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REVIEW ARTICLE

Possible Role of Percutaneous Nephrolithotomy in Management of Pediatric Renal Stones

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ABSTRACT

Background: Worldwide, there has been a notable increase in the incidence of pediatric urolithiasis. There are many aspects in which pediatric lithiasis differs from adult urolithiasis. Child's metabolic condition and anatomic structure contribute to medical planning and surgical planning respectively reducing the rate of surgical intervention repetition and protecting renal functions. The use of percutaneous nephrolithotomy (PCNL) to treat pyelo-calyceal stones in children began 3 decades ago. Very recently, miniaturization of endoscopic instruments allowed less invasive procedures with a low complication rate. This study aimed to provide an outline of possible role of percutaneous nephrolithotomy in management of pediatric renal stones.

Conclusions: It is possible to treat renal calculi percutaneously in children, and there is a high success rate with just one procedure. While shock wave lithotripsy (SWL) is often the go-to method for treating kidney stones in children, percutaneous nephrolithotomy (PNL) can be an important adjunct in some instances. When it comes to large renal stones (> 20 mm), the European Association of Urology guidelines suggest PNL as the main treatment option. Additionally, for lower renal pole stones larger than 10 mm. resistant stones, in addition to SWL.

Keywords: Percutaneous Nephrolithotomy; Pediatric; Renal Stones.

INTRODUCTION

Globally, pediatric urolithiasis is becoming more common. Unlike adult urolithiasis, pediatric lithiasis is distinct in many ways. Medical planning helps reduce the rate of surgical intervention recurrence and surgical planning protects kidney functions, based on the child's metabolic status and anatomic structure, respectively. Race, geography, socioeconomic status, and dietary habits are some of the variables that influence the prevalence of stone disease [1].

Stone disease is endemic in the MENA region. High consanguinity and hot climate have been associated with the endemicity of urolithiasis, despite the fact that racial and genetic factors do impact epidemiology [2]. The most prominent metabolic abnormalities linked to the development of pediatric stone disease include hypercalciuria and hypocitraturia [3,4].

Congenital abnormalities in the urinary system can lead to stone development, which can be accelerated by urinary tract infections. But even in the absence of infection, congenital obstructive anomalies such as ureteropelvic junction stenosis, posterior urethral valve, and duplication malformations can cause stasis, which in turn can lead to stone development [5].

Diet also has a role in stone formation. Because more calcium is excreted in urine when sodium intake is high, this makes people more likely to develop stones. A diet rich in protein causes a drop in urine pH and the precipitation of calcium oxalate because it increases the excretion of uric acid, oxalate, and calcium in the urine. Overconsumption of protein lowers urinary citrate levels, the strongest inhibitor of crystallization [6,7].

The most important symptom of hereditary stone disease is nephrocalcinosis, which is the return of stones within a year. Chronic renal failure is a danger for people with stone disease who have a hereditary predisposition but whose diagnosis and treatment are delayed. Consequently, doctors must be familiar with genetic epidemiology aspects in order to diagnose their patients [8].

A comprehensive metabolic and systemic evaluation should be performed on every child suspected of having stone disease. Examining the family medical history might help identify potential predisposing factors. It is important to consider the anatomical circumstances linked to urinary tract congenital malformations. Take note of any history of passing stones, dietary habits, or urinary tract infections. To diagnose and cure the passing stone, it is crucial to examine it [5,8].

Several laboratory tests can be performed, such as those on the blood, urine, electrolytes, urea nitrogen, calcium, creatinine, phosphorus, bicarbonate, albumin, total protein, and parathormone [1]. Urine spot tests can determine the calcium to creatinine ratio. The ratio ought to fall below 0.2 in pediatrics. If it's greater than 0.2, the test needs to be repeated. In order to rule out hypercalciuria, a 24-hour urine study must be performed if the results remain high after the second test. The diagnostic process also includes the collection of urine for culture. Over the course of 24 hours, the urine is analysed to determine the following: calcium, magnesium oxalate, uric acid, citrate, protein, and creatinine clearance. The pH of freshly peed urine is best measured [1]. It is recommended to analyse 24-hour urine for cystine if cystinuria is suspected [1].

Most renal and proximal ureteral stones should be treated with SWL as a first line of defence, according to the European Association of Urology (EAU) Paediatric Urology Guidelines recommendations [1]. The percentage of success ranges from 59% to 94% [9]. The size of the stone is the most crucial component among many that determine the process's final result. The success rate drops, and the retreatment rate rises as the stone size increases. According to a general finding about the relationship between stone location and stone-free rate, stones located in the renal pelvis and proximal ureter are more effectively treated with SWL than calyceal stones [10,11]. The use of nomograms allows for the joint evaluation of numerous success-influencing aspects. According to the nomogram presented by Onal *et al.* [12], the variables that increase the likelihood of success include the following: being younger than 5 years old, having a stone load less than 1 cm, the stone's location (pelvic or upper calyceal stone: exclusively in females), never having had a stone treated on the same side, and having only one stone. A history of open stone surgery, particularly in lower calyceal stones, has been found to limit the success rate of SWL, in addition to the criteria listed in this nomogram [13]. The variables that were found to influence the success rate in removing stones without causing complications included the stone's size, age, sex, location, and any previous treatments on the same side. Both nomograms were later shown to be helpful in estimating the SWL stone-free rate in their respective endemic populations and in other populations as well [14,15].

Between 1.5% to 35% of patients experience complications following SWL [9]. The two most common problems are stein Strasse and renal colic. Children with a high stone load often experience Stein Strasse, which can be treated with SWL [16]. Stein strasse development is reduced by pre-SWL stenting. The occurrence of subcapsular hematomas, renal parenchymal damage, and urinary tract infections is quite rare. There is a dearth of data regarding the long-term effects of SWL on children's kidneys. While some research suggests it has no effect on renal development at all, another study found it to have a negative effect on longitudinal kidney growth [17].

PERCUTANEOUS NEPHROLITHOTOMY

In some instances, PNL can play a substantial role, even though shock wave lithotripsy (SWL) is the gold standard for treating juvenile kidney stones. When it comes to large renal stones (> 20 mm), the European Association of Urology guidelines suggest PNL as the main treatment option. Additionally, for lower renal pole stones larger than 10 mm. resistant stones, in addition to SWL [18]. The main indications for PNL include stones, anatomic abnormalities, obesity, or treatment failure of ESWL [19].

Contraindication PNL in children include infection, high blood pressure, bleeding disorders, PNL is contraindicated during anticoagulant use, untreated urinary tract infection and mass in the kidney [20].

TECHNICAL ASPECTS OF PNL IN CHILDREN

Assuming the lithotomy posture, the patient is administered intravenous antibiotics and general anesthesia. To make room for the ureteroscope, the patient should lie flat on their back, with the foot turned to the side opposite the calculus. Prior to undergoing a PNL operation, ureteroscopy should be performed. To insert the safety guidewire, a cystoscopy is used; it must remain in place throughout the entire process. In the event of a medical emergency, such as perforation or bleeding, this guide wire would enable the insertion of a catheter [20].

While many facilities utilize sterile water for cystoscopy, regular saline is the way to go for ureteroscopy. By inserting the ureteroscope into the urethra, harm to the penile urethra is prevented. Although it is not required, UVJ dilatation is routinely performed by some institutes. First, the pediatric ureteroscope would be able to pass the UVJ with the aid of hydro dilatation from the high-pressure flow; second, it would be guided by the safety-wire; and lastly, it would be able to rotate the tip of the instrument using oscillated movements to seek out the ureter's center. If UVJ is not passed, a double-J stent is implanted, and the surgery is delayed for four to six weeks. The surgeon's hand should make precise movements while the ureteroscope is progressed through the ureter [20].

After the stone has been located, the laser wire's tip is moved forward. To begin lithotripsy, the same point is used to attempt to press the stone against the ureteral wall. The best spot for the laser is on top of the stone. The laser's pinpoint accuracy and shallow penetration depth make it possible to fragment without harming healthy tissue in the area. Standard operating parameters for a Holmium-Yag laser include an energy output of 0.6 joules and a pulse rate of 6–8 Hz. It keeps going until the pieces are almost as big as the ureteroscope. Given the anticipated natural transit of fragments, the basket is unnecessary. Following the completion of the treatment, the safety guidewire is withdrawn, and a urethral catheter is typically not required [19].

The miniaturisation of PNL devices has made it more accessible to children. Even though there isn't a universally accepted sheath size in the literature, most people agree that anything greater than 24 Fr is considered classic PNL [9]. For stones larger than 2 cm, PNL is still the gold standard treatment choice [1]. There is an 86% to 98% success rate in removing stones when given as monotherapy in a single session. The success rate is enhanced when the number of sessions or treatments is increased in conjunction with RIRS/SWL. [11,17].

Recent advances in equipment design have made it possible to perform PNL using a narrower nephroscope. Mini-PNL, ultramini PNL, and micro-PNL all reduce blood loss and make the nephroscope easier to operate in small kidneys, as stated in reference [21]. With smaller bleeding rates and the ability to do fewer sessions than RIRS, micro-PNL achieves stone-free rates comparable to mini-PNL in stones ranging in size from 10 mm to 20 mm. Therefore, these procedures could be a viable alternative to SWL and other minimally invasive therapies due to their high stone-free rates and reasonable complication rates [2]. Additionally, procedures involving the tubeless PNL approach, which do not involve a nephrostomy tube, a double-J stent, or a catheter into the ureter, were mostly performed on patients with simple stones smaller than 2 cm in size [22,23]. Miniaturized PNL can be worked with using high-power laser instruments, even in cystine stones [2].

By breaking the stone into smaller pieces, these methods hope that the urinary tract will naturally remove the smaller pieces. A possible drawback of this method is that it causes complete fragmentation without removal. Sizes of instruments can still be deemed too long for youngsters, even with thin calibration [11].

SONAR GUIDED PERCUTANEOUS NEPHROLITHOTOMY

Using ultrasonography (US) to guide mini-PNL procedures can be a safe, effective, and practical substitute for fluoroscopy in the hands of skilled surgeons. Radiation exposure to both the surgeon and the patient is reduced when US is used [24].

The procedure begins by inserting a ureteral catheter into the kidney (about 3–4 Fr) and then tapping it to a urethral Foley catheter. It is now the prone posture that the patient is placed in. Next, the pelvicalyceal system (PCS) will be seen using the Color-Doppler US guidance. The 18G access needle is attached to the bent US probe and passed into the desired calyx using a one-shot dilatation procedure [24].

The procedure involves removing the stylet and inserting a guidewire with a 0.035-inch J-tip into the specific calyx. A skin incision was made, and the nephrostomy tract was dilated using an 8 Fr polyurethane dilator. One 18 Fr Amplatz dilator passes over the Alken guide, which is then replaced, and an Amplatz sheath introduction into the PCS follows. The functional guidewire and Amplatz sheath remain in their original locations [24].

During renal access, all procedures are overseen by ultrasound instead of fluoroscopy. Lithotripsy involves the use of pneumatic lithoclast and the extraction of particles using forceps. Whether the patient has been stone-free is confirmed by the US at the end of the operation. It is possible to perform tubeless mini-PNL if the hole is not too large, there is no apparent stone residue, the bleeding is minimal, and just one tract was used to get access. After 12 to 24 hours, the ureteral stent and urethral Foley catheter are withdrawn. The placement of a double-J stent can be considered in situations when there is an inflammatory polyp in the ureter caused by stone blockage, obstruction of the pelvic ureteric junction, considerable residual stone, or concomitant lithotripsy of a stone on the same side of the ureter [24].

COMPLICATION OF PNL IN CHILDREN

In 10% of patients, blood transfusion is required due to haemorrhage, the most common PNL consequence. Fever and ongoing urine leakage from the nephrostomy site are two additional potential consequences of PNL [25].

The risk of complications in children undergoing PNL is 27%. Complication rates can be influenced by several factors, including the amount of time spent operating, the size of the sheath, the procedure's mid-calyceal puncture, and the production of partial staghorn stones [26].

The success percentage is unaffected by the stone's composition, and numerous punctures are required for cystine and infection stones [25]. Children who have undergone open surgery for stones in the past can also benefit from PNL as a therapy option. However, CT scans prior to surgery are necessary for anatomical assessment because this population has an elevated risk of colon injury [12]. Prior to PNL, several parameters can be assessed using clinical classifications. One such categorization is the Guy's stone rating system. When trying to predict how well kids will do, this method works well. The success rate is lower for High Guy when his stone score is high [13].

CONCLUSIONS

While shock wave lithotripsy (SWL) is often the go-to method for treating kidney stones in children, percutaneous nephrolithotomy (PNL) can be an important adjunct in some instances. When it comes to large renal stones (> 20 mm), the European Association of Urology guidelines suggest PNL as the main treatment option. Additionally, for lower renal pole stones larger than 10 mm. Also, stones that are resistant to SWL.

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