

EXTRACORPOREAL SHOCKWAVES LITHOTRIPSY (SWL): A PRACTICAL GUIDE FOR UROLOGISTS

AHMED R. EL-NAHAS

Urology Department, Urology and Nephrology Center, Mansoura University, Mansoura, Egypt

Abstract:

Introduction and Purpose: Extracorporeal shockwaves lithotripsy (SWL) is the treatment of choice for small non-complicated upper urinary tract calculi because of its non-invasive nature. This review is intended to provide practical guidance for urologists to optimize the use of SWL in clinical practice in order to achieve the maximum stone-free rate and minimize the incidence and severity of complications.

Methods: A PubMed search using the keywords SWL, extracorporeal shockwaves, and ESWL was conducted for articles published in the past 20 years. In addition, recent

international guidelines of urolithiasis were reviewed.

Results: All relevant research articles, reviews and metanalyses were read to construct a clinically oriented guidance for indications, contraindications, pre-SWL preparation, patients' management during and after SWL session, and methods to improve efficiency.

Conclusions: The keys to achieve best stone-free rates with minimal complications after SWL are proper patients' selection, adherence to guidelines recommendations to improve stone disintegration, and adequate follow-up till elimination of the stone fragments.

INTRODUCTION

Shockwaves lithotripsy (SWL) entails two stages, the first is stone disintegration and the second is elimination of the fragments. It is the only non-invasive stone disintegration treatment for urolithiasis. Therefore, it is preferred by many patients over minimally invasive treatment options like flexible ureteroscopy and percutaneous nephrolithotomy. The main disadvantages of SWL are the need for repeated treatment and lower stone-free rates compared with other minimally invasive methods.¹ It is crucial to properly select patients who will benefit from the non-invasive nature of SWL and achieve satisfactory stone-free rate in a single session of treatment. The second important pillar is to apply efficient techniques during an SWL session to maximize stone disintegration and minimize complications.²

Indications of SWL (According to international guidelines):^(1, 3)

1. Renal stones:

- Stone sizes less than 20 mm in any site of the kidney except lower calyx
- Stone sizes less than 10 mm in the lower calyx

2. Ureteral stones:

- Stone sizes less than 10 mm

Contraindications of SWL

1. Absolute Contraindications: (SWL should not be done for these patients)

- Pregnancy
- Obstruction distal to the stone site (calyceal diverticulum, UPJO, Ureteric stricture)
- Bleeding disorder (secondary to a disease such as ITP and hypoprothrombinemia or medications such as antiplatelets or anticoagulants).
- Uncontrolled hypertension.
- Untreated urinary tract infection (UTI).
- Arterial aneurysm near the stone
- Failure of stone targeting due to skeletal malformation (such as severe kyphoscoliosis) or due to morbid obesity (BMI >40 kg/m²).
- If there are more than one of the relative contraindications.

2. Relative Contraindications:

Many urologists prefer to avoid SWL for these cases because the results are not satisfactory. Despite there are some reports about doing SWL for these patients, we advise to use an alternative treatment other than SWL.

- Hard stones (calcium oxalate monohydrate, calcium phosphate and cysteine).
- Stone density >1000 HU on non-contrast CT (NCCT).⁴
- Lower calyx stones of 10-20 mm.⁵
- Obese patients (BMI >30 kg/m²) or skin to stone distance >10 mm.⁶

Pre-SWL work-up:

Proper patients' selection depends on:

1. History:

- a. Fever, UTI, Hypertension, liver disease, bleeding diathesis.
- b. Medications (antiplatelets, anticoagulants)
- c. Previous SWL and response to treatment
- d. Previous surgeries
2. **Examination:** pulse, temperature, and blood pressure
- a. SWL session should be postponed if there is fever or uncontrolled hypertension.
3. **Laboratory tests:**
 - a. Urine analysis and serum creatinine estimation are mandatory tests.
 - b. Urine culture and sensitivity can be done if there is suspicious of UTI because SWL session should be postponed till treatment of UTI.
 - c. CBC and INR can be done if there is suspicious of bleeding disorder. Flexible ureteroscopy should be done instead of SWL in patients with bleeding disorders.
4. **Radiological investigations:**
 - a. NCCT is the recommended radiological investigation because it shows stone size, site, density, skin to stone distance, renal anatomy, hydronephrosis, signs of renal infection and perirenal anatomy.
 - b. IVU can be done to show the pelvi-calyceal anatomy especially for lower calyx stones or there is suspicion of narrow calyceal neck.
 - c. KUB and ultrasound are not enough as pre-SWL radiological investigations.

Pre-SWL Preparations:

1. **All patients should understand the rationale for choosing SWL** for treating their stones and they should receive adequate information about advantages, disadvantages, and complications before SWL session.
2. **Prophylactic antibiotics are not recommended before SWL except in:**⁷
 - a. History of recently treated UTI.
 - b. History of recent instrumentations of the upper urinary tract.
 - c. Presence of stent or nephrostomy tube.
 - d. Diabetic patients.
 - e. Immune-compromised patients
3. **Ureteric stenting before SWL is not recommended [8,9]** because it did not affect the incidence of stricture formation in addition to the increasing patients' sufferings from the distressing symptoms of the ureteric stent. However, in patients with solitary kidney and large stone size (>10 mm), a pre-SWL ureteric stent can be placed.

During SWL session:

1. Pain control:

- a. Adults should receive adequate analgesia (such as non-steroidal anti-inflammatory drugs or opioids) to avoid pain induced movements during SWL session. Intravenous sedation can be added in anxious patients.¹⁰
- b. Children should receive general anesthesia before SWL session,

2. Stone localization:

Fluoroscopy is the most commonly used method for stone localization in the kidney or ureter. Localization should be done in two directions (postero-anterior and cephalocaudal). Ultrasonography is useful for radiolucent renal stones.

3. Patients' position:

Supine position is suitable for renal and upper ureteric stones because the shockwaves therapy head is applied to the flanks. In distal ureteric stones, the therapy head should be applied at the anterior surface of the lower abdomen. Therefore, the patient is placed in prone position. New SWL machines have movable therapy head that be applied to the anterior abdominal wall while the patient is in supine position.

4. Coupling:

The therapy head and the patient's skin should be adequately covered with gel to prevent formation of air pockets that lead to loss of shockwaves transmission from the machine to inside the body.¹¹

5. Power ramping:

The session should start at low power then every 100-200 shocks, the power is increased till reaching the desired setting for the machine. This gradual increase in power avoids excessive post-SWL bleeding because the low power stimulates vasoconstriction of the renal parenchymal vessels then when using high power, the bleeding is decreased.¹²

6. Shockwaves frequency:

A shockwaves frequency of 60 shocks/min (1 Hertz) had resulted in the best disintegration results. However, a frequency of 90 shocks/min (1.5 Hertz) can be used to shorten session time for each patient in hospitals with busy SWL schedules.¹³

7. Power limits:

In general, the power limits for children should be lower than for adults and the power limit for renal stones should be lower than that for ureteric stones. Every SWL machine has its own power limits.

8. Monitoring:

Monitoring that the stone is inside the focal area is important to ensure that shockwaves are applied to the stone to maximize disintegration and not to the renal parenchyma to minimize bleeding complications. Another advantage of monitoring is to know the power at which the stone is disintegrated to avoid unnecessary use of higher power. Ultrasonography allows for continuous monitoring while check fluoroscopy is done periodically.

9. Number of shocks per session:

The number of shocks in each session differs according to patients' age, stone location, and the machine characters.

- The maximum number in children is 2000 shocks/session
- In adults with renal stones, the maximum number is 3000 that can be 4000 shocks in certain machines.
- In adults with ureteric stones, the maximum number is 4000 shocks/session.

Post-SWL follow-up:

- Patients are allowed to go home after complete recovery from the sedation or anesthesia.

2. Instructions:

- Telling the patients that they may suffer from transient hematuria for one or two days and they may experience renal colic during passage of the stone fragments.
- Bed rest for one or two days until cessation of hematuria.
- Drinking plenty of fluids to be well hydrated because this will help in fragments elimination and decrease the severity and duration of hematuria.
- Explanation of the alarming symptoms and signs that require hospital visit for management. They include persistent hematuria, fever and intractable colic that did not response to medications.

3. Medications:

- Analgesics for pain control during passage of the stone fragments.
- Alpha blockers to facilitate fragments passage and shorten the time to stone-free.¹⁴
- Antibiotics in special situations mentioned before.

4. Radiological evaluation:

There is no specific interval between SWL session and radiological evaluation. However, if the fluoroscopy or ultrasonography showed stone disintegration during SWL session, radiological evaluation can be done after 2 weeks to give a

chance for fragment passage. If there was no response to SWL during the session, radiological evaluation can be after one or two days.

- KUB to determine disintegration of radio-opaque stones
- Ultrasonography for radio-lucent stone and for detection of post-SWL hydronephrosis due to obstructing steinstrasse.
- Low-dose NCCT is the preferred method for detection of the stone free status. It is better to be done after KUB and ultrasonography showed no residual stones because it will be the surest tool for declaring the patient free of stones. It can be done after one month for renal pelvis and ureteric stones and after three months for calyceal stones.

5. Repeated SWL sessions:

- Number of repeated sessions: If there is no stone disintegration after two SWL sessions, an alternative treatment is advised. If there is partial disintegration after two sessions, a third one can be applied to complete stone disintegration
- Intervals between sessions: In ureteric stones without disintegration after the first session, the second one can be after one or two days. For renal stones, the second session can be done after one or two weeks to allow for recovery of the renal transient changes after first session.¹⁵

Management of Complications:¹⁶

SWL is a non-invasive procedure, however, in rare cases significant complications necessitating hospital admission for treatment were reported.¹⁷

- Steinstrasse: Obstruction of the ureter with stone fragments after SWL.¹⁸
 - If there is complication such as fever, leukocytosis, increasing serum creatinine, or intractable pain, emergency renal drainage by ureteric stent or nephrostomy tube is recommended.
 - If there are no other complications, many treatment options can be done according to the size of fragments. They include SWL of a leading stone fragment, elective ureteroscopy for multiple coarse fragments, or MET for multiple small fragments.
- Persistent hematuria: If post-SWL hematuria persisted for few days, management depends on severity of hematuria. Severe hematuria with clots requires hospital admission, bed rest, hemostatic drugs (tranexamic acid),

continuous bladder irrigation, and blood transfusion if needed. Gross hematuria without clots can be treated conservatively.

3. **Hematoma:** Treatment of prerenal hematoma is conservative and follow-up after 3 months because most hematomas are resolved spontaneously.¹⁹
4. **Fever:** Post-SWL fever should be treated with appropriate antibiotics, antipyretics, and renal drainage if there is obstruction. Sepsis and septic shocks requires hospital admission and sometimes ICU management.

Post-SWL Residual Fragments:

1. The term clinically insignificant residual fragments (CIRF) is applied for calyceal fragments of ≤ 4 mm remaining for >3 months that did not cause infection, obstruction, or symptoms. These patients should be followed-up every three months for monitoring stone growth, development of symptoms or complications.²⁰
2. Calyceal residual fragment >4 mm, renal pelvis and ureteric residual fragments of any size should be treated.

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Address for correspondence:

Ahmed R. EL-Nahas
 Professor of Urology
 Urology and Nephrology Center,
 Mansoura University
 Elgomhoria street, Mansoura, 35516
 email: ar_el_nahas@yahoo.com
 Phone: +20502202222