes, peroperative and postoperative complications. Inclusion criteria were patients with kidney stones larger than 10 mm diameter or kidney stones with any size that failed SWL or PNL. Patients with bleeding disorders, previous urogenital surgery, intradiverticular stones, anatomic abnormalities such as horseshoe kidney or pelvic kidney were excluded.

The preoperative imaging scans including plain abdominal radiograph (KUB), intravenous urogram (IVP), and urinary ultrasound (USG) were reviewed to estimate the stone size and location and for evidence of obstruction. Low-dose non-contrast enhanced computerized tomography (CT) was performed for radiolucent stones (4 males and 3 females). Stone size was defined as the longest diameter, as measured on a KUB or CT with regard to the initial diagnostic imaging tool. 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. Preoperative evaluation also included, urine culture, urine analysis, serum creatinin and uric acid levels with a detailed medical history and clinical examination.

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All patients were treated with a second-generation cephalosporin antibiotic before and after the procedure. All procedures were performed under general endotracheal anesthesia. Success was defined as stone-free status or fragments <2 mm. Procedures were performed using active flexible ureteroscope (7.5F Storz, Tutlingen, Germany). The patient was positioned in a modified lithotomy position and in a slight Trendelenburg position on an endoscopy table with fluoroscopic imaging capability. After draping, cystoscopy (9F Wolf) was introduced to visualize the ureteral orifice and a 0.035/0.038-inch floppy-tipped guide wire was initially placed into the renal pelvis under fluoroscopic guidance to maintain access and remain in place as a safety guide wire in each case. The ureteral orifice dilatation was not performed in any patient. Ureteral access sheath (9.5F Cook) was introduced in 27 patients (61.3%) (14 boys and 13 girls). In the rest of the patients the flexible ureteroscope was passed into the ureter over a guide wire with replacement of a second safety wire. In all cases the holmium: yttrium-aluminum-garnet (Ho:YAG) laser was used as lithotriptor. The holmium laser fiber size (200-µm and/or 273-µm) was chosen according to the stone location. Mostly the 273-µ fiber was used however 200-µm fiber was used in case of lower pole stones which required more deflection. The laser frequency was mostly set at 6 Hz and the energy pulse at 0.6 J initially. Higher energy settings up to 1.4 J were required to treat harder calculi in 8 patients (18.1%). Fragments less than 2 mm were left to pass. We prefer “fragment anf left” technique while stone removal by using any retrieval devices was not used in any cases. Endoscopic inspection of both renal pelvis and ureter was routinly performed at the end of the procedure to rule out any trauma or residual calculi >2 mm. A suitable size and length double-J stent without string was placed in all cases ranged from 14 to 50 days (mean 16 ± 1.2 days). Foley catheter was not placed postoperatively in any cases. All patients were advised to force fluids to facilitate the spontaneous passage of the small fragments.

First evaluation visit was 2 weeks after the procedure and all patients were evaluated by urine analysis, urine culture, KUB and renal USG. Low-dose noncontrast CT was performed only in the patients with radiolucent stones. After the removal of double-j catheter, patients were seen every 3 months by urine analysis and ultrasonography for the first year and every 6 months thereafter. Mean follow-up period was 11.8 months (range 3 to 22 months). All data were presented as mean ± standart deviation (SD) or number of available cases (percantage). Statistical analysis of the patients’ baseline characteristics was performed using Student t-test. Statistical analysis was performed using the SPSS 15.0 (SPSS Inc., Chicago, IL) statistical software package.

RESULTS

The mean patient age was 5.8 ± 1.6 years (range 6 months to 12 years). Twenty-four patients had renal pelvic calculi, 20 patients had polar calculi (9 upper pole, 7 lower pole, 4 midpolar). Mean stone size was 12 ± 2.1 mm (range 8 to 25 mm). Calculi were single in 41 patients (93.1%) and multiple in 3 patients (6.9%). Ten patients (22.7%) were previously treated for the same stone, including 6 patients (13.6%) with SWL, 2 patients (4.5%) with PNL, whereas 2 patients (4.5%) had only stent placement.

Preoperative baseline patient characteristics were listed in Table 1. A total of 48 stones were treated in 44 patients (29 males and 15 females). Of the 44 patients, 41 had one stone, 2 had two stones, and 1 had three stones treated. None of the patients had bilateral stones. All patients underwent screening for the presence of metabolic risk factors postoperatively after the removal of double-j catheter and 18 patients (40.9%) were identified with metabolic abnormalities (Table 2).

Table 1. Preoperative baseline patient characteristics

Mean Age (years)	5.8 ± 1.6 (0.5 to 12)
Gender	29 male / 15 female
Stone Size (mm)	12 ± 2.1 mm (8 to 25)
Stone Side	13 left, 31 right
Stone Status	41 single, 3 multiple
Stone Location	24 renal pelvis, 9 upper pole, 4 midpolar, 7 lower pole
Previous SWL	6 (13.6%)
Previous PNL	2 (4.5%)
Preoperative DJ Stent	2 (4.5%)

SWL = Extracorporeal shockwave lithotripsy, PNL = Percutaneous nephrolitotomy

Table 2. Metabolic Abnormalities

Metabolic Abnormality	N
Hyperoxaluria	5 (11.3%)
Hypercalciuria	3 (6.8%)
Hypocitraturia	7 (15.9%)
Cystinuria	2 (4.5%)
Hyperuricemia	1 (2.2%)
None	26 (59%)

Table 3. Surgical Outcomes and Complications

Failure of initial ureteral access	3 (6.8%)
Urinary tract Infection	6 (13.6%)
Acute Pyelonephritis	1 (2.2%)
Hematuria	1 (2.2%)
Acute Urinary Retention	3 (6.8%)
Stone Free – 2 week	37 (84%)
Stone Free – 12 week	41 (93.1%)
Stone Free – 24 week	44 (100%)

The mean operating time per patient was found 51 ± 12 minutes (range 22 to 92 min). The operative time was calculated from the time of cystoscope insertion to the placement of the double-j catheter. In 3 male patients (6.8%) both placement of ureteral access sheath and introduction of flexible ureteroscope through the ureteral orifis was unsuccessful. Therefore double-j ureteral stent was placed and successful re-intervention was performed after 2 weeks in these 3 patients. The mean hospital stay was 1.8 days (range 1 to 3 days). Surgical outcomes and complications were listed in Table 3. There were no significant intraoperative complications. At the first (2 week) evaluation visit 7 patients (15.9%) (4 males and 3 females) has residual fragments of 3-5 mm detected by ultrasonography or KUB/non-contrast CT if needed.

The overall stone-free rate after a single procedure at 3 month follow-up visit was found 93.1% (41 patients). Three patients (6.9%) with residual calculi <5mm (2 males and 1 female) became stone-free within the first 6 month of surgery. A secondary treatment (SWL, PNL or re-FURS) was not required in any patients. No major complications occured. Postoperative complications were recorded in 10 patients (22.7%), including urinary tract infection (UTI) in 6 (13.6%) (5 females, 1 male), hematuria in 1 male patient (2.2%) and acute urinary retention early postoperatively in 3 male patients (6.8%), respectively. One patient (2.2%) presented with acute pyelonephritis and required rehospitalization for 3 days after being discharged. Patients with UTI treated with conservatively with oral antibiotics. Prolonged double-j stenting up to 6 weeks was perfomed to the patient with persistent hematuria. The patients with acute urinary retention were managed with a foley catheter for 24 hours. Based on the Clavien-Dindo classification of adverse events, 1 patient (2.2%) had grade I complications, 7 patients (15.9%) were grade II, 3 patients (6.8%) as grade III-a and no patients were grade IV.

DISCUSSION

The standart procedures to treat kidney stones in pediatric population do not differ from those used for adults: SWL, PNL (mini-PNL or mini-Perc), RIRS, and in selected cases laparoscopic surgery. Open surgery is reserved for selected cases, especially those with the need for anatomical correction of the urinary tract. SWL was introduced as a minimally invasive treatment for nephrolithiasis first in 1980 and the first successful use in the pediatric population was reported by Newman in 1986 (Newman *et al*., 1986). SWL has been the most preferred option as the first-line treatment for minimally invasive management of pediatric stone disease of the upper urinary tract (Muslumanoglu *et al*., 2003). In several pediatric series, SWL has been demonstrated to be successful in treating large stones (15-30 mm), with a 95% stone-free rate (Ather and Noor, 2003), staghorn calculi with a 73% stone-free rate (Orsola *et al*., 1999) and lower-pole calculi with a stone-free rate between 61% and 92% (Demirkesen *et al*., 2006).

Thus, the efficacy of SWL for renal stones in the pediatric population is well established. In a review of 22 pediatric SWL series, the stone-free rates were reported at least 70% at 3 months, although many of these series included results after multiple ESWL sessions that are known to improve the stone-free rate (D'Addessi *et al*., 2008). Whereas single-session stone-free rates may be as low as 44% (Muslumanoglu *et al*., 2003). In prepubertal pediatric population, multiple SWL sessions means multiple hospitalization, additional anesthesia and stress to both patients and parents. Thus single session treatment modalities are essential. While the efficacy of SWL is clearly established, there remains debate over the safety of this procedure, particularly in the very young patient with growing kidneys. Even though SWL can cause minor early complications, including hematuria, bruising, renal colic and perirenal hematoma it is important to be aware that long term complications were unclear. In 2006, Kramcheck *et al.* reported on a 19-year follow-up of adult patients treated with SWL, raising concerns of long-term effects, namely an increased risk of developing hypertension and diabetes (Krambeck *et al*., 2006).

Since Woodside *et al*. reported the first series of pediatric PNL, it becomes the standart treatment option for the pediatric kidney stone cases requiring surgical intervention such as cases with failure of SWL or larger stone burden (Woodside *et al*., 1985). Although PNL has significantly high stone-free rates (86-100%) compared with SWL (Galvin and pearle, 2006), the concerns on radiation hazards and effects on renal function are significant considerations for the pediatric population. It is associated with greater morbidity than either SWL or FURS which has been reported in up to 83% of cases (Michel *et al*., 2007). Serious complications arise mainly from the percutaneous puncture, associated with peristent bleeding requiring transfusion secondary to parenchymal damage and adjacent structures injuries, such as colon (0.8%) and pleura (3.1%) causing urosepsis (4.7%) (Michel *et al*., 2007). In cases with multiple caliceal stones, multiple access tracts may necessiatte, which may increase the complication rates and discomfort (Marguet *et al*., 2005). However flexible ureteroscopy offers an endoscopic technique that can access the entire intrarenal collecting system in a single session.

Refinements in endoscopic technology, combined with advances in intracorporeal lithotripsy, currently allow ureteroscopic management of calculi along the entire course of the upper urinary tract. Recently developed actively deflectable flexible ureteroscopes are smaller in diameter (7.5F) and they can be passed up the ureter without ureteral dilatation even in pediatric population. Recently a few centers have reported their experience of flexible ureteroscopy in pediatric patients; however, most of these published studies have included both kidney and upper ureteral stones. A significant number of older adolescents were also included in these studies (16-20). Unsal *et al*. recently reported the first series of RIRS procedure in the treatment of kidney stones in children <7 years with an overall complication rate of 5.8% and a success rate of 88% after a single session FURS (Unsal and Resorlu, 2011). A review of series of pediatric ureteroscopy revealed a stone-free rate after one procedure of between 77% and 100%. Most of these patients' stones were located in the upper ureter. Our stone-free and complication results are comparable to those previously published studies. In our series, 44 children underwent 44 RIRS procedures with a success rate of 93.1% at 3 month after a single treatment.

The practice of routine ureteral orifice dilatation before performing an ureteroscopic procedure in children remains controversial. In children, it has been suggested that dilatating the ureteral opening may predispose to both vesicoureteral reflux and ureteral stricture. However, balloon dilatation may allow safer passage of the ureteroscope, with less potential for ureteral perforation, as well as the ability to remove larger intact fragments. Perforation at the ureterovesical junction after balloon dilatation was reported in 1 of 5 preschool age patients by Unsal *et al. (*Unsal and Resorlu, 2011). In published studies to date, no convincing evidence has shown that dilating the ureteral orifice predisposes to either long-term reflux or stricture formation (Schuester *et al*., 2002). In our series, ureteral orifice dilation was not performed in any cases and no diffuculties of ureteral access sheath placement was observed. The safety and efficacy of ureteral access sheath in pediatric patients was studied in 8 children and a 100% stone-free rate and no postoperative ureteral strictures after a short follow-up of 10 months were reported (Jayanthi *et al*., 1999). In our series, we used ureteral access sheath in 27 (61.3%) patients and no ureteral stricture was observed within 12 months. Although some investigators have stated that children are able to pass stone fragments easier than adults, (Landau *et al*., 2001) Van Savage and coworkers found that of 33 children presenting with distal ureteral calculi, no child spontaneously passed a fragment larger than 4 mm (Van Savage *et al*., 2000).

We would suggest that stent insertion should also be considered in patients with larger stone burden to avoid the problems of severe colic, ureteric obstruction or urinary sepsis while they are returning home.

Conclusions

RIRS seems to be an important tool in the pediatric urologic armamentarium for treating kidney stones. FURS offers low morbidity of SWL but the potential stone-free rates approaching those of PNL in pediatric patients. Our results suggest that FURS is very effective and safe in the management of pediatric population with kidney stones; it has shown a high success rate with a few minor complications. We believe FURS can become a first-line theraphy for these patients.

Disclosure Statement

No competing financial interests exist.

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