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Original Article

Comparison of the results of shock wave lithotripsy with ultrasonic and fluoroscopic focus in pediatric age group; Fluoroscopic focusing how much is needed?

Fatih Ozkaya

Ataturk University, Faculty of Medicine, Department of Urology, Erzurum, Turkey

Abstract

Aim: Shock wave lithotripsy (SWL) is a well-known technique used in the treatment of kidney stones since the early eighties. For successful SWL, accurate visualization of the shock waves is performed by ultrasound (US) or fluoroscope (FS) to fully focus the shock waves on the stone. In this study, we aimed to investigate the effect of US and FS methods used for focusing on stone in SWL treatment of renal stones in pediatric patients on side effect and treatment success.

Material and Methods: Between January 2008 and January 2018, 495 children under 16 years of age who were treated with SWL using ultrasonic and fluoroscopic focusing were included in the study. Patients with fluoroscopic focus were classified as Group 1 and patients with ultrasonic focus were classified as Group 2. Demographic data, SWL parameters and success rates of the two groups were compared..

Results: There was no significant difference between the demographic data, stone localization and stone sizes of the groups. SWL success rate was 90.5% in group 1 and 92.3% in group 2. There was no significant difference between the two groups in terms of success (p = 0.474). Complication rates were 0.2% (1 patient) and 0.4% (2 patients) in groups 1 and 2, respectively, and there was no statistically significant difference (p = 0.495). With increasing clinical experience, ultrasonic focusing rates have increased and fluoroscopic focusing rates have decreased over the years.

Conclusion: In the pediatric age group, we recommend the use of ultrasonic focusing with the additional advantage of avoiding radiation, avoiding the fluoroscopic focusing method using ionized radiation for SWL. We believe that randomized prospective studies will be more informative and support our study.

Keywords: Shockwave; lithotripsy; focus; ultrasonic; fluoroscopic; kidney stone.

INTRODUCTION

Urinary system stone disease (USSD) is a rare condition in childhood. The disease is more common in under-developed and developing countries despite the prevalence of 2-3% in developed countries (1). The prevalence of USSD is reported to increase in children under 15 years of age (2). It has become a great health problem due to high morbidity and recurrence rates.

Shock wave lithotripsy (SWL) is a well-known technique, which is used for treatment of kidney stones since the beginning of 1980s (3). Currently, minimally invasive endoscopic procedures such as ureteroscopy or percutaneous nephrolithotomy tend to be used for treatment of renal or pelvic stones. On the other hand, SWL continues to be one of the treatment options for kidney stones <20 mm (4). Shock wave lithotripsy has a low complication rate and it does not require general anesthesia. The success rate is associated with the treatment protocol and the experience of the operator beside the patient and stone related factors (5-10).

A correct focusing of the stone is done through ultrasonography (US) or fluoroscopy (FS) for a successful SWL. Radio-opaque stones in the kidney or at the uretero-pelvic (UP) junction may usually be imaged both with US and FS. To the best of our knowledge, no studies are available in the literature comparing the ultrasonic and fluoroscopic methods in the treatment of kidney stones with SWL in the pediatric age group.

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Corresponding Author: Fatih Ozkaya , Ataturk University, Faculty of Medicine, Department of Urology, Erzurum, Turkey
E-mail: drfatihm@gmail.com

The present study was conducted with the aim of investigating the side effects of US and FS, which are used for focusing the stone in SWL treatment for kidney stones in pediatric patients and its influence on the treatment success.

MATERIAL and METHODS

A total of 495 patients were included in the study. While Group 1 included a total of 262 patients (154 boys and 108 girls), Group 2 included 233 patients (139 boys and 94 girls). More than 2500 SWL procedures were performed at the SWL Unit of the Urology Clinic, Atatürk University Medical School during the recent 10 years. A total of 496 children below 16 years of age were treated using the Siemens Lithostar Litotriptor (Germany®), which works with an electro-magnetic principle, with both ultrasonic and fluoroscopic focusing methods between January 2008 and January 2018. This age group comprised approximately 10% of all patients treated with SWL at our clinic. We used organ protectors in group 1. The patient records were evaluated retrospectively. In Patients for whom fluoroscopic focusing had been used were allocated to Group 1 and those for whom ultrasonic focusing had been used was allocated to Group 2. The stone size limit for SWL was 5-20 mm.

The patients were evaluated with medical history, physical examination, urinary examination, urine culture, serum creatinine and blood urea nitrogen (BUN) measurements. Diagnosis was made with direct urinary system graphy (DUSG), ultrasonography (USG), intra-venous urography (IVU) and/or reduced-dose non-contrast-mediated computed tomography (CT).

Stones were located at the upper pole in 47 (16.6%) patients, middle pole/pelvis in 185 (65.4%) patients and at the inferior pole in 51 (18%) patients. The stone load was calculated and classified with measurement of the long axis of the stone.

The exclusion criteria were as follows: Uncorrected hemorrhagic diathesis, ureteral stones, renal failure, uretero-pelvic junction obstruction and uretero-vesical (UV) obstruction. Shock wave lithotripsy was performed after proper anti-microbial treatment in the presence of urinary tract infection. These patients also continued to receive prophylactic antibiotic treatment beginning at the previous day before the procedure and continued during the following 3 days after the procedure.

The shock wave lithotripsy procedure was performed under sedo-analgesia in all children. While sedo-analgesia was provided with penthotal sodium 3-4 mg/kg and fentanyl 1-2 microgram/kg in children below 5 years of age, propofol 1-2 mg/kg and fentanyl 1-2 microgram/kg were used for children above 5 years of age. No patients required intubation or laryngeal mask.

Shock waves were created with 14 kV-20 kV energy for the procedure and the energy was gradually increased. The mean energy was 18 kV. The mean number of shock waves varied between 60-80 beats per minute and the total number of beats was on average 2530.5 beats during the procedure. The number of sessions that were performed with 2-3 week of intervals was 1-3. All patients were monitored for 2 hours after the procedure.

Shock wave lithotripsy was applied after insertion of a double J (DJ) ureteral stent in patients who had advanced hydronephrosis, solitary kidney or stones larger than 15 mm in diameter. Fragmentation was evaluated with DUSG and USG one week after the sessions. Radiolucent stones were detected with low dose non-contrast-mediated tomography in patients who had non-radio-opaque stones, but who were detected to have dilation on USG. The procedure was repeated 2 weeks later in the presence of fragments 5 mm or larger in diameter. All patients were evaluated 3 months after the last SWL. Absence of fragments or presence of clinically insignificant stones smaller than 4 mm after the sessions was accepted as success. Inability to obtain fragmented stones after 3 sessions of SWL was accepted as failure.

The data were analyzed using the SPSS 25.0 package program and the descriptive statistics were given as number and percent distributions. The inter-group comparisons were made using the chi-square test and a p level of <0.05 was accepted as statistically significant.

RESULTS

The mean age of the patients was 7.1 (1-16) and 8.6 (1-16) years, respectively in Group 1 and Group 2. The mean diameter of the stones was 8.73 and 8.9 mm, respectively in Group 1 and Group 2(p=0.208).

The locations of the stones were different between the groups, although not statistically significant (p=0.19). While the stone was on the right in 148 (29.9%) patients and on the left in 114 (23%) patients in Group 1, it was on the right in 134 (27.1%) patients and on the left in 99 (20%) patients in Group 2 (p=0.819). A total of 94 patients had a radio-opaque stone and ultrasonic focusing was used in all of these patients and fluoroscopic focusing was not used. The shock wave frequency, the shock wave number and the energy protocol were the same in both groups due to the standard study protocol in SWL procedures applied to pediatric patients in our clinic. Data regarding the demographic characteristics of the patients, stone size, stone location, SWL protocol and clinical data have been summarized in Table 1.

While the success rate was 90.5% in Group 1, it was 92.3% in Group 2 and no statistically significant difference was observed between the groups (p=0.474). The complication rate was 0.2% (1 patient) and 0.4% (2 patients) in Group 1 and 2, respectively, and there was no statistically significant difference between the groups (p=0.495).

The distribution of both methods used in SWL according to years has been summarized in Figure 1. The rate of ultrasonic focusing was observed to increase and that of fluoroscopic focusing was observed to decrease over years.

Table 1. Summary of Study

	Group 1 (n=262)	Group 2 (n=233)	Statictical Analysis (p)
		Demographic Data	
Age (year, mean)	7.1 (1-16)	8.6 (1-16)	
Sex (n,%)			
Male	154 (%31.1)	139 (%28)	0.843
Female	108 (%21.8)	94 (%19.1)	
		Factors Affecting SWL	
Stone Size (mm, mean)	8.73±3.98	8.9±3.66	0.208
5-9 (mm)	154 (%31.1)	112 (%22.6)	
10-15 (mm)	102 (%20.6)	112 (%22.6)	0.049*
>15 (mm)	6 (%1.2)	9 (%1.8)	
Stone Localization (n,%)			0.19
Upper pole	54 (% 10.9)	45 (% 9.1)	
Middle pole, pelvis	178 (% 36)	148 (% 29.9)	0.819
Lower pole	30 (% 6.1)	40 (% 8.1)	
Side (n,%)			
Right	148 (% 29.9)	134 (% 27.1)	
Left	114 (% 23)	99 (% 20)	
Opacity (n,%)			
Opaque	168 (% 33.9)	233 (%47.2)	0.000*
Non-opaque	94 (%19)	0 (% 0)	
		Parameters of SWL	
Shock wave frequency		60-80/min	
Number of shock waves (average beat)		2530,5	
Average Energy (kV)		18	
Average Fluoroscopy Time (sec)	0	61	0.000*
		Clinical Results	
Success, stone-free (n,%)	237/262 (%90.5)	215/233 (% 92.3)	0.474
Complication (n,%)	1 (%0.2)	2 (%0.4)	0.495

***: p<0.05 and statistically significant difference**

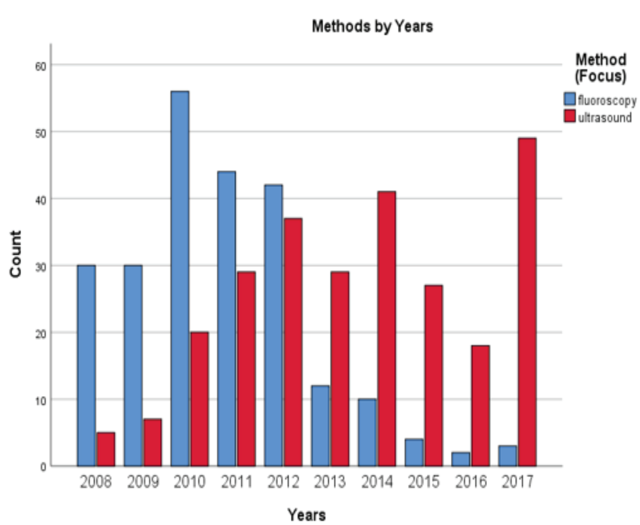

Figure 1. Number distribution of focusing methods used in SWL by years

DISCUSSION

The radio-opaque stones in the kidney and ureter may be displayed both with ultrasonography and fluoroscopy during SWL treatment. Not all urologists have an ultrasound system that could be connected to SWL machines or they are not familiar with ultrasonic focusing technique or they are inexperienced. This retrospective study was limited to kidney stones due to the difficulties in ultrasonic imaging of the ureteral stones.

An important advantage of ultrasonography is enabling real-time follow-up of the SWL procedure (11). The first study comparing the clinical outcomes of US-guided SWL and FS-guided SWL was conducted by Van Besien et al. and revealed that the former was no poorer than the latter (12). To the best of our knowledge, the present study is the first in the literature comparing both focusing methods in the pediatric age group. No difference was found between the groups with regard to the success rate of SWL and complications. Therefore, we consider that ionizing radiation is not necessary in the pediatric age group.

Not using ionizing radiation is an important advantage of ultrasonic focusing. In our study, fluoroscopy was not used in addition to ultrasonic focusing. The mean duration of fluoroscopy is 61 seconds. Although this dose is not a worrisome dose compared to other radiologic interventional procedures, we should consider the cumulative effect of ionizing radiation and furthermore, the ionizing radiation that the patient is subjected to should also be considered.

Ionizing radiation exposure of the operator is another issue to be considered (13). Radiation exposure should always be limited due to the risk of occupational cancer. This condition is much more important for patients who would be exposed to cumulative radiation during their life-time, particularly in the pediatric age group, due to the recurrent nature of USSD. When a high recurrence rate of USSD and the patients' likelihood of SWL exposure in the future are also taken into consideration, it would be better understood why ultrasonic focusing should be preferred in childhood.

A significant improvement in the success rate of using ultrasonography for the identification of kidney and proximal ureter stones was observed. The superiority of ultrasonic detection has not been demonstrated until now (14). However, with this study, we have seen that the same success rates have been achieved with fluoroscopic focusing method with the development of ultrasonic focusing method in SWL performed by the same operator.

Although the success rates of the two methods are similar, both methods have some difficulties. The use of laxatives to prevent bowel gas prior to fluoroscopy, radiation exposure, and non-focusing of non-opaque stones are weaknesses of fluoroscopic focusing. It is considered that even if stone detection with FS becomes difficult during treatment, including radiolucent stone cases, detection of fragments by ultrasonography may prevent interruption of the treatment and result in the delivery of sufficient shock waves to stones.

While 401 out of 495 children (81%) who underwent the SWL procedure in our clinic had radio-opaque stones, 94 (19%) patients had non-opaque stones. Both US and FS may be used for imaging in 4/5 of all cases. We preferred to avoid radiation by using the ultrasonic focusing.

The limitations of the study include not evaluating the components of the stones, not using the Hounsfield Unit in CT screening, not measuring the factors including the lower pole anatomy (infundibular length, width and the infundibulo-pelvic angle) and skin-to-stone distance, retrospective design of the study and not having information about the body mass index (BMI) of the patients.It is known that a higher BMI and skin-to-stone distance may have a negative effect on SWL success(15) (16). The other important limitation was operator dependent localization techniques. The operator will program the localization into the lithotriptor, decide on the frequency of adjustments during the procedure and assess the disintegration of a stone. This variability makes a direct comparison between localization techniques difficult. This study has used only one operator for both focusing methods.

CONCLUSION

In conclusion, we recommend the use of the ultrasonic focusing method in the pediatric age group, which has similar success rates, and provides an additional advantage by avoiding radiation, instead of the fluoroscopic focusing method, which uses ionizing radiation for SWL. We consider that randomized prospective studies would yield further information and support the results of our study.

Competing interests: The author declares that he has no competing interest.
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Fatih Ozkaya ORCID: 0000-0002-7776-4231

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