DOI: 10.7860/JCDR/2018/34147.11287

Original Article

Surgery Section

Clinical Value of Stone Radiodensity and Size in Predicting the Outcome of Extracorporeal Shockwave Lithotripsy in Renal Stones

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ABSTRACT

Introduction: The success rate of Extracorporeal Shockwave Lithotripsy (ESWL) depends on multiple factors. A major cause of ESWL failure is an undesirable stone composition.

Aim: The aim of this study was to evaluate the usefulness of measuring renal calculi attenuation values on unenhanced computerised tomography images as a predictor of the outcome of ESWL in patients with a single renal stone of 7-20 mm, located in the renal pelvis.

Materials and Methods: This retrospective study was conducted on 151 patients with renal stone of 7-20 mm within the renal pelvis who were referred to the Tohid Hospital, Sanandaj, Iran during the time period between May 2011 and May 2015. Patients with a single stone of 7-20 mm located in the renal pelvis were included in this study. Patients with elevated creatinine levels (more than 2 mg/dL), single kidney, obstructed kidney stones more than 20 mm and stones elsewhere in the collecting system were excluded from the study. For all patients Non-Contrast Computerised Tomography (NCCT) and ESWL was performed. Stone density, stone size and stone free rate were measured. Successful treatment of renal stones was defined as those patients who were stone free or were asymptomatic i.e., clinically insignificant residual fragments ≤4 mm in diameter, as measured by KUB X-ray and sonograhy three months after ESWL. The patients were further analysed by dividing them into six groups according to the stone density. All ESWLs were undertaken by STORZ SLK Lithotripter with fragmentation performed under fluoroscopic guidance. Data were analysed using SPSS statistical software version 18.0 and Chi-square test was also used.

Results: The results showed that the ESWL success rate in patients with small stone size and high stone radiodensity was (n=10, 52.6%), while in patients with large stone size and high stone radiodensity it was (n=4, 36.4%). There was a significant difference between the success rate of lithotripsy and stone radiodensity (p-value=0.0002).

Conclusion: The findings of the present study showed that stone radiodensity and stone size were useful parameters to predict the outcome of ESWL. We found a direct relation between the stone radiodensity and ESWL success rate. In addition, the results of our study showed that ESWL success rate in patients with small stone size (7-14 mm) was clinically remarkable. Considering these two parameters in conjunction with other stone parameters to select appropriate procedure is suggested.

Keywords: Densitometry, Kidney calculi, Treatment outcome

INTRODUCTION

Extracorporeal Shockwave Lithotripsy is the treatment of choice for most renal calculi ≤30 mm and its success rates is 60-99% [1]. ESWL was introduced in 1980 and it has revolutionized the treatment of urinary stones [2]. ESWL is a non-invasive and out patient procedure without the need for anaesthesia [3]. The failure of ESWL is imposing costs on patients and health system and also exposes them to ionizing radiation and to shock waves. To distinguish patients who would benefit from ESWL from those who need an alternative treatment is desirable [4]. The success rate of ESWL treatment depends on multiple factors including, stone size, stone location, stone composition and the presence of obstruction or infection [5]. Stone composition determination is considered as crucial for an optimal treatment algorithm [6]. The most important factor which affect the outcome of SWL is stone burden [7,8]. Data provided by NCCT is considered as new predictors of ESWL success [9]. Previous studies have reported that the consistency, size, shape, location, and attenuation value of urinary calculi measured in Hounsfield Unit (HU) density may predict success of Shock Wave Lithotripsy (SWL) as determined by the stone free rate [9-11]. Although, several factors were evaluated and reported as predictor of ESWL success, but the final report has not been concluded. Therefore, localization of above parameters could be useful to help the clinicians to decide in selecting appropriate procedure.

Hence, distinguishing those patients who would benefit from ESWL from those who need an alternative treatment is important and desirable. The aim of this study was to evaluate the usefulness of measuring renal calculi attenuation values on unenhanced computerized tomography images as a predictor of the outcome of ESWL in patients with single renal stone of 7-20 mm located in renal pelvis.

MATERIALS AND METHODS

This retrospective study was conducted on 151 patients with renal stone of 7-20 mm within renal pelvis who were referred to the Tohid hospital, Sanandaj, Iran between May 2011 and May 2015. The inclusion criteria were patients with single renal stone of 7-20 mm located in renal pelvis. Patients with elevated creatinine levels (more than 2 mg/dL), single kidney, obstructed kidney, stones more than 20 mm and stones elsewhere in the collecting system were excluded from the study. As ESWL is the preferred treatment for renal calculi of < 2 cm in diameter [7,9] therefore, patients with stones more than 20 mm were excluded from the study.

For all patients, NCCT and ESWL was performed. Stone density was assessed and reported by radiologist at the time of performing CT scan for all patients. The patients were further analysed by dividing them into six groups according to stone radiodensity and stone size as following:

Group 1: Consisted of 42 patients with attenuation value 500-700 HU and stone size of 7-14 mm;

Group 2: Consisted of 21 patients with attenuation value 700-900 HU and stone size of 7-14 mm;

Group 3: Consisted of 19 patients with attenuation value 900-1200 HU and stone size of 7-14 mm;

Group 4: Consisted of 37 patients with attenuation value 500-700 HU and size of 15-20mm;

Group 5: Consisted of 21 patients with attenuation value 700-900 HU and size of 15-20mm;

Group 6: Consisted of 11 patients with attenuation value 900-1200 HU and stone size of 15-20 mm.

In order to obtain a systematic and practical formula, these six groups were considered as "low density group", "medium density group" and "high density group" based on HU [12]. Also, we divided the patients in two groups as "small size group" and the "large size group" based on the stone diameter. The "low density group" consisted all patients with stone density less than 700 HU, the "medium density group" consisted all patients with stone density of 700-900 HU and the "high density group" consisted all patients with stone density more than 900 HU [12]. In the "small size group", stone diameters was 7-14 mm; while, the "large size group" had a diameter of 15-20 mm [Table/Fig-1].

All ESWLs were undertaken by STORZ SLK Lithotripter with fragmentation performed under fluoroscopic guidance. The relationship between HU, stone size and also the characteristics of the patients were analysed.

Group	Number of patients	Stone size (mm)	Stone radiodensity (HU)
1	42	7-14 (small)	500-700 (Low)
2	21	7-14 (small)	700-900 (Medium)
3	19	7-14 (small)	900-1200 (High)
4	37	15-20 (large)	500-700 (Low)
5	21	15-20 (large)	700-900 (Medium)
6	11	15-20 (large)	900-1200 (High)

[Table/Fig-1]: Grouping patients based on stone radiodensity and stone size.

All patients were managed without any anaesthesia or sedation. All procedures were performed using one STORZ SLK Lithotripter and by the same specialist, under fluoroscopy. Successful treatment of renal stones was defined as those patients who were stone free or who were asymptomatic, i.e., clinically insignificant residual fragments ≤4 mm in diameter, as measured by KUB X-ray and sonograhy three months after ESWL. Maximum of 4000 shocks per session were delivered to the stone at the frequency of two shocks per second and the energy power was set at 10 to 14 kV [4].

In order to meet ethical issues, the Ethics Committee Approval was obtained for this study and the informed consent was obtained from all patients.

STATISTICAL ANALYSIS

Data were analysed using SPSS statistical software version 18.0 and Chi-square test was also used.

RESULTS

The results showed that the ESWL success rate in patients with small stone size and low stone radiodensity was (n=40, 95.2%) while in patients with small stone size and high stone radiodensity were (n=10, 52.6%).

The results also showed that the ESWL success rate in patients with large stone size and low stone radiodensity was (n=30, 81.1%) while in patients with large stone size and high stone radiodensity it was (n=4, 36.4%).

The results showed that the ESWL success rate in patients with small stone size and medium stone radiodensity was (n=17, 80.9%) while in patients with large stone size and medium stone radiodensity it was (n=14, 66.7%) [Table/Fig-2].

Stone size (mm)	Stone radiodensity (HU)	ESWL success rate No. (%)	ESWL failure No. (%)
7-14 (small)	Low (500-700)	40 (95.2)	2 (4.8)
	Medium (700-900)	17 (80.9)	4 (19.1)
	High (900-1200)	10 (52.6)	9 (47.4)
15-20 (large)	Low (500-700)	30 (81.1)	7 (18.9)
	Medium (700-900)	14 (66.7)	7 (33.3)
	High (900-1200)	4 (36.4)	7 (63.6)

[Table/Fig-2]: Outcome of shockwave lithotripsy based on stone size and stone radiodensity.

The results showed that ESWL success rate in patients with low stone radiodensity was (n=70, 88.6%) while in patients with high stone radiodensity it was (n=14, 46.6%). There was a significant difference between the success rate of lithotripsy and stone radiodensity (p-value=0.0002) [Table/Fig-3].

Stone radiodensity (HU)	ESWL success rate No. (%)	ESWL failure No. (%)	p-value
Low 500-700	70 (88.6)	9 (11.4)	0.0002*
Medium 700-900	31 (73.8)	11 (26.2)	
High 900-1200	14 (46.6)	16 (53.4)	
Total	115 (76.1)	36 (23.9)	

[Table/Fig-3]: Outcome of shockwave lithotripsy based on stone radiodensity.
*p-value <0.05 is considered statistically significant

The results showed that ESWL success rate in patients with small stone size was (n=67, 81.7%) while in patients with large stone size it was (n=48, 69.6%). There was no significant difference between the success rate of lithotripsy and stone size statistically (p-value=0.08) [Table/Fig-4].

Stone Size	ESWL success rate No. (%)	ESWL Failure No. (%)	p-value
7-14 mm (small)	67 (81.7)	15 (18.3)	0.08
15-20 mm (large)	48 (69.6)	21 (30.4)	
Total	115 (76.1)	36 (23.9)	

[Table/Fig-4]: Outcome of shockwave lithotripsy based on stone size.
*p-value <0.05 is considered statistically significant

DISCUSSION

This study evaluated the usefulness of measuring renal calculi attenuation values to predict the outcome of ESWL. Stone size, stone location, stone composition, the type of lithotriptor used for the ESWL and the presence of obstruction or infection are factors that determine the ESWL success rate [5,13]. ESWL success rate differs between individuals. Patient characteristics such as obesity, skin to stone distance, age and BMI are among factors that affect ESWL success rate [14-16].

The results of our study showed that the ESWL success rate in patients with small stone size and high stone radiodensity was (n=10, 52.6%) while in patients with large stone size and high stone radiodensity it was (n=4, 36.4%). The difference of ESWL success rate in two groups was almost 16%. Although, the radiodensity of both groups were high but the ESWL success rate were different. The results of our study showed that ESWL success rate in patients with small stone size (7-14mm) was clinically remarkable. It seems that in addition to stone radiodensity, the stone size is an effective factor to determine the ESWL success rate. Although, in our study the difference between the ESWL success rate and stone size was not statistically significant, but it was significant clinically, because for 67 patients in small stone size group, the ESWL was successful while it was successful for 48 patients in large stone size. Given the difference between 67 and 48 patients which was 19 patients the difference was significant clinically.

In a study by Krishnamurthy M et al., they concluded that stone radiodensity is not able to predict ESWL outcome for stones less than 1 cm within the renal pelvis [13]. In another study by Lim K et al., stone size, time to ESWL, and stone density were determined as independent predictors of successful ESWL [17]. In a study by El Sotohi IA, patients were divided into three groups according to stone density. Although, the ESWL success rate was 81.7%, but no significant differences were found between groups based on stone size, stone site or radio-opacity [12].

The results of a study by Waqas M et al., showed that the ESWL success rate in patients with stone density of HU<500, 500-1000 and >1000 were 93.9%, 69%, and 58.3%, respectively [2]. Although, they were administered a maximum of 4000 shock waves with a maximum power of 18 kV and in the present study we delivered maximum of 4000 shocks per session to the stone at the frequency of two shocks per second and the energy power of 10 to 14 kV, the results were almost similar to our findings. Waqas M et al., also Concluded that in addition to stone radiodensity, BMI and Skin to Surface Distance (SSD) were strong predictors of outcome of ESWL for renal stones [2].

Similar to a study by Al-Marhoon M et al., we found that the smaller the size of the stone, the better place for the better and more efficient ESWL success was the renal pelvis [18]. Although, in a study by Nielsen T and Jensen J a negative correlation was found between stone size and the overall ESWL success rate. They found that upper calyx was associated with better ESWL success rate significantly, but intrarenal stone location was not predictive for treatment success [19].

As stone composition is related to hardness and affects the outcome of ESWL, therefore, preoperative determination of stone composition is essential for better stone management [20]. Stone composition is among those factors that affect the outcome of ESWL [17]. Since the precise determination of the chemical compounds of kidney stones prior to ESWL is difficult; therefore, predicting factors such as Mean HU are used [6]. In our study, we proved that the lesser the stone density was, the chance of stone fragmentation and stone free rate was greater. Also, we found a direct relationship between the ESWL success rate and stone density that is in both low and high size groups the more stone density was, the ESWL success rate was less.

Based on our findings, the efficacy of ESWL for patients with stone size less than 20mm within the renal pelvis and less stone density was more remarkable. On the other hand, comparing the stone size and its effect on ESWL success rate we found that the ESWL success rate for 7-14 mm stones with medium density was the same for 15-20 mm stones with low density. It seems that the combination of these two factors (stone size and stone density) was useful to determine the accurate ESWL success rate. Therefore, considering these two factors avoids wastage of the patients time and imposing more costs on the health system. They also help the physician to choose the appropriate procedure. According to our findings for patients with stone size more than 15mm and high stone density, ESWL is not an appropriate treatment of choice.

LIMITATION

We conducted our study on 151 patients with single stone of 7-20 mm located in renal pelvis. Also, patients with single kidney, obstructed kidney, stones more than 20 mm and stones elsewhere in the collecting system were excluded from the study. Further studies considering parameters like stone location, stone composition, the type of lithotripter used and factors such as obstruction, infection and multi stone kidneys with a large sample size are recommended.

CONCLUSION

The findings of the present study showed that stone radiodensity and stone size were useful parameters to predict the outcome of ESWL. We found a direct relation between the stone radiodensity and ESWL success rate. Also, we found that the ESWL success rate in patients with small stone size (7-14 mm) was clinically remarkable. It is suggested that these two parameters in conjunction with other stone parameters must be considered to select the appropriate procedure.

ACKNOWLEDGEMENTS

Authors would like to thank the Vice Chancellor for Research of Kurdistan University of Medical Sciences to support this study financially.

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FINANCIAL OR OTHER COMPETING INTERESTS: As declared above.

Date of Submission: **Oct 07, 2017**
Date of Peer Review: **Nov 07, 2017**
Date of Acceptance: **Jan 30, 2018**
Date of Publishing: **Mar 01, 2018**