BANGLADESH JOURNAL OF
UROLOGY
Bangladesh J. Urol. 2023; 26(1): 9-13
www.banglajol.info/index.php/BJU
DOI: https://doi.org/10.3329/bju.v26i1.69853

Original Article

ISSN : 2304 - 8514 (Print)
ISSN : 2304 - 8522 (Online)

Stone Attenuation and Skin-to-Stone Distance on Computed Tomography Predict the Performance of Shock Wave Lithotripsy

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Received: 10 - 09 - 2022
Accepted: 03 - 10 - 2022
Conflicts of interest: None

Abstract

Background: *Despite the fact that shock wave lithotripsy (SWL) is a non-invasive, secure, and efficient way to treat ureteral stones, the overall stone-free rate (SFR) varies significantly depending on the location and size of the stone.*

Objective: *To determine whether the performance of shock wave lithotripsy can be predicted using stone attenuation and skin-to-stone distance on computed tomography.*

Methods: *This prospective observational study was conducted in the Department of Urology at the National Institute of Kidney Diseases and Urology (NIKDU), Dhaka. Following ethical approval from NIKDU, 100 patients with ureteral stones were chosen for this study. A detailed history of these patients, as well as their drug and dietary histories, were recorded on a data collection form. Each patient had a CT scan to determine stone attenuation and skin-to-stone distance. The stone clearance rate after SWL was compared with stone attenuation and skin-to-stone distance. The Statistical Package for Social Sciences (SPSS) version 12.0 was used to analyse the data.*

Results: *There were 66 males and 34 females among the 100 study participants. The mean age of the study subjects was 48.54 ± 7.93 years. The success of SWL was significantly higher among normal-weight patients. Failure in SWL was 15%. The mean stone-to-skin distance was 9.33 ± 2.61 cm and 12.50 ± 3.00 cm in successful and failed SWL respectively. In both successful and failed SWL, the mean stone attenuation was 790.94 ±144.72 HU and 1164.67 ± 222.67 HU, respectively. The mean volume of stone was 1302.71 ± 181.51 cm^3 and 1853.33 ± 270.23 cm^3 in successful and failed SWL respectively. Sensitivity, specificity, PPV, and NPV were 80.0%, 67.1%, 70.8%, and 77.0% respectively, of stone-to-skin distance in the prediction of successful SWL at a cut-off point <10.25. Sensitivity, specificity, PPV, and NPV were 86.7%, 94.1%, 93.6%, and 87.6% respectively, of stone attenuation in the prediction of successful SWL at a cut-off point <1045 HU.*

Conclusion: *Stone attenuation and stone to skin distance are a good predictor of successful SWL.*

Keywords: Ureteral stone, CT scan and SWL.

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Introduction

Despite a wide range of current success rates (46%-91%), shock wave lithotripsy (SWL) is still a frequently used, noninvasive, safe, and successful treatment option for ureteral stones.[1,2] The choice of patient is significantly influenced by the size and placement of the stone. Body mass index (BMI) and stone attenuation on computed tomography (CT) are emerging as predictors of SWL fragmentation.[3,4] These factors might help the treatment of stone disease and limit unnecessary treatments. A major criticism of measuring stone attenuation is the volume averaging that occurs for smaller stones, resulting in fictitious low attenuation values that can confuse its association with the SWL outcome. [5,6]

Failure to remove the stone leads to unnecessary exposure to radiation and shock waves, increased patient suffering, and the need for additional treatment processes, all of which increase medical costs.[7]

Because of its accuracy in measuring stone location, size, number, and overall stone burden, non-contrast computed tomography (NCCT) is now advised as the primary diagnostic method for urinary stone illness.[7,6] Additionally, a number of studies have revealed a relationship between mean attenuation value (MAV) and the effectiveness of SWL treatment for kidney stones (Preminger et al., 2007). Despite its widespread use, little research has been done on the effects of other NCCT information, such as skin-to-stone distance (SSD) and MAV, on stone fragmentation in ureteral stone disease. [8,9,10]

The present study was carried out to determine whether stone attenuation and skin-to-stone distance on CT can predict the performance of SWL.

Methods:

Prior to the study, ethical approval was taken from the institute, and it was in accordance with the Declaration of Helsinki. This prospective observational study was conducted in the Department of Urology, NIKDU, Dhaka over a period of 12 months from August 2021 to July 2022. A total of 100 patients with ureteral stone of age ≤18 years referred for SWL were enrolled in this study. Severely ill patients were excluded from this study. All patients were informed regarding the study and written consent was taken from each patients. After enrollment in this study, general information such as name, age, gender etc. were recorded. CT scan was done for each patient to find out stone volume, location, stone attenuation and skin-to-stone distance.

If tolerated by the patient, up to 4,000 shocks (60–90/min) with an energy level of up to 8 according to the manufacturer's scale was delivered during each SWL session. The energy level 8 corresponded to 16.4 kV with the precise focus and 12.8 kV with the extended focus. In patients with pain resistant to analgesic treatment, the energy and number of shocks were reduced according to the patient's tolerance. Stones were targeted and fragmentation were monitored by biplanar fluoroscopy at regular intervals during treatment. Patients were further evaluated by kidney, ureter, and bladder (KUB) film, renal ultrasound, and sieving of urine to assess fragmentation, the presence of renal dilatation and expulsion of ureteral stones the day after the respective session. In cases of missing or inadequate disintegration in KUB, SWL was repeated once or twice at intervals of 1 day. The clinical outcome was defined as successful (visible stone fragmentation on KUB) or failed (absent fragmentation on KUB) immediately after the last SWL session.

Statistical analyses

Statistical analyses was performed using SPSS 12.0 software. Data presented on categorical scale were expressed as frequency and corresponding percentages and were compared between groups using Chi-square test, while data presented on continuous scale were expressed as mean and standard deviation and were compared between groups by using Student's t-Test and p value < 0.05 was taken as statistically significant. Sensitivity, specificity, positive predictive value, negative predictive value of stone attenuation and skin-to-stone distance was calculated to predict success of SWL.

Results:

Table I : *Demographic profile of the study subjects (N=100)*

	N	Success(n=85)	Failure(n=15)	p-value
Age (years)				
Mean±SD	48.54 ± 7.93	48.34 ± 7.90	49.67 ± 8.32	0.554
Gender				
Male	66	56 (65.9)	10 (66.7)	0.953
Female	34	29 (34.1)	05 (33.3)	
BMI (kg/m^2)				
Overweight and obese	40	29 (34.1)	11 (73.3)	0.004
Normal weight	60	56 (65.9)	4 (26.7)	
Mean±SD	24.86±2.17	24.61 ± 2.02	26.31 ± 2.49	0.005
Stone site				
Calyceal stone	44	38 (44.7)	6 (40.0)	0.735
Renal pelvis	56	47 (55.3)	9 (60.0)	

Among 100 study subjects, 66 males and 34 females. Mean age of the study subjects was 48.54 ± 7.93 years. Success of SWL was significantly higher among normal weight patients. Failure in SWL was 15%.

Table II : *Comparison of stone characteristics of the study subjects (N=100)*

	Success(n=85)	Failure(n=15)	p-value
Stone to skin distance (cm)	9.33 ± 2.61	12.50 ± 3.00	<0.001
Stone attenuation (HU)	790.94 ± 144.72	1164.67 ± 222.67	<0.001
Volume (cm^3)	1302.71 ± 181.51	1853.33 ± 270.23	<0.001

Stone to skin distance, stone attenuation and volume of stone were significantly lower in among the study subjects with successful SWL.

Table III : *Efficacy parameters of stone to skin distance and stone attenuation in prediction of success of SWL (N=100)*

	AUC	Cut-off	Sn	Sp	PPV	NPV
Stone to skin distance	0.788	10.25	0.800	0.671	0.708	0.770
Stone attenuation	0.914	1045	0.867	0.941	0.936	0.876

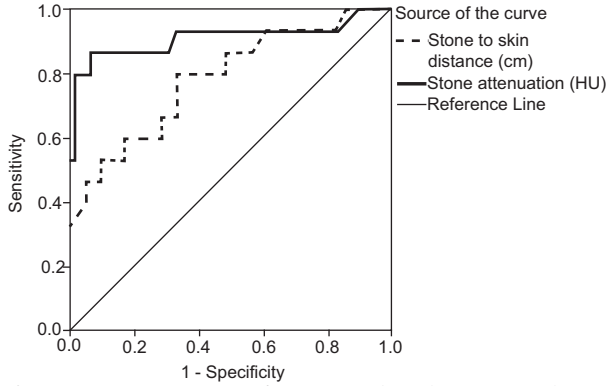

Figure 1: *ROC curve of stone to skin distance and stone attenuation to predict success of SWL.*

Stone attenuation was found better in predicting successful SWL than stone to skin distance. The ROC curves for different parameters were analyzed to find the optimum cut-off values to predict successful SWL (Figure 1). The optimum cut-off point for SSD would be <10.25 cm (sensitivity 80.0 %, specificity 67.1%), for patient stone attenuation <1045 HU (sensitivity 86.7 %, specificity 94.1%).

Discussion:

The use of CT for ureteral stone detection is well established and widespread throughout the world.[9] There are only slight variations between studies in

terms of the method for evaluating SSD in CT, which has been well reported in the literature.[9,7]

According to the study's findings, stone attenuation value and stone to skin distance (SSD) are reliable indicators of the success of SWL. In this investigation, stone to skin distance had sensitivity, specificity, PPV, and NPV values of 80.0%, 67.1%, 70.8%, and 77.0%, respectively, in predicting successful SWL at a cut-off point of 10.25. At a cut-off point of 1045 HU, stone attenuation had a sensitivity, specificity, PPV, and NPV of 86.7%, 94.1%, 93.6%, and 87.6%, respectively, in the prediction of successful SWL.

Stone attenuation has been found to be a predictor of SWL success in numerous investigations.[7,9] An SSD of more than 10 cm on the NCCT was a predictor of SWL, according to Pareek et al.[11] Perks et al.[12] made a similar observation, noting that a stone attenuation value of less than 900 HU combined with an SSD less than 9.0 cm was a good indicator of SWL success. Multiple clinical trials have demonstrated that increased stone attenuation value is associated with SWL failure. In earlier research, stone attenuation values varied from 578 to 837 for patients who received successful treatment and from 910 to 1,225 for individuals who did not receive good treatment.[11,12] The large range of previously reported stone attenuation values is thought to be caused by variations in the CT collimation width, the way stone attenuation is measured, and the lithotripter utilized.

Cut-off values for MAV have been suggested to be between 750 and 1000 HU for renal calculi and between 750 and 900 HU in studies examining mixed ureteral and renal stones as predictors of SWL failure.[13] However, separate examination of cut-off values for ureteral stones has only been performed in two studies: Pareek et al.[11] suggested 900 HU as the cut-off value in their study of 30 ureteral stones, and Ng et al.[9] defined a very different threshold of 593 HU as a potential predictor of treatment success in a study in 94 patients with upper ureteral stones. This study showed an association between stone attenuation and the success of ureteral stones using SWL.

Ng et al.[9] maintained that treatment planning is aided by a scoring system that uses stone volume, stone attenuation, and SSD to determine SWL outcome for upper ureteral stones.

Conclusion

In addition to helping to diagnose urolithiasis, NCCT also serves as a predictor of SWL success. The outcome of SWL is well predicted by stone attenuation and stone to skin distance.

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