ORIGINAL RESEARCH

Emergency department non-contrast computed tomography for suspicion of obstructive urolithiasis: Yield and consequences

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Abstract

Introduction: We aimed to analyze patterns of referral, yield, and clinical implications of non-contrast computed tomography (NCCT) in the acute evaluation of flank pain suspected as obstructive urolithiasis (OU) in a high-volume emergency department (ED).
Methods: The study comprised 506 consecutive NCCTs performed in the ED over four months. Detection rates of OU, incidental, and alternative findings were calculated. Imaging signs suspicious for recent passage of stones were considered positive for OU, while renal stones without signs of obstruction were considered unrelated to the acute presentation. OU, other findings requiring hospitalization, and incidental findings warranting further workup were considered situations in which NCCTs were warranted.
Results: NCCTs confirmed an OU diagnosis in 162 (32%) patients and non-clinically significant nephrolithiasis in 125 (25%). They revealed other findings in 108 (21%) patients, including 42 (8%) with clinically significant incidental findings and 26 (5%) with alternative diagnoses requiring hospitalization. NCCTs were entirely negative in 111 (22%) patients. Corroboration of these outcomes, together with overlapping of OU, incidental, and alternative significant findings in some patients resulted in an overall justified NCCT request rate of 44%.
Conclusions: The yield of NCCT performed in acute presentations of flank pain suspected as OU is relatively low, and over one-half of the scans are unwarranted. The pattern of requesting NCCT in the ED needs refinement to avoid abuse that may lead to radiation overexposure, psychological burden, physical harm, and financial overload.

Introduction

Non-contrast computed tomography (NCCT) is considered the standard reference imaging study for the diagnosis of urolithiasis.[1-4] Its high sensitivity and specificity, broad spectrum of indications, ease of processing, and rapid interpretation led to wide hospital availability and use.[2] Consequently, NCCT use for the detection of obstructive urolithiasis (OU) in emergency departments (ED) has increased considerably, and it has become the most preferred initial diagnostic imaging modality in many institutions.[5-7] NCCT provides invaluable information that may dictate the approach to the treatment of urolithiasis when used with caution and high clinical expertise for the assessment of acute flank pain. In addition, it may detect alternative causes for flank pain. When performed at a low level of suspicion and/or weak clinical basis, however, it may detect incidental findings that could lead to unjustified medical evaluations.[8-10] We aimed to analyze the pattern of requests and yield of NCCTs in diagnosing OU in the acute setting, and estimated its appropriateness and the associated clinical implications.

Methods

This retrospective study was approved by the medical center's institutional review board. We identified all NCCTs performed in the ED between January 1 and April 30, 2018. The ED in our institution is staffed by physicians certified in emergency medicine who perform the triage and initial assessment and establish the working diagnosis, followed by other medical specialty consultations if needed. All NCCTs requested for flank pain suspected as being due to renal colic were included in the study.

All the included patients were scanned by a multi-detector CT scanner (Brilliance; Philips Medical Systems, Cleveland, OH, U.S.) with 64 detector rows. The reconstructed slice thickness was 2.0 with an increment of 1.0 mm. The NCCT protocol consisted of scanning from the lung bases to the groins, in one breath hold. The tube voltage was set at 120 Kv while the tube current was 200 mAs, with automatic exposure adjustment according to patient size. The standard examination reports included the CT dose index (CTDI; mGy), dose-length product (DLP; mGy/cm), and effective

dose (EDose; mSv), which was calculated by multiplying DLP by the standard conversion coefficient for a CT abdomen/pelvis (κ=0.015). No oral or intravenous contrast was used, and the patient was in a prone position to facilitate the distinction between a stone located at the ureterovesical junction and one located in the bladder.

Ureteral stones and/or signs suspected as recent passage of stones (e.g., uretero/hydronephrosis, perinephric edema, periureteral edema, and stone in the bladder) were considered as validating the diagnosis of OU.[11] Renal stones without signs of obstruction were considered unrelated to the acute pain. Accordingly, the reported NCCT findings were classified as confirmatory for OU, incidental, alternative, or negative. Incidental findings were categorized by significance according to the American College of Radiology white papers.[12] Alternative findings were defined as the ones that could explain the patient's symptoms in the absence of OU.

The performance of an NCCT scan was considered as having been justified when the findings included OU, alternative findings requiring hospitalization, and clinically significant incidentalomas warranting further evaluation. The estimation of detection rates of NCCTs for OU, categorization of additional findings, and analysis of the clinical yield and warranting of NCCT were carried out by means of SPSS software version 25 (IBM Corp., Armonk, NY, U.S., 2017).

Results

The study comprised 506 consecutive NCCTs of patients presenting to the ED with flank pain of suspected OU origin. The mean age of the study population was 50 years (standard deviation [SD] 18) and predominantly male (62% males vs. 38% females). The average EDose per NCCT was 8 mSv (range 5.3–11.2). OU was identified in 162/506 patients (32%) and non-obstructive nephrolithiasis was detected in 125/506 (25%). NCCTs revealed 167 additional finding with no urolithiasis in 108/506 patients (21%), and they were negative in 111/506 (22%) patients. There were 76 patients with incidental findings (15%) and 65 patients (13%) with alternative findings among those 108 patients (Tables 1, 2).

Non-significant incidental findings included adrenal adenomas, hernia, and uterine fibroids, while significant incidentalomas were primarily lesions suspected for malignancy, such as renal and hepatic masses, pulmonary nodules, and lymphadenopathy. Forty-six significant incidental findings that required further ambulatory evaluation (e.g., imaging, biopsy, or specialist consultation) were found in 42/506 patients (8%) (Table 1). Alternative pathologies requiring hospitalization were detected in 26/506 patients (5%) (Table 2), with biliary disease being the most common among them.

Performance of NCCTs in the acute setting was warranted in 225/506 cases (44%), with 162 (32%) due to OU, 42

Table 1. Incidental findings by location, pathology, and need for further workup (102 findings in 76 patients)

Type of incidental finding	Overall	Led to further workup
Genitourinary, n		
Complex renal cyst	1	1
Renal mass	4	4
Angiomyolipoma	1	0
Adnexal cyst	1	0
Uterine fibroids	5	0
Other	6	0
Gastrointestinal, n		
Cholelithiasis	2	0
Hepatic lesion	10	6
Pancreatic mass/cyst	2	2
Pancreatic ductal dilatation	1	1
Atrophic pancreas	1	1
Esophageal dilatation	1	1
Bowel intussusception	1	1
Appendix mucocele	1	1
Other	5	0
Pulmonary, n		
Nodule	12	12
Pleural effusion	3	0
Metastasis	1	1
Other	3	0
Adrenal, n		
Hematoma	1	1
Mass	1	1
Adenoma/hyperplasia	9	0
Other, n		
Lymphadenopathy	8	8
Splenic lesion	2	2
Aortic aneurysm	2	2
Retroperitoneal sarcoma	1	1
Hernia (umbilical, inguinal)	13	0
Fat necrosis	1	0
Bone findings	3	0
Total findings	**102**	**46**
Total patients	**76**	**42**

(8%) due to significant incidentalomas, and 26 (5%) due to alternative causes needing hospitalization. There were five cases with more than one finding, yielding an overlapping rate of 1%. Among the 281/506 unwarranted cases (56%), 111 (22%) had negative scans, 125 (25%) had non-obstructive nephrolithiasis, 34 (7%) had non-significant incidental findings, and 39 (8%) had an alternative diagnosis allowing discharge, with an overlapping rate of 6% (30 cases).

Discussion

A CT scan provides a wide range of diagnostic capabilities at a high level of cost-effectiveness. As such, it has become

Table 2. Alternative findings warranting hospitalization (65 findings in 65 patients)

Alternative findings	Overall	Hospitalizations
Urinary tract infection	4	1
SOL of bladder	1	1
Adnexal lesion	5	0
Hepatitis	1	1
Biliary disease	8	4
Pancreatitis	1	1
Appendicitis	3	3
Diverticulitis	7	3
Colitis/enteritis	3	1
GI perforation	2	2
Epiploic appendagitis	4	0
Intestinal foreign body	1	1
Sclerosing mesenteritis	1	0
Pneumonia	3	1
Pleural effusion	2	0
Pulmonary embolism	1	1
Bone metastasis	3	2
Sacroiliitis	2	0
Vertebral fracture	2	1
Spinal stenosis	1	0
Discopathy	5	0
Vasculitis	1	1
Inguinal hernia	3	1
Splenic infract	1	1
Total	**65**	**26**

GI: gastrointestinal; SOL: space-occupying lesion.

the principal imaging tool in many institutions. Its availability and diagnostic advantages led to an exponential rise of its use in the ED setting in which a simple scanning procedure may rapidly and effectively deliver essential information for an accurate diagnosis.[12-14] The NCCT scan was largely adopted by EDs due to its proven superiority over ultrasonographic and conventional kidney-ureter-bladder studies in clarifying the cause of acute flank pain.[3-4]

However, it appears that this success led to a progressive decrease in selectivity for requesting the exam, resulting in a greater number of extraneous scans.[7,13] The monthly average number of NCCTs performed in the ED for flank pain has increased from 15–20 to 80–150 studies in a single decade.[8,9,15-18] Hyams et al demonstrated that NCCT use rates increased in flank pain patients from 20% in 2000 to 45% in 2008.[14] In opposition, other studies that focused on OU suggested a decreasing rate of correlation between clinical suspicion and imaging confirmation. The detection rate of OU in patients presenting with flank pain was 55–72% in the late 1990s and it decreased to 37–48% at the beginning of the millennium.[2-4,8,15,16]

Our OU detection rate of only 32% in a high-volume emergency setting with a mean of 127 NCCTs per month

may reflect this global decreasing rate. It may also be influenced by the business of our urban facility covering a population of half a million people, with persistent over-agglomeration. In such conditions, a quick, efficient imaging procedure may almost instantaneously resolve a case of flank pain while maintaining an adequate flow of patients and reducing wait times in the ED. We originally aimed to investigate the practice of NCCT referral in our ED, with an eye toward revealing some abuse of the imaging services. However, this turned out to be beyond the scope of our study. We believe that refined instructions of the ED staff to enhance its competence both in ordering NCCTs and in the potential risks related to NCCTs are probably a key to improving referral practices, but further studies are needed to address these issues.

The detection rate for incidentalomas was 15%, however, only 8% were of clinical significance and warranted further evaluation. Incidental findings are well-known byproducts of abdominopelvic CT scans,[12] and ongoing improvement in CT resolution has led to a marked increase in the detection of findings unrelated to the primary objective.[17,18] Incidental findings may assist in diagnosing a significant disease earlier in its course. On the other hand, they may lead to a cascade of testing, including invasive procedures, that result in financial costs up to $50 000 USD per patient and can cause harm to patients both physically and psychologically.[19,20] Importantly, our results suggest that only few patients who do not have urolithiasis would benefit from undergoing an NCCT scan in the context of incidentalomas.

Given its cross-sectional nature, NCCT results can suggest alternative diagnoses, since a variety of diseases can mimic renal colic. In the current study, NCCT diagnosed alternative findings (appendicitis, biliary disease, diverticulitis) that were followed by hospitalization in 5% of patients. Radiologists must be familiar with the spectrum of differential diagnoses that may be detected with this modality in order to accurately identify the source of flank pain.[13,21] We assumed that an alternative diagnosis requiring hospitalization would be considered as being one that justified the NCCT scan despite the absence of urolithiasis. However, the 26 (5%) patients found on NCCT to have highly significant morbidities needed extension to intravenous contrast administration protocols to arrive at the proper diagnosis.

Many earlier reports highlighted the presence of various additional findings in NCCTs performed for acute flank pain in the ED. They categorized the findings by systems and significance without providing any guidelines for the optimal indications or algorithm for requesting them.[8-10,15,16,20-23] In our study, we justified the performance of NCCT according to three criteria: the presence of OU, incidental findings requiring a workup, and alternative findings requiring hospitalization. Based on this, the referral to NCCT imaging studies was justified in 44% of our series. We consider this

rate is too low, given that most incidental findings proved to be benign, and that most of the alternative pathologies should have been scanned with intravenous contrast from the outset.Several studies have attempted to increase the detection rate of significant findings on NCCT by corroborating their request with clinical features, such as hematuria, nausea, personal and family history, and laboratory results. Validation of these scoring tools, however, resulted in unsatisfactory prediction characteristics.[24-28] In addition, it is possible that lack of a urological consultation before deciding upon referral to NCCT contributed to the apparently low detection rate and overuse. Nevertheless, NCCT in the ED usually provides a definitive diagnosis for patients who are uneasy about their condition. Given the delays of outpatient healthcare systems, the rapidity and 100% sensitivity and specificity of NCCT in the diagnosis of urinary stones justifies its use when appropriately selected.

Considering that the ED is a high-turnover, acute setting of presentation, diagnosis, and referral for treatment, our algorithm does not include standardized low-dose NCCT protocols. Although these protocols may reduce the effective dose radiation to 0.48 mSv per NCCT, they are associated with a significant decrease in their yield.[29] A study assessing the diagnostic effectiveness of low-dose NCCT for renal colic/flank pain in 33 patients revealed a reduction of sensitivity, specificity, positive predictive value, and negative predictive value for stone detection to 72%, 94%, 93%, and 75%, respectively. In addition, 35% of extra-urinary findings, including acute appendicitis, adrenal adenomas, ovarian dermoid, and gallstones, were missed by the low-radiation NCCT.[30] Thus, in our opinion, these protocols should be used with caution in the ED; however, they may have an important role for followup of patients with known active stone events or for assessing stone-free status after treatment of urinary stones. Intriguingly, despite the fact that low-dose NCCT protocols were initially described more than a decade ago, they are quoted today at <4 mSv and their implementation rates do not exceed 8%.[31,32] Further strategies and alternative clinical algorithms are needed to reduce NCCT use without increasing the risk of significant misdiagnosis in the ED.

Limitations

Our study is limited by its having been carried out in a single center and its retrospective design, as well as by the inability to objectively analyze the clinical assessment that led to the suspicion of OU and request for a NCCT scan. In addition, the NCCTs were interpreted by different radiologists, thus potentially exposing the findings to some inter- and intra-observer variability bias, as reported in the literature.[24] Lastly, for the methodology of our study, we decided to validate OU in the presence of signs for recent passage of stone and

to consider non-obstructing renal stones not related to the acute pain. However, uretero/hydronephrosis, perinephric edema, and periureteral edema may be other signs of pyelonephritis[33] with no OU, and rarely, a non-obstructing renal stone does cause pain. This fact might have slightly changed our justification rates. Despite these limitations, we believe the inclusion of consecutive patients and the high-volume ED of our large tertiary referral academic center represent real-life practice and mitigate some of these limitations.

Conclusions

The detection rates for OU on NCCT are decreasing in parallel with the increasing rate of NCCN use in the ED. It appears that more than half of those NCCTs are not warranted, thereby generating non-significant findings, and leading to unnecessary radiation exposure, unjustified expenditures, and psychological burden. Reducing overuse while minimizing misdiagnosis should be a priority when developing clinical algorithms for identifying the precise source of acute flank pain.

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