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Utility of Emergency Department Use of Abdominal Pelvic Computed Tomography in the Management of Crohn's Disease

Jenna Koliani-Pace, MD¹, Byron Vaughn, MD^{2,3}, Shoshana J. Herzig, MD¹, Roger B. Davis, ScD¹, Laurie Gashin, MD², Joshua Obuch, MD¹, and Adam S. Cheifetz, MD²

¹Department of Internal Medicine, Beth Israel Deaconess Medical Center, Boston, MA 02215

²Division of Gastroenterology, Beth Israel Deaconess Medical Center, Boston, MA 02215

³University of Minnesota, Department of Medicine, Division of Gastroenterology, Hepatology and Nutrition, Minneapolis, MN 55454

Abstract

Goal—The primary aim of this study was to determine predictors of clinically significant CT scans, paying particular attention to findings of previous CT scans.

Background—Use of Computed Tomography (CT) to assess patients with Crohn's disease (CD) in the Emergency Department (ED) is both costly and exposes patients to high levels of ionizing radiation while not clearly improving outcomes.

Study—Patients with CD who underwent CT scan in the ED from 2008–2011 at a tertiary referral center were assessed for clinically significant findings. A multivariable generalized estimating equation (GEE) model with logit link and exchangeable working correlation structure was constructed to assess for independent predictors of CT scans with clinically significant findings.

Results—A total of 118 patients with CD underwent 194 CT scans. 92/194 (47%) CT scans demonstrated clinically significant findings. Predictors of clinically significant CT scans included

Correspondences: Dr. Jenna Koliani-Pace, 330 Brookline Ave Boston, MA 02215, jkoliani@bidmc.harvard.edu, Phone Number: 617-632-8273, Fax Number: 617-632-8261.

Author Contributions:

Jenna Koliani-Pace MD – Study concept and design, acquisition of data, interpretation of data, drafting of the manuscript, critical revision of the manuscript

Byron Vaughn MD – statistical analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content

Shoshana J. Herzig MD – statistical analysis and interpretation of data, critical revision of the manuscript

Roger B. Davis ScD – statistical analysis, critical revision of the manuscript

Joshua Obuch MD – study concept and design, critical revision of the manuscript

Laurie Gashin MD – study concept and design, critical revision of the manuscript

Adam S. Cheifetz MD – study concept and design, interpretation of data, critical revision of the manuscript for important intellectual content, study supervision

Conflicts of Interest

Jenna Koliani-Pace MD – No conflicts to disclose

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ileal disease involvement (OR 3.47, $p=0.01$) and WBC (white blood cell count) >12 (OR 2.1, $p=0.03$). Most notably, patients with a CT scan without clinically significant findings performed in the preceding month were significantly less likely to have a clinically significant CT scan (OR 0.23, $p=0.005$).

Conclusion—Patients with CD who had a CT scan without significant findings the month prior are unlikely to have clinically significant CT findings. Ileal disease and an elevated WBC are predictive of clinically significant CT scans.

Keywords

inflammatory bowel disease; ionizing radiation; quality of care

INTRODUCTION

Computed tomography (CT) scans in the Emergency Department (ED) have become commonplace in the evaluation of patients with Crohn's disease (CD).^{1–4} The estimated use of CT scans in the ED to assess patients with CD ranged from 26–47% in 2001 to 42–78% in the late 2000s.^{1,2} While CT scans can be essential in the diagnosis of enteric fistulas, abscesses, or perforations, and are as accurate as other imaging modalities, there is a risk of overutilization.^{5–13} Patients presenting to the ED with abdominal pain are undergoing twice as many CT scans in comparison to a decade ago, yet the number of clinically significant findings and admissions have not significantly changed.^{1,2,4,14} Although the risk of a single CT scan is minimal, repetitive exams on young patients can expose them to harmful amounts of radiation, increase their risk of cancer and nephrotoxicity, as well as escalate medical costs.^{14,15} Patients with CD are at a particular risk of overutilization of CT scans as the number of ED visits by these patients has been increasing.^{3–6,15–19}

Ideally, CT scans should be performed on patients who have a high pre-test probability of a clinically significant finding. However, correctly identifying these patients can be challenging. Prior work has identified IBD related surgery, African American race, low body mass index (BMI), and C-reactive protein (CRP) as factors associated with clinically significant CT findings in patients with CD.²⁰ Two different predictive models have been developed to help clinicians determine the utility of ordering a CT scan. One model uses history of obstruction, history of abscess, presence of hematochezia, and WBC $>12,000$ to predict significant findings, whereas the other model uses erythrocyte sedimentation rate (ESR) and CRP.^{2,13} Only one of the two models accounts for with-in subject correlated data resulting from subjects with multiple CT scans in the study period, and neither assessed whether results from a prior CT could inform the decision to order a repeat scan. Furthermore, evaluating the predictive ability of previous CT scan findings has yet to be evaluated in the literature. Given that patients with CD frequently present to the ED and have high rates of readmission, including these data is essential to the decision making process.^{21,22}

The aim of this study was to determine predictors of a clinically significant CT scan in patients with CD while accounting for with-in subject correlated data and emphasizing the results of previous CT scans.

METHODS

Setting and Participants

Utilizing the electronic medical records from Beth-Israel Deaconess Medical Center (BIDMC), a large urban tertiary care center, we identified patients with the diagnosis of Crohn's disease (ICD-9 code 555.x) who presented to the ED between January 2008 and December 2011 and underwent a CT abdomen/pelvis. We cross-referenced the ED visits with CPT radiology codes for CT abdomen and/or pelvis, and used time stamps of patient arrival and departure from the ED to ensure that the CT scan was performed during the patient's ED course. Manual chart review was performed by the first author to confirm the diagnosis of CD by examining gastroenterology notes and endoscopy and pathology results. If there was a challenging case, it was reviewed with the last author. Patients were excluded if a diagnosis of CD could not be confirmed, the patient was found to have ulcerative colitis or indeterminate colitis (IBD-unspecified), the ED visit was the first presentation of CD, or the indication for CT scan (defined by the ordering physician) was not reasonably associated with CD (i.e. trauma or status post fall).

This study was approved by the local institutional review board (2012P-000279/4).

Database and Data Collection

The electronic medical record at BIDMC is robust and includes all outpatient and inpatient documentation and ED discharge and admission reports. Data extracted from the electronic medical record included demographic information, date and time of ED visit, chief complaint, laboratory results, and disposition following ED evaluation. Charts were reviewed to determine CD-specific information including disease behavior, disease location, history of abdominal surgery, and current medications. When more than one disease behavior was documented within gastroenterology notes, the predominant phenotype was recorded. Scanned ED documentation provided the vital signs at initial presentation. The type of CT scan, whether contrast was used, and the number of CT scans in the previous 1 month and 6 months were recorded. The findings of the CT scan in the preceding month were also recorded.

All of the study data were collected and managed through the utilization of REDCap (Research Electronic Data Capture), which is a secure, web-based application designed to support data collection for research studies.

Outcomes

Clinically significant CT findings included both non-CD and CD-related results. We defined clinically significant CD-related findings as new or worsening abscess, fistula, stricture, perforation, SBO, or colonic obstruction. The determination of a new finding was made by the first author's review of the radiology reports. If the radiology report did not designate the finding as new, the previous report was used as a comparison. Significant non-CD findings were felt to impact immediate care, but were judged to be unrelated to the underlying CD. Examples of significant non-CD related findings include appendicitis, cholecystitis, diverticulitis, pancreatitis, and pyelonephritis. CT scans with new, worsening, or unchanged

bowel inflammation or improved CD-related findings from prior imaging were not considered to be clinically significant. Incidental findings were defined as results that were unlikely to cause the patient's symptoms, did not require additional ED evaluation, and did not change management or disposition (i.e. admitted vs discharged).

Statistical Analysis

Statistical analysis was performed using SAS statistical software (version 9.2 for Windows, SAS Institute Inc., Cary, NC). A multivariable generalized estimating equation with logit link and exchangeable working correlation structure was used to identify independent predictors of a clinically significant CT scan. This allowed with-in subject correlated data to be taken into account, as several patients had multiple CTs over the study period. All potential predictors were incorporated into the model simultaneously to obtain fully adjusted odds ratios. Predictors evaluated included age, CD location, disease behavior, history of abdominal surgery, medications, temperature, heart rate, WBC, hematocrit (Hct), and CT scan without clinically significant findings the month prior to presentation. To derive clinically meaningful predictors in our models, continuous variables were transformed into categorical variables using clinically relevant cut points as follows: age ≥ 65 versus < 65 , temperature $\geq 100.4^{\circ}\text{F}$ versus $< 100.4^{\circ}\text{F}$, heart rate (beats per minute) ≥ 100 versus < 100 , WBC count $\geq 12,000$ (cells per microliter) versus $< 12,000$, and Hct $\geq 30\%$ versus $< 30\%$. Additionally, to avoid cells with too few observations, isolated perianal and colonic disease were grouped into a single disease location. Similarly, isolated small bowel disease and ileocolonic disease were grouped into a composite variable titled ileal disease involvement. Lastly, because not all patients had a CT scan in the preceding 30 days, a 3 category variable was used in our models, representing no CT scan, CT scan without clinically significant findings, and CT scan with clinically significant findings in the preceding 30 days.

RESULTS

Patient Demographics and ED Visit Information

Between January 2008 and December 2011, we identified 207 ED encounters of patients with CD. There were 194 ED encounters and 118 unique subjects that met the inclusion criteria (Figure 1). The total number of CT scans per patient ranged from 1–9. The baseline patient characteristics are summarized in Table 1. The median age was 49 (25th, 75th percentile: 40, 63) with females comprising 63% of the population. The most frequently observed disease behavior was inflammatory (46%), and the most common disease location was ileocolonic (64%). Sixty percent of patients had a previous CD-related surgery. During the study time period, there were 191 ED encounters of patients with CD with similar presenting symptoms who presented to the ED and did not undergo CT scans.

The characteristics for each ED visit are summarized in Table 2. Abdominal pain was the most common chief complaint (85%), followed by fever (28%) and nausea/vomiting (26%). The most frequently prescribed medications were mesalamines (29%), followed by corticosteroids (22%). Twenty-four percent of patients were not on any medications for their CD at time of presentation to the ED.

CT Scan Findings

Of the 198 CT scans included in the study, 47% had clinically significant findings (Table 3). The majority of the clinically significant findings (97%) were related to CD, with the most frequently observed being SBO (48% of clinically significant CT scans), followed by intra-abdominal abscess (20%). Overall, the presence of bowel inflammation (51%) was the most frequently noted CT finding. In 36 ED encounters (20%), the patient had a CT scan in the month prior to current ED presentation. These previous CT scans were performed in both outpatient and inpatient settings. Sixteen of these 36 CT scans (44%) performed the month prior to current ED presentation had clinically significant findings. There was no difference in the proportion of patients admitted to the hospital with clinically significant CT findings in comparison to patients without clinically significant findings.

The multivariable generalized estimating equation identified independent predictors of a clinically significant CT scan. ESR and CRP were present for less than 20% of observations and were therefore excluded as predictors. Compared to isolated colonic or perianal disease, ileal disease involvement (a combination of small bowel and ileocolonic disease) was a statistically significant predictor of a clinically significant CT scan (OR 3.47, 95% CI: 1.33–9.09). The only statistically significant laboratory value was WBC > 12,000, with an odds ratio of 2.10 (95% CI: 1.08–4.05). Importantly, patients with a CT scan without clinically significant findings in the preceding month were less likely to have a clinically significant CT scan compared to those who either had no CT scan or had a prior clinically significant CT scan in the preceding month (OR: 0.23, 95% CI: 0.08–0.64). A stricturing disease phenotype (OR: 3.11, 95% CI: 0.92–10.48) and anemia (OR: 1.94 95% CI: 0.92–4.08) neared statistical significance.

Discussion

There has been an increase in ED visits by patients with CD of 165% from 1994–1996 to 2003–2006, which has coincided with an increase in CT scans in the ED but without a corresponding increase in diagnosing CD complications.^{3,4} In order to help diagnose CD complications while simultaneously minimizing potential harmful side effects, CT scans should be used more judiciously in patients with CD.^{1,5,14–17,19} Identifying predictors of CT scans with clinically significant findings would help clinicians in the decision-making process.

This is the first study to demonstrate that prior CT scan findings change the pre-test probability of a repeat CT scan. Patients with CD who had a CT scan without clinically significant findings in the prior month were less likely to have a clinically significant finding on the current CT scan (OR 0.23, 95% CI 0.08–0.64). Though physicians may not be comfortable abstaining from ordering a CT, our data support that in certain low risk patients, such as those with inflammatory disease, a normal WBC, and a negative CT scan in the month prior, repeat imaging is likely of little value. Physicians should feel reassured in foregoing repetitive imaging in patients with CD without a clear clinical change.

In patients with CD the percentage of clinically significant CT findings in the literature has varied from 16.8% to 34.5%.^{1,2,13,20} However, we found that almost 50% of patients had a

clinically significant CT finding. This higher incidence is likely due to a more inclusive definition of what constitutes a CD-related CT finding (abscess, fistula, stricture, perforation, bowel obstruction), in addition to including non-CD related findings (i.e. appendicitis, cholecystitis, pyelonephritis, diverticulitis, and pancreatitis).

Our study is important, as only one other study has accounted for patients having multiple ED presentations within the study time period. Accounting for with-in subject correlation is essential, given the frequent nature of health care utilization in this population. Our GEE model identified ileal disease as a new predictor of clinically significant CD-related CT findings. We confirmed that $WBC > 12K$ is a predictor of CD-related findings.¹³ Histories of IBD surgery, previous obstruction, abscesses, as well as African American race, low BMI, hematochezia, ESR/CRP have previously been correlated with clinically significant CT findings.^{2,13,20} In our cohort, ESR/CRP were available in less than 20% of the observations and therefore could not be utilized in our model. Stricturing disease and anemia almost reached statistical significance, and a larger sample size may show these results to be significant as well. Although the percentage of patients taking immunomodulators and biologics was slightly less than other studies, similar to prior studies, CD-related medications were not found to be a predictor of clinically significant CT. Thus, we have identified several novel factors, particularly disease location and previous month's CT findings, which should be included in future predictive models for assessing CT scans in CD. Additionally, the predictive ability of anemia and stricturing phenotype should be evaluated in a larger population.

This study is limited by the inherent nature of a retrospective analysis and is thus subject to residual confounding. We also have not prospectively evaluated the predictive ability of the variables in our model. Additionally, as a tertiary care referral center, our results may not be generalizable, and should be validated at other centers. While the electronic medical record system is comprehensive, data collection was still limited by what tests were ordered. Thus, inflammatory markers, which were ordered in less than 20% of ED encounters, were unable to be included in our study. Additionally, we were unable to create a simple predictive model from these results because removal of non-significant predictors caused loss of significance of the remaining predictors, necessitating use of a full model to obtain unbiased estimates of associations. It most likely represents a confounder that could not be controlled for in this retrospective study design. However, the nature of this study was exploratory, and our statistical methods did account for with-in subject correlated data, allowing us to identify useful predictors that will inform larger validation models.

In conclusion, this study is the first to identify previous CT scan findings as a predictor of clinically significant findings on CT scan. In addition, we detected other novel predictors of clinically significant CT findings, including ileal disease involvement and $WBC > 12K$. These findings, particularly the results of CT scans in the prior month, are readily available to most ED physicians and should be prospectively evaluated as predictors that may assist clinicians in a more directed use of CT scans.

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Abbreviations

5-ASA	5-aminosalicylate
Anti-TNF	anti tumor necrosis factor
BIDMC	Beth Israel Deaconess Medical Center
BMI	Body mass index
CRP	C-reactive protein
CT	Computed Tomography
CD	Crohn's disease
ED	Emergency Department
ESR	Erythrocyte Sedimentation Rate
GEE	Generalized Estimating Equation
HCT	Hematocrit
IBD	Inflammatory Bowel Disease
MRE	Magnetic Resonance Enterography
REDCap	Research Electronic Data Capture
SBO	Small bowel obstruction
WBC	White Blood Cell Count

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Figure 1.
Patient Selection

Table 1

Patient Characteristic

Patient Characteristics:	with significant CT findings	without significant CT findings	N
N	70	66	118
Median Age (25th, 75th quartile)	47 (39,61)	51 (41,64)	49 (40,63)
Sex			
Male	25	20	44 (37)
Female	45	46	74 (63)
Race			
White/Caucasian	59 (84)	55 (83)	100 (85)
African American	6 (8)	9 (14)	12 (10)
Hispanic	2 (3)	1 (2)	2 (2)
Other	3 (4)	1 (2)	4 (3)
Disease Behavior			
Inflammatory	25 (36)	34 (52)	54 (46)
Penetrating	27 (39)	27 (41)	43 (36)
Stricturing	18 (26)	5 (8)	21 (18)
Disease Location			
Ileocolonic	49 (70)	38 (58)	75 (64)
Colonic	9 (13)	17 (28)	22 (19)
Small Bowel	12 (17)	9 (14)	20 (17)
Isolated perianal	0	1 (2)	1 (1)
Perianal Disease	16 (23)	15 (23)	27 (23)
Prior Crohn's-related Surgery ^b	50 (71)	32 (48)	71 (60)
Bowel Resection ^d	47 (67)	29 (44)	65 (54)
Diversion	1 (1)	2 (3)	3 (3)
Abdominal fistula/abscess	8 (11)	9 (14)	13 (11)
Peri-anal fistula/abscess	2 (3)	2 (3)	4 (3)
Median Number of ED Visits (range)	1 (1–7)	1 (1–9)	1 (1–9)

^a. IQR: interquartile Range (25,75)^b. Totals may be greater than 60 percent given multiple surgeries per patient^c. ED: Emergency Department^d. Bowel resection includes both small bowel and colon resections.

^e. Numbers in with and without CT findings columns do not add to total number of patients as there were patients both with and without significant CT findings

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Table 2

ED Characteristics

Characteristic:	with significant CT findings	without significant CT findings	N (%)
N	92	102	194
Median time to CT scan in hours (range)	3 (1–11)	3.5 (0.5–12)	3.5 (0.5–12)
Chief Complaint ^a			
Abdominal Pain	81 (88)	83 (81)	164 (85)
Rectal Pain	5 (5)	1 (1)	6 (3)
Nausea/vomiting	32 (35)	19 (19)	51 (26)
Diarrhea	7 (8)	18 (18)	25 (13)
Constipation	2 (2)	0 (0)	2 (1)
Abdominal Distention	4 (4)	2 (2)	6 (3)
Rectal Bleeding	3 (3)	8 (8)	11 (6)
Melena	0 (0)	0 (0)	0
Fever	10 (11)	18 (18)	28 (14)
Fatigue	7 (8)	4 (4)	4 (2)
Other ^b	7 (8)	13 (13)	20 (20)
Medications at the time of ED presentation ^c			
Oral mesalamine	26 (28)	25 (25)	51 (26)
Rectal mesalamine	2 (2)	0 (0)	2 (1)
Oral Steroids	18 (20)	24 (24)	42 (22)
Steroid Enemas	0 (0)	2 (2)	2 (1)
Antibiotics	12 (13)	12 (12)	24 (12)
Immunomodulators	16 (17)	18 (18)	34 (18)
Anti-TNF	9 (10)	14 (14)	23 (12)
No medications	23 (25)	24 (24)	47 (24)
Vital Signs on presentation to ED			Median (IQR)
Temperature (F)	98.2(97.6,98.8)	98.3 (97.6,99)	98.3 (97.6,99)
Systolic Blood Pressure	126 (112,141)	127 (111,142)	126.5(111.8,141)
Diastolic Blood Pressure	79 (67,88)	74 (64,85)	77 (65.5, 86)
Heart Rate	93 (82,108)	88 (76,106)	90 (79.5, 106)
Respiratory Rate	17 (16,18)	18 (16,18)	18 (16,18)
O2 Saturation	99 (98,100)	99 (8,100)	99 (98,100)
Lab Values on presentation to ED			Median (IQR)
WBC	11.3 (11,14.1)	9.8 (6.7,13.3)	10.4 (7.7,13.5)
Hemoglobin	13.3 (11–14.1)	11.9 (10.3,13.5)	12.5 (10.5,13.9)

Characteristic:	with significant CT findings	without significant CT findings	N (%)
Hematocrit	39.4 (34.2,41.8)	35 (31.1,39.7)	37.4 (32.1,41.1)
Lipase	33 (20,43)	28 (21,37)	30 (21,41)
AST	22 (15,31)	22 (16,31)	22 (15.8,31)
ALT	21 (14,33)	20 (14,28)	21 (14,31)
Alkaline Phosphatase	81 (60,122)	88 (62,123)	83.5 (61.3,122.8)
Total Bilirubin	0.5 (0.3,0.7)	0.4 (0.3,0.6)	0.4 (0.3, 0.6)
ESR	16 (5,46)	12 (9,52)	16 (8,46)
CRP	17.2 (6.3,50.5)	32.4(1.9,52)	27.7 (2.7, 50.6)

^a. Total may be greater than 100 percent given multiple complaints per patient per ED visit

^b. Other chief complaints included decreased ostomy output, alerted mental status, back pain, hematuria, flank pain, headache

^c. Total may be greater than 100 percent given multiple medications per patient

^d. ED: Emergency Department, 5-ASA: 5-aminosalicylate, Anti-TNF: anti tumor necrosis factor, ESR: Erythrocyte Sedimentation Rate, CRP:C-Reactive Protein

Table 3

CT scan Findings

Image Findings	N (% of all CT ordered)
Clinically Significant CD-related Findings ^a	92 (47)
Intra Abdominal Abscess	18 (9)
Stricture	12 (6)
Fistula	17 (9)
Perforation	6 (3)
SBO	44 (22)
Colonic obstruction	1 (0.5)
Clinically Significant Non-CD-related Findings	3 (1.5)
Diverticulitis	2 (1)
Pyelonephritis	1 (0.5)
CD Related Findings (Clinically Insignificant)	
Bowel Inflammation	70 (36)
Other ^b	9 (5)
Incidental Findings	
GYN	1 (0.5)
Nephrolithiasis	2 (1)
Renal Cyst	9 (5)
Adrenal Cyst	3 (2)
Lung Nodule/Opacities	4 (2)
Hydronephrosis	1 (0.5)
Hepatic Abnormality ^c	9 (5)
Pancreatic Abnormality ^d	5 (3)
Other ^e	17 (9)

N= 194

^a. Total may be greater than 100 percent given multiple findings on CT scans^b. Other Included: Sacroilitis, parastomal seroma, parastomal hernia, distention of sigmoid colon^c. Included: cholelithiasis, hepatoma, dilated common bile duct, hepatic hypodensity not further classified^d. Included: Pancreatic duct dilation, pancreatic hypodensity^e. Other included Compression fracture, splenic cyst, splenomegaly, hyperdensity in ureter, hiatal hernia, constipation, adenopathySBO: small bowel obstruction, GYN: gynecology

Table 4

Multivariable Generalized Estimating Equation of Clinically Significant CT scan

Parameter	Odds Ratio	95% CI		P
Patient Demographics				
Age >65	0.97	0.42	2.23	0.94
Crohn's Disease Characteristics				
Ileal Involvement ^a	3.47	1.33	9.09	0.01*
Penetrating ^b	1.02	0.45	2.32	0.96
Strictureing ^b	3.11	0.92	10.48	0.07
Surgical History				
Previous Crohn's-related surgery	1.89	0.86	4.17	0.11
Vital Signs				
Temp >100.4F	0.57	0.18	1.83	0.34
Heart Rate >100 bpm	1.29	0.69	2.41	0.42
Labs				
WBC >12K	2.10	1.08	4.05	0.03*
HCt >30%	1.94	0.92	4.08	0.08
Medications				
Presence of oral or pr steroids	0.65	0.31	1.36	0.25
CT Scan in previous 30 days				
Clinically Insignificant CT	0.23	0.08	0.64	0.005*
Clinically Significant CT	2.27	0.55	9.36	0.26

^a. Compared to isolated perianal or isolated colonic disease, includes both small bowel and ileocolonic disease

^b. Compared to inflammatory disease

WBC: White Blood Cell Count, HCT: Hematocrit