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Extracorporeal Shock Wave Lithotripsy in the Treatment of Pediatric Urolithiasis: A Single Institution Experience

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ABSTRACT

Purpose: To compare the efficacy and safety of the electromagnetic lithotripter in the treatment of pediatric lithiasis to that of the earlier electrohydraulic model.
Materials and Methods: Two groups of children with lithiasis aged between 10 and 180 months who underwent extracorporeal shock wave lithotripsy (ESWL). In the first group (26 children), ESWL was performed by using the electrohydraulic MPL 9000X Dornier lithotripter between 1994 and 2003 while in the second group (19 children) the electromagnetic EMSE 220 F-XP Dornier lithotripter was used from April 2003 to May 2006.
Results: In the first group, 21/26 children (80.7%) were stone free at first ESWL session. Colic pain resolved by administration of an oral analgesic in 6 (23%), brief hematuria (< 24 h) resolved with increased fluid intake in 5 (19.2%), while slightly elevated body temperature (< 38°C) occurred in 4 (15.3%). Four children (15.3%) failed to respond to treatment and were treated with ureteroscopy. In the second group 18/19 children were completely stone free at first ESWL session (94.7%). Complications were infrequent and of minor importance: colic pain treated with oral analgesic occurred in 1 (5.26%), brief hematuria (< 24 h), resolved with increased fluid intake in 4 (21%) and slightly elevated body temperature (< 38°C) monitored for 48 hours occurred in 6 (31.5%). Statistical analysis showed that electromagnetic lithotripter is more efficacious and safer than the earlier electrohydraulic model.
Conclusions: Technological development not only has increased efficacy and safety of lithotripter devices in treating pediatric lithiasis, but it also provided less painful lithotripsy by eliminating the need for general anesthesia.

Key words: *lithiasis; children; treatment; ESWL; efficacy; complications*
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INTRODUCTION

Urolithiasis in childhood is a rare disease with different epidemiologic features. Its frequency varies among geographic regions being between 0.1% to 5% of the child population (1). Due to the small number of patients, experience in handling pediatric patients is limited and there are only few articles reviewing its management in the international literature. In fact, except for the so-called wait and see strategy (in cases of small stones which can pass through the urinary tract do so automatically), of the other existing treatment options (ureterolithotripsy with flexible or rigid instruments, percutaneous nephrolithotomy and laparoscopic or open surgery stone removal), extra corporeal shock wave lithotripsy (ESWL) appears to be the most adequate treatment. It has been proposed that particular anatomic conditions of the infant body

such as the smaller size, as well as the increased peristalsis and flexibility of the child's ureter favor ESWL as the main treatment modality (2).

Evidence suggests that technological evolution has increased the efficacy of lithotripter devices in the treatment of adult lithiasis; however, literature on this specific cohort is quite scarce. In this paper, a retrospective review on a single center experience with ESWL in a pediatric population involving two different lithotripters (the electrohydraulic MPL 9000X Dornier and the electromagnetic EMSE 220 F-XP Dornier) is presented. The efficacy and safety of the electromagnetic lithotripter in treating pediatric lithiasis was retrospectively compared to that of the earlier electrohydraulic model.

MATERIALS AND METHODS

The material of our study consisted of two groups of children aged between 10 months and 15 years with lithiasis who underwent ESWL at the department of urology of the University Hospital of Heraklion Crete, between 1994 and 2006. Standard evaluation of the patients before ESWL included renal function tests, urinalysis, urine culture and intravenous pyelography. Stone size was defined as the longest stone diameter as measured on a plain abdominal radiograph. Patients with urinary tract infection were treated according to urine cultures with appropriate antibiotics. Contraindications of ESWL treatment were coagulation disorders, pyelonephritis, obstruction distal to calculi, non-functional kidney and hypertension.

ESWL was performed by using the electrohydraulic MPL 9000X Dornier lithotripter in twenty-six children (group A) between 1994 and 2003 and with the electromagnetic EMSE 220 F-XP Dornier lithotripter in nineteen children (group B) from April 2003 to May 2006. Both MPL 9000X and EMSE 220 F-XP Dornier lithotripters are third generation devices that have combined real time ultrasonographic and fluoroscopic localization facilities. Stone targeting, stone localization and monitoring was done either with ultrasound or x-ray locating system incorporated into the lithotripter. The same operator, a skilled urologist, performed the ESWL in both groups in the presence of experienced anesthetists during the entire ESWL procedure.

There was a retrospective comparison of efficacy (in terms of free stone rate at 1st ESWL and number of re-treatments) and safety (in terms of general anesthesia needs and complications). Evaluation of the patients before ESWL and follow-up studies were similar for both groups.

Standard follow-up studies including renal ultrasonography and a plain abdominal radiography were performed the day after the operation and twice after the 1st and 3rd month postoperatively. Patients were regarded as stone free or not, according to the results obtained at the first and third month. Treatment was considered successful in cases where the plain radiography or the transabdominal ultrasound showed either no signs of stone, or just insignificant residual fragments < 2 mm in diameter 3 months after the last ESWL session.

The SPSS® statistical software program was used to determine whether a significant difference in outcome parameters existed between the two study groups.

Patients Demographics and Stone Characteristics

Most patients were referred to our clinic from certain centers for ESWL. Metabolic evaluation for the etiology of urolithiasis was conducted by the pediatric nephrology unit or by the centers referring the patient.

Group A consisted of 17 boys and 9 girls aged between 12 months and 15 years (mean 8.7 years). The overall number of stones treated with ESWL was 28 (two patients had multiple stones). The average body height was 118.4 cm (range 52-153 cm) and the average body weight was 28.9 kg (range 7-49 kg) (Table-1). Seven children (28%) were younger than two years of age. All children were referred for ESWL for persistent pain (13 pts.), complicated urinary tract infection (5 pts.), obstruction (4 pts.) and hematuria (3 pts.). Stones were located in the upper ureter in 6 cases, the middle ureter in 8 and in the lower ureter in 12 cases. Stone size ranged from 5 to 14 mm (mean 10.9). Twenty-four children out of 26 had one

Table 1 – *Patient demographics.*

	Group A (MPL 9000X)	**Group B** (EMSE 220 F-XP)
Patients	26 (boys 17, girls 9)	19 (boys 11, girls 8)
Age in months (mean)	104.4 (range 12-180)	94.8 (range 10-168)
Body height in cm (mean)	118.4 (range 52-153)	113.2 (range 50-148)
Body weight in kg (mean)	28.9 (range 7-49)	28.7 (range 6-52)

Table 2 – *Stone characteristics.*

	Group A (MPL 9000X)		**Group B** (EMSE 220 F-XP)	
Number	28		25	
	Location	Side	Location	Side
Position	Proximal = 6	Right = 11	Proximal = 4	Right = 8
	Middle = 8	Left = 17	Middle = 8	Left = 15
	Distal = 12	Bilateral = 2	Distal = 10	Bilateral = 2
			Renal pelvis = 2	
Size in mm (range)	5-14 (mean = 10.9)		4-21 (mean = 12.3)	

or more stones in one ureter whereas 2 children had bilateral ureteral stones. Eleven out of the 28 stones were located on the right ureter while the remaining 17 were located on the left one (Table-2).

Group B consisted of 8 girls and 11 boys aged between 10 months and 14 years (mean 7.9 years) with 25 stones (two patients had multiple lithiasis). The average body height was 113.2 cm (range 50-148 cm) and the average body weight was 28.7 kg (range 6-52 kg) (Table-1). Five children (26.3%) were younger than two years of age. All children were referred for ESWL for hematuria (5 pts.) persistent pain (11 pts.) and complicated urinary tract infection (3 pts.). Eight stones out of 25 were located on the right side whereas the remaining 17 were located on the left side. Stones were located in the upper ureter in 4 cases, the middle ureter in 8, the lower ureter in 10, the renal pelvis in two cases and in the renal calyces in one case. Their size ranged between 4 and 21 mm (mean 12.3). Sixteen children out of 19 had a single unilateral ureteral stone whereas 2 children had bilateral ureteral stones. The remaining patient, an 8 year old boy with a history of persistent urinary tract infection had a 6 mm stone in the upper pole of the left kidney and an 8 mm stone in the left renal pelvis (Table-2).

RESULTS

Group A

In 14 children younger than 8 years of age, lithotripsy was performed under general anesthesia with endotracheal incubation (sodium thiopental 5 mg/kg, fentanyl 1-2 μg/kg and ataracurium 0.5 mg/kg). In 11 children older than 8 years, the treatment was attempted under intravenous analgesia (pethidine 1 mg/kg, midazolam 1-2 mg/kg) or sedation. In one case, IV sedation was converted to general anesthesia. The remaining patients did not receive any analgesia. Auxiliary procedures such as double J placement or

ureteral catheterization were not performed on any child.

Twenty-one children out of 26 (80.7%) were stone free at first ESWL session. Only 5 patients required multiple ESWL sessions: four children received a re-treatment while one child was retreated twice. Overall, 6 re-treatments were carried out with an average of 1.19 sessions per patient.

No major complications were observed in any child. Colic pain that resolved with oral analgesic occurred in 6 children (23%), brief hematuria (< 24 h) resolved with increased fluid intake in 5 (19.2%) and slightly elevated body temperature (< 38°C) in 4 (15.3%) (Table-3). There were no cardiac or anesthetic complications. Four children (15.3%) failed to respond to treatment and were further treated with ureteroscopy. Three of them had single stones with a diameter > 6 mm whereas one had two left lower ureteral stones of similar diameter. There were no emergency procedures required for ESWL failures, such as ureteral stent or nephrostomy tube insertion.

Group B

None of the patients required general anesthesia. A double J ureteral stent was placed prior to the ESWL procedure in 2 patients with multiple lithiasis and severe hydronephrosis in order to decompensate renal pelvis and prevent stasis.

None of the children required multiple ESWL sessions. Eighteen were completely stone free at first ESWL session (94.7%), while in one patient ultrasound evaluation revealed residual fragments < 2 mm. Complications were infrequent and minor: Colic pain that resolved with oral analgesic occurred in one case (5.26%), brief hematuria (< 24 h) which resolved with increased fluid intake in 4 (21%) and slightly elevated body temperature (< 38°C) monitored for 48 hours in 6 (31.5%) (Table-3). There were no cardiac or anesthetic complications.

In both groups

The mean voltage used was 18.75 +/- 2.5 kV (range 14-22 kV) and a mean of 1750 +/- 400 shockwaves (range 600-2900) was administered during a single ESWL session. Treatment time ranged from 25 to 100 minutes (mean 42.5 +/- 20 minutes).

Twenty-three children (15 of the group A and 8 of the group B) were treated as inpatients. The remaining children were sent home the same day. The total hospital stay ranged from 2 to 6 days (average 2.3 days) in both groups.

Statistics

A 2x2 table (Fisher's exact test) was performed in order to assess whether the difference between the two study groups in the number of patients who needed anesthesia was statistically significant. Difference in anesthesia needs between the two groups was statistically significant in favor of group 1 ($p = 0.0001$). A 2x2 table (Fisher's exact test) was also performed in order to asses whether the difference in

Table 3 *– Results.*

	Group A (MPL 9000X)	**Group B** (EMSE 220 F-XP).	
General anesthesia need	12 (46.1%)	0 (0%)	$p < 0.05$
Free stone rate (at 1st ESWL)	26 (80.7%)	18 (94.7%)	$p < 0.05$
Re-treatments	6 (23%)	0 (0%)	$p < 0.05$
Complications	Colic pain 6 (23%)	Colic pain 1(5.26%)	$p < 0.05$
	Hematuria = 5 (19.2%)	Hematuria = 4 (21%)	$p > 0.05$
	Body temperature elevation = 4 (15.3%)	Body temperature elevation = 6 (31.5%)	$p < 0.05$

the number of patients who needed re-treatments was statistically significant. The test provided evidence that group 2 lithotripter was more efficacious (p-value = 0.0241).

A comparison of free stone rate between the study groups was also performed: the risk of a positive outcome (relative risk) was equal to 1.29. The test of no association between the groups and the free stone rate provided evidence to support the hypothesis of a statistically significant relationship between the study group and stone free rate (p = 0.041).

COMMENTS

Modern management of ureteral stones has been dramatically influenced by the development of ESWL and now more patients with ureteral calculi are treated with this method.

Although numerous reported studies have documented the efficacy of ESWL for ureteral stones at all levels in adults, there exist only few articles reviewing the treatment of pediatric urolithiasis in the international literature. The most probable explanation is that urolithiasis in childhood is a rare disease and therefore experience in active stone treatment is limited. Moreover, it has been gradually applied to pediatric patients with caution and a longer period will be needed in order to verify its efficacy and morbidity in children.

Since this technique was designed for the treatment of adult lithiasis, questions have arisen regarding its application in pediatric patients (3). Most of the concerns were mainly focused on the selection of particular treatment modalities, taking into consideration such factors as the size, location and composition of the stone, the presence or absence of infection, as well as anatomical and psychological particularities of the child. Generally, treatment options of pediatric lithiasis and trends are similar to those of adult lithiasis. In fact, stone size and location are important factors-together with symptom severity, degree of obstruction, presence or absence of infection and level of renal function-in deciding whether to manage the stone initially by observation, awaiting spontaneous passage, or to actively intervene (4). Despite the smaller diameter of the child's ureter, the cut-of volume of 4 mm seems to be adequate to decide upon active intervention (5). According to the existing literature, ESWL has been proved to be an effective modality to treat pediatric upper urinary-tract calculi, with stone-free rates reaching 100% in many series, especially when the stone burden is < 20 mm (1,6). The effect of ESWL in large stone burden is controversial. Recent reports claim good results even with larger stone burdens, irrespective of stone location. Success has been reported for pediatric stones as large as 5 cm while there are also reports of successful ESWL monotherapy for staghorn stones in younger children (7). According to these reports, monotherapy can remove large stones (20 to 30 mm) with a 95% stone free rate and staghorn calculi with a 73% of stone-free rate, although re-treatment may be necessary (6,8). Other authors however found that larger stones are associated with poorer results, necessitate more ancillary procedures, and have a higher complication rate (9). According to Ather et al., a relatively higher rate of complications and treatment failures (20% and 19% respectively) probably indicates that ESWL is not as suitable for big stones as for small stones (10). In this study we adapted the European Association of Urology guidelines on urolithiasis and therefore we performed ESWL monotherapy in patients with stones of a volume of less than 20 mm. This fact possibly explains the high stone-free rates in both groups (80.7 and 94.7 respectively) achieved at first ESWL session.

Among the predictors of success, stone location seems to be controversial. Several authors showed that ESWL of lower ureteral stones is not as effective as in stones of the upper urinary tract due to certain difficulties in visualizing stones overlying the sacrum (11). According to Hammad et al. however, the efficiency of ESWL in the ureter may increase with a higher number of shock waves delivered (12).

Pediatric ESWL has been also reported be more effective in renal pelvic stones compared to calyceal stones (12,13). Demirkesen and co-workers however, found no statistically significant difference in the stone-free rate after ESWL for stones in the calices and renal pelvis in pediatric patients (14).

Although the efficacy of this method is clearly established, concerns about inhibition of the children's' growth and damage to their reproductive organs due to the exposure of high-energy shock

waves and radiation respectively have been raised. These concerns have been partially disproved by animal experiments that showed no long lasting influence on bodily growth and no permanent effect on both female and male reproductive systems (15,16). Moreover, the use of a small focusing area provided by the modern devices offered less damage to surrounding tissues (17).

Similar to our study, the number of complications reported in the current literature is low and are usually mild. Severe complications after ESWL are more seldom in children than in adults (18).

The more common complications are hematuria, and urinary infection with or without fever (1). Hematuria is almost always temporary and does not require medical or surgical treatment, while, urinary infection requires only appropriate antibiotic treatment in most of the cases (19). Steinstrasse and ureteral obstruction caused by stone fragments rarely occurs (13). Fragments < 4 mm are expected to pass spontaneously without further treatment, however, in case of persistence further treatment with ESWL endoscopic procedures or ureterolithotomy is required (17). Rarely reported subcapsular, intrarenal, and perirenal hematomas have been treated conservatively (13). According to the literature general anesthetic is required in 30% to 100% of children who undergo lithotripsy (3). However, this demand, together with the anesthesia method, differs considerably depending on the age of the child (20). Older children often tolerate ESWL under intravenous analgesia or sedation using pharmacologic agents such as midazolam, ketamine, or fentanyl (1), whereas most children up to the age of 13 years require general anesthesia (1,21). Our experience however suggests that it becomes possible to treat even younger patients without anesthesia by reducing the dimensions of the focus without the cost of a higher re-treatment rate. The need and the type of anesthesia depend also on the type of the lithotripter in use: lithotripsy with electrohydraulic devices results in a relatively higher risk of pain, a finding which is in accordance with that of other authors (22,23). On the contrary, when an electromagnetic lithotripter is employed, it is possible to manage a greater number of older children without general anesthesia thus correcting the defect of the earlier electrohydraulic lithotripters.

CONCLUSIONS

The electromagnetic lithotripters have significant clinical advantages over the electrohydraulic lithotripter in terms of anesthesia requirements, free stone rate and re-treatments. Therefore, it has become obvious that technological evolution of lithotripter devices has increased their efficacy and safety in treating pediatric lithiasis and provides less painful lithotripsy by eliminating the need for general anesthesia.

CONFLICT OF INTEREST

None declared.

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EDITORIAL COMMENT

Stamatiou and colleagues describe their single institution experience with pediatric lithiasis treatment by ESWL. The data presented is very informative especially considering the difficulty in collecting patients in this age range with a diagnosis of calculi.

However, caution must be taken in interpreting their findings. First, although comparing 2 different lithotripter energy sources, the groups were treated sequentially in a timeline which may allow for a bias of gained experience in favor of the second group (electromagnetic). Also, although stone size was not statistically different between groups, the measurement taken was the longest stone diameter instead of stone burden which would be more accurate.

Finally, it is encouraging to notice that no major complications occurred as a result of treatment.

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