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EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY;
OUTCOME IN PEDIATRIC UROLITHIASIS

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ABSTRACT... Aim and Objectives: (1) To determine the efficacy of extra-corporeal shock wave lithotripsy with reference to stone size, site and radiodensity in children. (2) To determine acute early complications during and following extra-corporeal shock wave lithotripsy in children. **Study Design:** Analytical case series study. **Material and Methods:** Fifty patients of either sex below the age fourteen (14 years) having renal, ureteric and bladder stones between 5-20 mm in size along with their long axis presented to department of urology Shaikh Zayed Hospital Lahore during the period of one year extending from 02-02-2008 to 02-02-2009 were included in this study. Children with serum creatinine level greater than or equal to 3mg/dl, obstruction distal to the stone, patient with active bleeding disorders, uncorrected hypertension, patient unfit for general anaesthesia, untreated urinary tract infection and patients with gross anatomical anomaly were excluded from study. All the patients were given shock waves under intravenous sedation or general anaesthesia in a standard manner on out door basis. All the children were evaluated for stone clearance and early complications at first 24-72 hours. At the end of three months ESWL treatment was considered successful, if the patients were stone free or had residual fragments 4 mm or less in size. **Results:** Out of the fifty patients, 40 (80%) were males and 10 (20%) females with male to female ratio of 4.1. The age range of patients was 2-14 years (mean ± SD 9.24±3.48 years). Thirty three patients (66%) had renal stones, 7 (14%) ureteric and 10 patients (20%) had bladder stones. Single successful treatment session was noted in 22 patients (44%), 18 patients (36%) received two sessions and 10 patients (20%) required three sessions for successful stone fragmentation. Seventeen patients did not show stone clearance even after three sessions within three months follow-up. Twenty one patients (42%) felt pain after lithotripsy session, and they were given injectable analgesia and the pain settled, haematuria in 17 patients (34%), impacted stone in five (10%), ureteric colic and urinary tract infection in three, three cases respectively and only one case developed steinstrasse. Twenty patients (40%) developed minor complications of anaesthesia, like nausea, vomiting which relieved with injectable antiemetics.

Key words: Pediatric Urolithiasis, Extracorporeal Shock Wave Lithotripsy, Complications of ESWL

.INTRODUCTION

Extracorporeal Shock wave lithotripsy (ESWL) is now accepted as the first-line therapy for most of the urinary tract stone disease in the pediatric population[1]. The stone clearance rate in children treated with ESWL is greater than that in adults[2]. In adults the efficacy of ESWL for lower polar stones is significantly lower compared with the other kidney locations[3]. Recently Ather and Noor4 reported that the stone clearance was not negatively affected by a stone size greater than 30mm; however lower pole caliceal stones in pediatric population also had relatively poorer clearance. Even ESWL monotherapy for staghorn stones in children have been reported to be successful in one recently reported series[5].The stone free rate evaluated three month after ESWL depends on stone disintegration, the disintegration itself depends on stone volume[6,7] stone composition, localization, type of lithotripter, applied shockwave number and energy[8,9].

Percutaneous nephrolithotomy (PCNL) appeared on the clinical horizon and become popular and effective, especially for larger stones. PCNL using adult nephroscope in a small child may cause increased damage to the renal parenchyma. In children PCNL is indicated for large stone burden, dilated obstructed kidneys, radiolucent or cystine stones (refractory to ESWL) residual stones after failed ESWL or open surgery. But it was overshadowed by the complete non-invasiveness of ESWL because PCNL itself is relatively invasive although minimally. Same is the case with ureterorenoscopy, which is also not free of complications[10].

Chaussy reported no complications up to 5 years following treatment with ESWL[11]. This increased popularity of ESWL led to rapid patient acceptance and clinical adoption throughout the world, which is almost without precedent[12]. Albaran et al said that ESWL was followed by excellent results and there are few major side effects. But at the same time he indicated that little work is being done for the documentation of pathological changes. Haemorrhage subscapsular or perirenal, haematoma[13], pancreatitis, steinstrasse and residual stones[14], loss of renal function without ureteral obstruction, albuminuria, urinary infection, haematuria, and new onset of hypertension, radiation exposure and increased rate of new stone formation are few complications which are reported in literature[15].

In Pakistan, since ESWL has recently been introduced in the Government sector, so we had a good opportunity to organize a disciplined study to elicit complications following ESWL treatment and also to work on the efficacy of lithotriptor in stone breakage and clearance. Shock waves are not without biological effects as these pass through the body. We should know the possible complications of ESWL treatment and our first aim should be to safeguard the benefit and well being of the patients undergoing ESWL therapy. By this study we were able to formulate basic data which helped us to establish steps to avoid complications and to measure safe limits of ESWL therapy in children for the benefit of patients and humanity.

MATERIAL AND METHODS

Fifty patients of either sex below the age fourteen (14 years) having renal, ureteric and bladder stones between 5-20 mm in size along with their long axis, presented to Department of Urology Shaikh Zayed Hospital Lahore during the period of one year extending from 02-02-2008 to 02-02-2009 were included in this study.

Exclusion Criteria

Children with serum creatinine level greater than or equal to 3mg/dl,obstruction distal to the stone, patient with active bleeding disorders, uncorrected hypertension, patient unfit for general anaesthesia, untreated urinary tract infection and gross anatomical anomaly like horse shoe kidneys, ectopic, duplicated kidney and ureter were excluded from the study.

Informed consent was obtained from all the patients, Parents. Detailed history and demographic profile of the patient like age, sex, presenting complaints and history of any other problem was elaborated. Complete physical examination was recorded. Basic laboratory investigations including, Blood complete examination, Urine analysis and culture sensitivity, Blood urea and serum creatinine, Ultrasound (kidney, ureter, and bladder) and Intravenous urography was performed.

Plain radiography of kidney, ureter and bladder was required to see stone size, shape and radio density. The stone size was divided into three groups. In the first group the stone size was between 6-10 mm, second group 11-15mm and in third group it was 16-20 mm. Stone density was considered low, equal and high relative to that of bone.

All these information were recorded on a specially designed proforma. Confounding variables were controlled. The site, size, number of shocks, voltage, stone fragmentation, procedure time, hospital stay, stone clearance on follow up and complications were recorded. All the patients were given shock waves under intravenous sedation or general anaesthesia in a standard manner on out door basis, employing an electromagnetic lithotriptor (Modulith CR SLX—OD-958/2004). All the children were evaluated for stone clearance and early complications at first 24-72 hours. At the end of three months ESWL treatment was considered successful, if the patient was stone free or had residual fragments 4 mm or less in size. All the information obtained from the proformas were transferred to SPSS version 12 and analyzed through its statistical package. Mean and standard deviation calculated for age. Frequency and percentages were calculated for sex, type of stone, position and size of stones and outcome. Chi square test was applied on complications of ESWL to find out P value. (Value < 0.05 was considered significant)

RESULTS

Out of the fifty patients, 40 (80%) were males and 10 (20%) females with male to female ratio of 4.1. The age range of patients was 2-14 years (mean±SD 9.24±3.48 years), table I describes distribution according to age. Of the fifty patients, 33 patients (66%) had renal, 7 (14%) ureteric, 10 patients (20%) had bladder stones and table-II describes the distribution of site and side of stones.

There were 88 ESWL treatment sessions performed on 50 patients. Single successful treatment session was noted in 22 patients (44%), 18 patients (36%) received two sessions and 10 patients (20%) required three sessions for successful stone fragmentation. Seventeen patients did not show stone clearance even after three sessions within three months follow-up.

The re-treatment sessions were generally spaced 7-14 days apart and the duration of each treatment session was 20-45 minutes.

It was noted that the calyceal stones required 2660 average number of shock waves (2400-3200 in range) at a mean voltage of 5.8K.V (5-7K.V in range) for adequate fragmentation with 1.6 average treatment session (1-3 in range). The detailed relationship of number of shocks and voltages of ESWL to stone location in successful cases is given in table III.

Table-I. Distribution of cases according to age (N=50)

Age (years)	No. of cases	%age
2-4	7	14%
5-7	10	20%
8-10	12	24%
11-13	16	32%
>13	5	10%
Mean + SD 9.24+3.48 years		*Range 2-14 years*

Of the ten bladder stones, 8 stones (80%) were successfully fragmented. Renal pelvic stones (18 cases) which measured 6-10mm in size, required 2611 average number of shock waves (1200-3200 in range) at a mean voltage of 6.2 K.V (4-8 in range) for adequate fragmentation and clearance. The values of average shock waves and mean voltage according to size of stone and final outcome with size of stone in different location are given in table 4 and 5 respectively.

Table-II. Size of stone (MM) in different locations

Location of stone	Size of stone (mm)			Total
	6-10	11-15	16-20	
Calices	5	-	-	5
Lower pole	5	2	4	11
Mid pole	2	-	2	4
Pelvis	3	1	3	7
PUJ	3	2	1	6
Ureteric (lower)	2	-	2	4
Ureteric (mid)	1	-	-	1
Ureteric (upper)	2	-	-	2
Bladder	1	3	6	10
Total	24(48%)	8(16%)	18(36%)	50(100%)

Overall success rate considering all the stones in kidney ureter and bladder was 66%(33 patients) which were either stone free or the residual stones less than 4mm in size at 3 months follow-up.Twenty one patients (42%) felt pain after lithotripsy session, requring injectable analgesia, haematuria was observed in 17 patients (34%), stone impaction in five (10%), Ureteric colic and UTI in three cases each respectively and only one case developed steinstrasse. Twenty patients (40%) developed minor complications of anaesthesia, like nausea, vomiting which sattled with injectable antiemetics. Tabele 6 describes the complications of ESWL.

DISCUSSION

Extracorporeal shock wave lithotripsy was first used in February 1980 to fragment human kidney stones. Because of its safety, low morbidity, non invasive character and greater patient acceptance, it has now

Table-III. Relationship of number of shocks and voltages of ESWL to stone location in successful cases

Location of stone	Range of shock waves (Number)	Mean of shock waves (Number)	Rang of voltage (K.V)	Mean of voltage (K.V)	Average No. of treatment session	Range of treatment session
Calices (5)	2400-3200	2660	5-7	5.8	1.6	1-3
Pelvis (7)	2400-3200	2828	5-9	7.3	2.0	1-3
PUJ (6)	1200-3000	2266	5-8	6.7	1.7	1-3
Lower pole (11)	1600-3200	2645	4-9	6.8	1.9	1-3
Mid pole (4)	2400-3200	2600	5-8	6.2	2.2	1-3
Ureter (7)	2400-3000	2728	5-9	7.1	1.3	1-2
Bladder (10)	2600-3000	2780	8-9	8.1	1.9	1-3
Mean±SD	1200-3500	2643 ± 184.61	4-9	6.9 ± 0.75	1.8 ± 0.29	1-3

Table-IV. The values of average shock waves and mean voltage according to size of stone

No of patients	Size mm	Average shock waves	Mean voltage KV
Renal stone (33)			
18	6-10	2611	6.2
5	11-15	2680	7.4
10	16-20	2580	6.7
Ureteric (7)			
5	6-10	2611	6.2
2	16-20	2580	6.7
Bladder stone (10)			
1	6-10	2600	8
3	11-15	2860	8.3
6	16-20	2766	8

become standard and preferred part of urologist's armamentarium for the treatment of 90-95% of patients with urolithiasis[16,17] Chaussy[18] Shock waves are not without biological effects as these pass through the body. As clinicians we should know the possible complications of ESWL treatment and our first aim should be to safe guard the benefit and well being of the patients undergoing ESWL therapy. The purpose of our study was to determine the efficacy of ESWL, elicit acute early complications and to establish the safe limits of ESWL treatment in children.

Although all the stones were less than 20mm in size in our patients, it was observed that the success rate declined with increasing size of the stones. The success rate with ESWL monotherapy was higher 66.70 %(12/18) in group1, while it was 40 %(4/10) in group3 with the stone size 16-20mm. In the case of ureteric stones, the success rate for stones measuring 6-10 mm in size was 80% (4/5), while it was100% (2/2) for the stones 16-20 mm in size. The success rate for bladder stones in group 1& group 2 was 100% and for group 3 it was 66.7 %(4/6).There is no published data available on the evaluation of efficacy of ESWL with reference to stone size. But it is clear from our results that there is decreasing response to ESWL on stone fragmentation as the size of the stone increases.

We observed that the size of the stone is not the only factor but radio-density of the stone is also very important in the outcome of ESWL treatment. Radiodensity of the stones is in fact radiographic assessment of the chemical composition of the stones. Slavkovic et al[19] described that calcium oxalate monohydrate and calcium

Table-V. Final outcome with size of stone (mm) different location

Location of stone		Size of stone (mm)			Total
		6-10	11-15	16-20	
Renal	Successful	12 (66.7%)	3 (60%)	4 (40%)	19 (57.6%)
	Failed	6 (33.3%)	2 (40%)	6 (60%)	14 (42.4%)
		18	5	10	33
Ureteric	Successful	4 (80%)	-	2 (100%)	6 (85.7%)
	Failed	1 (20%)	-	-	1 (14.3%)
		5	-	2	7
Bladder	Failed	-	-	2 (33.3%)	2 (20%)
	Successful	1 (100%)	3 (100%)	4 (66.7%)	8 (80%)
		1	3	6	10

Table-VI. Complication of ESWL and Chi Square analysis

Complications	No. of patients	%age
Haematuria	17	34.0
Impacted stone	5	10.0
Retention of urine	2	4.0
Pain	21	42.0
Postanaesthetic complication (Nausea/vomiting)	20	40.0
Stein Stress	1	2.0
Ureteric colic	3	6.0
Septicemia	3	6.0
P Value	0.01	-

phosphate stones are of high density and are extremely resistant to ESWL treatment. El-Gamal and El-Badry[20] reported that calcium oxalate dihydrate, apatite and struvite stones are of low density and respond well to ESWL treatment. Radiolucent stones (uric-acid) are pulverized well by ESWL treatment.

In our series twenty six (86.7%) low density (radio-density less than bone) stones were successfully treated. Only four (13.3%) stones of the kidney of low density were not cleared even after three months of follow-up. Their size was in the range of 16-20mm.There were 14 stones with radio-density equal to that of bone and 71.4% (10/14) were successfully fragmented and cleared at the end of three month follow-up. The stones with density greater than bone were successfully fragmented in 6 stones 33.3%. There is no much published data on the evaluation of efficacy of ESWL with reference to stone density. We may here corroborate findings of Murshidi et al[21] to describe the relationship of density of the stone with fragmentation and clearance. Calculi are crystalline structures and these possess imperfections or micro fractures. These crystalline structures are prone to crack along plane of micro fractures when shock waves are applied. High radio-density stones possess fewer imperfections or microfractures than others. That is why stones with higher radiodensity are resistant to fragmentation.

The over all success rate in the case of renal stone in our series was 66.7% (12/18). Which is far less than the results obtained by Kurien et al[22] who claimed 94% stone clearance in their pediatric patients, while a study by Demirkesen[23] et al revealed 83% stone clearance in renal stones.

This gross difference with our study may be due to their late follow up, after one year and secondly they delivered shock waves at an average of 18 K.V (15-24 in range) and delivered 858 shock waves per treatment session but in our study we delivered 26[23] shock waves per treatment session at an average of 6.8 K.V in the case of renal stone. Ramakrishnan et al[24] and El-Assmy[25] et al achieved 65% and 61% stone clearance rate respectively in their pediatric series. Mohayuddin et al[26] increased shock wave power (number of shock waves x voltage) by applying shock waves at maximum generation voltage of 19 K.V and tried to pulverize the stones in a single session. We observed that although ESWL treatment produced haematuria but when the voltage was increased to above 8 K.V, haematuria was heavy (a reflection of renal parenchymal injury). Thus for adequate fragmentation of stones as stone size increases, In our opinion instead of increasing the voltage above 8 K.V the number of shock waves may be increased.

In case of ureteric stones, the stone clearance rate was 85.7% (6/7). The reported success rate of in situ treatment of ureteric stone ranged from 79-88%[24,27]. Ramakrihnan PA, and Murota Kawano A workers applied high range of voltage (18-30 K.V) than that of our series (5-9K.V).

The success rate in bladder stones of our series was 80% (8/10), and the stones required average 2780 shock waves at a voltage of 8.1 K.V (8-9 K.V in range) 1.9 average treatment sessions. The bladder stones comparing, those of renal stones in our series required more number of shock waves, more number of average voltages and more number of average treatment session and even then the results were better than those of the renal. The reason may be that there is better drainage of fragments in case of bladder stones, secondly there is lot of space filled with fluid around the bladder stones resulting in better fragmentation. Al-Ansari et al[28] have claimed 100% results in their series of 10 patients with bladder stone.

Three (6%) of our patients presented with high grade fever i.e > 100F^0 within 24 hours of ESWL treatment. Pre ESWL, urine for culture was not performed as the patients did not clinically have any signs and symptoms of UTI and urine routine examination did not reveal any pus cells. Haematuria is the most common and immediate effect ascribed to shock waves. It is a reflection of parenchymal injury due to shock waves. Implosions of the bubbles under the pressure phase of shock wave lead to release of energy missiles. When this phenomenon occurs around the small vessels, it may produce disruption of the vessels[29]. Shokeir et al[30] reported that medullary vessels were more vulnerable to shock waves than the cortical vessels. Although medulla is located farther from the cortex and it receives relatively lower shock waves pressure but it is more sensitive in developing haemorrhage. This is due to meduallary vessels are surrounded by loose connective tissue which allows easier extravasation and detection. The trauma incurred to vessels by shock waves may range in severity from mild extravasation of blood cells to severe renal haemorrhage. We observed haematuria in 34% of our patients after ESWL treatment and which settled in all patients within twenty four hours.

In our series all patients received shock waves under general anaesthesia but 21 (42%) of them felt pain at the site of application of ESWL, after recovery from anaesthesia. They were given injectable narcotic analgesia and the pain settled in all the patients. In a study, this problem was recorded in 28 (44%) patients who were also managed on conservative basis[31].

Clinically steinstrasse can be described either complicated or uncomplicated. In complicated steinstrasse there is moderate to severe colic, fever (sepsis) nausea, vomiting and increasing hydronephrosis, which usually requires intervention. The uncomplicated steinstrasse is usually asymptomatic or causes mild pain and may be associated with mild degree of hydronephrosis. This type of steinstrasse usually clears spontaneously. Irani et al[32] reported (4.5%) incidence of steinstrasse. His patients were successfully treated with ESWL and no invasive procedure was done.

Two of our patient of bladder stones went into retention of urine on the 1st day after ESWL treatment. They were catheterized and admitted in the ward. It may be due to a large fragment of stone obstructing the internal meatus.

In a study by Al Ansari, 4 patients developed acute urinary retention due to urethral stone impaction, which were managed with multiple sessions of ESWL[28].

CONCLUSION

ESWL is safe and effective modality for the treatment of urinary stones as monotherapy in selected patients. The liberal use of ESWL for every type and size of stone is not justified. Although the stone size was less than 20 mm in our study but we have observed that with increasing size of the stone, fragmentation and clearance rate of the stone decreased.ESWL is safe and non invasive treatment modality, though ESWL is associated with certain complications but these are usually mild and transient.

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