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Prevalence of Ordering Computed Tomography Scans for Non-Traumatic Abdominal Pain in the Emergency Department at A Tertiary Care Center

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Abstract

Background & Aims*: Abdominal pain is the most common cause for emergency department (ED) referrals. Computed tomography (CT) scans of the abdomen and pelvis are the standard choice for the diagnosis of acute abdominal pain. However, the cost, radiation exposure, and availability of CT scans may make other imaging modalities preferable as first-line tools for non-traumatic abdominal pain. We retrospectively reviewed patient records of those presenting with non-traumatic abdominal pain to the ED and received an abdominal CT scan. Our study's goal was to identify ED prevalence of ordering CT scans for non-traumatic abdominal pain patients compared with other diagnostic imaging modalities such as ultrasound (US) or x-rays.*

Methods: *We analyzed demographic characteristics, comorbidities, clinical presentation, time of ordering abdominal and pelvic CT, CT scan findings, US orders, and admission status of patients presenting to the ED with non-traumatic abdominal pain from July 2017 to October 2017. Summary statistics of continuous variables were reported as mean ± standard deviation. We created a regression model to identify predictors of positive results of abdominal and pelvic CT scan*

Results: *A total of 496 patients were included in our study (mean age: 49.7 years; male-to-female ratio: 40:60). US imaging was ordered for 34 patients (7%), and x-ray/obstruction series were ordered for 55 patients (11%) before orders for abdominal and pelvic CT scans. Most patients were diagnosed with non-specific abdominal pain (n=154, 31%). A total of 173 patients (35%) received orders for abdominal CT scan immediately on evaluation in the ED before basic blood work. Seventy percent of patients were discharged from the ED after a few hours. In 30% of cases, were admitted for further evaluation.*

Conclusion: *CT scans are commonly ordered for the diagnosis of acute abdominal pain. Fifty percent of patient presented with abdominal pain had CT scan. The most common cause of abdominal pain based on CT scan results is nonspecific abdominal pain in our study. Majority of CT scans were ordered either at same time or after one hour after ordering preliminary blood work. Findings such as absence of diabetes mellitus, history of renal stones, leukocytosis, and acute kidney injury, were correlated enough to predict a positive CT result.*

Keywords: *Tomography, X-Ray Computed; Abdominal Pain; Emergency Service, Hospital; Medical Overuse; Radiation, Ionizing; Ultrasonography.*

Introduction

Abdominal pain accounts for 7% to 10% of all emergency department (ED) visits, and it is the most common cause for ED referrals from outpatient clinics [1]. Most cases of abdominal pain (31%) are diagnosed as non-specific abdominal pain, followed by renal colic (usually in male patients) [2]. Elderly patients are more likely to have a specific etiology of abdominal pain than younger patients [3].

Computed tomography (CT) scanning is an important diagnostic imaging tool used in the evaluation of abdominal pathology, except for patients suspected to have cholecystitis (US is preferred in those cases). A national hospital ambulatory medical care survey in the United States reported an increase in CT scan use in the ED from 2.6 million in 1995 to 16.2 million in 2007 [4,5].

The use of CT scanning results in financial consequences for health care organizations and exposure to radiation for patients [6]. One study found that low-dose CT scanning to minimize exposure to excessive radiation was non-inferior to high-dose CT scanning [4]. In our institution, CT scan of the abdomen and pelvis charges range from $2000 to $4000 depending on the type of study. CT scan of the abdomen and pelvis without intravenous contrast charge is $2655; with contrast, the cost is $3419. The price for a combination of a CT scan without contrast and CT scan with contrast is $3900. CT has the highest sensitivity and specificity in patients with acute abdominal pain. However, the positive predictive value of ultrasound (US) is comparable with CT in certain clinical conditions [4,5]. Therefore, considering the cost, radiation exposure, and availability, abdominal US may be offered for patients as an alternative first-line imaging study to evaluate non-traumatic abdominal pain who don't display an explicit peritoneal sign, renal colic pain without acute renal failure, gastroenteritis patients, or when high suspicion for cholecystitis. This can be followed by an abdominal CT if US findings are negative or inconclusive in the presence of persistent symptoms [4]. Yet, it is important to realize that Ultrasound is operator dependent and affected by body habitus.

In this retrospective medical records review study, our goal was to assess prevalence of ordering CT scans in patients who presented with non-traumatic abdominal pain to the ED in a tertiary care academic hospital. Our secondary goals were to identify the most common CT diagnoses based on scan findings for this patient population, assess the correlation with clinical presentation, determine whether US was considered before abdominal CT scan was ordered (for appropriate cases), and evaluate the number of patients admitted or discharged.

Materials and Methods

Study duration

We conducted a search for via Information Technology department for patients who presented to Jersey Shore University Medical Center who presented with abdominal pain from 07/01/2017 to 06/30/2018. The search yielded a total of 5,623 patients presented with abdominal pain (excluding patients with traumatic abdominal injury). Total number of 1,539 presented to ER with abdominal pain between 07/01/2017 to 10/01/2017 (see figure 1). Demographic characteristics including age, sex, ethnicity, comorbidities, clinical presentations, time of ordering CT abdomen, CT scan findings, US orders, and admission status were further analyzed for patients presented from 07/01/2017 to 10/01/2017. In that group, we excluded any patients who presented with abdominal pain yet did not receive orders for abdominal CT, pregnant patients, those with a history of cancer, presented with traumatic abdominal pain, and any patient younger than 18 years. Total number of 819 patients received CT scan in ER. 323 Patients were excluded. Of this group, 231 patients were cancer patients (We didn't track the type of cancer), 73 patients were below 18 (between 16-17), 19 patients had abdominal pain related to trauma. Medical records were retrieved from the ED registry database (Medhost). Positive findings on CT scan were defined as imaging suggestive of any pathological changes including inflammatory conditions e.g, appendicitis, diverticulitis, colitis, enteritis), bleeding (eg, retroperitoneal bleed, abdominal wall hematoma, intra-abdominal hemorrhage), ischemia (eg, bowel ischemia), perforation (eg, bowel perforation, gall bladder perforation, urinary bladder perforation), and obstruction (eg, small bowel obstruction, urinary stone causing obstruction). that explains the patient's abdominal pain.

The timing of ordering a CT scan was also estimated upon arrival to the ED, along with timing of ordering complete blood count, comprehensive metabolic panel, or urinalysis. We sought to determine the association between clinical presentation and positive imaging studies.

Settings

The ED at Jersey Shore University Medical Center consists of 60 beds (8 pediatric, 12 fast track, 5 behavioral health,5 trauma, 30 adult treatment beds). It is a suburban, tertiary care medical center that has a level 2 trauma center, cardiac catheterization lab, comprehensive stroke center and multiple residency programs (there is not an Emergency Medicine residency). There is 24/7/365 access to all radiology modalities (CT, US, MRI) with CT being the most rapid and easily accessible.

There are no specific written protocols for imaging of abdominal pain. Testing is ordered based on the history and physical and personal preference of the physician. At the time of the study ER physicians had access to imaging history for tests that were performed in part of our healthcare system, but not surrounding hospitals. The ED is staffed 24 hours a day by predominately board certified or residency trained Emergency Medicine physicians. There are approximately 90 thousand total visits per year. 20% of which are pediatric (72 thousand adult visits).

Ethical considerations

Our Institutional Review Board approved the study protocol. All study procedures were conducted under the Declaration of Helsinki regarding research involving human subjects.

Statistical analyses

Continuous variables were reported as mean ± standard deviation. Categorical variables were reported as frequencies. Correlations between categorical variables were obtained using Chi-Square test. A Logistic regression (enter) model that included demographic variables (age, sex, and race) and variables that were statistically correlated to the outcome (positive CT result) was used to predict the outcome. One variable (loss of appetite), though didn't statistically correlate to the outcome, was enforced in the model due to its clinical importance **[**6**]**. Hosmer-Lemeshow test was used to ascertain the goodness of fit of the model. An alpha value (p) less than 0.05 was considered statistically significant. Statistical analyses were done using IBM SPSS Statistics for Windows Version 25.0 (IBM Corporation, Artmonk, NY).

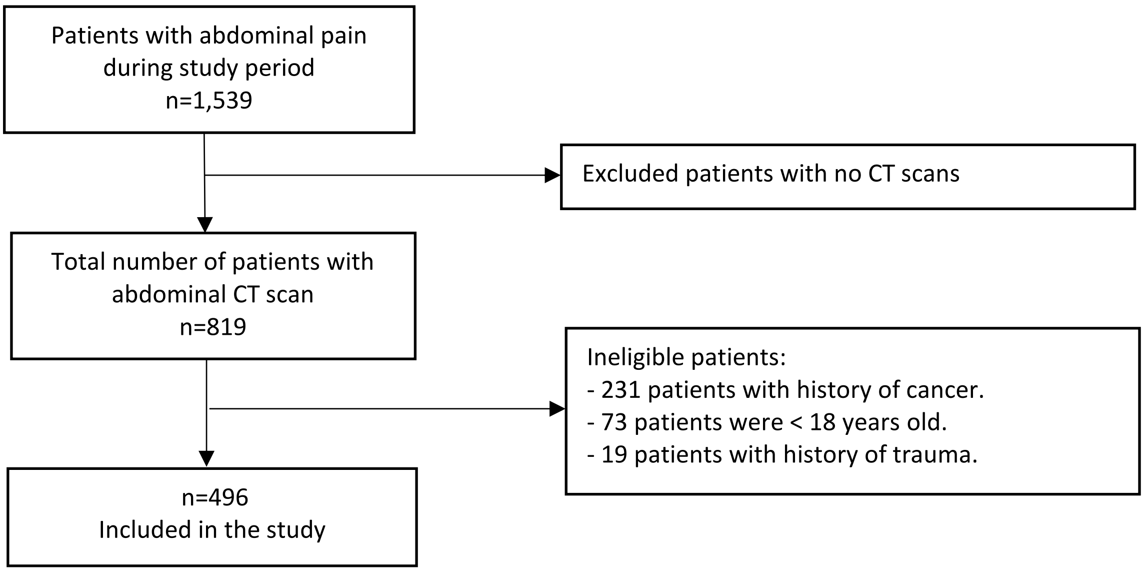

Figure 1. Flowchart of cases inclusion and exclusion.

Results

During the study duration, (07/01/2017 to 10/01/2017) total number of patients with abdominal pain was 1,539, and 819 (53.2%) received a CT scan of abdomen and pelvis. After applying the exclusion criteria on these 819 patients, a total of 496 medical records were manually reviewed.

Patients: The average age of our patients was 50±18.6 years, and the male to female ratio was 40:60. Most patients were white (73%). The most common comorbidities found in our patients were a history of prior abdominal surgery and hypertension (Table 1). 170 patients had no past medical history. The most common anatomically specific location of abdominal pain on presentation to the ED was left lower quadrant pain (18%) (Table 1) and most common findings on positive CT scans for pain on that site was diverticulitis.

Variable	Mean (SD)	Number of patients (%)
Age (years)	50 (18.6)	
Gender		
Male		200 (40%)
Female		296 (60%)
Race		
White		363 (73%)
Black		94 (18%)
Hispanic		35 (8%)
Other		4 (1%)
Medical History		
Hypertension		142 (28%)
Prior laparotomy		148 (29%)
Hyperlipidemia		61 (12%)
Diabetes		56 (11%)
Diverticulitis		34 (6%)
Gastroesophageal reflux disease		28 (5%)
Renal stones		28 (5%)
History of cholelithiasis		27 (5%)
Coronary artery disease		20 (4%)
Atrial fibrillation		20 (4%)
Appendectomy		27 (5%)
Locations of Pain		
Right Upper Quadrant		46 (9.2%)
Right Lower Quadrant		71 (14.3%)
Left Lower Quadrant		94 (18.9%)
Left Upper Quadrant		11 (2%)
Epigastric		57 (11.4%)
Flank		16 (3%)
Multiple areas/Generalized		121 (22.1%)
Other		80 (16%)

Table 1: Baseline characteristics of the patients, Comorbidities, and abdominal pain locations.

Imaging findings: Only 6% of the patients (n=34) had sonographic studies before CT scans. Of these, 6 were positive for cholecystitis, leiomyoma, and ovarian cyst, 5 were inconclusive, and 23 were negative. Abdominal x-rays (including obstructive series) was ordered in 11% of patients (n=55), and the majority were negative (n=53). Sixty percent of abdominal and pelvic CT scans did not show remarkable findings (n=300), and 40% (n=196) of scans revealed pathologies that explain the patients' abdominal pains, or "positive" findings. Twenty-six patients with positive CT findings had abdominal x-ray and/or US study prior to CT but were unremarkable. Three patients had negative abdominal x-ray and negative US study, yet CT scan came back positive.

Outcomes: The most common diagnosis observed in these patients was nonspecific abdominal pain (n=154, 31%), followed by appendicitis (n=42, 8%), renal colic (n=41, 8%), diverticulitis (n=40, 8%), gastroenteritis (n=39, 7%), gastritis (n=30, 6%), colitis (n=27, 5%), pyelonephritis (n=28, 5%), bowel obstruction (n=15, 3%), and perforation (n=11, 2%). Other miscellaneous diagnoses included mesenteric adenitis, pancreatitis, uterine leiomyoma, ovarian mass, ovarian abscess, ovarian cyst, mesenteric ischemia, constipation, pelvic inflammatory disease, abdominal wall hematoma, cholecystitis, and cholelithiasis, accounting for 13% of patients (n=69). At the end of the ED visit, 151 patients (30%) were admitted and 345 patients were discharged (70%).

Locations of Pain	Number	Results of CT Scan		Most common finding on + CT (n)
		Positive (n=196)	Negative (N=300)	
Right Upper Quad	46	29 (63%)	17 (36%)	Renal Stone (4), Pyelonephritis (3) gastritis (3)
Right Lower Quad	71	35 (49.2%)	36 (50.7%)	Appendicitis (14) Renal stone (11) Mesenteric adenitis (6) Colitis (4)
Left Lower Quad	94	49 (52.1%)	45 (47.8%)	Diverticulitis (16) Colitis (14) Renal stone (8)
Left Upper Quad	11	5 (45.4%)	6 (54.5%)	Colitis (2) Gastritis (1)
Epigastric	57	17 (29.8%)	40 (70.2%)	Acute pancreatitis (4) Gastritis (3) Bowel obstruction (2)
Flank	16	10 (62.5%)	6 (37.5%)	Renal Stone (7) Pyelonephritis (2)
≥2 areas (Generalized)	121	67 (55.4%)	54 (44.6%)	Appendicitis (7) Bowel obstruction (6) Diverticulitis (6)
Other	80	25 (32.%)	55 (68%)	Renal Stone (4),

Table 2: Sites of abdominal pain and association with abdominal CT findings (N=496)

Timing of CT scan: One hundred seventy-three patients (35%) received CT scan orders before / or at the same time preliminary blood tests (Complete Blood count and Comprehensive Metabolic Panel), while 290 (56%) and 29 (6%) patients received it within the 1st and 2nd hours after obtaining Complete Blood Count and Comprehensive Metabolic Panel, respectively.

Prediction of positive CT findings: The association of different clinical variables at presentation and positive imaging finding are shown in Table 3. Then, these variables, along with demographic variables (age, sex, and race) were included in a logistic regression model. One variable that did not correlate statistically was included due to its clinical importance (loss of appetite) **[**6**]**. Hosmer and Lemeshow test revealed a good fit (p=0.626), and no variables were removed from the model. Only absence of diabetes mellitus **[**OR=3.25(1.28-8.25), p=0.13**]**, history of renal stones **[**OR=3.1(1.1-9.3), p=0.36**]**, leukocytosis **[**OR=2.76(1.6-4.8), p<0.001, and acute kidney injury **[**OR=2.7(1.01-5.01), p=0.46) were correlated enough to predict a positive CT result. (see Table 4).

	All patients (N=496)	**CT + (n=196)**	**%**	**CT- (n=300)**	**%**	**P**
Diabetes mellitus	56	15	77	41	13.7	0.03
Hx of cholecystitis	17	2	1	15	5	0.01
Hx of gastritis/GERD	28	0	0	28	1	1.07
Hx of nephrolithiasis	28	20	10.2	8	2.6	0.0003
Ovarian cysts	11	1	0.5	10	3.3	0.03
Hx of laparotomy	148	46	23.5	102	34	0.012
Hx of diverticulitis	34	23	11.7	11	3.6	0.0005
Right lower quad	71	36	18.4	35	11.7	0.037
Epigastric	57	13	06.6	44	14.7	0.006
Nausea	222	99	50.5	123	41	0.037
Fever/chills	71	36	19.9	35	11.7	0.037
Left lower	55	29	14.8	26	8.6	0.033
Guarding	19	12	06.1	7	2.3	0.031
Leukocytosis	123	77	39.3	46	15.3	1.55
Elevated bili	55	30	15.3	25	08.3	0.015
Abnormal renal func.	52	29	14.8	23	7.7	0.011

Abbreviations: GERD, gastroesophageal reflux disease; CT+, positive computed tomography findings; CT-, negative computed tomography findings; Hx, history; func., function.

Table 3: Statistically correlated variables to positive results on CT scan.

	OR	95% CI for OR	P Value
Gender (female)	0.751	0.456-1.238	0.262
Age	0.986	0.972-1	0.056
Race (white)	0.534	0.038-7.507	0.642
Race (Black)	0.473	0.172-1.303	0.148
Race (Asian)	0.888	0.280-2.812	0.840
Absence of Diabetes	3.248	1.278-8.252	0.013
History of Cholecystitis	0.130	0.013-1.260	0.078
History of renal stone	3.160	1.078-9.268	0.036
Ovarian Cyst	0.111	0.009-1.314	0.081
History of abdominal surgery (all types) *			0.998
Abdominal pain (all locations) *			0.502
Nausea	1.430	0.921-2.220	0.111
Fever	1.819	0.893-3.704	0.099
Loss of appetite	1.115	0.372-3.344	0.846
Abdominal Tenderness (all locations) *			1.000
Guarding	2.789	0.746-10.426	0.127
Leukocytosis	2.759	1.592-4.782	<0.001
Elevated Bilirubin	1.868	0.878-3.975	0.105
Acute Kidney Injury	2.271	1.014-5.088	0.046

* OR for these variables were not reported as these variables include several items, and none of them was significant.

Table 4. Binary logistic regression model to predict a positive result on CT scan.

Result of CT scan based on timing: When CT abdomen and pelvis ordered before basic blood tests that resulted in 85 positive CT scans. 97 CT scans were ordered within an hour from ordering Complete blood count and Comprehensive metabolic panel and 14 within 2 hours after ordering preliminary blood work (see Figure 2).

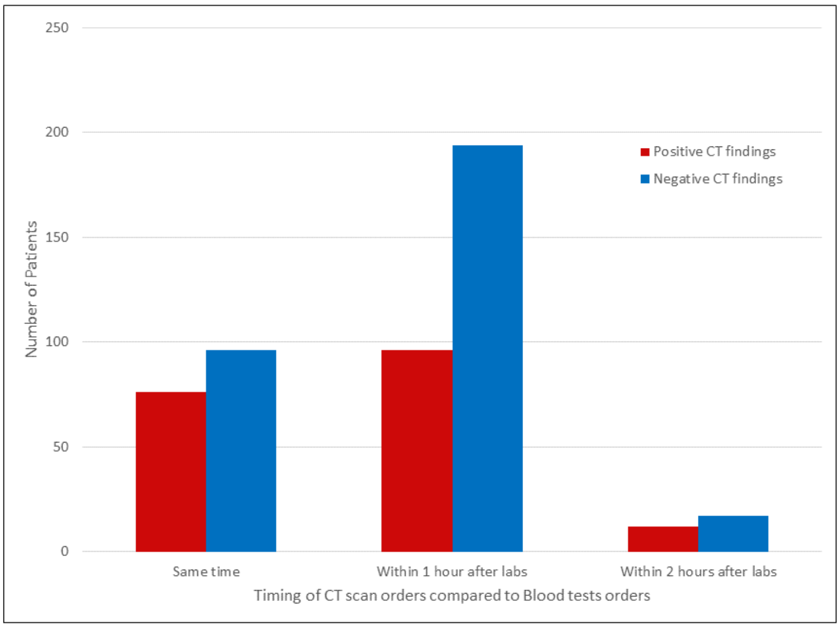

Figure 2. Positive and negative CT scans and their timing compared to labs.

Disposition of patients: Forty nine percent of patients with positive CT scan were admitted (n=97), and 50.9 % were discharged (n=99). Patients with negative CT scan who were discharged from ED was % 82 (n=246) and % 18 were admitted (n=54) (see Table 5).

	CT scan positive	CT scan negative	Total
Patients admitted	97 (49%)	54 (18%)	151 (30%)
Patients discharged	99 (50.9)	246 (82%)	345 (70%)
Total	196 (40%)	300 (60%)	496

Table 5. Put a title here

Discussion

Multiple pathological processes can cause abdominal pain, which makes imaging essential for identifying specific pathology. Common etiologies include inflammatory processes such as diverticulitis, pancreatitis, obstructive process (eg, bowel obstruction, obstructive renal stones), bleeding (eg, retroperitoneal bleed, abdominal wall hematoma), perforation (eg, bowel perforation), and ischemia (eg, bowel ischemia) [7].

We found that most patients (60%) who received CT orders had negative findings on CT (table 2). Similarly, Bhatt et al reported that 50% of patients had negative findings on abdominal CT scans of the abdomen [8]. Mindelzun et al reported that nearly one-third of patients with abdominal pain who present to the ED never had an established diagnosis [9]; this aligns with our findings where approximately 31% of our patients' non-specific abdominal pain with no abnormalities in the CT imaging.

In this study, eight percent (n=42) of patients diagnosed with acute appendicitis. Aranda-Narváez et al reported that Sensitivity of CT scan is significantly superior to ultrasound scan (97% vs. 86%) in diagnosing acute appendicitis, but positive predictive value is similar in both tests (92% vs. 94%) [10]. Johansson et al reported that diagnostic accuracy is high for US as well as for CT. US is better for diagnosing positive findings (Guarding, fever, nausea), while CT was better for excluding diagnosis of appendicitis [11]. With this comparable sensitivity and specificity Ultrasound could have been used as an initial diagnostic test for patients with low clinical suspicion of other concomitant or alternative pathologies. In conclusion, CT and ultrasound scan are excellent diagnostic tools for acute appendicitis and have contributed to a significant increase in surgical explorations with correct diagnosis [10].

Abdominal abscess is a feared complication of diverticulitis, appendicitis (most common diagnosis in our study), if the treatment is not administered in a timely manner. Abdominal US is less sensitive than CT in detecting abdominal abscess pathology. Dobrin et al conducted a retrospective review of 92 patients with abdominal US and CT scans of the abdomen and pelvis to evaluate an intra-abdominal abscess [12]. Dobrin et al reported a sensitivity and specificity for US of 75% and 91%, respectively, compared to 88% and 93%, respectively, for CT scan [12]. No data were available regarding the yield of abdominal US in the evaluation of abdominal pain in postoperative patients and neutropenic patients.

In addition, the radiation dose of the abdominal x-ray is comparable to that of a low-dose CT scan, however, with significantly less sensitivity (75% vs 46%) [13]. In our study, 11% of the patients (n=55) received abdominal x-ray, and 96% of them (n=53) had negative results.

Therefore, it's safe to conclude that abdominal x-ray should be avoided in the evaluation of patients with abdominal pain. Seven percent of patients (n=39) in our study presented with gastroenteritis and diarrhea, yet they received a CT scan of the abdomen and pelvis, a procedure that could possibly have been avoided. Aisenberg et al reported that CT scanning of the abdomen and pelvis bore no impact on management in most cases [14]. Instead, a thorough history and examination of those patients in addition to preliminary laboratory workup can prevent potential radiation toxicity and the high costs associated with CT use [14]. Should a CT scan be not obtained in these 39 patients, $117,000 of roughly estimated total charges could have been saved in our institution.

The most common site of pain in our patients was the left lower quadrant. The most common cause of left lower quadrant pain in adults is acute sigmoid or descending colonic diverticulitis [15]. Only 8% of our patients were diagnosed radiologically with diverticulitis. Patients with acute diverticulitis with typical symptoms of diverticulitis, previous history of diverticulitis, no guarding, and no lactic acidosis may not require any imaging [16]. Those patients can be treated medically without the need for radiologic examinations.

CT scanning is the investigation of choice for evaluating patients with suspected descending or sigmoid colon diverticulitis due to its high sensitivity and specificity and its ability to diagnose complications such as small bowel perforation. Therefore, CT helps determine whether surgical or medical treatment is warranted [17]. Also, CT scanning can rule out other causes of left lower quadrant pain that mimic diverticulitis [18] with a reported overall accuracy of 98% [19].

When comparing CT and US in diagnosing diverticulitis, graded-compression sonography and CT are both effective initial diagnostics according to a meta-analysis [20]. However, CT is more sensitive (50% to 100%) for revealing alternative diagnoses for left lower quadrant pain than US (33% to 78%) [18]. None of our patients was diagnosed with diverticulitis using the US. Abdominal radiography is extremely limited in the evaluation of suspected complications of diverticulitis. Abdominal radiography can demonstrate large amounts of retroperitoneal or intraperitoneal air but is significantly less sensitive than CT for small amounts of air. All diverticulitis complicated by perforation in our patients were diagnosed using CT scan.

More than one third of CT scans ordered in 0 hours (CT scan ordered before or / at the same time Comprehensive Metabolic panel, Complete blood count, urinalysis). De Burlet el al reported the results of her study suggests that a significant proportion of CT scans in patients with acute abdominal pain are not clinically indicated or are being performed prior to adequate clinical workup [21].

However, we must acknowledge the fact that Some diagnoses are especially time sensitive and need immediate investigation (aortic dissection, perforated viscus, hemodynamically unstable patients) and therefore, the study may be ordered immediately without preliminary work up.

As well, a healthy appearing CT scan has clinical utility because it allows for physicians to eliminate a diagnosis rapidly and reduce length of stay. Most of our patients (n=345, 70%) were discharged from the ED; only 151 (30%) patients were admitted for further evaluation. When we stratified discharges by CT scan results, forty nine percent of patients with positive CT scan were admitted (n=97), and 50.9 % were discharged (n=99). Patients with negative CT scan who were discharged from ED was 82% (n=246) and 18 %were admitted (n=54). The CT scan result was an important factor for whether to admit or discharge these patients. Barksdale et al reported in their prospective trial of 547 patients presenting to the ED with abdominal pain **[**22**]**. CT scanning altered the diagnosis in 54% of patients and frequently changed disposition patterns, with a greater proportion of patients discharged instead of admitted for observation **[**22**]**. In our study it was hard to determine whether CT scan alone was the primary factor to determine patient disposition as it is very difficult to find that clearly on patients' charts.

Limitations

Our study was limited in that it was conducted at a single institution, and the study was retrospective. None of the ordering physicians were aware of the study being conducted so it was a mirror of common practice. The other limitation is the clinical reason for doing the scan was not always easy to find in the medical records. If physicians are looking for a kidney stone or an abdominal aortic aneurysm, they may not wait for laboratory results. Some diagnoses are especially time sensitive and need immediate investigation, and therefore, the study may be ordered immediately. Also, a healthy appearing CT scan has clinical utility because it allows for physicians to eliminate a diagnosis rapidly and reduce length of stay. Length of stay prior to the diagnosis also has a cost and having appropriate information early in the assessment allows the care team to proceed with a diagnostic pursuit.

Conclusion

CT scans are commonly ordered for the diagnosis of acute abdominal pain. Fifty percent of patient presented with abdominal pain had CT scan. The most common cause of abdominal pain based on CT scan results is nonspecific abdominal pain in our study. Majority of CT scans were ordered either at same time or after one hour after ordering preliminary blood work. Findings such as absence of diabetes mellitus, history of renal stones, leukocytosis, and acute kidney injury, were correlated enough to predict a positive CT result.

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