

# PERCUTANEOUS NEPHROLITHOTOMY FOR PAEDIATRIC STONE DISEASE

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## ABSTRACT

We evaluated the outcomes and complications occurring following percutaneous nephrolithotomy (PCNL) procedures performed in paediatric patients. There were 291 paediatric patients (293 renal units) included in the current study and who underwent PCNL in our clinic between March 1999 and December 2014. We evaluated stone burden, duration of surgery and complications, success (stone-free) rate, residual fragments and auxiliary procedures, and follow-up details. The stone-free rate following PCNL was 88.3%. Early postoperative complications included excessive bleeding and transfusion in nine patients, and prolonged urinary extravasation following removal of the nephrostomy tube and requiring JJ stent placement in eight patients. The mean time to catheter removal was 2.8 days and the mean hospitalisation time was 3.5 days. The aim of kidney stone treatment is to achieve minimal kidney damage with the highest success rate. Therefore, minimally invasive procedures are important in the paediatric age group where life expectancy is high. PCNL is a safe and effective procedure for the treatment of kidney stones in children.

**Keywords:** Paediatric, percutaneous nephrolithotomy (PCNL), stone disease.

## INTRODUCTION

The prevalence of urolithiasis has been increasing due to infection and obesity as a result of changing dietary habits and environmental and lifestyle factors.<sup>1</sup> Malnutrition, racial factors, and anatomical and metabolic abnormalities are the most important risk factors responsible for the high incidence and recurrence rates in children.<sup>2</sup> Approximately 40-50% of children with urolithiasis have a metabolic abnormality such as hypercalciuria, hyperoxaluria, hypocitraturia, cystinuria, or hyperuricosuria, with hypercalciuria and hypocitraturia being the most common.<sup>3</sup> The prevalence of ureteral stones in children changes with age; overall, it is approximately 2-3%.<sup>4</sup>

The treatment of ureteral stones changes from follow-up to open surgery. Treatment procedures include extracorporeal shock wave lithotripsy (ESWL), ureterorenoscopy, retrograde intrarenal surgery, percutaneous nephrolithotomy (PCNL),

and, in some cases, laparoscopic surgery. The other type of procedure is open surgery, which is performed in cases with urinary anatomical abnormalities.<sup>5</sup> The treatment of ureteral stone disease in children is almost the same as with adults. Paediatric patients have a high risk of recurrence because of long life expectancy, and so minimally invasive treatment options are preferred. The use of ESWL is the first-line treatment option in children with upper ureter and renal pelvic stones <2 cm and lower pole calyx stones <1 cm according to European Association of Urology (EAU) guidelines. However, stone-free rates following ESWL decrease as the size of the stones increases. The other disadvantage of ESWL is the requirement for anaesthesia.<sup>6</sup> Open surgery began to lose ground when PCNL was first introduced in 1976.<sup>7</sup> PCNL is a minimally invasive treatment method but is not without its own risks, which include complications such as bleeding and injury to the collecting system.<sup>8</sup> The first paediatric PCNL was performed in 1985 and, over time,

PCNL has become the first-line treatment for kidney stones >2 cm, as described in the EAU guidelines.<sup>6</sup> Other conditions for which PCNL is performed include hard stones (such as cysteine and calcium oxalate monohydrate), unsuccessful ESWL procedures, and obstructed kidneys.<sup>6,9</sup> There are some clinical variables that affect the success rate of PCNL, including the kidney's anatomy, stone burden, and stone localisation. Stone-free rates following PCNL are reported in the literature as 73-96%.<sup>10</sup> Although ESWL is a well-established treatment method for paediatric and adult urinary stone disease, urinary stones resistant to ESWL and kidney stones >2 cm in size are best treated by PCNL, with minimal morbidity. In this study we report our experience with PCNL in the treatment of paediatric kidney stones.

## METHODS

We retrospectively examined data from our paediatric PCNL patients. All patients who were admitted to our clinic were evaluated preoperatively using routine laboratory tests, such as blood chemistry and urine analyses and culture. To scan the urinary system, urinary ultrasound, plain abdominal films, and intravenous (IV) urography were used. If necessary, computed tomography and renal scintigraphy were performed in cases of suspected renal abnormalities, retrorenal colon, and in patients with non-opaque stones. Procedures were performed under general anaesthesia and IV cephalosporin was given preoperatively for prophylaxis. After induction of anaesthesia, cystoscopy was performed and then a ureteral catheter (4-6 Fr) was inserted into the ipsilateral ureter containing the stone. Retrograde study was not performed in order to not blur the view of the stone during fluoroscopy. Patients were then moved to the prone position, renal puncture was achieved with an 18 G percutaneous-access needle and guidewire into the most suitable kidney pole using biplanar fluoroscopy guidance. This punctured tract was dilated with an Amplatz semi-rigid dilator or balloon dilator of up to 20 or 30 Fr, depending on the patient's age and size. Finally, the renal sheath was placed. A 24 or 26 Fr rigid nephroscope was used during the procedure. Heated, sterile saline (35-36 °C) was used for irrigation of the tract and kidney. The stones were located with the guidance of a video monitor and fluoroscopy and then a pneumatic lithotripter was used to disintegrate the big stone fragments, following which they were grasped with collecting

forceps; an aspiration catheter was used to aspirate the stone fragments that were too small to grasp. In the case of bleeding or the presence of residual stones, a re-entry nephrostomy tube might be placed and then radiopaque liquid given to check for perforation, residual or infundibular stone, and to correct the nephrostomy tube's position. An antegrade JJ stent was placed into the ureter if there was a need.

On the first postoperative day, the ureteral catheter was removed if urine colour was normal and a plain abdominopelvic radiograph was taken to check for residual stone fragments. Stones that were <4 mm were accepted as clinically insignificant residual fragments (CIRFs). If the stones were removed, or if there were only CIRFs present, then the procedure were considered to be successful.

## RESULTS

A total of 293 PCNL procedures were performed on 291 children (mean age: 9.33 years, range: 1-16) between March 1999 and December 2014. There were 148 boys and 143 girls, with 23 having a history of renal stone disease. A PCNL procedure was performed on the right kidney in 153 patients, on the left kidney in 136 patients, and on both kidneys in two patients. Of the 291 children, 194 had middle pole stones, 46 had lower pole stones, 32 had pelvic stones, 15 had multiple kidney stones, one had a semi-staghorn stone, and three had a staghorn stone (Table 1).

The stones were completely removed in 257 of 291 patients (success rate: 88.3%), with 43 patients having CIRFs. Complications occurred in 29 of 291 procedures (10.0%). Nine of the patients with complications had bleeding and required blood transfusion, eight patients had prolonged urinary extravasation after the nephrostomy tube removal and required placement of a JJ stent, seven patients had postoperative fever, and five patients developed urinary tract infection (UTI). None of the patients needed open surgery or had major complications (Table 2). Nephrostomy tubes were kept for a mean duration of 2.8 (range: 1-4) days and the mean hospitalisation time was 3.5 (range: 2-7) days.

## DISCUSSION

Open surgical procedures are being replaced by minimally invasive techniques due to technological improvements, especially in the last two decades.<sup>11</sup>

**Table 1: The location of the stones in the kidney.**

Stone location	Frequency, n (%)
Middle pole	194 (66.66)
Lower pole	46 (15.80)
Renal pelvis	32 (10.99)
Multiple placements	15 (5.15)
Partial	1 (0.34)
Staghorn	3 (1.03)

**Table 2: Outcomes of PCNL.**

Outcome	Frequency, n (%)
Complete stone clearance	257 (88.31)
CIRFs	43 (14.77)
Blood transfusion	9 (3.09)
JJ stent insertion	8 (2.74)
Fever	7 (2.40)
Urinary infection	5 (1.71)

CIRFs: clinically insignificant residual fragments;  
PCNL: percutaneous nephrolithotomy.

A similar trend is seen in the treatment of paediatric patients with kidney stones.<sup>12</sup> Children have a longer life expectancy than adults and so they have a higher risk of stone recurrence. Therefore, minimally invasive procedures are more frequently applied in children.<sup>13</sup> Currently, ESWL is accepted as first-line therapy in the management of urinary tract stones in children,<sup>6</sup> and provides a successful and safe modality to treat kidney stones.<sup>14,15</sup> However, ESWL has some limitations, such as the requirement for anaesthesia, difficulty with stones that are hard to split, and the pain experienced by patients when passing stone fragments. In contrast, PCNL is a safe and effective treatment choice for children. The success rate of the procedure in children is 66-100%, with the variability due primarily to the diverse structures of the stone(s) and the learning curve of the procedure.<sup>11,16-18</sup> Staghorn stones are difficult to manage during the PCNL procedure.<sup>19</sup> The size of dilatation is another important issue in PCNL and can be difficult, especially in children <7 years of age, when adult-sized equipment is used. Desai et al.<sup>17</sup> recommended that dilatation in children should not be larger than 21 Fr, especially in those

<8 years of age, and also stated that larger-sized dilatations might cause more bleeding.

In our study, most patients had decreased blood haemoglobin levels following PCNL, due to haemodilution or bleeding. It is important to decide whether blood transfusion is necessary. Equipment size, operation time, and stone burden were suggested as clinical variables affecting blood loss in paediatric PCNL.<sup>16,17</sup> In addition, the number of punctures has been described as a cause of bleeding.<sup>19</sup> It is important to keep in mind that children are less tolerant to bleeding. Unsal et al.<sup>10</sup> preoperatively evaluated 50 patients using 99mTc dimercaptosuccinic acid and repeated this 3-6 months after PCNL. Six of the patients had new focal cortical defects occurring within the dilatation area after the procedure. Wadhwa et al.<sup>20</sup> reported that PCNL did not cause alterations in renal function in children. Reisiger et al.<sup>21</sup> showed that ESWL, ureteroscopy, and PCNL did not affect renal growth during a 6-year follow-up period. However, we still need further studies to fully understand the impact of PCNL on the kidneys of children.

Radiation hazards are the other important issue, especially in children. The International Commission on Radiological Protection state that the safe annual doses are 150 mSv for the eyes and 500 mSv for the skin and other organs. However, a single dose must not exceed 50 mSv.<sup>22,23</sup> Kumari et al.<sup>24</sup> demonstrated that patients received a 0.56 mSv dose of radiation during 6 minutes of fluoroscopy during each surgery. However, patients are also exposed to radiation during the diagnosis and follow-up procedures.<sup>25</sup> It was reported that patients were exposed to a mean radiation dose of 29.7 mSv during all these procedures.<sup>23</sup>

Radiation also has effects on the cells of the surgeon's hands, including both deterministic and stochastic effects. Deterministic effects are dose-dependent and may lead to cataract formation, haematopoietic tissue and skin failure, and infertility. The stochastic effects are not dose-dependent and could lead to genetic changes that may cause cancer formation.<sup>26</sup> These effects of radiation exposure are more important in children than adults.<sup>27</sup> The development of hypothermia is also an important complication and depends on operation time and the induction of anaesthesia.<sup>28</sup> Heating the room and irrigation fluids is important in order to decrease the risk

of hypothermia. Placing an electrically heated blanket under the patient is another way of protecting the patient from hypothermia. We used all three of these measures in our procedures. The other complications of PCNL, such as fever and UTI, are commonly seen. Postoperative fever and UTI rates have been previously reported as 29.3% and 5.5%, respectively.<sup>29,30</sup>

## CONCLUSION

Although ESWL is the first-line therapy for small-sized stones, PCNL has to be the first choice for larger stones if there is no anatomical abnormality. Minimally invasive procedures are more important in paediatric patients because of the higher risk of stone recurrence and longer life expectancy compared with adults.

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