Patient and Institutional Characteristics Associated with Initial Computerized Tomography in Children Presenting to the Emergency Department with Kidney Stones

Justin B. Ziemba, Douglas A. Canning, Jane Lavelle, Angela Kalmus and Gregory E. Tasian*

From the Division of Urology, Department of Surgery, The Perelman School of Medicine at University of Pennsylvania (JBZ, DAC, GET) and Division of Urology, Department of Surgery (DAC, AK, GET), Department of Emergency Medicine (JL) and Center for Pediatric Clinical Effectiveness (GET), Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

Abbreviations and Acronyms

AUA = American Urological Association

CT = computerized tomography

ED = emergency department

PHIS = Pediatric Hospital Information System

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* Correspondence: Department of Surgery, Division of Urology, Wood Center, 3rd Floor, Children's Hospital of Philadelphia, 34th St. and Civic Center Blvd., Philadelphia, Pennsylvania 19104 (telephone: 215-590-0317; FAX: 215-590-3985; e-mail: tasiang@chop.edu).

Purpose: Professional associations recommend ultrasound as the initial imaging study in children with suspected nephrolithiasis but computerized tomography remains frequently used. We identified patient and institutional characteristics associated with computerized tomography as the first imaging study in children with nephrolithiasis diagnosed in the emergency department.

Materials and Methods: We performed a cross-sectional study of children 2 to 18 years old with nephrolithiasis who were referred to a freestanding pediatric hospital from 2003 to 2012. We identified the imaging modality first used to evaluate the child. Medical directors at the emergency department where children were first evaluated were sent a questionnaire to ascertain emergency department characteristics. Multivariate hierarchical logistic regression models were used to determine patient and institutional characteristics associated with initial computerized tomography.

Results: Of 536 eligible children 323 (60.2%) were evaluated at emergency departments from which surveys were returned. Of the 323 children 238 (71%) underwent computerized tomography as initial imaging. Ultrasound was available at all emergency departments. Older patient age was associated with higher initial computerized tomography use (OR 1.09, 95% CI 1.04−1.16). A more recent year of diagnosis (OR 0.80, 95% CI 0.72−0.88) and a clinical care pathway that used ultrasound as initial imaging (OR 0.29, 95% CI 0.01−0.38) were associated with lower initial computerized tomography use.

Conclusions: A clinical care pathway in the emergency department was the only institutional characteristic associated with lower computerized tomography use. Future studies are needed to determine whether care pathways using ultrasound for initial imaging in children with suspected nephrolithiasis would decrease inappropriate computerized tomography and improve adherence to national guidelines.

Key Words: kidney; nephrolithiasis; tomography, x-ray computed; ultrasonography; emergency service, hospital

THE incidence of nephrolithiasis in adolescents increased approximately 10% per year during the last 20 years.[1−3] During this period CT use in children diagnosed with nephrolithiasis at pediatric hospitals

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increased 26% to 45%.[4] Increasing CT use is concerning because of the risk of malignancy associated with ionizing radiation, which may be higher in children than in adults due to longer life expectancy and greater sensitivity of developing tissue to the effects of radiation.[5] In response to this potential harm from radiation the AUA and EAU (European Association of Urology) developed imaging guidelines for children with suspected nephrolithiasis in 2012 and 2013, respectively.[6,7] The 2 groups recommend ultrasound as first line imaging with noncontrast CT reserved when ultrasound is nondiagnostic.[6,7]

Currently CT is the most frequently used modality to evaluate abdominal pain and in children with suspected nephrolithiasis in the ED.[8,9] This is concerning because children with stones often undergo multiple CTs during a single stone episode and many of them experience recurrences.[4,10] There is substantial variability in CT use across hospitals participating in the PHIS after controlling for demographic and socioeconomic factors, which suggests that other factors affect CT use.[4] However, our knowledge of institutional characteristics associated with CT use is limited because prior studies were done using administrative databases.[2,4,8,9,11]

We determine patient and institutional characteristics associated with CT as the first imaging study in children with nephrolithiasis diagnosed in the ED at pediatric and nonpediatric hospitals. We hypothesized that institutional factors would have the strongest association with initial CT use. Our secondary aim was to characterize the patterns of diagnostic imaging at these hospitals.

MATERIALS AND METHODS

Study Population

We performed a cross-sectional study of all children 2 to 18 years old diagnosed with symptomatic kidney stones who were referred to the Division of Urology, Children's Hospital of Philadelphia, a 480-bed freestanding pediatric hospital. The Division of Urology has a prospectively maintained database of patients with nephrolithiasis who were initially evaluated at or referred to the hospital for continued treatment. We queried this database for patients with renal or ureteral calculi who underwent initial evaluation in the ED from 2003 to 2012. Excluded from analysis were patients with neuropathic bladder and anatomical urinary tract abnormalities.

A kidney stone episode was defined as the time from initial symptomatic presentation in the ED to stone passage or surgical management. We retrospectively reviewed all CTs and ultrasounds performed during a kidney stone episode. Since at least one of these studies was done in all patients, additional imaging such as plain x-ray or excretory urogram was not reviewed. The ED visit note for each child was not reviewed because these records were not available. This study was approved by our institutional review board.

Survey Instrument

We developed a survey to identify current characteristics of the EDs where children were diagnosed with nephrolithiasis. Questionnaire completion required approximately 5 minutes. The questionnaire consisted of a maximum of 29 questions (supplementary material, http://jurology.com/). It assessed hospital characteristics with answer choices for ED size and volume determined by reviewing national ED data.[12,13] The questionnaire also assessed the availability of imaging resources and consultants. To determine quality initiatives designed to deliver evidence-based therapy to patients we asked about a clinical care pathway in the ED to manage suspected nephrolithiasis in children. If a pathway was present, the respondent was asked to indicate the first line imaging modality.

The survey was pretested by administering it to a focus group of ED physicians to ensure that the questions comprehensively and accurately ascertained all ED characteristics potentially associated with imaging use. We revised the questionnaire based on the feedback.

We compiled a list of 110 local hospitals within the geographical referral base of our hospital. Each hospital was contacted by telephone to obtain the contact information of the ED medical director, which was used to distribute the survey by e-mail. A reminder to complete the survey was sent 1 and 2 weeks after the initial invitation. Survey data were developed, collected and managed with REDCap (Research Electronic Data Capture)[14] hosted at University of Pennsylvania. REDCap is a secure, web based application designed to support data capture for research studies.

Outcome Definition and Predictor Variables

The primary outcome was CT as the initial imaging study during the ED visit when the stone was diagnosed. The secondary outcome was the order of imaging during the ED visit. We determined the frequency of ultrasound and CT use during the stone episode and identified the first imaging study done in each patient using the radiology report date and time stamp.

The primary predictor was a clinical care pathway using ultrasound for initial imaging in children with suspected nephrolithiasis. Covariates assessed for inclusion in the regression model included patient demographics and institutional characteristics identified in the survey.

Statistical Analysis

Differences in age of the patients who underwent CT vs ultrasound as initial imaging were determined using the rank sum test after confirming nonparametric distribution. The chi-square test was used to evaluate differences in all categorical patient and institutional characteristics between patients who first underwent CT vs ultrasound.

We used hierarchical logistic regression models to estimate the association of patient and institutional characteristics with initial CT. Regression models were built using manual backward selection of covariates. Included in the final model were all covariates associated with CT at $p < 0.2$ on univariate analysis, those with a priori defined face validity and those showing significant