Extracorporeal Shock Wave Lithotripsy for Treatment of Upper Urinary Tract stones

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Abstracts:

The continued evolution of stone treatment modalities, such as endourologic procedures, open surgery and shock wave lithotripsy, makes the assessment of continuous outcomes are essential. Urolithiasis are an important health problem all over the world, especially in Middle East region.

Keywords: Urinary Tract stones, Extracorporeal Shock Wave Lithotripsy, lithotomy.

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Introduction:

In the Past 25 years, there have been significant new technologic and treatment advances in the management of urinary stone disease. More specifically, new trends in the surgical management of urinary tract calculi have become prevalent. Ureteroscopy (URS), extracorporeal shock wave lithotripsy (SWL), and percutaneous nephrolithotomy (PCNL) have largely replaced open stone surgery (OSS) for the management of stone disease in the current era. All of the above- mentioned procedures can be utilized for treatment of upper urinary tract calculi. The choice of procedure depends on the efficacy of the procedure in rendering the patient stone-free, and the risks associated with performing the surgical procedure. In parallel, new data have emerged regarding medical expulsive therapy (MET) for stones. More specifically, use of alpha blockers and calcium channel blockers has been shown in multiple randomized trials to be effective in facilitating stone passage **(1).**

The widespread availability of newer treatment approaches has resulted in increasing complexity of decision making in the management of upper urinary tract calculi. Although the American Urological Association has published guidelines for the treatment of urinary calculi, considerable variations in practice still exist **(2,3).**

Expectant treatment

Observation of renal stones, especially in calyces, depends on their natural history. There is a prospective trial supporting annual observation for asymptomatic lower calyceal stones < 10 mm. Intervention is advised for growing stones > 5 mm per year or if became symptomatic. **(4)**

Prevention of renal stones

Dehydration is considered as a general risk of urolithiasis. Increased fluid intake to maintain hydration status is a long-standing and well-recognized recommendation for urolithiasis prevention. Note that the AUA, EUA, EAU and CUA consistently recommend to maintain the urine output >2.0–2.5 L/d with a fluid intake at 2.5–3.0 L/d. **(5)**

Obesity and overweight are also considered as risk factors for urolithiasis**.** EAU recommends weight loss to maintain the normal body mass index (BMI) to reduce risk of kidney stone disease (KSD). **(6)**

Several metabolic abnormalities, such as hypercalciuria, hyperoxaluria, hypocitraturia, hypomagnesuria, and hyperuricosuria, are the known risk factors for urolithiasis. So, dietary modifications may correct these metabolic abnormalities and prevent kidney stones. **(7)**

Table (1): Summary of medical therapy for prevention of urinary stone disease **(8).**

Agent	Rationale	Dose	Specifics and side effects	Stone type
Alkaline citrates	Alkalinization Hypocitraturia Inhibition of calcium oxalate crystallization	5-12 g/d (14-36 mmol/d) Children: 0.1-0.15 g/kg/d	Daily dose for alkalinization depends on urine pH	Calcium oxalate Uric acid Cystine
Allopurinol	Hyperuricosuria Hyperuricemia	100-300 mg/d Children: 1-3 mg/kg/d	100 mg in isolated hyperuricosuria Renal insufficiency demands dose correction	Calcium oxalate Uric acid Ammonium urate 2,8-Dihydroxyadenine
Calcium	Enteric hyperoxaluria	1000 mg/d	Intake 30 min before meals	Calcium oxalate
Captopril	Cystinuria Active decrease of urinary cystine levels	75-150 mg	Second-line option due to significant side effects	Cystine

Febuxostat	Hyperuricosuria Hyperuricemia	80-120 mg/d	Acute gout contraindicated, pregnancy, xanthine stone formation	Calcium oxalate Uric acid
L-Methionine	Acidification	600-1500 mg/d	Hypercalciuria, bone demineralization, systemic acidosis. No long-term therapy	Infection stones Ammonium urate Calcium phosphate
Magnesium	Isolated hypomagnesuria Enteric hyperoxaluria	200-400 mg/d Children: 6 mg/kg/d	Renal insufficiency demands dose correction. Diarrhea, chronic alkali losses, hypocitraturia	Calcium oxalate
Sodium bicarbonate	Alkalinization Hypocitraturia	4.5 g/d	N/A	Calcium oxalate Uric acid, Cystine
Pyridoxine	Primary hyperoxaluria	Initial dose 5 mg/kg/d - Max.20 mg/kg/d	Polyneuropathy	Calcium oxalate
Thiazide (Hydrochlorothiazide)	Hypercalciuria	25-50 mg/d Children: 0.5-1 mg/kg/d	Risk for agent induced hypotonic blood pressure, diabetes, hyperuricemia, hypokalemia, followed by intracellular acidosis and hypocitraturia	Calcium oxalate Calcium phosphate
Tiopronin	Cystinuria Active decrease of urinary cystine levels	Initial dose 250 mg/d Max. 2000 mg/d	Risk for tachyphylaxis and proteinuria	Cystine

Medical expulsive therapy (MET):

Medical expulsive therapy should only be used in informed patients if active stone removal is not indicated. Patients treated with α-blockers, calcium-channel blockers (nifedipine) and phosphodiesterase type 5 inhibitors (PDEI-5) (tadalafil) are more likely to pass stones with fewer colic episodes than those not receiving such therapy **(9)**

Interventional management of renal stones:

Extracorporeal Shockwave lithotripsy (ESWL), percutaneous nephrolithotomy (PNL), and ureteroscopy (URS) are suitable treatment modalities for renal calculi. Flexible URS has lower stone free rate (SFR) for stones >20 mm, and staged procedures are often required. Stones >20 mm should be treated primarily by PNL because ESWL often requires multiple treatments. ESWL is effective for stones ≤20mm, except for those at the lower pole, for which endourology is considered an alternative due to poor clearance post-ESWL. Open or laparoscopic approaches are possible alternatives if other treatment modalities fail or are not available **(8)**.

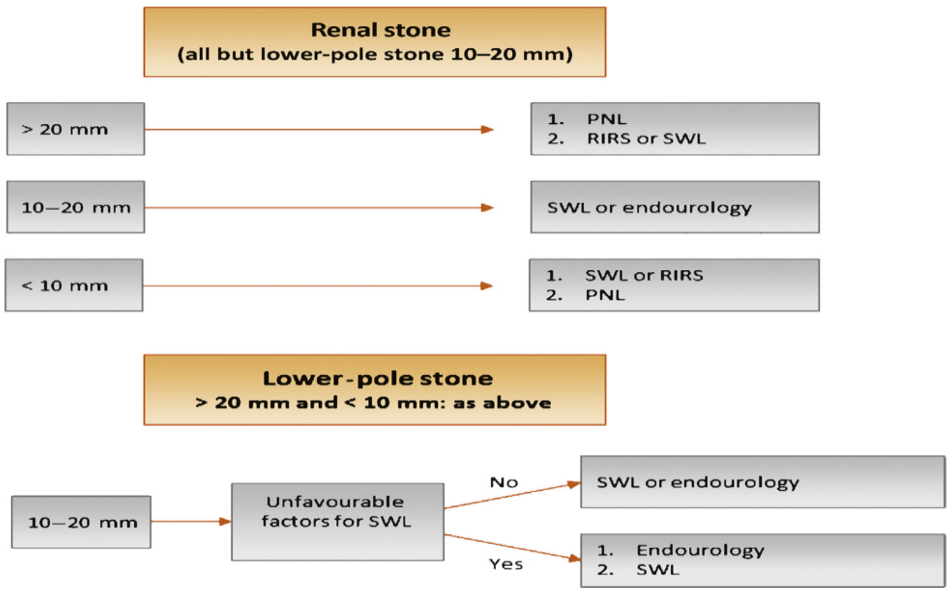

Figure (1): Treatment algorithm for urinary calculi **(8)**

Extracorporeal Shock Wave Lithotripsy (ESWL)

Shock wave lithotripsy (SWL), also referred to as extracorporeal shock wave lithotripsy (litho = stone, tripsy = "to crush"), is the use of shock waves to fragment urinary stones without the use of invasive techniques. It still is the only available non-invasive therapy to remove urinary stones **(10)**

ESWL has been a safe and effective non-invasive treatment option for nephrolithiasis since the early 1980s. Since then, lithotripter technology has been refined, and indications for ESWL have been widely used. It is an attractive option for patients as it provides a truly minimally invasive approach to achieve overall stone free rates (SFR) approaching 75%. **(11)**.

The Dornier HM3 extracorporeal shock wave lithotripter was the first clinical device of its kind. Commonly referred to as "the gold standard," it was the most used extracorporeal lithotripter for many years. **(12)**

ESWL is a noninvasive approach for treating stones using an extracorporeal lithotripter to target and transmit shock waves repeatedly to break up the stones and allow their evacuation from urine. However, there are concerns about the complications associated with high-energy shock waves. **(13)**

Extracorporeal lithotripters may differ in several aspects; however, all of them mainly consist of a shock wave source, that is, an electro-acoustic transducer, ultrasound and/or fluoroscopy imaging, a coupling device, and a patient treatment table. Most lithotripters are modular systems featuring shock wave coupling via a water cushion, multifunctional usage for diagnostics, and urologic interventions with an X-ray C-arm, image processing, and touch-screen user interfaces. **(14)**

Some lithotripters have localization systems that do not require a mechanical link to the therapy head. Furthermore, isocentric systems are popular, i.e., configurations where the shock wave beam axis and the X-ray or ultrasound beams have a common focus. In many lithotripters it is the patient treatment table that moves and not the shock wave source. X-ray transparent tables allow movement in all spatial axes to place the stone in the focus of the shock wave source. **(14)**

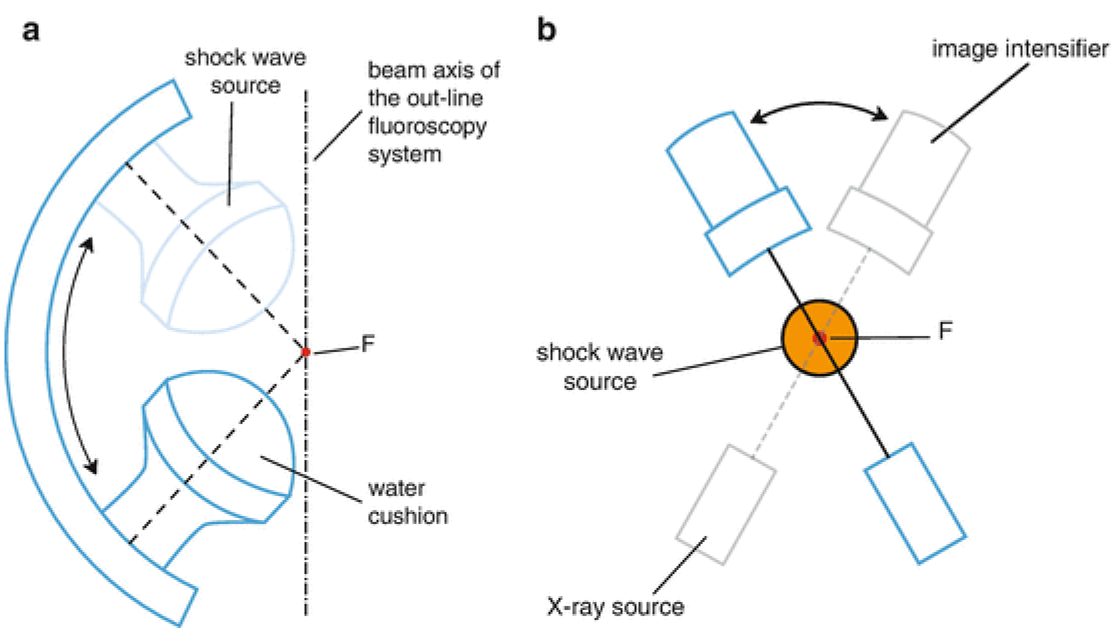

Figure (2): focusing of the shock wave source **(10).**

After aligning the system, properly positioning the patient and targeting the stone, shock waves are generated extracorporeally, enter the body with little attenuation through a water bath or a water-filled cushion, get focused on the stone, and fragment it. Normally several hundred to a few thousands of shock waves are needed to comminute a stone completely. In urological ESWL, stone debris passes through the urinary tract and the patient may return to his normal life in less than 48 h after shock wave treatment**.** The time to complete clearance of all fragments will depend on the stone size and location. Depending on the lithotripter, generally between approximately 2000 and 4000 shock waves are administered per session at a rate between 0.5 and 2 Hz (**15).**

Types of Shock wave generators:

A. Electromagnetic Lithotripters: -

A high voltage is applied to an electromagnetic coil, similar to the effect in a stereo loudspeaker. This induces high-frequency vibration in an adjacent metallic membrane. This vibration is then transferred to a wave-propagating medium (i.e., water) to produce Shock waves.

Advantages of the electromagnetic lithotripters are the wide range of energy that can be used as well as the long lifetime of the shock wave source (more than a million shock waves). Electromagnetic shock wave sources produce much less noise than electrohydraulic lithotripters. A prospective study done to evaluate Effects of ESWL on the hearing status of patients treated on an electromagnetic lithotripter and concluded that ESWL with this device does not cause harmful effects on the hearing function. **(16)**

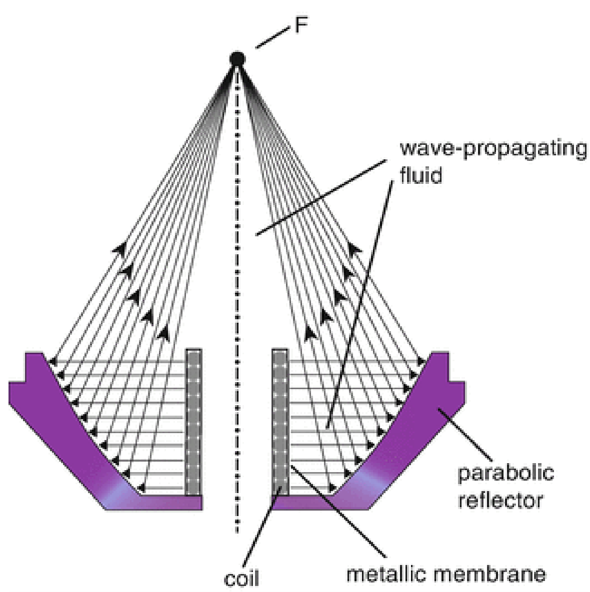

Figure (3): Schematic diagram of the cylindrical coil shock wave generator **(10).**

B. Piezoelectric Lithotripters: -

In 1880 the brothers Pierre and Jacques Curie demonstrated that application of mechanical stress to certain materials produces electricity, a phenomenon known as piezoelectric effect. Little later, Gabriel Lippmann mathematically deduced the converse piezoelectric effect, i.e., the conversion of a high-voltage peak into mechanical strain, which is used to produce pressure pulses for several biomedical applications. Common piezo-ceramics are barium titanate and lead-zirconate titanate. An important advantage of these materials is their long lifespan. When these elements are in contact with a fluid, their fast expansion produces a pressure pulse, followed by a tensile phase. **(17).**

Piezoelectric ceramics or crystals, set in a water-filled container, are stimulated via high-frequency electrical pulses. The alternating stress/strain changes in the material create ultrasonic vibrations, resulting in the production of a shockwave **(18).**

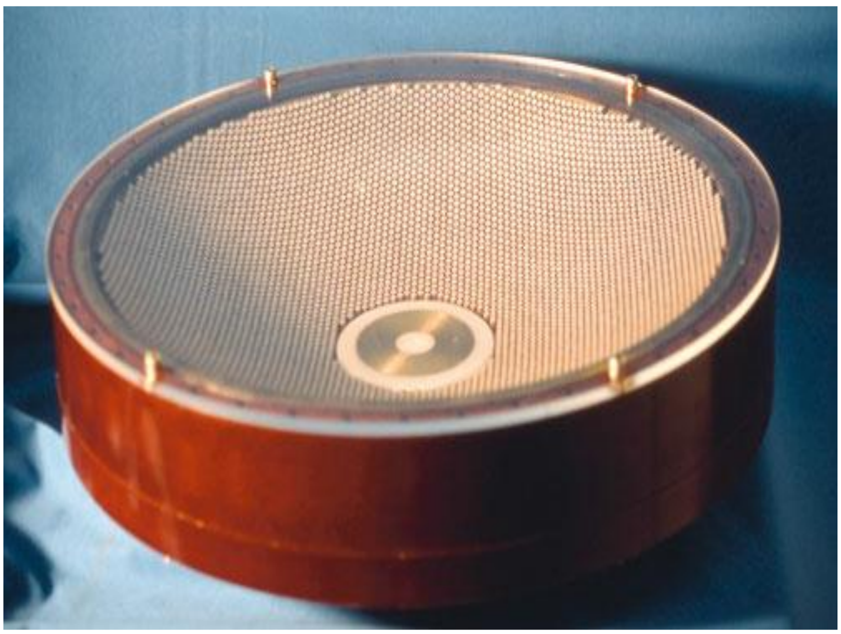

Figure (4): Piezo elements are arranged on a spherical bowel and activated simultaneously to generate a pulse wave**. Quoted from (19).**

C. Electrohydraulic Lithotripters: -

Spark-Gap Shock Wave Sources

Electrohydraulic shock wave generators produce underwater shock waves by electrical breakdown (15–30 kV) between two electrodes immersed in water, located at the focus (F1) closest to a Para-ellipsoidal metallic reflector. A high-voltage power supply stores the energy in a set of capacitors in order to abruptly discharge them across the underwater spark-gap by means of a trigger switch. Dielectric breakdown occurs and a fast-expanding plasma bubble is produced at temperatures of approximately 20,000 degrees Kelvin. This is accompanied by an intense emission of visible light and ultraviolet radiation. **(10)**

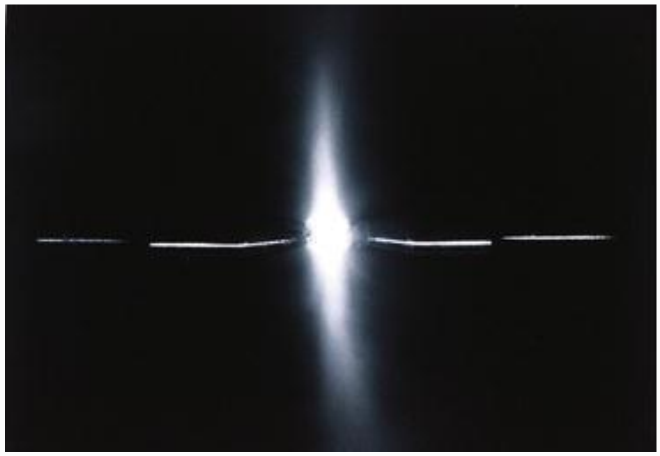

Figure (5): Photograph of a high-voltage discharge between two electrodes immersed in water. **(10).**

During a very short lag time, the current between the electrodes is low until the voltage at the spark-plug suddenly drops due to the electrical breakdown of the water. Depending on the properties of the water and the shape of the electrodes, the lag time can vary significantly from one discharge to the next. The plasma expansion generates an almost spherical shock front, which is isotopically radiated from F1 reflected off the reflector and focused on the second focus, normally referred to as F2**. (10)**

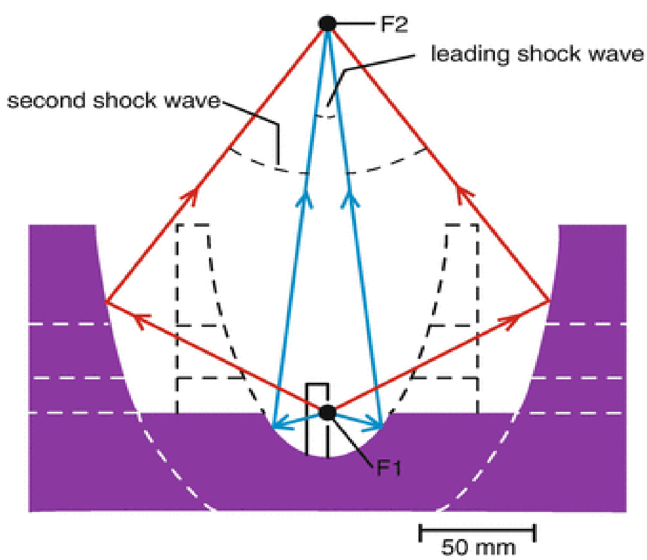

Figure (6): Schematic of a research electrohydraulic shock wave source with a double reflecting ellipsoidal surface **(20).**

Localization system of ESWL

Locating the Stone in Different axes, Table mobility is classified in x-, y-, and z-axis. Movement towards head and feet is defined as x-axis while lateral movement towards right and left is defined as y-axis and Vertical table movement is defined as z-axis **(21).**

The localization approach starts within the 0° projection. The goal is to position the stone in the center of the focus by adjusting all three dimensions x-axis (left-right), y-axis (head-feet) and z-axis (height-depth). Safe and precise stone localization in the 0°–30° plane required for successful ESWL. Prerequisite for a successful treatment is the safe and correct stone localization in both, the 0° and 30° camera position **(21).**

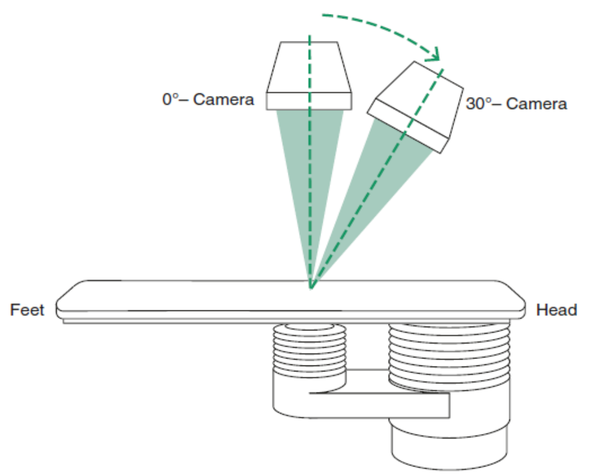

Figure (7): Camera position in 0° and 30°. Quoted from (**21**).

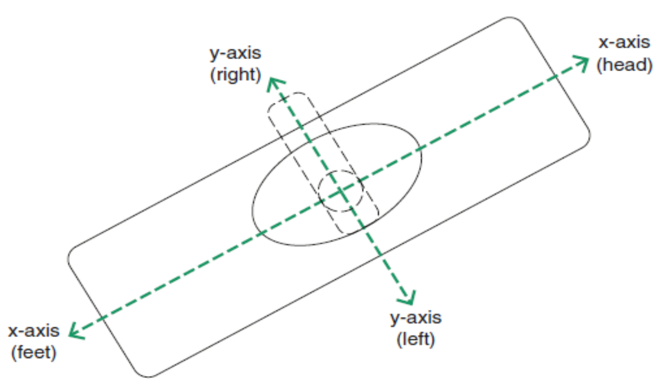

Figure (8): Defining x- and y-axis (**21**)

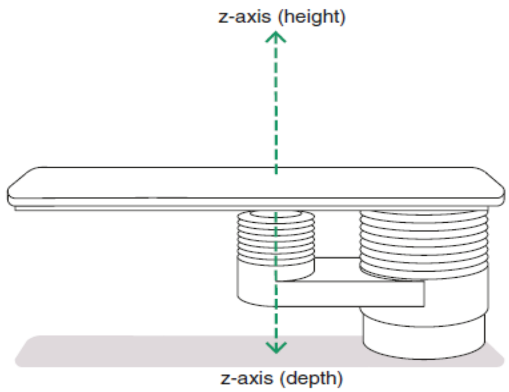

Figure (9): Defining z-axis **(21**)

Localization of calculi during shock wave lithotripsy is accomplished with either fluoroscopy or ultrasonography.

Fluoroscopy has the advantage of being more familiar to the urologist as well as increased ability to detect ureteral stones. The major disadvantages of fluoroscopy are increased risks of ionizing radiation exposure to the patient and to the surgical team and inability to identify radiolucent stones. It can localize radiopaque stones only. Automated fluoroscopic localization has been shown to decrease radiation exposure. **(22)**

Ultrasound can localize radiolucent calculi and has the advantage of real-time imaging and can detect ESWL complications as perinephric hematoma if occurred without x-ray exposure at a much lower cost than fluoroscopy. However, a highly trained operator is needed. U/S difficult to be used in morbid obese patients. Stones can also be obscured by an indwelling ureteric stent **(23).**

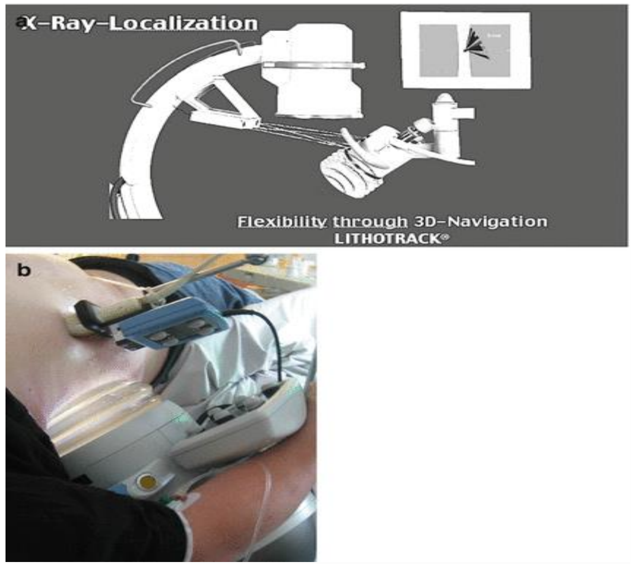

Figure (10): a) localization of renal stones by fluoroscopy b) localization of renal stones by fluoroscopy by ultrasound **(24)**

Figure (11): Use of color-coded duplex ultrasonography for localization of stones during ESWL. Quoted from **(24)**

- ✓ Radiolucent stones can be localized using intravenous injection or retrograde injection through a ureteric catheter. **(25)**

Combined system:

As the visualization and targeting of the non- or low-radiopaque stones seem to be difficult under fluoroscopic imaging, clinicians have mainly preferred sonographic guidance particularly in such cases. Based on the above-mentioned advantages and disadvantages of both modalities, combined use of these two methods has been proposed, designed and integrated in the new lithotripter systems to increase the accuracy of stone localization during ESWL. **(26)**

Risk factors limiting successful ESWL:

- The harder the stone, the worse the efficacy of treatment (degrees of hardness in decreasing sequence): Brushite (calcium hydrogen phosphate), cystine, calcium oxalate monohydrate, struvite, calcium oxalate dihydrate, uric acid. Hounsfield units of 1000 or more as confirmed by computed tomography may be detrimental.
- Calyceal neck anatomy may impair stone clearance. The following findings may be particularly unfavorable: long lower calyx portion (>1 cm), narrow calyx neck (<5 mm), and steep calyx angles.
- Anatomical abnormalities (e.g. pyelo-ureteral narrowness, horseshoe kidney), osseous deformities (e.g. scoliosis) or foreign matter (e.g. bone cement, endoprosthesis of the hip).
- morbid obesity resulting to large distance to the stone **(21).**

Optimization of ESWL

1. Shock rate

SFRs and risk of complications are associated with the shock rate of treatment. The optimal shock wave rate is not clear. Studies suggest that when compared to 120 shocks/min, ESWL at 60 to 90 shocks/min has better stone fragmentation and decreased risk of renal injury**. (27)**

2. Number of shocks

Excessive shockwave delivery may result in either renal injury or injuries to other organs. No past or current trials specifically define the ideal number of shocks per session. Furthermore, no specific recommendations for the total number of shockwaves (SW) per treatment have been given in ESWL guidelines. **(28)**

Each manufacturer provides advice for both maximum shockwave number and energy. The general upper limit for number of shocks is 4,000, although this number should be adjusted relative to the energy level used. Once fragmentation occurs, further disintegration may be limited due to attenuation from surrounding stone fragments. **(29)**

3. Ramping

In order to increase treatment effect and limit surrounding tissue damage protocols of ramping up the energy voltage at the beginning of the treatment or a series of low-energy pre-treatment shocks followed by a pause have been developed. By using a ramping protocol, it allows for anesthesia to better control pain which is important to prevent movement and subsequent decoupling of the shock head. When compared to a fixed voltage protocol ramping improves SFR, and also renal damage, as measured by urinary excretion of microglobulins, is decreased. In reported study, Ramping protocol cased statistically fewer ultrasound-detected renal hematomas (5.6%), compared with fixed power (13%). **(30)**

Although evidence of long-term and structural effects of lithotripsy is limited, it is known that hemorrhage may promote an inflammatory response, leading to nephron disruption, interstitial oedema, fibrosis and renal scarring. It is thought that ramping induces vasoconstriction; these stiffer vessels are less likely to bleed, preventing renal injury. **(31)**

Stepwise voltage ramping (500 SWs at 14 kV followed by 1000 SWs at 16 kV then 1000 SWs at 18 kV) was associated with a lower risk of renal damage compared with a fixed maximal voltage (2500 SWs at 18 kV) without affecting treatment effectiveness. Significantly fewer hematomas (detected by US) occurred in the ramping group (12/213, 5.6%) compared with the fixed group (27/205, 13%). **(30)**

4. Imaging and targeting

Regardless of the imaging modality used to target the stone, real time, in-line and frequent imaging is important to ensure the shocks are reaching their target. Increased fluoroscopy time has been associated with increased SFR. **(11)**

Excessive stone movement due to excessive respiration can lead to the stone migrating outside of the focal zone leading to decreased hit rate, therefore, it is important for repeat imaging to be performed throughout the treatment. Stone motion through the focus should not exceed 1 cm **(21)**

Ultrasound has become an increasingly important imaging modality for stone targeting as it reduces radiation exposure, allows for targeting of radiolucent stones and provides continuous real time monitoring of the procedure. **(32)**

5. Coupling

In order for the shocks to be effectively delivered, the energy produced by the shock head must transmit without impedance. inadequate coupling can occur when air pockets trapped during smearing semi-liquid gel impairing the acoustic energy transmission of shock waves and then significantly decreased effectiveness of stone disintegration **(33)**

Air pockets covering 1.5–19% of coupling area would decrease amplitude reduction of 20% in shock waves and even 2% air coverage could reduce stone disintegration rate by 20–40%. **(34)**

To avoid acoustic interference care should be taken to ensure that patients have optimal pain management thus preventing movement. Application of a generous amount of low viscosity coupling medium (gel) directly to the shock head can be beneficial. Optical Coupling Control (OCC) system, which equipped with an inline camera for air pockets observation, could help operator to repeat the coupling procedure and achieve less air-pockets coupling. **(34)**

6. Stone characteristics:

a. Stone location and burden

Stones in the lower pole, due to their position, are less likely to cleared due to poorer drainage of these dependent calyces. Supportive measures have been proposed to help improve clearance:

(I) Increasing urine production to 'flush out' fragments (diuresis).
(II) Using gravity to aid stone fragment passage by placing the patient in steep, prone Trendelenburg position (inversion).
(III) Using manual flank percussion to dislodge stone fragments through vibration. Patients typically undergo multiple sessions after ESWL treatment (percussion).

(31)

Staghorn calculi and stones larger than 2 cm in size are better served with more invasive procedures (such as PCNL), and are generally not recommended for treatment with ESWL. The ESWL has been the most used procedure for treating renal stones smaller than 20 mm in diameter due to its noninvasive nature, lower cost, fewer side effects, and faster recovery. **(35)**

b. Skin to stone distance

Obesity is increasing in the general population and is becoming more prevalent in stone formers. It can provide difficulties with on-table positioning, radiographic quality and in severe cases it can exceed the focal distance of lithotripters. Skin to stone distance of less than 10–11 cm has been shown to be an independent predictor of SFR following ESWL. Meanwhile, a higher body mass index (BMI >30 kg/m^2) is associated with decreased success. **(36)**

c. Stone composition

Stone composition has a significant impact on ESWL outcomes. Calcium oxalate monohydrate, cysteine, and calcium phosphate stones are relatively ESWL-resistant. Stones with mixed composition making them more amendable to fragmentation. Uric acid stones are quite "fragile" for ESWL, but can be challenging to target with fluoroscopy since they are radiolucent. Pyelography and ultrasound are options for real time targeting of radiolucent stones during ESWL. Assessment of stone passage post procedure will require either a computed tomography or ultrasonography for these patients. **(11)**

d. Stone density

Stone density is measured by the Hounsfield units (HU). In a prospective clinical trial, a linear relationship was demonstrated between HU and SFR. Stones that had a density <970 HU were significantly more likely to be successfully treated with ESWL compared to harder stones (98% vs. 38%). Patients should be counseled about lower ESWL success rates for stones with a density >1000 HU. **(37)**

Contraindications of ESWL:

1. Pregnancy

ESWL in pregnancy has been associated with many complications, including low birth weight, miscarriage, and placenta displacement. So, pregnancy is an absolute contraindication for ESWL. **(38)**

2. Aortic aneurysm

Patients with an aortic aneurysm are at increased risk of hemorrhage and rupture if they are treated with ESWL. **(39)**

3. Bleeding tendency

Patients who have a bleeding diathesis, or are on antiplatelet, antithrombotic, or anticoagulant drugs are at increased risk of bleeding. It is essential to stop these medications well before the procedure. In high-risk patients, if it is not safe to hold these medications, ESWL should be delayed, or alternative treatment plans (such as ureteroscopy) should be discussed with the patient as it can be performed in anticoagulated patients. **(40)**

In order to decrease the bleeding risk associated with anti-platelet therapy it is necessary to withhold these medications well in prior to the procedure. Some patients at particularly high risk may require bridging anticoagulation with heparin to minimize the period of time off anticoagulation**. (41)**

4. Untreated hypertension

Severe or untreated hypertension is a significant risk factor for bleeding and perinephric hematoma post ESWL and is an absolute contraindication. **(42)**

Diabetes, increased age, and obesity have also been associated with an increased bleeding risk**. (43)**

One of the most serious and feared complications of ESWL is the development of renal subcapsular hematomas. With this complication, that in most series fortunately does not occur more frequently than in approximately 1%, the blood loss is considerable and the effects on the renal function deleterious. Subcapsular hematoma is as a result of rupture of large vessels in the renal capsule. There is an increased risk for this complication in patients with high blood pressure**. (44)**

Figure (12): subcapsular hematoma on the left side after SWL **(45)**

5. Bacteriuria and Urinary tract infection (UTI)

Patients with infected stones, untreated urinary tract infections, or even bacteriuria are at an increased risk of pyelonephritis, bacteremia, and urosepsis if they are treated with ESWL. UTI should be treated before ESWL according to urine culture and sensitivity. **(46)**

Complications of ESWL:

1. Steinstrasse

One complication directly related to incomplete fragmentation is the pileup of fragments, otherwise known as **steinstrasse**, causing urinary tract obstruction. D'Addessi et al.

demonstrated that This complication appeared in 1–4% of patients, rising to 5–10% when the stone is >2 cm and to 40% where staghorn stones were present**. (47)**

The most common site of the steinstrasse (column of stone fragments obstruction) is the distal ureter (64%), followed by proximal ureter (29%), and mid ureter (8%), These days, refined extracorporeal shock wave lithotripsy technique has decreased the incidence of steinstrasse from 20% to 6% (**48**).

2. Renal effects

- Damage to the renal tissue can affect all parenchymal components. The degree of damage is linked to the level of energy and the number of shock waves delivered. **(49)**

- Almost all patients who undergo ESWL experience microhematuria and macrohematuria occurs in about 1/3 of patients. Macrohematuria is rarely severe, so in most cases does not require further medical interventions and resolves spontaneously within 12h. **(49)**

- **Renal hematomas** are rare and occur in <1% of patients who undergo ESWL and can be perirenal, subcapsular, or intrarenal hematomas. however, performing imaging after ESWL increases the frequency of hematomas by 20–25%. (**50)**

- Risk factors for development of post-ESWL renal hematomas were uncontrolled hypertension, anticoagulant or antiplatelet medications, old age, obesity, and large stone size. (**51)**

3. Extra-renal effects

- Extrarenal damage to the other organs is rare that includes perforation of the colon, hepatic hematoma, rupture of the hepatic artery, acute necrotizing pancreatitis, rupture of the spleen, rupture of the abdominal aorta, dissecting abdominal wall abscess, iliac vein thrombosis, pneumothorax, urinothorax. (**49)**

- Acute pancreatitis, associated with a significant increase in serum amylase and lipase levels have been reported following ESWL. (**52)**

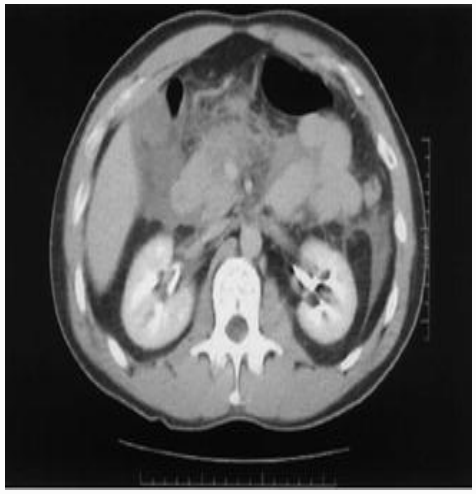

Figure (13): Contrast-enhanced CT scan of the abdomen demonstrating acute pancreatitis following ESWL … Quoted from **(52).**

1. Urosepsis

- Urinary tract infections are a common complication seen in up to 5% of patients treated with ESWL. Pyelonephritis or sepsis are rare, but are possible, particularly if patients with untreated bacteriuria (or untreated urinary tract infection) undergo ESWL. A **urinalysis** is mandatory before undergoing ESWL. If bacteriuria and pyuria are present (particularly with positive nitrites), patients should be treated based on **urine culture** sensitivities before undergoing ESWL. Particularly close attention needs to be paid to patients with a history of prior urinary tract infections, struvite stones, indwelling drainage tubes (foley catheter, ureteric stents, and nephrostomy tubes), diabetes, the elderly, immunosuppressed or immunocompromised state**. (53)**

2. Hypertension

- Several series have suggested that the incidence of hypertension following extracorporeal shockwave lithotripsy (ESWL) may be as high as 8%. The risk increased as the number of ESWL treatment sessions increased.

3. Radiation exposure

- Radiation exposure occur in fluoroscopy guided ESWL not US guided ESWL.
- Patients undergoing ESWL may receive a radiation dose between 30.1 to 162 mGy, depending on fluoroscopy exposure time that differs according to BMI, stone location, size & density. Radiation dose during ESWL can be measured by thermoluminescent dosimeter (TLD). To evaluate the entrance surface dose (ESD), each TLD chip is placed on back of patient at the entrance surfaces of the X-ray beam**. (54)**

4. Contrast Allergy

- Can occur during localization of radiolucent renal stones using fluoroscopy with contrast media guidance. Manifestations range from mild skin symptoms, such as urticaria, to anaphylaxis. Fatal anaphylaxis does occur with an estimated fatality rate of approximately 1 to 2 per 100,000 procedures. **(55)**

- Contrast media reactions can be prevented by a test dose for the intended contrast. Certain drugs can be used as a rapid prophylaxis of contrast allergy.

a) Hydrocortisone:

200 mg intravenously 5 and 1 hour before contrast injection

b) Diphenhydramine:

50 mg intravenously 1 hour before contrast injection (**56)**

Anesthesia and Analgesia in ESWL:

ESWL can be done in patients under either anesthesia (spinal, peridural or tracheal intubation) or analgesia. Successful treatment is generally based on shock waves transmitted to the desired target. Pain will lead to patient movements, which may result in shock waves hitting surrounding tissue rather than the stone. Anesthesia reduces this problem and, furthermore, permits the application of highest energy levels if necessary. Pain also leads to increased breathing movements, which may decrease the precision and efficacy of each individual shock wave. **(21).**

Table (2): Benefits of treatment under anesthesia compared to analgesia **(21)**

Benefits of treatment under anesthesia	Benefits of treatment under analgesia
Less patient movements → More shock waves reach target	**No anesthesia risk**
More consistent breathing movements → More shock waves reach target	
Higher maximum energy levels	
Entire therapy in one session	
Shorter fluoroscopy times	
Shorter treatment duration	

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