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Emergency Department Imaging Modality Effect on Surgical Management of Nephrolithiasis: A Multicenter, Randomized Clinical Trial

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Purpose: In the emergency department ultrasonography is emerging as an alternative to computerized tomography for diagnosing patients with nephrolithiasis. In this multicenter randomized clinical trial we examined rates of urological referral and intervention to elucidate whether the initial diagnostic imaging modality affected the management of nephrolithiasis.

Materials and Methods: Patients 18 to 76 years old who presented to the emergency department with renal colic across 15 diverse treatment centers were randomized to receive abdominal ultrasonography by an emergency department physician or a radiologist, or abdominal computerized tomography. We analyzed the 90-day followup for patients diagnosed with nephrolithiasis to assess subsequent urological evaluation, procedure type and time to intervention.

Results: Of 1,666 patients diagnosed with nephrolithiasis in the emergency department 241 (14.5%) had a consultation with urology at initial presentation, 503 (30%) saw a urologist in followup and 192 (12%) underwent at least 1 urological procedure. Median time to outpatient procedure and type of procedure performed did not vary significantly among imaging groups. Most patients (78%) had computerized tomography performed before elective intervention. Patients with ultrasonography performed by an emergency department physician were 2.6 times more likely to undergo computerized tomography before intervention than those who had ultrasonography performed by a radiologist.

Conclusions: Patients undergoing a urological intervention who had ultrasonography as initial imaging do not experience a significant delay to intervention or different procedure types, but the majority ultimately undergoes computerized tomography before surgery. Formal ultrasonography by a radiologist may encourage less computerized tomography preoperatively.

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

Abbreviations and Acronyms

CT = computerized tomography
ED = emergency department
PNL = percutaneous nephrolithotomy
SWL = extracorporeal shock wave lithotripsy
URS = ureteroscopy
US = ultrasonography

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COMPUTERIZED tomography remains the gold standard diagnostic imaging study for patients with suspected nephrolithiasis due to its high sensitivity for detecting stones.[1,2] Growing concerns over the long-term health consequences of cumulative ionizing radiation exposure and costs associated with CT have driven a trend toward minimizing radiation based

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imaging among patients and health care providers. This holds true in the emergency department, where ultrasonography is emerging as an alternative imaging modality for diagnosing nephrolithiasis.[3,4] Comparing these modalities has not shown any detriment to patient outcomes when US is used as the initial imaging study for suspected nephrolithiasis.[5]

It remains unclear how the use of US in the ED alters urological referral or treatment patterns. Previous single center studies have shown that as many as 37% to 86% of patients diagnosed with stones receive a consultation with a urologist[6,7] and 15% to 20% require a procedure for their stone.[6,8] With the increasing use of US as a first line imaging option in the acute setting, this change in practice pattern might alter subsequent evaluation or delay definitive intervention by the urologist.

In this secondary analysis of a multicenter randomized clinical trial we describe urological referral patterns and interventions for patients diagnosed with nephrolithiasis in the emergency department, and determine if the initial diagnostic imaging modality affects the type or timing of the surgical intervention for patients discharged from the ED with a diagnosis of nephrolithiasis.

METHODS

Subjects

Patients 18 to 76 years old who presented to the ED with suspected renal colic across 15 diverse academic emergency departments between December 2011 and February 2013 were randomized to an abdominal US performed by a radiologist, an abdominal US performed by an ED physician or abdominal CT to evaluate for suspected nephrolithiasis. Patients judged to have a high risk of a serious alternate diagnosis such as appendicitis, acute cholecystitis or aortic aneurysm as well as pregnant women were excluded from analysis. Men or women weighing more than 129 kg or 113 kg, respectively, patients with a solitary kidney, renal transplantation or on dialysis were also excluded from the study.

Procedures and Techniques

We analyzed the use of urological procedures at baseline and during the 90-day followup among patients diagnosed with a kidney stone, and quantified the type and timing of the procedures. We included the first procedure performed after baseline visit.

Definitions and Criteria

If multiple procedures were performed at a single encounter they were categorized based on the highest complexity with the rank from lowest to highest of ureteral stent placement, nephrostomy tube placement, SWL, URS and PNL.

Data Collection and Validation

The University of California, San Francisco, Committee on Human Research and the institutional review board at each participating site approved the study. All participants gave written informed consent. Study patients were assessed using telephone followup interviews at 3, 7, 30 and 90 days after the initial ED visit. Trained research assistants used a structured questionnaire to assess all of the subsequent health care they received during this time, including urological followup and urological procedures. Medical records were also reviewed for each patient. A detailed explanation of the prospective study design has been previously published.[9]

Statistical Tests

Chi-square and ANOVA statistics were used to compare categorical and continuous variables, respectively, across the 3 imaging arms. We examined the distribution of urological procedures stratified by ED vs nonED settings, across imaging arms, and used a chi-square to test for significance. As the data were not normally distributed, we used the Kruskal-Wallis nonparametric test to examine differences in days to first urological procedure performed by randomization arm. Statistical analysis was performed with SAS® version 9.3.

RESULTS

Baseline characteristics of patients discharged from the hospital with a diagnosis of nephrolithiasis are summarized in table 1. There were no significant [T1] differences among the imaging groups in age, self-reported race or gender. Approximately half of the patients had a history of kidney stones which did not vary by arm. Rates of recurrent stone formers as well as pain scores at presentation did not differ among groups ($p > 0.05$).

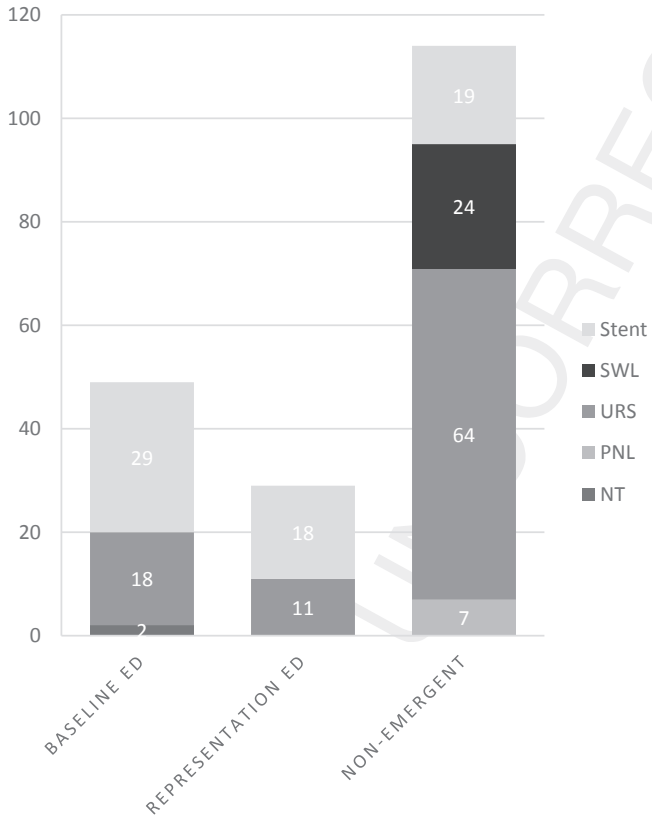
Of 1,666 patients diagnosed with nephrolithiasis in the ED 241 (14.5%) received a consultation with urology by telephone or in-person at the baseline ED visit. A total of 503 (30%) patients saw a urologist in outpatient followup visits. Including those seen emergently or in followup, 192 patients (12%) underwent 1 or more urological procedures, with 49 (26% of those with procedure) having an emergent procedure at the baseline visit and 143 (74%) having the procedure within 90 days of followup. Of those who had a followup procedure after the initial ED visit 29 (16%) had a procedure

Table 1. *Demographics of patients discharged with diagnosis of kidney stone by intent to treat arm*

	ED US	Radiology US	CT	p Value
No. female (%)	237 (42)	188 (37)	222 (40)	0.24
No. race (%):				0.88
White	253 (45)	233 (46)	253 (46)	
Hispanic	130 (23)	112 (22)	122 (22)	
Black	128 (23)	106 (21)	123 (22)	
Asian	25 (4)	25 (5)	30 (5)	
Native American	5 (1)	2 (0)	9 (2)	
Pacific Islander	1 (0)	1 (0)	2 (0)	
Mixed	15 (3)	18 (4)	15 (3)	
Missing/unknown/refused	1 (0)	6 (1)	2 (0)	
No. kidney stone history (%)	278 (50)	270 (54)	274 (49)	0.24
Mean age	40	40	41	0.71
Mean admission pain score (0—10)	8.3	8.2	8.3	0.45

emergently with repeat presentation to the ED and 114 (59%) underwent nonemergent procedures (see figure). Of patients with emergent procedures at the baseline visit or on repeat presentation ureteral stent placement was performed in 47 (60%), URS in 29 (37%) and nephrostomy tube placement in 2 (3%). Among the patients who underwent nonemergent procedures 64 (56%) underwent URS, 24 (21%) SWL, 19 (17%) stent placement and 7 (6%) PNL. There were no significant differences among imaging groups in the rates of emergent procedures performed at the baseline or repeat emergency room visit (table 2).

Of the patients who ultimately required a procedure after discharge from the baseline visit 111 of 143 (78%) had CT performed during initial presentation to the ED or as part of additional evaluation (table 3). Of those who went to the operating room without CT imaging (32) 69% underwent planned nonemergent procedures, most commonly URS. Patients who had a point of care US performed by an ED physician as the initial diagnostic study were more likely to have CT before intervention than those who had US performed by a radiologist (OR 2.55, 95% CI 1.22–5.38, p=0.01). Median time to planned nonemergent procedure was 24 days. There was no significant difference in time to nonemergent urological followup procedure across imaging groups (table 3).



Frequency of procedure by setting. *NT*, nephrostomy tube.

Table 2. *Followup procedures by intent to treat arm*

	ED US	Radiology US	CT
No. nonED procedure (%):			
PNL	5 (10)	1 (2)	1 (2)
URS	18 (38)	25 (53)	21 (44)
ESWL	9 (19)	7 (15)	8 (17)
Stent	3 (6)	7 (15)	9 (19)
Totals	35 (73)	40 (85)	39 (81)
No. ED procedure (%):			
URS	5 (10)	4 (9)	2 (4)
Stent	8 (17)	3 (6)	7 (15)
Totals	13 (27)	7 (15)	9 (19)

DISCUSSION

The present study prospectively evaluated the urological followup of a large cohort of patients who presented with a diagnosis of nephrolithiasis. The rate of urological consultation in the ED was 15%, similar to the 11% reported by Sterrett et al.[7] The rate of outpatient followup with urology was lower than reported in the published literature at 30% compared to 37% to 86%.[6,7] We found that the rates of urological procedures were similar to those reported in retrospective studies,[6,7] with approximately 12% to 20% of patients with nephrolithiasis requiring operative intervention. For patients who underwent urological intervention, temporizing procedures such as stent and nephrostomy tube placement were more common than ureteroscopy in the emergent setting. This is in contrast to survey data reporting a preference for ureteroscopy over stent placement previously suggested by survey results.[8] In the nonemergent context URS and SWL were the most commonly performed urological procedures, which confirms previous reports.[8,10] Our study was unique as it followed patients prospectively at multiple centers from presentation in the ED and examined how initial imaging modality affected treatment pattern. We found that consultation rates, frequency of intervention and types of procedures did not vary by whether the patient had

Table 3. *Urology consultation, imaging and followup*

	No. Urology Consultation at Baseline ED Visit (%)	No. CT before Intervention (%)	Median Days to Followup Intervention (IQR)
ED US:			
None	51 (10)	—	—
ED	19 (66)	6 (46)	—
Nonemergent	11 (31)	30 (86)	26 (9, 54)
Radiology US:			
None	50 (11)	—	—
ED	17 (74)	4 (57)	—
Nonemergent	16 (40)	23 (58)	26 (14, 56)
CT:			
None	49 (10)	—	—
ED	16 (64)	9 (100)	—
Nonemergent	13 (33)	39 (100)	22 (11, 33)
p Value	—	—	0.27

initial imaging with CT or US. Furthermore, the patients with initial US did not experience any delay to nonemergent urological intervention.

While ultrasound is emerging as a safe and reliable diagnostic imaging modality for patients presenting with renal colic, the role of CT as a diagnostic tool in the management of nephrolithiasis remains important. The majority of patients who required intervention for urinary stone disease underwent CT as part of their initial evaluation or on followup before proceeding with their procedure. A minority of nonemergent followup procedures was performed without the diagnostic certainty of CT but the context in which scans were ordered is important to highlight. Our study suggests that not all ultrasounds are performed equally in the eyes of the urologist. Patients who received point of care ultrasound performed by an ED physician had more than 2 times the odds of undergoing CT before their urological procedure than those who had a formal US performed by a radiologist at their initial presentation. Point of care US may be adequate for diagnosis, but it lacks the labeling, measurements and detailed anatomical visualization necessary for the urologist to feel comfortable proceeding with surgery without CT. To this end, for patients with a high likelihood of needing a urological procedure, a formal US with a radiologist could lead to a lower rate of subsequent CT. Conversely, urologists may be expected to order more CT outside of the emergency room setting to plan for surgical intervention for patients who received point of care US imaging at their ED presentation. While this practice appears not to have resulted in a delay in time to procedure, it would potentially disrupt urologists' workflow as they may need to account for ordering these studies before the procedure.

Strengths of this study included randomization and a long period of prospective followup. It is possible that a subject was lost to followup and presented elsewhere, but only 4.5% of subjects were lost to followup and this rate did not vary across study arms.[5] Limitations of our study included an inability to blind participants, care providers or investigators to the study arm. We also lacked data to inform the clinical severity and indications for procedures including patient creatinine, urine cultures and stone size as measured on imaging, which limited detailed characterization of the nephrolithiasis. Outcomes of the procedures performed were not tracked.

CONCLUSIONS

Our study demonstrates that in a population representing many different practice environments, ultrasound as an initial diagnostic imaging study for the patient diagnosed with nephrolithiasis in the emergency department is safe and does not delay patient care or alter the type of procedure performed by the urologist. However, urologists may need to account for the imaging quality as a preoperative study to make a surgical plan and may need to consider ordering CT before surgery.

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EDITORIAL COMMENTS

The authors present an important followup to the landmark study comparing US to CT for the evaluation of flank pain and suspected urolithiasis.[1] While the safety of US in terms of missing serious alternative diagnoses and avoiding adverse patient outcomes was demonstrated, urologists questioned

the impact of an ultrasound first approach on guiding management. The limitations of US (identifying ureteral stones, stone size overestimation) are known.[2,3] Therefore, one may hypothesize a need for additional imaging to achieve a definitive diagnosis and to help decide between expectant management and intervention. This requirement of obtaining more images after the initial ultrasound in turn may delay treatment.

However, this study shows that outpatient intervention was not delayed even though the majority of those undergoing surgery (78%) had CT in advance. Additionally, only 12% required intervention. Therefore, if every patient underwent CT, the clinical usefulness would be limited.

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The initial diagnostic imaging for a patient with renal colic has been an issue of debate for the medical community. During the last decade there has been an increase in the trend of using CT as the initial modality to evaluate patients with renal colic.[1] Despite this trend and its high sensitivity, CT has been associated with an increase in direct and indirect costs, proliferation of incidental findings and radiation exposure (reference 1 in article).[2]

In this study the authors showed that 78% of patients who ultimately had a procedure after discharge from the ED had CT before intervention. Compared to patients who were assessed by US performed by a radiologist, patients who were evaluated by point of care US were more likely to have CT before any urological intervention (OR 2.55). Importantly, there was no delay in an intervention based on initial imaging.

The results of this study are promising in incorporating point of care US in the initial evaluation algorithm for patients with suspected stone disease. Nevertheless, these findings do not preclude the necessity of CT in the treatment of the patient with stone disease. The decision still ultimately falls to the provider. Quality metrics are likely to grow out of these studies. Therefore, emphasizing the need for this prospective trial is one step in the quest of establishing a clinical decision model to evaluate patients with renal colic.

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