Medical & Surgical Urology

ISSN: 2168-9857

Bedzichowska et al., Med Sur Urol 2017, 6:3
DOI: 10.4172/2168-9857.1000193

Research Article OMICS International

Assessment of Efficiency and Safety of ESWL in Neurologically Immobilized Children with Urolithiasis-Single Center Experience

Agata Będzichowska[1], **Katarzyna Jobs**[1], **Bolesław Kalicki**[1], **Agnieszka Pskit**[1], **Kinga Pastucha**[1], **Piotr Murawski**[2], **and Anna Jung**[1]

[1]*Department of Pediatrics, Pediatric Nephrology and Allergology, Military Institute of Medicine, Warsaw, Poland*

[2]*Information and Communication Technology Department, Military Institute of Medicine, Warsaw, Poland*

[*]**Corresponding author:** Agata Będzichowska, Department of Paediatrics, Paediatric Nephrology and Allergology, Central Clinical Hospital of the Ministry of Defence, Military Institute of Medicine, Szaserów 128, 04-141 Warsaw, Poland, Tel: 48 261 817236; E-mail: abedzichowska@wim.mil.pl

Received date: September 08, 2017**; Accepted date:** September 19, 2017; **Published date:** September 26, 2017

Abstract

Introduction: Urolithiasis is one of the modern civilization diseases. Actually, its growing incidence in pediatric population is observed. Extracorporeal shock wave lithotripsy (ESWL) is widely used treatment method. Children with neurological disorders providing motion inability are large group of patients with urolithiasis. Referring such patients to lithotripsy procedure is controversial because motor disability and frequent anatomical deformations can restrict the ability to evacuate crushed stones. There are not many scientific data about safety, effectiveness and possible complications of ESWL method in this group, but it seems that it can be efficient.

The aim of the study was an assessment of ESWL safety and efficiency in terms of urinary stones migration and elimination from urinary tract in children with urolithiasis coexisting with physical disabilities

Material and Methods: Retrospective analysis of medical data of patients hospitalized in pediatric nephrology department between 2009-2015. Cases of children affected by urolithiasis accompanied by a permanent limitation of mobility, treated with ESWL were considered in detail.

Results: 42 ESWL procedures, concerning 22 children (11 boys, 11 girls), were performed among immobilized patients in observed period. Method effectiveness in terms of stone excretion was confirmed in 29 procedures (69%); in 13 cases (31%) elimination of crushed kidney stones was not observed. Initial localization of treated stone had influence on its excretion - significantly higher effectiveness when a stone was located in renal pelvis or upper calyces was reported. Urological intervention was necessary in 3 cases because of urinary tract blockage.

Discussion: The obtained result- 69% level of effectiveness in terms of stone elimination, is not significantly different from the results reported in the literature concerning treatment of fully fit patients. The necessity of urological intervention and postprocedural complications were not more frequent than in the population of children without neurological problems. Study restrictions were: relatively small number of observed patients and unknown stones composition.

Conclusion: ESWL procedure in children with limitation of mobility was effective and safe treatment of urolithiasis. Relation between location of crushed stone and the final effect of the treatment was observed.

Keywords: Urolithiasis; Children; ESWL; Neurological disorders with motion inability

Introduction

Urolithiasis is a disease that involves formation of stones in kidneys or urinary tract as a result of precipitation of substances that are normal or pathological ingredients of urine. In recent years, a systematic increase in its incidence is observed, also in children [1-5].

The majority of patients spontaneously excrete stones that are formed in the urinary tract, but in stones larger than 5 mm, conservative treatment is usually ineffective [6,7]. Minimally-invasive methods of treatment of urolithiasis include: ESWL, PCNL and URSL.

Among the three above-mentioned methods, the least invasive and the least burdening for a patient is ESWL procedure. Because of modernization of lithotryptors and significant development of experience in the application of the method, it becomes a golden standard in breaking stones of 5-20 mm, when free flow of urine from the urinary system is retained [8-10]. Extracorporeal lithotripsy can also be applied in treatment of multiple and staghorn urolithiasis, but in such cases, it is usually performed in several stages [8-10].

Complications of the procedure resulting from a direct effect on tissues and from moving of parts of crushed stones include: skin lesions (reddening, lividity, petechiae, skin necrosis), oedema and haematomas in renal parenchyma, erythrocyturia, proteinuria, dilatation of pelvicalyceal systems, urinary retention, hydronephrosis. Arterial hypertension can be a long-term complication. However, complications are observed less and less frequently and the majority of them is temporary [6,9,11,12].

The procedure is effective when the stone disintegration is observed. Another criterion of ESWL efficacy is the fact of crushed fragments evacuation. Final effect is usually assessed after 3 months from the procedure. Complete or partial (when residual fragments are up to 4 mm in its longest dimension) excretion of crushed stone is considered satisfactory result [8-10].

Evacuation of crushed fragments (efficient transport from the upper to the lower part of urinary tract) is facilitated by such factors as gravity, bowel peristalsis [13], ureter peristalsis. Thus, the location of kidney stones in renal pelvis and in the upper or middle renal calyx is the best prognosis for the effectiveness of ESWL method [6,8-10].

It results from the experience of the centre that to achieve better effect of the procedure, cooperation of the patient, consisting in various form of physical activity (e.g. going up and down the stairs, skipping with skipping rope), is necessary.

Children with neurological disorders providing motion inability are large group of patients with urolithiasis. Referring such patients to lithotripsy procedure is controversial because motor disability and frequent anatomical deformations can restrict the ability to evacuate crushed stones.

According to authors' best knowledge, in the available literature there is lack of scientific papers describing the safety, effectiveness and possible complications of ESWL in children with partial or complete lack of ability to move.

The aim of this study was to assess the effectiveness and safety of ESWL applied in children suffering from various neurological diseases causing partial or complete immobilisation.

Materials and Methods

In the present study, a retrospective analysis of medical records of patients hospitalised in 2009-2015 in the paediatric nephrology department was performed.

Children subjected to ESWL procedure, in whom the diagnosed urolithiasis was accompanied by various neurological burdens restricting mobility (children who were confined to bed or used wheelchairs) were included in the study. Patients with crushed stones following ESWL were considered in the analysis. Their demographic data and type of neurological condition were taken into consideration.

Exclusion criteria were: lack of stone disintegration in ultrasound examination after ESWL, abnormal course of urine outflow (an anatomical obstacle below a stone), coagulation disorders and body deformations forefending the appropriate positioning of a patient during the procedure.

Assessment of the effectiveness was conducted in terms of crushed stone excretion from urinary tract (observed during urination and confirmed in control ultrasound examinations). Evaluation the possibility of crushed fragments passage was the main aim of the study.

(In this specific group of patients, more important is ability of stone pieces migration and evacuation without complications than complete stone clearance in one procedure). The satisfactory therapeutic result was achieved in case of stone clearance or when residual fragments were up to 4 mm in the longest dimension. Safety of the method was appraised in terms of post complications.

The stone fragments passage was observed and its' size was measured during ultrasound examination on the first day after ESWL and repeated on the second day, two weeks and three months after ESWL. Every single ESWL procedure was analysed in detail. Size and location of stones in the urinary tract before the procedure were taken into consideration.

Statistical analysis

The calculations and analysis were performed with the use of Dell Statistica, version 13.

Numerical values for groups were compared with the use of U Mann-Whitney test. Location of stones (right or left kidney, location of stone in the kidney) was assessed using: Chi^2 Pearson, Chi^2 NW, Spearman's rank tests. Results for $p \leq 0.05$ were considered as statistically significant.

Results

Forty-two EWSL procedures with successfully crushed stones were performed in 22 partially or totally immobilised children in the paediatric nephrology department during 6-year observation period (Table 1). The number of procedures was dedicated to each patient individually, depending on its effect and patient's safety. ESWL was applied once in eleven patients. Eight patients underwent the procedure twice. Three patients required more procedures (three, five and six) in order to achieve satisfactory therapeutic result.

Staghorn urolithiasis affected one girl (stone 18 mm in longest dimension) and two boys (stones 17 mm in longest dimension) subjected to ESWL procedure. Girl's treatment was abandoned after five unsuccessful procedures. Satisfactory results in boys were achieved after one attempt in the first case and after three attempts in the second one. Stones were located in right kidney in each case of staghorn calculi.

All patients were treated by LITHOSKOP - the multifunctional lithotripter by Siemens. The number of shock waves and the energy were individually adjusted depending on age and body weight of each patient during ESWL. The energy intensity applied ranged from 10 to 19 kV, the pulses number from 1500 to 3000, with frequency 70-90/min.

In all cases, ESWL was conducted by using fluoroscopy imaging. All children underwent the procedure under general anaesthesia. The decision of pre-ESWL double-J stenting was taken in each case individually, depending on patients past clinical history of urinary retention or anatomical anomalies. Double-J stents were used in approximately 10% of procedures.

Post-ESWL treatment included: intravenous hydration, analgesics and spasmolitics. In our patients neurological disorders causing pareses were as follows: cerebral palsy, myelomeningocele and congenital hydrocephalus, drug resistant epilepsy and epileptic encephalopathy, and, in one case, spinal muscular atrophy. The above-mentioned disorders were concurrent in the majority of children.

Effectiveness of ESWL method, observed within 3 months from the procedure, was confirmed in 29 out of 42 single procedures (69%); in 13 procedures (31%) excretion of crushed stones was not observed. The examined population was divided into two groups, depending on the effectiveness of EWSL method.

The groups were compared in terms of sex, body weight, size and location of stone (Table 2).

Sex	
Female	11
Male	11
Number of procedures	42
Female	21
Male	21
Median age	10 years 6 months
Median body weight	30.9 kg
Location of crushed stone:	
Side	
RK	15
LK	27
Location in the kidney	
Upper renal calyces	6
Middle renal calyces	18
Lower renal calyces	10
Renal pelvis	8
Size of the crushed stone:	
5-10 mm	24
>10 mm (staghorn urolithiasis)	18 9
(F-Female; M-Male; RK- Right kidney; LK- Left kidney; n- Number)	

Table 1: Characteristics of studied population.

No statistically significant differences in patient's sex, age and body weight were found between the studied groups.

It was considered that concrement size was statistically significantly important for effectiveness of the procedure (p=0.03). Location of stones (right or left kidney, the location of stone in the kidney) was also analysed. Tests revealed: significantly higher effectiveness in excretion of crushed stones when a stone was located in renal pelvis (p=0.05) and in left kidney (p=0.01).

In case of stones located in upper calyces, the ESWL procedure was effective in all the patients (Table 2).

Tests did not reveal statistically significant relationship between stone diameter and number of procedures (R-Spearman=0.09, p=0.67) however, statistically significant correlation between stone location and number of sessions was observed (Chi^2 Pearson=23,24, p=0.0007).

In two cases children were referred to URSL procedure because of urinary retention caused by blockage of bladder ureteric orifice with passing crushed stone's parts. Initial calculi diameters were 20 mm and 10 mm. In case of one patient (girl with 8 mm stone), due to urinary retention caused by ureterostenosis and difficult anatomical conditions for ureteroscopy (scoliosis forefending the appropriate positioning of a patient) open surgery combined with crushing the stone in renal pelvis with the use of laser was carried out [14,15]. All of above mentioned stones were located in right renal pelvis.

In two cases minor early complications were observed. Elevated body temperature occurred in one case. In second case colic pain accompanied by vomiting was reported. There were no cardiac or anesthetic problems.

Total rate of complication was 12% (observed in 5 out of 42 cases). Cases when surgery intervention was needed (URSL in two cases, open surgery in one case) represented 7% of studied population. Reported complications were also presented according to Clavien Classification (Table 3).

	Group 1 effective ESWL method	Percentage of the effectiveness	Group 2 ineffective ESWL method	Statistical significance $p \leq 0.05$
Number of patients	29	69	13	
Sex of patients				0.51
Male	17		4	
Female	12		9	
Median age in years	10		12	0.45
Median body weight in kg	26.9		41	0.12
Location in the kidney				0.05
Upper renal calyces	6	100	0	
Middle renal calyces	10	56	8	
Lower renal calyces	6	60	4	
Renal pelvis	7	87.5	1	
Side				0.01
RK	3	20	12	
LK	26	96.3	13	
Size				0.03
Median stone size in mm	10		8	
Stones of 5-10 mm	15	62.5	9	
Stones>10 mm Staghorn stones	14 2	78 22.2	4 7	
(F-female; M-male; RK- right kidney; LK – left kidney)				

Table 2: Analysis of effectiveness of ESWL procedure depending on stone size and location in the kidney.

	Number of cases
Grade I	0
Grade II	2
Grade IIIa	0
Grade IIIb	3
Garde IVa	0
Grade IVb	0
Garde V	0

Table 3: Clavien Classification of noted complications.

Discussion

Urolithiasis is a civilization disease which frequently affects children, even in the first three months of life [1-5]. Technological development in construction of lithotryptors revolutionized the treatment of urolithiasis. They are actually widely used, so the experience of centres in the application of ESWL method has significantly increased, what evoked a marked increase in the effectiveness of urolithiasis treatment in children [6,8-10].

As a result of development of medicine an increase in the number of patients with various neurological problems causing partial or complete immobilisation is observed. Apart from many other disorders and complications resulting from primary diseases, motor disability is quite often accompanied by urolithiasis. According to generally accepted rules, immobilisation is not a contraindication to the procedure of extracorporeal lithotripsy.

Mobility restriction causes that a chance of excretion of crushed stone after the procedure seems to be smaller. Therefore, a question is whether it is justified to refer paraplegic or tetraplegic patients to ESWL procedure, especially as the method itself is connected with risk of various complications, and in children this procedure is performed under general anaesthesia.

According to presented results, ESWL procedure is safe and effective, also among the children with disability that restricts or prevents mobility.

The obtained result- 69% level of effectiveness is not significantly different from the results reported in the literature, achieved during the treatment of children without restricted mobility described in this paper (68-92% of effectiveness) [16-20].

In presented analysis, the influence of stone location on effectiveness of the procedure is similar to effectiveness of the procedure in fully fit patients. Perhaps gravity and physical activity influence the process of evacuation of stones in group of disabled patients in the same way as in healthy population – these children, even if they suffer from quadriplegia, are being sat, carried and rehabilitated.

In the presented material, the procedure seemed to be less effective in girls and when the crushed stone was located in right kidney. In addition, presence of staghorn stones only in left side was noted as well and might affect results according to location. However, unambiguous conclusions cannot be formed on the basis of observation of such small number of patients.

Interesting but confusing is the fact that effectiveness of the procedure in case of relatively bigger kidney stones seems to be higher. Perhaps bigger stones were crushed to smaller pieces more easily, what facilitated their evacuation. Urinary tract infections are more frequently observed in patients with restricted mobility than in healthy children. Struvite concrements, that are formed in the environment of urease-positive bacteria and repeatedly lead to the formation of staghorn urolithiasis, have different physical and chemical properties and due to this are crushed more easily than calcium oxalate stones that are prevailing in fully fit population [21]. Nevertheless, our results require confirmation in further studies.

A study restriction is the fact that composition of stones was not taken into consideration. On the other hand, the aim of the study was to measure the effectiveness of crushed stone excretion and clearance after ESWL. Efficacy of stone defragmentation was not the main aim in this research.

Other limitations of the research are: small group of patients, lack of the sufficient knowledge concerning radiolucency and hydronephrosis.

In the observed group, the necessity of urological intervention and postprocedural complications were not more frequent than in the population of children without neurological problems [22-24]. However, cooperation between nephrologists and urologists is essential, as it enables rapid performance of interventional procedure in case of such complications as blockage of stone's fragments resulting in urinary retention or hydronephrosis.

Similar studies concerning children population were not found in the available literature. However, there are several studies presenting the effectiveness of ESWL method in immobilised adults [25-27].

In 1991 Niedrach et al. published a study assessing the effectiveness of ESWL procedure in adult patients with spinal cord injury. The method turned out to be effective in the treatment of four out of nine patients, what was considered as an unsatisfactory result [25]. Verdu Tartajo et al. in 2006 described ten cases of adult patients after the operation of myelomeningocele, with urolithiasis. In three cases patients suffered from calculus of kidney and in seven patients it was calculus in bladder. In one case of kidney stone ESWL method was applied twice. However, the treatment turned out to be ineffective and the calculus was finally extracted with PCNL method [26]. Deliveliotis and his team also studied the effectiveness of ESWL method in patients with spinal cord injury. The procedure was performed in 15 paraplegic or tetraplegic patients. Its effectiveness was confirmed in 10 patients [27]. Safety and good tolerability of the procedure among immobilized patients was highlighted in all the above-mentioned studies. However, these studies concerned small groups of adult patients.

Conclusions

A method of crushing kidney stones with the use of shock wave generated extracorporeally, that was applied in children with motor disability restricting or unabling mobility, was safe and effective.

In the described group of patients with motor disability, the effectiveness of ESWL method depended on location of stone. An increase in the effectiveness of the procedure was observed with its location in renal pelvis and upper calyces.

A close cooperation of nephrological centres and urological centres is necessary in treatment of patients with urolithiasis and motor disability, in whom the risk of complications is higher than in general population. It enables appropriate qualification of patients to a procedure, rapid intervention in case of complications and a possibility to combine together several methods of treatment.

Autorship

Disclosure of potential conflicts of interest

Research involving human participants

Author of the first draft of the manuscript is Agata Będzichowska. All authors have directly participated in the conception, planning, collection, analysis, interpretation of data or critical revision of this manuscript. All authors of this paper have read and approved the submission of this version of the manuscript and takes full responsibility for the manuscript. There are no prior publications or submissions with any overlapping information, including studies and patients. There are no directly related manuscripts or abstracts, published or unpublished, by any authors of this paper. The contents of this manuscript will not be copyrighted, submitted, or published elsewhere. All authors disclose any potential, perceived, or real conflict of interest. There were no sponsors of this paper with no role in 1) study design; 2) the collection, analysis, and interpretation of data; 3) the writing of the report; and 4) the decision to submit the manuscript for publication. There has been no honorarium, grant, or other form of payment given to anyone to produce the manuscript. All authors of this paper declare not to have any commercial or associative interest that represents a conflict of interest in connection with the work submitted. The authors have not received any reimbursements, fees, funding or salary from an organization that may in any way gain or lose financially from the publication of the manuscript, either now or in the future. The authors do not hold any stocks or shares in any organization that may gain or lose financially from the publication of this manuscript, either now or in the future. The authors do not hold and are not currently applying for any patents relating to the content of the manuscript, they have not received any reimbursements, fees, funding or salary from any organization that holds or has applied for patents relating to the content of the manuscript. The authors do not have any other financial competing interests. There are not any non-financial competing interests to declare in relation to this manuscript. Informed written consent was obtained from patients parents and patient himself before submitting the manuscript. Preparing this article has not required bioethics committee approval, according to Bioethics Commission of Military Institute of Medicine in Warsaw, Poland. Institute's Department of Pediatrics, Pediatric Nephrology and Allergy,

Military Institute of Medicine, Warsaw, Poland. Representative is fully aware of this submission. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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