



Egyptian Society of Radiology and Nuclear Medicine
The Egyptian Journal of Radiology and Nuclear Medicine

www.elsevier.com/locate/ejrnmm
www.sciencedirect.com



ORIGINAL ARTICLE

Crohn's disease: Activity, complications and treatment. Evaluation using MDCT enterography and endoscopy

Ahmad Hafez Afifi ^{a,*}, Mohamad Ibrahim Kassem ^b

^a *Radiology Department, Alexandria University, Egypt*

^b *GIT Surgery Department, Alexandria University, Egypt*

Received 21 June 2012; accepted 10 July 2012

Available online 10 August 2012

KEYWORDS

Gastrointestinal;
 Small bowel;
 MDCT;
 Crohn's disease;
 Activity;
 Complications

Abstract Activity of small bowel inflammatory disease, mainly Crohn's disease had traditionally been a challenging task for radiologists and gastroenterologists. Conventional radiologic and endoscopic evaluations are frequently hindered by the length and caliber of small bowel loops. Conventional CT plays a significant role in the evaluation of extraenteric manifestations of small bowel disease, although it has a limited role for depicting bowel wall and luminal abnormalities. With the development of CT enterography, evolving new methods for evaluating the small bowel mucosal and submucosal abnormality were considered a byproduct of the recent advances in multidetector-row CT (MDCT) technology. Endoscopic correlation with imaging modalities are complementary tools for the final diagnosis of activity and complications of Crohn's disease.

Our purpose was to evaluate retrospectively the effectiveness of CT enterography for the assessment of the activity as well as diagnosing complications of Crohn's disease in 25 patients with a complementary role determined by colonoscopy with intubation of the terminal ileum and correlate with disease progression or regression and its treatment.

© 2012 Egyptian Society of Radiology and Nuclear Medicine. Production and hosting by Elsevier B.V. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Crohn's disease is a trans-mural inflammatory process that can extend to surrounding peri-enteric fat and mesentery and com-

monly affect the small bowel in 70% of the patients where 1/3 of these cases show lesions limited to the ileum (1).

The classic clinical presentations of Crohn's disease include abdominal pain, diarrhea, and weight loss, usually following a chronic relapsing course, with individual differences in the type and severity of symptoms (2). Complications include bleeding, obstruction, strictures, abscesses, and fistula formation (2,3).

In the past, radiological diagnosis of Crohn's disease in the small bowel was via barium examinations with confirmation of the diagnosis using endoscopy. Conventional endoscopy, although providing a direct view of the mucosal surface, is limited to the proximal small bowel or to the distal terminal ileum (in which case it is termed ileoscopy). Ileoscopy is further

* Corresponding author. Tel.: +20 203 5459009; fax: +20 203 5413710.

E-mail address: a_hafez73@yahoo.com (A.H. Afifi).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.



Production and hosting by Elsevier

compromised by the occasional inability to reach the cecum or intubate the ileum during colonoscopy (4).

Although barium small bowel follow-through can effectively depict transmural disease, it may be hindered for depicting mild or early disease, such as aphthous ulcers or other subtle mucosal abnormalities, in such cases direct visualization of the mucosal surface using endoscopy is crucial (4).

Newer techniques, such as capsule endoscopy and multi-detector computed tomography (MDCT) enterography, have the ability to provide a complete small-bowel evaluation. CT enterography has the ability to depict subtle findings in Crohn's disease such as mucosal hypervascularity or mild wall thickening, which are not depicted by standard barium examinations. Also evaluation of the surrounding mesenteric fat planes for stranding and fat proliferations and the assessment of enlarged draining lymph nodes is evaluated superiorly with CT enterography (5,6).

Computed tomography (CT) has traditionally been used to assess extra-enteric complications such as abscess, fistula, or obstruction. Additionally, CT is a promising tool in the assessment of the disease activity and follow up after initial treatment (7).

2. Materials and methods

Fifty CT enterography examinations done for 25 patients with known or suspected Crohn's disease were retrospectively evaluated by a radiologist who was blinded to the clinical history. The examined patients who agreed to participate in the study and provided with informed consent (met the study criteria) were enrolled. There were 15 women and 10 men; their ages ranged from 20 to 55 years (mean, 45.2 years) who were referred to the outpatient clinic of GIT surgical department then subsequently referred to the Radiology Department in the Main University Hospital of Alexandria, Faculty of Medicine.

One radiologist determined whether imaging findings of Crohn's disease were present and, if so, whether the findings progressed, regressed, or remained stable with consecutive follow up examinations. CT enterography findings were then compared with disease progression or regression based on symptoms and clinical follow up. Direct comparison of CT enterography and endoscopy was also performed.

Inclusion criteria: included a known or suspected diagnosis of Crohn's disease based on pathologic or endoscopic findings, consent from all patients to use medical records for research, ileo-colonoscopy with intubation of the terminal ileum, age of at least 18 years, and two contrast-enhanced CT enterography examinations between March 2009 and March 2012, and a minimum 2-week clinical follow-up after the second CT enterography.

Exclusion criteria: included pregnancy, renal insufficiency (high serum creatinine levels of 2 mg/dl or greater), and documented reaction to iodinated contrast material.

2.1. CT enterography technique

All patients who underwent CT enterography were used to taking nothing by mouth for 6 h before scanning, then ingested a total of 1,350 mL of oral water as a neutral contrast material mixed with mannitol (sorbitol) over a 60-min period as follows:

- Four hundred and fifty milliliters during the first and second 20 min (60,40 min before scanning) then 225 mL during the third 20 min (20 min before scanning) and lastly 225 mL on CT table.

Patients were scanned on a 16-MDCT scanner (Sensation 16, Siemens Medical Solutions). Glucagon (0.5 mg) was given IV immediately before scanning, and 150 mL of IV contrast material (iohexol; Omnipaque, GE Healthcare) was given at a rate of 4 mL/s. Single-phase scanning during the enteric phase was performed after a 45-s delay. Section thickness used was 3 mm and the reconstruction interval was 1.5 mm. Coronal reconstructions were performed at 3-mm-thick sections every 3 mm.

One radiologist with expertise in abdominal imaging, who was blinded to presenting symptoms and endoscopic results, reviewed all CT enterography exams and recorded any imaging findings of Crohn's disease that were present in the small bowel or colon.

Findings consistent with Crohn's disease included mucosal hyperenhancement, bowel wall thickening > 3 mm or complications such as bowel strictures, fistula, or abscess. While still blinded to clinical history and endoscopy results, the same radiologist then compared CT enterography examinations for each patient to determine whether imaging findings progressed, regressed, or remained stable between examinations. The location of the disease was also recorded (colon, small bowel, or both).

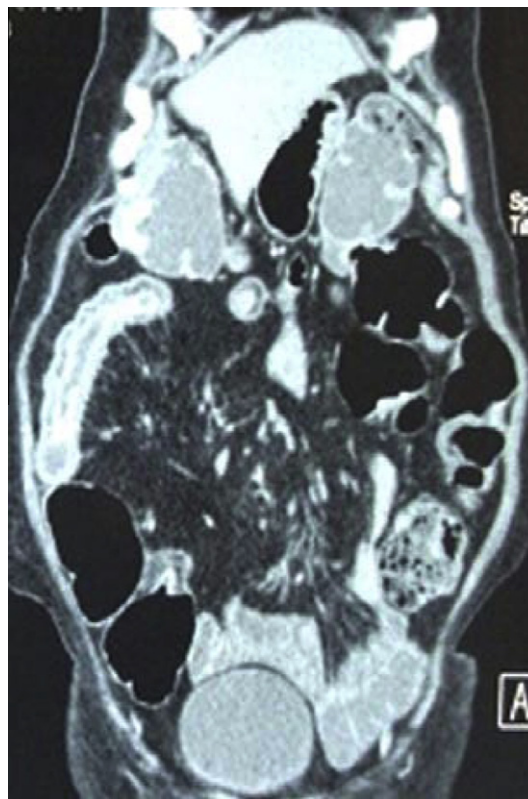


Fig. 1 Coronal CECT showing typical features of Crohn's disease as enhanced thickened mucosa, submucosal edema (mural stratifications), extraenteric fatty proliferation (Creeping fat sign) and engorged mesenteric LN.(Comb's sign).

CT enterography criteria used to determine the presence of active Crohn's disease included mucosal hyperenhancement, mural stratification, and mesenteric fat proliferations, stranding and engorged vasa rectae (Comb's sign). Mucosal hyperenhancement was defined radiologically as segmental hyperattenuation of the bowel wall (when absent mural stratification) compared with other normal loops or of enhanced inner aspect (mucosa) of the bowel wall (when present mural stratification). Figs. 1–3.

Comparison must be between bowel loops of the same region as well as of same degree of distention.

Endoscopic small bowel examination criteria determining active Crohn's disease included aphthous ulcers, fold thickening, linear ulcers and cobblestone pattern, and luminal stenosis with ulceration.

2.2. Interpretation of the MDCT enterography images

Axial images better to assess closely apposed small bowel loops and inter-loop abscesses,

Coronal images allowed a global view of the small bowel, helped to identify the terminal ileum and assess the length of involved segments and may help to identify and localize fistulas,

Sagittal images particularly helpful in evaluating the rectum and in detecting fistulas,

Coronal maximum intensity projections are helpful for visualizing perienteric mesenteric stranding and engorged vasa recta, and for evaluating vascular structures.

2.3. Clinical symptoms and follow-up

We used an electronic clinical database to record the presenting symptoms at the office visit before each CT enterography. Symptoms included abdominal pain, diarrhea, rectal bleeding, weight loss, nausea, and fever. A gastroenterologist with expertise in inflammatory bowel disease, who was blinded to CT enterography results, reviewed the clinical notes to determine whether symptoms had progressed, regressed, or remained

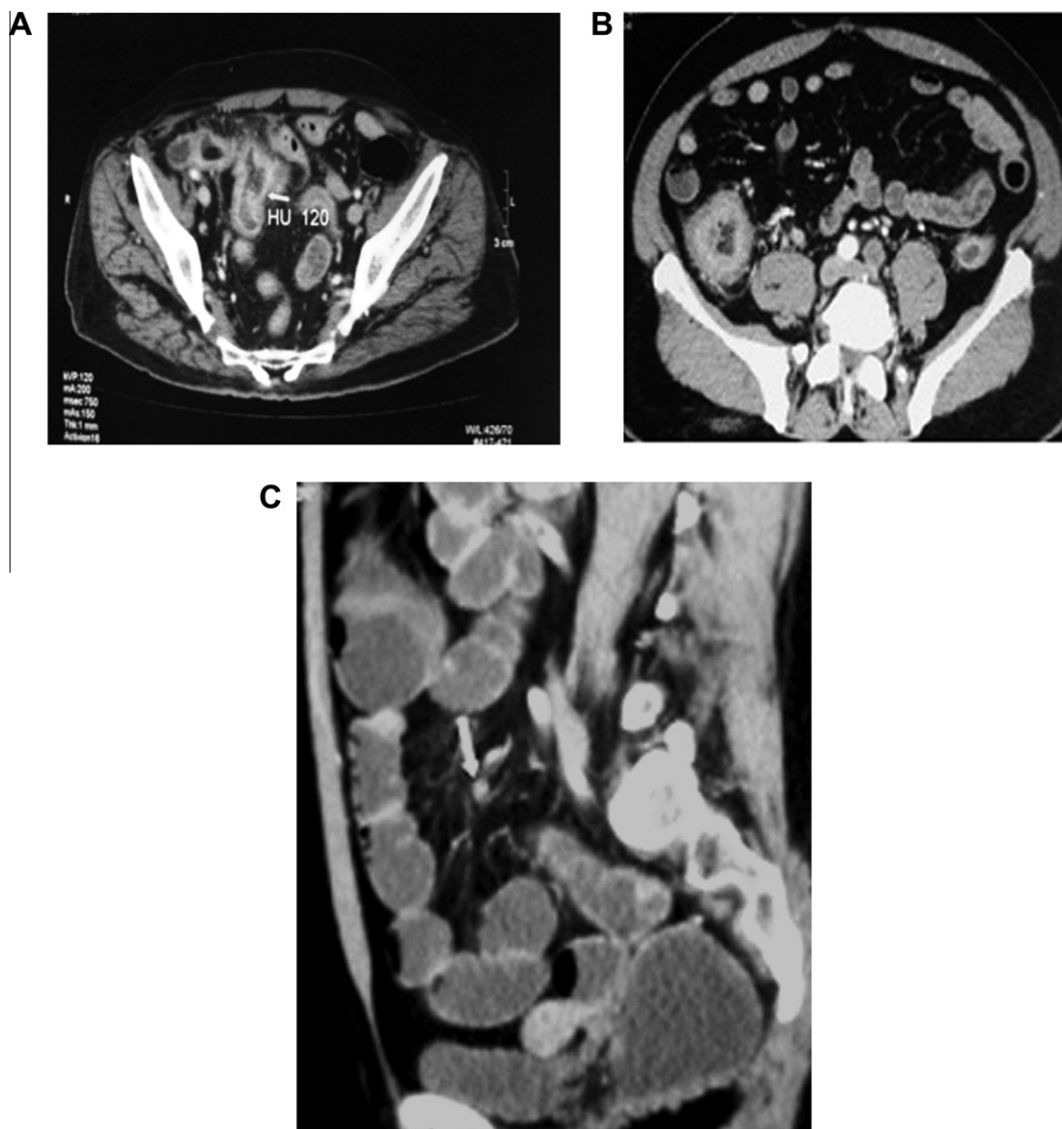


Fig. 2 A,B axial CECT and C sagittal CECT) revealed (A) sure signs of activity as attenuation value of enhancing mucosa 120 HU, (B) increased wall thickness of affected segment 6 mm, and (C) engorged mesenteric vessels and reactive adenopathy.

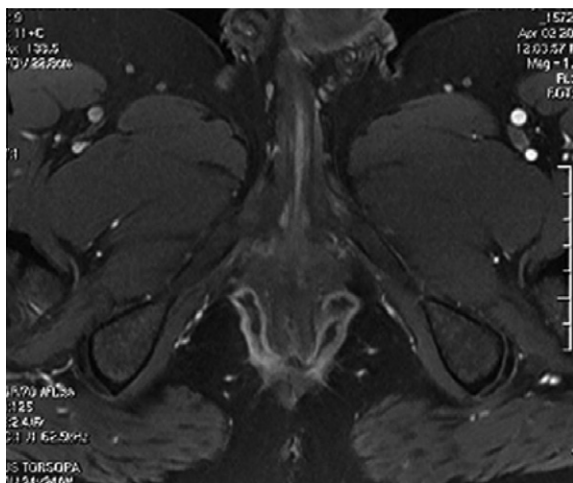


Fig. 3 Axial contrast enhanced fat suppression MRI revealed bilateral saddle shape perianal fistula with acutely inflamed enhancing margins. The shape of fistula and bilateral involvement is characteristic of Crohn's disease.

stable between examinations. Clinical follow-up after the second CT enterography examination was also performed using the electronic clinical note database. Interval changes in Crohn's disease treatment, symptoms, and the length of follow-up were recorded.

2.4. Endoscopy

All the 25 patients underwent endoscopy with intubation of the terminal ileum. A gastroenterologist with expertise in IBD reviewed all endoscopic examination reports and images to identify findings consistent with Crohn's disease. The mean time between CT enterography and ileoscopy was 4.2 days with a range of 0–30 days.

Twenty-one patients underwent terminal ileum biopsy and confirmed histopathologically. The other four patients had negative endoscopic results and hence did not undergo biopsy. In these patients, endoscopic assessment of the terminal ileum was used as the reference standard for the presence of active small bowel inflammation.

Because some histologic and endoscopic findings are non-specific for Crohn's disease, a panel of three gastroenterologists (C.A.S., E.V.L., and W.J.S. with 2, 9, and 11 years of subspecialty experience, respectively, in IBD) created a combined histologic and endoscopic reference standard. When biopsy of the terminal ileum was not performed, only endoscopic assessment of the terminal ileum was used. One of the gastroenterologists (C.A.S.) reviewed the written pathology and ileoscopy reports to categorize patients into one of three groups: *patients with definitely active Crohn's disease*, *patients with probable active Crohn's disease* and *lastly patients without Crohn's disease*.

Definitely active Crohn's disease cases had either chronic ileitis, or acute ileitis, which was diagnosed histologically in conjunction with ulceration, stenosis, or erosions that were evident at endoscopy.

Probable active Crohn's disease cases had several combinations of histologic and endoscopic findings, including (a) chronic ileitis at histologic analysis and normal endoscopic

results, (b) normal histologic findings but stenosis, ulceration, granularity, or friability at endoscopy, or (c) acute ileitis at histologic analysis, with granularity, friability, or erythema at endoscopy.

Eight patients subsequently underwent surgery with a mean time between CT and surgery of 18.4 days and a median of 21 days (Table 1, Figs. 4–11).

2.5. Data analysis

Changes in symptoms and CT findings were quantified either by *progression*, *stability*, or *regression*. The agreement of the change in CT findings versus symptoms was measured using the weighted kappa coefficient.

The percentage of CT enterography findings that agreed with symptoms overall and for each category (progression, regression, stable) was reported. The percentage of CT enterography findings that agreed with endoscopic findings was also reported. The statistical uncertainty of the percentages was quantified using the exact binomial method.

2.6. Statistical analysis

The mean maximal mural attenuation values for the distended jejunum and distended ileum were compared. Mural hyperenhancement was the most sensitive CT finding of active Crohn's disease. The degree of bowel wall enhancement correlates with the severity of active inflammation and is used to monitor anti-inflammatory therapy.

Mural stratification is visualization of the bowel wall layers on CT after IV contrast. Edematous bowel wall usually has a trilaminar appearance on CT enterography ("target" sign): an internal ring of mucosal enhancement, an external ring of serosal and muscular enhancement, and an interposed submucosal layer with decreased attenuation. In chronic IBD, fat deposition may be seen in the submucosa and should not be confused with the mural stratification that is seen with acute disease.

Comparisons were made by using a Student *t* test, with *P* values of <0.05 indicating a statistically significant difference. AX^2 analysis was used to determine differences in the grades of distention by using pair wise comparisons between the jejunum, ileum, and terminal ileum and between patients with Crohn's disease and those without Crohn's disease for each bowel segment.

3. Results

Disease progression or regression by CT enterography correlated with symptoms in 20 of 25 (80%) patients. Specifically, CT enterography and symptoms agreed in 15 patients with clinical disease progression, three patients with clinical regression, and two with clinically stable disease. In five of 25 patients (20%), symptoms progressed although CT enterography findings were improved ($n = 3$) and negative ($n = 2$) {at follow-up, four of the five patients improved and the remaining patient was stable symptomatically}.

Twenty-five ileoscopies were attempted in the 25 patients; all examinations reached the terminal ileum. Endoscopy findings correlated with CT enterography findings in most of the cases (24/25, 96%, i.e., positive endoscopy findings of Crohn's disease and positive CT enterography findings of Crohn's

Table 1 Summary of operative intervention in 8 patients with Crohn's disease complications. (Fig. 4-11).

Site of the disease	Indications of surgery	Operative procedures	Follow up
Jejunum (Fig. 4)	Massive lower GI bleeding with Hemoglobin (HB) 4 gm	Resection and anastomosis	Marvelous response, HB rises to 11gm, good response confirmed by CT
Terminal ileum (Fig. 5)	Intestinal obstruction due to distal ileal stricture	Limited resection and anastomosis	Good response confirmed by CT enterography
Terminal ileum and cecum (Fig. 6)	Attacks of Intestinal obstruction, Suspicion of tumor with associated appendicitis	Right hemicolectomy including appendectomy	Good response confirmed by CT enterography
Ileum (Fig. 7)	Anemia and adhesions	Limited three resections and anastomosis	Good response confirmed by CT enterography
Distal Ileum (Fig. 8)	Fistulation with UB with bleeding	Fistula closure and resection anastomosis	Good response confirmed by CT enterography
Left colon (Fig. 9)	Adhesion and ileocolic fistula	Limited resection and anastomosis of ileum with fistula (arrow) and left hemicolectomy	Good response by CT enterography and colonoscopy
Right colon (Fig. 10)	Large abscess formation with extension to iliaca muscles	Drainage followed with right hemicolectomy	Good response confirmed by CT enterography
Right colon (Fig. 11)	Ulceration and phlegmon adherent to UB	Drainage then RT hemicolectomy	Improved, confirmed with CT enterography

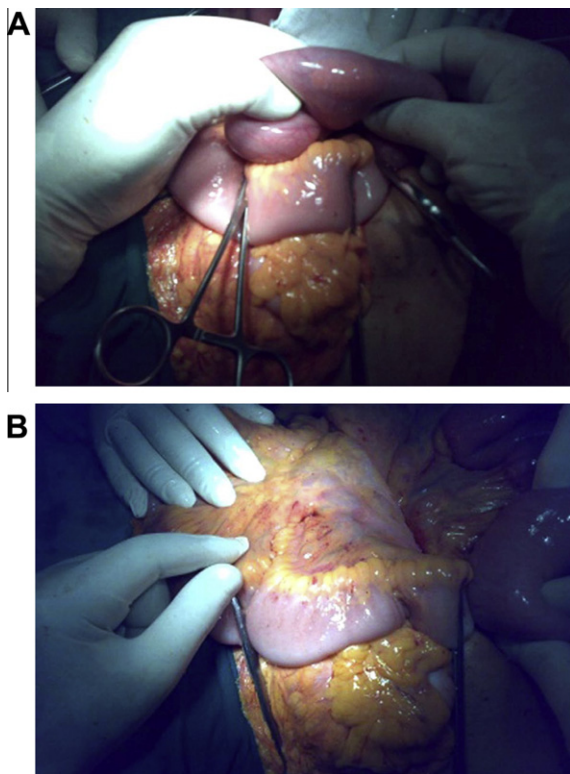


Fig. 4 A,B Intraoperative photographs for a 22-year-old female presented with massive lower gastrointestinal bleeding due to jejunal Crohn's disease, the affected jejunal segment with Crohn disease (A), and associated with mesenteric LNs (B). Resection and anastomosis of the limited jejunal segment was done.

disease). Endoscopic findings correlated with symptoms in all cases (25/25,100%).

Endoscopy showed inflammatory lesions in the 20 patients (mild disease, four; moderate disease, six; and severe disease,

10 patients). The endoscopist assigned grades to severity at endoscopy according to the score of Rutgeerts et al. (8) in patients who had previously undergone surgery.

For the other patients, they assigned grades to severity according to the Simple Endoscopic Score for Crohn's Disease, as stipulated by Daperno et al. (9), as follows: normal grade, no lesions; mild grade, aphthous lesions with normal mucosa between them or nonobstructing stenosis; moderate grade, diffuse aphthae; or severe grade, diffuse inflammation with large ulcers (> 2 cm), nodules, or stricture with inability to intubate the terminal ileum. For the purpose of statistical analysis, normal and mild grades at endoscopy were grouped and were considered as inactive disease, and moderate and severe grades at endoscopy were considered as active disease.

3.1. Radiological signs of Crohn's activity

Mural thickening greater than 3 mm in a distended bowel loop correlated highly with disease activity and, was present in up to 82.5% of patients, it was the most frequently observed CT finding in Crohn's disease. When associated with mural hyperenhancement, increased attenuation of the mesenteric fat is due to edema and engorgement of the vasa recta and is the most specific CT finding for active Crohn's disease.

CT enterography enabled correct identification of terminal ileum in all examined patients. The mentioned CT criteria for diagnosing active disease were good predictors of active small bowel disease at ileoscopy. Additionally, CT enterography is more sensitive in the detection of extraenteric complications such as abscesses and fistulas.

The performance of CT enterography in depicting Crohn's disease in patients with endoscopic and pathologic evidence of active terminal ileal disease was high as CT enterography correctly demonstrated active ileal Crohn's disease in 20 of the 25 patients. Active disease was demonstrated by mucosal hyperenhancement ($n = 14$), mural stratification ($n = 4$), or mesenteric fat stranding ($n = 2$).

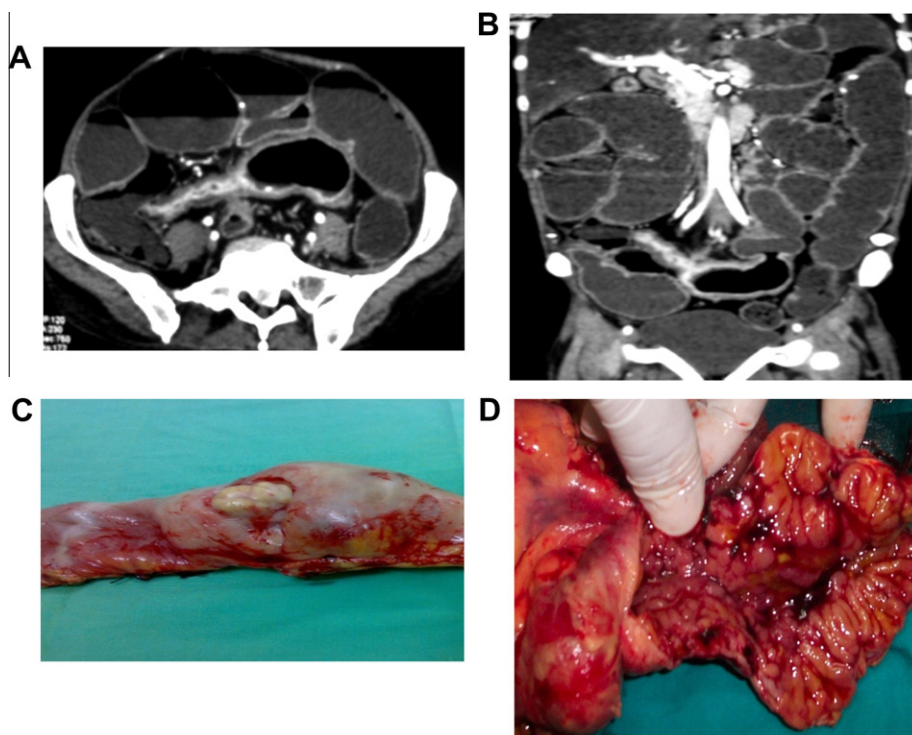


Fig. 5 A forty-year-old male patient presented with recurrent attacks of small intestinal obstruction due to Crohn disease of the terminal ileum, A, B axial and coronal CECT revealed long segment of stricture with enhancing thick mucosa, submucosal edema and dilated small bowel proximal to obstruction . C, D Surgical specimens reveal segmental Crohn disease of the terminal ileum treated with limited resection and anastomosis.

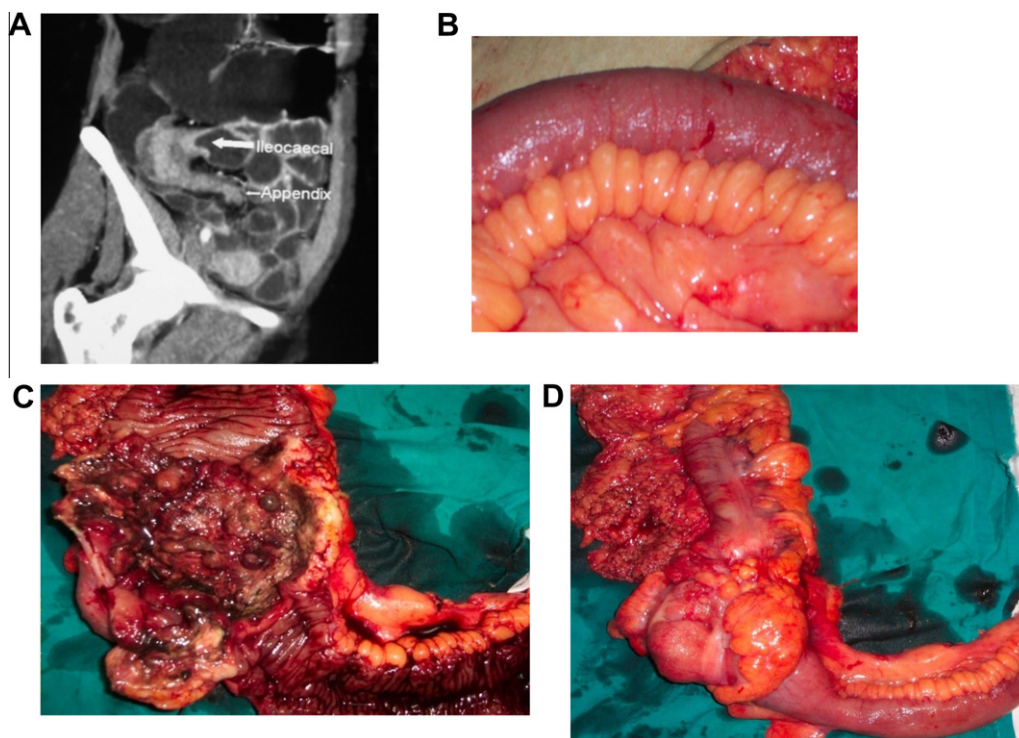


Fig. 6 A fifty-year-old female patient presented with small intestinal obstruction and bleeding, A. Sagittal oblique CECT revealed stricture at distal ileum and caecum due to active Crohn's disease associated with acute appendicitis. B, C, D surgical specimens reveal segmental Crohn's disease of the ileum and caecum (highly suspicion of tumor), and associated appendicitis treated with right hemicolectomy.

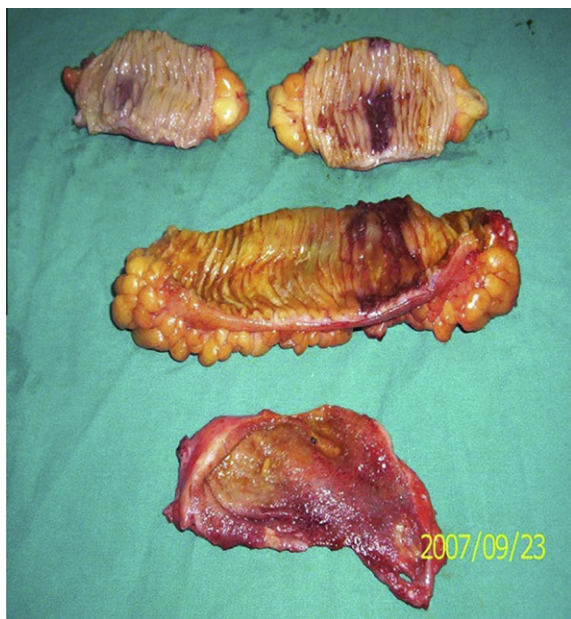


Fig. 7 A forty-two-year-old female patient presented with small intestinal stricture and adhesions causing bleeding and anemia, multiple limited resections and anastomosis was done; surgical resection specimens reveal Crohn's disease of the ileum (arrows).

Quantitative measurement techniques have been used to objectively correlate mural hyper-enhancement and wall thickness with disease activity. Using a mural attenuation threshold of 109 HU and an abnormal-to-normal loop enhancement ratio of more than 1.3, CT enterography is highly correlated with histologic findings of activity.

3.2. Endoscopic signs of Crohn's activity

The most common findings at endoscopy were erosions ($n = 12$), ulcers ($n = 8$), stricture ($n = 4$) and pseudopolyps ($n = 1$). On the basis of endoscopy, two false-negative CT enterography studies for colon disease were found at endoscopy. There were two false-positive CT enterography examinations (suspected disease in the terminal ileum in one patient, the colon in another).

The mean time between CT enterography examinations was 11.8 ± 7.0 months (median, 6 months; range, 1–22 months). The mean time between clinical examinations was 12 ± 5.4 months (median, 6 months; range, 1–19 months), nearly identical to the time between CT enterography examinations. The mean time between clinical evaluations before CT enterography was 6 days (range, 0–44 days). The average time of clinical follow-up was 12 weeks (range, 1–13 weeks).

3.3. Radiology of chronicity and complications of Crohn's disease

In chronic Crohn disease, mural stratification may be absent because of the transmural fibrosis, leading to a homogeneous and less-intense enhancement. Other signs include submucosal fat deposition, sacculations, fibrofatty proliferation, and strictures

Complications were detected radiologically in the form of fistulas (3 cases), sinus tracts (one case), abscesses (two cases) and phlegmons (one patient). Fistulas on CT enterography seen as enhancing tracts extend from the bowel to other structures. Sinus tracts had a similar appearance but did not extend to other structures. Abscesses seen as circumscribed extraluminal fluid collections with enhancing, well-defined walls and phlegmons were defined as extraenteric masses of fluid and soft-tissue attenuation

3.4. Correlated symptoms with CT enterography

Twenty patients with concordant symptoms and CT enterography, most had evidence of worsening disease (15/20, 75%). Imaging findings at CT enterography included bowel wall thickening with mucosal hyper-enhancement, ($n = 33$ examinations), fistula ($n = 4$), abscess ($n = 5$), adhesions ($n = 2$) and bowel obstruction ($n = 3$). For patient symptoms, abdominal pain was the most common complaint ($n = 20$), followed by diarrhea ($n = 9$), rectal bleeding ($n = 4$), and nausea ($n = 5$). Some patients presented with more than one complaint.

Most (12/15) patients with worsening findings on CT enterography received additional treatment for Crohn's disease. These patients showed symptomatic improvement at follow up with changes in Crohn's disease medical therapy ($n = 5$) and surgery ($n = 7$). US guided percutaneous drainage of abscess for three patients was done and no treatment was given for the other two patients who had no change in the symptoms.

Two patients with concordant symptoms and CT enterography had evidence of disease regression. The two patients with improving symptoms (resolution of gastrointestinal bleeding) were imaged to exclude other causes of bleeding. CT enterography in these patients showed resolution or decrease in colonic wall thickening and enhancement. One patient underwent initial endoscopy confirming disease in the colon and confirms resolution. At follow-up, however, both patients were asymptomatic.

Two patients with concordant symptoms and CT enterography showed no change in either symptoms or imaging findings. These patients were imaged because of continued diarrhea despite treatment and to follow-up suspected bowel strictures in the absence of symptoms. At CT enterography, one patient had stable thickening of the terminal ileum and the other remained negative. None of the patients with stable CT enterography findings received additional treatment for Crohn's disease, and both were stable at follow-up.

3.5. Uncorrelated symptoms with CT Enterography

Discordant CT enterography findings and symptoms were present in five of 25 (20%) patients. Four patients had worsening symptoms of pain but by CT enterography was improved. One patient with improved CT enterography had undergone interval resection of the diseased small bowel, and the others had decreased wall thickening and enhancement of the ileum. One endoscopy was performed at the time of the second CT enterography in the patients with ileal disease, which showed ileal erosions only (the initial endoscopy showed active Crohn's disease). At follow-up, the patients were asymptomatic without any change in Crohn's disease therapy. The patient

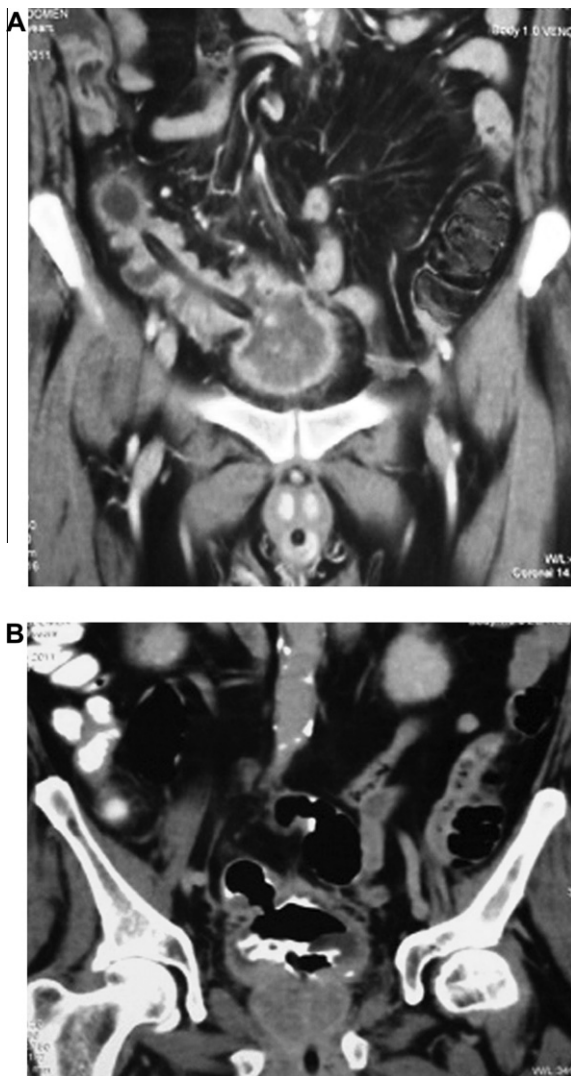


Fig. 8 (A and B) coronal CECT demonstrating entero-vesical fistula with Catheter seen passing from UB lumen to enter bowel lumen in A, and demonstrating actual site of fistula between distal ileum and UB lumen in (B)

with negative CT enterography underwent two ileoscopies, all of which were negative. At follow-up, the patient was asymptomatic and stable. Correlated and uncorrelated Symptoms with CT Enterography are shown in [Table 2](#).

4. Discussion

Although Crohn's disease has a low associated mortality rate, patients with Crohn's disease have significant morbidity, related to the potential for serious complications. Because no terminal cure exists for Crohn's disease, the goals of therapy are to maintain remission, minimize symptoms, and limit disease progression (10,11). The early treatment in patients with a relapse with follow up for the response to treatment results in minimization of disease complications (12).

CT enterography is a relatively new imaging technique that combines the improved spatial and temporal resolution of MDCT with large amounts of ingested neutral contrast mate-

rial. Unlike routine CT, which uses high-density oral contrast material, CT enterography uses neutral oral contrast material as water combined with mannitol, allowing bowel distention and detection of the abnormal mucosal enhancement that is one of the hallmarks of Crohn's disease (13,14).

Both types of endoscopy (capsule endoscopy and ileoscopy) depicted early or mild mucosal findings of small-bowel Crohn's disease than did CT enterography. (15) The benefit of CT enterography becomes more appreciable in patients with more advanced Crohn's disease who cannot undergo capsule endoscopy, because CT enterography can depict and facilitate the evaluation of complications as obstructions, fistulas, and abscess formations (16,17).

CT enterography is considered as a faster, more comfortable, and more sensitive technique than a barium examination in these patients. In addition, for patients in whom ileoscopy was unsuccessful, CT enterography may be used to rule out a stricture or obstruction before capsule endoscopy is performed. In fact, CT is now commonly used to rule out small-bowel obstruction in many clinical situations (18).

In clinical practice, patients can undergo initial evaluation with CT enterography to diagnose or exclude Crohn's disease and help determine whether surgical intervention is necessary or not.

CT enterography, similar to SBFT and enteroclysis, has a high sensitivity for diagnosing strictures. A stricture due to acute disease, manifested by bowel wall hyperenhancement, thickening, and mural stratification, is usually treated medically. Lack of enhancement and loss of stratification suggests transmural fibrosis and may require surgical intervention (19).

Wireless capsule endoscopy is contraindicated when strictures with a luminal diameter of < 1 cm are present. CT enterography, therefore, assumes an important primary role in the identification of the small bowel strictures (20).

Hara and colleagues (21) observed that CT enterography findings positively correlated with disease progression or regression. Colombel and colleagues (22) demonstrated that the perienteric findings of inflammation on CT enterography correlate with the levels of C reactive protein, a marker of disease activity.

Lee and colleagues (23) observed that when the "comb" sign is present, the patients were more likely to be admitted to the hospital and to receive aggressive treatment.

Voderholzer and colleagues (24) in a prospective comparison of wireless capsule endoscopy and CT enteroclysis, could not evaluate 27% of their patients with wireless capsule endoscopy because of strictures identified on CT enteroclysis. However, wireless capsule endoscopy has high sensitivity when mild mucosal abnormalities are present and may be useful in the assessment of Crohn's disease when both ileocolonoscopy and CT enterography are normal.

CT has an established role in the evaluation of extraenteric complications of Crohn's disease. The most common extraenteric complications include fistula, sinus tract, abscess and flegmon (25).

CT enterography has a high sensitivity for diagnosing fistulae. A recent study demonstrated that CT enterography correctly identifies the presence or absence of fistulae in 94% of patients. Multiplanar reformations are particularly useful for detecting fistulae. CT enterography can detect clinically unsuspected fistulae or even early adhesions, resulting in changes in the treatment regimen (26).

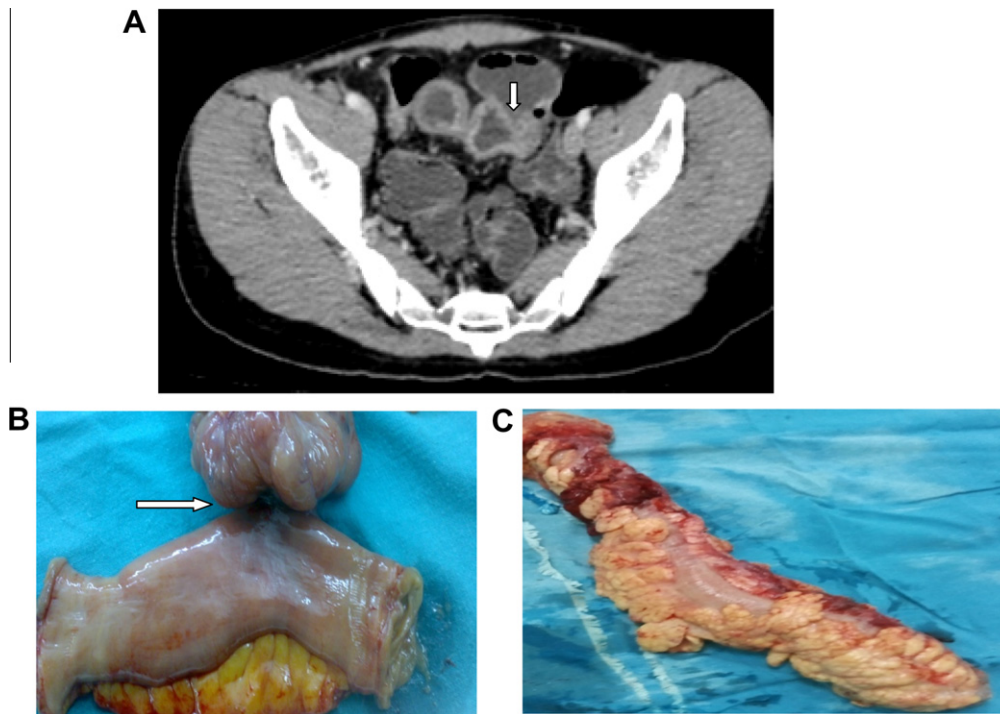


Fig. 9 A thirty-two-year-old female patient presented with attacks of adhesive intestinal obstruction and anemia, (A) axial enhanced CT revealed adhesions and fistula between distal ileum (with thick enhancing mucosa) and adjacent sigmoid colon. (B, C) Surgical specimens reveal Crohn's disease of the ileum and left colon (arrow, site of ileocolic fistula).

Other extraenteric manifestations of Crohn's disease, such as mesenteric lymphadenopathy, cholelithiasis, nephrolithiasis, sacroiliitis, and primary sclerosing cholangitis, can also be evaluated (27).

In our study, Fifty CT enterography examinations in 25 patients with known or suspected Crohn's disease were retrospectively evaluated by a radiologist who was blinded to the clinical history. Disease progression or regression by CT enterography correlated with symptoms in 20 of 25 (80%) patients. CT enterography and symptoms agreed in 15 patients with clinical disease progression, three patients with clinical regression, and two with clinically stable disease. In five of 25 (20%) patients, symptoms progressed although CT findings were improved ($n = 4$) and negative ($n = 1$).

Eight patients subsequently underwent surgery with a mean time between CT and surgery of 18.4 days and a median of 21 days. Patients were subsequently treated surgically for Crohn's disease with an improvement in symptoms ($n = 2$), and worsening of symptoms were due to Crohn's disease ($n = 6$) and not to a functional or non-Crohn's disease cause.

In our study, the ability of CT enterography to prove or exclude the presence of active Crohn's disease was high and correlated well with worsening symptoms. Therefore, in our study, it appears that CT enterography is an accurate test to determine whether worsening symptoms are due to Crohn's disease.

CT enterography is more widely available, cheaper, and faster, 20-s scanning time compared with 30 min needed to perform MR enterography (28,29).

In comparison with endoscopy, our findings suggest that CT enterography findings provide better correlation with endoscopically active disease than patient symptoms provide.



Fig. 10 Coronal CT image revealed large abscess involving right iliacus muscle, extending into upper thigh with its origin in right iliac fossa complicating Crohn's disease. Note: Associated thick enhancing bowel wall denoting active disease

Table 2 Changes in Symptoms, CT Enterography Findings, Treatment, and follow-Up.

Symptoms	CT enterography	(No of pat. = 25)	Treatment	Follow up
<i>Symptoms Correlated with CT Enterography (n = 20):</i>				
No change	No change	2	Stable (2)	Stable
Worse	Worse	15	Medical treatment (5) Surgery (7) Drainage (3)	Improved Improved
Improved	Improved	3	Regression (3)	Improved
<i>Symptoms uncorrelated with CT Enterography (n = 5):</i>				
Worse	Negative	1	No change (1)	Stable
Worse	Improved	4	Surgery (1) Stable (3)	Improved Stable



Fig. 11 Axial CT with contrast filling UB revealed large phlegmon extending from right iliac fossa, adherent and penetrating anterior wall of UB

Endoscopy correlated better with CT enterography findings (24/25, 96% i.e., positive endoscopy findings of Crohn's disease and positive CT enterography findings of Crohn's disease). Also endoscopic findings correlated with symptoms in all cases (25/25, 100%).

Larger studies have also shown that findings of Crohn's disease at CT enterography correlate highly with endoscopy. For example, in a study of 96 patients who underwent CT enterography and ileoscopy, bowel wall thickening and enhancement on CT enterography correlated significantly ($p < 0.001$) with ileoscopic and histologic findings of active Crohn's disease (1).

The main limitations of our study are the small number of patients (small sample size, which precluded any findings of statistical significance), difficult ileal intubation especially with strictures due to complicated Crohn's disease, a reliable reference standard for diagnosing Crohn's disease proximal to the terminal ileum is difficult, and its retrospective nature, this study is also at risk for selection bias because patients with worsening symptoms would be more likely to have more CT enterography than patients who improved or stable patients.

5. Conclusion

This study concluded that CT enterography examinations performed with water as oral contrast material may be useful for

monitoring Crohn's disease progression or regression. CT enterography is better for assessing and detecting transmural and extramural abnormalities of Crohn's disease.

The presence of CT criteria for active disease (i.e., mucosal hyperenhancement, mural stratification, or mesenteric fat stranding) was a good predictor of active small bowel disease at ileoscopy. In addition, small-bowel CT enterography findings correlated well with ileoscopy in the patients and helped to assess for complications and treatment of Crohn's disease. In the future, the evaluation of this technique in a larger group of patients suspected of Crohn disease is warranted.

References

- (1) Stange EF, Travis SP, Vermeire S, et al.. European evidence based consensus on the diagnosis and management of Crohn's disease: definitions and diagnosis. *Gut* 2006;55:i1-i15.
- (2) Lashner B. Clinical features, laboratory findings, and course of Crohn's disease. 5th ed. Philadelphia, PA: Saunders; 2000.
- (3) Daperno M, D'Haens G, Van Assche G, et al.. Development and validation of a new, simplified endoscopic activity score for Crohn's disease: the SES-CD. *Gastrointest Endosc* 2004;60:505-12.
- (4) Sostegni R, Daperno M, Scaglione N, et al.. Review article: Crohn's disease: monitoring disease activity. *Aliment Pharmacol Ther* 2003;17:11-7.
- (5) Bodily KD, Fletcher JG, Solem CA, et al.. Crohn disease: mural attenuation and thickness at contrast enhanced CT enterography—correlation with endoscopic and histologic findings of inflammation. *Radiology* 2006;238:505-16.
- (6) Hong SS, Kim AY, Byun JH, et al.. MDCT of small bowel disease: value of 3D imaging. *AJR Am J Roentgenol* 2006;187(5):1212-21.
- (7) Hara AK, Leighton JA, Heigh RI, Sharma VK, Silva AC, Petris GD, et al.. Crohn disease of the small bowel: preliminary comparison among ct enterography, capsule endoscopy. *Small-Bowel Follow through and Ileoscopy*. *Radiology* 2006;238:128-34.
- (8) Rutgeerts MS, Triester SL, Leighton JA, Leontiadis GI, et al.. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with non-stricturing small bowel Crohn's disease. *Am J Gastroenterol* 2006;101:954-64.
- (9) Brignola C, Belloli C, De Simone G. Assessment and monitoring in known Crohn's disease. *Eur J Gastroenterol Hepatol* 1994;6:78-85.
- (10) Paulsen S, Huprich J, Fletcher JG, et al.. CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. *RadioGraphics* 2006;26:641-62.

- (11) Boudiaf M, Soyer P, Terem C, Pelage JP, Maissiat E, Rymer R. CT evaluation of small bowel obstruction. *Radio Graphics* 2001;21:613–24.
- (12) Macari M, Megibow AJ, Balthazar EJ. A pattern approach to the abnormal small bowel: observations at MDCT and CT enterography. *AJR Am J Roentgenol* 2007;188(5):1344–55.
- (13) Wold PB, Fletcher JG, Johnson CD, et al.. Assessment of small bowel Crohn disease: noninvasive peroral CT enterography compared with other imaging methods and endoscopy-feasibility study. *Radiology* 2003;229(1):275–81.
- (14) Paulsen SR, Huprich JE, Hara AK. CT enterography: noninvasive evaluation of Crohn's disease and obscure gastrointestinal bleed. *Radiol Clin North Am* 2007;45(2):303–15.
- (15) Boriskin HS, Devito BS, Hines JJ, et al. CT enterography vs. capsule endoscopy. *Abdom Imaging* 2008.
- (16) Paulsen SR, Huprich JE, Fletcher JG, et al.. CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. *Radiographics* 2006;26(3):641–57.
- (17) Megibow AJ, Babb JS, Hecht EM, et al.. Evaluation of bowel distention and bowel wall appearance by using neutral oral contrast agent for multi-detector row CT. *Radiology* 2006;238(1):87–95.
- (18) Bruining DH, Loftus Jr EV. Technology insight: new techniques for imaging the gut in patients with IBD. *Nat Clin Pract Gastroenterol Hepatol* 2008;5(3):154–61.
- (19) Booya F, Fletcher JG, Huprich JE, et al.. Active Crohn disease: CT findings and interobserver agreement for enteric phase CT enterography. *Radiology* 2006;241(3):787–95.
- (20) Bodily KD, Fletcher JG, Solem CA, et al.. Crohn Disease: mural attenuation and thickness at contrast-enhanced CT Enterography—correlation with endoscopic and histologic findings of inflammation. *Radiology* 2006;238(2):505–16.
- (21) Hara AK, Alam S, Heigh RI, Gurudu SR, Hentz JG, Leighton JA. Using CT enterography to monitor Crohn's disease activity: a preliminary study. *AJR* 2008;190:1512–6.
- (22) Colombel JF, Solem CA, Sandborn WJ, et al.. Quantitative measurement and visual assessment of ileal Crohn's disease activity by computed tomography enterography: correlation with endoscopic severity and C reactive protein. *Gut* 2006;55(11):1561–7.
- (23) Lee SS, Ha HK, Yang SK, et al.. CT of prominent pericolic or perienteric vasculature in patients with Crohn's disease: correlation with clinical disease activity and findings on barium studies. *AJR Am J Roentgenol* 2002;179(4):1029–36.
- (24) Voderholzer WA, Beinhoezl J, Rogalla P, et al.. Small bowel involvement in Crohn's disease: a prospective comparison of wireless capsule endoscopy and computed tomography enteroclysis. *Gut* 2005;54(3):369–73.
- (25) Vandembroucke F, Mortelet KJ, Tatli S, et al.. Noninvasive multidetector computed tomography enterography in patients with small-bowel Crohn's disease: Is a 40-second delay better than 70 s? *Acta Radiol* 2007;1–9.
- (26) Booya F, Akram S, Fletcher JG, et al.. CT enterography and fistulizing Crohn's disease: clinical benefit and radiographic findings. *Abdom Imaging* 2009;34(4):467–75.
- (27) Vogel J, da Luz MA, Baker M, et al.. CT enterography for Crohn's disease: accurate preoperative diagnostic imaging. *Dis Colon Rectum* 2007;50(11):1761–9.
- (28) Tochetto Sandra, Yaghmai Vahid. CT Enterography: concept, technique, and interpretation. *Radiol Clin N Am* 2009;47:117–32.
- (29) Sempere GA, MartinezSanjuan V, MedinaChulia E, et al.. MRI evaluation of inflammatory activity in Crohn's disease. *AJR* 2005;184:1829–35.