Holmium Laser Ureteroscopic Treatment of Various Pathologic Features in Pediatrics

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OBJECTIVES
To assess the outcome of pediatric patients treated by ureteroscopy for various pathologic findings. A total of 31 children (median age 5 years, range 0.3 to 14) were ureteroscopically treated for ureteropelvic junction obstruction (UPJO) (n = 6, 1 primary and 5 secondary), ureteral strictures (n = 4), and calculi (n = 21). Miniscopes with a holmium laser were used for lithotripsy and ureterotomy.

METHODS
A total of 31 children (median age 5 years, range 0.3 to 14) were ureteroscopically treated for UPJO (n = 6, 1 primary and 5 secondary), ureteral strictures (n = 4), and calculi (n = 21). Miniscopes with a holmium laser were used for lithotripsy and ureterotomy.

RESULTS
The average age in the UPJO group was 1.8 years (range 0.3 to 4), the operative time was 40 minutes (range 30 to 50), and the hospitalization was 1.2 days (range 1 to 2). A successful clinical and functional outcome was maintained after an average follow-up of 16 months (range 8 to 30). The 4 cases of ureteral stricture included two located in the middle ureter and two at the ureterovesical junction. No failures had occurred in this group after an average follow-up of 25 months (range 8 to 40). The calculi cases comprised 10 lower ureteral, 2 upper ureteral, and 9 renal stones, with an average stone burden of 11 mm (range 5 to 20). Three patients (14%) underwent preoperative stenting. Two patients (10%) required ureteral orifice dilation. Postoperatively, 4 patients (18%) had a ureteral catheter left in place, 15 (71%) had an internal stent with an externalized string, and 2 (10%) did not require drainage. The average operative time was 39 minutes (range 15 to 90), and the hospitalization was 1 day (range 0.5 to 2). All patients were rendered stone free.

CONCLUSIONS
The results of our study have shown that the ureteroscopic approach in children with UPJO, ureteral strictures, and urinary calculi is safe and highly effective. Routine preoperative stenting and intraoperative ureteral dilation are not necessary. Stents with external strings were well tolerated and easily removed without anesthesia.

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efinements in endoscopic techniques and instrumentation, clinical experience, and the widespread popularization of endourology through well-established training programs have contributed to the improved efficacy and decreased morbidity of ureteroscopic procedures.1 In recent years, interest has been evolving in expanding this experience from adults to the pediatric population.2 Ureteroscopy performed in children for the treatment of calculi has been reported to be feasible and effective in several studies.3–8 Clinical studies on the outcome of applying the ureteroscopic approach for other pathologic findings, such as ureteral stricture and ureteropelvic junction obstruction (UPJO), however, are very limited.8 This report of our experience using holmium laser ureteroscopy to treat various pathologic findings in children will contribute additional data validating the implementation of this method in the pediatric setting.

MATERIAL AND METHODS
The study cohort included 31 pediatric patients who were referred for ureteroscopic treatment of various pathologic findings from June 2002 to December 2005. Parental informed consent was obtained for the operative and anesthetic procedures. Prophylactic perioperative wide-spectrum antibiotics were administered to patients with sterile urine, and patients with bacteriuria were treated according to the results of the antibiogram.

Under general anesthesia, the patients were placed in the lithotomy position. Cystoscopy and the approach to the ureteral orifice on the targeted side was performed using semirigid, double-channel 6.5F to 6.9F, 30-cm ureteroscopes. A 0.035-in. floppy hydrophilic tip guidewire (Sensor, Boston Scientific, Miami, Fla) was inserted up to the kidney under fluoroscopic guidance. Fluoroscopy was activated with attenuated amperage in the pulsed mode, according to the “as low as reasonably achievable” rules.9 Calibration of the intramural ureter was achieved with an 8F/10F coaxial introducer railroaded onto the guidewire. In the event that this maneuver was not successful, the ureteroscope was loaded on the guidewire and direct-vision
calibration performed. Then, the ureteroscope was retrieved and reintroduced beside the guidewire, which was left in place for safety. Flexible 7F to 7.5F ureteroscopes were used for locations unreachable by the semirigid instruments. In the case of retrograde intrarenal surgery (RIRS), a 9.5F/11F ureteral access sheath (Flexor, Cook Urological, Spencer, Ind) was used to facilitate multiple passages. The holmium laser was used for both stone fragmentation and endoureterotomy, and tipless nitinol baskets were used for stone retrieval. Retrograde pyelography was performed to attest the full-thickness cutting in the endoureterotomy cases. A 7F internal double-J stent with an externalized string was usually left in place for 5 to 7 days after ureterolithotripsy. Patients with minimal ureteral orifice edema were left unstented or with a 5F ureteral catheter in place for 1 day. Endopyelotomy 6F/12F or 7F double-J stents were placed in the endoureterotomy cases. Stone-free status and ureteral patency were assessed by plain abdominal films, Doppler ultrasonography, diuretic renal diethylenetriamine pentaacetic acid scan; DUS = Doppler ultrasonography; IVU = intravenous urography.

The 3 to 6-month follow-up evaluations included clinical examination, assessment of symptoms, confirmation of stone-free status, renal function, urinary tract patency, urine culture, and metabolic status. Prophylactic indications were given in relevant cases.

**RESULTS**

The study cohort consisted of 15 girls and 16 boys whose average age was 6.6 years (median 5, range 0.3 to 14).

**UPJO Group**

Retrograde holmium laser ureteroscopic endoureterotomy was performed in 3 girls and 3 boys (average age 1.8 years, range 0.3 to 4). Of these 6 patients, 5 (83%) had secondary UPJO after failed open dismembered pyeloplasty. All 5 patients had had nephrostomy tubes left in place with no ureteral stents for 7 days after the primary operation. The recurrences occurred within an average period of 3 months (range 1.3 to 5). One patient (17%) was concomitantly treated for primary congenital UPJO and renal calculi. The UPJO was located on the left side in 1 patient (17%) and on the right side in 5 (83%). Of these 6 patients, 3 presented with infectious events and abdominal/flank pain and 3 with decreased ipsilateral renal function and impaired drainage on diuretic renography, as well as aggravation of hydronephrosis on serial ultrasound imaging. Of the 6 children, 4 underwent preoperative renal drainage, 2 by percutaneous nephrostomy and 2 by internal retrograde stenting. The other 2 children did not undergo drainage before the procedure. The UPJO was attested in all cases by intraoperative antegrade or retrograde pyelography. The average length of the narrowed ureteral segment, as measured on digital radiography by calibrated software, was 6 mm (range 4 to 8). The retrograde approach to the UPJO was feasible without formal dilation of the ureteral orifice. Full-thickness endoureterotomies, preferentially with a posterolateral orientation, was performed after endoscopic surveillance to rule out the presence of pulsations. The setting of the holmium laser for this procedure was 365 μm, 1.4 J, and 15 Hz. Endopyelotomy stents (6F/12F) were placed in 2 patients and double-J stents (7F) in the other 4. All the stents were left in place with an externalized string placed intravaginally in the girls and attached with adhesive dressing to the penis in the boys. The average operative time was 40 minutes (range 30 to 50), and the average postoperative hospitalization was 1.2 days (range 1 to 2). No postoperative complications occurred in this group. The stents were well tolerated, and they were easily removed in the outpatient clinic, without anesthesia, after an average period of 5 weeks (range 4 to 6). A successful clinical and functional outcome has been maintained after an average follow-up of 16 months (range 8 to 30) (Table 1).

**Ureteral Stricture Group**

Four patients (average age 7 years, median 5, range 4 to 12) presented with ureteral strictures. They were primary percutaneously drained due to ureterocutaneous fistula in 1 and infection and obstruction in 3. The average stricture length was 7 mm (range 5 to 10). In 1 patient, the stricture was located in the middle right ureter and had occurred after iatrogenic injury during laparoscopic appendectomy. Holmium laser endoureterotomy was performed with a retrograde approach using a semirigid 6.5F ureteroscope in this case. An antegrade approach was

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**Table 1. Demographic and clinical data of patients treated for UPJO and ureteral strictures**

<table>
<thead>
<tr>
<th>Pt. No.</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Indication</th>
<th>Approach</th>
<th>Postoperative Stent (F)</th>
<th>Assessment of Outcome</th>
<th>Follow-Up (mos)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0.3</td>
<td>Male</td>
<td>Secondary UPJO</td>
<td>Retrograde</td>
<td>7</td>
<td>DDS, DDS</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>Male</td>
<td>Secondary UPJO</td>
<td>Retrograde</td>
<td>7</td>
<td>DDS, DDS</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>1.8</td>
<td>Male</td>
<td>Secondary UPJO</td>
<td>Retrograde</td>
<td>6/12</td>
<td>DDS, DDS</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>Female</td>
<td>Secondary UPJO</td>
<td>Retrograde</td>
<td>7</td>
<td>DDS, DDS</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>Female</td>
<td>Secondary UPJO</td>
<td>Retrograde</td>
<td>6/12</td>
<td>DDS, DDS</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Female</td>
<td>Primary UPJO</td>
<td>Retrograde</td>
<td>7</td>
<td>IVU, DDS</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>Female</td>
<td>UVJ stricture</td>
<td>Antegrade</td>
<td>6/12 (inverted)</td>
<td>DDS, DDS</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>Female</td>
<td>Mid-ureter stricture</td>
<td>Antegrade</td>
<td>7</td>
<td>DDS, DDS</td>
<td>36</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>Male</td>
<td>UVJ stricture</td>
<td>Antegrade</td>
<td>6/12 (inverted)</td>
<td>IVU, DDS</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>Male</td>
<td>UVJ stricture</td>
<td>Antegrade</td>
<td>7</td>
<td>IVU, DDS</td>
<td>40</td>
</tr>
</tbody>
</table>

UPJO = ureteropelvic junction obstruction; UVJ = ureterovesicle junction; DDS = diuretic diethylenetriamine pentaacetic acid scan; DUS = Doppler ultrasonography; IVU = intravenous urography.
used in the 3 other patients with a 7.5F flexible ureteroscope. The strictures had occurred after Cohen ureteral reimplantations in 2 of these 3 patients: one at the ureterovesical junction (UVJ) and one in the middle ureter. The third patient had complete UVJ obstruction after ureteral augmentation cystoplasty and transureteroureteral anastomosis. At the end of the procedures, we placed a 7F double-J internal stent in 2 patients and an inverted 6F/12F stent in the other 2 patients (Table 1). The nephrostomy tubes were removed 1 day after the operation. No treatment failures had occurred in this group after an average follow-up of 25 months (range 8 to 40).

**Calculi Group**

The calculi group comprised 21 patients. Of these, 10 (47%) had lower ureteral, 2 (10%) had upper ureteral, and 9 (43%) had renal stones. The average age of the children in this group was 7.9 years (median 7; range 0.9 to 14). The average stone burden as measured in the longest dimension was 11 mm (range 5 to 20).

All 12 patients with ureteral stones were symptomatic. The presenting symptom was renal colic in 7 (58%) and was nonspecific abdominal pain and macroscopic hematuria in 5 (42%). The average age of the children with frank renal colic and those with other symptoms was 12.4 years (range 10 to 14) and 3.6 years (range 2 to 5), respectively (P < 0.0001). The renal stones were asymptomatic in 6 patients (67%), and they were diagnosed after urinary tract infection in 3 (33%). Preoperative stenting was performed in 3 patients (14%), 1 with concomitant UPJ and renal stones and 2 with obstructing upper ureteral stones. Primary ureteroscopy was precluded by a very tight UVJ in 1 child (0.5%), who was treated in two stages: dilation and stenting followed by ureteroscopy. None of the stones in the preureteroscopic stented patients were pushed back during the stenting. Ureteral orifice dilation was necessary in 2 patients (10%). Postoperatively, 4 patients (19%) had a ureteral catheter left in place, 15 (71%) had an internal stent with an externalized string, and 2 (10%) had no drainage. The average operative time was 39 minutes (range 15 to 90), and the hospitalization was 1 day (range 0.5 to 2). All 21 patients were rendered stone free. No intraoperative complications occurred. Two children (10%) developed postoperative urinary tract infection. One 11-year-old boy developed a short anterior urethral stricture 3 months after RIRS. He was successfully treated with urethral dilation. The internal stents with external strings were well tolerated and were easy to remove in the office, without anesthesia.

Stone analysis revealed 11 cases of calcium oxalate (52%), 4 of calcium phosphate (19%), 4 of cystine (19%), and 2 of magnesium-ammonium-calcium-phosphate (10%). A comparison of stone composition by ureteral and renal location showed a significant preponderance of ureteral calcium stones (11 [92%] versus 4 [44%]; P < 0.05), and a trend toward more intrarenal cystine stones (3 [33%] versus 1 [8%]; P = 0.15) and struvite stones (2 [22%] versus 0; P = 0.09). The metabolic evaluation was positive in 6 patients (29%): 4 with cystinuria, 1 with absorptive oxaluria, and 1 with idiopathic hypercalciuria. No patients had had stone recurrence after an average follow-up of 25 months (range 4 to 48).

**COMMENT**

Children, especially prepubertal ones, pose specific anatomic and technical challenges for the endourologic approach because of the tiny ureteral orifices, tight UVJs, large psoas muscles, anatomic anomalies, and previous reconstructive surgery. Nevertheless, the expansion of endourologic skills, development of advanced miniscopes and devices, and recognition of ureteroscopic safety, effectiveness, and minimal invasiveness have led to evolving interest in adapting this technique to pediatric patients. Most of the experience gained in this field has been with the management of calculi. Pioneered by Shepherd et al. and Ritchey et al. in the late 1980s, this approach has had relatively extensive acceptance in endourologic centers. Wollin et al. reported their initial experience using holmium laser ureteroscopic lithotripsy in children. In a series of 19 pediatric patients, with an average age of 11 years and mostly treated with a retrograde approach, they achieved a stone-free rate of 84% after one procedure. Comparable results were reported by Thomas et al. in a series of 29 prepubertal patients. Minevich et al. recently presented the largest series of prepubertal ureteroscopic procedures. They treated 58 children and achieved a stone-free rate of 98%. The single case of residual stone occurred after RIRS and was retreated with shock wave lithotripsy. In centers lacking a holmium laser machine, ureteroscopic lithotripsy using pneumatic energy has been reported as an acceptable alternative, with success rates ranging from 87% to 94%. These studies were limited to the use of semirigid endoscopes, precluding an efficient approach to renal calculi. Even though our ureterolithotripsy group was mostly characterized by prepubertal children, 10F calibration of the UVJ allowed easy ureteral access, limiting the need for formal dilation to only 2 cases. We found ureteral calibration by loading the ureteroscope on the guidewire under direct vision to be a useful maneuver for avoiding the trauma related to overdilation. Concerns of the occurrence of vesicoureteral reflux and strictures secondary to dilation had been raised before the era of miniscopes. We believe that our method of gaining access by limiting the calibration to either 10F or to the ureteroscope diameter contributed to the decreased damage to the physiologic antireflux mechanism. Moreover, as reported in published reports, if reflux does occur, it is usually of low grade and resolves spontaneously. Almost one half of our patients with calculi underwent RIRS, in which a 9.5F/11F ureteral access sheath was straightforwardly inserted, even in children younger than 1 year of age, thereby facilitating multiple passages of the ureteroscope. We found internal stents with externalized...
strings to be very useful. They were well received by the parents and tolerated by the patients. Also, they were easily removed in the office, without anesthesia. The symptoms on presentation in our present series were specifically related to patient age, and stone composition was related to the location along the urinary tract.

In addition to patients with calculi, our series included children with UPJO and ureteral strictures. Open pyeloplasty, with a trend toward preferring laparoscopic pyeloplasty in the past 2 years, is considered the most efficient procedures for the treatment of UPJO.13–15 Despite the reported success rate of more than 90%, failures may sometimes occur, however infrequently. The experience gained with adults has revealed that recurrent UPJO can be endoscopically resolved, with a high success rate.16

The minimal invasiveness of the endoscopic approach in such cases also appears to be appealing in the pediatric population, obviating the need for another open repair. Pediatric endopyelotomy has been reported to have a success rate of 86%, with most of the reported pediatric series using an antegrade approach.17,18 Analyzing the outcome of percutaneous endopyelotomy in 37 patients with an average age of 11.5 years, Tallai et al.18 reported a radiologic success rate of 89%. The feasibility of a retrograde approach to UPJO was first assessed by Bolton et al.,19 who used the Acucise device in 2 patients. Minevich et al.8 presented their successful experience in treating six UPJO units in prepubertal patients using retrograde holmium laser endopyelotomy and a flexible ureteroscope.

In our series, the patients with UPJO were infants, with the youngest only 4 months old. This testifies to the feasibility of retrograde endoscopic endopyelotomy at almost any age. We preferred to use semirigid miniscopes, reasoning that they might be better stabilized to perform a controlled single-line ureteral wall incision. We did not encounter any problems with the retrograde approach to the UPJ without preoperative ureteral stenting. We refrained from using Acucise devices, not only because of cost restraints, but also because we believe that cutting under endoscopic surveillance is essential for the safety of this procedure. Although the outcome of our patients was successful clinically, functionally, and radiologically after an average follow-up of 16 months, longer follow-up is warranted to establish its success rate conclusively. Lessons learned from adult series have suggested that although failures become evident within the first 12 months, they can develop as late as 3 years after intervention.20 As such, pediatric patients should be followed up at least that long to ensure a lasting result.

We also achieved adequate results with 4 cases of ureteral strictures that were treated by ureterotomy. It was our preference to use an antegrade approach in the 3 children who had undergone previous surgery for vesicoureteral reflux by Cohen ureteral reimplantation. We believe that this practice permits easy access to the intramural ureter and allows maintenance of the cutting line in the reimplanted ureter long axis to avoid recurrent vesicoureteral reflux. Finally, our series was characterized by a low complication rate, and all complications were minor and simple to resolve.

CONCLUSIONS

The results of our study have shown that pediatric ureteroscopy is safe and highly effective. It appears that the indications for ureteroscopy in children emulate those in adults. Routine preoperative stenting and intraoperative ureteral dilation were not necessary, and stents with external strings were well tolerated and easily removable without anesthesia. We believe that this study has presented contributory data to support further extension of ureteroscopic indications in pediatrics.

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References