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Tracking of radiation exposure in pediatric stone patients: The time is now

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Summary

Background
Despite the increasing incidence of pediatric nephrolithiasis, there is little data quantifying the radiation exposure associated with treatment of this disease. In this study, pediatric patients with nephrolithiasis who were managed at a single institution were identified, and the average fluoroscopy time and estimated radiation exposure associated with their procedures were reported.

Methods
Stone procedures performed on pediatric patients between 2005 and 2012 were retrospectively identified. Procedures were classified as primary ureteroscopy (URS), stent placement prior to ureteroscopy (SURS), percutaneous nephrolithotomy (PCNL), and bilateral ureteroscopy (BLURS). Patient demographic information, stone size, stone location, number of radiographic images, and fluoroscopy times were analyzed.

Results
A total of 152 stone procedures were included in the final analysis (92 URS, 38 SURS, eight BLURS and 14 PCNL). Mean patient age at time of stone treatment was 15.94 $\pm$ 4.1 years. Median fluoroscopy times were 1.6 (IQR 0.8—2.4), 2.1 (IQR 1.6—3.0), 2.5 (IQR 2.0—2.9), and 11.7 (IQR 5.0—18.5) minutes for URS, SURS, BLURS and PCNL, respectively. There was a moderate correlation between stone size and fluoroscopy time ($r = 0.33$). When compared with ureteroscopic procedures, PCNL was associated with a significantly higher fluoroscopy time (11.7 vs 2.1 min, $P < 0.001$). The estimated median effective dose was 3 mSv for ureteroscopic procedures and 16.8 mSv for PCNL. In addition to radiation exposure during treatment, patients in this cohort were exposed to an average of one (IQR1-3) CT scan and three (IQR 1-8) abdominal X-rays. No new malignancies were identified during the limited follow-up period.

Conclusions
Radiation exposure during treatment of pediatric stone disease is not trivial, and is significantly greater when PCNL is performed. Given the recommended maximum effective dose of 50 mSv in any one year, urologists should closely monitor the amount of fluoroscopy used, and consider the potential for radiation exposure when choosing the operative approach. Prospective studies are currently underway to elucidate precise dose measurements and localize sites of radiation exposure in children during stone treatment.

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Introduction

The incidence of pediatric nephrolithiasis has been increasing over the past 25 years [1]. There has been a corresponding increase in radiation exposure as well. Because of an improved understanding of the risks conferred with increasing radiation exposure, there has recently been more emphasis on quantifying radiation exposure associated with diagnostic imaging [2]. However, little has been reported on radiation exposure during the surgical treatment of stones in the pediatric population.

In patients who require surgical intervention for stone disease, current treatment options include: ureteroscopy with laser lithotripsy, extracorporeal shock wave lithotripsy, and percutaneous nephrolithotomy (PCNL). Of the many factors considered when selecting a surgical approach (i.e. stone size, composition, location, and local anatomy), anticipated radiation exposure has historically been absent. Although procedure-specific stone clearance rates are similar to those seen in adults, pediatric patients have a high rate of recurrent disease and are more likely to require future diagnostic studies and surgical interventions that may be accompanied by additional radiation [3,4]. Moreover, heightened concern about radiation exposure in children stems from the fact that the impact of radiation exposure (i.e. the effective dose) is 50% higher in pediatric patients when compared with adults [5—7]. Recent epidemiologic studies have identified increased rates of malignancy in patients exposed to ionizing radiation as children [8—10]. Current pediatric computed tomography (CT) scan utilization alone is predicted to result in an additional 4800 future malignancies per year [11]. The increased risk of childhood radiation exposure is further supported by outcomes in survivors of the atomic bomb, where age of exposure and time since exposure had the largest impact on the development of hematologic malignancy [12]. Given that radiation exposure in the pediatric population carries the greatest risk of long-term consequences, it is evident that the exposure to ionizing radiation during both the diagnosis and treatment of pediatric stone disease must be defined and limited.

The aim of the present study was to retrospectively quantify radiation exposure during surgical management of pediatric stone disease at the present institution, and to identify modifiable risk factors, allowing for the development of protocols to reduce future exposure.

Methods

After IRB-approval, patients who underwent surgical management of nephrolithiasis at The Children's Hospital of Pittsburgh between 2005 and 2012 were stratified according to the surgical intervention performed. Surgical procedures were classified as primary ureteroscopy (URS), stent placement prior to ureteroscopy (SURS), percutaneous nephrolithotomy (PCNL), and bilateral ureteroscopy (BLURS). In cases where a stent was placed in a separate procedure occurring prior to the ureteroscopy, the fluoroscopy times associated with the stent placement and the ureteroscopy were summed. Patient demographics, imaging history, stone location, size, and procedural data were retrospectively obtained from the medical records.

Average fluoroscopy times were compared using the Student's t-test and a value of $P < 0.05$ was considered to be significant. Stone size and fluoroscopy times were assessed using Pearson's correlation coefficient r. Estimated average effective fluoroscopy doses were calculated by multiplying an accepted standard average effective dose per unit time by the total fluoroscopy time for each procedure [13]. Estimated average effective doses for imaging studies were extrapolated from reported reference standards [14].

Results

A total of 152 stone procedures on 142 patients were included in the final analysis. Specifically, 92 URS, 38 SURS, eight BLURS, and 14 PCNL were performed. Mean patient age at time of stone treatment was 15.94 ± 4.1 years (Table 1). Eleven patients (7.7%) had a systemic condition known to contribute to stone formation, most commonly inflammatory bowel disease. The most common genetic abnormality in the patient population was a defect in dibasic amino acid reabsorption (e.g. cystinuria), which occurred in four patients (2.8%). The median follow-up for this patient cohort was 19 months (1—83 months).

Median fluoroscopy times were 1.6 (IQR 0.8—2.4), 2.1 (IQR 1.6—3.0), 2.5 (IQR 2.0—2.9), and 11.7 (IQR 5.0—18.5) minutes for URS, SURS, BLURS and PCNL, respectively (Fig. 1). There was a moderate correlation between stone size and fluoroscopy time ($r = 0.33$, $P < 0.01$, Fig. 2). Being male and patient age were not associated with increasing fluoroscopy times. When compared with ureteroscopic procedures, PCNL was associated with a significantly higher

Table 1 Patient demographics by procedure.

	Mean age (years.) ± SD	Female sex (%)	Mean stone size (mm) ± SD	Median fluoroscopy time (minutes) (IQR)	Estimated effective dose (mSv) (IQR)
URS (n = 93)	15.76 ± 3.95	49 (53)	8.51 ± 5.4	1.6 (0.8—2.4)	2.3 (1.2—3.5)
SURS (n = 38)	15.92 ± 4.86	24 (63)	6.68 ± 3.7	2.1 (1.6—3.0)	3.0 (2.3—4.3)
BURS (n = 8)	16.37 ± 2.72	7 (88)	11.3 ± 6.3	2.5 (2.0—2.9)	3.6 (2.9—4.2)
PCNL (n = 14)	15.2 ± 4.58	8 (57)	15.5 ± 3.3	11.7 (5.0—18.5)	16.8 (7.2—26.6)

BURS: bilateral ureteroscopy; IQR: interquartile range; mm: millimeters; mSv: millisieverts; PCNL: percutaneous nephrolithotomy; SD: standard deviation; SURS: prestented ureteroscopy; URS: ureteroscopy.