Combined Use of Pyelolithotomy and Endoscopy: An Alternative Surgical Treatment for Staghorn Urolithiasis in Children

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Purpose: To present a combining pyelolithotomy and endoscopy, an alternative approach for treating staghorn calculi in children.

Materials and Methods: We treated 1414 children (age, 10 months to 17 years) with urolithiasis between 2009 and 2013 in the Pediatric Surgery Department and in the Pediatrics and Nephrology Department, Military Institute of Medicine in Warsaw. Most patients were treated conservatively. In 162 cases, an extracorporeal shockwave lithotripsy (SWL) procedure was needed. Surgery was only used in patients who had failed SWL. We performed minimally invasive procedures, ureterolithotripsy using semi-rigid and flexible ureterorenoscopes or percutaneous nephrolithotomy (PCNL) in 126 patients.

Results: In the most serious cases of staghorn or multifocal calculi, we performed a combined operation of pyelolithotomy with endoscopic removal of concrements from all calyces of the diseased kidney. In 15 out of the 18 combination treatments (83.3%), concrements were completely removed from the kidney in a single procedure. In three cases, fine concrements (5 to 6 mm) remained after the procedure, and these were candidate for SWL. In one case, a boy aged 4 years, symptoms of infection in the urinary tract occurred 2 days after the procedure.

Conclusion: Combining pyelolithotomy with endoscopy to remove concrements clears the diseased kidney without causing parenchymal damage in one procedure. The method is safe in children, does not require blood transfusion, and helps maintain kidney function.

Keywords: child; kidney calculi; surgery; treatment outcome; urologic surgical procedures.

INTRODUCTION

Urolithiasis is a well-known and widespread disease. The prevalence in Europe is 5–10% in adults and approximately 2% in children. The number of new cases has increased over the past few years, especially in much younger patients, particularly those aged < 1 year.[1,2] The disease is chronic, and regression occurs within 15 years in 30 –50% of affected patients.[1,3] The management of cases with new concrement formation is especially very problematic. According to data from the medical literature, approximately 80% of concrement created in the urinary system can be excreted spontaneously.[1,4] Such stones are typically 4–5 mm in diameter; however, in children, the spontaneous excretion of stones that are 9–10 mm of diameter is possible, possibly as a result of the greater elasticity of the urinary tract.[2] The duration that the concrement is present in the same location is a factor that determines its passage; after 4 weeks, the probability of spontaneous excretion is low.[5] The procedure for active concrement removal may obstruct the flow of urine from the kidney and make an individual susceptible to infection, obstruction of urine outflow from only one kidney, urinary system defects, stymied urine outflow, and inefficient analgesic treatment.[1] Therefore, the need for concrement removal using one of available method performs in about 25% of all group of patients and until in half of these patients with clinical symptoms.[1] The most severe form of urolithiasis is staghorn urolithiasis with metabolic disorders which results in concrements in urinary tracts. Typical stones include all calyces of the kidney and renal pelvis creating a typical ‘cast’ of tracts carrying urine from the kidney. The treatment of this type of urolithiasis is a challenge for a surgeon.

The aim of the study was to present an alternative, efficient method of concrement removal from the kidney

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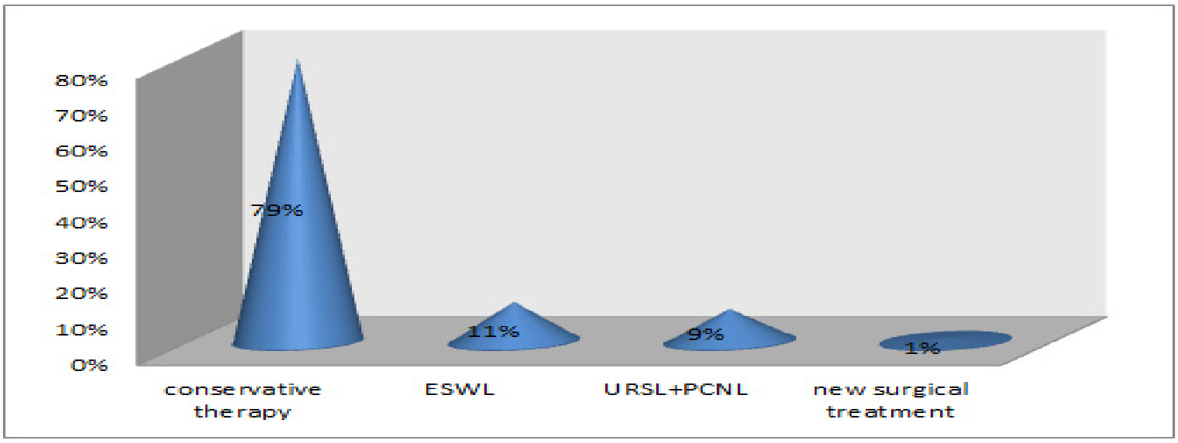

Figure 1. The treatment's methods used in children with urolithiasis (n =1414).
Abbreviations: ESWL, extracorporeal shockwave lithotripsy; PCNL, percutaneous nephrolithotomy; URSL, ureterorenoscopy with lithotripsy.

which is possible to use within staghorn urolithiasis in children.

MATERIALS AND METHODS

Study Population

A total of 1414 patients aged 10 months to 17 years with urolithiasis were treated in the Pediatric Surgery Department and Pediatrics and Nephrology Department of the Military Institute of Medicine between 2009 and 2013. Of whom 1111 (78.57%) patients were treated conservatively.

Procedures

An extracorporeal shockwave lithotripsy (SWL) procedure was needed in 162 (11.45%) cases. A total of 141 (9.97%) patients with different types of urolithiasis were treated using other surgical procedures. Surgical treatment was used only in the patients who were not suitable to undergo SWL procedure for many different reasons. In most of these patients, minimally invasive procedures (ureterolithotripsies) were performed using semi-rigid and flexible ureterorenoscopes (URS); percutaneous nephrolithotomy (PCNL) procedures were performed in 126 (17.82%) patients. In certain serious cases of staghorn or multifocal urolithiasis including renal pelvis and at least 3 calyces (most of concrements were from 11 mm to 50 mm), we performed a combination of pyelolithotomy and endoscopic removal of concrements from all calyces of each diseased kidney (**Figures 1-4**).

Inclusion and Exclusion Criteria

The inclusion criteria were: a lack of renal stones evacuation using minimally invasive procedures, or concrements in major and distal calyces including renal pelvis. In 2009–2013, 15 (1.06%) patients aged 1.5–10 years (mean age, 6.7 years; 10 boys, 5 girls) with staghorn urolithiasis underwent pyelolithotomy with endoscopic concrement removal. There were 4 children aged under 2 years of life. Twelve of these patients had unilateral urolithiasis, whereas the other three had bilateral urolithiasis (**Figure 2**).

Evaluations

The dominant symptom of these patients was pain in the lumbar area. Recurrent urinary tract infections, urosepsis, and urinary retention were also common. Before a decision on the surgical approach was made, the patients' conditions were precisely evaluated and assessed to detect metabolic changes that may be related to the cause of the urolithiasis. The diagnoses included hyperoxaluria type I in three cases, cystinuria in four cases, and hypercalciuria in the remaining cases. The patients with cystinuria were initially qualified to conservative treatment using Tiopronin and Captopril with urine alkalization by potassium citrate over 7.5 pH. The children with hyperoxaluria were given vitamin B6 with high fluid intake, the urine alkalization was also used. Unfortunately, this management did not protect the patients against the new concrements formation. The following basic examinations were performed in all patients: blood cell count, ionogram, urea and creatinine concentration test, urinalysis and urine culture, and assessment of urinary crystalloid excretion in urine collection samples. The presence of concrements within the urinary tract was assessed using ultrasonography. The radiological examinations included plain abdominal radiography, urography, or computed tomography with contrast. Before the procedure, dynamic scintigraphy was performed to determine the excretory and secretory function of the kidneys.

The conducted history results that in the majority of

Figure 2. Bilateral cystine urolithiasis in boy aged 2.5 years of life.

children the minimally invasive procedures were earlier performed. In 9 children, SWL procedures were repeatedly performed (from 2 to 5 times), in 3 cases PCNL was performed, in 4 cases retrograde intrarenal surgery (RIRS) was performed. In 4 children, different possibilities of minimally invasive treatment's ways were used, from SWL procedures to URS lithotripsy (URSL), RIRS and PCNL. Unfortunately, these procedures were ineffective, and in the kidneys were still big concrements. The size of the concrements ranged from 11 mm to 3 -5 cm, and the concrements were numerous, varied in size, and were located in several calyces and in the pelvis. In 3 cases, staghorn urolithiasis was accompanied by hydronephrosis as well as obstruction of the urine outlet in the ureteropelvic junction. In the case of sub-pelvic stenosis, the stenosis was excised using the Hynes-Anderson method and pyelotomy, during which the nephroscope was introduced into the kidney. After concrement removal, plastic reconstruction of the ureteropelvic junction was performed.

The pyelolithotomy procedure with endoscopic concrement removal consisted of several stages.

Stage 1: The kidney was accessed using lumbotomy and exposure of the renal pelvic and ureteropelvic junction. The entire kidney was not released from concretions with surrounding tissues; instead, a slanted 1–1.5 cm long incision was made in the renal pelvis to expose the concrements (**Figure 3**).

Stage 2: A staghorn concrement within the renal pelvis was crushed by a pneumatic lithotripter Wolf and the fragments of the concrement were removed using forceps via a small perforation made in the renal pelvis (**Figure 3**).

Stage 3: After the concrements were removed from the renal pelvis, their locations within the calyces were determined using a 9 French (F) nephroscope Wolf or 4.5 F ureteroscope (**Figure 3**).

Stage 4: These concrements were then crushed in stages using a pneumatic, laser and ultrasound waves. The calyces were sequentially 'cleaned' until all of the concrements were removed from the diseased kidney.

Stage 5: All calyces were assessed using a nephroscope, and the catheter pig -tail was placed from the renal pelvis to the urinary bladder to ensure appropriate outflow from the kidney. The incisions made in the renal pelvis were closed by using a running suture. A drainage tube was left near the kidney. The integuments were closed lamellarly.

After the procedure, the patients received second- generation cephalosporin within 3 days. The pig-tail catheter was removed 10 days after the procedure with the patient receiving brief intravenous anesthesia. After the procedures, blood cell count, ionogram, creatinine concentration test were performed. After the procedures, ultrasonography and plain abdominal radiography were repeated performed. These follow-up examinations were performed 1 week, 2 weeks, and 1 month after the procedure. In all children, renoscintigraphy was performed after 3 months to assess renal function after procedure.

Statistical Analysis

For the statistical analysis, the number of procedures was calculated for the retrospective (before the per-

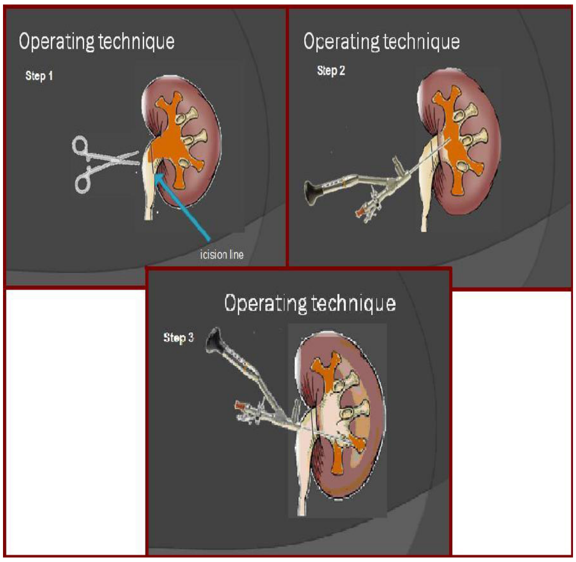

Figure 3. Stage 1: Pyelolithotomy and concrement's removal from renal pelvis. Stage 2: Concrement's removal from upper and interior calyces. Stage 3: Concrement's removal from lower calyces.

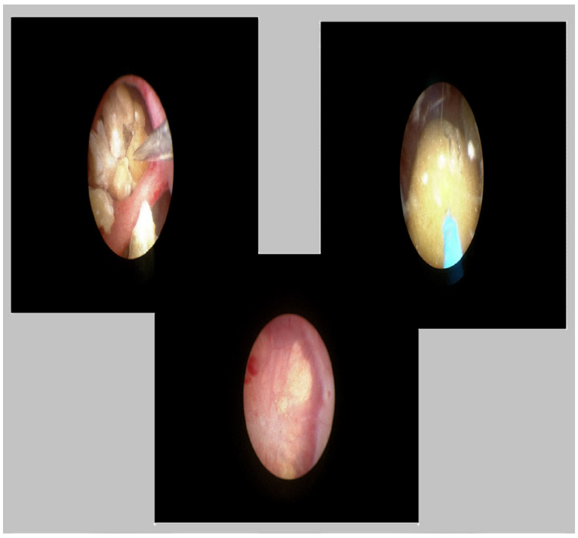

Figure 4. Intraoperative photos, the concrements in calyces of the kidneys.

formance of this procedure) and prospective (after the performance of this procedure) phases of the study. Continuous variables were compared using the Wilcoxon rank-sum test. The number of procedures in residual concrements was analyzed using a Kaplan-Meier survival function. Differences in continuous variables were expressed as mean difference (MD) with 95% confidence intervals (CI).

RESULTS

In 15 (83.3%) cases, the concrements were completely removed from the kidney within a single procedure. The duration of procedures ranged from 90 to 300 minutes (mean, 160 minutes). In the other 3 (16.7%) cases, concrements of 5–6-mm in size remained after the procedure and required SWL. Symptoms of generic infection in the urinary tract occurred in only 1 patient, a 4-year-old boy, on the second day after procedure. Escherichia coli was detected during culture of a urine sample. Pharmacological therapy consisted of an aminoglycoside (amikacin) and a carbapenem (meropenem). None of the patients required a blood transfusion because of blood loss within surgical procedure or after it. Follow-up after procedures ranged from 1 year to 5 years. At the same time, in all children, isotopic examinations of kidneys, creatinine concentration test and blood pressure were performed (**Table**).
Renoscintigraphy revealed that the renal function had

Table. Clinical characteristics of study patient.

No.	Type of Urolithiasis Diagnosed in Metabolic Examinations	1 Day Before Procedure		3 Months after Procedure		Urosepsis	Procedures in Residual Concrements	Follow-up after Procedure (months)
		Creatinine (mg/dL)	Blood Pressure (mmHg)	Creatinine (mg/dL)	Blood Pressure (mmHg)			
1	Hypercalciuria	0.22	94/60	0.2	90/60	(-)	None	27
2	Cystinuria	0.3	103/69	0.3	110/70	(-)	None	21
3	Hypercalciuria	0.32	95/60	0.42	110/65	(-)	None	61
4	Hypercalciuria	0.49	120/75	0.47	117/70	(-)	None	29
5	Hyperoxaluria	0.6	120/60	0.65	124/65	(-)	None	62
6	Cystinuria	0.6	125/70	0.7	115/70	(-)	None	50
	Cystinuria	0.75	120/75	0.9	109/72	(-)	SWL	22
7	Hyperoxaluria	0.3	90/60	0.22	92/60	*E. coli*	None	29
8	Hyperoxaluria	0.7	90/60	0.5	100/65	(-)	None	58
9	Cystinuria	0.5	124/82	0.6	122/80	(-)	None	28
	Cystinuria	0.92	108/65	0.79	127/75	(-)	None	23
10	Hypercalciuria	0.39	92/64	0.3	90/60	(-)	None	63
	Hypercalciuria	0.39	94/60	0.36	97/60	(-)	None	29
11	Hypercalciuria	0.8	127/70	0.77	125/72	(-)	SWL	18
12	Hypercalciuria	0.23	90/63	0.26	92/63	(-)	None	16
13	Hypercalciuria	0.5	109/70	0.6	100/60	(-)	SWL	58
14	Hypercalciuria	0.6	115/78	0.5	115/82	(-)	None	16
15	Cystinuria	0.31	110/65	0.34	110/70	(-)	None	23

Abbreviation: SWL, extracorporeal shockwave lithotripsy.

not worsened in any of the children 3 months after the procedure. In ultrasound examinations, it was not diagnosed any concrements in the urinary tracts. All patients are under the care of nephrology clinic.

DISCUSSION

SWL is the most minimally invasive surgical procedure for urolithiasis at present.[6] However, the success rates of complete concrement removal within the first procedure are 70–94%.[7] Other minimally invasive methods for achieving concrement removal include URS and PCNL. Concrement within the ureters can be removed via lithotripsy using rigid, semi-rigid, and flexible ureterorenoscopes.[8] However, in certain cases, concrement in the kidneys are removed using PCNL and mini-PCNL in children; the diameter of the nephroscope is 15 F. RIRS is a recently established urological procedure that removes concrements from the kidney using a flexible ureterorenoscope and the Holmium:Yag laser.[9] All health centers treating urolithiasis in children aim to minimalize the extent of the surgical procedures and the risk related to surgical treatment.[10] Nevertheless, in certain clinical situations, unconventional treatment might be required.

Despite being efficient and safe, minimally invasive methods have certain limitations, including early or late post-surgical complications.

However, there is some group of patients, for whom open surgery is only one appropriate and safe procedure. According to El-Husseiny and Buchholz, despite the fact that open surgery is currently rarely used, it is still one of the treatment's way of urolithiasis in adults and children.[11] The more complicated type of urolithiasis with anatomical anomalies, the more recommended is the use of surgical techniques.[11] In the health centers in the world provided with the right equipment, having a big experience and a team of experts, about 1-5.4% of patients with urolithiasis are operated.[12] According to Sumit and colleagues, 10% of children treated operatively required open surgery.[13,14]

In the most recent European Urology Association guidelines (2011) prepared by Knoll and Pearle regarding the treatment of children with urolithiasis, surgical procedures are allowed in certain cases, primarily those involving staghorn urolithiasis and children at a very young age.[12] In some health centers, all children under 1 year of life are operated and efficiency of procedures ranges from 90% to 100%.[15] Bartoletti and Cai described very precisely indications for open surgery in adults and they also highlighted the necessity to use minimally invasive methods as a treatment of choice in most cases.[16]

Complex procedure: Pyelolithotomy combined with endoscopic concrement removal is able to remove all concrements from a diseased kidney within a single procedure, but without causing parenchymal damage. In this procedure, all defects of the upper urinary tract may be fixed, and the inhibition of urine flow from the kidney may be resolved.[17] This method is safe for children, does not involve blood transfusions, and facilitates the preservation of kidney function.

The identification of disorders such as cystinuria is especially important in cases of severe chronic kidney failure, as certain metabolic disorders may damage the renal parenchyma (especially hyperoxaluria type I), or cases with a very high frequency of new concrement formation (for example in cystinuria). In the literature there are descriptions of "combined" methods used in adults.[18,19] These methods combine open surgery with minimally invasive methods at the same time. However, a described method was not used in children so far.

CONCLUSIONS

Primary surgical treatment of urolithiasis is minimally invasive endoscopic treatment. However, in complicated, select cases there is an opportunity to use surgical methods. Open surgery is required only for the urolithiasis which is difficult to treat. The new presented combination of open surgery and endoscopic technique used in complicated cases of staghorn urolithiasis is a safe and effective method, and it can be an alternative to the traditional methods.

CONFLICT OF INTEREST

None declared.

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