

Predictors of Success of Extracorporeal Shock Wave Lithotripsy Based On the Hounsfield Units of Calculi Measured By Non-Contrast Computed Tomography

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ABSTRACT

Objective To predict the success of extracorporeal shock wave lithotripsy (ESWL) for renal calculi based upon the Hounsfield units (HU) obtained from non-contrast computed tomography scans, along with patient related variables.

Study design Retrospective analytic study.

Place & Duration of study Lithotripsy Department, The Kidney Centre Postgraduate Training Institute Karachi, from January 2021 to June 2021

Methodology Patients with renal calculi of < 2-cm were divided into two groups: Group-A (HU < 1000) and Group-B (HU = 1000). All patients underwent ESWL. The energy levels varied from 60 to 90 shocks per minutes, while the frequency ranged between 0.5 to 2 Hertz. A total of 4000 shockwaves per session were administered based on the size and hardness of the calculus. The success of the ESWL was defined as complete clearance of the calculi or clinically insignificant residual fragments that were less than 4-mm in size noted either on plain x-ray abdomen or ultrasound scan, and did not cause any symptom for three months following the procedure.

Results The records of 142 participants (Group A: n=90 - 63.4% and Group B: n=52 - 36.6%) were analysed. The mean age of the patients was 40.2±14.6 years. There was male preponderance (n=74 - 52.1%). Renal pelvis was the commonest location (n=58 - 40.8%) of the calculi. The predictors of the success of ESWL were male gender, BMI of <30 kg/m², absence of comorbid conditions, and HU of <1000 (p < 0.05). BMI was the only statistically significant predictor for the success of ESWL when adjusted with other variables.

Conclusions BMI was a strong predictor of ESWL success rate. With higher HU and BMI, a decreased rate of clearance of calculi was found.

Key words Extracorporeal shock wave lithotripsy, ESWL, Non-contrast computed tomography, Hounsfield unit, Body mass index.

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INTRODUCTION:

The incidence of renal calculi has increased over the years with a recurrence rate of at least 50% in a lifetime.¹ Calculi form due to homogenous and heterogeneous nucleation.² Men are more commonly affected. Multiple factors contribute to calculus formation like genetic predisposition, dietary habits, environment and physical activity.^{3,4} Various treatment options are available for the management of renal calculi. Since the introduction of extracorporeal shock

wave lithotripsy the fragmentation of calculi has improved significantly with an excellent success rate in those with less than 2-cm size calculus.^{5,6}

The success of ESWL, which is a preferred therapeutic option for renal calculi, depends on several factors including size of calculus, body mass index, chemical composition, Hounsfield units, and anatomical location.^{7,8} This study was conducted to evaluate the impact of Hounsfield units on the success of clearance of renal calculi of < 2-cm size with ESWL.

METHODOLOGY:

This retrospective analytic study was conducted at the Lithotripsy Department of The Kidney Centre Postgraduate Training Institute in Karachi. The records of the patients who underwent ESWL for renal calculi from January 2021 to June 2021 were reviewed. Patients with renal calculus of less than 2.0 cm were included. Patients with abnormal renal anatomy, morbid obesity with a BMI of 40 kg/m² or higher, renal insufficiency, distal obstruction, uncontrolled coagulopathy, uncontrolled hypertension, renal artery or aortic aneurysm, active urinary tract infection, pregnancy, with ureteric stones, were excluded.

Ethical review board permission was obtained. The procedure was done after taking informed consent / assent from the patients where applicable. All patients underwent clinical evaluation and relevant investigations prior to the procedure. Non-contrast computed tomography (NCCT) was done in all patients. Slices were obtained every 5-mm to ascertain the size of the calculus and the highest mean Hounsfield unit (HU) value was measured. For the purpose of this study, the patients were categorized into Group A (HU <1000) and Group B (HU = 1000). In both the groups 4000 shockwaves per session were delivered with the energy levels between 60 to 90 shocks per minute. The frequency of shockwaves ranged from 0.5 to 2 Hertz. The Storz Modulith® SLK lithotripter was used for ESWL procedure which was performed in prone position.

One week after the ESWL patients were followed in the outpatient department. The assessment included a plain x-ray abdomen and ultrasonography. Patients with fragments of calculus of < 4-mm were reassessed after four weeks. The end result of ESWL was considered as a success when patients were cleared of all the fragments of calculi or had clinically insignificant residual fragments (CIRF) of < 4-mm with no symptoms, at three-month post procedure.

The data were collected and analyzed using SPSS

version 21. Descriptive statistics such as mean with standard deviation were calculated for continuous variables including age, BMI, and size of the calculus. For categorical variables such as gender, HU groups, anatomical location, and comorbid, frequencies with percentages were obtained. Chi-square test was used to compare the baseline characteristics of patients in two groups for categorical variables, while the independent student t-test or Mann-Whitney U-test were used for continuous data depending on normality or skewness. Normality was assessed using Shapiro Wilk's test. Univariate binary logistic regression was conducted to determine the effect of individual parameters on clearance of the calculi. The Odds ratio and 95% confidence interval were calculated. Multivariate logistic regression was used to determine the combined effect of variables on the clearance of calculus, and a predictive model was developed. A p-value of < 0.05 was considered as statistically significant.

RESULTS:

A total of 142 patients fulfilled the criteria of data review. There were 90 (63.4%) patients in group A and 52 (36.6%) in group B. The age of the patients was from 14 years to 77 years (mean age - 40.2±14.6 years). There were 74 (52.1%) male and 68 (47.9%) female patients. The most common comorbid conditions were hypertension (n=55 - 38.7%) and diabetes mellitus (n=39 - 27.5%). The most common anatomical location of the calculi was renal pelvis (n=58 - 40.8%). Most of the patients (n= 89 -62.7%) had four sessions of ESWL. Mean BMI, which was higher in patients of group B, found statistically significant (p=0.024). Details are given in table I.

The predictors of the clearance of calculus were male gender, BMI of <30 kg/m² (mention cutoff value), patients without comorbid conditions and HU <1000, with p < 0.05. The age, size and site of the calculi were insignificant variables. Details are given in table II. BMI was the only statistically significant predictor for the clearance of calculi (p < 0.001), while all other parameters became insignificant when adjusted with each other. It was noticed that with one-unit increase in BMI, the probability of calculus clearance was reduced up to 65% (odds ratio 0.35, 95% CI 0.22 – 0.55) as mentioned in table III.

DISCUSSION:

This study showed high success rate of ESWL procedure for renal calculi of less than 2.0 cm in large number of patients. This is in conformity with the reported literature. ESWL has several advantages like less pain, being minimally invasive and no

Table I: Comparison of Baseline Parameters

Variables	HU Groups Mean±SD n (%)		P value	Total n=142	
	Group A < 1000 90(63.4%)	Group B ≥ 1000 52(36.6%)			
Age (years)	40.9 ± 14.9	39 ± 14.3	0.616	40.2 ± 14.6	
BMI (kg/m ²)	31.2 ± 4.8	33.2 ± 5	0.024	32 ± 5	
Size of calculus (mm)	14.1 ± 3.7	13.5 ± 3.9	0.334	13.9 ± 3.7	
Gender	Male	51(56.7)	0.153	74(52.1)	
	Female	39(43.3)		29(55.8)	68(47.9)
Hypertension	37(41.1)	18(34.6)	0.444	55(38.7)	
Diabetes mellitus	23(25.6)	16(30.8)	0.502	39(27.5)	
Anatomical location of calculi	Upper pole	5(5.6)	0.412	9(6.3)	
	Mid calyx	13(14.4)		4(7.7)	17(12)
	Lower calyx	22(24.4)		18(34.6)	40(28.2)
	Renal pelvis	40(44.4)		18(34.6)	58(40.8)
	PUJ	10(11)		8(15.4)	18(12.7)
Shockwave sessions	2	16(17.8)	0.066	22(15.5)	
	3	24(26.4)		7(13.5)	31(21.8)
	4	50(55.6)		39(70.5)	89(62.7)

requirement of general anesthesia.⁹ However, these variables were not assessed during this study as focus was on the predictor of success of ESWL procedure.

Density and composition of the calculi are the crucial factors during ESWL. Higher density and hardness of calculus may result in decreased clearance after the shock wave sessions. ESWL is usually effective in breaking struvite, calcium oxalate dihydrate and uric acid calculi.¹⁰ The composition of calculi was not analysed in this study which is a limiting factor. In our study, the density of the calculus was indirectly determined by using NCCT. Hounsfield unit is a measure of characteristics of the calculus. This also helped in defining anatomy of the kidney and location of the calculi. NCCT has a sensitivity and specificity of over 95% with excellent spatial resolution, making it a superior modality to ultrasonography.¹¹

In our study different variables were assessed that may affect the clearance of calculus during the procedure. It was noted that males had 2.84 times better clearance than females. Individuals with comorbid conditions like hypertension and diabetes mellitus had a lower chance of success. The reason

for this remained unclear. This may need multicenter prospective studies to provide more convincing evidence. In a review article it was reported that patients who underwent ESWL had an increased tendency to develop diabetes mellitus and new-onset hypertension.¹² However, in another clinical trial same findings were not observed.¹³ In this study the BMI strongly predicted calculus clearance rate. With each unit increase in BMI, the probability of clearance decreased to around 65%. According to Massoud et al and El-Nahas et al studies, a BMI of greater than 30kg/m² was identified as the strongest indicator of unsuccessful ESWL outcomes.^{14,15}

HU is an indirect measure of composition and density of the calculus. This was used to divide patients into two groups. In this study we noted 59% less clearance of calculi when HU was =1000. Joseph et al reported that calculi with greater HU value (>1000) necessitated more shock waves during ESWL and the success rate was less.¹⁶ In index study age did not play a role in success of ESWL. However, Ullah et al found a positive correlation between increasing age and successful clearance of calculi.¹⁷ In pediatric population, especially the

Table II: Effect of Demographic, Clinical and Calculi Related Variables On The Success of ESWL

Variables			Clearance of stone		p-value
			Odds ratio	95%CI (lower-Upper)	
Age			1.02	0.99 - 1.04	0.097
BMI			0.363	0.24 - 0.5	< 0.001
Gender n (%)	Male	53(71.6)/74	2.84	1.42 - 5.7	0.003
	Female	32(47.1)/68	1		
Hypertension n (%)			0.16	0.07 - 0.33	<0.001
Diabetes mellitus n (%)			0.13	0.056 - 0.208	<0.001
Size of calculus n (%)			0.98	0.89 - 1.1	0.696
Anatomical location of calculi n (%)	Upper pole	6(66.7)/9	1		
	Mid calyx	8(47.1)/17	0.44	0.08 - 2.4	0.345
	Lower calyx	12(30)/40	0.21	0.05 - 1	0.05
	Renal pelvis	43(74.1)/58	1.43	0.32 - 6.5	0.639
	Pelvi-ureteric junction	16(88.9)/18	4	0.53 - 30.2	0.179
HU groups n (%)	< 1000	61(67.8)/90	1		
	≥ 1000	24(46.2)/52	0.41	0.2 - 0.82	0.012
Steinstrasse n (%)	Nil	71(58.2)/122	1		
	Grade 1	14(70)/20	1.7	0.6 - 4.7	0.32

(Univariate analysis)

Table III: Effect of Different Variables On Clearance of Calculi

Variables	Clearance of calculi		p-value
	Odds ratio	95%CI (lower-Upper)	
Male Gender	21.5	0.71 - 6.54	0.078
BMI	0.35	0.22 - 0.55	<0.001
Diabetes mellitus	0.07	0.002 - 2.5	0.148
Hypertension	0.45	0.04 - 5.1	0.519
HU group ≥ 1000	0.2	0.13 - 2.7	0.24

(Multivariate analysis)

children of young age, fewer sessions of shock are required for clearance of calculi.¹⁸

There were total 5 patients below 18 yrs old, while all remaining patients were adults age group, there was complete clearance in adolescents age group.

The success rate ESWL is more in patients with larger size calculi.¹⁷ However, same observation is not found in other studies. Wang et al found that a calculus of more than 12-mm led to a poorer outcome.¹⁹

LIMITATIONS OF THE STUDY

This was a retrospective study with small number of patients. The composition of the calculi was not determined. HU was used on NCCT as an indirect measure of the characteristics of the calculi. A better correlation could be achieved if chemical composition and HU were taken into account for the success of the procedure

CONCLUSIONS:

This study found that density of the calculus in HU and BMI as strong predictors of ESWL success rate.

With higher HU and BMI decreased calculus clearance was noted. Male patients had much better clearance rate. However, patients with comorbid conditions fared worse than those without them.

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Agha Zohaib: Substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of data for the work.

Habibullah Akbar Mohammad: Drafting the work or revising it critically for important intellectual content

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Salman el Khalid: Final approval of the version to be published.

Asad Abdullah: Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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