

Can we successfully predict the outcome for extracorporeal shock wave lithotripsy (ESWL) for medium size renal stones? A single-center experience

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Abstract

Background: Extracorporeal shock wave lithotripsy (ESWL) is one of the most used modalities in treatment of renal stones, but its effectiveness can be influenced by many factors related to the patient or the stone itself which may affect the success of stone disintegration. The aim of our study was to investigate the predictive value of some patient and stone-related factors for ESWL success for renal stones.

Methods: A total of 100 patients with single radiopaque renal stone 10–20 mm in diameter, undergoing ESWL were enrolled in this study. All patients had non contrast computed tomography (NCCT) done before ESWL. We evaluated body mass index (BMI), skin-to-stone distance (SSD), stone size and Hounsfield density comparing these values between stone free (SF) and residual stone (RS) groups.

Results: Of the 100 patients, 70% had successful disintegration. There was no significant difference between stone free (SF) and residual stone (RS) groups as regard age or BMI. Meanwhile, there was a significant difference between SF and RS groups as regard stones' density and SSD, with higher values in RS group but there was statistically insignificant difference as regard stone size ($p = 0.522$). Using logistic regression analysis, we found that Hounsfield unit (HU) was better in predicting successful disintegration than SSD but without statistical significance.

Conclusion: HU and SSD are the independent predictive factors for ESWL outcome, and they should be considered when planning ESWL in treatment of medium size renal stones.

Keywords

Stone disintegration, ESWL, non-contrast CT, renal stones, treatment outcome

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Introduction

After its introduction in 1980, ESWL has dramatically changed the management of urinary stones as it is minimally invasive, outpatient procedure and doesn't require anesthesia use.¹ ESWL still has an important place in all guidelines.² This is noteworthy as multiple recent studies have reported that technical advances with ureteroscopy (URS) achieved higher stone clearance rates and lower morbidity than previously.^{3,4} However, fewer complications and economic concerns support the use of ESWL, and this explains its ongoing prominence in all guidelines.^{5,6,7} A further explanation is that, the European Association of Urology (EAU) guidelines report that more than 90% of renal and ureteral stones might be candidate for ESWL according to the recent literature.²

Disintegration is the first step in the treatment of renal stones by ESWL, the response of a calculus to disintegration should be considered before using ESWL.⁸ Non contrast computed tomography (NCCT) has become the preferred modality for the diagnosis of renal stones due to its rapidity and high accuracy. NCCT not only provides information regarding urinary tract abnormalities but is also helpful in determining the stone location, size, shape, density, and skin-to-surface distance.⁹

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Multiple studies have evaluated imaging-based parameters and their effects on the success of ESWL with varying results.¹⁰ In our study, we evaluated the potential predictive values of patient, stone, and NCCT parameters on the success of ESWL for adult patient with renal stone.

Methods

Patients: This prospective study was conducted from January 2018 to August 2020 at a single tertiary care hospital. Before the start of the study, we obtained the approval of the ethical committee of our institution. Inclusion criteria were patients aged between 18–75 years affected by solitary radio-paque renal stone 10–20 mm in diameter without distal obstruction. All patients with active urinary tract infection (UTI), uncorrected coagulopathy, impaired renal function, pregnancy, single kidney, inferior calyceal stones >1 cm, multiple stones, any structural urologic anomalies, and those requiring stent application were excluded from the study.

Before ESWL, all the patients were evaluated after giving a written informed consent with history, clinical examination, complete blood picture, coagulation profile, kidney function test, and urine analysis and culture if needed. Plain X ray kidney, ureter, bladder (KUB), pelviabdominal ultrasonography and NCCT were done to all the patients.

NCCT technique: All scans were done using high speed 64 MSCT helical scanners (Toshiba, Japan). Body mass index was measured by dividing the weight (kg) by square of the height (m). The skin-to stone distance (SSD) was calculated on NCCT by measuring three distances from the stone to the skin at 0°, 45°, and 90° using radiographic calipers, and the average of these values was calculated to represent SSD for each stone. Stone size was measured using stone longest diameter in cm, the post scanning bone window protocol used to measure the stone attenuation value in HU.

ESWL technique: ESWL was performed using an electromagnetic Siemens Modularis device under sedation and analgesia. Under fluoroscopic guidance, in postero-anterior direction and 30° oblique direction, all patients received a fixed number of shock waves 3500 shockwaves, the power used was increased from 6 to 220 kV, using a standardized protocol and shock rate (80 shock waves per minute) are fixed in all patients. Patients were encouraged to drink plenty of fluids and discharged with proper medications including tamsulosin and pain killer.

Follow up schedule: Follow up was performed two weeks after ESWL by KUB and ultrasonography to assess for fragmentation. The patients were categorized into stone free (SF) or residual stone (RS) group. RS was defined as failure of stone disintegration or persistence of fragment >4 mm after three sessions which was indication for another treatment modality. The BMI, stone size, HU density and SSD were compared between the SF and RS groups.

The primary endpoint was the assessment of the association of patient, stone and NCCT parameters with the success of ESWL.

Table 1. Study population characteristics.

	SF	RS	p-Value
	Mean ± SD	Mean ± SD	
Number of patients (n%)	70 ± 70	30 ± 30	
Age (years)	42.90 ± 14.14	40.56 ± 14.39	0.252
BMI (kg/m ²)	27.49 ± 4.78	29.45 ± 4.95	0.065
Sex			
Male (n%)	30 ± 50.8	29 ± 49.1	
Female (n%)	25 ± 61	16 ± 39	
Side			
Right (n%)	52.4 ± 52.4	47.6 ± 47.6	0.152
Left (n%)	61.2 ± 61.2	38.3 ± 38.3	

Statistical analysis: Data was collected, coded and entered into Statistical Package for the Social Sciences (SPSS version 20.0). Kolmogorov-Smirnov test was used to check for normality of data. Statistical analysis was done using independent *t*-test, chi-square test and logistic regression analysis. *p*-Values were considered significant if <0.05.

Results

A total of 100 patients were included in this study, male to female ratio was 1.44:1 (59 males and 41 females). Of the 100 patients, 70 were classified as SF and 30 as having RS, mean ± SD of residual stone size was 6.50 ± 1.76 ranged from 5 to 10 mm. There was no significant difference in patient characteristics between SF and RS groups as regard age, BMI, or stone side as in Table 1.

There was a significant difference between SF and RS groups as regard the following NCCT parameters: stones' density and SSD, with higher values in RS group. While, there was statistically insignificant difference as regard stone size (*p*=0.522) as in Table 2.

Using receiver operating characteristic (ROC) curve, it was shown that HU could predict stone disintegration at a cutoff level ≤975, with 95.7% positive predictive value and 90% negative predictive value (Figure 1). Also, SSD could predict stone disintegration at a cutoff level ≤8.6 cm with 95.2 % positive predictive value and 71.1% negative predictive value (Figure 2).

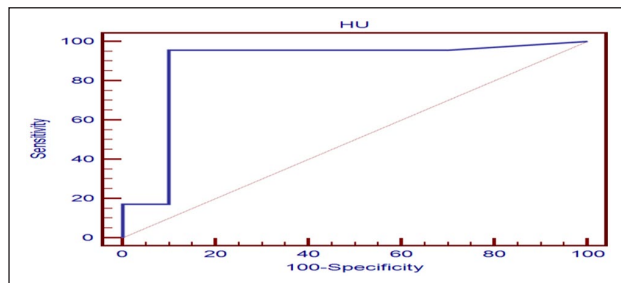
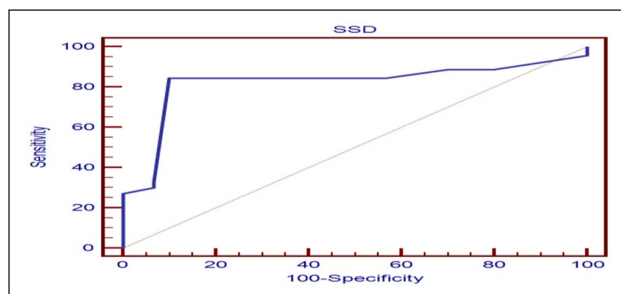
ROC shows that the SSD area under curve was found to be 82% while the HU area under curve was found to be 88.5% which means that HU was found to be better than SSD in predicting successful disintegration but this difference between areas did not reach statistical significant difference (*p*=0.348) (Figure 3).

Discussion

ESWL is considered an important treatment option in the field of urology. It has the main benefits of high safety and

Table 2. Comparison between SF and RS as regard NCCT characteristics.

	SF	RS	p-Value
	Mean $\pm$ SD	Mean $\pm$ SD	
Density (HU)	808.74 $\pm$ 227.84	1084.00 $\pm$ 173.17	0.000
Size (cm)	1.63 $\pm$ 0.17	1.66 $\pm$ 0.16	0.522
SSD (cm)	8.79 $\pm$ 1.92	10.43 $\pm$ 1.71	0.000

**Figure 1.** ROC curve for HU in prediction of successful disintegration.**Figure 2.** ROC curve for SSD in prediction of successful disintegration.

low invasiveness nature. However, multiple studies have showed that percutaneous nephrolithotomy (PNL) and URS have higher stone free rate than ESWL.¹¹ So, it is necessary to determine the potential predictors for ESWL outcome and to define the ideal treatment option for each patient.¹²

Hameed et al.¹³ reported that successful fragmentation using ESWL was decreased in stones with HU >1350, which required application of more shock waves. El-Assmy et al.¹⁴ used the Hounsfield value of the stones to predict stone composition and density, and the fragmentation success using ESWL, and selected HU >1000 as their cut off value. Also, Foda et al.¹⁵ demonstrated that stone disintegration failed if the stone density was > 934 HU and Massoud et al.¹⁶ reported that in patients with > 956.5 HU, ESWL should not be considered or offered to patients as a first treatment.

In 2018 Waqas et al.¹ in a study on 203 patients reported that patients having stone density of less than 500 HU were more likely to have stone clearance (93.8%), while patients

having values greater than 1000 HU were less likely to experience successful outcomes (24.5%). In our study, we found similar results the mean $\pm$ SD of HU was 808.74 $\pm$ 227.84 and the cutoff point for successful ESWL was $\leq$ 975.

According to a study conducted by Park et al. in 2012 on 43 patients, 33 patients were stone free versus 10 patients had residual stones. The mean SSD was 7.825 $\pm$ 1.215 cm for the stone free group versus 9.203 $\pm$ 1.451 cm for the residual stone group ($p < 0.01$). They described SSD as the only significant factor for prediction of ESWL success and they attributed that to loss of shock waves energy during penetration through excess body fat with increased SSD.⁹ Also, Badran et al.¹⁷ suggested that shock waves lose their energy by 10% to 20% for every 6-cm penetration and Perks et al.¹⁸ defined 90 mm as the threshold value for SSD beyond which the success rate decreases. While, Waqas et al.¹ reported that SSD of 100 mm as a cut off value with success rate of 71% in patients having SSD less than 100 mm.

We found similar results in our study, with the mean success value of SSD is 9.28 $\pm$ 2.00 range from 6 to 14 cm while cutoff value of SSD was 86 mm, with success rate of 70% in patients having SSD less than 86 mm. Also, we noted that HU was better than SSD in predicting success of ESWL but without statistical significance.

Pareek et al.,¹⁹ found that BMI was a significant predictor of success. Conversely, in our study, BMI failed to predict successful ESWL outcome, while SSD remained a significant predictor and this agrees with Ng et al.²⁰ and Choi et al.²¹ who found that BMI was not a significant predictor of ESWL failure. They suggested that the effect of BMI is probably related to the distance of the stone from the skin, which reflects the shock wave path in the body.

Waqas et al.¹ noted that there was a correlation between the stone burden (stone size, surface area, and volume) and the success rate but this wasn't significant in the multivariate analysis. Similarly, Pareek et al.¹⁹ showed that there was no significant difference between SF and RS groups as regard stone size. This agreed with our study, we have found that the difference in stone size was statistically insignificant between groups. This can be explained by the homogeneity of stone size in our study population leading to a type I error. In contrast, Bandi et al.²² concluded that stone volume was the best predictor of stone free status.

The main disadvantages of our study are mainly the wide range of stone size 10–20 mm, also we did not consider some factors like (stone volume, surface area, and Hounsfield density), pain, procedure complications and patient compliance. So, further multicenter studies on a larger number of patients are needed to validate our results.

Conclusion

ESWL is one of the most used modalities in management of renal stones but its effectiveness is influenced with variable factors. So, better patient selection is paramount to

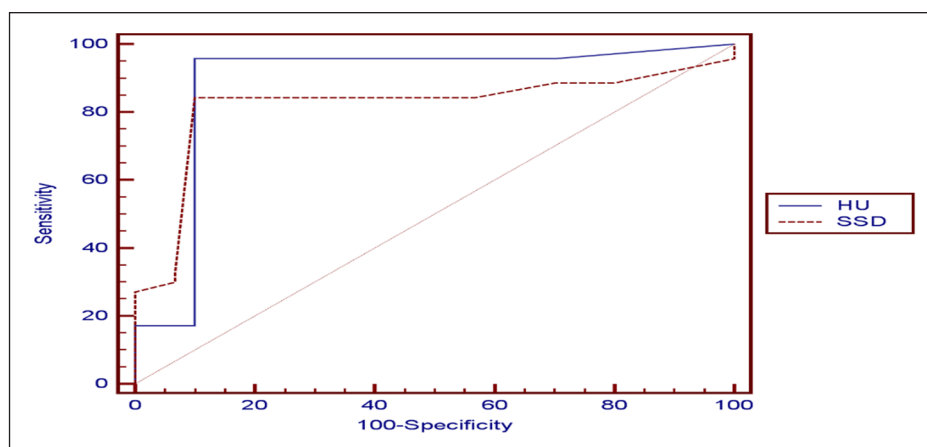


Figure 3. ROC for SSD and HU in prediction of successful disintegration.

improve ESWL outcome. We found that HU and SSD are the most powerful predictors of ESWL outcome and should be used for proper patient selection and planning the treatment of renal stones.

Declaration of conflicting interests

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