Extracorporeal Shock Wave Lithotripsy
Technical and Clinical Consideration

Essay

Submitted for Partial Fulfillment of Master Degree in Urology

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List of Abbreviations (Cont.)

AUA	American Urological Association.
BMI	Body Mass Index.
CIRFs	Clinically Insignificant Residual Fragments.
COD	Calcium Oxalate Di-phosphate.
COM	Calcium Oxalate Mono-phosphate.
CRP	C - Reactive Protein.
EAU	European Association of Urology.
ESR	Erythrocyte Sedimentation Rate.
ESWL	Extracorporeal Shock Wave Lithotripsy.
GFR	Glomerular Filtration Rate.
GI	Gastro-Intestinal.
HU	Hounsfield Unit.
IPA	Infundibulo-Pelvic Angle.
KUB	Plain x ray Kidney Ureter Bladder.
MAV	Mean Attenuation Value.
mpa	Maximum peak Pressure Amplitude.
NCCT	Non Contrast Computed Tomography.
NSAIDs	Non Steroidal Anti Inflammatory Drugs.
PNL	Percutaneus NephroLithotomy
SFR	Stone Free Rate.
THSWL	Twin Head Shock Wave Lithotripsy.
TSV	Total Stone Volume.
URS	Ureterscope.
WBC	White Blood Count.

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O

قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا
إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ
الْحَكِيمُ

صدق الله العظيم

سورة البقرة الآية

(٣٢)

Introduction

Since first presentation in West Germany in the early 1980s ***(Chaussy et al., 1984).*** After its introduction, extracorporeal shock wave lithotripsy (ESWL) dramatically changed the management of renal and ureteral calculous disease. It has remained the preferred method of treatment of renal lithiasis and proximal ureteral and midureteral stones for the past 20 years.

All lithotripsy machines share 4 basic components:

1. An energy source (shock wave generators): the shock wave may be generated by electrohydraulic, piezoelectric or electromagnetic energy.
2. Focusing system: In electrohydraulic systems, the principle of the ellipse is employed, in which a metal ellipsoid directs the energy that is created from the spark-gap electrode. In piezoelectric systems ceramic crystals are arranged within a hemispherical dish. In electromagnetic systems, either an acoustic lens or cylindrical reflector, used to focus shock waves.
3. Localizing or imaging system: commonly fluoroscopy and ultrasosongraphy are used to localize stones.
4. Coupling mechanism: to transmit the energy across the skin surface, through visceral tissues, and ultimately to the stone it self.

Newer machine often come with a multimodality treatment table that can be used for other urologic procedures ***(Auge and Preminger, 2002).***

The American Urological Association Stone Guideline Panel has classified ESWL as a potential first-line treatment for ureteral and renal stones smaller than 2 cm. Nevertheless, complex presentations frequently require endoscopic treatment ***(Lingeman et al., 2003).***

Technical improvements, such as synchronous twin-pulse technique with variable angles between the shock wave reflectors, have been attempted to increase the quality and rate of stone disintegration. In a study of 50 patients with renal or ureteral stones (mean size, 12.3 mm; range, 9-18 mm) undergoing the synchronous twin-pulse technique ***(Sheir, 2005),*** 17 patients (34%) were stone free, 20 patients (40%) had less than 5 mm residual stone< and 13 (26%) patients had residual stone of 6-9 mm at 14 days post-ESWL. Thirteen (26%) patients with greater than 5 mm residual stone underwent repeat ESWL. Post-treatment gross haematuria occurred in 50% of the patients on the day of treatment and resolved the next day. A comparison of this promising technique with conventional ESWL is awaited.

Sheir et al. (2003) evaluated the safety and efficacy of ESWL in patients with an anomalous kidney, including 49 patients with a horseshoe kidney, 120 patients with a malrotated kidney, and 29 patients with a duplex kidney. Two second-generation lithotriptors were employed. Although the type of renal anomaly and the type of lithotripter had no impact on the stone-free rate, stone length and number (stone burden) significantly influenced the stone-free rate. The prone position facilitated treatment in 38% of the patients with a horseshoe kidney and in 31% of patients with a duplex kidney. The overall retreatment success rate was 64.1%. However, with an overall stone-free rate of 72.2%. Sheir et al., deemed ESWL, for patients with an anomalous kidney, to be safe and reliable and to be considered the primary treatment option for stones smaller than 20 mm.

- **Future and controversies:**

Shock wave therapy is efficacious in treating urinary calculi. The mechanisms of action is based on pressure waves that, when focused onto a stone, fragment the stone into more easily passable pieces. Success rates, defined as becoming stone free or having residual fragments less than 4 mm in diameter are acceptable. However, future improvement of lithotripter design may increase success rates, decrease renal trauma, and increase patient comfort.

Controversy exists with some of the newer shock wave generators. The smaller focal zone and newer tabletop designs increase the indications for treatment and lower the anaesthetic requirements, but they may decrease overall efficacy of the treatment. Many newer generators require precise localization, with little margin for error in light of the greatly reduced focal zones. The focal zone of the original Dornier HM3 exceeded 2 cm, but most new electromagnetic generators have focal zones averaging only 6 mm. as a result, the operator must be more attentive and must actively compensate for respirator movements during treatment. On a positive note, however, less renal parenchyma is affected or damaged during treatment ***(Michael Grasso, 2006).***

Aim of the Work

The aim of the work is to review technical points regarding ESWL machine types and also techniques used in disintegration regarding the ideal stone, complication and side effects of ESWL will also be presented.

Shock Wave Generation

A-Shock wave source:

There are several types of shock wave generators available today, and lithotripters often are categorized on the basis of their energy source. There are three 1ry types of shock wave generators: electro hydraulic, electromagnetic, and piezoelectric sources. Another potential source is micro-explosive energy, but have not gained widespread acceptance as there is no commercially available lithotripter using this type generator ***(Lingeman et al., 2007).***

All shock wave generators are based on the geometric principle of an ellipse ***(Chow and Streem, 2000).***

- ***Electro hydraulic (spark gap) generators:***

In this type of generators shock wave is generated as spherically expanding wave from an under water spark gap electrode placed at one focus (termed F1) of an ellipsoid, focusing this wave onto a calculus at the other focus (termed F2) using a hemi ellipsoid reflector ***(Kim and Nadler, 2001).*** The clear advantage of this generator is its effectiveness in breaking stones, while disadvantages are substantial pressure fluctuations from shock to shock and relatively short electrode life ***(Cleveland et al., 2000a).***

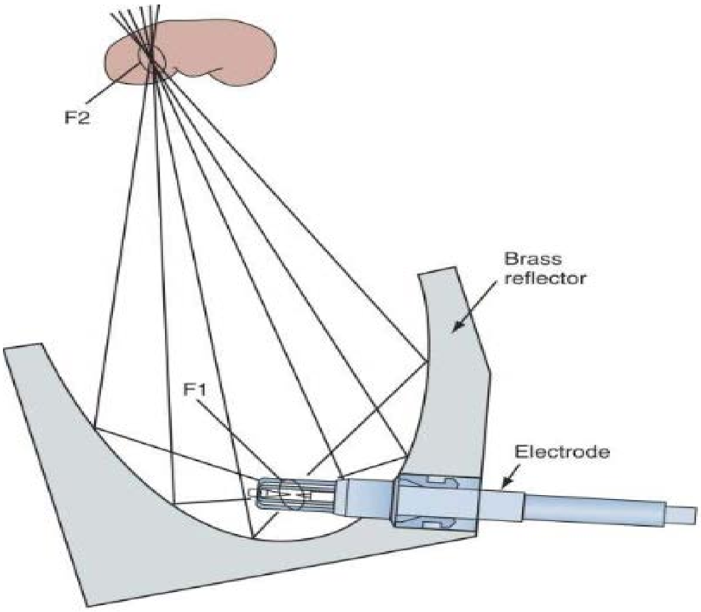

Fig. (1): Schematic view of an electrohydraulic shockwave generator. An electrode is used to generate a shockwave *(Lingeman et al., 2007)*.

- **Electromagnetic generator:**

This generator produces either plane or cylindrical shock waves. The plane waves are focused by an acoustic lens while the cylindrical waves are reflected by a parabolic reflector and transformed into a spherical wave ***(Chow and Streem, 2000).*** Electromagnetic generators are more controllable and reproducible than electrohydraulic generators because they do not incorporate a variable in their design such as the under water spark discharge. Other advantages include the introduction of energy into the patient’s body over a large skin area, which may cause less pain. In addition, a small focal pointy can be achieved with high energy densities, which may increase its effectiveness in breaking stones ***(Lingeman et al., 2007).***This generators will deliver several hundred thousand shock waves before servicing, thereby eliminating the need for frequent electrode replacement ***(Chow and Streem, 2000).***

A disadvantage of this design may be that the small focal region of high energy results in an increased rate of subcapsular haematoma formation ***(Dhar et al., 2004).***

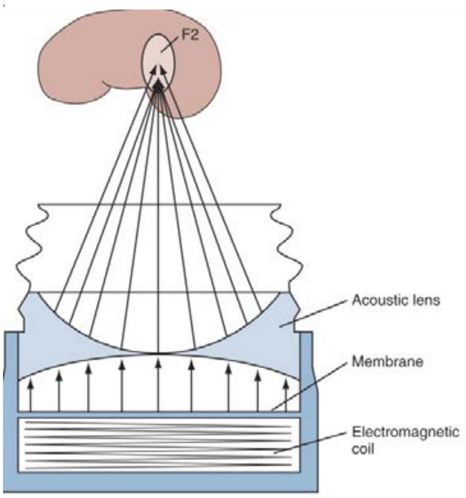

Fig. (2): Schematic view of an electro-magnetic shockwave generator that uses an acoustic lens to focus the shockwave. An electro-magnetic coil is used to generate the shockwave *(Lingeman et al., 2007).*

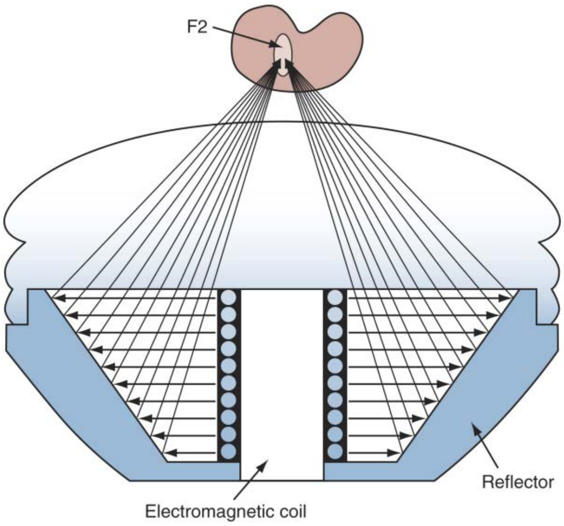

Fig. (3): Schematic view of an electro-magnetic shockwave generator that uses a parabolic reflector to focus the shockwave. An electromagnetic coil is used to generate the shockwave *(Lingeman et al., 2007).*