Current role of Extracorporeal Shockwave Lithotripsy (ESWL) in the treatment of urolithiasis and nephrolithiasis

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Abstract
ESWL is a non invasive modality for stone treatment based on shock wave therapy (SWT). It's an old technique but lost its popularity due to unsatisfactory and inferior results. This happened because of indiscriminate utilization of ESWL with respect to stone size, type and location etc. The older shock wave generators could disintegrate any stone but damaged the kidney and surrounding tissue as well. In twenty first century we have 4th generation highly powerful and efficient ESWL machines which are less traumatic, virtually painless and almost bloodless treatment modality for renal stones. It was thus concluded that ESWL is a minimally invasive treatment, that with an appropriate technique and patient selection achieves high effectiveness, thus maintaining an important role at this time. ESWL will remain first line treatment modality for nephrolithiasis and urolithiasis in well selected patients with limited stone burden.

Keywords: ESWL, Nephrolithiasis, Renal stones, Shockwave therapy, Urolithiasis.

Introduction
ESWL is a non surgical modality for stone treatment based on shock wave therapy. It's an age old technique and at the same time the most underutilized treatment modality in the complete urological armamentarium. Thirty five years back when the concept was laid by Prof. Chaussay in 1984, ESWL changed the entire scenario of kidney stones treatment.[1] With time it lost popularity due to unsatisfactory and inferior results. This happened because of indiscriminate utilization of ESWL with respect to stone size, type and location etc. The older shock wave generators like HM3 Dornier was a very powerful tool which could disintegrate any stone but damaged the kidney and surrounding tissue as well resulting into complications. This was another big reason for the dissatisfaction and loss of popularity of ESWL treatment. In twenty first century we have 4th generation highly powerful and efficient ESWL machines which are less traumatic, virtually painless and almost bloodless treatment modality for renal stones.

The principal of the ESWL treatment is rapid production of pulses of energy in the fluid environment from a source that result in generation of shock waves that form surfaces which fragment the material in their path. The uniqueness of shock waves lithotripter is in exploitation in shock wave focusing (Sturtevant et al 1996). The weak nonintrusive waves generated outside are transmitted through the body and targeted at a focal point to build sufficient strength to break the kidney stones.[2]

There are three main components of any lithotripsy machine:

1. Shock wave generator
2. Imaging modality
3. Lithotripsy Table.

The Shock wave generator is mainly three types –

Electro hydraulic (spark gap) generator (EHG): Discharge of underwater spark gap produces a gas bubble which expands with supersonic velocity. Its focal zone is large and develops high peak pressure. These machines are quite painful and highly damaging. The main disadvantage of this tool is significant pressure fluctuation from shock to shock and short life span of electrode, which needs frequent changing usually after two to three cases.

Electro Magnetic generator (EMG): In these machines metal membrane is lined on a spiral coil, when high voltage is applied to coil shock waves are generated which are either plane or cylindrical and focused by acoustic lens system. EMG is more

controllable and reproducible than EHG. Another advantage is shocks are delivered to the patient's body at larger skin area so it causes less pain and a small focal point can be achieved with high energy density to increase treatment effectiveness.

Piezoelectric generator (PEG): Several piezo - ceramic elements are mounted on to a spherical bowl and produce a self focusing device. Advantages are focusing accuracy, long life and almost painless procedure achieved. The only disadvantage is less effective stone fragmentation.

For imaging purpose an attached C arm and Ultra sonography (USG) machine can be used. USG can be easily attached with EMG that helps in focusing radiolucent stones and ureteric calculus very well. Also real time shock wave monitoring can be done easily.

Mechanism of Stone Comminution

Fragmentation of renal stone is done with shock waves due to mechanical stresses produced by them directly or indirectly by collapsing of cavitation bubble. There are several mechanisms described for stone disintegration like spall fracture, squeezing-splitting or circumferential compression (Eisenmenger 1998), shear stress or waves, super focusing because of stone geometry, cavitation and last dynamic fracture process.

Technique for successful outcome

Practically there are no definite standards regarding the quantification of clinical efficacy of shock wave therapy (SWT). Clayman et al 1996 introduced the term Efficiency Quotient (EQ) based on stone free rates at three months, retreatment rate and auxiliary procedures required. Fragility Index (Dretler et al 2003) that predicts SWT success based on stone size, stone location, radiographic appearance on KUB x-ray, CT attenuation value etc. The literature available has recommended 15mm size as optimal for SWT. Beyond this size, the success rate of the procedure and stone free rate diminishes and increases chances of auxillary procedures. Different types of stones show different response to SWT like calcium oxalate dihydrate, struvite, uric acid, apatite stones are considered as relatively softer stones than calcium oxalate monohydrate, cysteine and brushite stones. This also affects stone clearance. Stone density should be compared with 12^{th} rib. According to Mina S Krishanamurthy et al 2005, patient having stones bigger than 10mm and density more than 12^{th} rib exhibit less stone free rates.[3] Patients having stones more than 750 HU on CT scan have 10.5 times more chances of requiring three or more SWT sessions than patients having stone density less than 750 HU (N P Gupta et al 2005).[4] Change in window position of coupling also resulted in statistically significant improvement in the pattern of stone disintegration, from posterior to posterolateral to lateral after 500 shocks. According to Mahesh Desai et al 2004, stone clearance index depends on the infundibulo - calaceal anatomy which include infundibulo vertical angle, its width and length of infundibula. Stone clearance is more in short and wide infundibula with less acute infundibulo pelvic angle.[5]

Contraindication and Complications

There are certain rules for every game and the same holds good for ESWL as well. It is contraindicated in stone patients with pregnancy, severe skeletal deformity, aortic or renal artery aneurism, patient with urinary tract infection(UTI), severe obesity and in bleeding and coagulation disorders.

However, there are certain procedure related complications with SWT too. They are most commonly post procedure hematuria, UTI, pain, perinephric haematoma and steinstrasse etc. There are some rare side effects occurring more theoretically like hypertension in B/L SWT, diabetes in left kidney SWT, urinothorax, acute pancreatitis and chronic renal failure.

Review of Literature

In the current era SWT has its highest competition with RIRS and Mini Perc. These procedures are newer and technically demanding but some published literature that supports SWT treatment as first line. According to Yon Cui et al 2014, SWT treatment is first line treatment modality after a review of 160 patients with stone size 8mm to 15mm. Holmium laser lithotripsy was more costly.[6] Similar results were published by Alberto Budia et al 2016 stating that

ESWL treatment should be the first line of treatment due to its excellent stone clearance, cost effectiveness and being an outpatient procedure.[7] In another Meta analysis of 12 randomized and comparative studies published in 2017, it was concluded that ESWL is a minimally invasive treatment, that with an appropriate technique and patient selection achieves high effectiveness, thus maintaining an important role at this time.[8] After review of many more articles the take home message is to select proper patient for SWT treatment, keep the stone size <15mm, prior DJ stenting in bigger stones, avoid ESWL in stones >20mm size, don't do SWT in harder stones >1000 HU and exclude those patients who have stone in acute lower calyx or in calaceal diverticula. There are some procedure related precautions to lessen ESWL related complications like keep the number of shocks less <3000/sitting, avoid frequency <= 60/minute, don't accelerate voltage too fast as higher voltage damages more, advance generation ESWL machines are safer, avoid patient with pre existing renal impairment and pretreatment with 100-500 shocks at lower voltage.[9] Following these things we can improve stone clearance rate and safety of SWT along with decreased complications also.

Conclusion

Today, the stone patients are increasing day by day. All aspects of stone and patient should be weighed prior to selecting treatment option. In last two decades the treatment modalities is shifting from ESWL and open to PCNL and now towards URS and RIRS. Only experience can achieve the goal. Still ESWL will remain first line treatment modality for nephrolithiasis and urolithiasis in well selected patients with limited stone burden.

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Conflict of Interest

None.

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