Testing the New Parameters affecting The Outcome of Extracorporeal Shockwave Lithotripsy for Upper Ureteric Stones

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Abstract

Background: Extracorporeal Shock wave lithotripsy (ESWL) is widely used in treating patients with ureteral stones because it is effective, safe, and noninvasive. Based on factors such as size and the location of stones, there is a significant variation in the overall stone-free rate (SFR).

Aim of the study: To evaluate the effect of ureteral wall thickness (UWT), stone attenuation, the time from first attack of pain till first session of ESWL and stone/ rib density on the outcome of SWL in the treatment of upper ureteral stones (UUS).

Patient and methods: A prospective study when 127 patients with radio-opaque UUS ranging from 7 to 20 mm and treated by ESWL were included in this study. The effect of (stone/ 12th rib) density by KUB, ureteral wall thickness by NCCT and the time from first attack of pain till first ESWL session was studied.

Results: The overall successful fragmentation was 75.5%, with the overall success rates in the low density (LD) and high density (HD) groups were 83.8% and 52.94%, respectively. The average number of SWL sessions needed in the two groups for success was 1.9 compared with 2.7 sessions ($p<0.05$). For stones < 10 mm; those with ureteral wall thickness <3.25 mm have success rate about 90.3% VS 69.7% with ureteric wall thickness > 3.25 mm which is highly significant. Early ESWL within the first 24 hours of acute attack of first pain has successful fragmentation of 85.45%. With significant effect on number of ESWL sessions. The stone free rate reaches 91.1% for stones <10 mm.

Conclusions: The stone free rate is inversely affected by stone /12th rib density ; ureteral wall thickness and the time from first attack of pain till first session of ESWL, were important predictors of successful ESWL.

***Keywords**: **ESWL** Extracorporeal Shockwave Lithotripsy, **SSD** skin to stone distance, **MAV** mean attenuation value, **NCCT** non contrast CT scan, ureteral wall thickness **UWT**, stone /12th rib density (**LD** low density and **HD** high density).*

Introduction

Urolithiasis is a common disease with an increasing prevalence. In the general population, its lifetime risks for men and women are 13% and 7% respectively. After being formed in the renal collecting system, ureteric stones move downward into the urerer. The physiologic narrowings (pelviureteric junction, crossing over the iliac vessels, and the ureteric meatus) of the ureter are areas where stones tend to lodge. [(1)]

The degree of obstruction caused by urinary lithiasis depends on the size of the calculus, urothelial edema, location and the level of impaction where an urgent instrumental method of treatment is sometimes needed. There is still a debate on the best treatment method for ureteral calculi. Some of the varying treatment options include passage of ureteral stent, extracorporeal shockwave lithotripsy (ESWL), expectant management, open ureterolithotomy and ureteroscopy with basket extraction or intracorporeal lithotripsy [(2, 3)].

For ureteric stones that are uncomplicated and moderately sized, ESWL can be used as the first choice of treatment. ESWL is a safe, simple and robust procedure and for cases where stones are resistant to medical treatment without total indication of ureteral drainage, it is usually recommended [4-6]. In addition, ESWL cannot be used to fragment all urinary stones easily because its success rate depends on factors such as stone size, location and composition [7]. Using radiological tools such as kidney-ureter-bladder (KUB) x-ray and non-contrast computed tomography (NCCT), diverse studies have examined how to predict successful treatment by ESWL. Some studies have recently tried to correlate NCCT findings with the treatment success of ESWL.

Patients and Methods

Study design and setting:

This is a prospective study that included 127 patients with radio-opaque upper ureteral stones who referred to lithotripsy unit in Al-Shaheedd Ghazi al Hariri surgical specialties teaching hospital in Baghdad from August 2015 – October 2016, 78 males (average 40 years) and 49 females (average 48years), treated with extracorporeal shock wave lithotripsy (ESWL). All patients included in the study underwent: Ultrasonographic study, kidney-ureter-bladder (KUB) x-ray, computed tomogram (CT) without contrast, coagulation profile, urinalysis and culture, serum creatinine and fasting blood sugar. The night before ESWL, patients were directed to take laxative to help lower the gases in the intestine and promote the localization of stones. Also all patients were given analgesia before lithotripsy and those with positive urine culture treated with antibiotic according to the culture and sensitivity.

Inclusion criteria:

1. Single upper ureteric stone within size (≥7--≤20 mm)
2. First attack of pain.

Exclusion criteria:

1. Previous surgical intervention
2. Any contraindication for ESWL.
3. Stones that pushed back to the kidney when DJ insertion needed.
4. Bilateral or multiple ureteral stones.
5. Structural urinary tract abnormality

The new parameters that was studied in this study including the following:

A- Stone density relative to that of the 12th rib: Based on visual criteria, a density less than or equal to that of the 12th rib was assigned to the lower-density (LD) group while a density greater than that of the 12th rib was assigned to the higher-density (HD) group [8].

B- Ureteral wall thicknessUWT; was measured by NCCT in addition to other parameters like size, skin-to-stone distance (SSD), and the mean attenuation value [10].

C- Time from first attack of pain till first ESWL session: to evaluate the role of early intervention on stone free rate and treatment outcome; with early intervention means less than or equals to 24 hours.

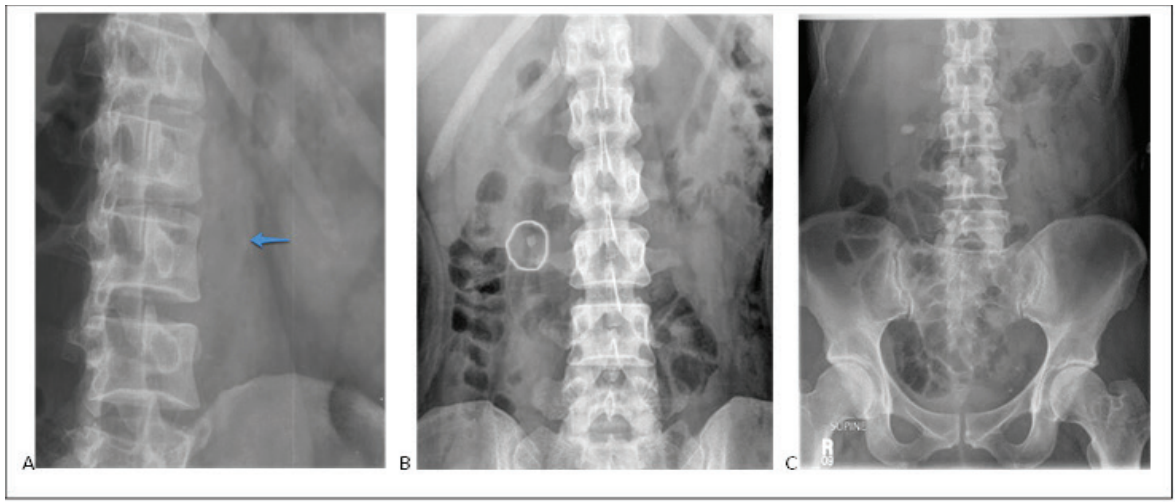

Fig 1: Classification of stone density: lower (A), equal (B), and higher density (C).

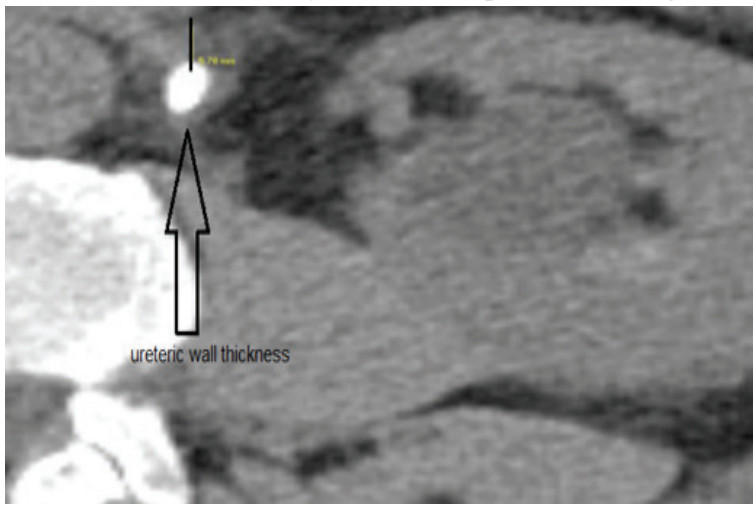

Fig 2: NCCT showing evident increase in ureteral wall thickness (UWT) around the large proximal ureteral stone.

ESWL technique:

After explaining the different treatment modalities and complications, informed consent was taken from the patient.The procedure was done on an outpatient basis. Using **Siemens Lithoskop** lithotripter .The number of shock waves ranges from 2500-3000 shocks in 15.5-16.7 k.v. according to patient tolerance and stone disintegration, with a frequency 2 Hz = 120 pulse/min. **(9)**

The patients were requested to return for follow up with plain film as well as an ultrasound examination after two weeks. This is to enable the detection of stone clearance and fragmentation along with the effect of treatment and upper urinary tract obstruction. A second session is scheduled after 2 weeks if significant (>4mm) fragments were still seen.

Statistical Analysis

Multiple t-test and Fisher's exact tests with two tailed p-value were used to evaluate stone characteristics, NCCT signs and KUB in order to predict the success rate of ESWL. A p-value less than 0.05 was considered to indicate statistical significance. The program used is SPSS version 24.

Results

The overall mean patient age out of the 127 patients evaluated was 42.3 years (24 - 63 years). The overall mean attenuation value (MAV) was 849.72 HU (460-1346) while the ureteral wall thickness (UWT) was 3.25 mm (0.9– 6.6 mm). No significant difference were found

regarding SSD while highly significant for the rest of variables (table 1).

Table 1: Baseline parameters using univariate analysis.

Characteristics	Successful fragmentation	Unsuccessful fragmentation	p-value
Time from 1stpain till 1st ESWL (days) (mean± SD).	3.5± 1.7	4.8±2.1	<0.001
SSD (mean ± SD) cm	11.1±1.8	11.6±1.4	0.160
Mean Attenuation value (HU) (mean, ± SD)	715 ± 132	989 ± 144	<0.001
Stone size, mm(mean± SD)	10.2 ± 2.67	12.5 ± 3.65	<0.001
Stone /12 rib density LD (N, %) / HD (N, %)	78(81.2%)/18(18.8%)	15(48%)/16(52%)	<0.001
Ureteral wall thickness mm.	2.98 ± 0.75	4.21 ± 0.90	<0.001

A total of 96 (75.5%) patients became completely SF after 3 months of follow up with regards to ESWL success rates. The mean stone size and mean attenuation value were 10.2± 2.67 mm and 715±132 **HU** respectively. Of these patients with successful fragmentation, the Low stone/12th rib density was found to have higher stone free rate than High stone /12th rib density stones, (78) patients (81.2%) **LD** versus (18) patients (18.8%) **HD** group respectively with (p=<0.001). Significant differences in the SFR and the number of ESWL sessions in patients with stone size less than or equal to 10 mm were found between both groups in the analysis of the subgroups divided by stone size (Table 2). In the two groups, the mean of ESWL sessions required for success were 1.5±0.7 in the L.D compared with 2± 1in the **HD** group.

Table 2: Comparison of treatment outcomes between low density and high density groups in accordance with stone size.

Stone Size	LD (n=93)	HD (n=34)	P value
Total treatment success	78 (83.87%)	18 (52.94%)	<0.001
≤ 10 mm (n=105)	81	24	
Ø treatment success	70 (86.4%)	16 (58.3%)	0.0368
Ø no. of ESWL session	1.50±0.7	2±1	0.0339
>10 mm (n=22)	12	10	
Ø Treatment success	8 (58.3%)	2 (20%)	0.04271
Ø no. of ESWL sessions	2.50 ±0.75	3.50±0.5	0.1185

Evaluation of the Ureteral wall thickness **(UWT)** and time from the first attack of pain was found to be significantly different in patients with successful fragmentation from that in the failed group; with UWT (2.89±0.75 vs. 4.2±0.9 mm) and time till first ESWL session (3.5±1.75 days vs. 4.8±2.1) respectively, with significant difference in the number of ESWL sessions needed especially in stones ≤ 10 mm as in tables (3 and 4).

Table 3: **Distribution of stones according to their size and the time from first attack of pain until the first session of ESWL**.

	≤ 24 hrs from onset of 1st attack of pain	**>24 hrs after onset of 1st attack of pain**	**P - value**
≤10 mm (n=105)	45	60	
Successful (total 86)	41 (91%)	45 (75%)	0.0415
NO. of ESWL sessions	1.75±0.5	2±0.5	0.0230
> 10 mm (n=22)	10	12	
Successful (total 10)	6 (60%)	4 (33.3%)	0.3913
NO. of ESWL sessions	2±0.5	2±0.75	1.0000

The effect of time and ureteral wall thickness (**UWT**) on stone fragmentation declines as the stone size increases so that there is less significant effect on the stone free rates and the number of sessions of ESWL required when the stone size is more than 10 mm. table (4).

Table 4: **Distribution of stone fragmentation outcome according to stone size and ureteral wall thickness.**

Stone size	**UWT≤ 3.25 mm**	**UWT> 3.25**	**P value**
≤10 mm (n=105)	62	43	
Treatment success (n=86)	56(90.3%)	30(69.7%)	0.0098
ESWL Sessions	1.5± 0.75	2±0.25	0.0007
> 10 mm (n=22)	12	10	
Treatment success(n=10)	5(41.6%)	5(50%)	1.000
ESWL Sessions	2.5±0.5	2.75±0.75	0.5524

Discussion

Stone fragility has been found to be correlated with effective shockwave energy transmission and stone composition. Also, brushite stones, cysteine, and calcium oxalate monohydrate are well known to be hard and resistant to ESWL. In radiological modalities, stone composition and attenuation value are related. Many studies have tried to establish that stone fragility can be predicted by the attenuation value of calculi. HU density by NCCT and radio density by KUB are the ways attenuation value can be measured [8].

Lim KH et al, [8] found a correlation between stone density on plain x-ray and HU density on CT. As a result, stone density on plain x-ray may be regarded as one of the factors acting alone that can be used to predict the success of ESWL.

Based on radiographic patterns, **Dretler SP,** [9] proposed the ability of a plain KUB to show stone fragility.

In this study, when SFR values of stone/12rib density stratified according to stone size, which is the most important independent factor, and a confounding parameter we found that ESWL failure can be predicted independently by using a stone density that is relative to that of bone (12^{th} rib) on KUB.

Sarica K et al, in another study [10] found that at the impacted stone site, ureteric wall **(UWT)** diameter is highly predictive. They therefore strongly recommend that in all such cases, before selecting between SWL and URS as treatment options, the calculation of the UWT diameter should be taken into consideration seriously.

In this study it is found that ureteric wall thickness UWT at the site of impacted stone is an important independant predictor for success of ESWL, and a value of less than 3.25 mm has significant success rate about 90.3% in stones less than 10mm.

In ER setting, the use of ESWL as a prompt therapeutic tool has not yet been given the deserved attention, although, in the treatment of ureteral stones, it is globally considered as one of the treatment options.

Ghalayini IF [11] in his study found that Emergency ESWL for obstructing ureteral stones has a satisfactory success rate and very low morbidity.

The study by **Tombal B et al, in 2005** [12] demonstrated that the proportion of patients who were stone-free (SF) after 48 hours and the proportion of patients discharged from the hospital after 72 hours were increased by 40% and 25% respectively in emergency ESWL when the stone was proximally located and less than 5 mm. They suggested that in these cases, it should be strongly recommended. Their study showed that emergency ESWL can be used to improve the removal of ureteral stones and reduce the duration of hospital stay if it can be proven that the location of the stone is proximal to the iliac vessels.

In the present study we found that doing ESWL within 24 hours from the first attack of pain felt by the patient and confirmed diagnosis of ureteral stone, this will limit the degree of inflammation and impaction and has great role in increasing stone free rates and the number of ESWL sessions especially for stones less than 10 mm.

In stone size more than 10 mm it is found than there is still effect of the time on the stone free rate and number of ESWL sessions but has no statistical significance .

Conclusions

The risk of ESWL failure is higher for a stone with a density greater than that of the 12th rib compared to that with a lower density.

Radiological findings on the preoperative KUB may be helpful for predicting ESWL outcomes.

Ureteral wall thickness as a secondary characteristic of Non-contrast CT scan is an important predictor of ESWL outcome for ureteric stones less than 1cm.

Ureteral wall thickness is correlated to the degree of inflammation and impaction of ureteral stone.

Early intervention using ESWL within <24 hours from first attack of pain is important predictor for ESWL Success

Recommendation:

Regular and precise calculation of these studied parameters will help us to reduce the cost of treatment

but most importantly limit the adverse effects of treatment intervals that are longer than usual, repeated SWL sessions and additional procedures on the QOL of the treated patients.

No **Conflicts of Interest**

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Ethical clearance: was taken from the scientific committee of the Iraqi Ministry of health

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