Urol Res (2007) 35:149–153
DOI 10.1007/s00240-007-0095-3

ORIGINAL PAPER

Clinical outcome of ureteroscopic lithotripsy for 2,129 patients with ureteral stones

Toshifumi Kurahashi · Hideaki Miyake · Nobutoshi Oka · Masashi Shinozaki · Atsushi Takenaka · Isao Hara · Masato Fujisawa

Received: 5 October 2006 / Accepted: 5 April 2007 / Published online: 24 April 2007

Abstract The objective of this study was to retrospectively analyze the clinical outcomes of ureteroscopic lithotripsy (USL) performed in patients with ureteral stones, and to investigate the factors associated with therapeutic outcomes. This study included a total of 2,129 patients with ureteral stones who underwent USL between December 1985 and March 2006 in a single institution in Japan. In this series, ultrasonic lithotripsy was primarily performed, and forceps and/or baskets were occasionally used for the removal of stones. Complete removal was defined as total clearance 1 day after the initial USL. The initial stone-free rate following a single treatment with USL was 73.3%. Of 569 patients diagnosed as having fragmentation of residual stones, additional therapy was not performed for 115 with stones likely to pass spontaneously, while the remaining 454 subsequently underwent extracorporeal shock wave lithotripsy. Thereafter, ureterolithotomy or percutaneous nephrolithotripsy was further added in 14. Ureteral perforation occurred in 14 patients, of whom 2 underwent nephrectomy; however, there were no other serious complications that could not be managed by conservative treatment. Whether ureteral stones were completely removed by an initial USL was significantly associated with the history of ureteral stone, severity of clinical symptoms, number of stones, localization of stones and maximal diameter of stones. Furthermore, multivariate analysis identified the severity of clinical symptoms, number of stones, localization of stones and maximal diameter of stones as independent predictors for complete removal of ureteral stones by the initial USL application. These findings suggest that USL could be a safe and effective treatment option for ureteral stones; however, other therapeutic strategies should also be considered in patients with currently identified risk factors associated with treatment failure following a single USL procedure.

Keywords Ureteral stones · Ureteroscopic lithotripsy · Ultrasonic lithotripsy · Extracorporeal shock wave lithotripsy

T. Kurahashi · H. Miyake (✉) · A. Takenaka · I. Hara · M. Fujisawa
Division of Urology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan
e-mail: hideakimiyake@hotmail.com

N. Oka · M. Shinozaki
Hara Genitourinary Hospital, Kobe, Japan

Introduction

In the early 1980s, the development of extracorporeal shock wave lithotripsy (ESWL) resulted in significant changes in the treatment of urinary tract stones [1]. With recent technological advances of ESWL, several investigators reported that satisfactory success rates could be achieved for all levels of ureteral stones by in situ ESWL; therefore, in situ ESWL has been accepted in many institutions as first-line therapy for patients with ureteral stones. In situ ESWL, however, may be initially unsuccessful in approximately 20% of patients [2, 3], and several factors associated with the limited efficacy of in situ ESWL have been reported, such as large size, localization in the distal ureter and impaction [1–3]. Thus, there is still controversy concerning the indications for management of ureteral stones, and ureteroscopic lithotripsy (USL) is still frequently performed as a primary treatment for ureteral stones [1]. In fact, despite its invasiveness, USL has been shown to

achieve higher success rates, faster stone delivery and is less expensive than ESWL [1, 4, 5]. In addition, more rapid and safer fragmentation of ureteral stones has been achieved with very high success rates by introducing several types of new generation lithotriptors, such as ultrasonic, pneumatic and laser lithotriptors [1].

Considering the significant role of USL in the management of ureteral stones, we carried out retrospective analyses of the clinical outcomes in 2,129 patients who underwent USL as primary therapy for ureteral stones at a single institution in order to identify the factors associated with therapeutic outcomes following USL.

Materials and methods

Between December 1985 and March 2006, 2,129 consecutive patients with ureteral stones who underwent USL in a single institution were enrolled in this study. The characteristics of these patients are summarized in Table 1. Patients who need medication to control symptoms associated with ureteral stones prior to USL were regarded as having severe symptoms, while the remaining patients without any medication were classified as having mild symptoms. Ureteral stones were defined as proximal if the stone was located in a position between the ureteropelvic junction and the upper margin of the sacroiliac joint, midureteral from this level down to the lower margin of the sacroiliac joint, and distal below the sacroiliac joint. In this series, the indications for USL were generally as follows: proximal and midureteral stones which could not be pushed back into the kidney by ureteral manipulation, and all distal ureteral stones.

Table 1 Patient characteristics

Age (range)[a]	50.9 ± 14.5
Gender	
Male	1563
Female	566
Past history of ureteral stone	
Negative	1234
Positive	895
Symptom associated with ureteral stones[b]	
Mild	480
Severe	1649
Site of ureteral stones	
Right	902
Left	1227
Number of ureteral stones	
Single	1819
Multiple	310
Location of ureteral stones	
Proximal	498
Mild	222
Distal	1409
Maximal of diameter of ureteral stones (mm)[a]	9.5 ± 5.0

[a] Data are presented as mean ± standard deviation

[b] Mild, patients who do not need any medication; severe, patients who need medication to control symptoms

USL was performed using rigid instruments (9.5-French Strutz, Tuttlingen, Germany; 8- or 8.5-French Wolf, Knittlingen, Germany) under either sedoanalgesia or spinal anesthesia. Depending on the sizes of the stones, forceps, baskets (Olympus, Tokyo, Japan), and/or the Sonop ultrasonic lithotripter (Aloka, Mitaka, Japan) was used for manipulation of ureteral stones. As a rule, at the end of the procedure, an internal double-J catheter was inserted, passed through the ureter and removed approximately 10 days postoperatively.

At our institution, judgment of USL treatment outcome was based on the findings of plain X-ray of the kidneys, ureter and bladder (KUB) 2 days after USL, and a successful outcome was defined as complete removal of all stones on KUB. When residual stone fragments larger than 4 mm were detected on KUB, additional treatment was promptly performed, whereas no further therapy was performed in patients with residual stones 4 mm or smaller.

Differences between patients with or without residual ureteral stones 2 days after an initial USL were compared using the Chi-square test. The significance of several factors in predicting a successful outcome of an initial USL was assessed by the Cox proportional hazards regression model. All statistical calculations were performed using Statview 5.0 software (Abacus Concepts, Inc., Berkely, CA, USA), and probability (P) values < 0.05 were considered significant.

Results

Of 2,129 patients included in this study, complete removal of ureteral stones by a single procedure of USL was achieved in 1,560; therefore, the initial stone-free rate was 73.3%. Of 569 who were diagnosed as having fragmentation of residual stones on KUB 1 day after an initial USL, there were no additional therapies performed in 115 with stones 4 mm or smaller, and spontaneous passage of these stones was subsequently confirmed in all of these patients. The remaining 454 with residual stones larger than 4 mm underwent secondary treatment with ESWL; thereafter, ureterolithotomy and percutaneous nephrolithotripsy were further added in 7 and 7, respectively. In this series, intraoperative ureteral perforation occurred in 14 patients after

USL, of whom 12 could be managed with drainage by an internal double-J catheter, and the remaining 2 underwent nephrectomy. In addition, postoperative complications requiring hospitalization developed in 13 patients, including urinary infection in 6, ureteral stricture in 4 and sepsis in 3. However, there were no other acute or late complications that could not be managed by conservative treatment without hospitalization.

We then evaluated several parameters as predictors of therapeutic outcome of USL. As shown in Table 2, it was significantly associated with the history of ureteral stone, severity of clinical symptoms, number of stones, localization of stones, maximal diameter of stones and whether ureteral stones were completely removed by an initial USL or not. Furthermore, multivariate analysis with Cox proportional hazards regression model identified the severity of clinical symptoms, number of stones, localization of stones and maximal diameter of stones as independent parameters predicting complete removal of ureteral stones by an initial USL (Table 3).

Discussion

Since the introduction of ESWL into clinical practice, ESWL has been applied to the treatment of ureteral stones as well, and several studies have reported that satisfactory therapeutic outcomes could be achieved by in situ ESWL at all levels of ureteral stones [1]. However, stone-free rates following in situ ESWL for ureteral stones are not as high as those for USL, particularly for large stones, distal ureteral stones and impacted stones [4–9]. For example, Park et al. reported that the overall stone-free rate following ESWL was 74.7%, and that this rate was significantly affected by the size of stones, being 83.6% when the stones were <1.0 cm and 42.1% and when the stones were ≥1.0 cm, while USL resulted in an overall stone-free rate of 87.8%, regardless of the size of the stones. Considering these findings, there is a significant role of USL in the treatment of ureteral stones; hence, in this study, we retrospectively analyzed data from 2,129 patients with ureteral stones who underwent USL as an initial treatment in a sin-

Table 2 Association between several factors and therapeutic outcome following a single ureteroscopic lithotripsy procedure

Variables	Complete removal of ureteral stone		*P* value
	Yes (*n* = 1560)	No (*n* = 569)	
Age (years) (%)			0.40
50 or younger	737 (74.1)	257 (25.9)	
51 or older	823 (72.5)	312 (27.5)	
(Mean value[a])	(50.5 ± 15.3)	52.1 ± 16.5	
Gender (%)			0.39
Male	1153 (73.8)	410 (26.2)	
Female	407 (71.7)	159 (28.3)	
Past history of ureteral stone (%)			0.0031
Negative	626 (69.9)	269 (30.1)	
Positive	934 (75.7)	300 (24.3)	
Symptom[b] (%)			<0.0001
Mild	290 (60.4)	190 (39.6)	
Severe	1270 (77.0)	379 (23.0)	
Site (%)			0.85
Right	659 (73.1)	243 (26.9)	
Left	901 (73.4)	326 (26.6)	
Number (%)			<0.0001
Single	1398 (76.9)	421 (23.1)	
Multiple	162 (52.3)	148 (47.7)	
(Mean value[a])	(1.1 ± 0.2)	1.4 ± 0.2	
Location (%)			<0.0001
Proximal or mild	176 (35.3)	322 (64.7)	
Distal	1384 (84.9)	247 (15.1)	
Maximal diameter (mm) (%)			<0.0001
10 or less	1248 (85.9)	205 (14.1)	
Greater than 10	312 (46.2)	364 (53.8)	
(Mean value[a])	(7.2 ± 3.9)	(15.9 ± 7.0)	

[a] Data are presented as mean ± standard deviation

[b] Mild, patients who do not need any medication; severe, patients who need medication to control symptoms

Table 3 Multivariate analysis of association between several factors and therapeutic outcome following a single ureteroscopic lithotripsy procedure

Variables	*P* value
Age (years) (50 years or younger vs. 51 years or older)	0.57
Gender (male vs. female)	0.093
Past history of ureteral stone (negative versus positive)	0.25
Symptom[a] (mild vs. severe)	0.039
Site (right vs. left)	0.76
Number (single vs. multiple)	<0.001
Location (proximal or mild vs. distal)	<0.001
Maximal diameter (mm) (10 or less vs. greater than 10)	<0.001

[a] Mild, patients who do not need any medication; severe, patients who need medication to control symptoms

gle institution, in order to reevaluate the clinical outcomes of USL.

In this series, 73.3% of patients were judged on KUB as showing complete removal of ureteral stones 1 day after USL, and an additional 5.4% of patients with residual stones 4 mm or smaller were later judged to be stone-free following spontaneous passage of these stones. Accordingly, complete removal of ureteral stones was achieved in a total of 78.7% of patients following a single USL procedure. Despite the relatively high proportion of included patients with proximal and midureteral stones, the stone-free rate following an initial USL in this study is comparatively low compared with that in previous studies [1, 4–9]. This could be explained by different intervals until judgment of therapeutic outcome; that is, whether complete stone removal was achieved is usually determined approximately 4 weeks after USL [4–9], while the present data were based on findings 1 day after USL. Recently, Pearle et al. reported the first ureteroscopy series which relied exclusively on CT imaging for follow-up, and their results were sobering with just 50% of patients actually rendered stone-free and 28% of patients with residual stone fragments greater than 4 mm. These findings suggest the superiority of CT over KUB for accurately diagnosing residual stone following USL.

According to the schedule used at our institution, some proportion of patients with residual stones, who may become stone-free after spontaneous passage, are routinely given secondary treatment; however, from the perspective of patients with ureteral stones, it would be the ultimate goal to achieve a stone-free state as soon as possible once the therapeutic approach has been started. Peschel et al. [6] also emphasized the importance of the early achievement of a stone-free state even in patients who were free of symptoms considering the awareness of residual stone fragments, such as the fear of colic, and the associated restriction of daily activity. Furthermore, the majority of patients with residual stones larger than 4 mm after an initial USL could be successfully treated by an additional ESWL performed immediately after the detection of residual stones. Collectively, these findings suggest that the therapeutic strategy used at our institution could be an attractive approach for patients with ureteral stones.

In this series, the complete removal of ureteral stones after an initial USL was significantly associated with a history of ureteral stone, severity of clinical symptoms, number of stones, localization of stones and maximal diameter of stones. This result is similar to that in several previous studies [1, 4]. To our knowledge, there are no previous studies evaluating factors associated with therapeutic outcome of USL by multivariate analysis; therefore, this may be the first study investigating factors independently affecting the therapeutic outcome of an initial USL. The severity of clinical symptoms, number of stones, localization of stones and maximal diameters of stones were identified as independent predictors of complete urinary stone removal by a single procedure of USL. These findings suggest that it would be necessary to reconsider the therapeutic strategy for patients with ureteral stones who have some of the independent risk factors identified in this study.

Here, we would like to indicate several limitations of this study. Initially, this study included patients treated over a period of 20 years. Although performed in a single institution, several changes have occurred during this interval, such as the surgeon, the device used for endoscopic manipulation and the design of ESWL, which may have influenced the outcomes. Next, ultrasonic lithotripsy has now been largely replaced by newer techniques [11] because of the limitations of this procedure, such as the lack of availability of flexible instruments; however, ultrasonic lithotripsy was primarily performed in this study. Although holmium:YAG laser is currently regarded as the new standard for USL considering its high successful treatment rate and low incidence of severe complications [12, 13], it remains controversial which type of lithotripsy should be used for ureteral stones [1, 9]. For example, Kupeli et al. [9] reported that there were no significant differences in therapeutic outcomes among electrohydraulic, ultrasonic and pneumatic lithotripsies. In addition, lithotripter technology varies between manufacturers, and outcomes obtained at different institutions are variable and machine specific, suggesting the difficulty in comparing the efficacies of different technologies. However, the reported outcomes of USL are favorable, irrespective of the kinds of energy used [1, 5–11]; therefore, if done by a skillful surgeon under suitable indications, the selection of therapeutic modalities may not have significant impact on the outcome of USL. Considering these findings, it would be necessary to perform a prospective study to more clearly characterize the role of USL in the management of ureteral stones.

In conclusion, our findings suggest that USL could be safely and effectively performed for patients with ureteral stones at all sites, and that early achievement of a stone-free state would be possible by promptly performing an additional treatment, mainly ESWL, based on the radiological finding judged 1 day after an initial USL. However, it would be necessary to investigate the efficacy of newly developed modalities for USL, such as holmium:YAG laser, for patients with risk factors associated with treatment failure following a single USL procedure used in this series, such as lack of severe clinical symptoms, localization at the proximal or mid-ureter, multiple stones and stone size greater than 1 cm.

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