Pain Perception During Shock Wave Lithotripsy: Does It Correlate With Patient and Stone Characteristics?

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Background: To investigate the correlation of various clinical parameters [number of shock wave lithotripsy (SWL) sessions, body mass index, patient age, gender, and stone characteristics] with pain perception during the SWL procedure.

Methods: A total of 88 patients who underwent 165 SWL sessions for renal or ureteral stones in our institution were included in the study. The degree of pain perception during the procedure was evaluated with a 10-point visual analog scale.

Results: A significant *p* value was reached when the cut-off value for stone burden was taken as 100 mm^2. Mean pain scores during the SWL procedures were affected by gender and the number of SWL sessions. However, they were not affected by laterality, patient age, body mass index, and location of stones.

Conclusion: Our results suggest that patient comfort is better during the first SWL session than in the following sessions for renal or ureteral stones with a stone burden of less than 100 mm^2. In addition, severity of pain during SWL treatment may be better tolerated in males than in females. [*J Chin Med Assoc* 2010;73(9):477–482]

Key Words: body mass, gender, lithotripsy, pain, urinary stones

Introduction

Shock wave lithotripsy (SWL) has become a routine procedure for the treatment of urinary stones. Analgesic requirements during the procedure have significantly decreased with the additional development of SWL technology. However, pain perception received during SWL is a multidimensional concept and may be affected by various factors including a wide variety of medical conditions. In addition, psychosocial factors such as expectations, emotions, and an individual's unique learning history may result in a variety of pain perceptions. Biological variables, including hormonal status and cardiovascular reactivity, may add further differences.[1–3] Given these multiple sources of variability, it is difficult to differentiate individual variation. Therefore, the evaluation of pain perception remains relatively subjective.

Considering urinary stone formers, patients are somehow experienced in coping with the renal colic type of pain (as approximately 50% of all the patients who had urinary stones expect recurrent stone formation, suggesting that they are able to identify nascent renal colic types of pain).[4,5] From the patient's perspective, pain perception during SWL is a stressful condition, and even affects the success of the procedure (involuntary movement of the patient as a reaction to pain during the procedure can make it difficult to focus on the stone).

This study aimed to evaluate the correlation of various clinical parameters [number of SWL sessions, body mass index (BMI), patient age, gender, and stone

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characteristics] with pain perception during the SWL procedure.

Methods

We prospectively evaluated a total of 88 patients (165 sessions) who underwent SWL for urinary stones. Before the procedure, we evaluated urinalysis, urine culture, coagulation profile, serum creatinine levels, and excretory urography. Exclusion criteria were signs and symptoms of urinary tract infection, pregnancy, moderate to severe hydronephrosis, renal insufficiency with serum creatinine > 2.0 mg/dL, and multiple bladder and/or radiolucent stones. Patients who received auxiliary procedures, such as percutaneous nephrostomy/double-J catheter insertion or endoscopic treatment before the first session of SWL and during the period between SWL sessions, were also excluded.

Using the same technician under the supervision of a urologist, all patients underwent 1–3 sessions of SWL using the EMD E-1000 lithotripter (EMD Medical, Turkey), an electrohydraulic unit that permits the use of X-ray for stone focusing. All the patients were given pain therapy with diclofenac sodium (Dikloron; Deva Medical, Turkey) 1 mg/kg intramuscularly, 5 minutes before the SWL session. Patients were previously informed not to use oral and/or intravenous/intramuscular analgesics at least 3 days before the procedure.

Between SWL sessions, radiographic investigations included radiographs of the kidney, bladder and ureter, and ultrasonography. Excretory urography was carried out if kidney, bladder and ureter examination, and ultrasonography were uncertain. All parameters related to stone characteristics (stone location, side, and burden) were determined by an experienced uroradiologist.

Before the procedure, patient data including age, gender, weight, and height were collected. The BMI was calculated for each patient by dividing weight in kg by height in m^2. The stone burden was calculated by multiplying the largest length of the stone by the shortest perpendicular length and was recorded in mm^2.

The number of shock waves (× 2,500) delivered to each patient and energy (13–19 kilovolts with a constant gradual increase) used in each SWL session were the same for all patients. The duration between each SWL session was 2 weeks. Otherwise, the patient was excluded from the study.

Immediately after the procedure, the degree of pain perception was rated by the patients using a 10-point visual analog scale (VAS).

For statistical analyses, SPSS version 11.5 (SPSS Inc., Chicago, IL, USA) was used. Results are expressed as mean ± standard deviation. Correlations of parameters with VAS scores were assessed with linear regression analysis. Differences in mean VAS scores in each parameter were assessed with the Mann-Whitney U and Kruskal-Wallis tests. Patients and stone characteristics between the first, second, and third SWL session groups were compared with 1-way analysis of variance and χ^2 tests. A 2-tailed p value of < 0.05 was accepted as statistically significant.

Results

Demographic data and patients' characteristics are shown in Table 1. Patients (age, weight, height, BMI, and gender) and stone (location, side, and burden) characteristics were comparable between all (first, second and third) SWL session groups (Table 2).

No statistically significant correlation was found between VAS (pain) scores and BMI or patient age. With regard to SWL session and stone burden, statistically significant correlations were demonstrated (Table 3).

Table 1. Patient and stone characteristics ($n = 88$)*

Age (yr)	46.04 ± 16.3
Weight (kg)	75.4 ± 12.02
Height (cm)	167.79 ± 6.02
BMI (kg/m^2)	26.79 ± 4.22
Stone burden (mm^2)	101.88 ± 76.84 (range, 25–400)
Gender	
Female	33 (37.5)
Male	55 (62.5)
Side of stone	
Right	39 (44.3)
Left	49 (55.7)
Pre-SWL stone location	
Renal pelvis	36 (40.9)
Calyceal system	20 (22.7)
Upper	11 (12.5)
Middle	1 (1.1)
Lower	8 (9.1)
Ureter	32 (36.4)
Upper	17 (19.3)
Middle	9 (10.2)
Lower	6 (6.8)

*Data presented as mean ± standard deviation or n (%). BMI = body mass index; SWL = shock wave lithotripsy.

Table 2. Patients and stone characteristics for first, second, and third SWL session groups*

	First session ($n=70$)	Second session ($n=53$)	Third session ($n=42$)	p
Age (yr)	46.37 ± 16.00	47.39 ± 15.54	48.52 ± 17.37	0.791†
Weight (kg)	75.48 ± 11.78	77.60 ± 13.73	75.28 ± 11.69	0.570†
Height (cm)	167.44 ± 5.90	167.53 ± 6.37	167.43 ± 7.30	0.996†
BMI (kg/m^2)	26.92 ± 4.11	27.67 ± 4.77	26.88 ± 3.84	0.561†
Stone burden (mm^2)	112.13 ± 90.10	97.50 ± 84.28	80.54 ± 62.92	0.144†
Gender (female/male)	29 (41.4)/41 (58.6)	22 (41.5)/31 (58.5)	20 (47.6)/22 (52.4)	0.785‡
Side of stone (right/left)	35 (50)/35 (50)	23 (43.4)/30 (56.6)	21 (50)/21 (50)	0.730‡
Pre-SWL stone location				0.879‡
Renal pelvis	32 (45.7)	20 (37.7)	17 (40.5)	
Calyceal system	17 (24.3)	15 (28.3)	13 (31.0)	
Ureter	21 (30.0)	18 (34.0)	12 (28.5)	

Values are presented as mean ± standard deviation or n (%); †1-way analysis of variance; ‡χ^2 test. SWL = shock wave lithotripsy; BMI = body mass index.

Table 3. Correlation of variables with mean visual analog scale scores

Variables	Correlation coefficient	p*
Age	–0.057	0.460
Weight	–0.003	0.995
Height	–0.014	0.953
BMI	0.107	0.810
SWL session	0.251	0.001
Stone burden	0.197	0.014

Linear regression analysis. BMI = body mass index; SWL = shock wave lithotripsy.

A significant p value was reached when a cut-off value for stone burden was taken as 100 mm^2 (Table 4). Mean stone burden was significantly higher in renal stones [115.7 ± 90.44 mm^2 (range, 25–400)] than in ureteral stones [63.13 ± 25.76 mm^2 (range, 25–132); $p<0.001$, Mann Whitney U test]. However, mean pain scores were similar between the 2 groups ($p=0.694$, Kruskal-Wallis test; Table 4).

The pain score during the SWL procedures was not affected by laterality, patient age, BMI, or the location of the stone. Statistically significant differences were observed between mean pain scores of the first and second or third session groups ($p=0.043$; Table 4). When we compared the mean pain scores of the first, second and third sessions of SWL treatment in each case ($n=27$), we also observed statistically significant difference between the first and second/third session groups ($p=0.008$ and $p=0.020$, respectively, Mann Whitney U test). Mean VAS scores for this selected group of patients were 4.29 ± 1.78 (first session), 5.62 ± 1.41 (second session) and 5.48 ± 1.29 (third session) ($p=0.004$, Kruskal-Wallis test). Mean pain scores were significantly higher in females compared with males ($p=0.002$; Table 4).

Table 4. Descriptive statistics for SWL session, BMI, gender, and stone characteristics

Variables	VAS score (mean ± SD)	p
SWL session		
First ($n=70$)	4.67 ± 1.97	0.043*
Second ($n=53$)	5.50 ± 1.29‡	
Third ($n=42$)	5.47 ± 1.15§	
BMI (kg/m^2)		
< 30	5.03 ± 1.7	0.058†
≥ 30	5.55 ± 1.27	
Gender		
Female	5.59 ± 1.51	0.002†
Male	4.8 ± 1.64	
Stone location		
Renal pelvis	5.18 ± 1.86	0.694*
Calyceal system	5.24 ± 1.52	
Ureter	5.01 ± 1.41	
Stone burden (mm^2)		
≤ 100	4.9 ± 1.62	0.005†
> 100	6.12 ± 1.3	
Side of stone (laterality)		
Right	5.07 ± 1.68	0.989*
Left	5.2 ± 1.6	

Kruskal-Wallis test; †Mann-Whitney U test; ‡$p=0.032$ vs. first SWL session, Mann-Whitney U test; §$p=0.043$ vs. first SWL session, Mann-Whitney U test. SWL = shock wave lithotripsy; BMI = body mass index; VAS = visual analog scale; SD = standard deviation.

During the follow-up period, no major complications such as bleeding were encountered, and none of the patients required an inpatient stay after SWL.

Discussion

Currently, SWL is accepted as a less invasive approach and most guidelines recommend it as the first-line treatment if the location and size of the calculi are appropriate for spontaneous passage of fragmented particles.[6] In contrast to surgery, SWL can also be performed with intramuscular or intravenous injection of analgesics. However, multiple sessions may be necessary to provide a stone-free status or significant fragmentation. Unfortunately, these extra visits to SWL centers can affect the psychological, functional, social, and economic life of the patients.[7] Shock wave-related pain is one of the most significant side effects of SWL. Therefore, proper pain management to ensure success and patient satisfaction is essential. A relaxed, cooperative patient during treatment is paramount in maintaining stone targeting for optimal fragmentation. Therefore, it is essential to choose an appropriate analgesic with minimal adverse effects. Despite reports of various studies comparing different analgesic techniques during SWL,[8–10] guidelines for pain management during the procedure have not been established. In clinical practice, diclofenac sodium is accepted as an effective analgesic with lower side effects than opioids, especially with regard to hemodynamic instability and respiratory depression. However, it is associated with mild gastrointestinal disturbances and occasional hypersensitivity reactions.[11] We prefer to use intramuscular diclofenac sodium as an analgesic during the procedure. No side effect related to the drug was observed in our study population. However, diclofenac sodium does not seem to be the ideal choice, because in the current study, mean pain scores ranged from 4 to 6 (Table 4). Moderate pain relief and patient comfort were achieved with diclofenac sodium during the SWL procedure.

Patients feel pain during SWL because of the direct effects of shock waves on cutaneous pain receptors, the renal capsule, and neighboring organs which have an abundant nerve supply, such as the 12th rib. In 2006, Yilmaz et al[12] compared the efficacy of subcutaneous prilocaine with intramuscular diclofenac sodium, and showed that local prilocaine infiltration alone could be used for analgesic purposes during SWL for renal stones. They achieved the best results with 20 mL-injection.[13] Therefore, the use of local infiltrative agents such as prilocaine or lidocaine, administration of topical agents such as EMLA (eutectic mixture of local anesthetics) or dimethyl sulfoxide cream, may relieve musculoskeletal pain.[8,9,14] Thus, combined use of diclofenac sodium and topical agents, or pretreatment with other nonsteroidal anti-inflammatory drugs such as rofecoxib,[15] may provide extra patient comfort, especially for stones larger than 10 mm. Kumar et al[16] have already investigated combined pain therapy, and reported that a combination of diclofenac and EMLA cream provided significantly greater analgesia than diclofenac or EMLA alone.

The type of SWL machine can also affect the pain perception of patients during lithotripsy. Recently, Aksoy et al[17] compared the effectiveness and safety of the second-generation electrohydraulic-based Dornier MPL 9000 (Dornier Medical Systems, Munich, Germany) and the third-generation electromagnetic-based Siemens Lithostar Modularis (Siemens AG, Munich, Germany) for the treatment of pediatric stone disease. The third-generation device allowed intravenous sedoanalgesia in all of the cases; however, with the second-generation device, intravenous sedoanalgesia was sufficient in only 39.9% of children. De Sio et al[18] evaluated the pain tolerability in SWL sessions with a relatively newer machine, and nearly half of the cases scored their pain on a VAS as 4 or 5. They reported that ketorolac was administered in selected cases. The scores in this previous study were comparable with our mean VAS scores. It is possible that lithotripters with less energy may cause less pain perception during a SWL procedure but produce lower success rates.[19]

In our study, the pain score during the SWL procedures was not affected by laterality, patient age, location of stones, or BMI. To our knowledge, few data are available that have analyzed the influence of these parameters on pain perception during SWL.[20,21] Initially, Franceschi et al[20] evaluated possible predictive factors for severe pain leading to an indication for analgesia during SWL and concluded that pain received during SWL could not be predicted by age, anxiety state, side of the stones and size, or diameter of the contact between the patient and convergence dome of the lithotripter. In contrast, they observed that the size and location of the stone were correlated with the pain level. In addition, they found that the superior caliceal, middle caliceal, and pelvic stones were the most painful calculi. We observed a significant decrease in pain perception, especially when the stone burden was lower than 100 mm^2 (nearly accounts for a 10 mm stone). However, in our study, we found that the location of the stone was not a significant parameter for pain perception during SWL. Although the mean stone burden for ureteral stones was lower than 100 mm^2 (63 mm^2), mean pain scores were similar between renal and ureteral stones. Therefore, pain scores seem to be affected by size rather than location. We believe that this result could be coincidental. Although the p value was significant, the correlation coefficient for stone burden was 0.176, suggesting a mild correlation (Table 3). Prospective randomized trials with a larger study population may give more conclusive data. In a study by Oh et al,[21] the subjective pain score was not affected by laterality or size of the stone, but it was affected by patient age, gender, and location of the stone. We observed that severity of pain was significantly lower in males than in females and in patients who underwent the first session of the SWL procedure. Several studies have been published that evaluated sex differences in pain.[2,22,23] Fillingim and Maixner[2] reviewed a sample of experimental pain studies and concluded that women exhibit a lower pain threshold and tolerance than those in men. A consensus has been reached that there are important sex differences in pain, but that these differences are currently poorly understood. Therefore, a greater pain sensitivity among women, mediated by sociocultural, psychological, and biological/hormonal factors, may have caused the significant pain score difference in our study.

Mean pain scores were significantly different when compared between patients who underwent the first and second, or first and third SWL sessions. We hypothesize that the second and third sessions exert an extra anxiety on the patient, because the patient becomes more experienced about the shock wave-related pain. Therefore, the first SWL sessions seem to be better tolerated by patients.

Potential limitations to our study should be considered. First, the visual analog scale is an easy, commonly used, but subjective method in the evaluation of pain perception. Second, the cause of pain is multifactorial in nature and we were unable to discriminate renal capsular pain and pain caused by movement of stones during SWL from cutaneous or costal pain (for renal stones). Third, pain itself is a very subjective phenomenon. For the same type of intervention, the degree of pain experienced varies from patient to patient, and can be affected by many factors such as age, personality, education, social status, patient knowledge, and the degree of understanding about the intervention.[24,25] Even ethnic differences have been documented.[26] Thus, some of our patients might have been more sensitive to pain and probably tended to give higher VAS scores.

In conclusion, our results show that pain perception during the SWL procedure does not correlate with patient age, BMI, laterality, or location of the stone. However, during a SWL session for renal or ureteral stones with a stone burden of less than 100 mm^2, a decreased pain perception was observed. However, this result could be coincidental. The first session in a SWL treatment is significantly less painful than the following treatments, and the severity of pain may be better tolerated in males than in females.

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