



## Trends in Imaging Use for the Evaluation and Followup of Kidney Stone Disease: A Single Center Experience

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**Purpose:** Recent reports support renal ultrasound as the initial imaging study to evaluate patients with suspected renal colic. However, urologists often advocate for computerized tomography to better define stone size and location, especially before proceeding with endourological intervention. One concern with using ultrasound as initial imaging is that computerized tomography may be required later, obviating the reduction in costs and radiation gained by using ultrasound.

**Materials and Methods:** We retrospectively reviewed the electronic health records of 10,680 episodes of stone disease in a total of 7,659 patients who presented to the emergency department or walk-in clinic with a chief complaint or visit diagnosis of urolithiasis from 2009 to 2015 at a single institution. Images obtained during the index encounter and in the following 90 days were recorded.

**Results:** The index encounter included computerized tomography in 47% of episodes, ultrasound in 20%, plain x-ray of the kidneys, ureters and bladder in 12% and no imaging in 29%. Of the index visits 49% included multiple testing. If no computerized tomography was obtained during the index visit, 10% of patients underwent computerized tomography later in the episode. Total imaging costs and radiation exposure during 90 days were significantly higher when computerized tomography was done at the index visit. If the initial image obtained during an episode was ultrasound, computerized tomography was performed in 20% of cases within 90 days.

**Conclusions:** Of patients who underwent an initial ultrasound 80% avoided computerized tomography imaging. Avoiding computerized tomography at the index visit was associated with substantial reductions in radiation exposure and imaging costs.

### Abbreviations and Acronyms

BMI = body mass index  
 CT = computerized tomography  
 ED = emergency department  
 KUB = plain x-ray of the kidneys, ureters and bladder  
 US = ultrasound

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THE diagnostic approach to patients with suspected renal colic often involves imaging the urinary tract. According to ACR® (American College of Radiology)<sup>1</sup> and AUA (American Urological Association)<sup>2</sup> noncontrast CT is the imaging modality of choice to evaluate acute flank pain and suspicion of urinary stone disease.

This is due to superior sensitivity and specificity for identifying ureteral stones and the ability to discover alternative diagnoses and characterize the size and location of the stone to facilitate management recommendations. Accordingly, the use of CT in the ED has increased significantly with time.<sup>3-6</sup> However,

alternative approaches to conventional CT have been proposed due to concern over cost and ionizing radiation exposure.

One approach to limiting radiation exposure is by performing US as the initial imaging modality for the workup of suspected urolithiasis. Smith-Bindman et al noted the safety of this approach in a large, multicenter, comparative effectiveness trial.<sup>7</sup> However, the downstream effects of this approach are not yet defined. In particular to our knowledge the need for subsequent imaging, and the associated costs and radiation exposure during an entire stone episode are unknown.

Our goal was to describe imaging use in a contemporary population of patients in light of the recent heightened awareness of increasing costs and ionizing radiation exposure. Specifically we sought to answer certain questions. 1) If ultrasound is done as the initial test to evaluate suspected renal colic, how many of those patients subsequently undergo CT? 2) If CT is not obtained at the index visit, how many patients require CT at a later date? We describe how these approaches impact overall cost and radiation exposure to the patient during the course of a stone episode.

## METHODS

The study setting was an academic medical center in Burlington, Vermont. The center provides most of the primary care for the largely urban and suburban county, maintains the only emergency department in the county and offers most of the urological services in this rural state.

Using data from the Epic electronic medical record system (Epic Systems, Verona, Wisconsin), all patients who presented to the ED or outpatient walk-in center from 2009 to 2015 with a chief complaint or visit diagnosis of urolithiasis were identified by ICD-9 and ICD-10 codes. In the same period all patient encounters in which abdominal CT, US or KUB was ordered were identified. These data sets were merged to identify patient episodes, defined as an index visit for urolithiasis plus all subsequent encounters in which that patient underwent CT, US or KUB within 90 days of the index event. A visit more than 90 days from the index encounter was considered the start of a new episode. Each episode was assigned the date of the index encounter in the ED or walk-in center and was characterized by which imaging modality was used first, other modalities used at the index encounter, modalities used at followup encounters and the total number of each modality used.

For cost evaluation we used typical published reimbursement values for each imaging modality, including \$594 for noncontrast CT, \$295 for US and \$138 for KUB.<sup>8</sup> Radiation exposure was estimated as 7.0 mSv for CT, 0.7 mSv for KUB and 0 for US.<sup>9</sup>

We report the mean  $\pm$  SD, 95% CI and 2-tailed *p* values. We used linear regression to evaluate

associations between patient characteristics and imaging modality, the Student *t*-test to compare means and chi-square analysis to test the significance of differences in proportions with *p* < 0.05 considered statistically significant. Data were analyzed with Stata®, version 14.1.

The study was approved by the University of Vermont Committee on Human Research in the Medical Sciences.

## RESULTS

During the 6-year study period a total of 10,680 patient episodes of care for 7,659 patients were identified. Of the patients 54% were women with a mean age at presentation of  $46.8 \pm 18.5$  years and an average BMI of  $29.2 \pm 7.5$  kg/m<sup>2</sup>. Of the episodes 45% occurred in married patients, 27% in current smokers and 92% in Vermont residents. There were 1, 2 and 3 episodes in 79%, 13% and 4% of patients, respectively. One patient experienced 20 episodes of nephrolithiasis in 5 years 1 month.

No imaging studies were recorded within 90 days of presentation for 2,566 of the 10,680 patient episodes (24%). A total of 2,163 episodes (20%) began with US as the initial imaging, of which 427 (20%) included CT during the following 90 days, including 221 (10%) with CT subsequent to US during the index visit.

A total of 2,163 episodes (20%) began with US as the initial imaging. In 427 of those episodes (20%) CT was performed during the following 90 days, including 221 (10%) with CT subsequent to US during the index visit. In 5,670 patient episodes (53%) CT was not performed at the index visit. CT was done at some point during the 90-day episode in 589 of these episodes (10%).

The estimated imaging cost for all episodes was \$505 (range \$0 to \$4,434). The average imaging cost for the 5,670 patients in whom CT was not done at the index visit was \$272. For the 5,010 episodes that included CT during the index encounter the average imaging cost in the 90-day period was 183% higher at \$769. The difference in average costs was \$497 (95% CI 484–510, *p* < 0.0001).

Average estimated radiation exposure was 4.4 mSv per episode (median 7, range 0 to 50.4). CT at the index visit was associated with a mean total radiation exposure during the entire episode of 8.1 mSv compared to 1.1 mSv if the index visit did not include CT. The difference in radiation exposure was 7.0 mSv (95% CI 6.9–7.2, *p* < 0.0001, see figure).

BMI was higher when the initial test was CT or KUB ( $29.7 \pm 7.5$  or  $29.5 \pm 7.0$  kg/m<sup>2</sup>) compared to US or no test ( $28.6 \pm 7.7$  or  $28.6 \pm 7.5$  kg/m<sup>2</sup>, respectively). The differences were significant (*p* < 0.0001).

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