



The Results and Long-term Complications of Extracorporeal Shock Wave Lithotripsy in Children (Staghorn calculi included)

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Citation: Marcelo Vilela, Isadora Frazão, Mariana Machado, Henry Linford and João Vitor Quirino (2019) The Results and Long-term Complications of Extracorporeal Shock Wave Lithotripsy in Children (Staghorn calculi included). J Clin Case Rep Clin Research 1(1): 105

Abstract

Aim: Extracorporeal shock wave lithotripsy (ESWL) is an extremely important, non-invasive option of treatment for urinary tract lithiasis (UTL) in children. The aim of this study is to describe the results of ESWL for the treatment of UTL in children; Including unilateral and bilateral staghorn calculi, focusing on the efficiency of calculi elimination and the complications occurring both during the procedure and within the following twenty-four months.

Methods: From January 2000 to June 2017, 22 children between 2 and 12 years, suffering from urinary tract lithiasis underwent extracorporeal shock wave lithotripsy in the city of Campo Grande, Brazil. A retrospective report of the results and complications of these patients was performed.

Results: Twenty-three calculi, ranging in size from 5.0 to 12.0 mm, were treated; twenty-one calculi were found in the kidneys and two were found in the ureter. Urinary tract dilation was present in 9.1% of the children at the time of the procedure. After 1 session of ESWL, 87% of the calculi were eliminated, while 13% had remaining calculi (stones ≥ 5 mm), which required another session to eliminate. A shock wave intensity of 13-15 kV was effective. Short-term complications (pain and hematuria), were observed in 9.1% of patients. Staghorn calculi could be eliminated by ESWL; however, an additional session was required when compared to other calculi.

Conclusion: In children, ESWL was shown to be safe and efficient in eliminating 100% of the treated calculi, with 90.9% of patients having a complete response after one session. Complications (pain and hematuria) were observed in 9.1% of patients. Unilateral and bilateral Staghorn calculi were successfully eliminated after two sessions. Prior urinary tract dilation did not affect the results.

Keywords: Extracorporeal Lithotripsy; Staghorn Calculi; Children; Complications, Efficacy

Introduction

Urinary tract lithiasis (UTL) is a frequently encountered medical condition in the elderly population, but has a much rarer presentation amongst children, only 1.0 to 3.0% of total cases, with a slightly higher prevalence in males [1]. Although rare, the complications associated with UTL necessitate proper management by urologists in this population.

Various treatment modalities have evolved over the last decades, from conventional surgery to percutaneous nephrolithotripsy (PNL) and ureterorenoscopy (UR). Recently, a new non-invasive technique was created, extracorporeal lithotripsy by shock waves (ESWL), which has had a great impact on the treatment of UTL in both children and adults and has successfully reduced the morbidity rate [2].

Although ESWL has been used in children for the treatment of UTL since its introduction in 1985, the popularity of this technique in pediatric patients has been limited by its potential complications, such as ureteral obstruction by

residual fragments, pain, hematuria, hemoptysis, sepsis, cardiac arrhythmia, and effects on other organs³⁻⁸. Minimally invasive techniques should be used to treat urinary calculi in children, since they have a higher recurrence rate than adults [2,3]. It is not uncommon for children to undergo multiple open procedures to treat their recurrent calculi [2].

Here, we report our experience with the use of ESWL for the management of calculi in children, including staghorn calculi, and evaluate efficacy and possible complications, to assist the treatment of urolithiasis in children.

The main risk factors for struvite and carbonate apatite staghorn stone formation include: metabolic defects, long standing history of stones, and repeated urinary tract infections with urease-producing bacteria (e.g. *Proteus*, *Klebsiella*, *Pseudomonas* and *Enterobacter*). Staghorn calculi and UTIs can occur concomitantly; in these cases, intermittent and recurrent infection may persist until the staghorn stone is removed [4].

Considering the risks associated with percutaneous surgery in pediatric patients together with the fact that these stones often present in undilated collecting systems [5]. ESWL monotherapy could be considered a viable treatment option for these patients.

Patients and Methods

This is an analysis of the medical charts of patients with UTL treated with ESWL. Between January 2000 and June 2017, 22 children underwent ESWL treatment (a total of 23 calculi in the urinary tract) at a single institution, the Urocenter (Center for Renal Calculi Treatment) of the Santa Casa Hospital, Campo Grande (MS), Brazil.

Patients were within the following criteria: age ≤ 12 years old and calculi ≥ 5.0 mm and < 12 mm. Patients with coagulopathies, urinary tract obstruction, fever, urinary tract infection (UTI), or any other adverse clinical conditions, like anomalous urinary tract, were excluded. However, patients with staghorn calculi and urinary tract dilation were included.

Eight children (36%) were female and fourteen (64%) were male. Median age was 8.0 years (range 2-12 years). The calculi were diagnosed either by ultrasonography and X-rays or an abdominal CT scan.

A Macstone lithotripter with radioscopy (Brazil) coupled with an electro-hydraulic generator was used for the procedures (Figure 1). The device reveals the exact location of the calculi by X- rays. General anesthesia was applied to all children.



Figure 1: Macstone lithotripter used

The mean energy of the shock waves ranged from 13.0 kV to 15.0 kV. The total number of shock waves delivered per session ranged from 3,000 to 3,500. Every session lasted for about 120 minutes.

As lesions to the lung or the surrounding structures rarely occur with the use of second or third generation lithotripters⁶, we did not apply any form of pulmonary protection to the children.

Three criteria classifications were given when evaluating treatment results: (i) failure, defined as the presence of any

residual fragments observed after three additional sessions; (ii) partial response, defined as when ESWL treatment resulted in remaining fragments that responded to further sessions; and (iii) success (stone-free), defined as the absence of calculi and any complications, symptoms, or sequelae.

All patients were monitored and treated for complications arising during the procedure and the twenty-four months following ESWL treatment. Patients were monitored for the following potential complications for two years following ESWL treatment: cardiac arrhythmia during the procedure, pain, UTI, sepsis, fever, ureteral obstruction (steinstrasse), hemoptysis, subcutaneous hematoma, hematuria, and clinical evidence of injury to other organs. Patient data were obtained during the consultation.

An abdominal ultrasonography and x-ray were performed 10 days after the procedure for all patients in order to evaluate the treatment results (Figure 2 and 3). In addition, an abdominal ultrasonography, urine culture, and urinalysis were carried out twice a year as follow-up. Patients who presented with fevers underwent a urinalysis and bacterial culture, aiming at diagnosing UTI.

ESWL results were described, along with the occurrence of short and long-term complications.



Figure 2: Bilateral Staghorn calculi before treatment



Figure 3: Bilateral Staghorn calculi after 2 sessions on each side

Results

Among the 22 patients treated, urinary tract dilation was present in 2 patients (9.1%) at the time of the procedure: 21 calculi were renal and 2 were ureteral. In all patients the calculi were radiopaque. No renal function impairment was detected in the kidneys involved.

Out of the 23 treated calculi, 20 (87%) were eliminated after 1 session. In addition, 3 (13%) residual calculi needed an extra session, all of which were staghorn calculi. No failure was observed (Table 1).

All patients had oxygen saturation and heart rate monitoring during each session.

General anesthesia was applied to all children. There were no complications during any of the procedures.

LOCATION	No. of Calculi	Stone Free N (%)	Partial success N (%)	Failure N (%)
KIDNEY	21	18 (85.7%)	3 (14.3%)	0
URETERAL	2	2 (100%)	0	0
TOTAL	23	20 (87%)	3 (13%)	0

Table 1: Distribution of the calculi successfully treated and residual fragments, according to their location
Unfortunately, a biochemical analysis of the stones could not be performed in all cases, as we were unable to obtain the eliminated fragments from our subjects

Twenty patients (90.9%) had to undergo only one ESWL treatment to eliminate the calculi. Two patients (9.1%), both with staghorn calculi, had a partial response, which required an additional session on each affected kidney to eliminate the calculi completely. The additional session on the same side occurred after 15 days.

Bilateral Staghorn calculi were approached in separated procedures, ninety days apart, after complete resolution of the calculus on the opposite side.

ESWL treatment produced minimal complications, with only 2 patients (9.1%) presenting with early complications; Both patients had Staghorn calculi and required hospitalization due to pain associated with hematuria in the region of treatment. Common analgesics were enough to control the symptoms. No other complication was found. (Table 2).

LOCATION	No. Stones	COMPLICATIONS						PERCENTAGE (%)
		Pain	Fever; Sepsis.	Steinstrasse; Injury to other organs.	Urinary tract infection	Subcutaneous hematoma; Hemoptysis; Cardiac arrhythmias;	Hematuria	
Kidney	18	-	-	-	-	-	-	-
Staghorn	3	3	-	-	-	-	3	100%
Ureteral	2	-	-	-	-	-	-	-
TOTAL	23	3	-	-	-	-	3	13%

Table 2: Complications within the first twenty-four months of treatment

Among the 22 patients, twenty of them did not require any other additional urological procedure, remaining stone-free during the twenty-four months observation period. The other two patients required an extra session to eliminate the calculi. However, both of these patients presented with staghorn calculi (one patient had a bilateral staghorn calculi). In addition, after the extra session, they remained stone-free for 24 months.

Discussion

This serial case report analyzes the efficacy and safety (complications within first twenty-four months) of ESWL treatment for UTL in 22 children, including those with bilateral staghorn calculi.

Of the 22 patients treated, 20 patients (90.9%) were stone-free after one session and two patients (9.1%) had a partial success, related to the resistance of their staghorn calculi to initial treatment. Here, we describe a high success rate for ESWL in UTL treatment, which is similar to those reported in other medical reports⁶⁻⁹. The success rate was notably higher for non-staghorn calculi.

The management of residual calculi is still controversial. The International Consensus on Lithiasis defines asymptomatic non-infected 1 - 4 mm calculus as susceptible to spontaneous elimination and clinically insignificant [1,10].

The recommendation for these stone fragments is expectant, with continuous monitoring; patients should be aware of the potential recurrent symptoms and the need for another intervention [1,11,12].

This strategy was adopted in our study and all patients eliminated the fragments spontaneously after ESWL. In this study, cardiac monitoring was performed in all cases and arrhythmia was not detected, which is similar to other medical reports [1,13-15].

In children, steinstrasse is observed in 5.4-10% of patients, a complication related to stone size > 20 mm [1,16,17], which was not included in this study (maximum of 12 mm calculi); Therefore, no steinstrasse was observed.

The use of internal stents was not deemed necessary, as children are capable of spontaneous elimination of fragments [1,8,18,19].

No evidence of ureter obstruction by fragments was observed and adjuvant therapies were unnecessary. However, the need of adjuvant treatment in ESWL treatments, ranging from 18.3% to 36.3%, has been reported [1,6,7].

While other studies have reported higher incidences of hematuria (49% of cases following ESWL) and fever (2.5% of cases following ESWL) [1]. we observed hematuria in only 9% (2) of cases, all of which were staghorn calculi cases. We did not observe fever or sepsis.

Prophylactic antibiotics (Cefalexin) were prescribed for seven days, which is standard of care following ESWL treatment.

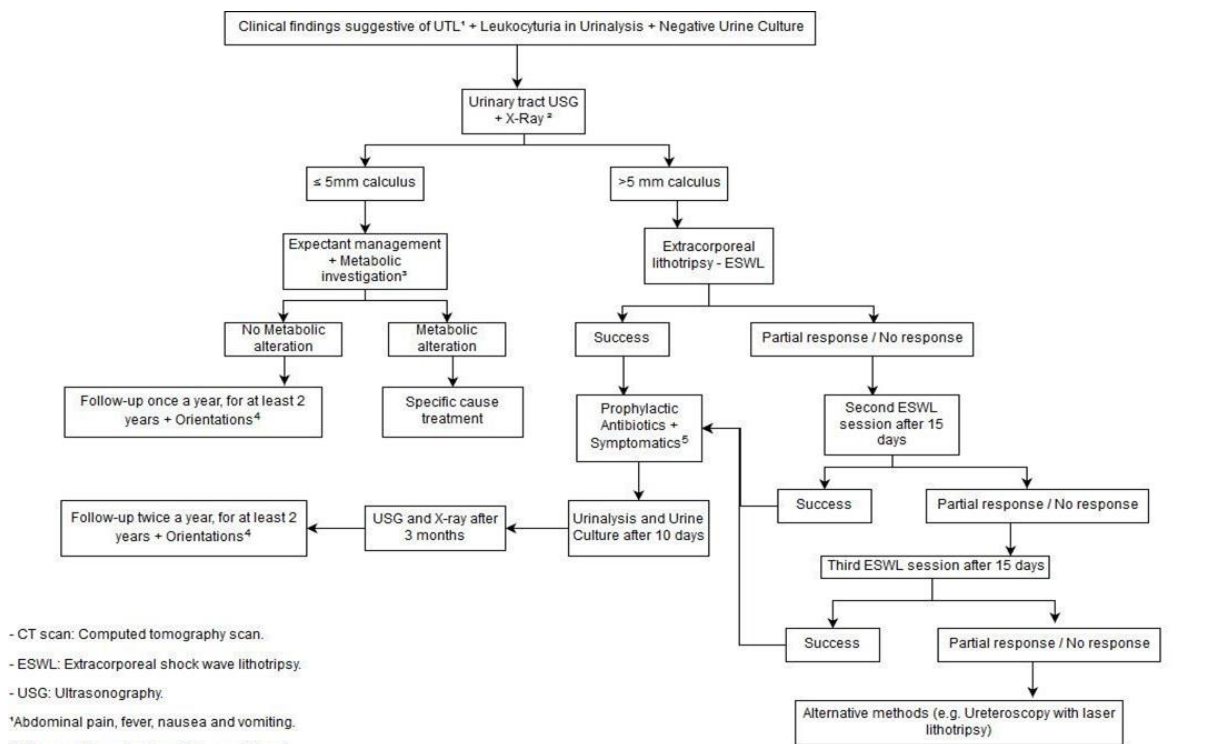
In this cases, a second-generation lithotripter with a small focus area was used; second- generation lithotripters do not present the same risk of hemoptysis in young children, as seen with first-generation lithotripters, whose shock waves may reach the pulmonary parenchyma [1]. Therefore, there was no need to provide any type of protection to the thorax. No cases of hemoptysis were reported.

Pain following ESWL is primarily the result of obstruction of the urinary tract by calculi fragments, and affected 9% of children who underwent ESWL treatment in this study, and is consistent with the literature [1,8,20].

All patients were treated with oral or intravenous analgesic agents.

Other studies have reported injuries such as sigmoid perforation, injuries to the small intestine (ileum), spleen and ureter, or colic fistulae, gastro-intestinal hemorrhages, pancreatitis, and arterial embolism of the inferior limbs^{1,14}. However, no injuries to the adjacent organs were observed in this study.

Therefore, we created an algorithm for Urinary Tract Lithiasis in Children Management:



- CT scan: Computed tomography scan.

- ESWL: Extracorporeal shock wave lithotripsy.

- USG: Ultrasonography.

⁴Abdominal pain, fever, nausea and vomiting.

²CT scan with contrast could be considered.

³ Metabolic investigation consisted in collection of one 24-hour urine sample for dosing calcium (Ca), phosphorus (P), uric acid, sodium (Na), potassium (K), creatinine(Cr), magnesium (Mg), citrate (Ci), oxalate (Ox) and cystine. Serum levels of fasting glycemia, calcium, phosphorus, uric acid, sodium, potassium, urea (U), creatinine, magnesium and chlorine (Cl) were measured as well [32].

⁴Dietetic orientations: Reduce sodium intake and increase ingestion of orange and lemon juice (high levels of citric acid). [33]

⁵Medication used: Seven days of Cefalexin; Dipyron and Ibuprofen when necessary.

^{*}This algorithm was made by a team of professionals in Urology, in an academic environment (Federal University of Mato Grosso do Sul).

Conclusion

This study concluded that the management of urinary tract lithiasis (UTL) by extracorporeal shock wave lithotripsy (ESWL) was safe and efficient in children; ESWL treatment eliminated 87% of calculi after 1 session, and the remaining calculi (13%), all of which were Staghorn calculi, required one additional session. All patients remained stone-free during the first twenty- four months after the procedure. The only complication recorded was pain and hematuria, seen in 9.1% of patients. Pain is the most common complication reported in other studies as well [1].

The intensity of the shock waves used was between 13-15 kV, was effective, and can be considered standard for the treatment of children in this situation. Moreover, patients with staghorn calculi or urinary tract dilation need not be excluded from ESWL treatment, as these calculi could be eliminated with additional ESWL session.

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