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ORIGINAL RESEARCH CONTRIBUTION

Prevalence and Clinical Importance of Alternative Causes of Symptoms Using a Renal Colic Computed Tomography Protocol in Patients With Flank or Back Pain and Absence of Pyuria

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Abstract

Objectives: The study was undertaken to determine the prevalence and clinical importance of alternative causes of symptoms discovered in patients undergoing flank pain protocol (FPP) computed tomography (CT) scans in patients with classic symptoms of kidney stone (flank pain, back pain, or both) without evidence of urine infection.

Methods: This was a retrospective observational analysis of all adult patients undergoing FPP CT scans at two emergency departments (EDs) between April 2005 and November 2010. All CTs (N = 5,383) were reviewed and categorized as “no cause of symptoms seen on CT,” “ureteral stone as cause of symptoms,” or “non–kidney stone cause of symptoms.” Non–kidney stone scans were further categorized as “acutely important,” “follow-up recommended,” or “unimportant cause,” based on a priori diagnostic classifications. All nonstone causes of pain and a random subset of subjects (n = 1,843; 34%) underwent full record review blinded to CT categorization to determine demographics, whether flank and/or back pain was present, and whether there was objective evidence of pyuria.

Results: Of all FPP CT scans during the study period, a ureteral stone was found to cause symptoms in 47.7% of CTs, with no cause of symptoms found in 43.3% of CTs. A non–kidney stone diagnosis was found in 9.0% of all CTs, with 6.1% being categorized as “acutely important,” 2.2% as “follow-up recommended,” and 0.65% with symptoms from an “unimportant cause.” In the randomly selected subset undergoing full record review, categorizations were similar, with 49.0% of CTs showing kidney stone as cause of pain and 9.0% a non–kidney stone cause (5.9% “acutely important”). When subjects with evidence of urine infection or without flank or back pain were excluded, ureteral stone was identified as the cause of pain in 54.9% of CTs, while non–kidney stone cause of symptoms was found in 5.4% of scans and acutely important alternate causes in 2.8% of scans.

Conclusions: While a non–kidney stone cause for a patient’s symptoms are found in nearly 10% of CTs done using a FPP, acutely important findings occur in less than 3% of scans done in patients with flank or back pain and absence of pyuria.

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Computed tomography (CT) has been described as the “best imaging study to confirm the diagnosis of urinary stone,” a condition that will occur in up to 12% of the population and recur in as many as 50% of these patients.[1] CT is now the first-line imaging test for suspected kidney stone, and use of CT in the emergency department (ED) has increased over 300% from 1996 to 2007, with ED patients who present with complaints of abdominal pain and flank pain seeing the highest growth in use of CT as part of their evaluation.[2,3] While CT scans are recognized as an accurate diagnostic test for kidney stone and for identifying alternative causes of symptoms, the benefit of this accuracy needs to be balanced against the risk of the test, specifically future malignancies resulting from exposure to ionizing radiation during the CT scan. The

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radiation dose from a typical regular dose CT scan for kidney stone is often near 10 mSv, with a recent analysis estimating that this amount of radiation may result in an additional malignancy in between 1 in 500 to 1 in 1,400 people (data extrapolated from historical radiation exposures, with incidence depending on age and sex).[4]

Renal colic is not life-threatening; however, the concern for significant alternate pathology that may present with similar symptoms is often cited as a reason to obtain CT in suspected renal colic.[5–7] Prior studies have found a rate of "alternative" or "additional" diagnoses in between 10 and 14% of CT scans obtained "for suspected renal colic."[8,9] However, despite a 10-fold increase in CT use to detect kidney stones in the ED setting in just over a decade, a recent study found no increase in the proportion of kidney stones diagnosed, number of significant alternate diagnoses, or admissions to the hospital.[10] This raises the question of how often CTs done for patients with symptoms of kidney stones reveal alternate causes and how clinically important these alternate causes are. For example, prior studies have combined all adnexal pathology into a single group (e.g., simple ovarian cysts in the same group as ovarian mass or ovarian torsion)[8] or included findings such as "enlarged lymph nodes," granulomas, or other entities of vague clinical significance as important alternate findings.[9,11] While masses and cancers are often cited as important alternate findings in CT for renal colic, prior studies have failed to examine whether these findings occurred in patients with known malignancies.[9,11]

It is common for institutions to have CT protocols specifically designed for detection of kidney stone (often known as a "stone," "renal colic," or "flank pain" protocol). Prior investigations have examined the prevalence of alternate findings in these types of scans, but often without confirming that subjects actually had symptoms consistent with renal colic (in this article "typical" or "classic" symptoms are used to specify patients who have flank and/or back pain). A CT protocol for kidney stone may be ordered when a clinician simply wants a noncontrasted CT.

Finally, in two of the largest prior series looking at alternate diagnoses, either the top or the second most common "significant alternate diagnosis" listed is CT signs of pyelonephritis.[8,9] While CT may show evidence of pyelonephritis, CT is typically not necessary for diagnosis of acute uncomplicated pyelonephritis. Presence of pyuria can identify pyelonephritis and the possibility of an infected obstructing ureteral stone, a potential surgical emergency. Point-of-care urine dipstick analysis allows rapid screening for pyuria. While this test is imperfectly specific, it is sufficiently sensitive that it is unlikely to miss a complicated urinary tract infection. Point-of-care results are typically available prior to decisions about imaging (i.e., ordering a CT scan), which may not be the case for laboratory-performed urinalysis.

The larger goal of our study group is to help identify patients with suspected renal colic who may not require CT scanning or who may be appropriately directed to alternate imaging (including low or ultralow-dose CT scanning) without fear of missing significant alternate pathology. Identifying patients with suspected renal colic who have a lower risk of acutely important findings and defining the prevalence and type of these findings is an important first step in our efforts to identify patients who may safely avoid a full-dose CT examination. We sought to determine the prevalence and clinical importance of alternate causes of symptoms discovered by CT in ED patients undergoing imaging for suspected renal colic with classic symptoms (flank or back pain) and absence of pyuria.

METHODS

Study Design

This was a retrospective medical record review of all "flank pain protocol" (FPP) CT scans (noncontrast CT scans of the abdomen pelvis ordered primarily for suspected renal colic). This study was approved by the Yale University Institutional Review Board (Human Investigation Committee) with waiver of consent.

Study Setting and Population

The study population consisted of adult patients at two distinct emergency department (ED) settings from April 2005 to November 2010. The inclusion criterion was performance of a FPP CT scan during the time period; exclusion criteria were a FPP CT scan performed outside of the ED or in a patient under 18 years of age.

The Yale-New Haven Hospital (YNHH) setting is a tertiary-care, urban, academic ED that cares for over 80,000 adult visits per year. The Yale-New Haven Shoreline Medical Center (SMC) ED is a freestanding suburban ED without residents that sees over 20,000 mixed adult and pediatric patient visits per year. Both the YNHH and the SMC EDs are staffed from the same pool of approximately 40 attending physicians. CT scanning is available 24/7 in both locations and dictated reports are kept on the same PACS system (Synapse, Fujifilm, Tokyo Japan).

Study Protocol

All FPP CT scans were reviewed for categorization of findings. A random subset of approximately one-third of all CTs underwent full record review for categorization of findings, basic demographics, and presence of flank or back pain and pyuria. Record review methods were performed using explicit methodology as described by Gilbert et al.[12] and detailed in the sections below.

During the study period, all physician and nursing notes from both sites were recorded on a templated, handwritten record that was scanned and became electronically retrievable (Lynx Medical Systems, Bellevue WA). Laboratory, imaging, and pathology results, as well as dictated operative reports and discharge summaries, are also electronically retrievable (Sunrise Clinical Manager, Eclypsis, Atlanta, GA).

Categorization of CT Findings. All CT scans and reports were queried using IDXRad (GE Healthcare, Waukesha, WI) for FPP CT scans at our institution during the time period of interest. The query returned the patient name, date of birth, medical record number, accession number, date, time, location of scan, and full text of the dictated reports.

CT scans were classified based on the dictated reports as nondiagnostic, diagnostic of symptomatic ureteral stone, or diagnostic of non–kidney stone cause. A ureteral stone was considered present if the dictated report specified that a stone was visualized from the proximal ureteropelvic junction to the distal ureterovesical junction or between those locations (proximal, mid, distal ureter). Ureteral stones were further subcategorized as large (>5 mm) or small (5 mm or less). The size of the ureteral stone was categorized this way for descriptive purposes, as stones 5 mm and smaller are much more likely to pass spontaneously without intervention. If the CT scan showed stone in the bladder and/or the dictated report specifically mentioned signs of "passed stone," this was categorized as urolithiasis (in the "passed stone" category). Asymptomatic kidney stones (i.e., in the renal parenchyma) were noted but not considered causative of symptoms. Non–kidney stone causes of pain were further categorized using a priori criteria as "acutely important" (a diagnostic CT finding *requiring* intervention or follow-up), "follow-up recommended" (CT finding diagnostic of symptoms with follow-up recommended but not immediately necessary), and "unimportant cause" (CT finding diagnostic of symptoms, follow-up not required).

The explicit diagnostic entities in each of these categories were based on prior literature[8,9,11,13] and clinical experience of the group. The group, composed of an emergency physician (CM), internist (CG), and urologist (DS) arrived at this list by consensus prior to beginning the study. Explicit categorizations are listed in Data Supplement S1 (available as supporting information in the online version of this paper). Incidental findings were defined as any findings noted on CT reports that were not associated with symptoms and were noted, but were not a primary goal of this investigation. While blinding between CT findings and other patient factors was maintained as much as possible, focused record review was performed when necessary by the reviewer (s) to determine if findings on CT that may be symptomatic correlated with patient presentation (e.g., side and location of pain) and to determine if findings on CT were previously known (e.g., postoperative findings or progression of known malignancy).

Initial screening review of CT reports was conducted by research assistants (RAs) who were trained in review of CT reports using a standard manual and proctored initial reviews, including verification of accuracy by blinded review of standardized records prior to beginning independent reviews. All nonstone causes of symptoms and any reports where the RAs were unsure were reviewed and categorized by one of three physician investigators (CM, BD, CG). In instances where final categorization remained unclear, consensus review by the group was performed. CT categorization was blinded to the separate record review, including determination of the presence of flank/back pain and pyuria. All categorizations were abstracted into a standard form.

Full Record Review. Approximately one-third of all CTs (n = 1,853; 34.4%) were randomly selected for full record review. This number of records was selected to maximize our precision given the available resources for record review. A full record review was also performed on all patients from the larger group determined to have nonstone causes of symptoms. Record review was performed by trained RAs who were blinded to the CT categorization. Demographic data, chief complaint, disposition, presence or absence of flank or back pain, and pyuria were abstracted into a standardized data form.

Presence of Flank and/or Back Pain and Definition of Pyuria

All clinician notes (EMS record if present, triage note, nursing assessment, resident or midlevel provider assessment if present, and attending physician assessment) were reviewed to determine if the patient complained of any flank or back pain. The templated ED record used during the study period (Lynx) includes specific areas prompting the clinician to record the presence or absence of flank or back pain. The presence of flank pain or back pain in any source was considered to confirm the presence of some flank or back pain even if other sources stated it was not present or did not mention it. If the ED record specifically stated that the CT was not performed for renal colic (e.g., CT for trauma, contrast intolerance, or allergy with suspected abdominal pathology) this was considered "not for renal colic" and grouped with CTs in patients lacking flank or back pain even if flank or back pain was present.

Pyuria was considered present if a point-of-care urine dipstick test was positive for leukocyte esterase at initial encounter, regardless of subsequent laboratory analysis. If a urine dip was not initially obtained, presence of leukocyte esterase on formal laboratory dip was used, regardless of number of white cells on microscopy. If no urinalysis was obtained, pyuria was considered to be absent.

Reliability of Categorization and Screening Criteria. Inter-rater reliability was calculated for categorization of CT findings and presence of back/flank pain and pyuria. For CT categorization, 10 records were randomly selected from each of the seven initial categorization groups (no cause of symptoms from CT, three categories of kidney stone cause, three categories of non–kidney stone cause) for blinded review and recategorization. This yielded 70 records that were blindly re-reviewed. For presence of flank or back pain and pyuria, 50 charts from the subset for full review were randomly selected and re-reviewed, with the re-reviewer blinded to results of the initial review. This number of records was chosen based on the experience of our statistician to generate a reasonable confidence interval for agreement statistics given the number of possible categorizations. Overall agreement and kappa were calculated to determine inter-rater reliability.

Data Analysis

Data for CT categorization and separate record reviews were performed using standardized abstraction forms developed using FilemakerPro 11.0 (Filemaker Inc., Santa Clara CA). Statistical analysis was performed using JMP (SAS Institute, Cary NC) and Vassarstats (for kappa,

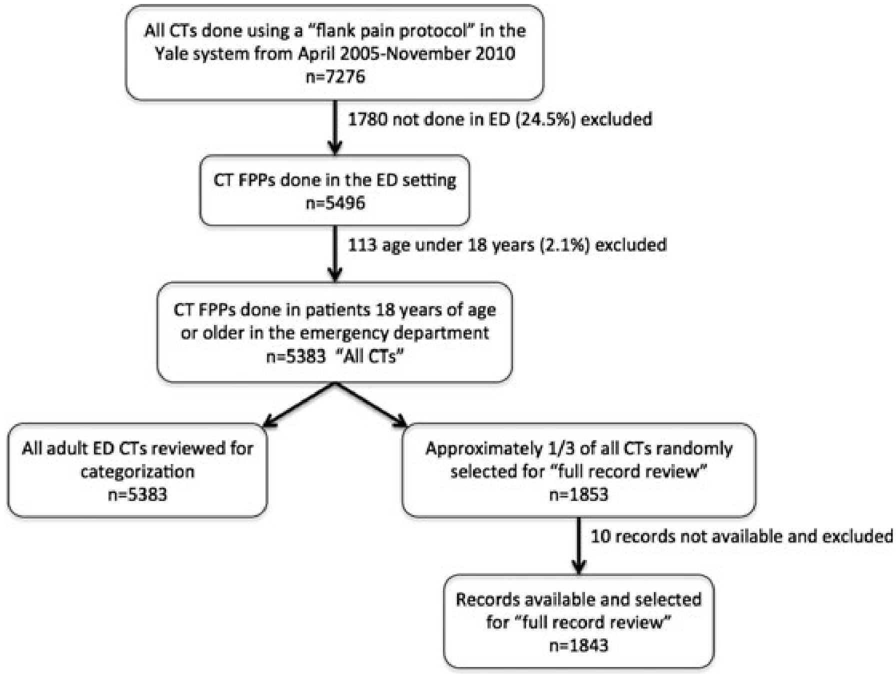

Figure 1. Flow chart of inclusion and review. FPP = flank pain protocol.

www.vassarstats.net). Patients who had more than one CT scan in our data set were noted, but each CT was treated as an individual encounter. Records that lacked interpretable data for >80% of fields were excluded (<1% of encounters). All records that were randomly selected (records for full review and for agreement statistics) were selected from the overall set using a random number generator in Excel (Microsoft, Redmond WA).

RESULTS

Characteristics of Study Subjects

The initial radiology query yielded 7,276 FPP CT scans between April 5, 2005, and November 25, 2010, of which 5,383 (74%) were performed in the ED in patients 18 years of age or older. Of the 1,853 visits randomly selected for full review, 10 ED records were unavailable, leaving 1,843 records for analysis, as shown in Figure 1. Demographics, chief complaint, point-of-care urine testing, and disposition are shown in Table 1.

Main Results

Analysis and categorization of the CT scans overall and breakdown of "acutely important" alternate causes of symptoms are shown in Table 2. Of all FPP CT scans done in the ED during the study period (n = 5,383) there was no cause of symptoms seen on CT in 43.3%, ureteral stone as cause of symptoms in 47.7%, and non–kidney stone was the cause in 9.0%. Of the 9% with nonstone cause of symptoms, 329 CT scans (6.1% of total) had "acutely important findings," 119 CTs (2.2% of total) had findings with "follow-up recommended," and 35 CTs (0.65% of total) showed an "unimportant cause" of symptoms. The breakdown of types of acutely important findings, in decreasing order of prevalence in the final group, is shown in the lower part of Table 2. The prevalence and type of acutely important alternate causes was similar in the overall group as in the subset undergoing full record review.

Table 1
Demographics, Chief Complaint, Point-of-care Urine Testing, and Disposition of Patients in the Subset Selected for Full Record Review, Overall, and by Location (1,843 of 1,853 Randomly Selected Records Available for Review)

Characteristic	All	YNHH Location	SMC Location
Number of subjects	1,843	1,340 (72.7)	503 (27.3)
Age (years), mean ± SD	44.7 ± 15.4	43.0 ± 14.8	49.4 ± 16.0
Female sex	965 (52.4)	263 (52.3)	702 (52.4)
Ethnicity/race			
White	1,163 (63.1)	691 (51.7)	472 (94.0)
Hispanic	354 (19.2)	335 (25.1)	19 (3.8)
African American or black	242 (13.1)	236 (17.7)	6 (1.2)
Other/unknown	84 (4.6)	78 (5.5)	6 (1.2)
Chief complaint			
Flank pain	1,136 (61.6)	828 (61.8)	308 (61.2)
Abdominal pain	457 (24.8)	336 (25.1)	121 (24.1)
Back pain	98 (5.3)	64 (4.8)	34 (6.8)
Hematuria	49 (2.7)	36 (2.7)	13 (2.6)
Other	103 (5.6)	76 (5.7)	27 (5.4)
POC urine dip done	1,298 (70.4)	1,006 (75.8)	292 (41.4)
POC urine heme positive	991 (76.3)	760 (75.6)	231 (79.1)
POC urine heme negative	307 (23.7)	246 (24.5)	61 (20.9)
Disposition			
Admit	227 (12.3)	184 (13.7)	42 (8.3)
Discharge	1,626 (87.8)	1,156 (86.3)	461 (91.7)

Values reported as n (%) unless otherwise noted
YNHH = Yale-New Haven Hospital; POC = point of care; SMC = Yale-New Haven Shoreline Medical Center.

Table 2
Categorization of Diagnosis Based on Dictated CT Report

	All CTs		Subset for Full Record Review			
Diagnosis	All (*n* = 5,383)	% of all	Subset for review (*n* = 1,853)	% of all	Subset With FP/BP and No Pyuria (*n* = 1,156)	% of all
No cause of pain seen on CT	2,331	43.3	778	42.0	458	39.6
Kidney stone as cause of pain	2,569	47.7	908	49.0	635	54.9
Small stone (5 mm or less)	1,834	34.1	679	36.6	489	42.3
Large stone (>5 mm)	492	9.1	146	7.9	89	7.7
CT signs of passed stone	243	4.5	83	4.5	57	4.9
Non–kidney stone cause of pain	4,83	9.0	167	9.0	63	5.4
Acutely important cause	329	6.1	109	5.9	32	2.8
Follow-up recommended	119	2.2	44	2.4	23	2.0
Unimportant cause	35	0.7	14	0.8	8	0.7
Acutely important alternate causes	*n*	%	*n*	%	*n*	%
Diverticulitis	55	16.7	20	18.3	6	18.8
Appendicitis	23	7.0	10	9.2	5	15.6
Mass concerning for new malignancy	34	10.3	11	10.1	4	12.5
Ovarian/adnexal/uterine	21	6.4	10	9.2	4	12.5
CT evidence pyelonephritis	95	28.9	30	27.5	3	9.4
Peri/intrarenal hemorrhage	9	2.7	4	3.7	3	9.4
Hydronephrosis w/o stone	22	6.7	6	5.5	1	3.1
Biliary (cholecystitis or choledocholithiasis)	8	2.4	2	1.8	1	3.1
Pneumonia	15	4.6	4	3.7	1	3.1
Bowel perforation	3	0.9	1	0.9	1	3.1
Bowel obstruction	9	2.7	1	0.9	1	3.1
Retroperitoneal pathology	5	1.5	1	0.9	1	3.1
Colitis or enterocolitis (treated)	3	0.9	1	0.9	1	3.1
Pancreatitis	10	3.0	1	0.9		
Other (renal vein thrombosis, large mesenteric cyst, foreign body)	3	0.9		0.0		
Aneurysm or dissection	4	1.2	1	0.9		
Abscess (thoracoabdominal)	3	0.9	1	0.9		
Traumatic injury	5	1.5	3	2.8		
Post-operative findings (urgent)	2	0.6	2	1.8		
Total acutely important alternate causes (% of all CTs):	329 (6.1%)		109 (5.9%)		32 (2.8%)	

All CTs in the study period (column 1), in the subset for full record review (column 2), and the subset after excluding patients who lacked flank/back pain or had pyuria. Lower part of the chart shows the breakdown of acutely important alternate causes of symptoms in each group (based on categories in Data Supplement S1).

The last column in Table 2 shows the categorization, number, and types of acutely important alternate causes in the subset undergoing full record review after removing CTs of patients who did not have flank or back pain or who did have pyuria. Removing these CTs reduced the number of CTs in the group by 37.6%, from 1,853 to 1,156. CTs were initially excluded if flank or back pain was not present (*n* = 278, or 15.0%) and then excluded if pyuria was present (*n* = 419, or 22.6%). Presence of pyuria was determined by point-of-care urine dipstick in 70.8% of patients undergoing full record review (1,305 of 1,843), with formal urine dip results used when present in the remainder. There were 85 patients with no urine results recorded (4.6%), and pyuria was not considered present in these patients. After excluding patients without flank or back pain or with pyuria, the prevalence of "non–kidney stone" alternate causes of symptoms is 5.4% (63 of 1,156) of CTs in the group, with acutely important alternate causes of symptoms found in 2.8% of CTs (32 of 1,156).

Table 3 shows alternate causes of symptoms determined to be "follow-up recommended," as well as "unimportant causes of symptoms" based on categorizations in Data Supplement S1. These are shown for the overall group, the subset selected for full review, and those within the subset with back and/or flank pain and absence of pyuria.

There were 21 patients in the overall group with a "dual cause" for symptoms on CT (typically a symptomatic kidney stone and another acutely important cause of symptoms), and in these cases the more serious cause of symptoms (i.e., nonstone cause) was used for analysis. While each CT result was treated as a distinct entity, there were a substantial number of patients who underwent more than one CT during the period studied; the 5,383 CTs reviewed were performed on 4,845 unique subjects, with 4,439 subjects receiving only one CT in the sample and 406 subjects (8.4%) receiving two or more CTs (Table 4). One patient was categorized twice in the "acutely significant alternate cause" category, a woman with teratoma diagnosed initially by FPP CT who had the teratoma removed, then returned several years later with a recurrent teratoma, again diagnosed with FPP CT.

Table 3
Breakdown of Alternate Causes in Which Follow-up Is "Recommended" and Where an Unimportant Alternate Cause of Symptoms Was Found in Each Group, Based on Data Supplement S1

Variable	All CTs *n* (%)	Subset for Review *n* (%)	Subset for Review: Patients with FP/BP and no pyuria, *n* (%)
Follow-up recommended			
Symptomatic renal cyst (large or complex)	23 (19.3)	10 (22.7)	5 (21.7)
Mass consistent with malignancy (known or progressive)	14 (11.8)	4 (9.1)	2 (8.7)
Hydronephrosis without stone (mild, known, or progressive)	17 (14.3)	5 (11.4)	2 (8.7)
Ovarian/adnexal/uterine (nonurgent)	15 (12.6)	8 (18.2)	2 (8.7)
Nonspecific bowel wall thickening	7 (5.9)	3 (6.8)	3 (13.0)
Postoperative/procedural findings (non-urgent)	7 (5.9)	1 (2.3)	0 (0)
Mesenteric lymphadenitis	5 (4.2)	3 (6.8)	3 (13.0)
Pyelonephritis (treated)	3 (2.5)	0 (0)	0 (0)
Biliary (nonurgent)	6 (5.0)	3 (6.8)	0 (0)
Traumatic injury (nonurgent)	4 (3.4)	1 (2.3)	1 (4.3)
Ileus (not requiring intervention)	4 (3.4)	2 (4.5)	2 (8.7)
Peri/intrarenal hemorrhage (progression of known)	4 (3.4)	1 (2.3)	0 (0)
Splenomegaly	3 (2.5)	1 (2.3)	1 (4.3)
Pneumonia (known or progressive)	2 (1.7)	0 (0)	0 (0)
Pleural effusion (small or progression of known)	1 (0.8)	1 (2.3)	1 (4.3)
Other (undescended testicle, bladder diverticulum)	2 (1.7)	1 (2.3)	1 (4.3)
Nonspecific lymphadenopathy	2 (1.7)	0 (0)	0 (0)
Total	119	44	23
Other unimportant cause			
Ovarian/adnexal/ uterine	15 (42.9)	6 (42.9)	3 (37.5)
Epiploic apendagitis	11 (31.4)	4 (28.6)	2 (25)
Symptomatic renal cyst (small)	3 (8.6)	1 (7.1)	1 (12.5)
Enterocolitis (not treated)	4 (11.4)	2 (14.3)	1 (12.5)
Hydronephrosis (bilateral s/p Foley)	1 (2.9)	1 (7.1)	1 (12.5)
Other (redundant sigmoid colon)	1 (2.9)	0 (0)	0 (0)
Total	35	14	8

FP/BP = flank pain/back pain.

Table 4
Number of Patients in the Overall Sample Who Received One or More Than One CT FPP During the Study Period

Number of CTs Performed	No. of Patients With This No. of CTs	Total CTs in Sample
1	4,439	4,439
2	323	646
3	54	162
4	18	72
5	7	35
6	2	12
7	0	0
8	1	8
9	1	9
Total	4,845	5,383

FPP = flank pain protocol.

Reliability of Data

There was agreement regarding categorization of CT diagnosis in 56 and 58 of each set of 70 randomly selected CTs that underwent blinded re-review, resulting in 80.0 and 81.4% overall agreement with kappas of 0.75 and 0.80, respectively. The majority of discrepancies were between the "other unimportant cause," "follow-up recommended," and "no cause of pain for CT" categories. In both sets, there was 100% agreement (10 of 10) for acutely important alternate causes of symptoms.

There was agreement in 96% of records undergoing blinded re-review for the presence of flank and/or back pain, with kappa of 0.85. For presence of pyuria, overall agreement was 96% with kappa of 0.81.

DISCUSSION

We found that a non–kidney stone cause of symptoms was found in 9% of CTs using a renal colic protocol, similar to prior studies that have reported rates of 10% to 14%.[8,9,11,13] However, in our investigation about one-third of these causes were not acutely significant. Moreover, in CTs performed on patients with flank or back pain and absence of pyuria, the prevalence of nonstone causes of symptoms approached 5%, with acutely important alternate causes for symptoms being found in less than 3% of CTs. To our knowledge, this is the largest review of consecutive CTs performed for suspected renal colic in patients presenting to the ED and included two distinct EDs. In addition, we used a more methodologically rigorous and clinically relevant approach to categorizing CT findings than prior studies have.

In 1996, Smith et al.[14] published the seminal paper that ushered in the age of CT as a first-line test for renal colic, reporting findings on 292 consecutive CTs of patients with acute flank pain. They found ureteral stones in 34% of CTs, and abnormalities unrelated to stone disease in 10.3% of CTs. Since then, several studies have examined findings on CT for suspected kidney stone with numbers of CTs reviewed between 233 and

4,000.[9,11,13,15,16] Our analysis yielded a prevalence of symptomatic kidney stones in about half (47.9%) of scans performed, compared to prior studies that have found prevalences of between 34 and 78%.[9,11,13–16] Prevalence of stone diagnosis is higher in studies in which another study (such as ultrasound) may prompt CT diagnosis or when CT is not generally performed for a first episode of renal colic. Additionally, studies may have categorized kidney stones in the renal parenchyma (unlikely to be symptomatic) together with symptomatic ureteral stones, while our study did not consider parenchymal stones to be diagnostic of symptoms.

Our analysis found no cause of pain in 43.5% of CTs, higher than prior studies that have cited CTs nondiagnostic or "normal" in as few as 10% of scans.[9] This is likely due to prior studies excluding CTs with incidental findings from the category of normal scans. While not a primary goal of this investigation, we did track incidental findings, defined as not related to presenting symptoms. We found some mention of incidental findings to be present in over 60% of studies, similar to a prior study looking at incidental findings in ED patients undergoing CT for flank pain.[13] We looked explicitly into whether findings were related to symptoms.

Our initial prevalence of alternate diagnostic findings on CT (9.0%) is similar to other studies which have found rates between 9.9 and 15.6%.[9,11] However, categorization of alternate causes of symptoms into "acutely significant," "follow-up recommended," and "unimportant" better reflects the clinical significance of these findings. Katz et al.[8] identified 101 of 1,000 patients with "alternative or additional diagnoses," listing the most frequent cause of alternate diagnoses as "adnexal masses" (occurring in 18 patients). However, 12 of these were cysts, a diagnosis better made with ultrasound and unlikely to require treatment or follow-up in premenopausal women. We specifically categorized findings such as these (adnexal and renal cysts) based on clear criteria not used in prior studies.[17,18] Other conditions of questionable relation to symptoms and need for intervention, such as "granuloma," "lymphadenopathy," "mesenteritis," "porcelain gallbladder," etc., have often been included in prior studies.[8,11] Our study used a priori categorizations based on the consensus clinical experience of two emergency physicians, an internist, and a urologist, which are more reflective of the true clinical significance of these findings.

It is also possible that the actual prevalence of significant findings on CT is decreasing as the ease of getting a CT and willingness to order a CT have increased over time. It may be that more CTs are being performed in patients previously thought to have a low prevalence of disease (renal colic or other), thus yielding a lower prevalence of pathology.

We are not aware of any prior study that has attempted to identify a subset of CTs done using a renal colic protocol where the prevalence of important alternate diagnoses may be lower. One study examined the effect of "limiting the referral base," by only including CTs ordered by urologists, but did not find an effect on additional findings.[16] Our study provides a better estimate of how often and what type of diagnosis may be expected as a "surprise" in what otherwise appears to be a straightforward kidney stone—a patient with flank or back pain and no evidence of urine infection. Additionally, the CT finding of evidence of pyelonephritis (easily screened for by presence of pyuria) often makes up a substantial number of the "alternative findings" cited in other papers, in one series being the number one alternative diagnosis.[9]

The larger goal of our group is to reduce unnecessary ionizing radiation from CTs performed for suspected renal colic. This may be accomplished by not doing a CT or by performeing a "low-dose" CT scan. While data about low-dose CT protocols for renal colic have been published in Europe, and the use of low-dose protocols has been suggested in the United States, to our knowledge no large trial of kidney stones diagnosed in the ED in the United States using low-dose protocols in actual patients has been published.[19–22] Data from our institution examining CTs for renal colic between 1996 and 2002 found an effective radiation dose of approximately 6.5 mSv for single-detector CTs and 8.5 mSv for multidetector CT.[23] All CTs in our institution are now performed using multidetector CTs. While we did not capture the radiation dose from CTs in the current study, an ongoing separate study with prospective enrollment of subjects from May 2011 to October 2012 has demonstrated an average effective dose of 10.5 mSv for CT FPPs, higher than that done in the prior decade. Discussions with our radiologists at our institution about low-dose protocols have been hampered by concerns that CTs with a FPP may be indiscriminately ordered by clinicians who actually may be looking for pathology that is more serious than a kidney stone, and there is concern that low-dose protocols may miss these findings. A recent article demonstrated that low-dose protocols may be accurate for the detection of appendicitis, but this was done outside of the United States.[24] Demonstrating a lower incidence of alternate findings may help increase the adoption of low-dose protocols, or obviate the need for CT entirely in certain cases, as CTs are often done in a first episode of renal colic because of the concern for alternate pathology.[25]

Future work will require prospective application of screening criteria and determination if there are additional historical, physical examination, and point-of-care testing that may obviate or reduce the need for ionizing radiation in selected patients with suspected kidney stone, while maintaining an acceptable risk threshold for not missing significant alternate diagnoses.

LIMITATIONS

Our study is limited by being a retrospective review of data. Our intent was to capture CT scans performed in patients with true clinical concern for renal colic, including classic symptoms. While we are confident that we captured all CT scans using a FPP at our institution during the period of study, the presence of flank or back pain (while typically present in renal colic) is an imperfect surrogate for whether the clinician truly suspects kidney stone. Classification of some of the CT findings, including the category and whether the CT findings were incidental or diagnostic, involved judgment based on available data. While there was good interobserver agreement, there was variability.

There was some evidence of pyuria in 22.6% of subjects after excluding subjects without flank or back pain. Point-of-care dipstick analysis is an imperfect test for pyuria. It is likely that many patients defined as having pyuria may not have had large numbers of white cells on urine microscopy or may simply have provided contaminated specimens. While point-of-care urinalysis for leukocyte esterase is not specific, it is likely to be sufficiently sensitive so as not to miss the population we were concerned about (pyelonephritis and infected obstructed stone). Point-of-care urinalysis also has the significant advantage of typically being available before a decision to obtain a CT scan, which would often not be the case for laboratory-performed urinalysis. In this study, the presence of pyuria was determined by point-of-care urinalysis in the majority of subjects (70.8%, or 1,305 of the 1,843 undergoing full record review), with formal laboratory dipstick analysis used in the remainder.

As a templated, handwritten chart that is then scanned into a system where it is retrievable remotely as a pdf file, the Lynx system is remarkably well suited for record review. For example, the record specifically prompts the clinician to document the presence or absence of data we were attempting to capture (flank and back pain). However, there were records and data that were missing in whole or in part.

While these are limitations of the retrospective nature of this approach, it would be difficult to accrue the numbers to determine the range and type of acutely significant alternative causes of symptoms. In addition to being the largest study of its type to date, we relied on accepted methods for record reviews not reported in prior studies. Our intent is to use the results from this investigation to guide prospective investigations.

CONCLUSIONS

This study suggests that acutely significant alternate findings on CT for renal colic are less common than previously reported and occur in less than 3% of CTs using a renal colic protocol in patients with flank or back pain and absence of pyuria. After screening criteria are applied, the top significant diagnoses found on CT for suspected kidney stone are diverticulitis, mass suspicious for malignancy, appendicitis, and ovarian and adnexal pathology.

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Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. Diagnostic classifications of nonstone causes of symptoms found on CT report.

Announcement:

During the 2012 Annual Meeting, many presenters at the annual meeting recorded brief presentations of their research with Scott Joing, MD, Academic Emergency Medicine's section editor for Dynamic Emergency Medicine. Many of these presentations were posted on Facebook and Twitter during the meeting, allowing a new way to disseminate research presentations and foster communication during our meeting. This project now contains 80 recordings of presenters covering a wide variety of the research presentations from the meeting, and represents a unique approach to creating an archive of the research presentations from the meeting. We hope in future years to create recordings of all of the meetings presentations, and would appreciate advice from SAEM members on the best ways to complete this task and the formats of these recordings. Links to these presentations are on Academic Emergency Medicine's website, and can be found at Academic Emergency Medicines Vimeo.com account, http://vimeo.com/aem. The qr code for the vimeo portfolio is included below.

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