Management of Urinary Tract Calculi by Extracorporeal Shock Wave Lithotripsy

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ABSTRACT

From July 1989 to April 1993, Extracorporeal Shockwave Lithotripsy (ESWL) was performed on 642 patients, of which 21 were from the pediatric age group. All treatments were done on a second generation lithotriptor-Siemens Lithostar, which does not require any modification for positioning of children. Fragmentation was achieved in all the patients (100%). A complete stone free rate was achieved in 17/21 patients (80.9%). Three (14.3%) patients had insignificant residual fragments whereas 1 (4.8%) had a residual fragment approximately 4 mm in size. 5640 shocks were required on an average. We have used low energy Shockwaves with good results! General anesthesia was required for lithotripsy in only one child. The average fluoro exposure time was 1.6 minutes. We conclude that ESWL is a safe and effective method for treating urinary tract calculi in children.*

Key words: *Extracorporeal Shockwave lithotripsy (ESWL), Calculi*

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Shock waves are high energy pressure fronts of multiple low frequency waves that rise sharply to peak in nanoseconds and then slowly decay(1). Being longitudinal waves, they can be reflected, refracted and focussed like the sound waves. Since shock waves are of low frequency, they are capable of penetrating tissues with little loss of energy, unlike high frequency waves, such as ultrasound. When moving from an area of low (body tissue) to high (stone) acoustic impedance, a significant dissipation of energy occurs resulting in a tensile force capable of breaking the stone. A similar force is generated when moving into an area of very low impedance (air in lungs). Shockwaves may be generated by any mechanism that provides for an abrupt release of energy. In lithostar, it is achieved by a sudden sharp movement of a membrane in an electromagnetic field.

Extracorporeal Shockwave Lithotripsy (ESWL) has for the first time provided **a** completely non-invasive technique for the management of renal ureteral and bladder calculi. It has swiftly gained worldwide acceptance as an effective and safe method in adults. Although several studies on a small number of children have demonstrated that ESWL can be used safely in young patients, its application to the pediatric population as a whole has been more gradual(2,3).

We report our results of ESWL treatment with Siemens' Lithostar in 21 children.

Material and Methods

Since commissioning of lithotripsy unit in our hospital in July 1989, till April 1993, we have carried out a total of 1185 sittings on 642 renal units. A total of 41 sittings have been used on 21 children. There were 12 boys and 9 girls. We have taken children up to the age of 17 years for our study as in other reported series. The youngest child was 4 years old and the average age was 10.7 years.

All patients were evaluated with plain films, IVU, urine analysis, urine culture and routine blood investigations including coagulation tests. A detailed metabolic work-up was also carried out in most patients. Retrograde pyelography was carried out only in those patients where better anatomical delineation was desired before double J stenting.

The treatment was individualized depending on the size, site and number of stones and presence of other associated problems like urinary tract infection, stone impaction, obstruction, state of renal function, congenital or acquired renal abnormalities.

In general, our criteria for selection of cases was as follows: *(i)* Stone size of 2.5-3 cm or less, single or multiple; *(ii)* Normal anatomy of pelvicalyceal system and ureter without distal mechanical obstruction; (*iii*) Radio-opaque stones; *(iv)* Sterile urine; and *(v)* Normal BT, PT and CT.

One child with a larger stone mass was accepted for ESWL after explaining the risks involved due to higher number of sittings and Shockwaves required.

The indications for pre-ESWL double-J stenting were: (i) Stone surface area greater than 40 sq mm (5 cases); (ii) Solitary functioning kidney (no case); (iii) Bilateral stone disease (no case); *(iv)* Presence of azotomia (no case); (v) Patients coming from great distances who could not report to emergency services in case required (one case); and *(vi)* In ureteric stone where there is no water chamber around the stone (preferably with a push back into the pelvis, (one case).

A maximum of 4,000 shocks were given in one treatment sitting. The strength of shocks used for pediatric patients was low, upto a maximum of 17.2 KV. Plain X-rays were taken after one day, three weeks and three months and whenever, else required. Barring our initial cases, we have been following the policy of providing a gap of at least two weeks between successive treatment sittings. This is required for renal functional changes to recover and fragments to pass. Fragments larger than 4 mm were treated with repeat ESWL.

All patients were admitted preferably one day prior to the procedure, and for next 24 hours following the procedure, unless indicated otherwise. General anesthesia was administered for pre ESWL stenting in all pediatric patients. The lithotripsy was carried out under light sedation. The stents were removed under local anesthesia. General anesthesia was required in one child for lithofripsy and in one child for removal of stent and stone fragments by ureterorenoscopy. An antibiotic was given to cover the period of lithotripsy and five days after. Close monitoring of radiation exposure was done during the procedure. Follow up has ranged from 3 months to 3 years.

Results

A total of 21 patients were treated. Of these, 18 had renal calculi, two had ureteral calculi and one had a bladder calculus. Fifteen out of 18 patients had a single stone, whereas 2 patients had 2 stones each and one had 3 stones. The stone size as calculated by multiplying length with width ranged from 48 sq mm to 1125 sq mm. With an average of 345 sq mm. Seven patients (33.3%) were subjected to pre-ESWL double J stenting. In six patients the indication was a large stone mass. The seventh patient came from a far off place and had two small stones. Nine patients (42.6%) could be tackled with a single sitting, eight patients (38.1%) required two sittings, three patients (143%) required three sittings and as many as seven sittings were required for one patient who still has a small 4 mm fragment. Three more patients (14.3%) have tiny residual fragments (<3 mm). Rest of the seventeen patients (80.9%) are totally stone free. The patients with ureteric and bladder calculi are free of stones. The shock wave requirement ranged from 1,600 to 25,400 with an average of 5,640 shocks per patient. This is more than our adult figure 5,175 shocks per patient. If the patient who required 25,400 shocks is excluded, the average falls down to 4,115 shocks. The total fluoro exposure time ranged from 0.4 min to 4.6 min with an average of 1.6 min which is equivalent to radiation exposure of an IVP. In terms of post-procedure complications mild hematuria was invariably noticed. No case of severe hematuria occurred and no blood transfusion was required. Mild fever was noticed in one child. In one child fragments got obstructed in the ureter and required ureteroscopjc retrieval.

Discussion

Urinary stone disease is relatively uncommon in the pediatric population and accounts for only 2 to 3% of all stone formers(4). In our series of 642 patients, it was 21 (3.2%). Any patient who has had even a single stone episode, has a very high chance of recurrence - approximately 50% over 5 years(5). For the pediatric patients who are at the beginning of their lives, it imposes a significant burden. Therefore, it is desirable that stone management should" involve the least traumatic procedure. This makes ESWL the preferred method of choice whenever applicable. Emphasis should also be placed on a detailed metabolic work up and institution of a life-long stone preventing regimen.

The fragmentation rate of stones in our pediatric patients was 100% compared to 98.2% for our adult patients. Children, perhaps have softer stones as compared to adults. This may also be due to a better shock wave transmission through the smaller body volume.

Overall stone free (80.9%) rate is better than our adult stone free rate of 70.2%. In our adult patients, 14.7% had significant residual fragments whereas in the pediatric patients, the same rate was less than 5% (1/21). This was despite larger stone size in our pediatric patients (3.45 sq cm versus 2.68 sq cm). The friable stone composition is responsible for rapid and uncomplicated clearing of fragments.

Earlier reports with first generation lithotriptors(2,3) revealed the need for technical adaptation to the device when focussing on children and confirmed the need for shielding the lungs when treating patients less than 135 cm tall or 30 kg in weight. With the second generation devices like the Lithostar treatment can be achieved without technical modifications used in suspension of the patient into the bath tub. There is no bath tub in the second generation lithotriptors. The Siemens' Lithostar has a shock tube with a water column in it which comes apd lies against the patient's body. The elimination of the bath tub has eliminated the need for general anesthesia for lithotripsy. Indeed, we have used general anesthesia for only our first pediatric patient.

Concerning the potential tissue damaging effects, one must consider the pressure amplitudes in the focal zones. The shock wave pressure should be high enough to disintegrate the stone. At the same time it should also be as low as possible to minimize tissue damage. In pediatric patients, the tissues are more delicate. Also, the intervening tissues between the point of entry of shock waves and the stone are less. This makes the Shockwaves more effective in stone disintegration as well as damaging tissues. *In vitro* studies have shown that the minimum level to initiate disintegration of urinary stones was approximately 200 bar. Kidney tissue damage can occur at 400 bar. The maximal pressure amplitude in the Lithostar is 380 bar at 19 KV. In our pediatric patients, the maximum strength that we have used is 17.2 KV and we tried to stay at < 16 KV wherever possible. In our patients we have not encountered any perirenal/renal hematoma compared to 0.4 to 0.6% in other series(2,6). Our stone fragmentation and clearance rates are comparable to the quoted series. We, therefore, recommend low energy shock waves for children.

The earliest clinical studies by Choussey(l) showed the lung to be extremely susceptible to the effect of shock wave therapy. Children are particularly vulnerable because of close proximity of the lung to the kidney. The gating of the shock wave delivery to respiratory cycle or ECG or both is available in most lithotriptors. We couple the shock wave delivery to the expiratory phase of respiratory cycle, thus reducing the chances of pulmonary damage and increasing the shockwave delivery to the stone. We have not encountered any case of hemoptysis or respiratory distress among our patients.

Coupling with ECG is done only if there is an underlying cardiac disease or ectopics occur during treatment. Only one child had ectopics during treatment, which subsided on stopping the treatment. Further treatment could be continued with EKG gating.

Skin ecchymosis at the site of shock wave entry is common both in adults and children and may be related to imperfect coupling between shock tube and the patients' body.

Another consideration in pediatric patients is radiation exposure and machines using ultrasonic guidance may appear to have an advantage. However, smaller fragments are difficult to visualize with ultrasonography. Use of ultrasound demands an experience with the use of ultrasonography, whereas most urologists are already familiar with the .Jf-ray images of stones, the total fluoro exposure in our patients of 1.6 min average is less than that of an IVP.

It is concluded that ESWL is a safe and effective method for treating urinary that calculi in children.

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