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A comparison of outcomes after percutaneous nephrolithotomy in children and adults: A matched cohort study

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Summary

Introduction
Percutaneous nephrolithotomy (PCNL) has surpassed open stone surgery as the operation of choice for large and complex stone burdens (figure). Although the procedure was developed in adults, its principles have been extrapolated to children. There is a paucity of literature comparing outcomes of PCNL in adults and children for similar stone burdens.

Objective
The purpose of this study was to evaluate outcomes following PCNL among children and adults with similar stone burdens.

Patients and methods
Data on patient characteristics and outcomes for 2196 consecutive patients undergoing PCNL at a single institution were collected prospectively from January 1992 to July 2013. Thirty-one pediatric patients undergoing 39 PCNLs were identified. Each pediatric PCNL was matched in a ratio of 1:4 to adult PCNLs by year of surgery and stone burden characteristics (staghorn, partial staghorn, number of stones). All PCNLs were performed by two fellowship-trained endourologists who operate on both adult and pediatric patients. Ultrasonic lithotripsy was used primarily. The primary outcome measure was stone-free rate (SFR) at hospital discharge. Secondary outcomes included the need for second-look nephroscopy, length of hospital stay, complication rate, and blood transfusion rate. The Student *t* test was used for continuous variables and the Fisher exact for categorical variables.

Results
The median age for the pediatric group was 13.9 ± 4.30 years and for the adult group was 55.4 ± 15.1 years. Pediatric patients tended to present with metabolic stones, with no difference in rates of infection stones. No difference was found in SFR at time of hospital discharge (86.1% vs. 86.4%, $p = 0.2$). More pediatric patients required a second access tract than adult patients (15.4% vs. 4.52%, $p = 0.02$). There was no significant difference in the need for second-look nephroscopy, length of stay, or complication rates (overall and by Clavien classification subgroup) between both groups. The rates of blood transfusion were low in both groups (0% vs. 0.6%, $p = 0.80$).

Discussion
There was no difference in primary and secondary outcomes among children compared with adults undergoing PCNL in our study. The outcomes reported in this study were similar to published literature. A limitation of this study is the low number of pediatric patients. However, it is unique to have a single-center study that compares PCNL outcomes in both adult and pediatric patient and accounts for stone burden characteristics.

Conclusions
Although principles of PCNL were developed in adults, this study affirms the safety and efficacy of PCNL in both pediatric and adult patients.

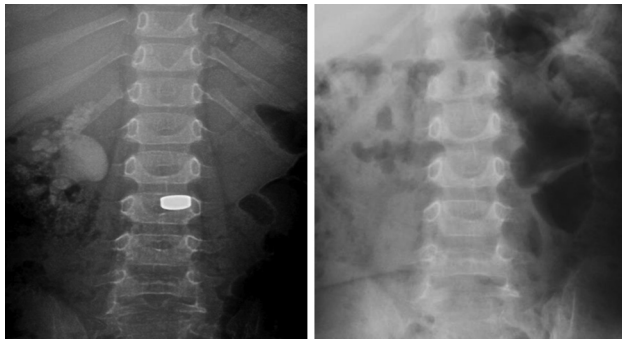

Figure Preoperative and postoperative kidney ureter bladder radiograph of a child who underwent a simultaneous right PCNL and endoscopic removal of a watch battery.

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Introduction

Children represent 2–3% of all stone formers, and recent data suggest urolithiasis affects up to one in 1000–1700 children in the United States [1]. Recent evidence also suggests that the incidence of stone disease is increasing in children, which may be due to dietary and/or environmental factors [2]. In children, stones are more often a result of metabolic abnormalities or urinary infection than in adults. There is a high rate of recurrence in pediatric stone formers and, due to their young age, there is a long interval for stones to recur.

Historically, open renal surgery has been indicated for patients with complex or large stone burdens. Since the advent of percutaneous nephrolithotomy (PCNL), stone surgery and reoperation for these patients have become far less invasive. PCNL was first described in adults in 1976 [3] and subsequently in children in 1985 [4]. Several reports have suggested that PCNL is safe and effective in children [5–11]. These studies are mostly limited to case series and many lack a control group for comparison.

Many of the surgical principles used in PCNL were developed in adults, but then directly applied to children. One key consideration is the smaller size of the urinary tract. Techniques that use smaller access tracts, including mini-perc [12–14], ultra-mini perc [15], and micro-perc [16,17], have gained popularity in children. Other technical considerations unique to children undergoing PCNL relate to the smaller blood volume and increased risk of hypothermia from irrigation solutions.

In addition, differences in outcomes after renal stone surgery between children and adults may also exist. Zeng et al. [12] reported a large retrospective series of children undergoing mini-PCNL and compared them with an adult cohort. They found that children had a higher stone-free rate (SFR), and required fewer access tracts and a smaller nephrostomy tract. However, each pediatric patient was not matched to adult controls and they only reported that the proportion of staghorn stones, and multiple and solitary stones were balanced between both groups. PCNL in children compared with matched adult controls for similar stone burdens has not been previously reported. We hypothesize that the SFR following PCNL in children will be similar to that of adults when matched for stone burden characteristics.

Methods

Data for this study were extracted from a large single institutional PCNL database that contained clinical, intraoperative, and outcome data for 2196 consecutive PCNL from January 1992 to December 2012. Clinical data included patient age, gender, presenting symptom, comorbidities, presence of urinary tract malformation, and stone burden characteristics (i.e., the number of stones, staghorn configuration, and partial staghorn configuration). Intraoperative data included side of operation, location of stone, location and number of tracts, and operative time. Outcome data included SFR at discharge, length of hospital stay, need for second-look nephroscopy, occurrence of complication coded according to the Modified Clavien Classification System [18], and stone composition. SFR was defined as no residual stones $\geq$3 mm on postoperative kidney ureter bladder (KUB) radiography, ultrasound, nephrostogram, or computed tomography (CT), according to surgeon preference. Postoperative CT was used in 12% of adult patients for postoperative imaging and 3% of pediatric patients. We considered the SFR at discharge as our primary outcome. All other outcomes were considered predefined secondary outcomes. All PCNLs were performed by one of two fellowship-trained endourologists using standard techniques, and access was typically obtained in the operating room under fluoroscopic guidance, which has been described elsewhere [19].

Dilation of the access tract was in general performed to 24F and rarely up to 30F, depending on the size of the child, the renal anatomy, and stone burden. Throughout the duration of the data collection, several different rigid nephroscopes were employed including a 26F adult instrument (Karl Storz Endoscopy, Tuttlingen, Germany), a 22F pediatric rigid nephroscope (Gyrus/ACMI- Olympus, Southborough, MA, USA), and a 17F pediatric scope (Karl Storz Endoscopy). Intracorporeal lithotripsy devices used included ultrasonic, pneumatic/Lithoclast (EMS, Nyon, Switzerland), holmium:YAG laser, and electrohydraulic lithotripsy (EHL). The selection of device in each case was determined by the size of endoscope used, the stone hardness, and the collecting system anatomy.

Thirty-one pediatric patients (age $\leq$ 18 years) who underwent 39 PCNLs were identified. These PCNLs were matched in a 1:4 ratio with adult PCNLs from our dataset, which brought our total cohort to 195 PCNLs. The matching criteria included year of surgery, and stone burden characteristics (number of stones, staghorn configuration, and partial staghorn configuration). Within these parameters matched controls were selected for completeness of data, then by random assignment (i.e., controls with at least 90% complete data fields were assigned to each pediatric PCNL). When more than four possible matches were available, controls were labeled with a random number generator within Excel (Microsoft Corp, Redmond, WA, USA) and PCNL data corresponding to the lowest four random numbers assigned were selected as controls.

All statistical analyses were performed with SPSS v.20 (IBM Corp., Armonk, NY, USA). The Student *t* test was used for normally distributed continuous variables. The Mann–Whitney U test was used in cases where the assumption of normality was not met. The chi-square and Fisher exact tests were used to evaluate categorical data where appropriate. Multivariable logistic regression for SFR at discharge, secondary procedures, and linear regression for length of hospital stay were attempted. However, no additional independent predictors of these outcomes were identified, therefore multivariable regression analyses are not presented.

Results

Our study population included 39 pediatric PCNLs and 156 adult controls. Table 1 summarizes the baseline characteristics of this cohort. Patients presented with pain (57.4%), urinary tract infection (23.1%), and hematuria (15.4%) in equal proportions between pediatric and control

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