Chapter 28
Pediatric Percutaneous Nephrolithotomy

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Abstract Advances in endourological techniques and their successful application in adult renal calculi over the last 30 years have led to a dramatic move from open surgery to minimally invasive techniques for pediatric urolithiasis. This chapter will focus on percutaneous nephrolithotomy (PCNL) and the tips and tricks in the procedure to achieve a successful outcome.

Keywords Pediatric • Urolithiasis • Percutaneous nephrolithotomy • Mini perc

Introduction

Pediatric urolithiasis has an overall incidence of 1–2 % of that observed in the adult population [1]. Urolithiasis is an endemic disease in the stone belt across the Middle East and Asian subcontinent. One report suggests an incidence of 17 % among children in Turkey [2]. Stones may be calcium oxalate stones which are reported to be the most frequent [3] or noncalcium-containing stones.

Over the last three decades with the successful results in the minimally invasive management of adult renal stones, there has been a shift from historical open surgery in children [4] to a minimally invasive approach. The minimally invasive techniques include extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and ureteroscopy (URS).

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This chapter will describe the technique of PCNL the authors favor in management of pediatric urolithiasis.

Indications and Contraindications

Most children are suitable for PCNL irrespective of size/habitus (obesity) or abnormalities of the curvature of the spine (scoliosis).

The main indications for PCNL may be classified as:

1. *Stone size and location*
   (a) Staghorn calculus
   (b) Multiple stones
   (c) Renal pelvic stone >2 cm
   (d) Lower pole >1 cm
   (e) Stone surrounding a foreign body
2. *Anatomy*
   (a) Stone secondary to a UPJ obstruction
   (b) Infundibular stenosis
   (c) Stone within a calyceal diverticulum

The main contraindications are:

1. Uncontrolled hypertension
2. Active sepsis
3. Coagulopathies

Preoperative Workup

The preoperative workup prior to a PCNL consists of determination of the size, number, location of the stones, anatomical configuration of the kidney, and the renal function.

The authors prefer the following workup:

1. Plain X-ray KUB and renal ultrasound: Studies have shown that a combination of these two will detect up to 90 % of stones [5].
2. DMSA: This gives information about the function of the kidney.
3. An IVU may be used in some cases to determine the anatomy of the collecting system or where there is a strong index of suspicion of renal tract calculi not evident on the plain X-ray or ultrasound.

4. In selected cases only, an unenhanced spiral CT scan (the gold standard for diagnosing renal tract calculi in adults) may be considered.
5. Baseline blood hematology and biochemistry (FBC, creatinine, and electrolytes) and a group and save.
6. A "spot" urine may be analyzed for metabolic analysis instead of the 24-h urine collection [6]. Where possible, the retrieved calculus should be sent for stone chemical analysis.
7. Within 24 h of the surgery, the child should have another plain X-ray KUB and renal ultrasound scan to reconfirm location and number of calculi.

The Team

One of the most important requirements for a successful PCNL is the presence of a regular team who undertakes these procedures. In our institute, we have two pediatric urologists, two interventional pediatric radiologists, two pediatric anesthetists, and a pool of nursing staff who perform the PCNL. Our experience has shown that working as a team makes it more efficient and safe. A radiographer is also required for the procedure.

Instrumentation

For a PCNL, there is general equipment that is required and specific instrumentation for the PCNL. It is important to have all the instrumentation available to allow a choice of which instruments to use depending on the nature of the stone.

The General Equipment Requirements

1. A fluoroscopy machine (C-arm) with monitor.
2. A camera stack system: In our institute we have the benefit of OR-1 which allows for movement of multiple monitors to achieve the best ergonomic layout for a minimally invasive procedure.
3. A general instrument trolley.
4. Portable US machine.
5. Omnipaque mixed with normal saline (50:50).
6. Surgical table that allows screening.

Specific PCNL Requirements

Preliminary Ureteric Catheterization

1. Cystoscope
2. Ureteric catheter
3. Foley catheter
4. Adhesive tape

Puncture and Access Tract

1. Nephrostomy drape.
2. Needle: Kellett needle or similar puncture needle. The authors prefer a smaller gauge "skater" needle (Angiotech) for the puncture.
3. Dilators: Alken telescopic dilators or balloon dilators.
4. Guidewires: Straight and J tip guidewires and hydrophilic guidewires.
5. Sheath: Amplatz sheath 24 or 26 or mini-perc sheath 15 or 16 French.

Stone Fragmentation/Retrieval

1. Nephroscope
2. Ultrasonic lithotripter
3. Swiss lithoclast
4. Laser (Ho: YAG) with different size fibers
5. Stone retrieval basket (nitinol basket)
6. Forceps
7. Flexible cystoscope

Post Retrieval

Nephrostomy drainage tube with bag

Operative Technique

The operating room layout is depicted in Fig. 28.1 for a left PCNL.

The authors prefer to use the mini-perc system which in our experience (unpublished) appears to be safer and allows for repeated punctures without significant extravasation of contrast. This is demonstrated in the accompanying video.

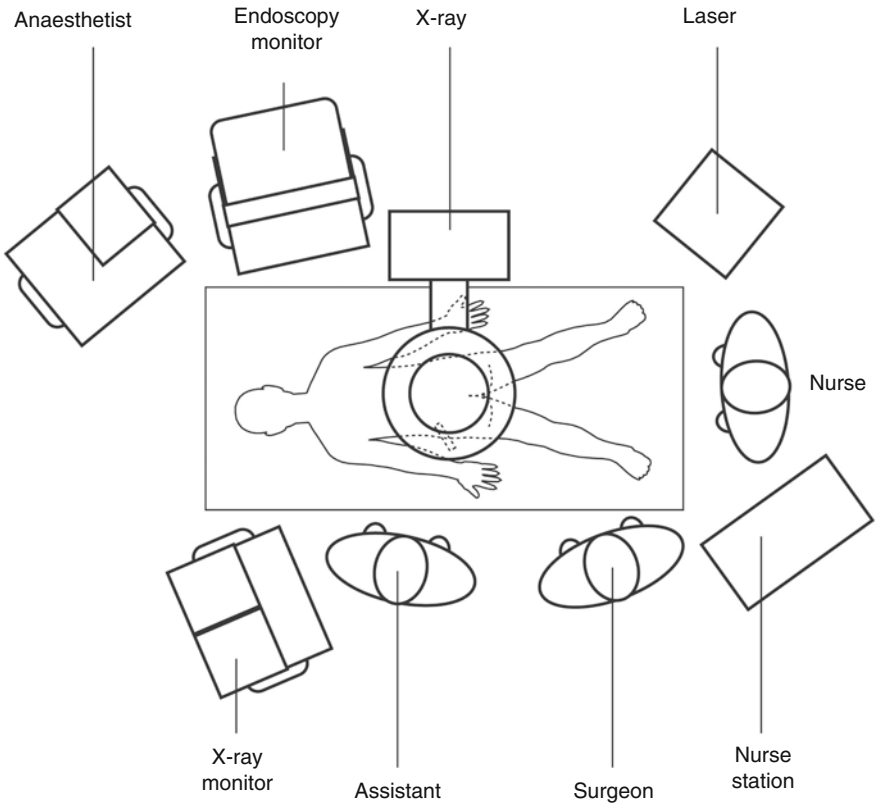

Fig. 28.1 The layout and positioning of personnel and equipment in the operating suite for a left PCNL

Anesthesia

General anesthesia with endotracheal intubation and muscle relaxation

Preoperative Antibiotics

We prefer an aminoglycoside such as gentamicin at induction; however, local microbiology guidance with antibiotic prophylaxis should be used at induction.

Preliminary Ureteric Catheterization

With the patient in lithotomy position, a cystoscopy is performed, and under screening control, the ureteric catheter is positioned just in the region of the pelvis.

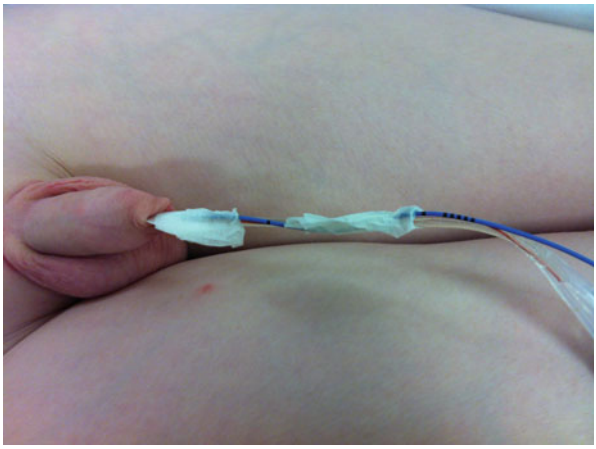

Fig. 28.2 The Foley catheter and ureteric catheter in place and anchored with adhesive tape

Tip: Positioning at this position allows for distention of the collecting system with saline if ultrasound-guided puncture is contemplated.

Once the ureteric catheter is positioned, a Foley catheter (size 8 or 10 Fr depending on age of the child) is inserted, and the ureteric catheter is fixed to the Foley catheter using the adhesive tape. This prevents the ureteric catheter being displaced (Fig. 28.2).

After securing the ureteric catheter, the patient is transferred across to the trolley. The operating table is then padded with appropriate supports for the chest and the pelvis with plenty of warming mattresses and absorbent sheets, as during the procedure, there is a risk that the child may get cold despite warmed saline irrigation.

Position

The patient is placed in the prone position (Fig. 28.3) with appropriate support as described. In this case, a small rolled towel is placed below the left side to raise this by a 30–45° angle. This allows the posterior lower pole calyx to rotate into an end-on position.

Puncture

Depending on the surgeon's preference, the puncture can be performed either by ultrasound guidance or fluoroscopic guidance. It is important to perform a retrograde study via the ureteric catheter to ascertain the calyceal anatomy and hence the best site to puncture to obtain complete stone clearance. In most cases, we perform a lower pole posterior calyx puncture.

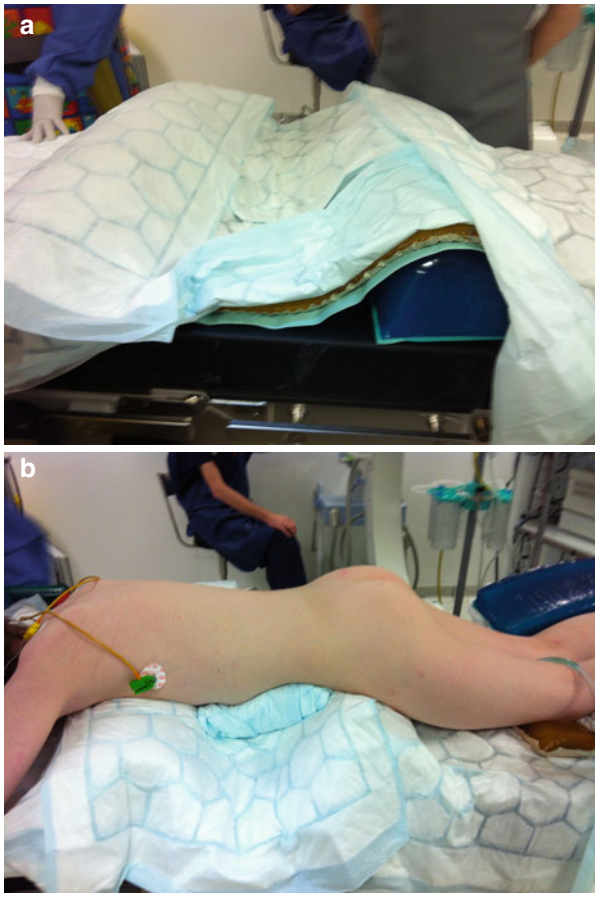

Fig. 28.3 (**a**–**b**) Patient in prone position: note the warming mattress and bolsters to achieve the correct position with slight elevation of the left side for a left PCNL

Prior to the puncture, the assistant injects a saline methylene blue combination (100 ml saline and few drops methylene blue to make it light blue) via the ureteric catheter to distend the collecting system. The puncture is then performed. Removal of the stillette of the needle will reveal blue-colored saline dripping out of the needle confirming its position within the collecting system. A further contrast study with saline and omnipaque will confirm the position of the needle in relation to the punctured calyx.

Dilatation and Access Tract

Following puncture of the collecting system, a straight or J tip guidewire is inserted into the system. Wherever possible, it is important to try and maneuver the guidewire down the ureter to prevent its accidental displacement. However in some cases, coiling of the guidewire within the collecting system may be inevitable.

A skin incision is made to enable dilatation over the guidewire. The skin incision needs to be in the appropriate width depending on the size of the Amplatz sheath to be used.

The tract is dilated with an 8 Fr dilator. Following this, the authors prefer to use the Alken telescopic dilators to the size required. A useful tip is to dilate by one size over the size of the Amplatz to be used and then remove the last dilator. This allows easy placement of the Amplatz sheath. The entire dilatation is monitored by fluoroscopy.

Stone Fragmentation/Retrieval

Once the Amplatz sheath is introduced, the nephroscope is introduced, and saline irrigation commenced. Careful rotating movement of the sheath allows the sheath to be maneuvered in different directions to explore the different calyces.

Once the stone is visualized, fragmentation may be undertaken by several techniques – lithoclast, laser, or ultrasound. Choice of technique depends on personal preference and size of the Amplatz sheath.

Tip: Occasionally, some calyces especially the upper and middle pole posterior calyces may be difficult to negotiate with the Amplatz sheath. In these instances, using a flexible cystoscope may enable the calyx to be entered, and using a laser or nitinol basket, the stone may be fragmented and grasped and retrieved.

If there are multiple stones in various calyces, more than one puncture may be required to obtain complete clearance.

Clearance is confirmed both by ultrasound and fluoroscopically.

Once the procedure is completed, the Amplatz sheath is removed, and a nephrostomy is inserted over the guidewire. The size of the nephrostomy can vary from 6 Fr to 24 Fr depending on the need for drainage and tamponade. We use an 8 Fr nephrostomy as standard. Recently, a tubeless PCNL has demonstrated similar results [6]. The Foley catheter and ureteric catheter are removed at the end of the procedure.

Postoperative Management

Analgesia: In most cases, we give a single bolus of opiates during recovery and then oral analgesia.

Diet: The child is allowed to eat and drink as soon as he/she recovers.

Nephrostomy: Is clamped at 24 h and removed at 36 h if the child remains asymptomatic.

Antibiotics: Oral antibiotics (we prefer co-amoxiclav) are prescribed for 1 week followed by antibiotic prophylaxis till stone-free.

Imaging: All children are followed up at 3 months with an ultrasound and plain X-ray KUB.

Complications

1. Failed puncture.
2. Bleeding: This is the most common complication [7]. Although most of the bleeding is venous and stops spontaneously, in cases of excessive bleeding, the Amplatz sheath should be removed, and a tamponading nephrostomy should be inserted.
3. Residual calculi: These may require further PCNL or ESWL.
4. Renal parenchymal injury: This usually heals with adequate drainage via the nephrostomy.
5. Sepsis: Sepsis is unusual and resolves with systemic antibiotics.
6. Injury to adjacent organs: Although rare, injury to the colon during puncture has been described [7].

Conclusion

For a successful PCNL, the essential requirements are a well-organized team and joint working with an experienced surgeon and uroradiologist. In most cases, success of PCNL in obtaining complete stone clearance should be about 90 %. It is important to note that there is a learning curve for PCNL, and in the initial stages, it is useful to have an experienced surgeon as a preceptor.

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