Use of Unenhanced Abdominal Computed Tomography for Assessment of Acute Non-Traumatic Abdominal Pain in the Emergency Department

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ABSTRACT: **Background:** Acute non-traumatic abdominal pain is typically evaluated by abdomino-pelvic computed tomography (CT) with oral and venous contrast. The accuracy of unenhanced CT for diagnosis in this setting has not been widely studied.

Objectives: To assess the accuracy of unenhanced CT in establishing the etiology of acute non-traumatic abdominal pain.

Methods: We retrospectively reviewed the medical and imaging records of patients aged ≥ 18 years who presented to the emergency department (ED) during a 6-month period with acute non-traumatic abdominal pain of unknown etiology, and who were evaluated with non-contrast CT within 24 hours of ED admission. Clinical details were recorded. A presumptive clinical diagnosis and CT diagnosis were compared to the discharge diagnosis which was considered the reference standard. The requirement for informed consent was waived.

Results: Altogether, 315 patients – 138 males (44%) and 177 females (56%) – met the inclusion criteria; their mean age was 45 years (range 18–90). Clinical diagnosis correlated with the CT findings in 162 of the cases (51%). CT was accurate in 296/315 cases (94%). The leading diagnosis in cases of a mismatch between CT diagnosis and discharge diagnosis was infection mostly in the urinary tract (12/18). Sensitivity, specificity, positive predictive value and negative predictive value were 91%, 99%, 91% and 85% respectively. The discharge diagnosis was unchanged in the patients who returned to the ED within 1 week of the first admission.

Conclusions: In this study, unenhanced CT proved to be a feasible, convenient and legitimate examination for the evaluation of patients with acute non-traumatic abdominal pain presenting to the ED.

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KEY WORDS: abdomen, non-traumatic pain, imaging, computed tomography/magnetic resonance imaging (CT/MRI), emergency department

Acute abdominal pain is a common complaint in patients presenting to the emergency department (ED), yet a precise diagnosis regarding the origin of pain is often difficult because of non-specific overlapping clinical symptoms and signs and the wide differential diagnosis. An early, accurate diagnosis is crucial to optimize management and minimize the risk of serious complications.

Helical multislice computed tomography (CT) scanner machines allow fast volumetric examination of large volumes in thin slices and limit patient exposure to radiation. CT was shown to provide greater diagnostic accuracy than ultrasound (89% vs. 70%, $P < 0.001$) in patients with acute abdominal pain [1]. CT was also shown to improve the diagnostic confidence of the referring physician, allow fast and effective patient management, and reduce the rate of hospital admissions [2-4]. Thus, CT has become the imaging technique of choice for evaluation of patients with acute abdominal pain excluding cases of biliary stone disease. According to Larson et al. [3], the number of ED visits that included a CT examination increased from 2.7 million to 16.2 million from 1995 to 2007, a 5.9-fold increase and a compound annual growth rate of 16%. The most rapidly growing indication for CT studies during this period was the assessment of abdominal pain, which was performed in 2.7% of ED visits in 1995 as compared to 12.8% in 2007 [3].

Except in cases of suspected renal colic, the routine CT scan protocol for evaluation of acute abdominal pain involves administration of both oral and intravenous (IV) contrast [5,6]. Both oral and IV contrast material are of benefit to the interpreting physician; however, they also have drawbacks. Oral contrast administration may delay diagnosis and treatment [7], and ingestion of a large volume of contrast material may be difficult for some patients. Exposure to IV contrast material is associated with increased risk of nephrotoxicity, a large spectrum of allergic reactions, and even death in rare cases [8]. In addition, the use of oral and IV contrast material leads to increased radiation dose for patients [9,10].

Although both oral and IV contrast are still widely used for CT evaluation in cases of acute abdominal pain, com-

parisons of studies performed with and without oral contrast provided similar accuracy [11-16]. Some authors have found that CT studies that include IV contrast administration had a better diagnostic accuracy for the diagnosis of acute appendicitis [17], while others reported similar results if IV contrast was avoided [14,18,19]. Two studies concluded that neither IV nor oral contrast administration had a practical benefit in the CT evaluation of patients with acute abdominal pain [12,20].

During the last few years we have relied on unenhanced abdomino-pelvic CT examination for the evaluation of acute abdominal pain to reduce patient discomfort, prevent contrast-induced side effects, minimize patient exposure to ionizing radiation, shorten the time to diagnosis in the ED, and decrease the cost of CT evaluation. In the current study, we aimed to determine whether non-contrast CT was sufficient to determine the etiology of acute abdominal pain.

PATIENTS AND METHODS

STUDY DESIGN AND SETTING

We retrospectively reviewed the medical records and CT studies of patients who were admitted to the ED of an academic tertiary-care medical center during a 6-month period (1 January to 30 June 2013) due to acute non-traumatic abdominal pain and who underwent CT evaluation of the abdomen and pelvis. Patients with non-traumatic abdominal pain were included if the pain began within 72 hours before admission. Institutional Review Board approval was obtained and the requirement for informed consent was waived.

PARTICIPANT SELECTION CRITERIA

Patients who were 18 years or older, who were referred for CT examination from the ED, had no known severe co-morbidities, and who underwent unenhanced CT of the abdomen and pelvis within 24 hours of ED admission were included in the study. Excluded were patients younger than 18 years, or patients with a known medical condition that could cause acute pain, for example malignant diseases involving abdominal organs, abdominal vascular stenosis, or severe cardiovascular disease.

CT STUDY PROTOCOL AND INTERPRETATION

All scans were obtained with a 128-slice helical CT scanner (Optima 660, GE Healthcare, Milwaukee, WI, USA), using standard parameters for abdominal examination [120 kVp, automated mA, 0.6 mm slice thickness reconstructed in 2.5 mm slices, ASIR-30, large field-of-view (FOV) and 512×512 matrix]. Coronal and sagittal multiplanar reconstructions (MPR) with 3 mm image thickness were included in all examinations. CT diagnosis was drawn from the CT reports during ED admission.

METHODS, MEASUREMENTS, AND OUTCOMES

Data including patient demographics, location of pain, leukocyte count, presumptive ED diagnosis, hospitalization, surgical or interventional procedures and outcomes, and repeat admission to the ED within 1 week of the initial admission were recorded for all patients. ED or hospital discharge diagnosis, and CT diagnosis following examination at ED admission and upon retrospective review during the current study, were compared. The discharge diagnosis, which was established according to surgical/clinical follow-up, histopathological analysis or both, was considered the standard of reference for the correct diagnosis.

STATISTICAL ANALYSIS

Statistical analysis was performed with SPSS version 20 (SPSS-IBM, Chicago, IL, USA). Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for unenhanced CT were calculated. The accuracy of CT diagnosis was compared for age, gender, pain localization, leukocytosis, and surgical condition. Chi-square test and Fisher's exact test were used, and $P < 0.05$ was considered statistically significant.

RESULTS

A total of 315 consecutive patients were included: 138 males (44%) and 177 females (56%) with a mean age of 45 years (range 18–90 years). During the study period 72 patients with acute non-traumatic abdominal pain were referred for enhanced abdominal CT. Localization of the abdominal pain upon presentation to the ED is summarized in Table 1.

Overall, 248/315 patients (79%) were discharged home from the ED and 67 (21%) were admitted to the hospital of whom 27 patients underwent surgery. The clinical diagnoses before imaging, as reflected by the written referral order for CT, the diagnoses provided by unenhanced CT, and the discharge diagnoses are summarized in Table 2. In eight cases, more than one possible disease was noted by the clinicians. The clinical diagnosis correlated with the imaging diagnosis in 182 of 315

Table 1. Localization of acute abdominal pain at presentation

Pain localization	No. (%) of patients
Right abdomen	9 (2.8%)
Right upper quadrant	7 (2.2%)
Right lower quadrant	169 (53.6%)
Left abdomen	8 (2.5%)
Left upper quadrant	2 (0.6%)
Left lower quadrant	78 (24.8%)
Upper abdomen	10 (3.2%)
Lower abdomen	12 (3.8%)
Diffuse	20 (6.3%)
Total	315 (100%)

Table 2. Comparison of diagnoses based on clinical findings at presentation to the Emergency Department, diagnosis made by unenhanced CT, and discharge diagnosis

	Clinical diagnoses	CT diagnoses	Discharge diagnoses
Renal colic	206	123	121
Appendicitis	72	24	24
Non-specific abdominal pain	20	123	106
Urinary tract infection (including pyelonephritis and prostatitis)	5	7	27
Hernia	6	5	5
Diverticulitis	4	7	6
Pancreatitis	3	1	1
Cholecystitis/biliary colic	2	6	6
Small bowel obstruction	2	0	0
Abscess	1	1	1
Hematoma/bleeding	2	1	1
Gastroenteritis, colitis, ileitis	1	8	9
Volvulus	1	1	1
Appendigitis epiploica	0	3	3
Tumor or metastases	0	3	2
Ovary cyst/torsion	0	2	2
All	323*	315	315

*In eight cases more than one diagnostic possibility was noted

cases (59%) and was in concordance with the discharge diagnosis in 162 cases (51%).

In comparison with the discharge diagnoses, the CT diagnoses obtained during ED admission were accurate in 296 of 315 cases [93.7%; 95% confidence interval (95%CI) 90.74–96.33%]. Sensitivity, specificity, PPV and NPV, defined as the ability to reach an accurate diagnosis on the basis of the CT study, were 91%, 99%, 91% and 85%, respectively.

There was no discrepancy in the diagnosis achieved with unenhanced CT and the at-discharge diagnosis in patients with surgical pathologies or other sources of pain that eventually required surgical intervention. In 18 patients there was a discrepancy between the CT and discharge diagnoses; among them 67% were diagnosed as having lower urinary tract infections (UTI). If we define abdominal pain caused by UTI as non-specific, which would be appropriate since the diagnosis of UTI is usually based on urinalysis rather than on imaging, the accuracy rate of CT would increase to 97.5%, sensitivity to 96%, specificity to 99%, PPV to 96% and NPV to 94%. The six remaining cases of discrepancy between the unenhanced CT and discharge diagnoses included four cases of acute pyelonephritis, one case of renal colic with a non-obstructing stone mistakenly diagnosed as a phlebolith, and one case of acute gastroenteritis with minimal bowel changes on CT.

Among patients who were discharged home from the ED after imaging and treatment, 20 patients (6.6% of the study population or 8.4% of those discharged home) returned within a week. In this subgroup of patients, 14 were diagnosed with renal colic (70%), 2 with urinary tract infection (10%), 2 with non-specific abdominal pain (10%), 1 with diarrhea (5%), and 1 with constipation (5%). Nine of the 20 underwent repeat CT with oral and IV contrast, which resulted in a change in diagnosis in only one case from renal colic to subsequent pyonephrosis.

No relationship was found between diagnostic accuracy of CT and clinical or demographic parameters, including age ($P = 0.43$), gender ($P = 0.58$), pain localization ($P = 0.31$), presence of leukocytosis ($P = 0.4$), hospitalization ($P = 0.86$), surgical condition ($P = 0.14$), or repeated admission to the ED ($P = 0.73$).

In four patients, there were incidental findings at CT that were not relevant to the clinical picture but were important for future management (one pancreatic mass, one vertebral fracture, two cases of diverticulosis). These incidental findings were not included in our statistical analysis.

DISCUSSION

In our series of 315 adults who presented to the ED with acute non-traumatic abdominal pain, non-contrast abdomino-pelvic CT provided an accurate diagnosis in 94% of the patients. There was no discrepancy between CT and the diagnosis at discharge in patients requiring surgical intervention.

The literature regarding unenhanced CT ability to accurately diagnose the source of pain is scarce. Only two previous studies compared the performance of enhanced and unenhanced CT in patients with acute non-traumatic abdominal pain. Hill et al. [12] in their study of 661 patients (147 underwent unenhanced CT) showed an accuracy rate of 94.6% versus 92.5%, respectively [12]. Basak and colleagues [20] showed 2.59 diagnostic confidence levels for the non-enhanced CT as compared to 2.64 for the enhanced CT in 93 patients. Both studies concluded that contrast administration is not necessary, as unenhanced CT enables the radiologist and the clinician to accurately diagnose an acute abdominal process. MacKersie and associates [19] compared the performance of unenhanced CT versus plain abdominal X-rays. Among the 91 patients examined, unenhanced helical CT yielded an overall sensitivity, specificity, and accuracy of 96%, 95%, and 96% respectively [19].

Three previous studies examined the accuracy of enhanced CT in acute abdominal pain. Strömberg et al. [21] in a study of 2222 patients with acute non-traumatic abdominal pain found a CT accuracy rate of 96.8%. Hill and colleagues revealed 94.6% CT accuracy [12], while Laméris et al. [1] reported 89% sensitivity and 77% specificity of enhanced CT in defining the cause of pain. Recently, Miller et al. [22] assessed the added

value of systematic unenhanced abdominal CT on ED diagnosis in elderly patients with non-traumatic acute abdominal symptoms. They concluded that unenhanced abdominal CT improves ED diagnosis accuracy (76.8% to 85%, $P= 1.1x10^{-6}$) and management (88.5% to 95.8%, $P = 2.6x10^{-6}$) rates compared to current practice. It allowed diagnosing 30.3% of acute unsuspected pathologies, 3.4% of which were an unexpected surgical procedure requirement.

It is important to emphasize that we are liberal in the use of non-contrast abdominal CT for evaluation of non-traumatic abdominal pain; thus our radiologists are experienced in reading unenhanced examinations. Some authors have noted that only inexperienced readers derive significantly increased accuracy from contrast-enhanced CT as compared to unenhanced CT [17]. Lane et al. [23] noted that in order to match the accuracy of unenhanced CT to that of enhanced CT, there must be sufficient understanding of abdominal anatomy, increased experience in interpreting unenhanced CT, and greater awareness of the features suggestive of a specific or alternative diagnosis. Perhaps a better strategy, in cases where an inexperienced trainee is reading the unenhanced examination, would be to review the images while the patient is on the table and, according to the findings and degree of clinical suspicion, determine the need for contrast administration.

Our study results are in concordance with previous publications describing the diagnostic capabilities of unenhanced abdominal CT, which demonstrates a similar diagnostic accuracy rate to that of an enhanced study. These results encourage the approach that the use of any contrast agent is not necessary to accurately diagnose the pathology in patients with acute non-traumatic abdominal pain in the ED setting.

Non-traumatic abdominal pain is an important reason for referral to the emergency department. The ED physician is compelled to rapidly and accurately detect the origin of pain to optimize the patient's management. Yet, the spectrum of differential diagnoses is wide, and symptoms and signs overlap and may be misleading, so the clinical assessment in these patients remains one of the most challenging areas in emergency medicine. Correct clinical diagnosis was reached in our series in only 51% of patients and this is consistent with previous studies [24]. CT has proved to be the diagnostic modality of choice for identifying the source of pain [1,4]. In addition, CT was shown to enable discharge of 17%–22% of patients from the ED, who would otherwise be admitted as inpatients [2,4,25]. CT was also shown to be of paramount importance in increasing the diagnostic confidence of the ED physician regarding the origin of pain and the proper treatment that should be employed [4,25].

Routine abdomino-pelvic CT examinations are performed cranio-caudally using oral and IV contrast administration. Oral contrast material may be helpful to distinguish bowel loops from other abdominal structures or abdominal fluid collections, especially in thin patients, and to differentiate normal from abnormal bowel loops. Intravenous contrast administration allows better discrimination of focal pathology in solid organs, is essential for vascular evaluation, and may improve delineation of infectious, inflammatory and neoplastic conditions. However, both oral and IV contrast have associated risks and limitations. The use of oral contrast is time consuming. It may delay diagnosis and treatment, surgical management, and slow ED throughput. Huynh et al. [7] found a significant decrease in ED time to either treatment or discharge in patients undergoing unenhanced CT scans for the evaluation of suspected renal colic, as compared to patients who underwent conventional enhanced abdomino-pelvic CT scan because of acute abdominal pain. Both oral and IV contrast are associated with higher radiation exposure. Wang et al. [9] found that the use of positive oral contrast increased the volume CT dose index (CTDI vol) by 11% when using automatic exposure control; Amato and group [10] reported a 19–71% increase in radiation dose for specific internal organs associated with IV contrast administration. Use of IV contrast material is associated with increased risk for the patient, including nephrotoxicity, a wide spectrum of allergic reactions, and even death [7,8]. Allergic reactions develop following IV iodine contrast administration in 0.2%–0.6% of patients, with 1%–2% of reactions graded as severe [8]. The incidence of nephropathy associated with exposure to iodinated contrast agents is estimated to be 2%–7% [8]. Extravasation may occur in the injection site, with a reported incidence of 0.1%–0.9, and sometimes can cause severe tissue damage. In addition, drinking a large amount of contrast may be difficult for patients in severe pain or with nausea and vomiting, increasing the risk for aspiration. Oral contrast ingestion eventually causes marked diarrhea in the majority of patients, adding to their discomfort.

Most of the available data examining the added CT performance from use of contrast in patients with acute abdominal pain focused on specific diagnoses, notably acute appendicitis, diverticulitis, and small bowel obstruction [11-18]. All authors concluded that CT performed without oral contrast matched the results of CT with oral contrast administration, with high diagnostic acumen with and without oral contrast [1,11-16].

Taking into account all aspects of performing an abdomino-pelvic CT in patients presenting to the ED with acute non-traumatic abdominal pain, including patient comfort, patient safety, patient exposure to ionizing radiation, time to diagnosis, diagnostic outcome, and cost-effectiveness, eliminating the use of contrast in these patients may be expedient.

LIMITATIONS

Our study has several limitations due mainly to its retrospective nature. Unenhanced CT was only performed when specifically requested, thus introducing referral bias into the results. There is no definite scale or ratio in this retrospective study of

those referred for unenhanced CT compared to enhanced CT, thus this potential bias is not assessable. The high sensitivity, specificity and accuracy of unenhanced CT in our study group may be influenced by the methodology of our study relating to CT diagnosis given by highly experienced readers. There is no direct comparison between unenhanced and enhanced CT performance in the same group of patients, and correlation was made with our results and results of enhanced CT diagnostic capability derived from previous studies. Final ED diagnoses were biased, as the final diagnosis was highly influenced by CT results in the majority of the cases. In addition, there was a selection bias regarding our study group. Not all patients with acute abdominal pain were sent to CT with a specific request for an unenhanced study. In patients with suspected vascular compromise (mesenteric event or organ infarction) or bowel pathology, conditions that might be missed on an unenhanced examination, the request of the ED physician was for an enhanced CT. On the other hand, in all patients with suspected renal colic an unenhanced study was preferred. Lastly, a clinical diagnosis was derived from the written referral order of the ED physician. We understand that the format of such an order is not ideal to present the full clinical insight of the ED physician regarding the patient's condition. Nevertheless, despite these limitations the primary purpose of our study, to examine whether such an imaging approach can be justified clinically, was achieved.

CONCLUSIONS

Unenhanced CT is feasible and convenient, and may be used as a legitimate protocol for the evaluation of selected patients with acute non-traumatic abdominal pain presenting to the ED. Routine use of unenhanced CT in such patients will make examinations easier for the patients, facilitate examination and evaluation in the ED, while avoiding possible contrast-induced side effects and decreasing examination costs.

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