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Ureteroscopic management of distal ureteral stones in children: holmium:YAG laser vs. pneumatic lithotripsy

Aim: In this retrospective study, we aimed to compare the treatment results of pneumatic and holmium laser-assisted ureteroscopy in managing distal ureteral calculi in children.

Materials and methods: The study group included a total of 36 children (23 boys, 13 girls) who underwent ureteroscopy between June 1998 and April 2008 due to distal ureteral calculi. Pneumatic lithotripsy was performed in 11 children and holmium:YAG laser lithotripsy in 25.

Results: Their ages ranged from 18 months to 14 years (mean: 8.5 ± 3.5 years). The overall success rate for the holmium:YAG laser lithotripsy (100%) was higher than that of pneumatic lithotripsy (81.8%), but the difference was insignificant (P = 0.087). The complication rate was higher in pneumatic lithotripsy than in holmium:YAG laser lithotripsy (36.4% versus 4%, P = 0.023). Treatment time and hospital stay were shorter in the holmium:YAG laser lithotripsy group than in the pneumatic lithotripsy group (32.4 min versus 42.3 min, P = 0.041; 17.4 h versus 33.6 h, P = 0.013, respectively).

Conclusion: This study showed that the success rate for holmium:YAG laser lithotripsy was almost identical with that achieved by pneumatic lithotripsy in the treatment of distal ureteral stones; ureteroscopic holmium:YAG laser lithotripsy had significant clinical advantages over pneumatic lithotripsy in terms of operative time, and hospitalization duration, stent requirements, and complication rates.

Key words: Laser, lithotripsy, pediatric ureteroscopy, ureteric calculi

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Çocuklarda distal üreter taşlarının üreteroskopik tedavisi: holmium:YAG lazer ile pnömotik litotripsinin karşılaştırılması

Amaç: Bu retrospektif çalışmada, çocuklardaki distal üreter taşlarının pnömotik ve holmium lazer litotriptörlerle üreteroskopik tedavi sonuçlarını karşılaştırmaya amaçladık.

Yöntem ve Gereç: Çalışma grubu Haziran 1998 ile Nisan 2008 tarihleri arasında distal üreter taşı nedeniyle üreteroskopi yapılan 23'ü erkek, 13'ü kız toplam 36 çocuğu içeriyordu. Pnömotik litotripsi 11, holmium-YAG lazer litotipsi ise 25 çocuğa uygulandı.

Bulgular: Yaşları 18 ay ile 14 yıl (ortalama: 8.5 ± 3.5 yıl) idi. Holmium:YAG lazer litotripsinin total başarısı (% 100) pnömotik litotripsininkinden (% 81.8) daha yüksekti, fakat fark önemli değildi (P = 0.087). Komplikasyon oranları pnömotik litotripsi grubunda holmium:YAG lazer litotripsi grubundan daha yüksekti (% 36.4'e karşın % 4, P = 0.023). Tedavi süresi ve hastanede kalış holmium:YAG lazer grubunda pnömotik litotripsi grubundan daha kısa idi (sırasıyla 32.4 dakikaya karşın 42.3 dakika, P = 0.041; 17.4 saate karşın 33.6 saat, P = 0.013)

Sonuç: Bu çalışmada, distal üreter taşlarının tedavisinde holmium:YAG lazer ve pnömotik litotripsinin başarı oranları benzer bulunmuştur. Ancak operasyon ve hastanede kalış süresi, stent gereksinimi ve komplikasyon oranları bakımından holmium:YAG lazerin daha avantajlı olduğu gösterilmiştir.

Anahtar sözcükler: Lazer, litotripsi, pediatrik üreteroskopi, üreter taşı

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Introduction

Recent technological developments have provided smaller endourological equipment and more efficient intracorporeal lithotriptor sources, such as the holmium:YAG laser. As a result of these developments, the treatment of urinary stones has undergone tremendous changes (1). Ureteral calculi are encountered less frequently in children than adults (2). Although excellent results have been reported in adults, ureteroscopy in the pediatric age group requires greater technical skill and a higher level of endosurgical expertise (3). Initial experience with pediatric ureteroscopic holmium laser lithotripsy has encouraged pediatric urologists to use these treatments in children in view of their minimally invasive nature and the higher success rates reported (1,4). Currently, ureteroscopy has become a widely accepted modality for ureteral stones. In the present study, we compared the success rates, complications and limitations between the 2 most commonly used intracorporeal lithotriptors: pneumatic and holmium:YAG laser lithotripsy.

Materials and methods

During the 10–year period of the study, 36 children with distal ureteral calculi were treated with ureteroscopic lithotripsy in the Department of Urology, Ataturk University School of Medicine. Between June 1998 and January 2003, a pneumatic lithotriptor (Vibrolith, Elmed Inc., Turkey) was used, after which holmium:YAG laser (Auriga, Wavelight Laser Technologie AG, Germany) with a 365 μm wide-probe tip was utilized for the procedure. In this period, pneumatic lithotripsy was performed in 11 (Group I) and holmium:YAG laser lithotripsy in 25 children (Group II). The evaluation of these children included medical history, physical examination, urinalysis, urine culture with sensitivity, serum creatinine level, and coagulation profile. Additionally, a plain abdominal radiograph of the kidney, ureter and bladder (KUB), excretory urography and/or ultrasonography, or a combination of these, were used to diagnose, locate, and define the stone burden. Informed consent was obtained from parents of all children. Children with urinary tract infection (UTI) were treated with culture-specific antimicrobials before intervention. The distal ureter was considered as the ureteral portion between the distal edge of the sacroiliac joint and the ureterovesical junction. Entry criteria were radiopaque/radiolucent single or multiple stones at the distal ureteral portion, ≤15 mm in diameter, follow-up at our institution, and age younger than 15 years. Exclusion criteria were abnormal coagulation profile, UTI and presence of a nonfunctioning kidney. The stone size was measured with a scale from the KUBs for their greatest length and width. All patients were placed in the lithotomy position under general anesthesia. In all patients, a safety guide wire was placed via cystoscopy into the ureter under fluoroscopic guidance and ureteroscopy was performed as described in the other pediatric series (1,3). In both groups the same ureteroscopic instruments were used; ureteroscopy was performed using 1 of 2 rigid ureteroscopes: 8 F (Karl Storz, Germany) and 9.8 F (Olympus, Germany). Balloon dilatation of the ureteral orifice was not required in any patient. Stone-free status was defined according to the description of Gupta (1): 1) Complete clearance, both endoscopic and fluoroscopic, at the time of ureteroscopy; 2) Complete fragmentation but incomplete clearance at the time of ureteroscopy with complete clearance at 3 months. Children were followed at 2 weeks, 3 months, and then annually with a KUB radiograph and ultrasonography.

Statistical analysis: SPSS 11.5 statistical software was used to analyze the data. Patient characteristics and treatment parameters/outcomes between the 2 groups were compared using univariate analyses (chi-square or Mann-Whitney test). Differences were considered statistically significant at values of $P < 0.05$.

Results

Twenty-three boys and 13 girls with a mean age of 8.56 ± 3.53 years (range, 18 months-14 years) were treated. The 2 patient groups were comparable with respect to age and stone size ($P = 0.538$ and $P = 0.787$, respectively, Table 1). The boy:girl ratios were 1.2 (6/5) in the pneumatic lithotripsy group and 2.1 (17/8) in the holmium:YAG laser lithotripsy group. The presenting symptoms were colicky flank or abdominal pain in 16 (44.4%), gross hematuria in 6

Table 1. Patient characteristics and treatment variables/outcomes according to management with pneumatic or holmium:YAG laser lithotripsy.

	Pneumatic group (Group I)	Holmium:YAG laser group (Group II)	*P value*
No. of patients (n)	11	25	
Age, years	8.0 ± 4.3	8.8 ± 3.2	*0.538*
Success rate, %			
After 1 procedure	8/11 (72.7)	24/25 (96)	*0.076*
After 2 procedures	9/11 (81.8)	25/25 (100)	*0.087*
Stone size, mm	7.9 ± 3.1	8.3 ± 3.3	*0.787*
Treatment time, min	42.3 ± 15.2	32.4 ± 12.5	*0.041*
Hospital stay, h	33.6 ± 23.0	17.4 ± 17.2	*0.013*
Complication rate, %	4/ 11 (36.4)	1/25 (4)	*0.023*
Stent requirement, %	9/11 (81.8)	11/25 (44.0)	*0.039*
Follow-up, month	13.2 ± 13.2	10.2 ± 10.9	*0.320*

All parameters are means ± standard deviation (SD) or number (percent)
Parameters between the 2 groups were compared using Mann-Whitney or Chi-Square test.

(16.7%), and fever in 3 (8.3%) children. After a single ureteroscopy session, complete stone removal was achieved in 24 children (96%) in the holmium:YAG laser lithotripsy group and in 8 children (72.7%) in the pneumatic lithotripsy group (P = 0.076). After 2 ureteroscopy sessions, stone-free rates were 100% (25/25) and 81.8% (9/11) in these groups, respectively (P = 0.087). In the pneumatic lithotripsy group, intervention failed in 3 children after 1 procedure, and 1 of these children was successfully treated after 2 procedures. Two children in the pneumatic lithotripsy group were not stone-free at the end of ureteroscopy. In 1 patient, the stone migrated proximally, and he was subsequently treated with shock wave lithotripsy (SWL). In the other case, the stone was impacted and covered with hyperplastic mucosa and fragmentation failed with lithotripsy; he was treated with ureterolithotomy (Table 2).

The average operation time was 42.3 ± 15.2 min in the pneumatic lithotripsy group versus 32.4 ± 12.5 min in the holmium:YAG laser lithotripsy group (P = 0.041, Table 1). The postoperative hospital stay ranged from 12 to 72 h (mean ± SD: 33.6 ± 23.0 h) in the pneumatic lithotripsy group and 6-48 h (mean: 17.4 ± 17.2 h) in the holmium:YAG laser lithotripsy group (P = 0.013, Table 1).

A double-J stent was inserted in 5/11 (45.4%) patients in the pneumatic group; of the remaining patients, 4/11 (36.4%) had a ureteral catheter (3F or 4F) for 12 h and 2/11 were stentless. For the laser group, a double-J stent was inserted in 7/25 (28%) patients; of the remaining patients, 4/25 (16%) had a ureteral catheter (3F or 4F) for 12 h and 56% were stentless (14/25). Postoperative stent requirement in the pneumatic lithotripsy group was higher than in the holmium:YAG laser lithotripsy group (81.8% and 44%, respectively, P = 0.039). All ureteral catheters were removed the next day. Double-J stents were removed the next week. Intraoperative and postoperative complications occurred in 5 patients (13.8%), the majority of which were minor (Table 2). The complication rates for ureteroscopic lithotripsy were 36.4% in the pneumatic lithotripsy group versus 4% in the holmium:YAG laser lithotripsy group (P = 0.023, Table 2).

Four patients initially underwent an unsuccessful SWL procedure before the ureteroscopic intervention. These children were successfully treated with ureteroscopic intervention with holmium:YAG laser lithotripsy. Only 1 boy (9 years old) had an anatomic abnormality (ureterocele containing a 10 mm distal ureteral calculus). A stone basket or grasper was used

Table 2. Complications of pneumatic and holmium:YAG laser lithotripsy for treatment of distal ureteral stones.

Complication	Pneumatic lithotripsy (Group I) (n = 11)	Holmium:YAG laser lithotripsy (Group II) (n = 25)
Postoperative fever	none	1
Mild hematuria	2	none
Stone migration	1	none
Stone fragmentation failure	1	none
Total	4 (36.4%)	1 (4%)

for extraction of the big fragments in 10 patients (8 patients in pneumatic lithotripsy and 2 patients in holmium:YAG laser lithotripsy groups), and additional extraction procedures were significantly different in favor of the holmium:YAG laser lithotripsy group ($P < 0.001$). Average follow-up duration was 11.1 ± 11.6 months (range: 3-48) for all patients.

Discussion

Ureteroscopy has been the preferred first-line therapeutic modality for distal ureteral calculi in adults (5). However, management of distal ureteral calculi in the pediatric population still poses a technical challenge for pediatric urologists. Thus, the use of ureteroscopy and SWL for the treatment of distal ureteral calculi in the pediatric age group remains controversial. Many reports have compared the efficacy and safety of the 2 procedures (5-7). The results of the ureteroscopy were found to be far superior to that of SWL (5-7). Since 1980, technological developments in both the miniaturization of ureteroscopes and introduction of the holmium laser have changed the entire scenario in pediatric ureteral stone management (1,4). Today, open surgery is rare and the management of ureteral stones in children is gradually becoming more like that in adults (6). Pediatric ureteroscopy has gained widespread acceptance among pediatric urologists (4). Ureteroscopic stone treatment has provided good results, varying from 62.5% to 100%, in pediatric ureteral calculi (3,4,8-12). Reddy et al. (8) presented the initial report of success using endoscopic holmium laser lithotripsy for pediatric urolithiasis. Success rates (stone-free) following one or multiple procedures were 62.5% and 100%, respectively. Although ureteroscopy is a more invasive procedure than SWL, the success rate with ureteroscopic lithotripsy is better. Furthermore, the availability of effective intracorporeal lithotripsy techniques and modern instruments provide a high safety profile and minimal morbidity in pediatric ureteroscopic intervention (8,9).

There are a few comparative studies in adults related to the results of pneumatic lithotripsy versus holmium:YAG laser lithotripsy (13,14), but there is no such comparative study in children. Bapat et al. (13) reported a comparative study between holmium:YAG laser lithotripsy and pneumatic lithotripsy in managing adult upper ureteral stones, and they reported that the holmium:YAG laser lithotripsy demonstrated significant clinical advantages over pneumatic lithotripsy in terms of fragmentation rates, complication rates and the need for auxiliary procedures. To our knowledge, the current study is the first series comparing the 2 different lithotripsy techniques in pediatric patients.

The current study had the potential limitations of being non-randomized and retrospective in nature. However, the present study was performed in the same institution using 2 different intracorporeal lithotripsy modalities in different time periods, and patient characteristics and inclusion/exclusion criteria were similar. The operator, definition of success, and follow-up procedure were also the same. Additionally, there was no selection bias of patients since only one kind of lithotripsy was used, i.e. pneumatic lithotripsy initially (June 1998 - January 2003) and the holmium:YAG laser lithotripsy more recently (February 2003 - April 2008).

Routine dilatation of the ureteral orifice before ureteroscopy in children remains controversial. According to El-Assmy et al. (11) and Shroff and Watson (15), there is no need for dilatation of the intramural ureter before each ureteroscopy, but other authors have recommended routine dilatation (4,9,12). Ureteric dilatation before ureteroscopy depends on the size of the instruments available, and the surgeon's preference and experience (9,12). While balloon dilatation allows easier passage of the rigid ureteroscope into the ureteral orifice as well as the extraction of larger stone fragments, its disadvantage is the need for post-ureteroscopic stenting (10). None of our patients required ureteral dilatation.

Another debated issue is the need for stent placement after the ureteroscopic intervention. Most pediatric urologists prefer routine placement of a ureteral stent after ureteroscopic lithotripsy in children (3,9,10). Safwat et al. (4) placed a stent in 11 of 15 patients. They did not suggest stent placement in the situation of minimal ureteral manipulation. Koura et al. (9) preferred a stent insertion in cases of significant stone burden, ureteral trauma, impaction and edema of the ureteric orifice. In the present study, ureteral stents were placed postoperatively in 20 (55.5%) of 36 patients if there was significant stone burden, mucosal trauma, impaction, edema of the ureteric orifice, or long operation time. Although ureteric stents are commonly used after ureteroscopy in children, stents can lead to discomfort, or "stent syndrome", and migration, and will require repeated anesthesia for removal (16). In our series, postoperative stent requirement in the holmium:YAG laser lithotripsy group was lower than in the pneumatic lithotripsy group (44% versus 81.8%, respectively).

The reported complication rate in different pediatric series ranges from 0% to 7% (4,11,17). Reported complications of ureteroscopic intervention are infrequent and generally minor, such as fever, mild hematuria and renal colic; however, major complications such as ureteral perforation and extravasations have been reported (11,12). Dogan et al. (12) reported ureteral perforations in 2 of the first 5 patients in their series. We had no perforation or extravasations in our series, as also reported by Koura et al. (9) and Schuster et al. (10). In our study, total complications of ureteroscopic lithotripsy were 13.8%, but this rate was only 4% in the holmium:YAG laser lithotripsy group. Complications in the pneumatic lithotripsy group were frequent but minor (mild hematuria, stone retropulsion, and failure of stone fragmentation). Minor complications were managed conservatively. Koura et al. (9) suggested that maintenance of a safety guide wire and constant visualization of the ureteral lumen are necessary to prevent complications during the procedure.

Holmium:YAG laser lithotripsy demonstrated more advantages from the aspect of the operation time and hospital stay. Pneumatic lithotripsy fragments the calculi into multiple chunks, and these chunks are extracted using a stone basket or grasper (14). However, the fragments created by the holmium:YAG laser are smaller and are easily washed out by the side of the scope either during the procedure or afterwards. With pneumatic lithotripsy, the operator has to manipulate the device to hunt for the moving stones (13). Furthermore, requirement of additional extraction procedures was significantly higher with pneumatic lithotripsy. These factors may explain the reason for the longer operation time with pneumatic lithotripsy compared to holmium:YAG laser lithotripsy.

The pneumatic lithotriptor is an efficient and economical device, but it is associated with a high incidence of proximal stone migration (13). Holmium:YAG laser is the most effective intracorporeal lithotriptor and it has significant advantages over the other intracorporeal lithotripsy techniques in terms of proximal stone migration, available small-caliber probes, tissue damage, success rates, and morbidity (12). The holmium:YAG laser is expensive and carries high maintenance costs. However, incidence of redo after the holmium:YAG laser lithotripsy is low, and it causes the least stone retropulsion (1). Additionally, it can be used in various pathologic situations such as ureteropelvic junction obstruction and ureteral stricture (18). As a result, the economic burden may be reduced with holmium:YAG laser.

Conclusion

The results of our study have shown that holmium:YAG laser lithotripsy in the pediatric age

group is associated with shorter operation time and postoperative hospitalization period, as well as lower complication rate and stent requirement. These data also suggest that holmium:YAG laser lithotripsy is safe with minimal morbidity as first-line treatment in pediatric distal ureteral calculi.

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