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PAEDIATRIC URETERIC CALCULI: IN-SITU EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY

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Objective To evaluate prospectively the efficacy of in-situ extracorporeal shock wave lithotripsy (ESWL) in the treatment of ureteric calculi in the paediatric age group.

Patients and Methods Twenty children (aged 2.2 – 16 years) with 22 ureteric stones were evaluated and treated with in-situ ESWL using the Dornier S lithotripter. The stone burden ranged from 6 – 14.8 mm (mean 11 mm). ESWL was performed under intravenous sedation or general anaesthesia on an outpatient basis.

Results The stones were located in the upper ureter in 11 cases, in the mid ureter in 2 cases and in the lower ureter in 7 cases. At 3 months, a successful outcome (stone-free status) had been achieved in 18 cases (90%). The success rates related to the different levels of the ureter were 91%, 100% and 85.7% for the upper, mid and lower ureter, respectively. Four cases (22.2%) needed re-treatment to be stone-free. Pre-ESWL double-J stenting was required in 10% of the cases. The postoperative period was uneventful. None of the patients had post-treatment ureteral obstruction or urinary infection. Mild post-operative complications were encountered in the form of mild transient haematuria in all and colics in 8 patients.

Conclusion In the paediatric age group, in-situ ESWL may be an effective modality for treating ureteric calculi at all levels of the ureter. It has no procedure-related morbidity.

Keywords ureter, children, calculi, ESWL

INTRODUCTION

Since its introduction in 1982 by Chaussy et al., extracorporeal shock wave lithotripsy (ESWL) has become the standard treatment for most renal and an increasing number of ureteral calculi[1,2]. Initially, ESWL had been considered contraindicated in the treatment of urolithiasis in children[3]. Following the study of Newman et al., however, ESWL began to be used in paediatric patients in some centers[4] and eventually has proved to be the treatment modality of choice for renal calculi in the paediatric age group[5, 6].

In this study we prospectively analyze the results of in-situ ESWL treatment of ureteric stones in 20 children to evaluate the efficacy of the procedure.

PATIENTS AND METHODS

Between May 1999 and March 2000, 20 children with ureteric stones were treated with in-situ ESWL using the Dornier S electromagnetic lithotripter. The patient group consisted of 13 boys and 7 girls aged between 2.2 and 16 years (mean 10.45 years). The main presenting symptoms were pain in 12 (60%), fever due to urinary tract infection in 4 (20%) and haematuria in 4 (20%) patients. 6 children (30%) presented with more than one symptom. Indications for in-situ ESWL were ureteric calculi with a diameter > 5mm, smaller ureteric calculi which had failed to progress after a 4-week interval of medical treatment, and those causing persistent pain, obstruction or infection. The evaluation of all 20 children included history, physical examination, urine analysis, urine culture (if needed) and serum biochemistry. Ultrasonography and excretory urography were performed for diagnosis. The mean stone burden per ureter was 11 mm (6 - 14.8 mm). A total of 21 ureters were treated, as one child had bilateral ureteric stones. The number of stones treated was 22, because one child had 2 stones in the same ureter. Radiologic evaluation of the kidneys showed mild dilatation of the pelvicalyceal system in 16

Table 1: Distribution of Stones

Level of Ureter	No. of Patients	No. of Ureters	No. of Stones
Upper ureter	11	12	12
Mid ureter	2	2	2
Lower ureter	7	7	8
Total	20	21	22

Table 2: In-Situ ESWL Treatment Specifications

	Upper Ureter	Mid Ureter	Lower Ureter	Overall
Mean stone burden (mm)	11.3	10.4	10.6	11
Mean no. of sessions	1.25	1.32	1.4	1.3
Mean no. of shocks	4850	5155	5680	5171

renal units and moderate dilatation in 5 renal units. On radiography, none of the treated stones appeared to be impacted.

All patients underwent in-situ ESWL with the Dornier S electromagnetic lithotripter which has combined inline real-time ultrasonographic and bi-planar fluoroscopic localization facilities. No attempts were made to manipulate the stones. Tapes were used to secure the children to the lithotripter leaving the skin over the respective area uncovered. Upper ureteric calculi were treated in the supine position, while mid and lower ureteric calculi were treated in the prone position. In patients with upper ureteric calculi a lead shield was used to protect the lungs. Localization of the stones was achieved by ultrasonography in 2 children (upper ureter), while fluoroscopy was needed for localizing the stones in 15 children. A combination of both modalities was used in 3 cases. Radiolucent stones were identified using intravenous or retrograde injection of contrast media.

In some children with thin abdominal cavities it was difficult to focus on the stone. The problem was overcome by placing a 500-1000 cc intravenous fluid bag between the shock head and the patient, taking care to place an adequate amount of ultrasonic gel between each interface as described by Myers et al.[2].

The number of shocks per stone per session was determined according to the degree of disintegration of the stone as it appeared on the monitor. The mean number of shock waves was 3400 (ranging from 2700 to 4000) per session. The mean energy was 17 kV (range 14-19 kV). We used the modification of the Puigvert technique[2]. The mean fluoroscopy time was 86 (43-117) sec. The procedure was terminated when stone disintegration was achieved or 4000 shock waves were applied. Patients who did not have any fragmentation despite two ESWL sessions were considered failures. Those with incomplete fragmentation after two sessions were allowed a third "last" session. Cases requiring further sessions were considered failures. The minimum time between two sessions was 2 weeks. Failure was not considered until 3 months after the final session.

Success was defined as complete disappearance of all stone fragments on a follow-up film of the kidney, ureter and bladder, and ultrasonography or excretory urography.

All ESWL sessions were carried out on an outpatient basis either under intravenous seda-

Table 3: Results of In-Situ ESWL at Various Levels of the Ureter

	Upper Ureter	Mid Ureter	Lower Ureter	Total
No. of Patients	11	2	7	20
Positive results (stone-free)	10 (91%)	2 (100%)	6 (85.7%)	18 (90%)
Failure	1 (9%)	0	1 (14.3%)	2 (10%)

tion using fentanyl 2-2.5 μg/kg or midazolam 0.15mg/kg (14 children) or under general anaesthesia (6 children). Ureteric catheters were used for the localization of faintly opaque or radiolucent stones in 3 cases (1 mid ureter, 2 lower ureter). In two patients a double-J stent was inserted before ESWL treatment. One of them had bilateral ureteric calculi, while the other presented with infected hydronephrosis. The stents were removed after all fragments had been cleared. When the urine culture was positive, a prophylactic culture-specific antibiotic treatment was given 48-72 hours before ESWL treatment and continued for 10 days postoperatively. Then the patient was re-evaluated. Follow-up included KUB on days 1, 14, 30 and 90 as indicated. Excretory urography or ultrasonography were used for follow-up imaging of the urinary tract.

RESULTS

A total of 22 ureteric calculi were treated in 21 ureters of 20 patients. The stones were located in the upper ureter in 11 cases, in the mid ureter in 2 cases, and in the lower ureter in 7 cases (Table 1). The mean duration of a treatment session was 52 minutes (range 32-74 minutes). The number of shocks and sessions needed to fragment the ureteric calculi at different levels is shown in Table 2. A stone-free status was achieved in 18 (90%) children. Two cases (10%) were considered failures. One needed ureteroscopy, while the other was managed by open ureterolithotomy. The detailed results are shown in Table 3.

Fourteen out of 18 patients (77.7%) became stone-free after one ESWL session only. Three patients (16.67%) required two sessions (one of them had bilateral ureteric stones), while one patient (5.5%) needed 3 sessions (the patient had two ipsilateral lower ureteric stones). All patients suffered from transient haematuria. Eight children suffered from colics that was managed by spasmolytics and/or analgesics. In none of the patients we encountered post-treatment urinary infection or ureteral obstruction. Mild ecchymosis at the site of shock wave entrance occurred in 3 cases. No intra-operative or postoperative haemoptysis or gastrointestinal complications were seen. No post-treatment retroperitoneal or perirenal haematomas were reported.

DISCUSSION

ESWL is the treatment of choice in most cases of urinary stone disease and has been readily accepted both by urologists and patients because of its ease of application and efficacy[7]. In-situ ESWL has been reported widely in the management of ureteric calculi in adults[8]. However, the application of ESWL in children has only been accepted gradually, because paediatric urolithiasis is relatively uncommon and there are concerns about the safety of ESWL in children[8]. Side effects, especially long-term effects, of ESWL in paediatric patients have not yet been assessed sufficiently, therefore some physicians refrain from using ESWL in this group of patients.

In our series, no retroperitoneal or perirenal haematoma or any other specific complication related to ESWL could be detected. When treating upper ureteral calculi, a lead shield was used for lung protection. In a study conducted by Demirkesen et al. where ESWL was applied to stones in the upper pole of the kidneys of pediatric patients the lungs were protected by elevating the upper half of the body with supportive pillows and, thus, moving the kidney away from the lung area[9]. Although Al Busaidy et al. did not use any lung or ovary shields when treating 63 ureteric calculi in paediatric patients, they did not report any ESWL-related complications in their series either[8]. Also Frick et al. noted no long-term effects of ESWL on children in terms of renal

Table 4: Comparison of Results of In-Situ ESWL for Ureteric Calculi in Children Reported in the Literature

Author	No. of Patients	No. of Calculi	Overall Success (%)	Auxiliary Procedures (%)	Re-Treatment Rate (%)
Myers[2]		208	91.1%	17.7%	9.2%
Moazam[18]		13	82.0%	NA	NA
Moreno[19]	14		71.4%	14.28%	NA
Al Busaidy[8]	63		87.0%	6.0%	36.0%
Elsobky[20]	11		100.0%	NA	36.0%
Vandeursen[21]		11	90.5%	NA	27.0%
Marberger[22]		8	100.0%	NA	0%
Newman[23]		5	100.0%	NA	0%
Al Farsi[24]	19		94.4%	11.76%	NA
Landau[15]	38		97.3%	2.7%	16.2%
Present study	20		90.0%	11.1%	22.2%

infarction and blood pressure[6]. Similarly, the safety of ESWL has been confirmed by various other authors [7,10,11].

Concern has been raised regarding the adverse effects of ESWL on the ovaries and epiphysis of the bones of paediatric patients during ESWL treatment[12,13]. McCullough evaluated the effects of shock waves on the rat ovary. He found no harmful short-term effects of the shock waves[12]. However, long-term effects on the ovaries of girls are not yet known. Nevertheless, invasive procedures such as ureteroscopy expose children to a greater risk of immediate complications, which probably outweigh the theoretical long-term dangers of ESWL [8].

The treatment of children with lithotripsy requires some modifications of the adult protocol, which depends on the type of the lithotripter used as well as the age and size of the child. Some authors used a modified infant car seat for small children[14]. In this series simple tapes were used to secure the children either in the supine or prone position. The same procedure was described by Landau et al.[15]. For thin children we used the same maneuver as described by Myers et al [2]. It was effective in localizing the stones and focusing shock waves on them.

More than 40% of stones larger than 5 mm remain for at least one year[16,17]. So we considered a stone diameter > 5 mm an indication for in-situ ESWL in this series. Stones causing obstruction, infection or persistent pain were also managed by ESWL as suggested by other authors[15,16,17].

The overall success rate in this study was 90% which compares favourably to the results reported in other series using different types of machines (Table 4). There was no appreciable difference in the success rate between the different levels of the stone in the ureter (Table 3). Similar results have been reported by other authors[8,15]. However, it should be noted that in our cases the stone burden was less in the mid and lower ureter compared to the upper ureter; also they needed a larger number of ESWL sessions and shocks to achieve the same success rate of the upper ureteric calculi (Table 2).

Success was considered only on complete disappearance of all stone fragments. This is in contrast to other definitions of success which include the presence of residual fragments < 3 mm[7, 8]. In this series 14/18 successfully treated patients (77.7%) needed only one ESWL session. The success rate of the first ESWL session reported by others is nearly the same ranging from 64% to 90%[8,15]. Four out of 18 cases needed more than one session, so the re-treatment rate in this series was 22.2%. This rate is comparable to the re-treatment rates recorded in other studies (Table 4). Al Busaidy et al. reported a high re-treatment rate reach-

ing 36%[8]. They explained this high re-treatment rate by a large mean stone burden and the small focal zone of the lithotripter used. On the other hand, series with a 0% re-treatment rate consisted of a small number of patients and are, thus, not comparable.

In this series we strictly observed a 2-week interval between two successive sessions. This protocol agrees with Myers et al.[2] who recommend that re-treatment of any calculi should not be done earlier than at least 2 weeks after the initial session. The appearance of the calculus on a post-treatment X-ray could be misleading. Some stones appear to be grossly unchanged or have subtle changes, however, at follow-up 2 weeks later many of these stones might appear well pulverized or absent[2,25,26]. In contrast to this treatment schedule, Gobish used a boosted, stentless, ventral technique for ESWL of mid and lower ureteric stones in adults. The boosted sessions were done on days 1, 2, 7 and 14 depending on the requirements[27]. He recommended this regimen to attain a high clearance rate within a short time, thereby avoiding auxiliary procedures[27].

To be successful, auxiliary procedures were used in this series in 11.1% of cases. In a large series of 208 paediatric ureteric calculi, Myers et al. used auxiliary procedures in only 17.7% of their cases[2]. Other urologists reported similar results (Table 3). No ureteric stents were used routinely in this series. A double-J stent was fixed before ESWL treatment twice in this series, one of them in a case of bilateral ureteric stones and the other in a case of infected hydronephrosis. Most children do not require elective stenting[14]. Stents do not affect fragment passage, and most urologists agree about not using stents except in cases of expected steinstrasse and ureteral obstruction[15,17].

In this series ureteric catheters were used in 3 cases (15%) to localize the stones. Landau et al.[15] used ureteric catheters in 15 (39.5%) out of 38 children for better identification and localization of the stones during ESWL. However, Van Kote et al. used ureteral catheters preoperatively in 19 of 22 paediatric patients with pelviureteric stones [28].

There is some controversy as to whether anaesthesia should be applied during ESWL in paediatric patients. In this series, 6 children (30%) needed general anaesthesia; all of them were below the age of 8 years. In the remaining 14 children (70%) intravenous sedation using fentanyl or midazolam was sufficient. Some authors routinely apply general anaesthesia in children below the age of 10 years[10]. Surely, the need for anaesthesia differs according to the age of the child, the degree of his cooperation and type of the lithotripter used.

A significant proportion of urinary stones in the paediatric age group is secondary to metabolic disturbances. Landau et al. found that 42% of their cases had metabolic disturbances[15]. This highlights the importance of metabolic evaluation in this age group and explains the high stone recurrence rate reported in children. It has been stated that stone recurrence in the paediatric population, regardless of the initial method of treatment, ranges from 10-20%[29,30]. Due to this high recurrence rate, non-invasive techniques offering the advantage of low morbidity should be selected for the treatment of urinary stones in children. Recent studies have documented satisfactory results with the use of ureteroscopic techniques in children, particularly in the treatment of mid and lower ureteric calculi[31]. However, because of the fragility of the ureter in the paediatric age group, ureteroscopic maneuvers should only be performed and handled by experienced endourologists in well equipped centers[32]. Paediatric ureteroscopy, particularly in the upper ureter, is associated with potential complications such as urethral injury in males, ureteric perforation and stricture of the ureter in both sexes[33]. Moreover, ureteroscopy requires a significant learning curve by the surgeon. On the other hand ESWL is technically much simpler. It is a safe and effective procedure to treat paediatric ureteric calculi.

We conclude that, not only in adults but also in the paediatric age group, ESWL can provide satisfactory fragmentation and clearance of calculi at all levels of the ureter without postoperative morbidity.

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RESUME

Calculs Urétéraux Chez l'Enfant : Lithotripsie Extra-Corporelle In Situ

Objectif : Cette étude avait pour but l'évaluation prospective de l'efficacité de la lithotripsie extra-corporelle in situ dans le traitement des calculs urétéraux chez l'enfant. **Patients et Méthodes** : Vingt deux enfants âgés de 2,2 à 16 ans, avec 22 calculs urétéraux, ont été traités par lithotripsie extracorporelle utilisant un lithotripteur Dornier S. La taille du calcul variait de 6 à 14,8 mm (moyenne 11 mm). La lithotripsie a été réalisée sous sédation intraveineuse ou anesthésie générale en ambulatoire. **Résultats** : Le calcul était situé dans la portion haute de l'uretère dans 11 cas, dans la portion moyenne dans 2 cas et dans la partie basse dans 7 cas. A 3 mois, un succès (absence totale de calcul) a été obtenu dans 18 cas (90%). Les taux respectifs de succès selon les sièges du calcul, de haut en bas, étaient de 91%, 100% et 85,7 %. Un traitement complémentaire a été nécessaire dans 4 cas (22,2%). La montée d'une sonde double J avant la lithotripsie a été nécessaire dans 10 % des cas. Les suites étaient simples. Il n'avait ni obstruction urétérale ni infection urinaire. De légères hématuries et coliques transitoires ont été observées après la lithotripsie. **Conclusion** : Chez l'enfant, la lithotripsie extra-corporelle in situ est une procédure efficace dans le traitement des calculs urétéraux quelque soit le siège. Il n'y a aucune morbidité liée à la procédure.

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