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Non-contrast MDCT for Ureteral Calculi and Alternative Diagnoses: Yield in Adult Women vs in Adult Men

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Purpose: To determine the yield of non-contrast multi-detector computed tomography (MDCT) of the abdomen and pelvis in diagnosing ureteral calculi as well as other alternative acute conditions in male vs in female adult patients presenting to the emergency department with new onset of symptoms.
Methods: Our institutional review board approved a retrospective review of the official reports of the non-contrast MDCT examinations of the abdomen and pelvis performed on adults (18 years and older) presenting to our emergency department with a suspected ureteral calculus from October 1, 2011 to October 30, 2013. Patients with recently documented ureteral calculi, known urinary tract infection, malignancy, and trauma were excluded from the study. From a total of 1097 non-contrast MDCT examinations of the abdomen and pelvis over the 2-year period, 400 randomly selected examinations were reviewed (approximately one-third of all the examinations). We compared the prevalence of ureteral calculi between the male and female population. *P* values and confidence intervals were determined using software Stata 14. Other acute intra-abdominal and intra-pelvic findings amenable to prompt medical care were also documented and analyzed separately.
Results: The mean patient age was 55.2 years, with a range of 19-90 years. This included 170 female (mean age 56.8 years) and 230 male patients (mean age 54.2 years). Ureteral calculi were detected in 170 (42.5%) of the patients [111 males (48%) and 59 females (34.7%)] with a prevalence which was statistically significantly higher in the male patients compared to in the female patients ($P < 0.01$, confidence level of 95% and CI of 13.2-13.4). An alternative diagnosis was made based on the MDCT findings in 49 patient cases (12.25 %), including 26 females (15.29%) and 23 males (10.00%). There was no statistically significant difference in alternative acute findings in male compared to in female patients ($P > 0.05$). This was with the exception of acute pyelonephritis, which was statistically significantly higher in the female patients ($P < 0.01$).
Conclusion: The likelihood of making the diagnosis of a ureteral calculus on non-contrast MDCT of the abdomen and pelvis was statistically significantly higher in male patients compared with female patients presenting to our emergency department. However, there was no statistically significant difference in the alternative diagnoses, with the exception of pyelonephritis, which was more common in women.

Introduction

Urolithiasis is a common condition with an approximate lifetime risk of 12% and a recurrence rate close to 50%. The clinical presentation can be inconsistent and sometimes mimics other intra-abdominal and inter-pelvic disorders, based on the calculus size and location. The differential diagnosis is often broad, especially in women, where the presentation can be similar to acute conditions involving the pelvic genital organs.[1-3]

Non-contrast multi-detector computed tomography (MDCT) of the abdomen and pelvis is considered the standard imaging examination for suspected ureteral calculi. MDCT has a high accuracy for the diagnosis and measurement of ureteral and renal calculi. Hydronephrosis and hydroureter in the absence of an obstructive calculus can indicate a recently passed calculus. Additionally, hydronephrosis, or hydroureter, when mild, can indicate upper urinary tract infection.[3]

The utility of non-contrast MDCT for the detection of other acute findings contributing to the presenting symptoms in male vs in female patients may be less clear. These conditions are often broad and can involve any abdominal and pelvic organs, including the gastrointestinal tract, genitourinary organs, and abdominal vessels.[4] A study by Katz et al. in 2000[5] rendered a 10% alternative diagnosis in 1000 patients presenting with suspected renal colic. Hoppe et al. in 2006[6] showed that the rate of acute alternative diagnosis in a group of 1500 non-contrast CT scans of the abdomen and pelvis was approximately 14%. More recently, a review of 1853 CT reports by Moore et al. in 2013 found an alternative cause in 9% of the patients. The rate of acute, clinically relevant causes in the patients presenting with acute back/flank pain and no pyuria was estimated at 3%.[7]

Patients with complications from calculi or following subsequent procedures are more likely to be followed by additional CT scans, and therefore are exposed to a higher radiation dose. Many

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patients presenting with acute flank pain are younger adults of childbearing age who are potentially more susceptible to radiation.[8,9] The cost of non-contrast MDCT is relatively high, which may contribute to the increasing cost of suspected renal colic management and follow-up in North America.[10,11]

Few studies elaborate on the overall diagnostic yield of non-contrast MDCT of the abdomen and pelvis (including ureteral calculi and alternative diagnoses) in male vs in female patients, to our knowledge.[6,7,12,13] We therefore identified and compared the diagnosis of ureteral calculus and other acute conditions found on non-contrast MDCT of the abdomen and pelvis in men vs in women, and the implications it may have for prospective imaging and patient management.

Patients and Methods

Our institutional review board approved our study. Our study conducted a retrospective review of non-contrast CT examinations of the abdomen and pelvis performed between October 1, 2011 and October 30, 2013 at the emergency departments of 2 academic medical centers. All CT examinations were performed according to the departmental protocol using a 64-slice MDCT scanner. Volumetric imaging was obtained from the base of the thorax to the proximal femora. Collimation was 64 by 0.5 mm that was reconstructed to 3 mm axial slices. Subsequently, 3 mm coronal and sagittal multiplanar reconstructions were performed for all examinations. Oral contrast was not administered.

We included the CT scans performed on adult patients (18 years and older) presenting to our emergency departments with signs or symptoms suggesting renal colic/an obstructing ureteral calculus. All the patients with non-obstructive renal calculi, known upper or lower urinary tract infection, recent flank or abdominal/pelvic trauma, or known renal or urothelial malignancy were excluded from the study. We also excluded any patients who were recently diagnosed with an obstructiving ureteral calculus recent imaging examinations, as we were trying to determine the frequency of newly diagnosed obstructing utereral calculi in symptomatic patients. Non-obstructing renal calculi were also excluded, as these are much more frequent and are mostly asymptomatic.

A third-year radiology resident reviewed and documented the following parameters in the CT reports and electronic medical records using Microsoft Excel 2010 worksheets: age, gender, presence of a ureteral calculus, calculus size, alternative diagnosis if present on the basis of CT, and urinalysis results. The CT findings were documented and correlated with the follow-up notes and urinalysis to confirm the diagnosis.

A total of 1097 non-contrast MDCT examinations obtained between October 1, 2011 and October 30, 2013 met our inclusion criteria. Based on the available literature, we used the Excel RAND function on the Microsoft Excel 2010 worksheets to randomly select 400 scans (approximately one-third of the examinations). Data analysis was performed using Microsoft Stata 14. We compared the frequency of ureteric calculi and other acute diagnoses made based on the CT scans in male vs female patients. *P* values and confidence intervals were calculated using Chi-square test. A recently passed calculus was suggested in the CT reports based on the presence of unilateral hydronephrosis or hydroureter, in the absence of a ureteral calculus.

Results

A total of 1097 non-contrast MDCT scans were performed between October 1, 2011 and October 30, 2013, as noted above. We reviewed the reports on 400 randomly selected cases

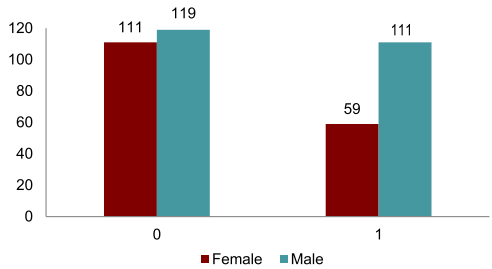

FIG 1. 0 is the number of patients without a ureteral calculus, and 1 is the number of patients with ureteral calculi. (Color version of figure is available online.)

including 170 female (42.5%) and 230 male (57.5%) patients. The mean patient age was 55.2 years (ranging from 19-91 years). The mean calculus size was 5.6 mm (from 2 to 15 mm).

A ureteral calculus was identified in 170 patients (42.5%) including 111 males (48%) and 59 females (34.7%). Positive results were significantly higher in men with $P < 0.001$, a confidence level of 95% and a CI of 13.2-13.4 (Fig 1).

Urinalysis was performed in 321 patients (80.3%). The presence of hematuria or 5 or more leukocytes or both were considered a positive urinalyses. From the total number of urinalyses, 235 were positive (73.2%) and 86 were negative (26.8%). The negative predictive value of the urinalyses was 87.7% using the positive CT result as the reference standard. However, 114 patients (28.5%) had positive urinalysis and no CT findings; they were diagnosed with urinary tract infection, and were treated accordingly.

An alternative diagnosis explaining the patient's signs or symptoms were identified in 49 patients (12.23%), 2 of whom had simultaneous ureteral calculus. This included 26 females (15.3%) and 23 males (10.0%). There was no statistically significant difference in the overall alternative acute findings in the male vs in the female population, with $P > 0.05$ and CI of 0–2 (Fig 2). This is however, with the exception of acute pyelonephritis/pyelitis, which was significantly more common in the female population (2 males and 10 females, $P < 0.01$). Pyelonephritis was diagnosed in patients with unilateral renal enlargement, perinephric standing, and urothelial thickening on CT. The diagnosis was confirmed by urinanalysis and chart review.

Acute appendicitis was found in 5 patients (1.3%) including 4 males (1.7%) and 1 female (0.6%). The diagnosis was made based on enlarged appendiceal diameter and surrounding inflammatory changes on non-contrast CT. Follow-up ultrasound was performed on the one female patient, with the findings further confirming the diagnosis. All 5 patients underwent appendectomy. Both surgical and pathological reports confirmed the diagnosis.

Biliary disorders, including acute cholecystitis and cholangitis, were identified in 3 patients (0.8%), 2 males (0.9%) and 1 female (0.6%). The diagnosis was made based on gallbladder wall thickening, pericholecystic stranding and fluid, as well as bile duct dilatation, on CT. The diagnosis was confirmed by hepatobiliary

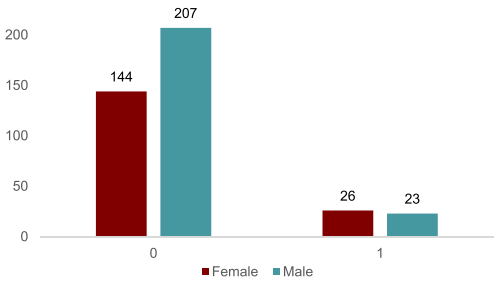

FIG 2. Alternative diagnoses. 0 is the number of patients without an acute alternative diagnosis, and 1 is the number of patients with an alternative diagnosis based on MDCT findings. (Color version of figure is available online.)

TABLE 1
Detailed acute differential diagnosis identified on non-contrast CT and the actual number of male patients with these diagnoses. The percentages are calculated from *a total number of 230*

Alternative acute diagnosis	Male, *n* (%)
Pyelitis/pyelonephritis	2 (0.87%)
Acute appendicitis	4 (1.8%)
Acute diverticulitis	3 (1.3%)
Lower lobe pneumonia	1 (0.4%)
Active Crohn disease	1 (0.4%)
Pancreatitis	3 (1.3%)
Biliary disorders	2 (0.9%)
Colitis/bowel perforation	2 (0.9%)
Epiploic appendigitis	1 (0.4%)
Ovarian disorders	NA
Fibroid degeneration	NA
Prostatitis	1 (0.4%)
May-Thurner syndrome	1 (0.4%)
Hemorrhagic cystitis	1 (0.4%)
Renal vein thrombus	1 (0.4%)
Total	23 (10.0%)

ultrasound, and in one patient using MRCP. Pancreatitis was suggested in 4 patients (1%), 3 males (1.3%) and 1 female (0.6%), based on peripancreatic fluid and loss of normal pancreatic fat lobules on CT. This was later confirmed by elevated serum lipase level. Peripancreatic fat stranding was the main finding on the initial CT scans.

Acute diverticulitis was identified in 6 patients (1.5%), including 3 (1.3%) males and 3 females (1.8%). Pertinent findings included diverticulosis associated with colonic wall thickening and haziness of the pericolonic fat. There was evidence of perforation and abscess formation in one of the female patients, who was then referred to general surgery. Follow-up contrast-enhanced CT of the abdomen and pelvis confirmed the diagnosis. There were 5 patients with suspected colitis (1.3%) including 2 males (0.9%) and 3 females (1.78%) presenting with a relatively long segment of the colonic thickening. Free air was present in one of the female patients, associated with severe thickening and pneumatosis of the splenic flexure. Follow-up CT angiogram of the abdomen and pelvis confirmed perforated ischemic colitis in this patient. Active Crohn's disease was diagnosed in 1 male patient (0.4%) based on relevant previous history and the CT findings of small bowel wall thickening including the terminal ileum. In this patient, the terminal ileum and ascending colon were thickened with marked peripheral stranding.

TABLE 2
Detailed acute differential diagnosis identified on non-contrast CT and the number of such diagnoses in *female patients*. The percentages are calculated from *a total number of 170*

Alternative acute diagnosis	Female, *n* (%)
Pyelitis/pyelonephritis	10 (5.9%)
Acute appendicitis	1 (0.6%)
Acute diverticulitis	3 (1.8%)
Lower lobe pneumonia	3 (1.8%)
Active Crohn disease	0
Pancreatitis	1 (0.6%)
Biliary disorders	1 (0.6%)
Colitis/bowel perforation	3 (1.8%)
Epiploic appendigitis	1 (0.6%)
Ovarian disorders	2 (1.2%)
Fibroid degeneration	1 (0.6%)
Prostatitis	NA
May-Thurner syndrome	0
Hemorrhagic cystitis	0
Renal vein thrombus	0
Total	26 (15.3%)

Ovarian abnormalities were found in 2 female patients (1.2%), including one patient with hemorrhagic ovarian cyst, and one patient with suspected ovarian torsion. In the first patient, there was a large high-attenuation ovarian cyst with surrounding fluid, and in the other, the ovary was enlarged and in an abnormal location, which was strongly suggestive of torsion. The diagnosis in both patients was confirmed by follow-up ultrasound. The patients were referred to the gynecology service for appropriate management.

Prostatitis was suggested (0.4%) in one patient (0.4%) based on high attenuating material in the dependent bladder. This patient was referred to urology, underwent CT urography and then cystoscopy, which showed clot in the bladder but no mass or mucosal abnormality. May-Thurner syndrome was suggested in 1 male patient (0.4%) based on an expanded hyperdense left common iliac vein with substantial focal narrowing as it passed under the left common iliac artery. This was further confirmed on ultrasound, and the patient was treated with anticoagulants.

A detailed analysis of the alternative findings on non-contrast MDCT is summarized in Tables 1 and 2. No attributed cause for the presenting symptoms was found on 183 scans (45.75% of the patients).

Discussion

Non-contrast MDCT of the abdomen and pelvis has become the standard imaging modality for the assessment of suspected urolithiasis. It provides accurate information on stone size and location, which determines the likelihood of spontaneous passage vs the need for intervention. Patients afflicted by urolithiasis are frequently younger adults, which makes the radiation exposure more concerning.[14,15]

To our knowledge, there are only a few studies which elaborate in detail on the diagnostic yield of non-contrast MDCT of the abdomen and pelvis, and particularly on the differences between males and females. We found that overall 54.2% of the CT scans were diagnostic (for a ureteral calculus or for an alternative diagnosis, or rarely for both). This is very similar to a review conducted by Moore et al. in 2013[7] reporting a cause for pain in 56.5% of patients, but is lower compared to a study conducted in 2006 by Hoppe et al,[6] which reported a yield as high as 90%. This may be due to exclusion of the patients with prior documented calculi or recent ultrasound suggestive of ureteral obstruction. Additionally, we excluded the non-urgent findings detected on the CT scan from the analysis, in order to narrow down the data. Another potential explanation is the increase in utilization of CT in recent years in the assessment of patients presenting with symptoms related to suspected disorders other than ureteral calculi.

The prevalence of ureteral calculi in our analysis was 42.5%. We found a statistically significantly higher prevalence of ureteral calculi in the males compared to in females (48% vs 34.7%). These numbers are similar to the results of a review of 215 CT scans by Sarofim et al. in 2016,[13] showing a detection rate of the ureteral calculi which was statistically significantly higher in males compared to in females (43.3% vs 29.6%, $P < 0.04$). However, this study demonstrated a statistically significant difference in the rate of other acute diagnosis (9.7% vs 2.5%, $P = 0.04$), which is not the case in our review of a larger sample ($n = 400$). The results of a study performed in 2014 by Hall et al. is also comparable to our findings, with a ureteral calculus rate of 45.4% in a review of 513 patient records (56% males vs 31% females, $P < 0.0001$) and low negative predictive value of urinalysis; however, the prevalence of other acute diagnoses was not determined.[12]

Other acute abnormalities mimicking the symptoms of obstructive uropathy were identified in 12.3% of our patients. Alternative

findings were only slightly higher in women (6.8% in females and 5.8% in males), with no statistically significant difference, other than pyelonephritis, which was shown to be statistically significantly higher in women. This is despite the fact that in the female population, the possible causes of acute abdominal or pelvic symptoms are broader, considering the diversity of conditions affecting the pelvic genital organs. These disorders are better assessed with ultrasound, but they can be identified on non-contrast MDCT.

A study by Patatas et al[16] shows lower diagnostic yield of non-contrast CT in younger female patients, further emphasizing the difficulty in choosing the appropriate imaging modality for suspected renal colic in this group (24.1% rate of ureteral calculi in women 45 years and younger vs 32.8% in women older than 45 years).

Katz et al., in a review of a 1000 consecutive CT scans, demonstrated an alternative diagnosis rate of 10%. Although this study does not directly compare the male vs female diagnostic yield, the leading alternative diagnosis in the female group was adnexal in origin, found in 18 patients, which is better assessed on sonography, as noted above.[5] We identified ovarian disorders in only 2 patients; however, our sample in comparison was smaller with lower total number of females.

The most frequent alternative cause of diagnosis in our analysis was found to be pyelonephritis, which was statistically significantly higher in the female population, and understandably so given that the prevalence of urinary tract infection is higher in women. However, this result should be interpreted with caution given the actual number of patients was small. This particular diagnosis, however, was not part of the analysis in some of the previous reviews, although renal abscess and emphysematous pyelonephritis were occasionally seen.[5,7,16,17]

It is of note that alternative findings occasionally may be subtle or not apparent on non-contrast MDCT examinations, especially in case of vascular etiologies (ie, venous or arterial thrombosis and bowel ischemia). As such, follow-up CT (or MRI) with IV contrast is pivotal for establishing the correct diagnosis. For instance, ischemic bowel was suggested with the finding of thickened bowel loops in a vascular distribution, mesenteric stranding, and heavily calcified aortic branches in one of our patients on CT. Diagnosis in this scenario was confirmed by follow-up CT angiography.

Our study shows that the likelihood of identifying an obstructing ureteral calculus by non-contrast MDCT of the abdomen and pelvis is statistically significantly higher in our male patients compared to our female patients. There were, however, no statistically significant differences in the identification of any other alternative acute diagnosis as a cause of flank pain. This is with the exception of pyelonephritis, which was statistically significantly higher in female patients. This difference is expected, as the overall rate of urinary tract infection is higher in women compared to in men. As such, correlation with more cost-effective, less invasive tests, including urinalysis, may be a superior choice in the first step assessment of female patients.

Study Limitations

This was a retrospective review of the reports issued on the non-contrast MDCT, with a relatively small sample size. We tried to confirm the accuracy of the diagnosis made on the non-contrast CT examinations by thoroughly reviewing the charts, follow-up imaging, and operative reports. However, the rate of false-positive CT results was difficult to determine in our study, given that follow-up clinical notes were not available for all of with positive CT findings. Additionally, we were unable to determine the rate of false negatives (for example in case of non-calcified ureteral calculi), which would otherwise bring more insight to the utility of non-contrast MDCT in the acutely symptomatic patients. Our review did not include incidental or chronic findings including renal cysts or masses. Finally, we only included the symptomatic patients and did not assess the small number of asymptomatic or so-called silent stones.

Conclusion

Our study showed that diagnosis of a ureteral calculus on non-contrast MDCT of the abdomen and pelvis was significantly higher in adult male patients compared with in adult female patients. However, no statistically significant differences were seen in alternative acute diagnosis as a cause of flank pain between the 2 groups, with the exception of acute pyelonephritis, which was statistically significantly higher in women.

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