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Retrospective cohort study on clinical predictors for acute abnormalities on CT scan in adult patients with abdominal pain

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ABSTRACT

Purpose: Identification of clinical predictors of acute and surgical pathologies on abdominal CT in patients with non-traumatic abdominal pain (NTAP).

Methods: Retrospective chart review cohort study of adults who had abdominal CT scans for investigation of NTAP in the Emergency Department in a tertiary care center in Lebanon. Multivariate analyses were performed to identify predictors of pathologies on CT scan.

Results: This study included 147 patients who had abdominal CT scans for NTAP. Mean age was 39.8 ± 15.1 years and 58.5 % of patients were females. Less than half (44.9 %) had normal scans. Women had significantly higher rates of normal scans compared to males. Right lower quadrant (RLQ) tenderness was associated with significantly higher odds of having acute abnormalities on CT and of having surgical diagnoses, while epigastric tenderness was negatively associated with these two outcomes. Right and left upper quadrants and diffuse abdominal tenderness, and an abnormal neutrophil count were found to be associated with surgical diagnoses on CT.

Conclusions: Women are less likely to have acute and surgical pathologies on CT ordered for non traumatic abdominal pain. Epigastric tenderness is negatively associated with abnormal and surgical CT results while RLQ tenderness is associated with an abnormal CT that is likely surgical in nature. These findings should help improve diagnostic accuracy of ordering providers and improve resource utilization.

1. Introduction

Non-traumatic abdominal pain (NTAP) is a common presentation to Emergency Departments (ED) worldwide, accounting for 3–13% of adult ED visits [1]. NTAP has a wide differential diagnosis ranging from benign self-limiting to life-threatening surgical emergencies, and encompassing gastrointestinal, gynecologic, urologic, vascular, and musculoskeletal conditions [2]. Clinical assessment of patients with NTAP remains challenging because of the large number of etiologies involved, the relatively high frequency of atypical presentations and the overlapping symptoms of different diseases [3]. As such, due to the lack of validated prediction rules for life-threatening or surgical diagnoses, emergency physicians increasingly rely on diagnostic imaging for more rapid and accurate diagnosis in patients presenting with NTAP [3].

CT scanning is often used to investigate the cause of NTAP in the ED since it is sensitive, fast and readily available at all times [4]. Abdominal CT scans play a major role in improving the diagnostic certainty in the ED setting of NTAP, which leads to more appropriate management and results in more timely surgical interventions [5]. Additionally, CT scanning of patients with NTAP was shown to significantly reduce the rate of admissions by up to 28 % as well as that of exploratory surgeries [4,6]. As a result, over the past decade, a substantial increase in CT scan use has been observed in the US [7], Europe [8], and Australia [9].

Unfortunately, abdominal CT scans are not without costs, limitations and risks. One out of three CT scans performed can be potentially replaced by a less invasive form of imaging or need not be done at all

Abbreviations: ACR, American College of Radiology; CT, computed tomography; NTAP, non-traumatic abdominal pain; ED, Emergency Department; LLQ, left lower quadrant; LUQ, left upper quadrant; RLQ, right lower quadrant; RUQ, right upper quadrant; US, ultrasound

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[10]. Moreover, abdominal CTs have been shown to be a major contributor to collective radiation dose [11], which increases the risk of secondary malignancies [10], most particularly in young adults [10]. Therefore, clinicians must carefully select the NTAP patients who are most likely to benefit from CT imaging in order to avoid excessive and unnecessary radiation and expenses. For this reason, Scheinfeld et al. examined laboratory parameters that could be used as predictors of a negative abdominal CT in young adults with NTAP and concluded that none of them is reliable and reassuring enough to avoid CT imaging [12].

While patterns of CT scanning have been extensively reported on in the developed nations, little is known about CT scanning trends in the developing world. A recent alarming study conducted in Brazil from 2001 to 2011 showed a significant increase in CT scan use, where the numbers more than tripled over the study period [13]. This trend can be extrapolated to all developing countries including Lebanon where no documentation of CT scan patterns has been done on a national scale.

This study describes characteristics of patients who underwent CT imaging for NTAP at a tertiary care center ED in Lebanon and identifies clinical predictors of acute surgical and non-surgical pathologies on abdominal CT scans.

2. Material and methods

2.1. Study setting and design

This retrospective chart review cohort study was conducted at the XX Medical Center, the largest tertiary care center in Lebanon with over 55,000 ED visits annually. Adult patients (> 19 years of age) who underwent abdominal CT scans in the ED during the study period (January 1, 2016 - December 31, 2016) were considered eligible for inclusion. A total of 436 patiens were initially found to have undergone CT imaging and their charts were reviewed. Patients (n = 289) were excluded for the following reasons: no abdominal pain on admission, traumatic cause of abdominal pain, known medical history of cancer, inflammatory bowel disease, pregnancy or left the ED before completing their care. A total of 147 patients remained after the exclusion process and were included in the study. The institutional review board at the XX Medical Center (XXMC) approved this study.

2.2. Data collection

Data was collected using a manually filled data collection sheet. Collected variables included information about demographic characteristics, past medical and surgical history, symptom description and physical exam findings, laboratory tests, and CT scan findings.

CT imaging was performed on either Philips iCT 256 detectors or Siemens Somatom Sensation 64 detectors. The dose length product (DLP) in mGy*cm was collected as a measure of CT tube radiation exposure.

2.3. Statistical analysis

Data was analyzed using the Statistical Package for the Social Sciences (SPSS 24). Bivariate analysis was done using the Mann-Whitney test for the continuous variable, and Pearson's Chi-square test and the Fishter's exact test for categorical variables. Statistical significance was set at p-value of less than 0.05. Multivariate analyses were performed for both dependent variables namely acute abnormality on CT scan and surgical CT scan diagnosis using a backward selection procedure. Variables found to be statistically significant at the bivariate level in addition to those considered as being clinically meaningful were included in the logistic regression analysis.

Table 1
List of surgical and non-surgical CT diagnoses of patients with non-traumatic abdominal pain.

Acute Abnormality on CT	N (%)	Required Surgery
Normal CT Scan	**66 (44.9%)**	–
Abnormal CT Scan	**81 (55.1%)**	**36 (24.5%)**
Acute Hepatitis	1 (1.2 %)	No
Appendicitis	26 (32.1 %)	Yes
Cholecystitis	5 (6.2 %)	Yes
Colon Cancer - Perforated	1 (1.2 %)	Yes
Diverticulitis	5 (6.2 %)	No
Gastritis/Enteritis/Colitis	11 (13.5 %)	No
Epiploic Appendagitis	2 (2.5 %)	No
Extrahepatic Biliary Ductal Dilation	1 (1.2 %)	No
Hernia	1 (1.2 %)	No
Mesenteric Adenitis/Panniculitis	9 (11.1 %)	No
Nephrolithiasis	2 (2.5 %)	No
Ovarian Cancer	1 (1.2 %)	No
Ovarian Cyst	2 (2.5 %)	No
Pancreatitis	4 (6.2 %)	No
Gallstone Pancreatitis with Cholecystitis	3 (2.4 %)	Yes
Small Bowel Obstruction	3 (3.7 %)	No
Splenomegaly	1 (1.2 %)	No
Transmesocolic Herniation	1 (1.2 %)	Yes
Urinary Tract Infection/Pyelonephritis	2 (2.5 %)	No
Total	**147 (100.0%)**	

3. Results

The study included 147 patients who received CT scans for NTAP. The mean age was 39.8 (± 15.1) years and over half were females (58.5). Most patients (91.7 %) had CT scan with IV contrast. DLP ranged from 222.50–3029.00 mGy*cm and the mean DLP was of 907.96 ± 415.03 mGy*cm.

CT scans identified an acute abnormality in 55.1 % of cases. Around quarter of patients (24.5 %) had diagnoses that required surgery (Table 1). Acute pathologies identified on CT scan in descending frequencies were: appendicitis (32.1 %), enteritis/colitis (11.1 %), and mesenteric adenitis (8.6 %).

Baseline characteristics of patients who had normal vs abnormal CT scan diagnoses as well as those with non-surgical vs surgical diagnoses are compared in Table 2. Chronic illnesses were not found to be significantly different between the different groups. Gender on the other hand differed between the two groups with 71.2 % of females having normal CT scans as compared to 28.8 % of males.

At the bivariate analysis, reported complaints, including diarrhea and vomiting, vital signs namely tachycardia and temperature and prior ED presentations for abdominal pain were not significantly different between the groups while some physical exam findings showed significant difference. Epigastric tenderness was found in 34.8 % of patients with normal CT scans versus 9.9 % of patients with acute abnormality on CT ($p < 0.001$). RLQ tenderness was positive in 61.1 % of patients with surgical CT diagnoses compared to 27.0 % of patients with non-surgical CT diagnoses ($p < 0.001$). Guarding was found in 24.0 % of patients with surgical CT diagnoses compared to 6.0 % of patients with non-surgical CT diagnoses ($p = 0.022$). In terms of laboratory tests, an abnormal WBC count was more likely in the abnormal CT group ($p = 0.025$) as well as the surgical CT group ($p = 0.002$). Abnormal results for neutrophil percentage ($p = 0.010$), total ($p = 0.011$) and direct bilirubin ($p = 0.005$) were also more likely in the group with surgical CT finding. (Table 3).

After adjusting for several condounders (listed under Table 4) female gender was shown to be negatively associated with the finding of an acute abnormality on CT. Moreover, RLQ tenderness was associated with significantly higher odds of having acute abnormality on CT while epigastric tenderness was in fact negatively associated with the same outcome (Table 4).

Similarly, RLQ tenderness was associated with significantly higher

Table 2
Bivariate analysis of baseline characteristics of patients with normal/abnormal and non-surgical/surgical CT diagnoses.

	All (N = 147)	CT Diagnosis			Required Surgery		
		Normal (N = 66)	Abnormal (N = 81)	p-value	No (N = 111)	Yes (N = 36)	p-value
Female n (%)	86 (58.5)	47 (71.2 %)	39 (48.1 %)	0.005	67 (60.4 %)	19 (52.8 %)	0.422
Age (mean ± SD) **Chronic illnesses** n (%)	39.8 ± 15.1 32 (21.8)	38.6 ± 13.612 (18.2 %)	40.8 ± 16.1 20 (24.7 %)	0.416 0.341	39.6 ± 14.8 25 (22.5 %)	40.4 ± 16.0 7 (19.4 %)	0.874 0.697
Prior Abd. Surgery n (%)	52 (35.9)	28 (43.8 %)	24 (29.6 %)	0.078	42 (38.5 %)	10 (27.8 %)	0.243

HTN = hypertension, DM = diabetes mellitus, DL = dyslipidemia, CAD = coronary artery disease, CVA = cerebrovascular accident, Abd.= Abdominal. Chronic illnesses included: HTN, DM, DL, CAD, CVA, and psychiatric illness.

odds of having surgical CT diagnoses (Table 5) while epigastric tenderness was in fact negatively associated with the same outcome. Diffuse abdominal tenderness, RUQ tenderness and LUQ tenderness were also found to be strong positive predictors of identifying surgical CT scan diagnosis (Table 5).

Guarding on physical exam did not show to be significantly associated with either outcomes at the level of the multivariate analysis (Tables 4 and 5). Similarly off all laboratory variables, only an abnormal neutrophil count was found to increase the odds of having a surgical diagnosis on CT scan (p = 0.004) (Table 5).

Table 4
Multiple logistic regression of acute abnormality on CT scan.

	Adjusted odds ratio	95 % CI	p-value
Gender (Male) Female	0.230	0.079–0.672	0.007
Epigastric tenderness (No) Yes	0.267	0.087–0.822	0.021
RLQ tenderness (No) Yes	15.113	1.733–131.822	0.014

Variables entered into the model were: gender, PMHx_AbdSurg, Hx_Diarrhea, Epigastric Tenderness, WBC, Hx_FeverChills, Hx_Vomiting, Vitals_Tachycardia, RUQ Tenderness, RLQ Tenderness, Lipase.

4. Discussion

This study examines CT findings in patients presenting with NTAP to the ED of a tertiary care center in Lebanon. Its findings are important from a resource utilization perspective and to guide the diagnostic approach to NTAP by highlighting clinical predictors of acute pathologies on abdominal CT in this population. NTAP is a common presentation to the ED and abdominal CT scans allow physicians to further

Table 3
Bivariate analysis of clinical and laboratory findings of patients with normal/abnormal and non-surgical/surgical CT diagnoses.

	Abnormal CT Diagnosis			Required Surgery		
	Normal (N = 66)	Abnormal (N = 81)	p-value	Non-surgical (N = 111)	Surgical (N = 36)	p-value
Current Symptoms						
Vomiting	15 (22.7 %)	19 (23.5 %)	0.917	25 (22.5 %)	9 (25.0 %)	0.759
Diarrhea	7 (10.6 %)	17 (21.0 %)	**0.090**	19 (17.1 %)	5 (13.9 %)	0.649
Fever/Chills	8 (12.1 %)	18 (22.2 %)	0.110	19 (17.1 %)	7 (19.4 %)	0.750
Previous Episodes[a]	8 (12.1 %)	14 (17.3 %)	0.383	18 (16.2 %)	4 (11.1 %)	0.456
Tenderness						
Any	62 (93.9 %)	77 (95.1 %)	1.000	105 (94.6 %)	34 (94.4 %)	1.000
RUQ	13 (19.7 %)	11 (13.6 %)	0.318	19 (17.1 %)	5 (13.9 %)	0.649
LUQ	0 (0 %)	5 (6.2 %)	**0.065**	3 (2.7 %)	2 (5.6 %)	0.596
RLQ	19 (28.8 %)	33 (40.7 %)	0.132	30 (27.0 %)	22 (61.1 %)	< **0.001**
LLQ	4 (6.1 %)	10 (12.3 %)	0.197	10 (9.0 %)	4 (11.1 %)	0.746
Epigastric	23 (34.8 %)	8 (9.9 %)	< **0.001**	27 (24.3 %)	4 (11.1 %)	**0.091**
Umbilical	0 (0 %)	4 (4.9 %)	0.128	4 (3.6 %)	0 (0 %)	0.572
Suprapubic	2 (3.0 %)	2 (2.5 %)	1.000	3 (2.7 %)	1 (2.8 %)	1.000
Diffuse	11 (16.7 %)	18 (22.2 %)	0.400	25 (22.5 %)	4 (11.1 %)	0.135
Guarding	1 (2.8 %)	9 (16.1 %)	**0.082**	4 (6.0 %)	6 (24.0 %)	**0.022**
Vital Signs						
Tachycardia	19 (29.7 %)	20 (25.3 %)	0.559	29 (26.9 %)	10 (28.6 %)	0.843
Temperature	0 (0 %)	3 (3.8 %)	0.253	1 (0.9 %)	2 (5.7 %)	0.148
Abnormal Labs[b]						
WBC Count	19 (28.8 %)	38 (46.9 %)	**0.025**	35 (31.5 %)	22 (61.1 %)	**0.002**
% Neutrophils	37 (56.1 %)	55 (67.9 %)	0.140	63 (56.8 %)	29 (80.6 %)	**0.010**
Total Bilirubin	2 (5.6 %)	5 (16.1 %)	0.236	3 (5.4 %)	4 (36.4 %)	**0.011**
Direct Bilirubin	2 (5.6 %)	4 (12.9 %)	0.404	2 (3.6 %)	4 (36.4 %)	**0.005**
ALP	1 (3.0 %)	4 (10.8 %)	0.361	3 (5.4 %)	2 (14.3 %)	0.260
SGOT	6 (16.7 %)	5 (11.9 %)	0.547	7 (11.5 %)	4 (23.5 %)	0.242
SGPT	7 (17.5 %)	5 (10.4 %)	0.335	9 (13.0 %)	3 (15.8 %)	0.717
g-GT	8 (20.5 %)	11 (25.6 %)	0.587	12 (18.8 %)	7 (38.9 %)	0.111
Lipase	6 (15.0 %)	9 (20.0 %)	0.546	10 (15.2 %)	5 (26.3 %)	0.309

RUQ = Right Upper Quadrant, LUQ = Left Upper Quadrant, RLQ = Right Lower Quadrant, LLQ = Left Lower Quadrant, MAP = Mean Arterial Pressure, SpO2= O2 Saturartion, WBC = White Blood Cell, ALP = Alkaline Phosphatase, SGPT = Alanine Transaminase, SGOT = Aspartate transaminase, g-GT = Gamma-glutamyltransferase.

[a] Previous Episodes include any presentation to the ED 1 year prior to presentation for a complaint of abdominal pain.

[b] The cut-offs used for abnormal labs were 11,000/cu.mm for WBC count, 65 % for % neutrophils, 1.2 mg/dL for total bilirubin, 0.3 mg/dL for direct bilirubin, 235 IU/L for ALP in 15 − 21 years old patients,120 IU/L for ALP in > 21 years old patients, 50 IU/L for SGOT, 50 IU/L for SGPT in females, 65 IU/L for SGPT in males, 50 IU/L for g-GT, 60 U/L for Lipase.

Table 5
Multiple logistic regression of surgical CT scan diagnoses.

	Adjusted odds ratio	95 % CI	p-value
History of fever/chills (No) Yes	0.188	0.038–0.934	0.041
RUQ tenderness (No) Yes	11.589	1.701–78.951	0.012
LUQ tenderness (No) Yes	27.407	1.623–462.827	0.022
RLQ tenderness (No) Yes	34.767	4.910–246.184	< 0.001
Diffuse tenderness (No) Yes	7.866	0.866–71.419	0.067
Neutrophil (Normal) Abnormal	7.898	1.952–31.962	0.004

Variables that were entered in the model were: Gender, Age, Prior abdominal surgery, Vomiting, Diarrhea, Fever/chills, Previous episode, Tender, RUQ, LUQ, RLQ, LLQ, Epigatric, Suprapubic, Diffuse, Guarding, Tachycardia, Temperature, WBC Count, % Neutrophils.

evaluate the patient's pain. In this study, almost half (44.9 %) of NTAP patients who underwent CT scans had normal results. In these patients, familiarity with important predictors of acute pathologies can help avoid CT imaging and the associated radiation risk and increased healthcare costs.

In this study, a higher proportion of patients who underwent CT scans were females (58.5 %), which could be due to a lower threshold for CT imaging of women with NTAP. Indeed, women have been shown to outnumber men in the number of CTs performed for NTAP in previous studies [14,15]. In a study by Gibson et al. females were 11 % more likely to undergo CT scans compared to males [16].

In our study, these women had significantly higher rates of normal scans compared to males. Actually, women with NTAP are significantly more likely to have alternative diagnoses that are better visualized by ultrasound (US) such as ruptured ovarian cysts, ectopic pregrnancy or pelvic inflammatory disease. [15] Females were also previously found to have higher attributed incident cancers and cancer-related mortality from CT scans performed [16]. Radiation can thus be detrimental for young females who are known to have a greater lifetime attributable risk of cancer incidence than males for any radiation exposure at any age [16]. Consequently younger female population may benefit most from initial sonographic evaluation prior to CT imaging [15].

Moreover, epigastric tenderness on physical exam was found to be negatively associated with finding a new acute abnormality on CT scan, or for having a CT scan result that requires surgery. Among the patients included in this study, only 8 out of 31 patients with epigastric tenderness had an abnormal CT scan, and of those, only 4 were surgical. Since epigastric pain is a common presenting complaint, with data showing that it can account for up to 25 % of NTAP presentations to the ED [17], unnecessary CT scans for such presentations can be of concern. Epigastric pain has a broad differential diagnosis that commonly includes pathologies of the stomach, gallbladder, and pancreas, many of which can be diganosed by imaging modalities other than CT scans. For instance, Adhikari et al. showed that bedside ultrasound in the ED can detect gallstones in more than one third of patients presenting to the ED with isolated epigastric abdominal pain [18]. These findings suggest that abdominal CT scans should not be the study of choice for all patients presenting to the ED with acute epigastric pain. Given its accuracy, noninvasive nature and accessibility, bedside US is an optimal imaging method that could be performed in the ED to evaluate these patients [17]. Second-level radiological imaging can be subsequently performed in patients with inconclusive US or in those that did not respond to standard pharmacological treatment [19]. However, it is important to note that US have a variable diagnostic accuracy for conditions that commonly present with epigastric pain. They are highly sensitive and specific for diseases of the gallbladder, biliary tree and liver, but not so much for others such as renal stones, pancreatitis and mesenteric ischemia [17,19]. Therefore, when clinical and laboratory findings are suggestive of diseases for which US lack sensitivity and/or specificity, first-line CT scanning would be more appropriate for diagnosis. Indeed, the American College of Radiology (ACR) criteria for imaging patients presenting with acute epigastric pain vary depending on the suspected diagnosis and consist of initial US imaging for presumed pancreatic or hepatobiliary etiologies and CT imaging for renal or vascular causes [20].

Furthermore, in this study, RLQ tenderness was found to be associated with an abnormal CT scan that is likely surgical in nature. In general, in patients with acute RLQ pain, appendicitis is the most common cause and most frequent surgical diagnosis [21]. RLQ tenderness has 81 % sensitivity for this condition [22], especially when localized at McBurney's point. Indeed, in this study, appendicitis was diagnosed on 21 out of the 32 patients who presented with RLQ tenderness. As such, according to the ACR and American Family Physician for the evaluation of acute NTAP in adults, CT with intravenous contrast is recommended for adults with acute RLQ pain.[2] In cases of appendicitis, abscess, or perforation, CT significantly increases physicians' diagnostic certainty by more than 30 % [5]. It provides information that can be used to diagnose or exclude appendicitis and can provide a surgical road map for more appropriate management [23–25]. Nevertheless, RLQ pain can be caused by other conditions including Crohn's disease, right-sided colitis or diverticulitis, and obstetric and gynecologic pathologies in women [21]. To avoid unnecessary CT imaging, the Alvarado score combines history, physical exam and laboratory findings and can be used to identify patients with low likelihood for acute appendicitis who would benefit from investigation for alternative diagnoses. Even for patients with suspected appendicitis, if limiting radiation exposure is especially important, US could be performed initially followed by CT with contrast if US is inconclusive [20].

Additionally, among physical exam findings included in this study, diffuse abdominal tenderness was found to be associated with surgical CT diagnoses. Among patients with NTAP, non specific abdominal pain has actually been reported to be the main operative diagnosis and CT was shown to be highly effective at identifying patients with non-specific NTAP who need urgent intervention [26,27]. Conditions that often present with diffuse or nonspecific pain include small bowel obstruction for which CT imaging with contrast is recommended and mesenteric ischemia for which CT angiography is recommended by the ACR [20]. CT scans can also help elucidate the site, size and cause of active bleeding in patients with retroperitoneal hemorrhage, for which acute abdominal pain is the most common presenting symptom [28]. Contrast enhanced CT is irreplaceable for critical and life threatening conditions such as hollow viscous perforation, leaking aneurysm, bowel ischemia, and severe pancreatitis [29].

More specifically, RUQ tenderness and LUQ tenderness were also found to be associated with surgical CT diagnoses. Actually, CT imaging is specifically beneficial in patients with retrocecal appendicitis, deeply located sigmoid diverticulitis, gastrointestinal perforation or obstruction where the utility of US is limited [19]. In their case series on retrocecal appendicitis presenting with RUQ pain, Ong et al. concluded that CT would be useful for patients with nonspecific clinical findings and RUQ pain to rule out retrocecal appendicitis [30]. However, according to the ACR, RUQ tenderness should still be initially evaluated by ultrasonography, especially when the clinical impression is of gallbladder or hepatobiliary pathology [31]. In adult cases with suspected appendicitis, however, CT has been shown to be more sensitive than US for diagnosis [32].

For patients with LUQ tenderness, given the broad spectrum of potential diagnoses, clinical guidelines offer mixed recommendations with regards to CT imaging [2,33]. Nonetheless, the utility of CT imaging for LUQ pain cannot be overlooked, as it provides imaging of the spleen, pancreas, kidneys, intestines and vessels and was found to be 69% sensitive and 100 % specific for the diagnosis of LUQ pain [33]. In their study on the negative predictive value of CT imaging of patients presenting to the ED with NTAP, Ham et al. found that patients with false negative CTs were most commonly presenting with epigastric pain

and least commonly with LUQ pain, thus further affirming the role of CT for diagnosis of LUQ pain [34]. As for epigastric pain, the ACR criteria for imaging patients with LUQ pain depend on the suspected etiology. CT is recommended for critically ill patients with high clinical scores or for patients with suspected renal or vascular pathologies. In some cases of LUQ pain, however, when the clinical presentation suggests esophageal or gastric pathologies, endoscopy or upper GI tract series may be more appropriate for diagnosis [2].

Although our study did not find any significant associations between many of the laboratory tests and abnormal CT scan findings at the multivariate level, the bivariate analysis showed that many of these elements were significant or at least borderline significant. An abnormal WBC count, a neutrophil left shift and elevated total and direct bilirubin all had at least borderline significant associations with abnormal CT scan results and were significantly associated with surgical CT diagnoses at bivariate analysis. An abnormal neutrophil count remained significantly associated with a surgical CT diagnosis on multivariate analysis. Actually, leukocytosis has been strongly linked to an inflammatory process in NTAP patients but it is neither specific nor sensitive in identifying the etiology of NTAP [15,35,36]. Moreover, Sheinfeld et al. conducted a study on lab data that could be used to reduce the number of CT scans performed on young adults with NTAP and found that granulocyte percent is a significant and independent predictor of a positive CT in women [12]. Nevertheless, they also found that many patients with normal results for predictor laboratories had serious abdominal diagnoses requiring prompt treatment [12]. Similarly, Modahl et al. reported that 58 % of patients with elevated and 40 % of patients with normal leukocyte counts had positive results [14]. As such, in case of high clinical suspicion, while laboratory results can assist physicians in developing a working diagnosis, normal results should always be interpreted with caution and in combination with other clinical findings.

4.1. Limitations

This study has some limitations related to its retrospective single-center design. Both contrast enhanced and unenhanced CTs were included in our study and the accuracy of CT findings is limited by lack of clinical follow up on negative CTs for further identification and analysis of false negative cases. Ham et al. actually found that half of the patients with false negative CT results were diagnosed with pancreatobiliary disease. They also reported that abnormal lipase, ALT or WBC count as well as epigastric tenderness are potential indicators of NTAP patients with pathology missed by CT [34]. The small sample size is another limitation that may have led to the loss of significance of physical exam and laboratory elements on multivariate analysis and that may have resulted in an overestimation of the association between certain physical findings and surgical CT diagnoses. The study findings are however applicable to other similar urban tertiary care center EDs.

Future studies should investigate the predictive value of localized abdominal tenderness, particularly in younger patients for whom radiation exposures are most concerning. Prospective studies are needed to confirm the current findings and better characterize clinical predictors of positive CT scans, especially since previous studies had mixed results while investigating these elements [2,37,38].

5. Conclusions

For patients presenting to the ED with NTAP, the location of pain can be a good predictor of acute pathology. Because of the numerous etiologies of NTAP involving many organ systems, especially in female patients, imaging strategies should be guided by the location of abdominal pain among other clinical findings and the subsequent differential diagnosis. Epigastric tenderness is negatively associated with abnormal and surgical CT scan results while RLQ tenderness is associated with an abnormal CT scan that is likely surgical in nature. Whereas CT imaging would be beneficial for patients with RLQ pain and for some cases of non specific, LUQ and RUQ pain, US may be the most appropriate initial imaging study for most patients with RUQ, epigastric and LUQ pain.

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Declaration of Competing Interest

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