ANESTHESIA FOR EXTRACORPOREAL SHOCK-WAVE LITHOTRIPSY : TEIKYO UNIVERSITY HOSPITAL EXPERIENCE USING THE THIRD GENERATION LITHOTRIPTER

Koji Kurihara, Yutaka Kamiyama, Keisuke Saito, Mitsuko Yasuda, Hisamitsu Ide, Satoru Muto, Hiroshi Okada and Shigeo Horie

The Department of Urology, Teikyo University School of Medicine

A single-board certified urologist with training and experience in anesthesiology was assigned to treat 502 patients (185 with renal stones, 317 with ureteral stones) using the Dornier Compact Delta lithotripter under general or epidural anesthesia. Data were obtained regarding stone location, stone size, shockwave use, stone-free rate, and complications. In all, 502 stones were treated with the Dornier Compact Delta lithotripter. Among renal stones, 73% were in the renal pelvis. Among ureteral stones, 60% were in the upper, 10% in the middle, and 30% in the lower ureter. Diameters of 61.8% of stones were less than 1 cm. The mean number of shocks was 3,471 at a mean power setting of 5. The stone-free rate for renal stones was 71.5%, while for ureteral stones this reached 99%. The efficiency quotient was calculated as 0.65. One patient with a renal stone developed perinephric hematoma requiring 3 units of transfusion. With a success rate higher than that reported for other lithotripters, the Dornier Compact Delta lithotripter represents a feasible treatment for urolithiasis. We stress that even in the third generation machines the lithotripsy under anesthesia can improve the treatment efficacy.

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Key words : ESWL, Kidney stone, Efficiency quotient, Stone-free rate, Ureteral stone

INTRODUCTION

Since Chaussy, et al.[1] reported success with the Dornier HM3 lithotripter in 1980, the extracorporeal shock wave lithotripsy (ESWL) has become the "gold standard" for noninvasive treatment of renal and ureteral stones. Since 1980 several newer devices with different energy sources for shock waves and different methods for imaging of calculi have become commercially available. All of these new lithotripters appear to overcome a main disadvantage of the HM3 by reducing the degree of anesthesia required or increasing portability. However, these new lithotripters showed a decreased rate of success. We studied the efficacy of treatment with the Dornier Compact Delta lithotripter in cases with operation by the same surgeon, to avoid inter-operator variability.

MATERIALS AND METHODS

From January 1, 2003 to December 31, 2005, ESWL was used to treat 502 patients with symptomatic renal and ureteral stones at a university-based tertiary care hospital by a single urologist (KK). Before initiation of treatment all stones were diagnosed radiographically by abdominal plain film (KUB), noncontrast abdominal computed tomography with 3-mm axial slices, drip-infusion pyelography, or various combination of these. Stone location and feasibility of treatment by lithotripsy were decided preoperatively at a weekly departmental conference attended by staff urologists, including a review of abdominal radiographs. Once a diagnosis of renal/ureteral calculi was made, patients were advised of their treatment options and written consent was obtained for lithotripsy.

All patients were treated using a third generation lithotripter : Dornier Compact Delta lithotripter with an electromagnetic shockwave source and a fully integrated fluoroscope.

All preoperative, operative, and postoperative data were recorded at the time of treatment and during postoperative evaluation by a single surgeon. These data subsequently were forwarded and stored in the departmental data base with File Maker Pro software (File Maker, Tokyo, Japan). Preoperative stone size and location, operative details including shockwave intensity, number of shocks used, and modality of anesthesia were recorded. During postoperative follow-up success of treatment was assessed radiographically at 1 month and 3 months after treatment according to guidelines for the evaluation of treatment with ESWL. We defined the success of treatment as a residual stone burden of less than 4 mm. Also recorded were intraoperative and/or postoperative complications.

An audit of outcome of treatment was performed within the department by a group of staff urologists not in charge of the ESWL procedures. After removal of unconfirmed data, a comparative efficiency quotient (EQ) was calculated as % stone-free/(100%＋%

retreatment + % auxiliary procedures), as reported by Denstedt et al.[2].

RESULTS

Of the 502 patients (334 male and 168 female) with renal or ureteral stones treated between January 1, 2003 and December 31, 2005, stones less than 1 cm in diameter were present in 310 patients (61.8%), while 149 patients (29.7%) had stones from 1 to 2 cm. Stones with diameters greater than 2 cm numbered 43 (8.6%), 4 of which were staghorn calculi (0.80% of all stones). Stones located in the kidney represented 36.9% of all stones, while ureteral stones accounted for 63.1%. Location and size (Table 1) were further categorized according to the classification recommended by the Japanese Urological Association[3]. The details appear in a footnote to the Table.

Table 1. Size and location of stones

	DS2	DS3	DS4	DS5	DS6	Total (%)
R1	3	3	4			10 (1.9)
R2	6	55	48	18	8	135 (26.9)
R3	1	12	20	4	3	40 (8.0)
U1	20	110	53	5	1	189 (37.6)
U2	2	21	6	1		30 (6.0)
U3	22	55	18	3		98 (20.0)
Total	54	256	149	31	12	502

Stone location: R1, renal calyceal diverticulum; R2, renal pelvis; R3, ureteropelvic junction; U1, upper ureter; U2, middle ureter; U3, lower ureter. Stone size: DS2, ≤4 mm; DS3, 4 mm< ≤10 mm; DS4, 10 mm< ≤20 mm; DS5, 20 mm< ≤30 mm; DS5, 30 mm<.

In treating patients with the Dornier Compact Delta lithotripter, the supine position was used in the vast majority of cases. General anesthesia with midazolam (Astellas, Tokyo, Japan) was used in 70% of patients. The remaining 30% were treated with epidural anesthesia with or without intravenous analgesia, or both in some combination. Stone presence and location subsequently were confirmed fluoroscopically on the lithotripter table. The mean number of shocks used was 3,471, at a mean shockwave intensity of 5 (maximum 6).

Among all 502 patients, 91.4% (459) completed standard aftercare consisting of follow-up clinical examinations and post-ESWL imaging (CT or KUB) at 1 month and 3 months after treatment. Patients not stone-free whose remaining fragments were less than 4 mm were considered to have experienced treatment failure. These patients subsequently were retreated with ESWL and/or managed with alternative procedures including percutaneous nephrolithotripsy (PNL) or transurethral uerterolithotripsy (TUL). No patients underwent open procedures such as nephrolithotomy or ureterolithotomy.

Of the 459 patients who completed aftercare, 385 (83.9%) were stone free and 55 (12.0%) exhibited stone fragments measuring less than 4 mm, accounting to a total success rate of 95.9%. Further analysis of total success based on stone location and size (Table 2, 3) indicated greater success with stones measuring less than

Table 2. Fragmentation after 3 months according to stone location, based on total stones

DL	Stone-free percentage	Fragments 0 to 4 mm (percentage total success)	Fragments exceeding 4.1 mm	No fragmentation	Total
R1	5 (50)	8 (80.0)		2	10
R2	78 (64.5)	112 (92.6)	6	3	121
R3	25 (69.4)	31 (86.1)	4	1	36
U1	163 (94.2)	173 (100)			173
U2	24 (92.3)	26 (100)			26
U3	90 (96.8)	90 (96.8)	3		93
Total	385 (83.9)	440 (95.9)	13	6	459

Stone location: R1, renal calyceal diverticulum; R2, renal pelvis; R3, ureteropelvic junction; U1, upper ureter; U2, middle ureter; U3, lower ureter.

Table 3. Fragmentation after 3 months according to stone size, based on total stones

DS	Stone-free percentage	Fragments 0 to 4 mm (percentage total success)	Fragments exceeding 4.1 mm	No fragmentation	Total
DS2	46 (90.2)	51 (100)			51
DS3	212 (89.8)	228 (96.6)	4	4	236
DS4	107 (79.9)	130 (97.0)	3	1	134
DS5	18 (66.7)	23 (85.2)	4		27
DS6	2 (18.2)	8 (72.7)	2	1	11
Total	385 (83.9)	440 (95.9)	13	6	459

Stone size: DS2, ≤4 mm; DS3, 4 mm< ≤10 mm; DS4, 10 mm< ≤20 mm; DS5, 20 mm< ≤30 mm; DS5, 30 mm<.

Table 4. Comparison of studies

Model of lithotripter	Reference	Patients (n)	Overall stone-free rate	EQ
Dornier HM3	Drach et al.[6]	1,840	77	0.67
Modulith SL20	Liston et al.[12]	500	78	0.57
Lithostar C	Mobley et al.[13]	19,962	76	0.64
Medstone STS	Cass[11]	2,934	72	0.67
Econolith	Simon[14]	500	75	0.56
Dornier Doli S	Nakada et al.[15]	270	74	0.65
Dornier Delta	White et al.[5]	4,621	59	0.51
Dornier Compact Delta	Nabi et al.[8]	137*	82	0.53
Dornier Compact Delta	Present study	502	83.9	0.65

EQ, efficiency quotient ; * patients with ureteral calculi.

2 cm (total success rate, 97.1%). Irrespective of size ureteral stones fragmented more readily than renal stones (99.0% vs 90.4% ; Table 2). Retreatment with ESWL and/or alternative treatments were recommended for all 19 patients who exhibited treatment failure and/or symptoms from residual stones. Postprocedure interventions were carried out in 19 patients (4.1% of total group), all initially being retreated with lithotripsy. However, 10 of the patients eventually were treated with TUL while 3 patients (all with staghorn calculi) successfully underwent PNL. Treatment complications from ESWL were rare, but one perinephric hematoma developed that required transfusion of three units of blood. No complications, including ureteral injuries which required surgical interventions, from ESWL of ureteral stones were noted. Using these data for calculation, EQ yield a value of 0.65 (Table 4).

DISCUSSION

The Dornier HM3 lithotripter[4], now established as the gold standard against which all other commercially available lithotripters are measured, was introduced in 1984. Since then, use of shockwave has become central to the treatment strategy for ureteral and renal calculi used by urologists in Japan. Subsequent lithotripters have been developed to vary shockwave source and power, and to enhance portability, safety, and ease of use. Although each newer lithotripter may have some advantages over the HM3, these advances are offset to some degree by reduced efficacy in most cases[5]. Urologists must weigh the benefits of new enhanced features lowering cost and enhancing flexibility of use against the risk of decreased total success[5].

Numerous studies have examined the performance of commercially available lithotripters in comparison with the HM3. A large series reported in 1986 by the United States Cooperative Study, found a stone-free rate of 77.4% for the HM3 and also confirmed a retreatment rate of 16% and a post-ESWL procedure rate of 8%[6]. We presently examined the success rate with the Dornier Compact Delta lithotripter in 502 cases, representing the largest series ever reported for this specific device. Stone-free rates in previous reports varied from 59% to 82% with an E.Q. ranging from 0.51 to 0.67. Our stone-free rate (83.9%) was the highest ever reported among the series including more than 100 patients. This success led to a decrease in the retreatment rate and suggested that the ESWL with the Dornier Compact Delta lithotripter could be the procedure of choice for monotherapy of urolithiasis (Table 4).

Using the Dornier Delta lithotripter, including the same shock wave generator used in this study, White et al.[5] obtained an overall stone-free rate of 59%. In the study, ureteral stones accounted for 25.62% of the cases, while the percentage of ureteral stones in our study was 63.1%. We found that ureteral stones could be fragmented more readily regardless of stone size or location ; the difference in proportion of ureteral stones thus could explain the difference in stone-free rate. Lalak et al.[7] and by Nabi et al.[8] reported a stone-free rate after treatment of ureteral stones using the Dornier Compact Delta lithotripter of 79% and 82%, respectively. Our stone-free rate after treating ureteral stones was 99.0%. Nabi, et al. basically used sedo-analgesia for ESWL and we used general or epidural anesthesia. The mean number of shockwaves in their series was 2,400 at mean power setting of 4, but 3,471 shockwaves at mean power setting of 5 were used in our series. The better stone-free rate could be attributed to intensity and number of shocks. Since we chose general anesthesia in most patients, we could apply stronger and more numerous shocks.

Advances in lithotripter technology, including the shockwave source, the focusing element, the coupling device, and the calculus-imaging unit have been reported to equally influence the effectiveness of a lithotripter[9]. We add that the type of anesthesia chosen could influence the stone-free rate following ESWL. Few investigators have compared the type of anesthesia with the outcome of ESWL. Sorensen, et al.[10] demonstrated that for single or upper ureteral stones less than 2 cm, a significantly higher 3-month stone-free rate was achieved when general anesthesia was used instead of intravenous sedation.

Although we obtained a good clinical outcome with the Dornier Compact Delta lithotripter, some certain study conditions and limitations should be noted. First, we assigned a single-board certified urologist who also was an experienced anesthesiologist to perform these procedures. Such rare combined qualifications would be uncommon among urologists in general. Second, we did not analyze the success of fragmentation according to composition of the stone. Despite these drawbacks, our study provided useful objective data appropriate for comparison of effectiveness between commercially available lithotripters, and reminds us of the importance of anesthesia in the era of third generation ESWLs.

CONCLUSIONS

The Dornier Compact Delta lithotripter is effective in treating ureteral and renal calculi. We can stress that even with the third generation machines, lithotripsy performed under anesthesia can improve the treatment efficacy.

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和文抄録

SWL と麻酔：帝京大学医学部附属病院での第 3 世代 Lithotripter の使用経験

栗原　浩司，上山　　裕，斉藤　恵介，安田　弥子
井手　久満，武藤　　智，岡田　　弘，堀江　重郎
帝京大学医学部泌尿器科学教室

目的：Dornier Compact Delta lithotripter の腎および尿管結石に関する有用性に関する報告は少ない．われわれは尿路結石に対する Dornier Compact Delta lithotripter の有用性を検討した．

方法：泌尿器科専門医で麻酔科専門医である 1 人の医師（KK）が502例の尿路結石患者（腎結石185例，尿管結石317例）を全身麻酔ないしは硬膜外麻酔下に，Dornier Compact Delta lithotripter で結石破砕を行った成績を，結石存在部位・使用衝撃波数・stone free rate・副作用について検討した．

結果：腎結石の73％は腎盂に存在した．尿管結石は60％が上部尿管に10％が中部尿管に30％が下部尿管に存在した．結石径は61. 8％が 1 cm 未満であった．平均使用衝撃波数は3, 471発衝撃波強度は 5 であった．Overall stone free rate は83. 9％であった．腎結石の stone free rate は71. 5％であり，尿管結石の stone free rate は99％であった．Efficiency quotient は0. 65であった．副作用は腎結石患者で腎周囲血腫を生じ，3 単位の輸血を必要とした．

結論：Dornier Compact Delta lithotripter は，他の破砕器と比較して尿路結石の治療に有用であると考えられた．また，本論文の結果は，第 3 世代の lithotripter を用いた場合でも，麻酔下に破砕を行うことの意義を再認識させるものであった．

（泌尿紀要 **53**：545-549，2007）