African Journal of Urology

ORIGINAL RESEARCH Open Access

# Comparison of different shock wave frequencies on stone disintegration in extracorporeal shock wave lithotripsy; 60, 80 and 100/min

Mohamed Ahmed Mohamed El Taher[1*], A. Reda[2], A. M. Abdel Latif[2] and M. A. El Gammal[2]

## Abstract

**Background:** We know that SWL started on February 07, 1980, by Christian Chaussy with a wide range of indications. Complication rate has always remained very low and usually limited to minor side effects and complications. This study shows the impact of different shock wave release frequencies 60, 80 & 100/min on disintegration of renal stones.

**Methods:** A total number of 210 patients with mean age (40 ± 15) years with renal stone who were candidate for SWL divided into 3 groups each are 70 patients on rate 60,80 and 100 per min), Chi-Square test, Fisher's exact test used in the study.

**Results:** Complete stone clearance( defined as complete stone free) was obtained in 184 patients 87.6% after one session, the highest success rate 94.3% were obtained in the second group of patients ( with shock wave frequency 80/min) followed by the first group 87.1% (with shock wave frequency 60/min), and patients with highest frequency (100/min) had the lowest success rate 81.4%.

**Conclusions:** The best option is using intermediate shock wave rate 80/min to obtain highest success rate and mild pain. Using high rate 100/min is not favorable due to least disintegration rate with highest pain. Using rate 60/min shows less success than rate 80/min despite it less painful.

**Keywords:** Renal stones, SWL, Different shock wave frequencies, Stone disintegration, Outcome, Complications

## 1 Background

Following extensive research that started as early as 1963, the first human extracorporeal lithotripsy was performed on February 07, 1980, by Christian Chaussy, Bernd Forssmann and Dieter Jocham using a Dornier HM1 lithotripter [1], SWL is performed in a wide range of indications, and complication rate has always remained very low and usually limited to minor side effects and complications [2].

The best evidence to maximize SWL outcomes through understanding of the basic physics of shock waves, case selection, optimal SWL technique( positioning, coupling, dose escalation, number of shocks, and treatment rate) and the use of post-SWL adjunctive treatments to maximize fragment passage is presented [3].

Data on the impact of SW delivery rates on ESWL efficacy in renal stones are still sparse and inconsistent [4, 5].

## 2 Methods

A total number of 210 patients with mean age (40 ± 15) years with renal stone who were candidate for SWL were recruited from January 2019 through January 2020.

*Correspondence: Mohamed_el_taher7392@yahoo.com
[1] Faculty of Medicine, Assiut University, Assiut, Egypt
Full list of author information is available at the end of the article

Patients were assigned to 3 equal groups based on shock-wave frequency.

First group (70 pt.) underwent SWL with shock wave frequency of 60 shock waves per minute. Second group ( 70 pt.) underwent SWL with shock wave frequency of 80 shock waves per minute, Third group (70 pt.) underwent SWL with shock wave frequency of 100 shock waves per minute, Using (DORNIER COMPACT DELTA 2) lithotripter, patients were randomized as who came at Saturday underwent SWL with rate 60/min, who came Monday underwent SWL with 80/min and who came Wednesday underwent SWL with 100/min.

Sample size estimated by Slovin's formula as: Sample Size $= N/\left(1 + N * \mathrm{e}^2\right)$

$N =$ population size; $e =$ margin of error.

### 2.1 Type of study
Prospective randomized comparative study.

### 2.2 Inclusion criteria
Stone size less than 2 cm and density up to 1200 HU with age group more than 18 y.

### 2.3 Exclusion criteria
Age group less than 18 y. Stone size 2 cm or more and density more than 1200 HU. Multiple stones or lower calyceal stone or stented ureter.

### 2.4 Workup of the study
Each patient received instructions for SWL before the session as regard the technique and it's complications. Written consent was obtained before session.

### 2.5 Pre-session evaluation
Demographic data of the patients recorded as Age, sex, Body Mass Index Stone site, burden, location & density.

Laboratory data as CBC count, coagulation profile Urinalysis, (±) urine culture.

Imaging Studies as KUB, Pelvi-abdominal ultrasonography, Non-contrast CT scan.

### 2.6 During session
#### *2.6.1 Technique*
Each patient received NSAIDs (1amp) on normal saline infusion before starting the maneuver, and the patient positioned on supine position & stone localization done then SWL session started by low voltage energy (1st level) and then gradually increases the power of energy until reached (3rd level). The rate of increasing the voltage of the shock wave depended on the patient tolerability.

Data as time of the procedure, Number of shock wave, Voltage and Degree of pain recorded.

### 2.7 Post session
The patient checked for vital signs & medical expulsive therapy prescribed for 3 weeks and followed-up with abdominal U/S & KUB.

### 2.8 Statistical analysis
The collected data were revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 25), Chi-Square test, Fisher's exact test used in the study.

## 3 Results
In one hundred eleven (111) patients, 52.9%, their stones were in the right kidney, and the rest of patients 47.1% had their stones in the left kidney, and the stones were radio-opaque in 195 patients 92.9% and radio-lucent in 15 patients 7.1%. One hundred twenty-three patients 58.6% had pelvic stones, while 36 patients 17.1% had a middle calyceal stones and 51 patients 24.3% had an upper calyceal stones, and the mean Hounsfield unit (HU) was $843.28 \pm 241.32$. There is no statistical significant difference between studied groups as regard stone site, opacity, HU and stone side.

As regard stone localization, in 195 patients 92.9%, their stone were localized using Fluoroscopy and in 15 patients 7.1%, their stones were localized using ultrasound, and the duration of session was $45.60 \pm 10.54$ min As regard the duration of sessions, there were statistical significant differences between patients groups where the duration of session decreases as the frequency rate increases.

One hundred sixty-one patients 76.7% had no pain during session, 43 patients 20.5% had mild pain, and 6 patients 2.9% had moderate pain during sessions As regard sensation of pain during session, there were statistical significant differences between patients groups where pain sensation increases as the frequency rate increases.

Complete stone clearance was obtained in 184 patients 87.6% after one session, and the rest of patients 26 patients 12.4% were not cleared after the first session

and scheduled for second session There was statistically significant difference between studied groups where the highest success rate 94.3% were obtained in the second group of patients ( with shock wave frequency 80 / min) followed by the first group 87.1% (with shock wave frequency 60 / min), and patients with highest frequency (100/min) had the lowest success rate 81.4%.

## 4 Discussion

The use of SWL for the treatment of renal stones has brought a revolution in the field of urology. It has not only reduced hospitalization time and morbidity, but also cost effective. SWL therapy is noninvasive, anesthesia-free and can be administered in an outpatient setting. Therefore, ESWL remains the first choice for treating renal and upper and middle ureteric stones [6].

In the shorter interval between SW pulses at higher delivery rates, the more bubbles are generated. Although cavitation bubbles on stone surfaces contribute to stone fragmentation, continuous cavitation bubbles act as a barrier to SW energy transmission by forming bubble clouds, thereby reducing stone fragmentation effects. Thus, slower SW delivery rate removes the bubble barrier extent on the stone surface and supports better cluster dynamics that facilitate superior fragmentation [7].

In convenient with our study, several studies evaluated the impact of SW delivery rates on stone clearance in kidney stones comparing SW delivery rates of 60 versus 120 pulses per min. Most of these studies reported better success rates in kidney stones with the lower SW delivery rate of 60 pulses per min [3, 8, 9] Since then, several RCTs have begun investigating the effect of decreasing SW frequency on procedure efficacy. The first RCTs were studies conducted by Madbouly et al. [10] and Pace et al. [4]. These groups compared the treatment outcome of SWL at 120 SW/minute versus 60 SW/minute, and both studies showed better outcomes using low-frequency SWL. Since then, several studies have further compared the influence of delivering high-frequency SWs versus low-frequency SWs and confirmed improved results with low-frequency SWL [5].

Though differences in efficacy between high-frequency versus intermediate- and low-frequency SWL are obvious, there remains controversy about the comparative efficacy of intermediate- versus low-frequency SWL. Yilmaz et al. observed no difference in treatment outcome when comparing 90/minute and 60/minute SW rates, but the 90 SW rate was considered to be the optimal frequency because of reduced procedural duration [11].

As an indicator of treatment success, the complication rate is as important as the efficacy rate. Though decreased SW frequency may reduce incidental damage because of the decreased total number of shocks, it concurrently shows more effectiveness in stone fragmentation due to the altered cavitation bubble dynamics. Capillary rupture can be avoided by allowing more time for bubbles to dissipate between shocks [12]. In our study, no major complications were noticed, and only mild hematuria reported by patients immediately post-session which remain only few hours in most cases.

As regard the duration of sessions, results were in convenient with the studies previously done as Kanget al. [9] found that low-frequency SWL is more effective than high-frequency SWL, and the main drawback is that it takes a longer time. Also, madboly et al. [4] performed a trial involving 156 patients harboring renal stones. Participants were randomized to receive either 60 or 120 SW/min their data analysis showed a success rate that was 8.7% higher in the slow wave group, as well as a decreased total number of shock waves required for success, at the cost of a longer treatment time.

As regard sensation of pain during session, result was in convenient with the studies previously done as Berwin et al. [13] with study of 179 patients who received their first SWL for a solitary kidney stone as first group on rate 60/min & second group 120/min. Result showed first group (53%) of patients with no pain & second group (47%) could not tolerate the full treatment, requiring a reduction in either shock wave number or energy level. Also in study done by Kim et al. [14] with 180 patients on 2 groups as first group underwent ESWL on rate of 90/min & second group 120/min. Result showed A total of 116 (64.4%) patients with no pain & 64 (35.6%) patients most of them in the second group showed mild pain (Figs. 1, 2).

## 5 Conclusion

SWL is still one of the most safe & cost-effective methods in treatment of kidney stones. Duration of sessions decreases with increase in frequency of shock wave disintegration, while pain sensation increases with increasing frequency of shock wave disintegration.

Intermediate shock wave frequency (80/min) is associated with highest success rate 94.3%. Highest shock wave frequency (100/min) is associated with lowest success rate as well as highest pain sensation.

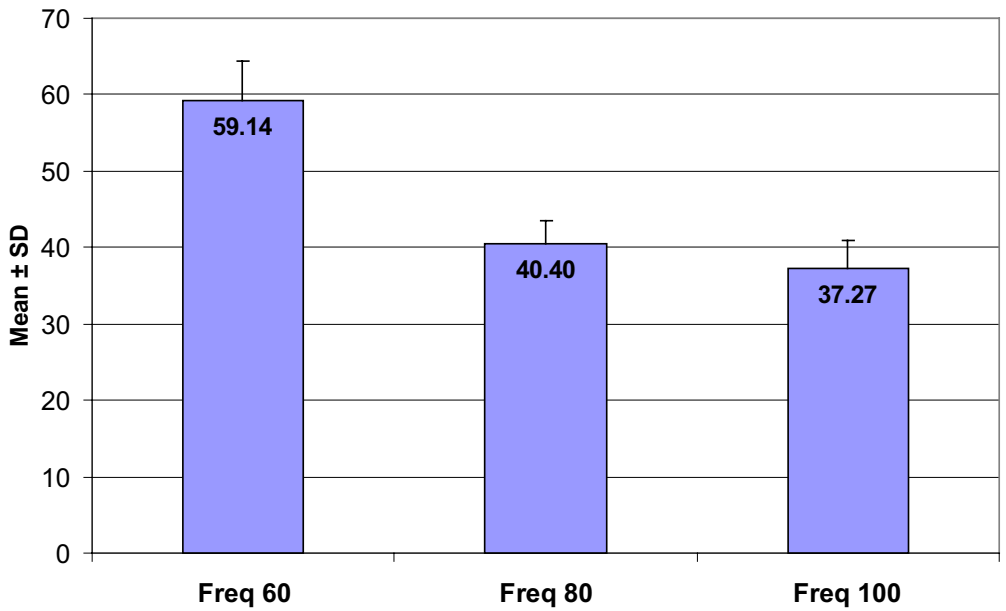


**Fig. 1** Duration of session in each group

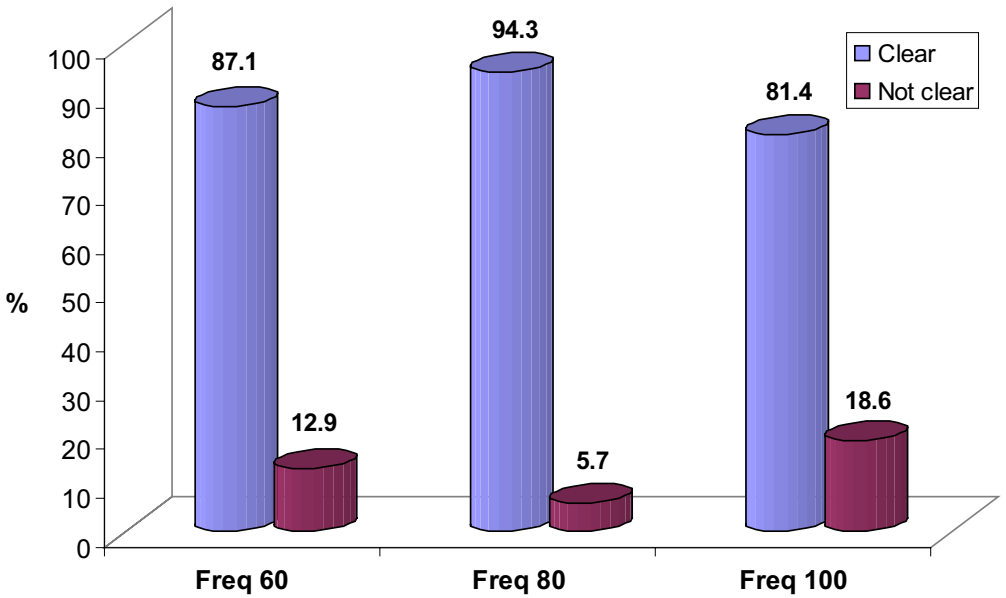


**Fig. 2** Stone clearance in each group

**Abbreviations**
ESWL: Shockwave lithotripsy; Swl: Shockwave.

**Authors' contributions**
MAE contributed to creation of new software used in the work. AR contributed to design of the work. AMA contributed to analysis and interpretation of data. MAE drafted the work and substantively revised it. All authors have read and approved the manuscript.

**Funding**
None.

**Availability of data and materials**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Ethics approval and consent to participate**
This study approved by Institutional Review Board (IRB) of Faculty of Medicine Assiut University with approve number 17200000. Informed written consent to participate in the study was provided by all participants.

**Competing interests**
The authors declare that they have no competing interests.

**Author details**
[1] Faculty of Medicine, Assiut University, Assiut, Egypt. [2] Urology and Nephrology Hospital, Assiut University, Assiut, Egypt.

Received: 25 July 2020 Accepted: 25 December 2020
Published online: 25 January 2021

**References**

1. Chaussy CH, Eisenberger F, Wanner K, Forssmann B, Hepp W, Schmiedt E, Brendel W (1976) The use of shock waves for the destruction of renal calculi without direct contact. Urol Res 4:175
2. Tailly GG (2013) Extracorporeal shock wave lithotripsy today. J Urol Soc India 29(3):200–207
3. Al-Ansari A et al (2006) Prognostic factors of success of extracorporeal shock wave lithotripsy (ESWL) in the treatment of renal stones. Int Urol Nephrol 38(1):63–67
4. Madbouly K et al (2005) Slow versus fast shock wave lithotripsy rate for urolithiasis: a prospective randomized study. J Urol 173(1):127–130
5. McClain PD, Lange JN, Assimos DG (2013) Optimizing shock wave lithotripsy: a comprehensive review. Rev Urol 15(2):49–60
6. Al-Marhoon MS et al (2013) Extracorporeal shock-wave lithotripsy success rate and complications: initial experience at Sultan Qaboos University Hospital. Oman medical journal 28(4):255–259
7. Choi MJ, Coleman AJ, Saunders JE (1993) The influence of fluid properties and pulse amplitude on bubble dynamics in the field of a shock wave lithotripter. Phys Med Biol 38(11):1561–1573
8. Li WM et al (2007) Clinical predictors of stone fragmentation using slow-rate shock wave lithotripsy. Urol Int 79(2):124–128
9. Kang DH et al (2016) Comparison of high, intermediate, and low frequency shock wave lithotripsy for urinary tract stone disease: systematic review and network meta-analysis. PLoS ONE 11(7):e0158661–e0158661
10. Pace KT et al (2005) Shock wave lithotripsy at 60 or 120 shocks per minute: a randomized, double-blind trial. J Urol 174(2):595–599
11. Berwin JT et al (2009) Pain in extracorporeal shock wave lithotripsy. Urol Res 37(2):51–53
12. Oh SJ et al (2005) Subjective pain scale and the need for analgesia during shock wave lithotripsy. Urol Int 74(1):54–57
13. Zhong P, Zhou Y, Zhu S (2001) Dynamics of bubble oscillation in constrained media and mechanisms of vessel rupture in SWL. Ultrasound Med Biol 27(1):119–134
14. Yilmaz E et al (2005) Optimal frequency in extracorporeal shock wave lithotripsy: prospective randomized study. Urology 66(6):1160–1164