Effect of Extracorporeal Shock Wave Lithotripsy on Kidney Growth in Children

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Abbreviations and Acronyms

DMSA = dimercapto-succinic acid

SWL = shock wave lithotripsy

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Purpose: We investigated whether shock wave lithotripsy affects kidney growth in children.

Materials and Methods: This prospective controlled study included 150 children with renal stones who presented for shock wave lithotripsy between March 2005 and February 2010 (group A). The control arm included 100 children without any urological problems who were enrolled in the study after obtaining written maternal consent (group B). All children in both groups underwent abdominal ultrasound to assess renal size (bipolar renal length), which was repeated after 6 months for group A and after 1 year for both groups.

Results: Bipolar renal size in group A increased significantly at 6 months and 1 year after shock wave lithotripsy. Renal growth did not differ based on patient age at shock wave lithotripsy ($p = 0.472$), number of shock wave lithotripsy sessions ($p = 0.65$) or number of stones ($p = 0.405$). There was no significant difference between the rate of kidney growth in children who underwent shock wave lithotripsy during the year of the study and normal controls.

Conclusions: Shock wave lithotripsy has no deleterious effect on the normal rate of renal growth in children. This outcome is not affected by either the number of stones or the age of the child at shock wave lithotripsy.

Key Words: cicatrix, kidney calculi, lithotripsy, radionuclide imaging, ultrasonography

Shock wave lithotripsy has been used as an efficient therapeutic modality for upper urinary tract stones in children.[1,2] The question that arises in the minds of the parents is, is shock wave lithotripsy safe for my child? It is well known that any insult affecting the growing kidneys of children might affect development. The safe application of shock wave lithotripsy includes not only the absence of any effect on kidney function, but also the absence of any renal growth retardation. In a previous study we documented the safety of shock wave lithotripsy on renal function by excluding the presence of renal parenchymal scarring or effect of glomerular filtration rate after shock wave lithotripsy.[3] In that study we tried to determine the effect of shock wave lithotripsy on the growth of pediatric kidneys, and whether stone burden and number of shock wave lithotripsy sessions might have an impact.

PATIENTS AND METHODS

This prospective controlled study included 150 children 3 to 14 years old with renal stones who presented to the shock wave lithotripsy unit at our institution between March 2005 and February 2010 (group A). Exclusion criteria consisted of renal scarring due to previous surgery or vesicoureteral

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reflux, bilateral renal stones, radiolucent stones and compromised function on the affected side due to long-standing obstruction. The control arm included 100 children of the same age without any urological problems who volunteered to participate in the study (group B). We were cautious in selecting the children for the control group. Any child with a long-standing debilitating disease was excluded from the study. The pediatricians were consulted about every case before the children were included in the study as controls. All children in the control group presented complaining of acute illness, mostly acute episodes of chest infection or acute diarrheal disease. After the children were completely cured of the presenting illness, the parents were invited to have the children participate in the study.

All children in group A underwent abdominal ultrasound to assess bipolar renal size together with DMSA renal scan, plain x-ray of the kidneys, ureters and bladder, and excretory urography before extracorporeal shock wave lithotripsy. Ultrasound and DMSA scan were repeated 6 months and 1 year after SWL to assess the size of the kidney and to exclude the presence of scarring. Children in group B were evaluated by ultrasound to assess renal size, which was repeated after 12 months. Renal size in both groups was measured in the longest dimensions of the kidney from the upper to the lower pole (bipolar dimension) by the same operator using the same ultrasound device (Sonoline™).

All children with renal stones (group A) underwent lithotripsy using the Lithotripter S (Dornier MedTech, Wessling, Germany). Fluoroscopy was used for stone localization. The procedure was done with patients under general anesthesia using 1.5 mg/kg ketamine and 0.05 mg/kg midazolam. Small children required placement of tape under the body for suspension. The water cushion was adjusted according to body configuration.

Patients were reevaluated by plain radiography and abdominal ultrasound 2 and 4 weeks after the SWL session. Those who had sizable fragments were scheduled for another session 4 weeks later. The maximum number of sessions allowed for our patients was 3, and those who did not become stone-free were scheduled for percutaneous nephrolithotomy.

SWL was considered successful if patients were rendered stone-free. Unsuccessful SWL was defined as lack of evidence of disintegration or fragmentation on plain radiography and ultrasound after 3 SWL sessions.

SPSS®, version 15.0 for Windows was used for data management and analysis, and Microsoft PowerPoint® was used for charts. Qualitative data were expressed as frequency and percentage. Quantitative data were reported as mean ± SD. For comparison of 2 means in paired samples the paired t test was used. The p value was considered significant if 0.05 or less and highly significant if 0.01 or less. For comparison of mean age and kidney size in groups A and B an independent sample t test was used as the data were parametric. The general linear model repeated measures procedure was used for ANOVA as the same measurement was made several times in each subject or case.

RESULTS

Group A included 96 boys (64%) and 54 girls (36%). Mean patient age was 7.8 years (range 3 to 14). A total of 117 children (78%) had a single renal stone, 23 (15.3%) had 2 stones and 10 (6.7%) had 3 stones in the same kidney. The number of stones managed by SWL in this study was 193, and mean stone size was 12.85 mm (range 8 to 29).

A mean of 2,000 shock waves were administered per session (range 800 to 2,600). Mean power used per session was 17 kV (range 14 to 20). Of the patients 65.3% required 1 session, 26% required 2 sessions and 8.7% required 3 sessions of SWL. Number of SWL sessions was directly proportionate to the number of stones. Of children with 1 renal stone 94 (80.3%) required 1 session, 21 (17.9%) required 2 sessions and 2 (1.7%) required 3 sessions of SWL. Of children with 2 renal stones 4 (17.4%) required 1, 17 (73.9%) required 2 and 2 (8.7%) required 3 sessions of SWL. No child who had 3 renal stones could be rendered stone-free with 1 SWL session. Of these patients 1 (10%) required 2 sessions, while the majority (9 children, 90%) required 3 sessions. Overall stone-free rate was 92%.

Of the 100 controls (group B) 93 completed followup, compared to 147 patients undergoing SWL (group A). All patients in group A underwent urinalysis and blood pressure measurement before the first session. These tests were also repeated at 4 weeks, 6 months and 1 year. No patient had significant proteinuria or hypertension.

Complications were encountered in 13 patients (8.6%). Nine patients (6%) presented with renal colic associated with passage of stone fragments and 3 (2%) presented with impacted lower ureteral stones with subsequent uncomplicated hydronephrosis that required ureteroscopy after failure of medical therapy. One 6-year-old child required hospitalization for high grade fever (39C) with no renal back pressure changes and was managed conservatively. No frank hematuria (requiring hospitalization), ecchymosis or perirenal hematoma was detected by ultrasound in any patient.

All children underwent DMSA renal scan before SWL, and at 6 months and 1 year after the last session. As mentioned previously, no patient had renal scarring before SWL. Cases of residual stones after the third session (8%) were considered SWL failures, and percutaneous nephrolithotomy was planned. No patient in the study exhibited any degree of renal scarring on DMSA scan after SWL.

All patients underwent abdominal ultrasound to determine bipolar renal length by the same operator using the same ultrasound device before SWL, and 6 months and 1 year later. Mean ± SD bipolar renal length was 8.46 ± 0.749 cm (range 7 to 10.2) before SWL, 8.62 ± 0.742 cm (7.2 to 10.3) 6 months after SWL and 8.81 ± 0.742 cm (7.5 to 10.3) 1 year after SWL. Three patients were lost to followup 1 year after SWL (table 1). By comparing the bipolar renal length before SWL and 6 months and 1 year postoperatively, we found that bipolar renal length progressively increased and the increase was statistically significant ($p = 0.00$, table 2).

Patients in group A were stratified into 3 age groups (up to 5 years, 6 to 10 years and older than 10 years) to determine whether age at SWL might affect renal growth (ie younger children undergoing SWL might have renal growth insult, while older ones might not). For each group we compared renal size before SWL, and 6 months and 1 year postoperatively. Then we compared renal size at 6 months and 1 year after SWL in each group. We found that there was no significant difference between renal growth rates of the 3 age groups ($p = 0.472$). Similarly there was no statistically significant difference in renal growth in patients undergoing 1 vs 3 SWL sessions ($p = 0.65$) or those who had 1 vs 3 stones ($p = 0.405$).

Group B included 100 normal children without urological problems. Of the patients 70 were boys and 30 were girls. Mean age was 7.96 years (range 3 to 16). Mean ± SD renal size at the beginning of the study was 8.5 ± 0.72 cm (range 7.1 to 10.2). At 12 months mean ± SD renal size was 8.9 ± 0.73 cm (range 7.6 to 10.4). In this group bipolar renal size had increased significantly at 1 year ($p = 0.00$).

By comparing groups A and B, we found that both groups matched regarding patient age. We also found that there was no statistically significant difference between rates of kidney growth in children undergoing SWL throughout the year of the study and normal controls.

Table 1. *Patient characteristics*

Mean ± SD age (yrs)	7.80 ± 3.11
No. gender (%):	
M	96 (64)
F	54 (36)
Mean ± SD renal size (cm)	8.46 ± 0.75
No. stones (%):	
1	117 (78)
2	23 (15.3)
3	10 (6.7)
No. SWL sessions (%):	
1	98 (65.3)
2	39 (26)
3	13 (8.7)
No. stone-free (%)	138 (92)
No. complications (%)	13 (8.6)

Table 2. *Comparison of renal size by age*

	No. Pts	Mean ± SD cm Renal Size (range)
5 Yrs or younger:		
Preop	40	7.6088 ± 0.30422 (7.00–8.20)
6 Mos postop	40	7.7775 ± 0.30675 (7.20–8.30)
12 Mos postop	40	7.9725 ± 0.31296 (7.50–8.50)
6-10 Yrs:		
Preop	78	8.4551 ± 0.36419 (7.70–9.40)
6 Mos postop	78	8.6218 ± 0.36809 (8.00–9.50)
12 Mos postop	76	8.8237 ± 0.39661 (8.00–9.60)
Older than 10 yrs:		
Preop	32	9.5375 ± 0.32304 (9.00–10.20)
6 Mos postop	32	9.6906 ± 0.30518 (9.20–10.30)
12 Mos postop	31	9.8645 ± 0.27634 (9.30–10.30)

DISCUSSION

This prospective controlled study assessed the safety of SWL and its effect on renal growth in 150 children 5 to 14 years old with renal stones compared to 100 age matched controls. Mean stone size was 12.85 mm (range 8 to 29). Following treatment of 193 stones, 92% of patients became stone-free. Our stone-free rate was higher than the rates reported by Brinkmann[4] (83%) and Rizvi[5] (84.2%) et al but lower than those reported by Rodrigues Netto[6] (97.6%) and Landau[1] (97.3%) et al.

The overall complication rate in our study was 8.6%. All complications were mild and were managed conservatively. No patient exhibited perirenal or subcapsular hematoma. Our results were comparable to those reported by Kotb[7] and Lottmann et al,[8] and better than those reported by Slavkovic et al (16.7% incidence of perirenal hematoma).[9]

No patient in our study had renal scarring after SWL, as demonstrated by DMSA renal scan, regardless of age, stone burden or number of SWL sessions needed. Our results were comparable to those of Traxer,[10] Reis[11] and Vlajkovic[12] et al.

A total of 147 patients in group A and 93 in group B completed the study. By comparing the renal size in each group before SWL and 1 year later, we found that bipolar renal length had increased significantly in both groups at 1 year. Additionally the difference in rates of renal growth between the groups at 1 year was not statistically significant. However, while SWL (up to 3 sessions) did not impair normal renal growth and did not cause proteinuria or hypertension in any child out to 1 year of followup, longer followup is still required.

Many studies have documented the safety of SWL on kidney function but none has discussed kidney size as an important parameter of renal growth after SWL. Claro et al studied the effect of SWL on renal growth in an animal model.[13] They concluded that SWL does not affect overall subject or renal growth, but may cause permanent histological damage and significant changes in renal function.

The pattern of renal growth of children in groups A and B was similar to that reported by Rosenbaum et al, who studied the normal pattern of renal growth in children by plotting growth curves for renal size (in cm) against age (in years).[14] By plotting our data on their growth curves, our results in both groups were comparable to their findings.

CONCLUSIONS

Shock wave lithotripsy (up to 3 sessions) is a safe treatment modality for children with renal stones. SWL does not impair the normal pattern of renal growth and does not cause proteinuria or hypertension in children up to 1 year postoperatively. However, longer followup is still required.

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