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Crohn's disease: A retrospective analysis between computed tomography enterography, colonoscopy, and histopathology

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ABSTRACT

Introduction: To investigate the spectrum of computed tomography enterography (CTE) findings of active Crohn's disease (CD) in comparison to endoscopic, histopathologic and inflammatory markers.
Methods: Hospital records of 197 patients with known or suspected CD who underwent CTE over a period of 5 years were reviewed. Eighty-nine patients fulfilled the inclusion criteria. Three-point severity scores for endoscopy, pathology, and haematologic inflammatory markers were recorded. The findings on CTE were identified by three readers and correlated with endoscopic, pathologic, and haematologic severity scores. Statistical analysis was carried out employing a Pearson Chi square test and Fisher exact test. Receiver operating characteristic (ROC), visual grading characteristic (VGC) and Cohens' kappa analyses were performed.
Results: The CTE findings which were significantly correlated with the severity of active disease on endoscopy include bowel wall thickening, mucosal hyperenhancement, bilaminar stratified wall enhancement, transmural wall enhancement, and mesenteric fluid adjacent to diseased bowel ($p < 0.05$). Only bowel wall thickening and bilaminar stratified wall enhancement correlated with the pathological severity of active CD. ROC and VGC analysis demonstrated significantly higher areas under the curve ($p < 0.0001$) together with excellent inter-reader agreement ($k = 0.86$).
Conclusion: CTE is a reliable tool for evaluating the severity of active disease and helps in the clinical decision pathway.
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Introduction

Crohn's disease (CD) is a chronic and relapsing inflammatory bowel disease that runs a slow-moving course consisting of inflammatory exacerbation and regression.[1–3] The accurate clinical assessment of CD in identifying the gastrointestinal location, disease activity, and the presence of complications is a challenge. Several studies employed capsule endoscopy, magnetic resonance imaging enterography (MRE) and computed tomography enterography (CTE).[2–4] The American College of Radiology (ACR) appropriateness criteria which is universally employed, demonstrated that CTE and MRE are the most appropriate imaging techniques in the evaluation of an adult patient with known or suspected CD, with each imaging modality being comparable in results.[5]

CTE has emerged as a superior imaging modality from conventional barium studies in the diagnosis and follow-up of patients with suspected or known CD.[6] CTE offers the ability to evaluate the intraluminal as well as the extraluminal abnormalities associated with CD. It can clearly depict inflammatory changes such as wall thickening, stratification, mural (or mucosal) hyperenhancement, vasa recta engorgement (Comb's sign), mesenteric fluid, and complications such as abscess formation and fistulae.[7] It has also been shown to reliably guide changes in management and treatment of patients with CD.[8] However, an updated comprehensive approach

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to computed tomography (CT) findings with endoscopic, laboratory and histologic data has been relatively limited, especially with advances in CT technology over the last decade,[3,9–12] although several studies have correlated the CTE findings with only histopathological findings.[13,14] Most studies have been limited to 16-64 slice CT scanners and well as different magnetic field strengths in magnetic resonance imaging.[15] Nevertheless, CTE as compared to MRE serves as the preferred imaging modality due to superior delineation of bowel involved as well as a better spatial resolution with rapid acquisition.[15,16] The aim of this study is to investigate the spectrum of CTE findings of active CD in comparison to endoscopic, histopathologic and inflammatory markers.

Materials and methods

Study design and population

Our Institutional Review Board approved this retrospective study. One hundred and ninety-seven patients with known or suspected CD who underwent CTE between January 1 2010 and January 1 2015 had their medical records reviewed. Demographic data, colonoscopy findings, histopathological diagnosis, inflammatory blood parameter values and CTE findings were recorded.

Exclusion criteria

Study exclusion criteria were: age below 18 years old, renal insufficiency (serum creatinine >1.3 mg/mL, estimated glomerular filtration rate (eGFR) < 45), pregnancy, lactation, intravenous contrast allergy, growth of enteropathogenic bacteria in stool cultures, positive serologic markers for celiac disease, acute bowel obstruction, use of nonsteroidal anti-inflammatory drugs less than 4 weeks before CT examinations.

Diagnostic and clinical inclusion criteria

Patients with suspected or newly diagnosed CD were included if they fulfilled the clinical, endoscopic, or histologic criteria or any combination of these. Clinically, the patients had diarrhoea and/or abdominal pain either for more than 1 month, or in repeated episodes., These were associated with 1 or more of the following findings: C-Reactive Protein (CRP) > 5 mg/L, thrombocytosis, anaemia, fever, weight loss, perianal abscess/fistula, or a family history of inflammatory bowel disease.

Endoscopic criteria (at least 1)

Ulcerations and/or stenosis in the terminal ileum, inflammation in the colon not involving the rectum, or aphthous lesions in the colon.

Histologic criteria (at least 1)

Epithelioid cell granulomas, chronic inflammation of the colon not involving the rectum, or chronic inflammation in the lamina muscularis mucosae or deeper.

Haematology tests

Serum markers for measuring CD inflammatory activity are CRP and erythrocyte sedimentation rate (ESR). Cut-off values for CRP and ESR were 2.5 mg/L and 15 mm/h, respectively. All values higher than these two cut-offs were labelled as positive.

Endoscopic procedures and histopathology

On the day prior to colonoscopy, patients were allowed to consume an unrestricted breakfast and lunch till 3 pm, followed by a full-fluid dinner until 7 pm. Only clear fluids were allowed after 7 pm. The patients received (a) 4 L (L) of polyethylene glycol solution (PEG) (Fortrans, Ibsen, Paris, France) divided into 2 L consumed from 7 to 9 pm on the day preceding the colonoscopy, and 2 L on the day of the colonoscopy; or (b) 2 L reduced-volume ascorbic acid-supplemented PEG-electrolyte solution (AscPEG) (MoviPrep, Norgine, Harefield, UK) plus 1 L of clear fluids and dose-split over 2 days. This ensured that thre was greater better palatability and acceptability in the success of colon treatment for patients.[17] The first L of AscPEG was consumed at 7pm the day before colonoscopy, and another 1 L of AscPEG plus a minimum of 500 mL of clear fluids on the day of the colonoscopy. Both preparations were completed between 90 min and 4 h before the procedure.

The colonoscopy technique employed a standard video-colonoscopy using conscious sedation or propofol-assisted anaesthesia. It was performed by three gastroenterologists at our institution, each with a minimum of five years' expertise in colonoscopy.

Severity scores for both the endoscopic and histopathological findings on biopsy of the distal/terminal ileum were determined separately by the gastroenterologists and the pathologists, respectively. On endoscopy these were described as; 1: inactive inflammation seen as minimal non-specific mucosal erythema (Fig. 1a), 2: mild active inflammation defined as mild to moderate mucosal erythema with few small mucosal ulcers (Fig. 1b), 3: moderate to severe active inflammation defined as multiple large ulcers with surrounding substantial mucosal oedema and erythema (Fig. 1c). On histopathology, the findings were categorized by the following: 1: no inflammation to mild ileitis defined as the presence of mild neutrophilic infiltrate in the surface epithelium and congested capillaries in the lamina propria (Fig. 2), 2: moderate ileitis defined as the presence of moderately higher neutrophilic infiltrate in the surface epithelium and congested capillaries in the lamina propria with or without the presence of crypt abscesses (Fig. 3), 3: severe ileitis defined as abundant neutrophilic infiltrate, congested capillaries in the lamina propria, and ulceration (Fig. 4). Note that the presence of ulceration, regardless of the cellular composition of the tissue, classifies the finding as severe activity.

CTE procedures

Patients fasted for at least 6 hours prior to the examination; this was to decrease the possibility of misinterpreting a foreign body as a polyp or tumor. Patients then ingested three 450-mL (mL) bottles of neutral contrast agent (VoLumen; Bracco Diagnostics, Princeton, NJ) over a 45-min period (total of 1350 mL) On entering the CT scan table, the patients ingested an additional 225 mL of water to adequately distend the stomach and duodenum. Patients were given 20 mg of Buscopan (Butylscopolamine) intravenous 5 minutes prior to the CT acquisition provided that no contraindications for this drug existed. This served to relax and better distend the small bowels.

Single-phase CTE studies were performed employing either a 256 multi-detector CT scanner (Philips Brilliance iCT, Philips Healthcare, The Netherlands) or 64-channel scanner (Somatom Sensation 64; Siemens Medical Solution, Erlangen, Germany). The 256-slice scan parameters throughout the studies were as follows: detector width of 256 × 0.625 mm, pitch of 1.08:1 ratio, rotation time of 0.27 s, 120 kVp, 200 mA, with x,y and z-axis modulation (DoseRight), and scanning time of 6.1 s. The 64-slice scan parameters were: detector width of 64 × 0.625 mm, pitch of 0.981:1 ratio,

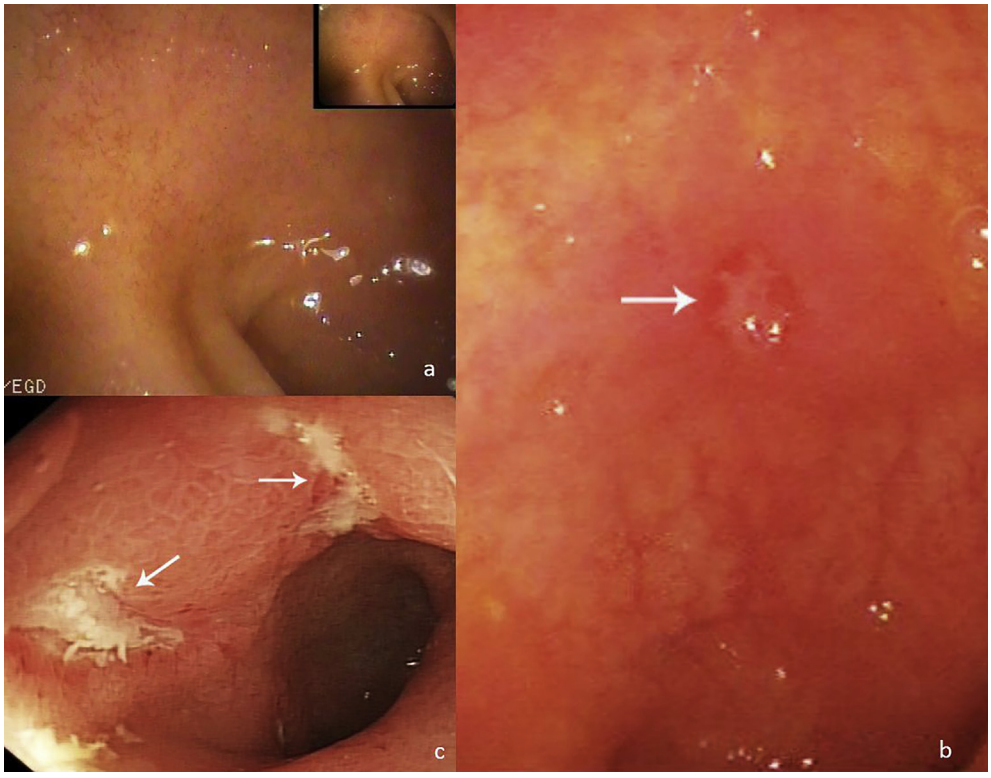

Figure 1. (a–c) demonstrate the endoscopic findings in patients with (a) inactive inflammation with mild non-specific mucosal erythema in the terminal ileum, (b) mild active disease with tiny ulcer and surrounding erythematous mucosa (arrow) in the terminal ileum, and (c) moderate to severe active inflammation with multiple large ulcers (arrow) in the ileum with mucosal edema and erythema.

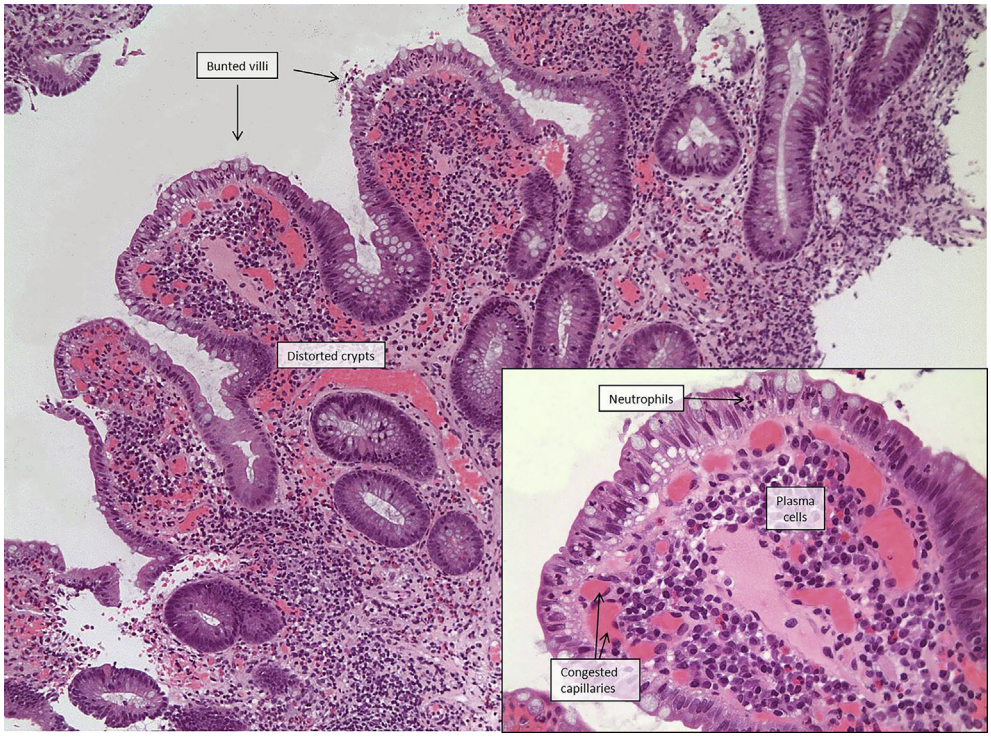

Figure 2. Endoscopic biopsy of the small bowel; H&E, 200×, magnified box 4-00x: small bowel mucosa showing acute on top of chronic inflammation. The acute inflammation is mild and is characterized by a mild neutrophilic infiltrate in the surface epithelium (*arrows*) and congested capillaries in the lamina propria (*asterisks*).

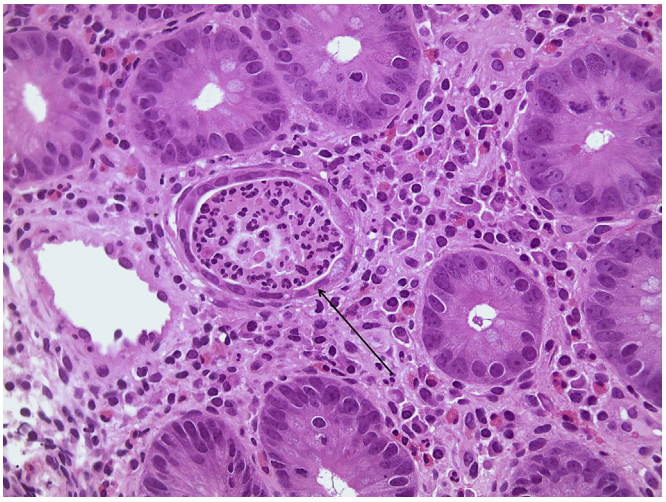

Figure 3. Endoscopic biopsy of the colon; H&E, 400x: a crypt abscess is seen (*arrow*) within the colonic mucosa, indicating at least moderate inflammatory activity.

rotation time of 0.27 s, 120 kVp, 200 mA, with x,y and z-axis modulation (CareDose 4D), and scanning time of 5.4 s.

Through a 22-gauge venous catheter placed in the right brachiocephalic vein, contrast material was injected with an automated dual barrel power injector (Optivantage, Mallinckrodt, Cincinnati). Low dose axial scanning was done 45 s after the initiation of intravenous contrast administration, with craniocaudal scan direction. A maximum of 100 mL of contrast media (Optiray, Mallinckrodt, Cincinnati), intravenously injected at a flow rate of 4 mL/s followed by 100 mLs of saline at 4 mL/s.

Image Reconstruction parameters were set: Transaxial and coronal images were reconstructed with 0.625 mm slice thickness (0.5 mm increment) using a smoothing convolution kernel (field of view 380 × 380 mm, image matrix, 512 × 512), reconstruction interval of 0.5 mm, field of view of 350 × 350 mm, and an iterative reconstruction technique software (iDose[4]; Philips Healthcare, Cleveland, OH) with a window width and level of 350 and 50, respectively.

Examination interpretation and comparison

The multi-reader analysis consisted of three radiologists (N.K, O.G and M.A) with a mean of 10 ± 8.3 years' experience. Eighty-six complete cases were chosen from the study that had underwent endoscopic, laboratory, and histopathological findings as well as an additional 14 cases that had confirmed CD, totalling 100 cases which were not revealed to the interpreting radiologists. Readers viewed images in a single sitting and were permitted to manipulate the window and level of the images. Each reader indicated the locations of suspicious findings and provided a decision confidence level from 1 to 3 where 3 indicated that pathology was definitely present and 1 represented pathology definitely not present. Images were reviewed using a reporting workstation (IMPAX 6.3.1, AGFA) with a GSDF-calibrated 3 megapixel monitor. Each radiologist recorded the following criteria: (a) the presence and location of abnormal wall hyperenhancement including stratified mural hyperenhancement with no wall thickening (Fig. 5a), wall thickening with increased mucosal enhancement and submucosal edema (bilaminar stratification; Fig. 5b), wall thickening with increased mucosal and serosal enhancement (trilaminar stratification; Fig. 5c) with either submucosal edema or fat, thickened wall with transmural enhancement (Fig. 5d); and presence of strictures which are defined as narrowed lumen of the affected bowel segment with dilatation of the proximal loop (Fig. 6a). The following extraluminal abnormalities were also reported:

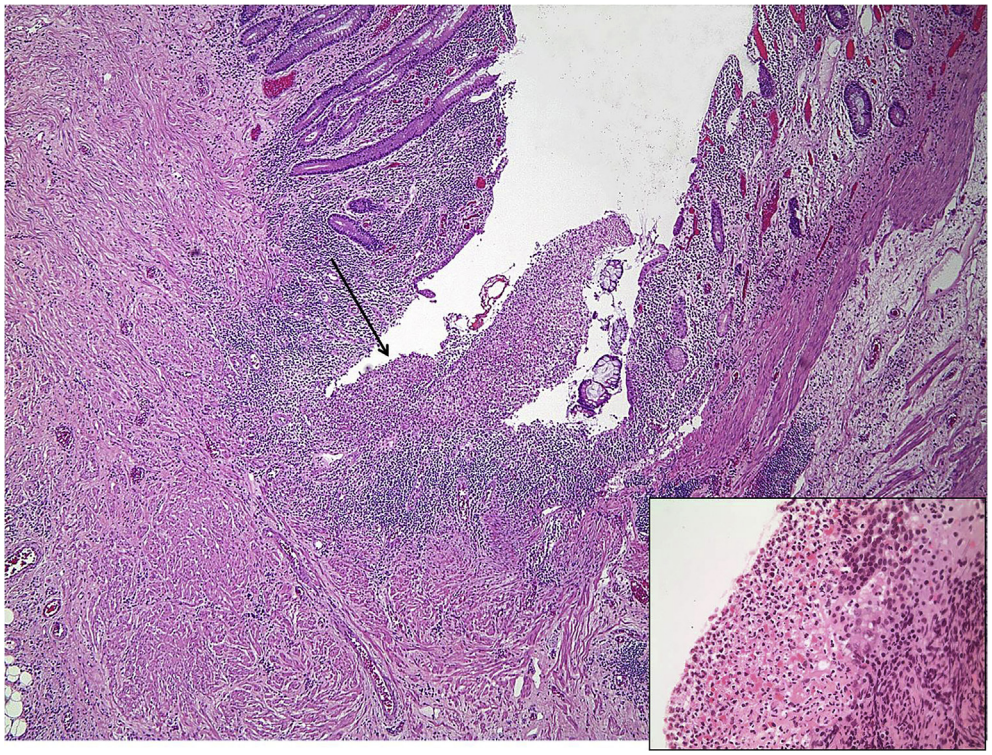

Figure 4. Bowel resection specimen; H&E, 20x: a fissuring ulcer is seen *(arrow)* in the mucosa of the small bowel. Presence of this ulcer is indicative of severe inflammatory activity. Magnified box a400x: fibrinopurulent exudate from the ulcer bed.

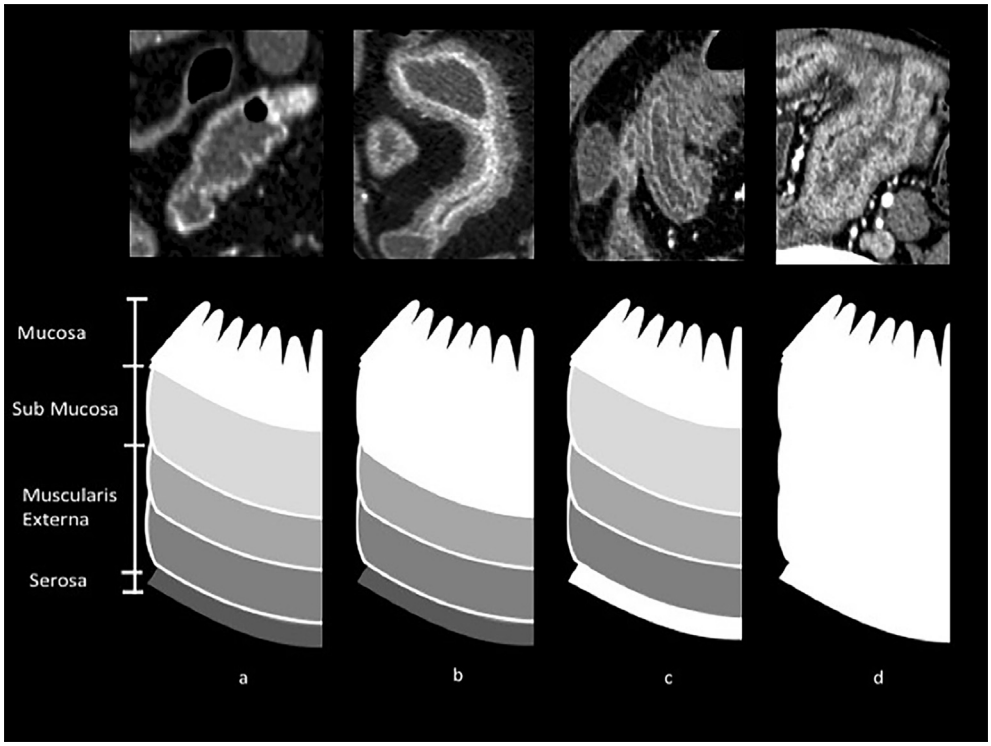

Figure 5. (***a***) diagram illustrating the different layers of the bowel wall, illustrating the pattern of mucosal enhancement *right* mucosal enhancement without significant bowel wall thickening as seen on CTE, (***b***) diagram illustrating the pattern of enhancement of the bowel wall in bilaminar stratification *right* bilaminar enhancement of the bowel wall as seen on CTE., (***c***) diagram illustrating the pattern of enhancement of the bowel wall in trilaminar stratification *right* trilaminar enhancement of the bowel wall as seen on CTE, (***d***) diagram illustrating the pattern of transmural enhancement of the bowel wall *right* transmural enhancement of the bowel wall as seen on CTE.

prominent vasa recta (comb's sign, Fig. 6b), adjacent mesenteric fluid (Fig. 7a–c), abscess/phlegmon formation either within or outside the bowel wall (Fig. 7d), fistula tracts (Fig. 8a–b), ascites, and sacro-iliitis (Fig. 8c).

Visual grading assessment

The visual grading characteristic method was used to illustrate viewer preference based on the quality of the small bowel wall.

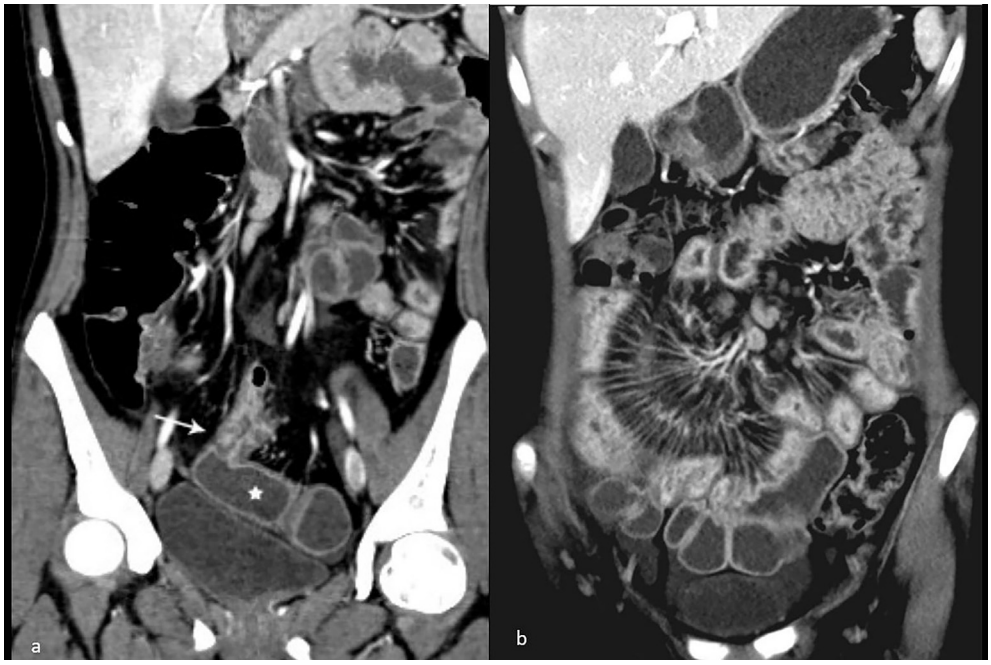

Figure 6. **(a)** 21 year-old woman coronal reconstruction through the abdomen and pelvis showing an ileal stricture (arrow) with proximally dilated bowel loops (star) in the mid-pelvis with bilaminar stratification of the bowel wall, **(b)** 30 year-old woman: coronal reconstruction through the abdomen and pelvis showing congestion of the vasa recta (Comb's sign) with transmural enhancement and diffuse thickening of the bowel wall.

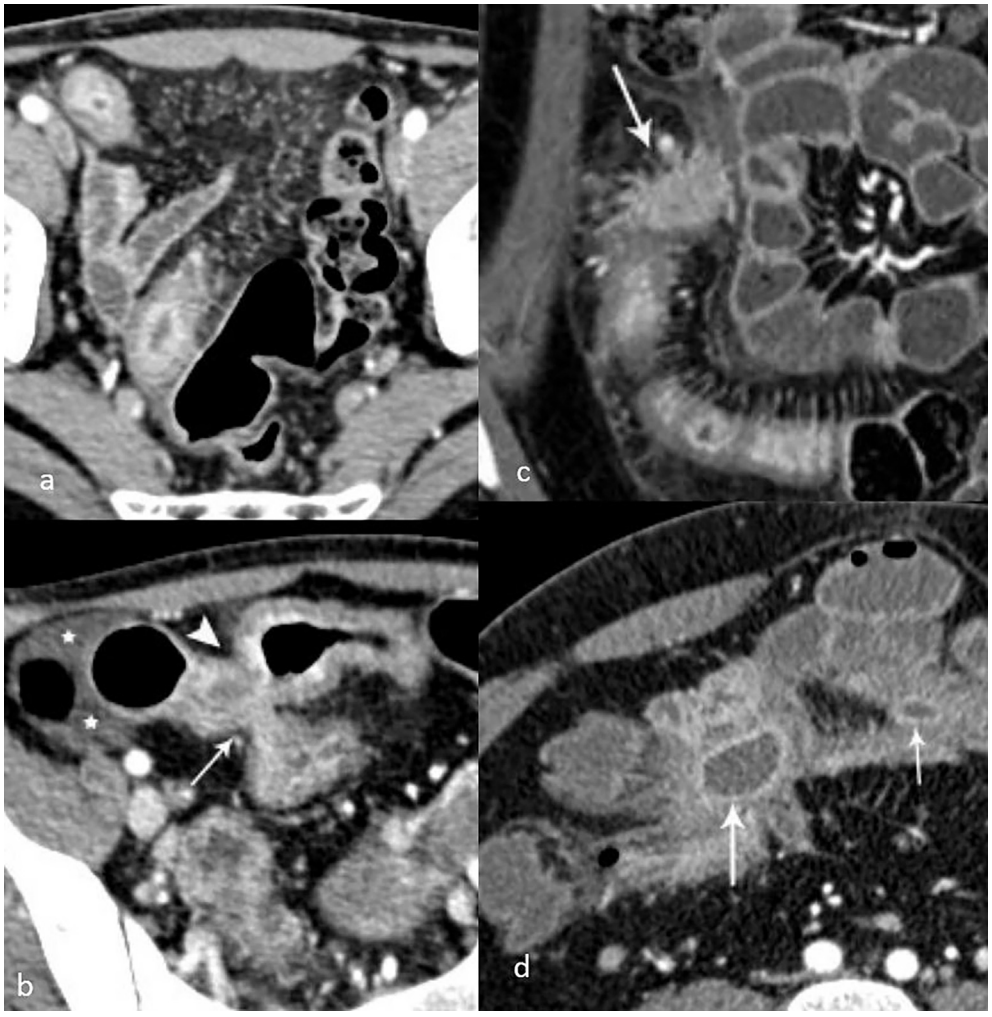

Figure 7. **(a)** 36-year-old male: axial cut through the pelvis showing mesenteric fat streaking adjacent to an inflamed bowel wall with bilaminar stratification and prominence of the vasa recta; **(b)** 21-year-old female: axial cut through the pelvis showing extraluminal fluid collection (stars), ileo-ileal (arrowhead) and ileo-colonic (arrow) fistula formation, and bilaminar stratification of the bowel wall; **(c)** 17-year-old female: coronal cut through the abdomen and pelvis showing phlegmon formation (arrow) near significantly inflamed bowel segments, with prominent vasa recta, bowel wall thickening and bilaminar stratification; and **(d)** 40-year-old male: axial cut through the lower abdomen showing abscesses formation (arrows) adjacent to severely inflamed bowel wall with complex fistula tracts.

Specifically, for this work, confidence levels from 1 to 3, where 3 indicated excellent visualization of bowel wall, while 1 indicated poor visualization.[18,19]

Statistical analysis

The different findings on CTE were identified, evaluated, and separately correlated to the previously determined severity scores, endoscopy, histopathology, and to the inflammatory markers looking for significant associations. Statistical analysis was carried out using a Pearson Chi square test and Fisher exact. Results were considered statistically significant if $p \leq 0.05$.

The ROC analyses employed the Dorfman-Berbaum-Metz approach using readers as random and cases as fixed. Cases were treated as fixed on the basis that the limited image sample size was not taken as a representative of all images. Images were blinded to readers and truth was correlated against the histopathology and colonoscopy results. Inter-observer agreements were calculated using Cohen's kappa analysis. Excellent, moderate, fair, and poor agreements were defined with *k* values of 0.60–1, 0.41–0.60, 0.21–0.40, and <0.20 respectively.

Results

One hundred and ninety-seven consecutive patients underwent CTE for suspected CD between January 2010 and January 2015. Of these, only 89 patients fulfilled the study criteria. Of those 89 patients, 65 had already been diagnosed, and the remaining 24 patients had been undergoing investigation for suspected CD which were then confirmed. Sixty-seven patients had undergone endoscopy with reports on record available for review. Fifty-six patients had a positive histopathological sample either by endoscopy ($n = 53$) or surgical resection ($n = 3$). For the 11 patients with endoscopy but no corresponding biopsy, the purpose of the procedure was to follow-up on the gross intestinal mucosal changes, as recommended by the patients' clinicians. All endoscopic procedures were performed within one month of the CTE study (mean 10 days with a range of 1–30 days). Seventy-six patients had inflammatory marker (ESR/CRP) levels.

Patient demographics

Patients' age ranged from 18 to 74 years (mean = 40.8 years). There was equal distribution between males ($n = 44$) and females ($n = 45$) ($p > 0.05$).

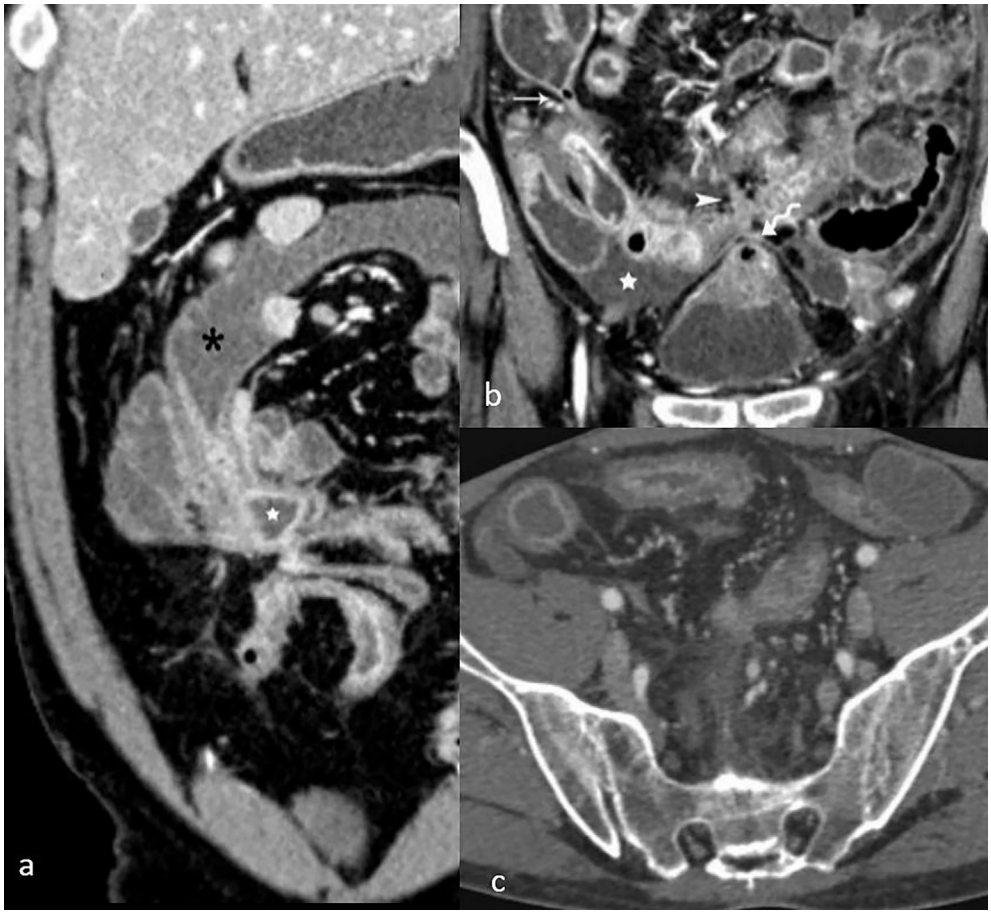

Figure 8. **(a,b)** 35-year-old male: **(*a*)** coronal cut through the abdomen and pelvis showing complex ileo-ileal and ileo-colonic fistulae formation with intervening abscess (star). The transverse colon (asterisk) is pulled and dilated due to scarring and stricture; **(*b*)** coronal cut through the abdomen and pelvis showing complex ileo-ileal (arrowhead), ileo-colonic (arrow), and ileo-vesical (curved arrow) fistulae formation with adjacent extraluminal fluid accumulation (star) and bilaminar bowel wall stratification. There is an intra-vesicular pocket of air with bladder dome thickening associated with the ileo-vesical fistula; and **(c)** 40-year-old male: axial cut at the level of the sacro-iliac joints, showing advanced bilateral sacroiliitis with joint fusion. Note is made in the abdomen of prominent vasa recta, with thickening and bilaminar stratification of the bowel wall.

CTE, endoscopy and histopathology

On CTE images, inflammation was found in the terminal ileum in 81 patients (91%). Eight patients had other identified affected segments including sigmoid colon, jejunum, and the ileo-colic anastomosis in patients with previous bowel resection. The length of the affected segments ranged between 1.2 cm and 40 cm with a mean of 9.2 cm.

Mild disease (severity score 1) was found in 9 colonoscopies and on 4 pathology reports. Mild to moderate disease (severity score 2) was found in 53 colonoscopies and on 40 pathology reports. Moderate to severe disease (severity score 3) was found in 5 colonoscopies and on 12 pathology reports. The disease severity on colonoscopy was significantly associated with the following CTE findings: mucosal hyperenhancement ($p = 0.01$), bowel wall thickening ($p = 0.01$), bilaminar stratification ($p = 0.02$), transmural enhancement ($p = 0.04$), and adjacent mesenteric fluid ($p = 0.02$). The disease severity on histopathology was significantly associated with the following CTE findings: bowel wall thickening ($p = 0.004$) and bilaminar stratification ($p = 0.04$). Finally, six patients had colonoscopy results without pathology reports but were known cases of CD with remote pathology proven disease. Laboratory values of CRP and/or ESR were present for 76 patients among whom 63 patients had high values suggesting active inflammation. No statistically significant relation could be found between any CTE finding and the presence of increased levels of CRP and/or ESR. Moreover, concomitant conditions that might be responsible for the inflammation were not individually identified in each patient.

Table 1 summarizes all our data and shows the relation of each CT finding to the pathology scores, endoscopy scores, and level of inflammatory markers.

Image evaluation

Receiver operating characteristic – the three-point scale demonstrated a significant difference ($p = 0.0001$) between protocols with mean ROC values demonstrating increased reader confidence in CTE compared to histopathology and surgical specimens with the area under the curve reaching 0.938 with reader confidence at 1.0 (Fig. 9a).

Visual grading characteristic - the three-point scores individually graded by the three readers for the CTE scan. The graphs clearly demonstrate that when the small bowel is well dilated, bowel wall enhanced, and reduced quantum noise demonstrates preference to excellent image quality over good image quality ($p = 0.0001$) (Fig. 9b).

Kappa analysis – the CTE protocol yielded excellent inter-observer agreement ($k = 0.86$). There was a strong positive relationship between mean bowel wall visualization and

Table 1
Associations between different CTE findings and inflammatory markers, colonoscopy and pathology scores.

	CRP/ESR +	*p*	Col 1	Col 2	Col 3	*p*	Path 1	Path 2	Path 3	*p*
Mucous hyperenhancement	96.8	0.5	67	98	100	0.01	4	39	100	0.8
Bowel Wall thickening	82.5	0.9	22	89	80	0.01	25	88	91.7	0.004
Bilaminar enhancement	57.1	0.8	0	60	80	0.02	0	63	66.7	0.04
Trilaminar enhancement	1.6	0.6	0	9	0	0.7	0	3	8.3	0.5
Transmural enhancement	49.2	0.08	22	59	20	0.04	25	53	58.3	0.5
Stricture	49.2	0.4	22	53	60	0.02	25	58	58.3	0.4
Combs Sign	55.6	0.5	22	59	60	0.1	25	58	58.3	0.4
Adjacent fat	49.2	0.08	33	43	80	0.2	75	50	25	0.1
Adjacent fluid	23.8	0.1	0	19	60	0.02	25	28	0	0.1
Ascites	14.3	0.5	0	11	0	0.4	0	13	8.3	0.7
Abscess/phlegmon	15.9	0.4	11	11	40	0.1	0	18	8.3	0.5
Fist/sinus	17.5	0.1	11	13	40	0.2	25	15	8.3	0.6
SI	20.6	0.4	9	53	20	0.9	0	33	8.3	0.1

Note: Col = Colonoscopy and Path = Histopathology, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate.

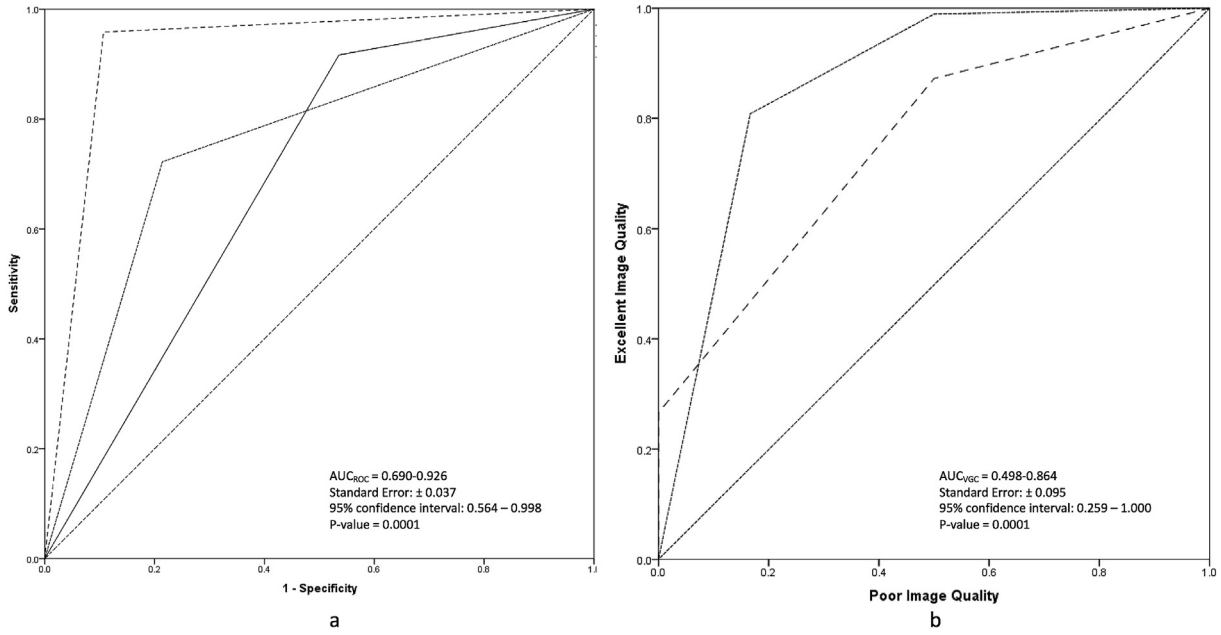

Figure 9. **(a)** ROC curve and **(b)** VGC curve. Each curve demonstrates significant increases in the area under the curve and 95% confidence intervals.

histopathology findings with excellent image quality and reader confidence ($r = 0.51$, $p < 0.001$).

Discussion

CTE, as well as MRE, is a well-established technique in the evaluation of CD. CTE has a high sensitivity and specificity for the detection of active small intestinal inflammation that has shown a better interobserver agreement with an improved spatial and contrast resolution when compared to MRE.[20] When employing neutral contrast agents, intestinal manifestation on the bowel wall and mucosa have enabled increased reader confidence and given accurate detection of inflammation processes. In contrast to endoscopy, it also evaluates the extramural manifestations involving the adjacent mesentery and fat, and depicts most of the disease complications including fistulas, abscesses and strictures.[16,21] Importantly, differentiating active CD from non-active disease requires significant experience in radiological interpretation.[22,23]

In the current study, all possible enteric and extra-enteric findings of CD on CTE were described, however, the presence of adenopathy was not included due to the low specificity of this finding and the controversy surrounding the definition of pathological lymph nodes. Bilaminar stratification was strongly correlated with CD severity on both endoscopy and histology. This can indicate that the low intramural attenuation part of this pattern is mostly related to the presence of edema, which is in turn related to the activity of CD.[24] However, these radiological patterns are not unique to CD as they [18] are also present in other conditions such as radiation enteritis and graft versus host disease.[25]

The correlation between the intra-intestinal findings of mural hyperenhancement and bowel wall thickening and the severity of CD on endoscopy and histopathology, were in concordance with recent studies, although most correlations were found with endoscopy and some were able to demonstrate this correlation with histology.[9–11,21] As for the extra-enteric complications in our series, the presence of inflammatory strictures and adjacent fluid was significantly indicative of the disease severity only in relation to endoscopic scores and not histology. The study could not demonstrate any significant statistical correlation between the severity of CTE findings and inflammatory blood markers, as demonstrated previously by Solem et al..[26]

There are emerging technologies in imaging that have assessed the bowel wall in CD such as dual energy/source CT,[27] dual layer monochromatic energy,[28] and iodine mapping.[29] These modalities are superior to nuclear imaging such as PET/CT since they as they visualize active disease and the presence of extra-intestinal complications such as strictures, abscesses, and fistulae. Nevertheless, these technologies have only demonstrated that iodine quantification can be used in distinguishing normal small bowel from active inflammatory CD.[30] But, the ability to investigate the value of these techniques in grading and monitoring CD has many limitations to date with the only imaging grading system being developed for MRI only.[31] Therefore, CT is still gaining momentum in its clinical utility as a stand-alone modality, however, when correlated with colonoscopy, histopathology and inflammatory bowel markers, further studies in iodine quantification within the bowel wall before, during and after treatment require large scale studies to prove this.

There were limitations in our study. While reviewing our patients' records, there was subjective variations in history taking. Laboratory values of CRP and ESR were not present in all patients (n = 13). Also, some of these patients had been referred to our institution for imaging and endoscopy/biopsy only. Therefore, in these cases it was difficult to reliably correlate clinical presentation to imaging findings. Endoscopy procedures were performed by three different gastroenterologists that could result in reporting variations. Also, no real-time tapes of the procedures were available, which restricted our analysis to the reports and endoscopic images taken at the time of the procedures. Pathologically, the limitations lie in the biopsies themselves: CD is characteristically patchy, whereby there are discrete areas of involvement that are separated by areas of perfectly normal bowel. This makes the possibility of endoscopic sampling normal tissue in a diseased bowel likely.[32] Therefore, not all patients with CTE had all the other laboratory, endoscopic, and pathologic examinations available for inclusion in the analysis. Finally, mural enhancement was not quantified of the affected segments, instead, employing qualitative description of the bowel wall hyper-enhancement in relation to the normal segments. This can possibly weaken the association of our findings with the activity of CD.

Conclusion

Crohn's disease is a chronic inflammatory disease with recurrent flares which necessitates frequent monitoring. Sparing the patient disease exacerbation can be achieved with regular follow-ups and early identification of progression. Inflammatory blood markers provide information on disease activity, however, their long half-life and non-specificity make them less reliable.[33] While there was no association between CTE findings and inflammatory blood markers, bowel wall thickening with bilaminar stratification on CTE were significantly associated with severe CD as manifested on both endoscopy and histopathology. Moreover, recent studies are showing superiority of CTE for longitudinal disease monitoring, as it allows a reliable prediction of disease progression or regression.[34,35] Therefore, an update of the CTE criterion is being proven to be more and more a reliable tool for the evaluation of disease activity that can be employed for clinical decision making, sparing the patient the burden of flares and subsequent diagnostic workup.

Conflict of interest statement

None.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was waived as this was a retrospective study.

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