Slow vs Rapid Delivery Rate Shock Wave Lithotripsy for Pediatric Renal Urolithiasis: A Prospective Randomized Study

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Abbreviations and Acronyms

KUB = plain x-ray of kidney, ureters and bladder

PCNL = percutaneous nephrolithotomy

SWL = shock wave lithotripsy

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Study received institutional review board approval.

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Purpose: We compared slow vs fast shock wave frequency rates in disintegration of pediatric renal stones less than 20 mm.

Materials and Methods: Our study included 60 children with solitary 10 to 20 mm radiopaque renal stones treated with shock wave lithotripsy. Patients were prospectively randomized into 2 groups, ie those undergoing lithotripsy at a rate of 80 shock waves per minute (group 1, 30 patients) and those undergoing lithotripsy at a rate of 120 shock waves per minute (group 2, 30 patients). The 2 groups were compared in terms of treatment success, anesthesia time, secondary procedures and efficiency quotient.

Results: Stone clearance rate was significantly higher in group 1 (90%) than in group 2 (73.3%, $p = 0.025$). A total of 18 patients in group 1 (60%) were rendered stone-free after 1 session, 8 required 2 sessions and 1 needed 3 sessions, while shock wave lithotripsy failed in 3 patients. By comparison, 8 patients (26.6%) in group 2 were rendered stone-free after 1 session, 10 (33.3%) required 2 sessions and 4 (13.3%) needed 3 sessions to become stone-free. Mean general anesthesia time was significantly longer in group 1 ($p = 0.041$). Postoperatively 2 patients in group 1 and 4 in group 2 suffered low grade fever (Clavien grade II). Significantly more secondary procedures (percutaneous nephrolithotomy, repeat shock wave lithotripsy) were required in group 2 ($p = 0.005$). The predominant stone analysis was calcium oxalate dihydrate in both groups. Efficiency quotient was 0.5869 and 0.3437 for group 1 and group 2, respectively ($p = 0.0247$).

Conclusions: In children with renal stones slow delivery rates of shock wave lithotripsy have better results regarding stone clearance than fast delivery rates.

Key Words: high-energy shock waves, kidney calculi, lithotripsy, pediatrics, urolithiasis

Urolithiasis constitutes an important part of our practice.[1] The introduction of shock wave lithotripsy during the early 1980s dramatically changed the management of urinary tract stones. During the last 2 decades the development of new lithotripters has changed completely the way in which patients with stones are treated.[2,3] Epidemiological studies have revealed an increase in the incidence of pediatric stones worldwide.[4] It is accepted that pediatric patients have increased clearance rate of stones compared to adults.[5]

Shock wave lithotripsy was first successfully used in children in 1986,[6] and is now considered first-line treatment for the management of pediatric stones of the upper urinary tract.[7–9] In adults stone disintegration during SWL has been

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improved by slowing the rate of delivery. Consequently slow rates of SWL have contributed to better treatment options.[10,11]

Few studies have focused on the relation of the frequency rate of shock wave delivery to renal stone clearance in adults.[10–12] To our knowledge no previous study has been published comparing slow vs fast shock wave frequency rates in pediatric urolithiasis except 1 abstract presented in 2001.[12]

We compared slow and fast shock wave frequency delivery rates in disintegrating pediatric renal stones smaller than 20 mm and the impact on stone clearance. Terms of comparison included treatment success, anesthesia time, secondary procedures, costs and efficiency quotient.

PATIENTS AND METHODS

A total of 60 patients with a mean ± SD age of 5.56 ± 3.54 years (range 3 to 14) presenting with solitary radiopaque renal stones (10 to 20 mm) between August 2011 and July 2012 were included in the study. Patients were recruited from the outpatient clinic and were prospectively randomized (envelope method) into 2 groups. Group 1 consisted of 30 patients undergoing SWL at 80 shock waves per minute and group 2 included 30 patients undergoing SWL at 120 shock waves per minute. We chose these rates based on previous studies using either rate separately in adults, young adults and children, which had proved safe. Also ungated SWL proved to be safe in children.

Exclusion criteria consisted of multiple stones, moderate or severe hydronephrosis, active infection, coagulopathy, stone size less than 10 mm or more than 20 mm, bilateral renal stones, radiolucent stones, anatomical abnormality in the ureter or ureteropelvic junction, cardiac pacemaker and uremia. Preoperative imaging included ultrasound, KUB and/or excretory urography. Maximum longitudinal diameter (length) was used to reflect the size of the stone.

The study received institutional review board approval, and parents gave informed consent after proper counseling. All selected patients fulfilling the inclusion criteria were treated with SWL using the Dornier Lithotripter S (Dornier Medical Systems, Kennesaw, Georgia) with the 220 electromagnetic shock wave emitter. Fluoroscopy was used for stone localization.

The procedure was done with patients under general anesthesia. Intravenous fluids were administered throughout the procedure. All children underwent lithotripsy using the same device with a gradual incremental energy increase from 14 to 20 kV. We usually start by low amplitude initially and increase it gradually from 14 to 24 kV, except that in children younger than 4 years we increase it to only 18 kV to reduce the possibility of renal tissue injuries. Maximum number of shock waves delivered was 2,500, except if complete fragmentation was evident on fluoroscopy screen before reaching 2,500 shock waves.

Patients were kept under observation for 3 hours until fully conscious and urine was relatively clear of blood. On discharge from the hospital the parents were instructed to maintain adequate fluid intake in their children, in general 1 to 2 cc/kg per hour according to body weight.

An analgesic (diclofenac pediatric suppository) was prescribed on discharge home. Parents were also instructed to check for expected hematuria and passage of stone fragments, and to report if the child had a fever or colic.

Stone fragments were collected for chemical stone analysis. Patients were reevaluated with KUB and abdominal ultrasound 2 and 4 weeks after the SWL session. Those who had sizable fragments were scheduled for another session 3 weeks later. The maximum number of sessions allowed for our patients was 3.

Primary outcome measure was stone-free rate (success rate), while secondary outcome measures included anesthesia time and repeat treatment rate, complications, secondary procedures, cost and efficiency quotient.

Stone-free rate was defined as no residual fragments or only 1 clinically insignificant fragment (less than 3 mm, which was nonsymptomatic, noninfectious and nonobstructive) on KUB and ultrasound. Unsuccessful SWL was defined as lack of evidence of disintegration or fragmentation on KUB and ultrasound after 3 SWL sessions.

Data were statistically described in terms of mean ± SD and range, or frequency (number of cases) and percentages when appropriate. Comparison of numerical variables between the 2 groups was done using the Student t-test for independent samples. For comparing categorical data chi-square testing was performed, with the Fisher exact test used when the expected frequency was less than 5.

All p values less than 0.05 were considered statistically significant. All statistical calculations were done using SPSS®, version 15 for Windows®.

RESULTS

Table 1 shows demographic data and outcomes for the 2 groups. The groups were comparable in terms of age, male-to-female ratio, stone size, stone site and total number of shock waves administered.

The success rate in group 1 was 90%, with success in 27 patients and failure in 3, compared to a 73.3% success rate in group 2, with success in 22 patients and failure in 8. A total of 18 patients in group 1 were rendered stone-free after 1 session, 8 needed 2 sessions and 1 needed 3 sessions, while SWL failed in 3 patients. By comparison, 8 patients in group 2 required 1 session, 10 required 2 and 4 needed 3 sessions to become stone-free, with 8 failing SWL. Mean time of general anesthesia was significantly longer in group 1 (table 1).

Postoperatively 2 patients in group 1 and 4 in group 2 suffered low grade fever (Clavien grade II). Subcapsular hematoma or significant hematuria was not reported in either group. No arrhythmia was detected during SWL sessions. The 11 cases that failed SWL (3 in group 1 and 8 in group 2) subsequently were managed by PCNL. Number of repeat treatments and secondary procedures (PCNL or