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Original Research Article

A Observational Study on the Effectiveness of Extracorporeal Shock Wave Lithotripsy (ESWL) for Stone Disintegration in Children at a Tertiary Care Hospital

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Conflict of interest: Nil

Abstract

Background: Urolithiasis affects 1-5% of children.
Renal stone therapy using extracorporeal shock wave lithotripsy (ESWL) is non-invasive.
In this study, we assessed the effectiveness and variables that predicted the success of ESWL for stone disintegration in paediatric patients.

Material and Methods: In this retrospective analysis, 58 paediatric patients under the age of 18 who were receiving ESWL were included**.** The stone size, stone location, density were assessed by appropriate investigations. The disintegration of stones was performed by ESWL. Stone-free status or the presence of clinically insignificant residual fragments (CIRF) at the end of three months (5mm) were used to define ESWL success.

Results: the mean age was13.26±3.82, and mean size of the stones was 10.33±0.364mm (9.6-11.06). Post ESWL, the success rate i.e stone free rate was 54 (93.1%) patients with no residual stones. There is significant strength of association of size of stone, density of stone administration of anaesthesia and complications with number of session/sittings, number of ESWL shocks received and stone free rate (SFR) in patients

Conclusion: ESWL has a good stone-free rate when used as the first line of treatment for paediatric urolithiasis stones that are smaller than 10mm in diameter, have less than 1000HU and are located in the upper ureter (SFR). The location of the stone and the SAV are independent indicators of ESWL success, and anaesthesia is useful when doing ESWL on children younger than 12 years old.

Keywords: Paediatric, Urolithiasis, Lithotripsy.

Introduction

In the past few decades, urolithiasis has become more common in children around the world, with 1-5% of Asian children affected. [1] . Since the 1980s, juvenile renal stones have been treated with extracorporeal shock wave lithotripsy (ESWL), which has revolutionised non-invasive management of renal stones.[2]. Due to a shortage of instruments appropriate for treating children and additional concerns about renal injury and stunted renal growth, acceptance for this therapy modality was slower than that for adults. During the year 1990s has shown not only the high efficacy,[3] but also safety of ESWL in children for short and long term. [4] ESWL has become choice of procedure for managing majority of the upper urinary tract calculi in children.[5,6] Numerous studies have showed shock wave lithotripsy with an overall stone clearance rate of almost about 80% at the 3 months of follow-up in paediatric group with stone size up to 20mm. [7,8] .ESWL is not without complications; one of such is stein Strasse which may occur due to obstructed ureteric fragments. Although ureteral stenting believed to be useful in preventing such complications as renal colic and obstruction post ESWL, but no documented role against stein Strasse formation.[9]. Before treating urolithiasis, a few aspects need to be taken into account, including their size, composition, location, and existence of hydronephrosis, as well as anatomical considerations such the presence of a solitary kidney, strictures, and obesity. [10,11]. We sought to assess the effectiveness, safety, and outcome of ESWL as a primary mode of treatment for paediatric urolithiasis.

Objectives: To evaluate the results, safety, and effectiveness of ESWL in children with urolithiasis.

Material and Method

It is a retrospective study carried out at the Bangalore Nephro-Urology Institute's department of urology. Children with urolithiasis under the age of 18 who received therapy from ESWL were included in the study. Prior to ESWL, each of the included kids underwent a thorough evaluation of their medical histories, physical exams, and pertinent investigations. Renal Ultrasonography, a simple x-ray, or a computed tomography scan were used to locate the stone and measure its size. 11 of the patients who were included underwent DJ stenting prior to ESWL because of infection and severe flank discomfort; these patients were treated with analgesics and antibiotics.

For renal and ureteric calculi, the patient was placed in the supine position and subjected to ESWL using a Dornier MEDTEC deltaII lithotripter with a therapeutic power of10/12 KV and up to 2000 shocks per session, at a rate of 60 shocks per minute, while being monitored by real time USG or fluoroscopy. In 40 patients had ESWL without the use of anaesthesia, whereas theremaining18 patients who were under the age of 12 years needed general anaesthesia. Patients were evaluated seven to ten days after each therapy session using the USG/X ray KUB to look at the fragmentation and elimination of calculi. If any additional sessions were required, one was held after 7–10 days. Stone-free status or the presence of clinically insignificant residual fragments (CIRF) at the end of three months (5mm) were used to define ESWL success. [12] Failure of the ESWL was defined as the inability to reduce the size of the stone or the persistence of stone pieces at the 3-month mark. Statistics: The demographic details of the patient are presented Mean±SD, frequency and percentage. Correlation was tested using Kendal Tau and Spearman's correlation, chi-square test and ANOVA to determine the difference between the means of groups as applicable. Multinomial logistic regression between gender, stone size, site, SAV (stone absorption unit), IV sedation and SFR (Stone Free rate) to derive equation of fitness to model. The statistical analysis was performed using the SPSS version 23.

Results

A total number of 58 children have included in current study with 18 patient have undergone ESWL under anaesthesia and other 40 without anaesthesia. Other demographic details in our study showed; mean age of the children was 11.25±3.8yrs, with male to female ratio of 1.5:1. Renal stone laterality: right-35 and left-23. 51children had radio-opaque stone type and other 7 had radio-lucent stones on radiological finding.

Table 1: Correlation of size of stone, density of stone, administration of anesthesia and complications with no of sitting, no of ESWL shocks and stone free rate.

	No of sitting **r value** **p value**	**No of ESWL shocks** **r value** **p value**	**SFR** **r value** **p value**
Size of stone in mm (n-58)	0.379 $<0.001^{***}$	0.359 $<0.001^{***}$	-0.486 $<0.001^{***}$
SAV in HU (n-58)	0.469 $<0.001^{***}$	0.441 $<0.001^{***}$	-0.065 0.63
General Anesthesia administered (n-58)	-0.329 0.012^{**}	-0.465 0.002^{**}	0.358 0.006^{**}
Post ESWL complications (n-58)	0.231 0.065	0.284 0.031^{*}	-0.374 0.004^{**}

Legend to table no. 1: No of sitting, ESWL shocks and SFR is significantly associated with size of stone, SAV, anesthesia administered and complications.
Abbreviations: SAV– Stone absorption unit. HU-Hounsfield units, ESWL-Extracorporeal shock wave lithotripsy. SFR -Stone free rate category- complete clearance, stone size of insignificant size<4mm within 3 months of ESWL and not cleared.
Kendal Tau correlation was used for correlation of size and SAV with others. Spearman's correlation was used for the rest.
p<0.05 is significant.

There is significant strength of association of size of stone, density of stone administration of anaesthesia and complications with number of session/sittings, number of ESWL shocks received and stone free rate (SFR) in patients. (Table 1)

Table 2: Difference in gender, site, age, SAV, size, No of sittings and ESWL in SAV groups.

<table>
<tr><th rowspan="2">Variable</th><th colspan="4">SAV (HU)</th><th rowspan="3">Critical ratio
p value</th></tr>
<tr><th>≤750</th><th>751-1000</th><th>>1000</th><th>All</th></tr>
<tr><td>N</td><td>29</td><td>20</td><td>9</td><td>58</td></tr>
<tr><td colspan="6">Gender, n (%)</td></tr>
<tr><td>Male</td><td>17</td><td>12</td><td>4</td><td>33</td><td rowspan="2">0.683
0.820</td></tr>
<tr><td>Female</td><td>12</td><td>8</td><td>5</td><td>25</td></tr>
<tr><td colspan="6">Stone site, n (%)</td></tr>
<tr><td>Lower calyx</td><td>5</td><td>2</td><td>1</td><td>8</td><td rowspan="5">0.586
0.598</td></tr>
<tr><td>Upper calyx</td><td>5</td><td>3</td><td>3</td><td>11</td></tr>
<tr><td>Mid pole</td><td>7</td><td>5</td><td>0</td><td>12</td></tr>
<tr><td>Upper uretur</td><td>5</td><td>6</td><td>1</td><td>12</td></tr>
<tr><td>Renal pelvis</td><td>7</td><td>4</td><td>4</td><td>15</td></tr>
<tr><td colspan="6">Age in years</td></tr>
<tr><td>Mean±SE
(95% CI)</td><td>13.45±0.72
(11.97-14.92)</td><td>13.25±0.93
(11.3-15.2)</td><td>12.67±1.02
(10.3-15.04)</td><td>13.26±3.82
(12.25-14.26)</td><td>0.14
0.87</td></tr>
<tr><td colspan="6">Size of stone in mm</td></tr>
<tr><td>Mean±SE
(95% CI)</td><td>9.83±0.577
(8.65-11.01)</td><td>10.25±0.416
(9.38-11.12)</td><td>12.11±0.964
(9.89-14.3)</td><td>10.33±0.364
(9.6-11.06)</td><td>2.46
0.095</td></tr>
<tr><td colspan="6">SAV in HU</td></tr>
<tr><td>Mean±SE
(95% CI)</td><td>640.34±17.8
(603.85-676.84)</td><td>874.5±13.77
(845.67-9.3.33)</td><td>1193.33±29.15
(1126.1-1260.5)</td><td>806.9±28.2
(750.41-863.39)</td><td>157.54
$<0.001^{***}$</td></tr>
<tr><td colspan="6">No of sittings</td></tr>
<tr><td>Mean±SE
(95% CI)</td><td>1.52±0.107
(1.3-1.74)</td><td>1.95±0.17
(1.59-2.31)</td><td>2.89±0.111
(2.63-3.15)</td><td>1.88±0.102
(1.68-2.08)</td><td>39.46
$<0.001^{***}$</td></tr>
<tr><td colspan="6">No of ESWL shocks</td></tr>
<tr><td>Mean±SE
(95% CI)</td><td>2782.76±220.06</td><td>3625±351.45
(2889.4-4360.6)</td><td>5777.78±222.22
(5265.3-6290.2)</td><td>3537.9±214.18</td><td>46.18
$<0.001^{***}$</td></tr>
</table>

	(2331.99-3233.53)			(3109.04-3966.8)	

Legend to table no. 2: There was no difference in gender, age, size and site of stone. No of ESWL shocks, sittings and SAV significantly higher in patients with high SAV.
Abbreviations: SAV– Stone absorption unit. HU-Hounsfield units, ESWL-Extracorporeal shock wave lithotripsy. SFR -Stone free rate- complete clearance or stone size of insignificant size<4mm within 3 months of ESWL.
Chi square test was used for analyzing the difference for gender and site; Exact test was used when variable size was<5; one way ANOVA for age, size and SAV; Welch ANOVA for no of sittings and ESWL.
p<0.05 is significant.

We divided the patients into three groups based on the SAV as group 1 <750HU, group 2 750-1000HU and group 3 >1000HU. There was no significant mean difference between the groups with respect to the age, gender, site of stone and size of stone. There is statistical significant mean difference in groups with respect the number of sittings and the ESWL shocks required for the treatment. Group 3 required more number of sittings for the treatment and more ESWL shocks. (Table 2)

Table 3: Multinomial logistic regression between gender, stone size, site, SAV, iv sedation and SFR.

Variable	Patients, n (% of all)	Success, n (%)	p
Gender			
Male	33(56.9)	31(93.9)	0.774
Female	25(43.1)	23(92)	
Size of stone in mm			
≤10	35(60.3)	34(97.1)	0.136
>11	23(39.7)	20(87)	
SAV in HU			
≤750	29(50)	27(93.1)	0.825
751-1000	20(34.5)	19(95)	
>1000	9(15.5)	8(88.9)	
Site of stone			
Lower calyx	8(13.8)	7(87.5)	0.352
Upper calyx	11(19)	11(100)	
Middle calyx	12(20.7)	11(91.7)	
Upper ureter	12(20.7)	12(100)	
Renal pelvis	15(25.9)	13(86.7)	
Anesthesia administered			
Sedation iv	18(31)	18(100)	0.078
Local anesthesia	40(69)	36(90)	

Legend to table no. 3: gender, stone size, site, SAV and sedation could not significantly predict SFR. But SFR was higher in stone size <10 mm, SAV<1000 HU, upper ureter, upper calyx and iv sedation.
Abbreviations: SAV– Stone absorption unit. HU-Hounsfield units, ESWL-Extracorporeal shock wave lithotripsy. SFR -Stone free rate- complete clearance or stone size of insignificant size<4mm within 3 months of ESWL.

Success rate of the stone measuring <10mm (97.1%) was higher than the stone measuring >11mm (87%) which was not significant. success rate of stone clearance was decreased with increased in the stone density SAV in HU non-significantly. The lower calyceal stones and the pelvis stones have the lower success rate when compared to the other site of location of renal stones.

Multiple regression analysis revealed that No. of sittings = 0.111(stone size in mm) +0.02(SAV in HU)-0.144(site of stone)-0.501(sedation anaesthesia administered)-0.115.p value for size and SAV was<0.001; p value for sedation IV was 0.001 and site of stone was 0.004. p value for fitness of the above model was <0.001. 77.6% of the variation in no of sittings required for

ESWL was explained by the variations in the above variables. In the three month study, 45 patients had no residual stones, and 8 patients had residual fragments that were clinically insignificant and smaller than 5 mm, contributing to an overall success rate i.e. SFR of 54 (93.1%). Four children required additional treatment, including one who needed percutaneous nephrolithotomy (PCNL) and two others who needed ureteroscopy and laser stone fragmentation (URSL). 47 children did not experience any difficulties, but 11 children had complication. Six of these patients had discomfort, which was conservatively handled, and four of them had mild hematuria.

Discussion:

Further reductions in morbidity and death rates have been achieved thanks to ESWL in the treatment of urolithiasis. [13] ESWL has a 60-95% overall success rate in treating upper urinary tract stones.

Large renal calculi, stones in dependent or obstructed portions of the collecting syste m, obesity, and body habits that impair im aging are some of the characteristics linke d to a low success rate of ESWL. [14]

The effectiveness of ESWL in paediatric patients with renal calculi was examined in the current investigation. The overall clearance rate of the stones in this study was found to be 54 patients (93.1%). Our clearance rate of the renal stones was in relation with the other previously reported by Brinkmann OA et.al. [3] Success rate of the ESWL based on the SAV unit with >1000 was 88.9% which was lower compared to other groups and the number of sitting in such patients was high. According to the previous studies conducted, [15,16] the requirement of the anaesthesia for the ESWL in children less than 12 yrs of age was 30-100% which was similar to the finding of our study, where 31% of children less than 12yrs of age required general anaesthesia duringthe ESWL.

The number of sessions or sittings, the qua ntity of ESWL shocks received, and the pa tients' SFR were all significantly and stron gly correlated with the use of anaesthesia. (Table1). In our study, success rate of ESWL with the stone size <10mm was 97.1% compared to stone with size of >11mm was 87% which was lower similar to the other study done by Pareek G et. al., [17] other authors like Ather et. al., concluded with their study that the bigger stones are associated with poor results, requiring more number of additional sittings for the procedure and high complication rate. [18]

In line with other research [19,20], we identified a statistically significant correlation between the number of treatment sittings, the number of ESWL, the size of the stone, the density of the stone, the administration of anaesthesia, and problems (table 1). However, the total accuracy of predicting stone composition from plain radiographs was shown to be ju st 39%. [21] Stone shape, homogeneity, and radiographic density in comparison with bone on a simple abdomen film have all been used to predict stone composition and fragility. In our study (Table 2), there was significant mean difference between the three groups based on the SAV (HU) value with number of sitting required for the treatment with critical value of 39.46 and p<.001 (HS). There was significant difference between the means of ESWL shock waves received by the three groups based on SAV units, with the SAV>1000HU required higher ESWL shock waves and sitting when compared to the one patients who have SAV <750HU units. These findings are in par with the similar study conducted by Massoud et. al., [22] and Joseph et. al., [23] Recent studies have used high resolution CT protocols to predict the outcome of ESWL. The worst outcome was with the calculus density >750HU and stone diameter >1.1cm as 77% of those needed more than three sessions of ESWL and clearance rate was

60%, [24] similar kind of study by the Wang et al concluded that stone density >900HU and volume >700mm^3 were significant predictors of ESWL failure. [25] There is significant mean difference between the three groups based on SAV with the ESWL shock wave delivered to patients, the <750HU has mean of 2782.76 (±220.06 SE), 750-1000HU was 3625 (±351.45SE) and >1000HU was 5777.78 (±222.22 SE), which was similar findings as study conducted by Pareek et.al., as the SAV increases the number of shock waves delivered to the patients for treatment. [17]. In patients with high SAV the success rate of ESWL was low, as compared to other study conducted by Amr M et. al., [22] Dretler and Polykoff [26] introduced the concept of the stone fragility on ESWL, based on the composition of the stone. Similarly, patients with the high SAV >1000 required multiple sittings of ESWL with mean sitting of 2.89(±0.11). [27] Lower calyceal stone and renal pelvic stones had the lowest success rate with ESWL (87.5% and 86.5% respectively) compared to other stone location, which is similar to other previous studies. Predictor of the failure in these groups based on SAV was found with stones lower calyx when compared to the other site of location which was in relation with the previous studies done to evaluate the failure and success rate of ESWL based on site of stone. [22]

Conclusion

ESWL has a good stone-free rate when used as the first line of treatment for paediatric urolithiasis stones that are smaller than 10mm in diameter, have less than 1000HU, and are located in the upper ureter (SFR). SAV and the location of the stone are separate determinants of ESWL success. When doing ESWL on children under the age of 12, anaesthesia is useful.

Limitation:

Lithotripters with varying shock wave pro perties could alter the outcomes of the ES WL. Theexamination of success prediction did not take this into account.Future ESW L research should concentrate on the chara cteristics of stones and the creation of tools that can adjust to certain stone qualities.

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