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ORIGINAL ARTICLE

SWL outcome in artificial hydronephrotic vs. non-hydronephrotic kidney for preschool children with high-density renal stones

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Abstract

Objective To assess the effect of artificial hydronephrosis on the result of shock wave lithotripsy (SWL) in preschool children.
Materials and methods A prospective randomized trial was performed between January 2013 and January 2017 with 300 pediatric patients, having kidney stones with a size of 1–2 cm and a density of 750–1100 HU. The patients were randomized into two groups: group A, in which a ureteric catheter was fixed and artificial hydronephrosis was performed by fluid irrigation prior to SWL, and group B which did not undergo hydronephrosis. SWL outcomes were compared between two groups.
Results In total, 153 cases were assigned to group A, and 147 cases were assigned to group B. Regarding demographic data, there was no statistically significant difference between the two groups. There were also no statistically significant differences in the number of shocks and energy power needed for each group. The results of SWL after the first session favored group A with a stone-free rate (SFR) of 90.8% vs. 75.5% for group B. The SFR after SWL was significantly in favor of group A (94.1%) vs. (86.4%) for group B.
Conclusion The use of an artificial hydronephrosis technique to make interface around the stone improves stone-free rate and decreases the need for retreatment after SWL.

Keywords SWL · Renal · Pediatric · Stons · Hydronephrosis

Introduction

Extracorporeal shock wave lithotripsy (SWL) is currently a first-line procedure for most upper urinary tract stones < 2 cm in size because of its established success rates, minimal invasiveness and long-term safety with minimal complications [1, 2]. Despite these advantages, SWL has the considerable disadvantage of a low success rate after the first session. Repeated SWL is commonly necessary to achieve complete clearance [3, 4]. Moreover, after these multiple sessions, the failure rate is expected to be between 10 and 30% [3, 5, 6].

In children, residual stones are associated with more adverse clinical outcomes than in adults [7]. As repeat SWL requires additional anesthesia and more stress on the child and his or her family, many urologists prefer to use other minimally invasive procedures, including percutaneous nephrolithotripsy (PCNL), mini PCNL, micro PNL, ultra-mini PCNL and retrograde intrarenal surgery (RIRS). These procedures have a higher success rate after one session; however, the degree of invasiveness is still higher than that of SWL because these procedures require either renal or ureteric manipulation.

In our study, we investigated the outcome of creating a hydronephrotic kidney and applying stone irrigation during SWL. We think that this procedure may achieve a higher success rate than traditional SWL and lower morbidity than the other invasive procedures. We selected children with high-density renal stones that were expected to be resistant to traditional SWL based on preoperative computed tomography (CT).

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Patient and methods

This study was a prospective randomized controlled study of pediatric patients aged 1–6 years who had renal stones amenable to SWL and presented at our hospital from January 2013 to January 2016. These participants fulfilled the following inclusion criteria: renal stones sized (1–2 cm) and stone density from 750 to 1100 H.U.

Eligible patients were randomized using sealed opaque envelopes to an SWL with artificial hydronephrosis group or a non-hydronephrotic group. Randomization was performed in the clinic. The study protocol was approved by the hospital ethics committee. Informed consent, to the procedure and possible complications, was obtained from all parents.

We excluded children who underwent renal surgical procedures before SWL, had an active urinary tract infection, had an uncorrected bleeding disorder, had distal obstruction to the stone, were unfit for general anesthesia or previously undergone unsuccessful SWL.

This study had two groups:

Group A: consisted of 153 pediatric patients who underwent artificial hydronephrosis.

Group B: The control group consisted of 147 pediatric patients who did not undergo artificial hydronephrosis.

Statistical analysis

Continuous variables were recorded as the means with SDs, and categorical variables were recorded as frequencies. Differences between the groups were assessed using Student's *t* test for continuous variables, and the Chi-square test for categorical variables with P value ≤ 0.05 indicating significance. All statistical analyses were performed using IBM statistical software version 16 (Chicago, IL, USA).

Considering a type 1 statistical error less than 5%, a type 2 statistical error less than 20%, a possible drop-out rate of 10% and based on previous reports [8, 9], the difference in first session success rate between the two groups was 15%. A total sample of 320 patients was selected, with 160 patients in each group. Figure 1 shows the flow of patient selection throughout the study.

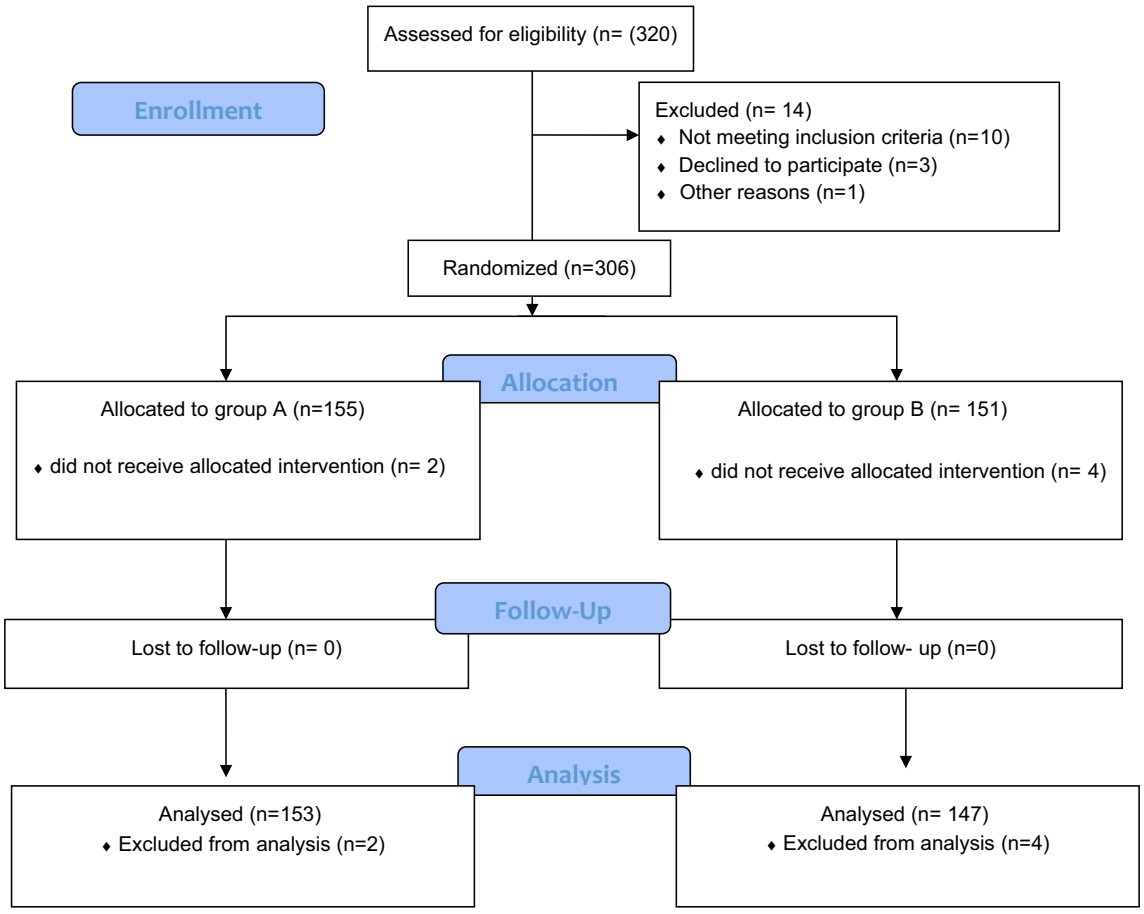

Fig. 1 Consolidated Standards of Reporting Trials (CONSORT) diagram for patients flow through the study

Technique

After informed consent was obtained from the parents, the patients were placed under general anesthesia, and a 4F ureteric catheter was fixed using pediatric cystoscopy, manipulated to be in renal pelvis, and the external part of the ureteric catheter was fixed to a Foley catheter for immobilization during SWL and then connected to a continuous inflow of fluid (saline 0.9%) elevated to 100 cm above the SWL table level to create ipsilateral renal hydronephrosis in the group (A) patients just before the SWL session (confirmed by ultrasound; the grade of hydronephrosis ranged from grade 1 to grade 2). The ureteric catheter was kept in place for one day post SWL to be removed with urethral catheter in the outpatient clinic during follow-up. In the group (B), SWL began after general anesthesia without this step.

The Dornier Gemini lithotripter® is a fully integrated electromagnetic shockwave source, with fluoroscopic and ultrasonic guidance is used.

Energy level (E 12 mm): the effective energy in the focal plane was delivered to an area of 12 mm diameter and measured in mJ. We started at E1 (the lowest level which equals 16.0 mJ) and increased gradually until we reached energy level E5 (which equals 41.0 mJ). We started the session slowly to obtain the best results without exceeding 75 J.

All patients were treated in the supine position. The stone was localized via ultrasound in all cases of the study; fluoroscopic localization was not used to minimize the risk of radiation.

The SWL session usually starts at E1 for the first 250 shocks and then moves to the next level for the next 250 shocks, and the voltage is then gradually increased up to a maximum of E 5.

The shock waves were delivered at a rate of 70 shocks/min. The number and energy of the shock waves used were modified until adequate fragmentation was achieved or the maximum number of shocks was reached. A maximum of 2600 shocks or 75 J energy of shock waves was planned for each session.

All the patients were followed up after 2 weeks by ultrasound and plain urinary tract film (KUB) to assess the need for another session of SWL. Low-dose non-contrast CT was performed 3 months post treatment to assess stone-free status, which was defined as no detectable stone on low-dose non-contrast CT.

Results

The patient demographics and stone characteristics are shown in Table 1. The mean ages of both groups were comparable (3.9 years) in group (A) and (3.6 years) in group (B), with no significant difference (P value 0.6). There was no statistically significant difference in sex distribution between the two groups ($P=0.623$).

Table 1 Patient demographics and stone characters

	Group A	Group B	P value
Number	153	147	
Age (years) Mean	3.9	3.6	0.6
Male: female	80:73	71:76	0.623
Stone size	12.3 mm ± 2.7	12.9 mm ± 2.5	0.153
Stone density	967 HU ± 102.6	954 HU ± 112	0.182
Number of shocks	2353 ± 120	2381 ± 153	0.472
Power energy	53.2 MJ ± 15.7	55.9 MJ ± 16.4	0.73

Table 2 Results of first session of SWL

	Group A	Group B	P value
Disintegrated stone size	12.1 mm ± 2.3	9.8 mm ± 1.9	0.001
Disintegrated stone density	905 ± 89.9 HU	790 HU ± 75.5	0.0001
Number of shocks	2293 ± 135	2300 ± 160	0.521
Power energy	52.2 MJ ± 15.7	57.4 MJ ± 16.4	0.32
Stone free rate	140/153 (90.8%)	111/147 (75.5%)	0.001
Site of stone			
Renal pelvis	87 (96.6%)	79 (84.9%)	0.001
Upper calyx	20 (83.3%)	14 (63.6%)	0.001
Middle calyx	19 (79.1%)	13 (52%)	0.001
Lower calyx	14 (56%)	5 (22.7%)	0.0001

The stone size and density were comparable between the two groups, as shown in Table 1. Regarding the number of shocks and energy power needed by each group, there was no statistically significant difference between the groups.

Table 2 shows the results of the first session of SWL, which impressively favored group A—SFR 90.8% vs. 75.5% for group B.

The stone-free rate 3 months after SWL was significantly in favor of group A—94.1% vs. 86.4% for group B (Table 3).

As the results of SWL differed according to the site of renal stone, we compared the stone-free rates of the two groups according to the site of the kidney stone (Table 3).

Postoperative complications were nausea and vomiting in 5 and 4 cases in groups A and B, respectively. They were managed conservatively with antiemetic drugs. Fever occurred in two cases in each group. They were managed conservatively with antipyretics (paracetamol) and antibiotics (amoxicillin).

Only one case in group B presented with obstruction of the kidney; low-dose non-contrast CT revealed steinstrasse in the lower third of the left ureter. Ureteroscopy was

Table 3 Stone-free rate after 3 months according to the site of the stones in the kidney

Site	A	SFR (A) (%)	Re-treatment %	B	SFR (B) (%)	Re-treatment %	*P* value
Stone pelvis	88/90	97.7	5 (5.5%)	86/93	92.4	10 (10.7%)	0.79
Stone upper calyx	23/24	95.8	2 (4.1%)	19/22	86.4	6 (27.2%)	0.15
Stone middle calyx	22/24	91.6	3 (12.5%)	22/25	88	5 (25%)	0.23
Stone lower calyx	21/25	84	5 (20%)	14/22	63.6	15 (68.1%)	0.001
Overall stone free rate	144/153	94.1		127/147	86.4		0.001

Table 4 Postoperative complications

	Nausea vomiting	Fever	Stein strass	Hematuria
Group A	5	2	0	2
Group B	4	2	1	2
Total	9	4	1	4

performed, and the stones were extracted by dormia basket, and the ureteric catheter was inserted for 5 day. Only two cases, one in each group, presented by hematuria, which was managed conservatively; there were no cases of hematoma (Table 4).

Discussion

The treatment of urolithiasis in children has gained increased attention from pediatric urologists, possibly due to the increasing incidence of kidney and ureteral stones [10].

The reported action of shock waves on stone results from the production of compressive and tensile forces at the fluid–stone interface [11, 12]. The stone material is thereby broken off in layers (spalling); if the outer fragmented layer does not fall away during SWL, this delay the subsequent fragmentation of deep layers by reflecting and diffusing the shockwaves [13]. Therefore, we postulated that continuous stone irrigation during SWL improves success in multiple ways: (1) by increasing the fluid–stone interface, (2) by irrigating stone fragments away from the deep layer, which improved wave delivery to the non-fragmented part of the stone, (3) by flushing out the stone fragments mechanically, (4) by improving the drainage of the fragments as a result of a catheter placement for 1 day after SWL.

In our series from the last 3 years, 300 children aged 1–6 years presented to our department with renal stones amenable to SWL. This series is one of the largest pediatric SWL series reported and, to the best of our knowledge, is the largest reported pediatric series using the Dornier Gemini lithotripter®.

Multiple studies have documented the efficacy of SWL in children, with an overall stone-free rate of 79.9% reported at the 3-month follow-up [14–16]. In other studies, the overall stone-free rate was 95.8% for renal stones and 94.8% for ureteral stones [17–19].

In our study, we discussed the effect of our technique on increasing the stone-free rate; the overall success rate for renal stones in both groups was 90.3%, with the stone-free rate 3 months after SWL significantly favoring group A (94.1% vs. 86.4% for group B). Additionally, the rates were, 97.7% vs. 92.4% for stones located in the renal pelvis, 91.6% vs. 88% for middle caliceal stones, 95.8% vs. 86.4% for upper caliceal stones and 84% vs. 63.6% for lower caliceal stones.

The overall success rate in our study was similar to that reported by other SWL series, in which stone-free rates ranged from 75% to 98% in children [18]. However, we found that the application of our new technique increased the efficacy of SWL for renal stones regardless of their location in the kidney.

Moreover, the results of the first session of SWL were more favorable for group A, which had an overall SFR of 90.8% compared with 75.5% for group B. This means that more than 15% of cases would not have required retreatment or face the hazards of repeated anesthesia, which may compensate for the invasive technique used in group A.

There are a number of factors that make comparisons among SWL series difficult. A significant finding in this pediatric series was the low stone-free rate in children with lower caliceal stones; the success rate decreased from 89.8% for mid-caliceal stones to76.5% in the lower caliceal group. The retreatment rate for lower pole stones was higher than that of stones in other locations, mainly because of the retention of fragments due to the dependent position of the lower pole. Penn et al. [20] reported that the stone-free rate of patients with lower pole stones was much lower than that of patients with renal pelvic stones. Interestingly, we found that our new technique decreased the retreatment rate for renal stones in different locations; in particular, the rate of retreatment for lower caliceal stones decreased from 68.1% in group B to 20% in group A.

We found that all complications were mild, ranging from vomiting to low-grade fever in a small number of cases, with no statistically significant difference between the two groups. Concerning the time required under anesthesia to

fix the ureteric catheter, we believe the decreased need for retreatment and the lack of complications compensates.

Limitation of study

Further studies with more patients in the same age group are needed to consolidate the statistical results. The use of a ureteric catheter for 1 day may have an effect on the stone-free rate, which we could not control. The invasive technique of ureteric catheter insertion and fixation for 1 day may affect the child's quality of life, but such data were not reported statistically.

Conclusions

Using an artificial hydronephrosis technique to change the interface around the stone improves the stone-free rate and decreases the need to retreat after SWL using Dornier Gemini lithotripter® in preschool pediatric renal stone patients. We believe that the invasiveness of the technique used in our study was compensated by the high stone-free rate of the first session which prevented the need for retreatment. We recommend applying the new technique to large multicenter series to obtain more accurate results.

Author contributions MA: Project development, data collection, manuscript writing and revision. AH: Data collection. MSA: Data collection, Data Analysis, Revision. AA: Data collection.

Compliance with ethical standards

Conflict of interest There is no conflict of interest.

Informed consent The research on human patients after informed consent.

References

1. Holman E et al (2004) Endoscopic management of pediatric urolithiasis in a developing country. Urology 63:159–162
2. Sarkissian A et al (2001) Pediatric urolithiasis in Armenia: a study of 198 patients observed from 1991 to 1999. Pediatr Nephrol 16(9):728–732
3. Muslumanoglu AY, Tefekli A, Sarilar O, Binbay M, Altunrende F, Ozkuvanci U (2000) Extracorporeal shock wave lithotripsy as first line treatment alternative for urinary tract stones in children: a large scale retrospective analysis. J Urol 170(6 Pt 1):2405–2408
4. El-Assmy A, El-Nahas AR, Abou-El-Ghar ME, Awad BA, Sheir KZ (2013) Kidney stone size and hounsfield units predict successful shockwave lithotripsy in children. Urology 81(4):880–884
5. El-Nahas AR, El-Assmy AM, Awad BA, Elhalwagy SM, Elshal AM, Sheir KZ (2013) Extracorporeal shockwave lithotripsy for renal stones in pediatric patients: a multivariate analysis model for estimating the stone-free probability. Int J Urol 20(12):1205–1210
6. Habib EI, Morsi HA, Elsheemy MS, Aboulela W, Eissa MA (2013) Effect of size and site on the outcome of extracorporeal shock wave lithotripsy of proximal urinary stones in children. J Pediat Urol 9(3):323–327
7. Afshar K, McLorie G, Papanikolaou F et al (2004) Outcome of small residual stone fragments following shock wave lithotripsy in children. J Urol 172(4 Pt 2):1600–1603
8. Nicely ER, Maggio MI, Kuhn EJ (1992) The use of a cystoscopically placed cobra catheter for directed irrigation of lower pole caliceal stones during extracorporeal shock wave lithotripsy. J Urol 148(3 Pt 2):1036–1039
9. Graham JB, Nelson JB (1994) Percutaneous caliceal irrigation during extracorporeal shock wave lithotripsy for lower pole renal calculi. J Urol 152(6 Pt 2):2227
10. Schmiedit E, Chaussy C (1984) Extracorporeal shock wave lithotripsy of kidney and ureter stones. Urol Int 39:193
11. Brendel W (1986) Shock waves: a new physical principle in medicine Eur. Surg Res 18:177
12. Whelan JP, Finlayson B (1988) An expermintal model for the systematic investigation. J Urol 140:395
13. Thomas R, Frentz JM, Harmon E et al (1992) Effect of extracorporeal shock wave lithotripsy on renal function and body height in pediatric patients. J Urol 148:1064
14. Nazli O, Cal C, Ozyurt C et al (1998) Results of extracorporeal shock wave lithotripsy in the pediatric age group. Eur Urol 33:333
15. Longo JA, Netto NR Jr, Muslumanoglu AY, Tefekli AH, Altunrende F, Karadag MA (1995) Extracorporeal shockwave lithotripsy in children. Urology 46:550
16. Baykal M, Akcay M (2006) Efficacy of extracorporeal shock wave lithotripsy for ureteric stones in children. Int Urol Nephrol 38(2):225–229
17. Ather MH, Noor MA (2003) Does size and site matter for renal stones up to 30 mm in size in children treated by extracorporeal lithotripsy? Urology 61(1):212–215 **(discussion 215)**
18. Rodrigues Netto N, Jr Longo JA, Ikonomidis JA, Rodrigues Netto M (2002) Extracorporeal shock wave lithotripsy in children. J Urol 167(5):2164–2166
19. Ehreth JT, Drach GW, Arnett ML, Barnett RB, Govan D, Lingeman J et al (1994) Extracorporeal shockwave lithotripsy: multicenter study of kidney and upper ureter versusmiddle and lower ureter treatments. J Urol 152(5 Pt 1):1379–1385
20. Penn HA, De Marco RT, Sherman AK, Gatti JM, Murphy JP (2009) Extracorporeal shock wave lithotripsy for renal calculi. J Urol 182(4):1824–1827