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HYDRONEPHROSIS PREDICTS SYMPTOMATIC URETEROLITHIASIS, BUT DOES NOT PREDICT NEED FOR INTERVENTION IN PATIENTS WITH SUSPECTED RENAL COLIC

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Hydronephrosis Predicts Symptomatic Ureterolithiasis, but Does not Predict Need for Intervention in Patients with Suspected Renal Colic

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Hydronephrosis Predicts Symptomatic Ureterolithiasis, but Does not Predict Need for Intervention in Patients with Suspected Renal Colic

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Abstract

Computed tomography (CT) is now a first-line test for renal colic, but is costly, potentially harmful, and rarely changes patient care. Hydronephrosis is often present with symptomatic kidney stones, and is reliably determined using point-of-care ultrasound at the bedside, but it is unknown whether the presence of hydronephrosis indicates a large stone that is more likely to require intervention (6mm or greater). We hypothesized that while hydronephrosis would be associated with symptomatic ureterolithiasis, neither the presence nor the degree of hydronephrosis would accurately predict the size of urinary tract stone.

This was a two-center retrospective study of randomly selected patients from a 4-year period, abstracted by a single blinded reviewer. We obtained a list of all patients who received a CT scan for suspected renal colic between 04/05 – 04/09. Hematuria was defined as >5RBCs per HPF. Symptomatic stones were defined as those in the renal pelvis, ureter or bladder. The presence and the degree of hydro were reported as they appeared in the dictated CT result.

630 charts were randomly selected from 2973 records. 53 charts were excluded because they didn't include urinalyses, and 15 were excluded because of age <18 years, leaving 562 chart records for analysis. 48% were male with a mean age of 45 years. 216 (38%) had no stone, 71 (13%) had asymptomatic stones, and

275 (49%) patients had symptomatic stones. Of the patients with symptomatic stones, 29 (11%) had hematuria alone, 82 (30%) had hydro alone, 154 (56%) had both hematuria and hydro, and 10 (4%) had neither. The combination of hydro and hematuria was 56% sensitive and 97% specific for detecting a symptomatic stone with a positive likelihood ratio (LR+) of 20.1 (95% CI 10.1-40.1). Of the patients with symptomatic stones, 229 (83%) were small and 46 (17%) were large. Hydronephrosis alone did not distinguish large stones from small stones (OR 1.7, 95% CI 0.6-4.7), though moderate or severe hydronephrosis was mildly indicative of a larger stone (OR 3.1, 95% CI 1.4-6.9).

The combination of hydronephrosis and microscopic hematuria as a predictor of symptomatic urinary tract stone disease has a greater specificity and positive likelihood ratio than either parameter alone. Hydronephrosis of any degree does not distinguish stones likely to require intervention (6mm or greater) from those unlikely to require intervention, though moderate/ severe hydronephrosis is associated with larger stones. The results of this study may be helpful in the creation of a clinical decision rule to limit the use of CT scans for patients with suspected renal colic.

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INTRODUCTION

Renal colic is a common condition. The lifetime risk of developing a stone in the US approaches 13% for men and 7% for women. Caucasians are affected more than other races, and patients afflicted with stones are likely to have recurrent attacks of renal colic throughout their lives. There are also data to suggest that the prevalence of urinary tract stones has continued to increase over the last two decades (1).

Given the rapid and often severe onset of symptoms that characterize renal colic, many of these patients are initially evaluated in the emergency department. According to the National Hospital Ambulatory Medical Care Survey, there were 1.1 million emergency department (ED) visits for renal colic in 2000. This represented 1% of all ED visits in 2000 (2). While the last decade has seen a reduction in average length of inpatient stay for urolithiasis as well as a decrease in the number of open surgical procedures for urolithiasis, the estimated total expenditure for individuals with claims of urolithiasis in 2000 was $2.1 billion, representing a 50% increase since 1994. The explanation for this increase in spending is thought to be multi-factorial, but it is clear that the cost of emergency department care represents a disproportionately large percentage of this increase (3). While the treatment of renal colic has changed little in the last two decades, the advent of CT scanning has dramatically changed the approach and costs associated with diagnosis of urinary tract stones.

Since it's development in the 1970s, the use of CT as a diagnostic modality has continued to increase rapidly. In 2007, an estimated 62 million CT scans were obtained in the US, compared to only 3 million in 1980 (4). For large US hospitals, CT scans account for more than 10% of diagnostic imaging examinations, but 67% of effective radiation from diagnostic radiology (5). This rapid increase in CT scanning is driven by evolving technology that makes it a relatively comfortable exam for patients, and a highly reliable test for clinicians. Over the last decade, CT has displaced intravenous pyelography (IVP) as the gold standard for diagnosis of urolithiasis. In 1998 studies were conducted comparing CT to IVP. CT was shown to have significantly better sensitivity and specificity compared to IVP (96% vs. 87%, and 100% vs. 94% respectively)(6). In 2004, an article on the subject was published in the *Clinical Practice* section of The New England Journal of Medicine, which asserted that unenhanced helical CT was "the best imaging study to confirm the diagnosis of a urinary stone in a patient with acute flank pain." (7).

While CT is now accepted as the first line diagnostic test for suspected renal colic, its increasing use presents problems of cost and safety. Between the years 2000-2006, Medicare expenditures for imaging doubled, and the frequency of CT scanning increased by 17% per year during that 6-year period. The increasing use of CT scans also poses a problem of patient safety, as the high dose of ionizing radiation present a long-term cancer risk to the patient. Recent estimates suggest that as many as 2% of cancer deaths are the result of radiation exposure from CT scans, and that there will be 12.5 cancer deaths for every 10,000 CT scans (4).

There are various ways to measure the radiation dose delivered by CT scanning. The *absorbed dose* measures the amount of energy absorbed per unit of mass, and is measured in grays (Gy). One gray is equivalent to one joule of radiation energy per one kilogram of mass. Most CT scans, however, administer radiation in a non-homogenous pattern, exposing certain organs to a relatively higher or lower level of risk. *Effective dose* (expressed in Sieverts (Sv) is another measure that serves to approximate the true biological risk of radiation exposure, providing an estimate of the overall harm done to the patient from the radiation dose. As an example, a typical adult AP chest X-ray results in .01mSv of radiation to the patient, compared to 10mSv for an abdominal CT (4).

Most of the data that have helped quantize the true biologic risk of diagnostic radiation comes from large survivorship studies of the atomic bomb drop in Japan, 1945. A subgroup of the survivors had received a dose of radiation comparable to that of patients receiving diagnostic CT scans, and it was shown that this subgroup had a significantly increased risk of developing cancer. Large-scale studies have recently begun to specifically evaluate the cancer risk from diagnostic radiology, and preliminary data from these studies, in conjunction with data from the Japanese survivorship studies, indicate that CT scans carry a significant long-term cancer risk to patients (4). Furthermore, it has been shown that patients with a known history of renal colic are more likely to have serial CT scans in the ED, and therefore are at risk of getting multiple doses of ionizing radiation (8).

Despite the increasing use of CT, there are data to suggest that its use for suspected renal colic confers no benefit to acute care of the patient. One study demonstrated that while the use of CT had increased by more than 25% between the years 1997-1999, that there had been no associated reduction in the hospital admission rate, the rate of discharged patients returning to the ED, or the rate of patients who were admitted to the hospital within 30 days. These data suggest that while the frequency of CT scanning has increased, that there has been no significant change in the acute management of patients presenting to the ED with suspected renal colic. This study also demonstrates that while a small percentage of CT findings reveal non-stone diagnoses that could affect acute management, most of these cases had pre-examination characteristics suggestive of the abnormality (9). Only 2% of patients who receive CT for suspected renal colic have urgent diagnoses, and for those diagnosed with urolithiasis, CT findings rarely alter the course of management (10). CT scanning in suspected renal colic is generally performed for three reasons:

1) To confirm the presence of a kidney stone as a cause of symptoms.
2) To distinguish stones likely to require intervention/consultation from stones likely to pass spontaneously.
3) To exclude other serious causes of symptoms.

Despite growing concern about the overuse of CT scanning, and evidence to show that CT does not change the management of patients with suspected renal colic, there have been no successful attempts to create a clinical decision rule to guide the use of CT scans in this patient population. A successful decision rule would distinguish patients with and without kidney stones, and predict which stones are likely to require intervention (15).

A review of the literature indicates that there have been three attempts to create a clinical decision rule to limit CT scans for suspected renal colic. The first was in 1985, when Roth produced a retrospective study of 206 patients that sought to evaluate the utility of plain abdominal radiograph in predicting ureteral stones. He developed an 11-item prediction rule based on history, physical exam, and urinalysis, concluding that it was more accurate than plain film alone for the diagnosis of renal colic (11). In 1993, Roth and Elton sought to further evaluate the accuracy of a clinical prediction rule, in an attempt to limit the use of unnecessary IVP. In a study of 203 patients, they created a scoring system up to six points based on pain, hematuria, and KUB result. Patients with a score of 4, 5, or 6 had a 90%, 96%, and 98.5% respective probability of having a stone. Roth and Elton concluded that using their scoring system, a certain subset of patients with kidney stones could be identified, and that these patients could be spared IVP for their diagnoses (12).

While these studies have had a significant impact in the diagnostic tendencies of ED physicians, both were conducted in a time when CT was not the primary diagnostic modality for urinary tract stones. Because CT offers higher sensitivity and specificity than IVP, clinical decision rules being developed today should be designed to meet this more stringent gold standard. Furthermore, the previously developed decision rules did not attempt to identify those patients with stones requiring surgical extraction, nor did they attempt to discriminate those patients with life-threatening diagnoses mimicking renal colic. Because these are both benefits of CT scan, they should also be elements of a contemporary clinical decision rule.

In 2007, Broder attempted to develop a contemporary decision rule that would limit CT scanning for patients with uncomplicated renal colic while also ensuring that patients with diagnoses requiring surgical intervention received a diagnostic scan. The study included 262 patients, but data analysis failed to yield a decision rule because the study was under-powered. Specifically, Broder found that only 1% of the patients evaluated for suspected renal colic were ultimately shown to have alternative diagnoses requiring immediate intervention. A contemporary clinical decision rule would have to accurately identify patients requiring immediate intervention, but there were too few of those patients in Broder's study to reach statistical significance (10).

Interestingly, previous studies have shown a higher rate of urgent alternative diagnoses for patients evaluated for suspected renal colic. In 2000, Katz found that for 1,000 consecutive CT exams for suspected renal colic, 10% of patients had a wide spectrum of significant alternative diagnoses, including appendicitis, pancreatitis, pyelonephritis, and diverticulitis (13). In a 2006 study of 1,500 CT scans done for suspected renal colic, Hoppe found that 6% of patients had alternate diagnoses requiring immediate intervention (14).

Of course, CT is an accurate marker for these alternate urgent diagnoses, and a contemporary decision rule should be similarly accurate. Another advantage of CT scan is that it can identify both the size and the position of a urinary calculus. Previous work has shown that both the size and the location of a stone correlate to the likelihood of it passing spontaneously (15). Coll showed that the spontaneous passage rate for stones 1 mm in diameter was 87%; for stones 2-4 mm, 76%; for stones 5-7 mm, 60%; for stones 7-9 mm, 48%; and for stones larger than 9 mm, 25%. The need for urologic intervention also increased as the size of the calculus increased.

While several studies have examined markers such as hydronephrosis and hematuria as predictors of the presence of a urinary calculus (16-21), to my knowledge, there has not been significant work that examines hydronephrosis as a predictor of stone size. Furthermore, while there has been work to evaluate hydronephrosis and hematuria as independent predictors of urolithiasis, they have not yet been evaluated concurrently. More robust clinical predictors of stone disease, and an examination of how hydronephrosis correlates to the size of a stone could serve as important information in the creation of a clinical decision rule that would reduce the use of CT scans.

STATEMENT OF PURPOSE/HYPOTHESIS

The purpose of this study was to identify clinical variables that would effectively predict the presence and the size of urinary tract stones in patients presenting the emergency department. This study is designed as the first component of a larger study that will ultimately lead to the development of a clinical decision rule that would safely limit the use of CT scans for patients presenting with suspected renal colic. The specific aims of this study are:

1. To determine whether the presence of hydronephrosis predicts urinary tract stone size in patients with symptomatic ureterolithiasis.

2. To determine whether degree of hydronephrosis predicts urinary tract stone size in patients with symptomatic ureterolithiasis.

3. To determine the sensitivity and specificity of hydronephrosis and hematuria as predictors of urinary tract stone, alone and together.

We hypothesize that:

1. The presence of hydronephrosis will not be useful in predicting stone size.

2. The degree of hydronephrosis will not be useful in predicting stone size.

3. Hydronephrosis and hematuria together will predict presence of symptomatic ureterolithiasis better than either parameter alone.

METHODS

Overview

In this retrospective study, data were abstracted from two distinct ED environments in which CT for suspected renal colic is frequently performed. Records of patients receiving a CT for suspected renal colic were identified over a four-year period, yielding approximately 3,000 patient visit records. Predictor variables were abstracted from these charts, and the institutional review board at Yale University approved the study.

Inclusion/Exclusion Criteria

Data were collected retrospectively on all ED patients receiving a CT for the diagnosis of suspected renal colic for a period of four years at Yale-New Haven Hospital Emergency Department (YNHH ED) and the Shoreline Medical Center Emergency Department (SMC ED). For both hospitals this is a specific order, a CT flank pain protocol (FPP), which requires the ordering MD to include basic information regarding the reason for ordering it in a computerized order entry system. While almost all CT FPPs are ordered for the suspicion of renal colic, occasionally a CT FPP (non-contrast) CT may be ordered for another diagnostic purpose. If the provider ordering the study clearly indicated that the CT FPP was being ordered for a purpose other than determining the presence of kidney stone (either in the radiology order or in the chart) the patient was excluded from analysis. Patients charts were also excluded from analysis if age at CT was <18 years, or if missing documentation resulted in >20% of data fields left unfilled.

Study Sites

Patient records were taken from two Emergency Department sites, both part of the Yale-New Haven Hospital system. The first site was the Yale-New Haven ED in New Haven, CT. The second site was the Shoreline Medical Center in Guilford, CT.

Yale-New Haven Hospital (YNHH) is an urban, tertiary care center that is a designated level I trauma center. There are approximately 72,000 visits to the adult ED each year. The population of the primary catchment area is 350,000 and includes a diverse ethnic and cultural mix. Women and minorities are strongly represented in the population. Women represent approximately 51% of the ED population, and the racial representation is approximately: 50% white (not of Hispanic origin), 33% black (not of Hispanic Origin), 15% Hispanic, 1% Asian, and 1% other. Patients rarely self-identify as American Indian or Pacific Islander.

The Shoreline Medical Center (SMC) ED is a state-of-the-art, free standing ED that was opened in 2005. It is a 10 bed emergency facility staffed 24/7 with Board Certified attending physicians in emergency medicine. It is not a trauma center, but does accept ambulance traffic and has a heliport for acute patient transport. It is a full service ED with 24/7 on site lab and 24/7 CT and radiology. Radiology performed ultrasound is currently available from 7A-11P, however emergency physicians have access to bedside ultrasound equipment 24/7. The SMC ED has mid-level providers, but is not a teaching facility and does not have residents in any specialty or consultants on site.

Data Acquisition

ED records have been kept at YNHH and SMC EDs using the Lynx medical record system (Lynx Medical Systems, Bellevue WA, www.lynxmed.com) from April 2005 to the present. The Lynx system provides the clinician with a templated paper record with prompts for standard aspects of the history and physical examination. These records are tailored to complaints that tend to be fairly consistent for patients with suspected renal colic (e.g. flank pain, back pain, abdominal pain, hematuria). It has the flexibility for the provider to write and diagram, and while extracting certain discrete data points is more labor intensive than it might be for a true electronic medical record (EMR) it allows for more broad inclusion of patient documentation than might be possible with a complete EMR.

A review of all CT flank pain protocol (FPP) performed in the period from 3/14/05-2/7/09 yielded 2,973 CT FPP of which 2904 (97.7%) were done on 2,711 unique patients, with an age range of 9-94 years. This represents an average of 61.8 scans per month in adults (>18 years) over this 47-month period, or approximately 2 per day. Of the 2904 CTs done on adults, 749 (25.8%) were done at the Shoreline Medical Center and 2155 (74.2%) were done at the YNHH ED (of note, the SMC opened for business in 2005 from 3P-11P only and has steadily expanded it volume and operating hours; in July of 2008 it opened 24/7). The average age of all adult patients undergoing CT FPP was 45.4 years (range 18-94 years old). Of these adult patients, 1,390 (47.9%) were male, and 1,513 (52.1%) were female.

Data Abstraction

Over a period of 10 weeks, 630 of the 2,904 patient-visit records was randomly selected using a random number generator. Using the Lynx and MDLink systems, patient records were accessed via a secure Internet connection from computers in the Emergency Medicine offices. Patient data was recorded in a Microsoft Office Access 2007 database (Microsoft, Redmond WA).

Predictor variables and CT results were recorded by a single abstractor, with blinding between clinical predictor variables and CT results. All clinical predictor variables were abstracted from the Lynx system, whereas radiologic and laboratory variables were abstracted from the MDLink system. CT results were abstracted from the official radiology report accessed via the MDLink system. Blinding was accomplished by recording patient data from the MDLink system and data from the Lynx system on alternating days, and identifying patient records by medical record number.

Predictor Variables and Outcomes Groups

All variables are independently listed in table 1. Predictor variables were developed based on a review of the literature, clinical experience, and availability of data recorded in the patient record. Variables are organized into three categories: clinical, radiologic, and laboratory. Clinical variables were abstracted from ED charts found in the Lynx charting system. All elements of past medical history as recorded in the ED chart were self-reported by the patient. Radiologic and laboratory variables were recorded from MDLink.

For the purpose of statistical analysis, certain ordinal predictor variables were collapsed into categories. In the ED chart, “pain severity” was reported on a scale of 1-10, and was recoded as mild (1-3), moderate (4-6), or severe (7-10) because some ED charts listed pain severity as mild/moderate/severe, as opposed to a numerical listing. In the MDLink system, hematuria on urinalysis was originally reported as 0-1, 2-5, 6-10, 11-30, or >30 RBCs per HPF, and was recoded as either “absent” or “present,” with the definition of present hematuria being >5 RBCs per HPF. Total amount of opioids given was standardized to equivalent morphine dose using the narcotic equivalency chart (figure 2) from the Yale Department of Internal Medicine Survival Guide 2009-2010.

Results of the CT were abstracted from the dictated radiology report, and hydronephrosis was considered present if it was noted in the dictation. Degree of hydronephrosis was also abstracted from the radiology report and was recorded as either “none”, “mild/minimal”, “moderate”, “severe”, or “present, unknown degree”. Presence and size of urinary tract stones were also abstracted from the CT report. CT images were not viewed by the author, and not used for data abstraction.

All patients included in the analysis fell into one of four diagnostic outcome groups: no stone, small symptomatic stone, large symptomatic stone, or non-symptomatic stone. Symptomatic stones were defined as those located in the renal pelvis, ureter, or bladder with location corresponding to patient symptoms, and large stones were defined as ≥6mm. Stones reported to be in the renal parenchyma were considered to be asymptomatic.

Data Analysis

Data analysis was completed with the SAS software program JMP® version 8.0.1. Exploratory analyses were conducted on age, sex, and race to assess distribution characteristics. Histograms of distribution data were generated using JMP® 8 Graph Builder tool.

Using two predictor variables, presence of hematuria (Hm) and presence of hydronephrosis (hydro), patient records were grouped into four categories: +Hm/+Hydro, +Hm/-Hydro, +Hydro/+Hm, and –Hm/-Hydro. Each category was divided into patients with stones and patients without. For patients with stones, data were further divided into large, small, and asymptomatic stones, as defined above. Sensitivities and specificities with 95% confidence intervals were calculated using 2x2 tables.

Further 2x2 tables were created using the presence of hydronephrosis as a predictor large vs. small stone. Hydronephrosis of any degree was considered test positive, large stone was considered disease positive, and small stone was considered disease negative. Similarly, a 2x2 table using the degree of hydronephrosis as a predictor of large vs. small stone was created. Moderate or severe hydronephrosis was considered test positive, mild hydronephrosis was considered test negative, large stone was considered disease positive, and small stone was considered disease negative. For stone size calculations, patients with no stone or non-symptomatic stones were excluded from the analysis.

Table 1. Predictor Variables

Clinical	
Age at CT	Alcohol Use
Sex	Narcotic Use
Ethnicity	Abdominal Tenderness (location, degree, localized/diffuse)
Prior ED Visits	Abdominal Distention
# respresentations for FP/BP/AP/Hematuria	CVA Tenderness
Date of initial presentation	Flank Tenderness
Time of initial presentation	Lumbar Tenderness
Highest Pulse	Final ED Diagnosis
Highest SBP	Disposition
Highest DBP	Total Time in ED
Highest Temperature	Total Narcotics Given
Lowest SBP	Normalized Amount Morphine
Medication	Total Toradol Given
DNR/DNI Status	Insurance Status
Pain Duration	
Pain Severity	
Pain Onset	**Radiographic**
Course of Pain	# CT FPPs
Flank Pain	# other CT Abd/Pelvis
Lumbar Back Pain	# other CTs
Pain Radiation	Ultrasound done
Pain Change with Movement	KUB
Previous History of Stones	CT scout
Previous History of Stones Tx	# stones on FPP
Fever	Stone Size
GI Symptoms	Stone Location
Diarrhea	Presence of Hydronephrosis
Urinary Symptoms	Degree of Hydronephrosis
Subjective Hematuria	Presence of Hydroureter
Condition Limiting History	Bladder Distention
Hx of Malignancy	Perinephric Stranding
Pancreatitis	Presence of Renal Cyst
Gallstones	Presence of Renal Mass
PUD	Other Imoprtant Diagnoses
Preexisting Renal Disease	CT Results Requiring follow-up
HTN	
Diabetes	
CAD	**Laboratory**
High Cholesterol	Urine HCG
Atrial Fibrillation	Urine Dip (hematuria, leuks, nitrite)
CVA	Urinalysis (WBC, RBC, Ca oxalate)
Prior Abdominal/Pelvic Surgery	Creatinine
FMH Kidney Stones	WBC blood
Smoking History	Lipase

Figure 2. Narcotic Equivalency Chart

Opiod Agonist	IV (mg)	PO (mg)
Morphine	10	30
Oxymorphone	1	10
Hydromorphone	1.5	7.5
Oxycodone	NA	20
Oxycontin	NA	20
Fentanyl	0.1	NA
Meperidine	100	300

RESULTS

Sample

The initial sample consisted of 630 patient charts. 15 patients were excluded because of age < 18 years at time of CT, and 53 were excluded because of incomplete data, yielding 562 patient charts included in the analysis. 52% of the patients were female with a mean age of 44.6 years. 63% of patients were white, 17% were Hispanic, and 16% were African American. Based on review of dictated CT report, 216 patients (38%) had no stones, 71 (13%) had non-symptomatic stones, and 275 (49%) of the patients had symptomatic stones.

The subset of patients with symptomatic stones had a mean age not significantly different from the whole sample (44.8 and 44.6, respectively), but women and African Americans were significantly less represented in this subset. (figure 3). Women were 52% (48.5-59.2%, P=0.01) of all patients, and 40% (32.7-47.4%, P=0.01) of patients with symptomatic stones. African Americans were

16% (12.0-19.9%, P=0.01) of all patients, and 6% (3.1-10.6%, P=0.01) of patients with symptomatic stones.

Presence of Stone by Predictor Variable

Of the 275 patients with symptomatic stones, 10 (4%) had neither hydro nor hematuria, 29 (10%) had hematuria alone, 82 (30%) had hydro alone, and 154 (56%) had both hydro and hematuria (figure 4). For detecting the presence of a symptomatic kidney stone, hematuria alone was 66.5% (95% CI 60.6-72.0) sensitive and 70.4% (95% CI 64.7-75.5) specific, hydronephrosis alone was 85.8% (95% CI 81.0-89.6) sensitive and 92.3% (95% CI 88.5-95.0) specific, either hematuria or hydro was 96.4% (95% CI 93.2-98.1) sensitive and 65.6% (95% CI 59.7-70.9) specific, and the combination of hydro and hematuria was 56.0% (95% CI 50.0-61.9) sensitive and 97.2% (95% CI 94.4-98.7) specific with a positive likelihood ratio of 20.1 (95% CI 10.1-40.1). (Figure 5).

Stone Size by Hydronephrosis

258 (46%) patients had hydro, and 275 (49%) patients had a symptomatic stone, of which 229 (83%) were small and 46 (17%) were large. The presence of hydronephrosis as a predictor for distinguishing a large stone from a small stone yielded an odds ratio of 1.4 (95% CI 0.5-3.9).

For cases of hydronephrosis, 161 (62%) were documented as mild, 50 (19%) as moderate, 3 (<1%) as severe, and 44 (17%) as unknown degree (figure 6). Moderate/severe hydro as a predictor for distinguishing a large stone yielded an odds ratio of 3.1 (95% CI 1.4-6.9). (Figure 7).

Firgure 3. Patient Characteristics

		Stone			
	No stone	Non-symptom	Small	Large	Total
Age, mean (SD)	45.2 (16.2)	44.3 (13.6)	44.0 (14.0)	48.9 (13.5)	44.6, (15.5)
Women	147 (68)	47 (66)	91 (40)	18 (39)	326 (52)
Race Caucasian	111 (51)	45 (63)	159 (70)	36 (78)	394 (63)
Hispanic	34 (16)	16 (23)	43 (19)	7 (15)	104 (17)
African American	63 (29)	8 (11)	16 (7)	0	98 (16)
Asian	0	0	3 (1)	0	3 (<1)
Other/Unknown	8 (4)	2 (3)	8 (3)	3 (7)	31 (5)
	216	71	229	46	562

Figure 4. Clinical Outcomes Groups by Predictor Variable

		Stone Present			
	No Stone	**Non-symptomatic**	**Small**	**Large**	**Total**
.-Hm/-Hydro	157 (28)	31 (6)	9 (2)	1 (<1)	198 (35)
.+Hm/-Hydro	47 (8)	30 (5)	25 (4)	4 (1)	106 (19)
.-Hm/+Hydro	2 (<1)	4 (1)	70 (13)	12 (2)	88 (16)
.+Hm/+Hydro	10 (2)	6 (1)	125 (22)	29 (5)	170 (30)
Total	216 (38)	71 (13)	229 (41)	46 (8)	562

Figure 5. Hematuria and Hydronephrosis as Predictor Variables for Symptomatic Stone

	Sensitivty (95% CI)	**Specificity (95% CI)**	**LR+ (95% CI)**
Hematuria alone	66.5 (60.6-72.0)	70.4 (64.7-75.5)	2.2 (1.8-2.7)
Hydro alone	85.8 (81.0-89.6)	92.3 (88.5-95.0)	11.2 (7.5-16.8)
Both hematuria and hydro	56.0 (50.0-61.9)	97.2 (94.4-98.7)	20.1 (10.1-40.1)
Either hematuria or hydro	96.4 (93.2-98.1)	65.6 (59.7-70.9)	2.8 (2.4-3.3)

Figure 6. Clinical Outcome by Degree of Hydronephrosis

	No Stone	Non-symptomatic	Small	Large	Total
None	204	61	34	5	304
Mild	5	7	132	17	161
Moderate	2	2	34	12	50
Severe	0	0	1	2	3
Unknown degree	5	1	28	10	44
Total w/Hydro	12	10	195	41	258

Figure 7. Presence and Degree of Hydronephrosis as Predictor Variables of Large Stones

	Sensitivity (95% CI)	Specificity (95% CI)	OR+ (95% CI)
Presence of Hydro	89.1 (75.6-95.9)	17.4 (12.5-23.7)	1.4 (0.6-4.7)
Mod/Sev Hydro	46.9 (29.5-65.0)	79.0 (71.9-84.8)	3.1 (1.4-6.9)

CONCLUSIONS

This study confirms that hydronephrosis on CT scan, particularly with hematuria, is strongly associated with ureterolithiasis. While more severe hydronephrosis is associated with larger stones, the presence of hydronephrosis alone does not make it significantly more likely that the stone will be large enough to require intervention (6mm or greater). This finding is important because while ureteral stones are difficult to visualize using point-of-care ultrasound imaging, hydronephrosis is reliably visible (40). The combination of hydronephrosis and hematuria, both available on point-of-care testing, may be helpful in a decision rule to limit unnecessary CT imaging.

DISCUSSION

The findings of this study are consistent with previous studies that have evaluated hematuria and hydronephrosis as independent markers for stone disease (18,20). The current study indicates that when used in combination, hydronephrosis and hematuria are highly specific (97.2%, 95% CI 94.4-98.7) for predicting urolithiasis of any size. Taken together, the presence of both yields a positive likelihood ratio (LR+) of 20.1 (95% CI 10.1-40.1). For application to medicine, a positive likelihood ratio >5 is generally thought to be robust enough to be effectively applied to the pre-test probability of a patient having disease, with a LR+ of 10 or greater being very helpful (22).

Interestingly, hematuria alone was found to be only 66.5% (95% CI 60.6-72.0) sensitive for the presence of any sized urinary tract stone. This is significantly lower than similar studies that have found a sensitivity ranging from 84-93% ((19,21,23). This discrepancy is likely due to the fact that the present study used >5 RBCs per HPF as a cut off value for positive hematuria, whereas previous studies used >2 RBCs per HPF. However, this discrepancy may also demonstrate some degree of selection bias in the present study. The major inclusion criterion for this study was that patients had received a non-contrasted CT for suspected renal colic. 9% of these patients did not have a reported urinalysis, and were not represented in the sensitivity calculation. Furthermore, patients were likely to have had urinalyses done before being sent to CT. The results of the urinalysis may have influenced the physician's decision about whether to send the patient to CT, or simply to treat empirically for renal colic. If a physician had a high suspicion for the presence of renal colic based on clinical information (i.e. non-CT imaging and hematuria on urinalysis), that physician may have decided to treat for stone disease without ordering a CT for diagnosis. This would have effectively eliminated a portion of the 'true positives,' in this analysis, leaving a relatively larger group of patients who did not have hematuria, but were sent to CT because the diagnosis of urinary tract stones was less certain. In this latter group, there would have been a relatively higher percentage of 'false negatives', or patients without hematuria who were sent to CT because a physician maintained a strong suspicion of stone disease. This selection bias could possibly account for the significantly lower sensitivity found in the current study.

While non-contrast enhanced computed tomography remains the gold standard for the diagnosis of urinary tract stones (24), it is still common practice to use transabdominal ultrasound (US) in conjunction with a plain kidney, ureter, and bladder radiograph (KUB) in the acute phase of renal colic because of its low cost, accessibility, non-invasiveness, and low radiation dose. Previous comparisons of US and CT for the visualization of a urinary tract stone have shown sensitivities of 12-93% for US, and 91-96% for CT (24-27). However, when any clinically relevant abnormality (either hydronephrosis or visualization of lithiasis) are considered on US, its sensitivity increases significantly, rising from 61 – 92% in one study (28). Henderson reported that using KUB + US to evaluate for either hydronephrosis or lithiasis was 97% sensitive for detecting stone disease (29).

Used in conjunction with clinical markers such as hematuria, the presence of hydronephrosis as detected by ultrasound could be an important component of a clinical decision rule that would limit the use of CT scans in patients with suspected renal colic. While decision rules have been previously attempted, none has successfully employed the use of US for detecting hydronephrosis (10-12). Several clinical algorithms using US have been suggested (30-32) and in 2006 Kartal completed a prospective trial of 227 patients attempting to validate the clinical algorithm proposed by Noble in 2004 (33). Kartal found that by using hematuria and US alone, more than 50% of patients seen in the ED for suspected renal colic were able to be discharged safely home without receiving a CT scan. However, a significant percentage of US-negative patients were ultimately found to have stone disease, and the author concluded that the addition of more clinical predictive parameters would potentially increase the accuracy and safety of such an algorithm. Kartal's study illustrates that US could be safely used as part of a standard management strategy for patients with suspect renal colic, but that development of a clinical decision rule will require that other clinical indicators be validated before an effective decision rule can be implemented.

As discussed above, this study found that the presence of hydronephrosis is not predictive of stone size, and that the degree of hydronephrosis is modestly predictive of stone size. In developing a rule for suspected renal colic, it is important to be able to predict both the presence and the size of the stone, as large stones are less likely to pass spontaneously, and are more likely to require intervention. (15,34). The results of the present study demonstrate that while hydronephrosis is useful for predicting the presence of a stone, it is not a robust marker of stone size. While US has been used to visualize urinary tract stones and estimate their size, it is of limited use in the visualization of small stones. In 2002, Fowler reported that for detecting stones ≤3.0mm, US was only 13% sensitive; and for stones 3.1-7.0mm, US was 26% sensitive. US was 71% sensitive for stones larger than 7.0mm, however, the size above which less than 50% of stones pass spontaneously (15).

KUB is another imaging modality that would potentially be part of a decision rule, but carries a similarly low sensitivity for the detection of urinary tract calculi. While originally thought to have a sensitivity of 90% based on the percentage of stones that are radiopaque in the general population (35), more recent studies have shown the sensitivity of KUB to be only 58-66% (36-38). Like ultrasound, KUB is a more sensitive exam as stone size increases. In a study of 100 patients, Chan demonstrated that while KUB was only 66% sensitive for detecting urolithiasis, KUB was able to detect all stones larger than 5mm (38).

For the development of a clinical decision rule, KUB and US may not be sensitive enough to visualize small stones, but hydronephrosis and other clinical markers could be used to predict the presence of a stone too small to be identified by either imaging modality. For large stones that likely require intervention, KUB and US are considerably more sensitive, and could be used to identify the subset of patients that would require urologic intervention.

This present study has multiple limitations. First, CT was used as the diagnostic indicator of the presence of urolithiasis. While CT is currently used as the gold standard in the diagnosis of urinary tract stones, it is not as accurate as direct visualization, or confirmation of stone passage. This study is also limited by its sample size. 2,973 patient-charts were collected as described above, but because of time restraints, only 630 charts were reviewed and abstracted. The intention of the author is that trained personnel will abstract the remaining patient charts, and that later analysis will be more adequately powered. Another limitation of the study is that the data abstractor was aware of the hypothesis of the study as patient records were reviewed. This introduced a bias that will hopefully be eliminated as trained data abstractors begin work on the project. The variability in radiologist reporting is another limitation of this study. Data were abstracted from the reports of multiple radiologists, representing a possible diagnostic variability in the data. Finally, this study is limited by its retrospective nature, however it was designed as the first component of a larger study that will conclude in a prospective validation of a clinical decision rule. Once the remaining charts are abstracted, classification and regression tree (CART) analysis will be completed based on multiple clinical variables in accordance with methodological standards (39). The product of CART analysis will be a well-powered clinical decision rule for the management of patients presenting with suspected renal colic. Ultimately this decision rule will be validated prospectively using ultrasound as a point-of-care test in both emergency departments used in this study.

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