Percutaneous Nephrolithotomy for Complex Caliceal Calculi and Staghorn Stones in Children Less than 5 Years of Age

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ABSTRACT

Background and Purpose: Treatment of children with staghorn and complex caliceal calculi is one of the most challenging problems in urology. We present our experience with percutaneous nephrolithotomy (PCNL) monotherapy for staghorn and complex caliceal calculi in children less than 5 years of age.

Patients and Methods: Between 1991 and 2004, 27 boys and 9 girls aged 11 months to 4.5 years underwent PCNL for staghorn (33%) or complex caliceal (67%) calculi. The average bulk of the stones was 140.17 ± 42.16 mm² (range 61–253 mm²). Staging of the procedure was preferred in children with renal insufficiency, urinary-tract infection, fragmentation time >60 minutes, or a stone burden requiring more than two tracts. Essential steps of the technique were a dynamic contrast study to select the appropriate-size Amplatz sheath and ultrasound guidance for renal access.

Results: The average operative time was 72.11 ± 28.86 minutes. The stone-free rate was 86%, the mean hemoglobin drop was 2.2 ± 0.95 g/dL, and the mean hospital stay was 3.5 days. Less than half of the patients (42%) were treated in a single stage, the remainder requiring multiple procedures. Only 39% could be treated with a single tract. There was statistically significant increase in the blood loss in patients requiring multiple tracts (P = 0.008); however, staging the procedure did not increase the blood loss (P = 0.06).

Conclusion: Percutaneous nephrolithotomy is safe and effective in children less than 5 years of age. Staging the procedure, instrument modification, the timed “multi mini-perc” technique, and ultrasound-guided access help in achieving maximum stone clearance with minimal morbidity.

INTRODUCTION

Treatment of children having staghorn or complex caliceal calculi is one of the most challenging problems in urology. Since its first description by Fernström and Johansson,1 percutaneous nephrolithotomy (PCNL) has become an established procedure in adults. This technique had been extended to the pediatric age; however, its applications in those younger than 5 years were limited.2-4 Later, Mor and associates5 (7 cases), Dawaba and colleagues6 (25 cases), Callaway and coworkers3 (8 cases), and Boddy et al7 (5 cases) extended their indications to children less than 5 years of age. Further studies have revealed that PCNL in the pediatric age group is safe from a functional and anatomic point of view.6 Although combined PCNL and shockwave lithotripsy (SWL) were preferred by some,7,9 PCNL monotherapy is an effective alternative to SWL with regard to effects on renal function or scarring.2,5,8

We present our experience with PCNL monotherapy in staghorn and complex caliceal calculi in children less than 5 years old. To our knowledge, this is the largest series of PCNL in such young children, especially for staghorn and complex caliceal calculi.

PATIENTS AND METHODS

Between 1991 and 2004, 27 boys and 9 girls aged 11 months to 4.5 years (average 2.34 ± 1.10 years) underwent PCNL for staghorn (complete or partial; 33% of series) or complex caliceal calculi (L:R 1.8:1). Complex caliceal calculi were defined as those stones with or without extension into the renal pelvis.
and those stones in kidneys with complex caliceal anatomy (Figs. 1 and 2). The mean bulk of the stone was 140.17 ± 42.16 mm² (range 61–253 mm²). The number of tracts, number of stages, hemoglobin drop, transfusion rate, stone-free rate, hospital stay, and long-term renal function were analyzed. Statistical analysis was carried out using Student’s t-test and the chi-square test as appropriate.

Details of surgical procedure, basic surgical work-up, and our method of PCNL with modification for children have been detailed in our earlier publications. Only the relevant points of surgical importance are mentioned here.

The number of tracts was determined preoperatively by studying the plain and contrast films taken in both straight and lateral oblique positions. The size of the tract was determined at the time of the procedure as follows. Ultrasound guidance was used to puncture the appropriate calix for access, and if necessary, fluoroscopic adjustments were made (Fig. 3). A retrograde dynamic contrast study was done via a ureteral cathe-

FIG. 1. Example of removal of complex stone. (A) Complex renal calculi. (B) Intravenous urogram. (C) Complete clearance achieved with three nephrostomy tracts.

FIG. 2. Another example of removal of complex stone. (A) Staghorn calculus. (B) Three punctures and stages. (C) Complete clearance.
ter to measure the infundibular width and length and the angle of entry into the pelvis or to the stone. After analysis of the pelvicaliceal anatomy, the appropriate tract size (Amplatz sheath) was selected (Figs. 3 and 4).

The decision to stage the procedure was made preoperatively in children with renal insufficiency (3% of the series) or urinary-tract infection (20%), those requiring more than two tracts for complete stone clearance, and children with bilateral stones. During the surgical procedure, staging was elected in those in whom the nephroscopy time exceeded 60 minutes and children in whom bleeding obscured vision. These children underwent staged procedures after nephrostomy-tube drainage until the urine became clear.

The success of the procedure was determined by ultrasound scans and plain radiographs taken 48 hours and 30 days postoperatively. Any fragment not visible on plain films or seen on ultrasonography to be <3 mm was considered insignificant and managed conservatively.

RESULTS

The average operative time (whatever the number of stages) was 72.11 ± 28.86 minutes (range 15–150 minutes). Less than half of the patients (42%) could be treated with a single-stage procedure, and treatment through a single tract was possible in

FIG. 3. Selection of appropriate tract size. (A) Dynamic contrast study in 11-month-old child with pelvic and lower-caliceal calculi. (B) The 14F nephroscope is smaller than infundibular width.

FIG. 4. Selection of tract size and instruments. (A) Planned punctures for left staghorn calculus. (B) Clearance of main bulk using 18.5F nephroscope (tract size 21F). (C) Lower-caliceal stone and rest of pelvic stone cleared with 14F nephroscope (tract size 16F).
only 39%. Small tracts were used in the majority and thus the stone bulk was cleared preferably with smaller nephroscopes (Fig. 5): a 16F tract with a 14F nephroscope was used in 22%, a 20F tract with an 18.5F instrument in 31%, a 22F tract with a 20F nephroscope in 42%, and a 26F tract with a 24F instrument in 6%. The average age of the children in these groups these groups was 1.6 ± 0.8, 2.3 ± 1.2, 2.8 ± 1.1, and 2.5 ± 0.7 years, respectively.

There was statistically significant increase in the blood loss with patients having multiple tracts (Table 1). However, staging the procedure did not increase the blood loss ($P = 0.06$). Two children (both with staghorn calculi) required blood transfusion, one of whom had a single-stage procedure. Tract size had no bearing on the hemoglobin drop ($P = 0.28$). The stone-free rate was 86% without any statistical difference according to the tract size (Table 2). Overall hemoglobin drop, hospital stay, blood transfusion rate, and postoperative nephrostomy leak are depicted in Table 3.

The mean follow-up was 26.9 ± 10.5 months (range 1–78 months). Functional assessment (intravenous urogram/DMSA scan) was available in 20 patients (55.5%).

**DISCUSSION**

Although SWL is preferred for simple stones, PCNL should be the treatment for staghorn and complex caliceal calculi, as SWL is associated with high rates of recurrence in children owing to the metabolic abnormality and urinary-tract infection. In our study, PCNL produced good stone clearance (86%) without functional compromise.

Postoperative bleeding is one of the most serious concerns in PCNL. This assumes special importance in children, particularly those less than 5 years of age, as loss of even few milliliters of blood necessitates infusion of fluids and blood, causing water and electrolyte imbalance that mandates intensive care postoperatively.

Over the past decade, concepts regarding pediatric PCNL have evolved with various modifications such as use of the peelaway sheath, the multi-mini-perc technique, slender nephroscopes with a 9F Lithovac sheath and the modified Swiss Lithoclast probe (EMS) of 0.8 mm (Fig. 5). The combination of mini-perc with modified lithotripsy devices has several advantages. Although the tract size (Table 2) had no bearing on the hemoglobin drop in our study, selecting the tract size according to the width of the infundibulum and its angle of entry into the renal pelvis helps in preventing the overdilatation of the infundibulum (see Fig. 3) and subsequent bleeding catastrophe. Use of slender nephroscopes (14F, 18.5F, 20F) facilitates maneuverability inside the pelvicaliceal system to access the stone-bearing calix. Use of modified instrumentation with pneumatic lithotripsy along with the suction device (Swiss Lithoclast) hastens stone fragmentation and can be used effectively through these slender nephroscope channels without compromising the saline irrigation or vision during the procedure, thereby reducing the operative time. We strongly believe that selection of appropriate tract size (see Table 2 and Figs. 3 and 4) and use a combination of slender nephroscopes and pne-

**TABLE 1. FACTORS AFFECTING HEMOGLOBIN DROP**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Stone bulk</th>
<th>Hb drop (g/dL)</th>
</tr>
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<tbody>
<tr>
<td>No. of tracts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single ($n = 14$)</td>
<td>130.9 ± 39.5</td>
<td>1.8 ± 0.9</td>
</tr>
<tr>
<td>Multiple ($n = 22$)</td>
<td>146.1 ± 43.6</td>
<td>2.6 ± 0.9</td>
</tr>
<tr>
<td>$P$ value $^a$</td>
<td></td>
<td>0.008</td>
</tr>
<tr>
<td>No. of stages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single ($n = 15$)</td>
<td>136.3 ± 48.4</td>
<td>2.0 ± 0.7</td>
</tr>
<tr>
<td>Multiple ($n = 21$)</td>
<td>143.8 ± 38.1</td>
<td>2.5 ± 1.1</td>
</tr>
<tr>
<td>$P$ value $^a$</td>
<td></td>
<td>0.06</td>
</tr>
</tbody>
</table>

$^a$Student’s t-test.
matic lithotripsy has not only reduced the blood loss but also helped in achieving higher stone-free rates. Although an increase in the number of tracts has adverse effect in terms of blood loss (Table 1), staging the procedure allows the tract to mature, which makes the PCNL procedure relatively simple without significant blood loss, leading to faster stone disintegration. It also has several benefits such as reduction of hypothermia, avoidance of electrolyte imbalance, and prevention of postoperative infection.

Ultrasound-guided access not only creates a straight tract to the desired calix but also prevents visceral injury (spleen and liver), an important consideration in that some physiological visceroptosis is expected in these young children. We had three infants in whom in the liver and spleen were seen to lie between our initially chosen puncture site and the target calix; we avoided harm by selecting more oblique and posterior tracts.

Finally, the issues to be addressed while treating a child with large stone bulk or staghorn stones are a long operative time leading to hypothermia,14 residual stones, blood transfusion, visceral injury, and radiation exposure. We addressed the above issues by the following modifications (“staged multi mini-perc concept”):

- Restricting the operative time to 60 minutes;
- Staging the procedure (see Table 1);
- Selecting an appropriate tract size (see Table 2 and Figs. 3 and 4);
- Technical modifications (see Fig. 5); and
- Ultrasound-guided puncture with fluoroscopic adjustment.

### CONCLUSION

Percutaneous nephrolithotomy is a safe and effective procedure for staghorn and complex caliceal calculi in children less than 5 years of age. Ultrasound-guided fluoroscopy-adjusted tract puncture, staging the procedure wherever appropriate, instrument modification, and the timed multi mini-perc technique help in achieving maximum stone clearance with minimal morbidity.