Pediatric Percutaneous Nephrolithotomy: Assessing Impact of Technical Innovations on Safety and Efficacy

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ABSTRACT

Objectives: To assess the safety and efficacy of percutaneous nephrolithotomy (PCNL) in the pediatric age group and the impact of certain technical modification on the ultimate outcome.

Patients and Methods: We studied 45 renal units in 40 patients under 15 years of age who underwent PCNL at our institute. The average age was 9.2 years (range 11 months–15 years). There were 5 bilateral, 11 multiple, and 9 staghorn calculi. The average calculus size was 2.04 (0.9–4.5) cm. The PCNL was done with an ultrasound-guided peripheral puncture, a planned staged approach in some cases, and minimal tract dilatation with the use of a pediatric nephroscope and a specially designed slender probe for pneumatic intracorporeal lithotripsy.

Results: Complete stone clearance was achieved in 41 of the 45 renal units, giving an overall clearance rate of 91%. Minor pyrexia (<100°F/2 days) was seen in 10 patients, whereas serious pyrexia was seen in 5. One patient had a prolonged leak from the nephrostomy site, which responded to double-J stenting, and one patient had a pelvic perforation with hypotension, which responded to conservative treatment. The average fall in hemoglobin was 1.6 g/dL, but none of the patients required blood transfusion.

Conclusion: We believe that our alterations in the standard technique of PCNL with the use of pediatric instruments can make it a safe and effective option in the modern management of pediatric urolithiasis.

INTRODUCTION

Pediatric urolithiasis, while relatively uncommon in the West, is endemic in developing countries. The high incidence of metabolic and infective origins of calculi in this age group with the resultant high recurrence rate makes complete calculus clearance an integral aspect of any management option. Although SWL is the treatment of choice in most smaller calculi, percutaneous nephrolithotomy (PCNL) is increasingly used in patients in whom SWL is contraindicated or has failed. Most series of pediatric PCNL employ the standard technique used in adults. In this article, we aim to evaluate the safety and efficacy of PCNL in the management of pediatric urolithiasis with special emphasis on certain technical modifications.

PATIENTS AND METHODS

We retrospectively analyzed the case records of 40 patients (45 renal units) younger than 15 years who underwent PCNL at this hospital from January 1991 to December 1997. There were 27 boys and 13 girls, ranging in age from 11 months to 15 years, the median age being 9.2 years (Table 1). The commonest presentation was with pain and urinary tract infection. The basic work-up of these patients included a urine culture, plain film, ultrasound examination of the abdomen, and intravenous urography. There were 11 multiple and 9 staghorn calculi (Fig. 1; Table 1). Five patients had bilateral calculi (Fig. 2). Our principal indication for PCNL was a large calculus burden, the other indications being summarized in Table 2.

All procedures were done with the patient under general anesthesia, and the operating urologist made the initial ultrasound-guided renal puncture with the help of a 5-MHz B&K® probe. Tract dilatation was done under fluoroscopic control using the Alken telescopic dilating system. A safety guidewire was inserted in all cases and left outside the dilator sheaths. Tract caliber was limited to the minimum size required, depending on the size of the targeted calix, the width of the infundibulum, and the age of the patient. A 14F Wolf pediatric nephroscope with a 2.4-mm working channel along with smaller
(18.5F and 21F) sheaths were used in children <8 years of age and those with nondilated collecting systems. The tract was further dilated, to 24F and beyond, in older children with dilated pelvicaliceal systems and large calculus burdens. Here, an Amplatz sheath was used in conjunction with the pediatric nephroscope.

In our initial 25 cases, the operation was planned as a staged procedure in younger children with nondilated collecting systems and those with gross sepsis. Nephrostomy tubes were placed for drainage as the first stage, and calculus removal was done through the mature tract 48 hours later. Initial access and calculus removal was combined as a single stage only in older children with dilated collecting systems. In our last 20 cases, tract access and calculus manipulation were combined in all instances unless there was gross sepsis at initial puncture or bleeding after tract dilatation that impaired visibility.

Ultrasonic disintegration was employed in our initial 6 cases. Later on, however, with the availability of pneumatic lithotripsy (Swiss Lithoclast® and EMS®), we designed a slender (0.8-mm) probe with a 7F suction cannula that could be passed through the pediatric nephroscope. This slender probe with a suction device, although not available on the market, can be made to order with the EMS®. Because the working channel of the pediatric nephroscope does not allow simultaneous placement of the guidewire and a suction device, the working guidewire was removed after introduction of the nephroscope and confirmation of its position within the collecting system. The safety guidewire is essential in the event that the nephroscope position is incorrect.

We have adopted a policy of restricting nephroscopy time to 1 hour, deferring any remaining calculus removal to a second stage. A follow-up radiograph was obtained 48 hours later in all cases. A hemoglobin estimation was obtained 48 hours later in the last 31 cases. Relook nephroscopies were carried out in patients suspected of having residual stone from the postoperative radiograph. Nephrostomy tubes were removed after 48 hours after confirmation of complete clearance and provided the drainage was clear and there was no fever. Patients were followed up with a urine culture and ultrasound examination at 1 and 3 months. Appropriate metabolic evaluation was done in all cases. An intravenous urogram was obtained at 6 months.

**RESULTS**

The operation was completed in a single stage in 21 cases, whereas it was planned as a two-stage procedure in 9 cases.
Fifteen patients required a relook nephroscopy either for residual fragments which were missed at intraoperative screening or because the calculus burden was too large to be cleared in the allotted nephroscopy time.

The calculus was cleared through a single tract in 32 cases, whereas 8 patients required two tracts and 5 required three tracts. Forty-two tracts were through the middle posterior calix, which is our choice of entry for initial intrarenal access. Sixteen tracts were through a lower calix, and two were through an upper calix. The primary tract was dilated to 2.1F in 17 cases, to 2.4F in 14 cases, and beyond 2.4F in only 4 cases. All accessory tracts were limited to <2.1F. Ultrasound energy was used for calculus fragmentation in our initial 6 cases, whereas pneumatic lithotripsy was used in the subsequent 39 cases. The average operating time was 75 minutes (range 25-120 minutes).

Complete calculus clearance was achieved in 41 renal units (91%). Of the four patients with residual calculi, three underwent SWL, all of whom were completely cleared of calculus, and one was lost to follow-up. One patient with associated pelvicureteric junction obstruction underwent a simultaneous endopyelotomy. Ten patients had minor pyrexia (fever <100° F lasting for <2 days), while five patients had serious pyrexia (fever >100° F>2 days). One patient had a persistent urinary leak from the nephrostomy site and required double-J stenting. One patient had a pelvic perforation with electrolyte imbalances, which was managed conservatively with prolonged nephrostomy drainage. The average drop in hemoglobin was 1.6 (0.1-4.6) g/dL. Blood loss was also assessed on the basis of the amount of tract dilatation and the number of tracts in 31 renal units in patients for whom preoperative as well as postoperative hemoglobin values were available (Table 3). None of the patients required blood transfusion. The average hospital stay was 5.2 days (range 4-13 days).

Patient follow-up ranged from 1 month to 3 years. Seven patients were lost to follow-up. No late complications were observed. One patient had a recurrent stone on the ipsilateral side and was managed by SWL. A postoperative urogram was avail-

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<th>Table 2: Indications for PCNL</th>
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<td>Large calculus burden</td>
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<td>Poor renal function</td>
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<td>Pyonephrosis</td>
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<td>Failed SWL</td>
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<td>Patient preference</td>
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<th>Table 3: Decline in Hemoglobin in Relation to Tract Number and Extent of Dilatation</th>
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<td>Single Tract</td>
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<tr>
<td>&lt;2F</td>
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<td>No. of cases</td>
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<td>Mean Hb drop (g/dL)</td>
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<td>SD</td>
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*At least one tract was >2F.
able in 33 patients (including all of those with multiple tracts), all of whom showed stable or improved renal function.

DISCUSSION

Problems in the management of pediatric urolithiasis relate to the high incidence of metabolic and infective etiologies, the small size of the kidneys, and the apprehension regarding the long-term effects of various newer treatment modalities on the developing kidneys. Shockwave lithotripsy is the treatment of choice for most small calculi.\textsuperscript{1-5} Percutaneous lithotripsy has been carried out in children and is indicated in cases where SWL is contraindicated or has failed.\textsuperscript{6-12} The initial recommendation was to restrict the use of this modality to children older than 8 years, but later, the procedure was extended to younger children also.\textsuperscript{3,11,12} Most of these reports were of a few cases only and, with a few minor modifications, basically involved the same technique used in adults. However, we believe that PCNL in this group requires technical modifications, especially if its use has to be extended for managing complex calculi.

We use an ultrasound-guided puncture through the cup of the desired calix for initial intrarenal access. This technique permits a peripheral puncture, which traverses minimum cortical tissue, avoids injury to any major intrarenal vessel, and establishes the shortest straight tract between the skin and the calix. This approach also avoids visceral injury and minimizes radiation exposure.

Staging the procedure by obtaining intrarenal access in the first procedure and deferring definitive calculus manipulation to a second sitting has been recommended by Stapleton and Kroovand.\textsuperscript{3} This plan helps reduce bleeding and fluid absorption by having the operation take place through a mature tract. Of our initial 25 cases, we staged the procedure in 8 patients. Six of these patients were <8 years of age with nondilated collecting systems, and two patients had gross sepsis. With increasing experience, especially with limiting the tract dilatation to 18.5F or 21F in the younger patients with narrow infundibula, it was possible to combine tract access and calculus manipulation at the same sitting without increasing blood loss. Of our last 20 cases, we have staged the procedure in only one, in whom there was gross sepsis.

Segura has suggested the use of adult instruments even in children.\textsuperscript{13} Although a few reports have mentioned the use of pediatric instruments, most authors carry out tract dilatation to 24F and beyond.\textsuperscript{2,8,10,12,14} Moreover, none of these studies has analyzed the impact of the degree of tract dilatation on the extent of blood loss. We strongly believe that our policy of minimum tract dilatation with the use of a pediatric nephroscope has several advantages. First blood loss secondary to injury to major vessels near the infundibulum is avoided. Second, maneuverability within the pelvicaliceal system is better, resulting in greater calculus clearance through a minimum number of tracts while simultaneously avoiding traction injury to the infundibulum during leverage of the nephroscope (Fig. 3). Blood loss has been a major complication of pediatric PCNL cited in literature.\textsuperscript{2,11,14} Tuncay et al reported blood transfusion in 3 of

FIG. 3. Intraoperative contrast studies with 18.5F sheath (A) and 21F sheath (B). Sheath is smaller than infundibular width thereby reducing infundibular damage and blood loss.
their 12 procedures. They used tract dilatation up to 24F in children <8 years and >30F in children >8 years. Caffaway et al. reported significant blood loss altering treatment in 4 of their 18 children. Three of these patients required blood transfusion, and the subsequent procedure had to be postponed in one patient because of excessive blood loss during the first stage. Our overall drop in hemoglobin was 1.6 g/dL. Analyzing this further, we found that the blood loss was least (drop of 0.66 g/dL) in the group of patients with a single tract in whom dilatation was restricted to 21F; this difference was statistically significant (p < 0.05). Interestingly, there was no difference in blood loss between patients having a single tract 24F or more (1.8 g/dL) and patients having multiple tracts, all of which were 21F or less (2 g/dL, p > 0.05). The blood loss was maximum in the group having multiple tracts wherein the primary tract was dilated to 24F and beyond. These observations assume even greater significance in the light of the fact that dilatation up to 24F and beyond was carried out primarily in older children with significant hydrenephrosis, a group which inherently has a lower chance for significant blood loss. Zattoni et al. also have reported a reduced incidence of major intrarenal vessel injury using a pediatric nephroscope in pediatric and select adult patients. However, there was no objective estimation in their study of actual blood loss or its relation to other factors such as patient size, degree of tract dilatation, or hydrenephrosis.

The principal drawback in using pediatric instruments was the unavailability of an effective energy source for intracorporeal lithotripsy that could be delivered through smaller instruments to enable calculus clearance without prolonging the operative time. After our extremely encouraging experience with pneumatic lithotripsy in adults, we believe that this form of energy would be useful in pediatric PCNL, especially if smaller instruments were to be used. We thus developed a slender pneumatic lithotrite, which had a 0.8-mm probe and a 7F suction cannula. Pneumatic lithotripsy has proved to be an efficient form of intracorporeal fragmentation. Teh et al. have demonstrated using a plaster of paris cast model that pneumatic lithotripsy is significantly more effective than other forms of intracorporeal lithotripsy. We were successful in fragmenting all calculi, reflecting the same observation in the clinical setting. Our average operating time has been only 75 minutes (range 25–120 minutes).

In addition to being effective, pneumatic lithotripsy is safe. Numerous studies in experimental animals have demonstrated no significant immediate or delayed adverse bioeffects even when a large number of shocks is administered directly to the collecting system wall. This fact is extremely relevant in this age group with compact collecting systems and where there is significant morbidity from pelvicicalcal perforations. We have had only one pelvic perforation, which occurred at the time of tract dilatation.

Addition of a suction device to the pneumatic probe has significantly increased its efficiency. Moreover, the suction and fragmentation can be carried out independently, an advantage over ultrasonic disintegration. During the early stages of disintegration, the probe is projected beyond the suction cannula, and the bulk of the calculus is cleared. At the end of the procedure, the suction tip is brought flush with the probe. In this position, the probe is applied directly to the pelvic wall, where the excursion is just enough to disimpact the gravel stuck to the
mucosa without traumatizing it while suctioning off all the gravel.

Although the technique's well established in adults, there is a lack of data concerning the use of multiple tracts in children. In most of the literature, PCNL is used chiefly as a part of combination therapy in managing complex and branched calculi.11,12 We have employed two tracts in eight patients (Fig. 4) and three tracts in five patients. There was no significant increase in blood loss in this group, especially when the tract dilatation was limited to 21F. The maximum rise in the serum creatinine concentration in this group was 0.2 mg/dL. No patients demonstrated a significant deterioration of function on follow-up intravenous urograms. This outcome demonstrates the safety of aggressive PCNL monotherapy with the use of multiple tracts in treating multiple and staghorn calculi in this age group.

CONCLUSIONS

Percutaneous nephrolithotomy is effective in children, with a clearance rate of 91%. We recommend its use in cases where SWL is unsuitable or has failed. We believe that limiting dilatation of the tract to <21F is the most important single factor which increases its safety. Pneumatic lithotripsy with the addition of a suction device has greatly enhanced the efficiency of this procedure, making possible the use of smaller tracts without increasing operative time. Aggressive PCNL creating multiple tracts is also safe provided tract dilatation is restricted to 21F. This technique makes PCNL monotherapy a viable alternative to combination therapy for treating complex staghorn and multiple calculi in this age group.

REFERENCES


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