Ultrasonography Significantly Overestimates Stone Size When Compared to Low-dose, Noncontrast Computed Tomography

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OBJECTIVE To evaluate the differences between low-dose noncontrast computed tomography (NCCT) and renal ultrasound (US) in the identification and measurement of urinary calculi.

MATERIALS AND METHODS A retrospective review was conducted at 3 institutions of patients evaluated for flank pain with both renal US and NCCT, within 1 day of one another, from 2012 to 2015. Stone presence and size were compared between imaging modalities. Stone size was determined by largest measured diameter. Stones were grouped into size categories (≤5 mm, 5.1-10 mm, and >10 mm) based on NCCT and compared with US. Statistical analysis was performed using 2-sided *t* tests.

RESULTS One hundred fifty-five patients received both a renal US and NCCT within 1 day. In 79 patients (51.0%), both US and NCCT identified a stone for size comparison. Fifty-eight patients (37.4%) had a stone visualized on NCCT but not on US, and 2 patients (1.3%) had a stone documented on US but not seen on NCCT. The average NCCT size of the stones missed on US was 4.5 mm. When comparing the average largest stone diameter for US (9.1 mm) vs NCCT (6.9 mm), US overestimated stone size by 2.2 mm ($P < .001$). US overestimated stone size by 84.6% for stones ≤5 mm, 27.1% for stones 5.1-10 mm, and 3.0% for stones >10 mm.

CONCLUSION US significantly overestimated stone size and this was most pronounced for small (≤5 mm) stones. The potential for systematic overestimation of stone size with standard US techniques should be taken into consideration when evaluating endourologic treatment options. UROLOGY 95: 67–71, 2016. © 2016 Elsevier Inc.

Noncontrast computed tomography (NCCT) is the gold standard for the evaluation of nephrolithiasis.[1,2] The advantages of NCCT include superior sensitivity and specificity, the ability to identify ureteral calculi, the accurate assessment of stone size, and the ability to discover alternative pathology accounting for the clinical presentation. Despite these advantages, there is growing concern over increased cost and most importantly the cumulative risk of ionizing radiation exposure.[3] For these reasons, recent research has been conducted to evaluate the safety of using renal ultrasound (US) as an alternative to NCCT for the evaluation of patients with suspected urolithiasis. Most notably, Smith-Bindman,[4] in a multicenter comparative effectiveness trial, showed that the use of initial diagnostic US had no significant differences in high-risk diagnoses, with complications or serious adverse events, when compared to NCCT for patients presenting to the emergency department (ED) with renal colic.

With the possible expanding use of US as a first-line diagnostic modality, it is important to evaluate not only the safety of this approach but also the diagnostic accuracy needed to guide urologic management decisions. It is necessary to provide patient care throughout the entire stone episode, not only in the acute setting. Whereas ensuring a safe discharge from the ED is the initial goal, the importance of follow-up care to ensure stone passage or recommend surgical removal must not be overlooked. The latter relies on accurate diagnosis and stone measurement obtained through imaging.

One proposed limitation of US is the inability to accurately determine stone size.[5] Stone size is the main factor used to predict spontaneous stone passage, as smaller stones <5 mm are more likely to pass without surgical intervention.[6,7] In the absence of infection or compromised

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renal function, observation can therefore be recommended for most small stones. Previous studies have looked at the comparative sensitivity, specificity, and size concordance between US and NCCT with mixed results. In general, US is thought to have inferior sensitivity and specificity, while overestimating stone size.[5,8-10]

The existing literature has compared standard dose computed tomography (CT) with ultrasonography. More recently, low-dose CT has become the standard of care at many institutions for the evaluation of urolithiasis. In fact, low-dose CT is now the preferred imaging modality in patients with acute flank pain and suspicion of stone disease according to the American College of Radiology Appropriateness Criteria.[11] Whereas low-dose CT has been shown to compare favorably with standard dose CT in terms of sensitivity and specificity for the diagnosis of urolithiasis, it may miss small stones (<3 mm).[12,13] In addition, concern regarding image quality in obese patients may limit the effectiveness in this patient population. The American Urological Association currently recommends low-dose CT only in patients with a body mass index (BMI) < 30 kg/m^2.[14] With the use of low-dose CT imaging, it is possible that the previously reported differences between standard dose CT and US would be less pronounced. In our contemporary series, low-dose CT protocols were used for all patients, further expanding the body of literature to include this current paradigm.

To address these timely questions, we performed a multicenter retrospective study to compare the concordance between US and NCCT in patients who received both imaging modalities within 1 day for the work-up of suspected renal colic.

MATERIALS AND METHODS

After obtaining institutional review board approval, we performed a multicenter retrospective review of patients who obtained renal US and NCCT imaging within 1 day at 3 academic institutions (University of Vermont Medical Center, Massachusetts General Hospital, Dartmouth-Hitchcock Medical Center) between 2012 and 2015.

Inclusion was limited to adult patients >18 years of age. Only formal radiologic US, not bedside-US, were included. CT images were obtained using a low-dose stone protocol with an estimated dose between 1.5 and 5 millisieverts. Patients were excluded if images were obtained >1 day apart, if imaging was of poor quality for interpretation, and/or if staghorn calculi were present (Fig. 1). Data collected from review of patient charts were used to quantify baseline patient characteristics (sex, age, BMI). All NCCT images were independently reviewed to document stone presence and measure the size of the predominant stone of interest. One reviewer from each center performed the stone measurements. A standard protocol was followed using abdominal windows and zooming in to best visualize the stone of interest. Three measurements were made (length, width, height) using axial, sagittal, and coronal sections. Stone size was determined

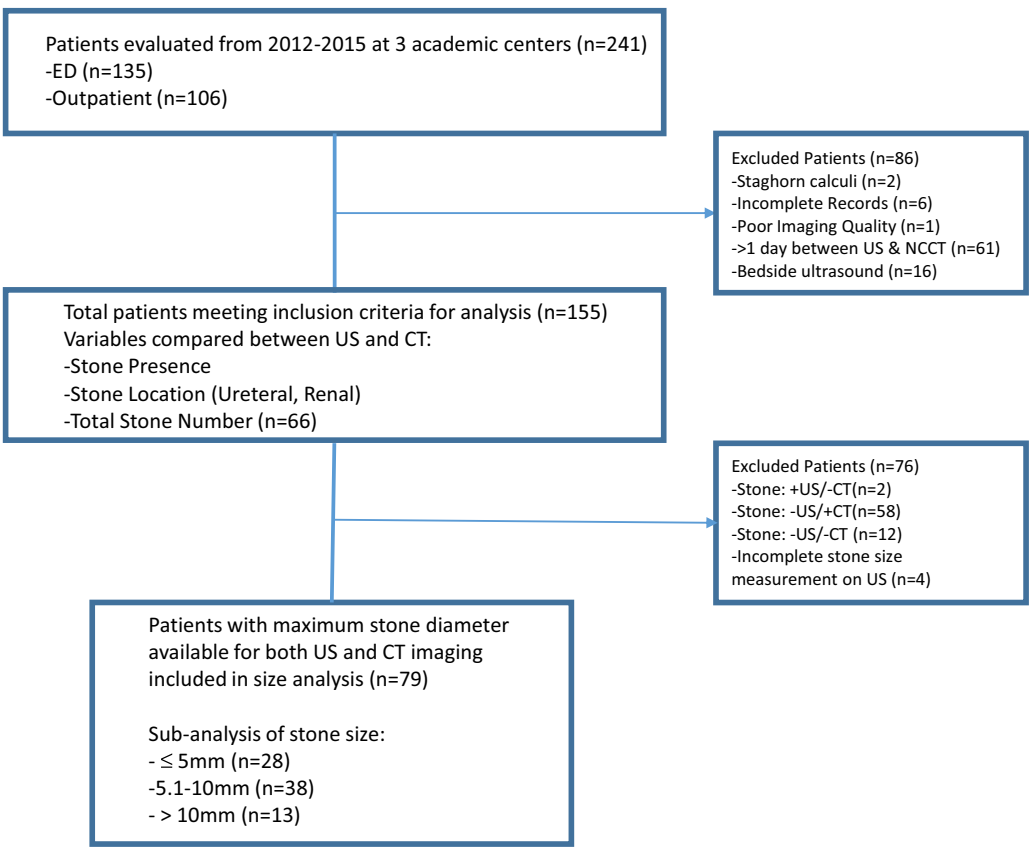

Figure 1. Flow diagram of patients included for each analysis in the study. (Color version available online.)