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ORIGINAL ARTICLE

Evaluation of Skin to Stone Distance by Non-Contrast Computed Tomography as an Independent Predictor of Stone-Free Rate of Extra-Corporeal Shockwave Lithotripsy for Renal Pelvic Stones

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ABSTRACT

Introduction: Pakistan is situated in the Afro-Asian stone belt. We come across a vast majority of patients having renal calculi. The treatment of renal stones has evolved from open surgery to extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS) in past 20 years.

Objective: To determine mean skin to stone distance (SSD) in patients undergoing ESWL for renal pelvic stones and to compare mean SSD between patients with successful ESWL and failed ESWL outcomes for renal pelvic stones.

Subjects and Methods: This descriptive case series study was carried out in the Department of Urology, Institute of Kidney Diseases Hayatabad Medical Complex Peshawar from September 2017 to March 2018. A total of 50 patients with renal pelvic stones were enrolled for the study. After consent, non-contrast computed tomography of the kidney ureter and blabber (NCCT KUB) was performed and SSD was measured. All patients underwent ESWL. The patient status either as stone free or having residual stones based on NCCT KUB result was noted on 3rd month. Patients having no stone fragments were defined as stone free and the procedure was defined as successful.

Results: The mean age of the patients was 39.02 +/- 12.16 years. 33 (66%) were male and 17 (34%) were female. ESWL was successful in 39 (78%) of patients. 11 (22%) of the patients had residual stones. The mean SSD in patients with successful ESWL outcome was significantly lower than the patients with failed ESWL outcome (10.9 +/- 3.0 vs 14.8 +/- 1.8 cm, p-value = 0.001)

Practical Implication: The study results will help the urologists in deciding appropriate treatment modality for patients with renal pelvic stones.

Conclusion: We conclude that SSD is lower in patients with successful outcome of ESWL in comparison to those with failed outcome. Therefore pre-treatment NCCT KUB should be used in patients with renal stones to determine the SSD which might predict the outcomes of ESWL.

Keywords: Renal calculi, Skin to stone distance, extracorporeal shockwave lithotripsy.

INTRODUCTION

ESWL is a non-invasive method for the treatment of urinary tract calculi in adults.[1] Today 96% of all urinary tract stones are successfully treated by this method.[2] The failure of ESWL necessitates multiple sessions which leads to an increase in the medical costs as well as the development of undesirable complications such as acute renal injury, hemorrhage and edema.[3] Proper case selection depends on several factors for both the success of ESWL and the avoidance of the side-effects of this treatment. Factors which affect the success of ESWL can be categorized as stone factors (including stone size, location, composition, degree of obstruction, skin to stone distance, stone attenuation value), clinical factors (solitary kidney, abnormal ureteral anatomy and comorbidities such as concomitant infection), patient factors (age, gender, body mass index) and technical factors (type of lithotripter, source of energy).[4,5]

NCCT KUB has become the gold standard modality for diagnosis and subsequent evaluations of patients with renal stones. NCCT KUB not only provides information regarding urinary tract abnormalities but also aids in determining the stone location, size, shape, density, and skin to stone distance (SSD).[6] Nakada and colleagues were the first to use SSD to predict the outcome of ESWL when they analyzed 64 patients with 5-15 mm lower pole kidney stones. The investigators measured the length from the skin to the center of the stone at 0^0, 45^0 and 90^0 and used the average of these values as the SSD. The reported results illustrated that an SSD > 10 cm was a strong predictor of ESWL treatment failure.[7] Abdelaziz et al. evaluated 89 patients who received ESWL for renal and upper ureteric calculi measuring 5-20 mm, over a 12 month period. ESWL success was observed in 68.5% of patients. There was no significant difference seen when the effect of SSD and ESWL outcome was studied ($p < 0.26$). Patients who underwent ESWL with either successful or failed outcomes had a mean SSD of 10.6 ± 2.0 and 11.2 ± 2.6 cm, respectively.[8]

Failure of stone disintegration results in unnecessary exposure to shock waves and radiation and requires alternative treatment procedures, which increases medical costs. It is therefore important to identify predictors of treatment success or failure in patients who are potential candidates for ESWL before treatment. Literature review shows that there is no consensus among researchers regarding use of SSD as a predictor of ESWL outcome.[7,8] The aim of this study was to determine mean SSD for the successful disintegration and stone-free status of renal stones using ESWL.

MATERIAL AND METHODS

Method: This descriptive case series study was carried out in the Department of Urology, Institute of Kidney Diseases Hayatabad Medical Complex Peshawar from September 2017 to March 2018. SSD was defined as the distance from the skin to the center of renal pelvis stone. It was measured in centimeters at an angle of 90 degree in the prone position, using NCCT KUB, before the patient underwent ESWL. Complete clearance of stone, after 3 sessions of ESWL, which was confirmed on NCCT KUB at three months, was considered as successful outcome. SFR was determined by measuring the percentage of patients with successful outcome of ESWL.

Population: Adult patients visiting urology outpatient department and diagnosed with renal pelvic stone were enrolled for the study.

Sampling: Patients were enrolled by non-probability, consecutive sampling technique. The study inclusion criteria included age 20-60 years, both genders male and female, stone size 10 to 15 mm, solitary renal pelvic stone, patients with normal body mass index (BMI) of 18 to 25 kg/m^2, and stone density of 500 to 800 hounsfield units (HFU) on NCCT Scan. Our exclusion criteria included patients with fever, pus cells on urinalysis, raised total leucocyte count (TLC), deranged coagulation profile and any contra-indication to ESWL on history.

Sample size: The sample size was 50, keeping mean SSD in patients with treatment failure 11.2+2.6 cm[8], confidence interval 95% and margin of error 0.01 under WHO sample size calculation formula.

Data collection procedure: After approval from the ethical committee of the hospital, patients who presented in Urology OPD of Institute of Kidney Diseases Peshawar and meeting the study criteria were enrolled for this study. Written informed consent was taken from all the patients. Demographic data like name, age, sex, height, weight & BMI were noted. Their detailed history and physical examination were recorded to strictly follow the selection criteria and control confounders. Before the patient underwent ESWL, NCCT KUB was performed for all the patient. The scans were evaluated by a consultant radiologist having at least 2 years of experience for measurement of stone size, location of stone and SSD was measured in each patient according to the operational definition. Each patient underwent three sessions of ESWL. Stones were fragmented under f1uoroscopic guidance. The stone clearance was assessed by plain X-Ray KUB and ultrasound at the end of each session and confirmed by NCCT KUB at the end of third month counted from 1st session of ESWL by the same radiologist. The patient status either stone free or having residual stones based on NCCT KUB result were noted. All the gathered information was collected on a predesigned performa.

Data analysis plan: Data were analyzed using SPSS version 21. Numerical variables like age, BMI, stone density and SSD were described as mean +/- standard deviation. Categorical variables like gender, side of stone, location of stone and treatment outcome (successful or failed) were described in terms of frequencies and percentages. Numerical and categorical variables were compared between treatment outcomes (successful vs failed) by applying independent T-test and Chi-square test respectively, keeping p-value < 0.05 as significant.

RESULTS

A total of 50 patients, including 33 (66%) male and 17 (34%) female, who underwent ESWL for renal pelvic stones were included in the study. Complete stone clearance was achieved in 39 (78%) of the patients (successful outcome) whereas 11 (22%) of the patients had residual stones (failed outcome) at three month follow up (Fig. 1). Table 1 shows the comparison of patients based on outcome, after three sessions of ESWL. Overall the mean age of the patients was 39.02 +/- 12.16 years a range of 20-60 years. The mean age of the patients with successful outcome was 38.38 +/- 12.08 years whereas the mean age of the patients with failed outcome was 41.27 +/- 12.74 years (p-value > 0.05). 24 (48%) and 15 (30%) in patients with successful outcome whereas 9 (18%) and 2 (4%) in patients with failed outcome were male and female respectively (p-value > 0.05).

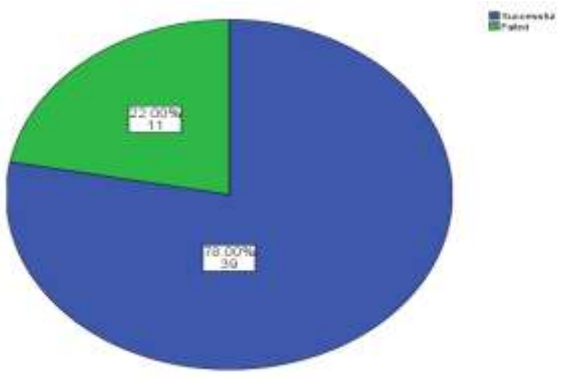

Figure 1: Outcome of ESWL.

Overall the mean BMI of the patients was 21.70 +/- 2.65 kg/m^2 with a range of 18-25 kg/m^2. The mean BMI of the patients with successful outcome was 21.59 +/- 2.65 kg/m^2 whereas the mean BMI of the patients with failed outcome was 22.09 +/- 2.74 kg/m^2 (p-value > 0.05). The mean stone size was 11.86 +/- 1.60 mm with a range of 10-15 mm. There was no statistical difference in mean stone size between patients with successful outcome and those with failed outcome (11.62 +/- 1.43 vs 12.73 +/- 1.95 mm, p-value > 0.05). Similarly there was no statistical difference in mean stone density between patients with successful outcome and those with failed outcome (760.59 +/- 418.80 vs 724.46 +/- 382.87 HFU, p-value > 0.05). The mean SSD was 11. 67 +/- 2.65 cm. The mean SSD in patients with successful outcome was significantly lower than those with failed outcome (10.94 +/- 3.04 vs 14.26 +/- 1.77 cm, p-value < 0.05).

Table 1: Comparison of patients based on outcome of ESWL.

Variable	Outcome		p-value
	Successful	Failed	
Age (years)	38.38 +/- 12.08	41.27 +/- 12.74	0.492
Gender Male Female	 24 (48%) 15 (30%)	 9 (18%) 2 (4%)	 0.256
BMI (kg/m^2)	21.59 +/- 2.65	22.09 +/- 2.74	0.585
Stone Side Right Left	 16 (32%) 23 (46%)	 5 (10%) 6 (12%)	 0.528
Stone Size (mm)	11.62 +/- 1.43	12.73 +/- 1.95	0.941
Stone Density (HFU)	760.59 +/- 418.80	724.46 +/- 382.87	0.798
SSD (cm)	10.94 +/- 3.04	14.26 +/- 1.77	0.001

BMI-body mass index, HFU-hounse field units, SSD-skin to stone distance.

DISCUSSION

ESWL was first introduced in 1980 by Chaussy et al.[9] and was successfully applied to patients with urolithiasis.[10] ESWL can be a modality treatment for most upper urinary tract stones, because of its simplicity, noninvasiveness and minimal morbidity. However, some stones are difficult to fragment by ESWL or the fragments may remain in the urinary tract even after successful fragmentation of the stone. Compared with endourological lithotripsy and open surgeries, ESWL is a noninvasive method and has similar SFR in appropriate patients. However, the success rates range from 34% to 76%.[11-12] Since residual stones can cause hydronephrosis followed by a decrease in renal function or urinary tract infection, residual fragments should be removed even if they are less than 4 mm in diameter.[13] In our study complete stone clearance was achieved in 78% of the patients. We considered the presence of residual fragment of any size as failure of the procedure, as such 22% of the patients in our study had residual fragments at the end of three months.

Radiographic assessment of the stone is required to decide on the best treatment. Determining the role of NCCT in predicting the SFR in shockwave lithotripsy is important. Several studies have shown that NCCT provides a rapid assessment of the stone size, stone surface area, stone density, SSD, stone number, and stone location, and all these parameters have attempted to predict the successful rate of SWL.[14,15] It is therefore recommended as the standard diagnostic tool in urinary stone disease.[16]

Several studies have shown an impact of mean stone density on treatment success of ESWL in kidney stones. Saw et al. firstly demonstrated that stone density obtained by NCCT correlated with stone fragility. They found that the higher the stone density, the greater the number of shockwaves needed for fragmentation.[17] Similarly, Pareek et al. demonstrated that stone density on pre-treatment NCCT can predict the SFR after ESWL. Stone density not only correlated with the numbers of shockwaves required, but also associated with the sessions of shockwave treatment needed.[18] A prospective observational study was conducted in Sindh Institute of Urology and Transplant (SIUT), Karachi, Pakistan. The study showed that stone fragmentation with ESWL was 100% successful in patients with stone density of < 1000HFU whereas the success rate was 35% in patients with

stone density of > 1000 HFU.[19] Many other clinical studies have also verified the effect of stone density in the SFR after ESWL.[5,20] In the current study, we observed no difference in the mean stone density between patients with successful ESWL outcome and those with failed outcome. This could be explained by the fact that we included patients with stone density of 500-800 HFU in order to control the effect of stone density on stone fragmentation.

Several investigators have demonstrated that BMI can also help to predict the outcome of ESWL. Abdelghany et al. reported obesity (BMI > 30 kg/m^2) as a negative predictor for ESWL for lower ureteric stones. They described chances of tenfold increased failure rate in patients with BMI > 30 kg/m^2 than those with BMI < 30 kg/m^2 after two sessions of ESWL.[21] In another study, SFR for normal weight and morbidly obese patients for upper urinary tract stones were 82% and 67%, respectively.[22] Müllhaupt, et al. suggested the cut-off value of BMI as 25.9 kg/m^2 for prediction of ESWL outcome.[23] In our study however, BMI was insignificant as we have taken the normal patients with BMI 18-25Kg/m^2.

Many investigators have suggested SSD as an important predictor of ESWL outcome. Mohammad, et al. described significant influence of SSD for ESWL in renal stones.[20]. Müllhaupt, et al. studied the effect of SSD on ureteral stone fragmentation and described its significance. The SSD at 90^0 with a cut off value of 11.9 cm was a stronger predictor of stone fragmentation than SSD T 0^0 and 45^0.[23] Other studies failed to show a similar effect of SSD on stone clearance with ESWL.[24,25] Our study demonstrated that higher SSD is a bad prognostic factor for clearance of renal stones. SSD was significantly lower in patients with successful outcome in comparison to patients with failed outcome.

The study has some limitations. First, we included only 50 patients, which may not be representative of the larger population undergoing ESWL. Second, the study only included patients with normal BMI and stone density < 800 HFU, which may limit the generalizability of the findings to patients with different characteristics.

CONCLUSION

In conclusion, this descriptive case series study of 50 patients with normal BMI and stone density < 800 HFU undergoing ESWL suggests that SSD may be an important factor in predicting treatment success. Our findings show that patients with smaller SSD tend to have better treatment outcomes, as evidenced by a higher SFR. However, given the limitations of this study, further research is needed to confirm these findings in larger and more diverse patient populations, and to determine the optimal SSD threshold for predicting treatment success. Nonetheless, these results provide a useful starting point for clinicians in identifying patients who may benefit from ESWL or need alternative treatment options based on their SSD measurement.

Conflict of Interest: There are no conflicts of interest to disclose for the authors.

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Ethical Approval: The ethical and review board of the Institute of Kidney Diseases, Peshawar, Pakistan, gave its approval to this study.

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