Radiation Exposure in the Acute and Short-Term Management of Urolithiasis at 2 Academic Centers

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Abbreviations and Acronyms

CT = computerized tomography

IVP = excretory urography

KUB = plain x-ray of the kidneys, ureters and bladder

PCNL = percutaneous nephrolithotomy

SWL = shock wave lithotripsy

URS = ureteroscopy

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Purpose: Diagnostic imaging has a central role in the evaluation and management of urolithiasis. A variety of modalities are available, each with benefits and limitations. Without careful consideration of imaging modalities in quantity and type patients may receive excessive doses of radiation during initial diagnostic and followup evaluations. Therefore, we determined the effective radiation dose associated with an acute stone episode and short-term followup.

Materials and Methods: A multicenter retrospective study of all patients who presented with an acute stone episode was performed. The analysis included all imaging studies related to stone disease performed within 1 year of the acute event. Using accepted effective radiation dose standards for each of these examinations, the total radiation dose administered was calculated and compared by patient characteristics including stone location, stone number and intervention strategy. The primary outcome assessed was a total radiation dose greater than 50 mSv, the recommended yearly dose limit for occupational exposure by the International Commission on Radiological Protection.

Results: We identified 108 patients who presented to our respective institutions with a primary acute stone episode between 2000 and 2006. The mean age in our cohort was 48.6 years and 50% of the patients were men. Patients underwent an average of 4 radiographic examinations during the 1-year period. Studies performed included a mean of 1.2 plain abdominal films of the kidneys, ureters and bladder (range 0 to 7), 1.7 abdominopelvic computerized tomograms (range 0 to 6) and 1 excretory urogram (range 0 to 3) during the first year of followup. The median total effective radiation dose per patient was 29.7 mSv (IQR 24.2, 45.1). There were 22 (20%) patients who received greater than 50 mSv. Analysis of stone location, number of stones, stone composition, patient age, sex and surgical intervention indicated no statistically significant difference in the probability of receiving a total radiation dose greater than 50 mSv.

Conclusions: A fifth of patients receive potentially significant radiation doses in the short-term followup of an acute stone event. Radiographic imaging remains an integral part of the diagnosis and management of symptomatic urolithiasis. While debate exists regarding the threshold level for radiation induced fatal malignancies, urologists must be cognizant of the radiation exposure to patients, and seek alternative imaging strategies to minimize radiation dose during acute and long-term stone management.

Key Words: calculi, nephrolithiasis, kidney, radiation dosage

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THE use of imaging technology is critical to the evaluation and treatment of patients with urolithiasis. Historically IVP, plain abdominal films of the kidneys, ureters and bladder, and ultrasonography were performed to assess stone burden. Currently CT represents the gold standard for acute diagnostic imaging for urolithiasis with nearly 100% sensitivity.[1]

During initial diagnostic and management periods patients frequently undergo multiple imaging modalities for which each examination has an inherent degree of radiation exposure associated with its use. The biological effects of significant radiation exposure are of increasing concern to physicians and patients.[2] In this context we evaluated the number and type of studies performed in patients with renal colic during the initial diagnostic and subsequent treatment periods. We also estimated the total radiation exposure associated with these diagnostic procedures. We hypothesized that this exposure would be significant for a large proportion of our patients.

METHODS

A retrospective chart review was performed to identify all patients who presented with an acute stone episode and were followed at our 2 large stone centers. Only patients presenting with their first stone episode or first symptomatic episode in the last 5 years were included in analysis. We excluded patients younger than 18 years, those for whom the initial medical presentation occurred elsewhere and who were subsequently referred for treatment, and those who were lost to followup before completing a 1-year followup. We identified all imaging studies related to stone disease performed on these patients at our individual institutions within a year of the acute event. Studies were determined to be related to stone disease if the associated diagnosis was renal colic, flank pain, or kidney or ureteral stone. Demographic data including patient age, race and gender, and stone characteristics including location, number and composition were recorded. Stone location was defined as distal, middle or proximal ureter and renal pelvis. Surgical intervention for the treatment of the urinary tract calculus including SWL, URS, PCNL and/or open surgery was noted.

Using accepted effective radiation dose standards for each of the imaging modalities we calculated the total effective radiation dose for each patient, and correlated this number with patient and stone characteristics and surgical intervention.[3]

Although reported effective radiation doses vary, typical exposures are 1.7 mSv for a 2-film KUB, 2.5 mSv for IVP and 10 mSv for abdominal or pelvic CT.[3] Since patients with stones often undergo a combined abdominopelvic CT, the cumulative typical dose can be estimated to be 20 mSv per CT. Our primary goal was to identify the proportion of patients who received a total radiation dose greater than 50 mSv, the recommended yearly dose limit for occupational exposure by the International Commission on Radiological Protection.[4] This level of radiation was selected because there are no standardized dose limits for patient exposure.

We evaluated patient demographics, stone characteristics and surgical treatment modality to determine if any of these factors was associated with the number or type of radiographic studies performed. We also correlated the frequency of the primary outcome (radiation dose greater than 50 mSv) with patient characteristics (ie age, race, stone features and surgical intervention). Continuous variables were compared with the Student's t test if normally distributed and the Wilcoxon rank sum test if not normally distributed. Categorical outcomes were compared with the chi-square test or Fisher's exact test as appropriate. Average radiation doses were compared as a secondary end point using the t test or ANOVA as appropriate. The relationship between age or number of stones and average radiation dose was assessed using simple linear regression. All testing was 2-sided with $\alpha = 0.05$. We did not correct for the effects of multiple testing. We used SAS® version 9.1 for all statistical analyses.

RESULTS

A total of 108 patients with a primary acute stone episode and a minimum of 1 year of followup were evaluated at our institutions between October 2000 and October 2006. Mean patient age in our cohort was 48.6 years with a 1:1 male-to-female ratio. The mean number of stones identified per patient was 1.7 (IQR 1, 2). The most common stone location was the renal pelvis (48%) followed by the distal ureter (29%), with the remainder located in the proximal and mid ureter (15% and 8%, respectively). A stone analysis was available on the offending stone obtained from passage or treatment in 34% (37) of patients. Stone composition was calcium oxalate monohydrate in 46% of patients, calcium phosphate in 19% and uric acid in 11%. Surgical intervention was performed in 94 patients (87%). The remaining patients were treated medically. URS was the most commonly performed procedure comprising 72% of procedures, with 23% of patients undergoing PCNL and 4% undergoing SWL. No patients underwent an open surgical intervention.

Patients were subjected to an average of 4 radiographic examinations during the 1-year period. Imaging studies performed included a mean of 1.2 KUBs (range 0 to 7), 1.7 abdominopelvic CTs (range 0 to 6) and 1 IVP (range 0 to 3) during the first year of followup. Therefore, patients were exposed to a mean cumulative effective radiation dose of 1.8 mSv from KUB, 2.5 mSv from IVP and 34 mSV from CT imaging. The median effective radiation dose per patient was 29.7 mSv (IQR 24.2, 45.1). The figure displays the total estimated effective radiation dose for each patient. A total of 22 patients (20%) received a radiation dose greater than 50 mSv. There was no statistically significant correlation among stone number, location and composition, patient