Role of Multi-detector CT in Assessment of Patients Suspected with Chronic Inflammatory Bowel Disease

Ahmed Mohamed Monib ,Sherif Hamed Abu Gamrah ,Amira Mokhtar Bayomi
Department of Radiodiagnosis, faculty of Medicine, Ain Shams University, Cairo, Egypt.

ABSTRACT

Background: Crohn's disease and ulcerative colitis evolve with a relapsing and remitting course. Determination of inflammatory state is crucial for the assessment of disease activity and for tailoring therapy .Computed tomography enterography (CTE) has become a main modality for the evaluation of inflammatory bowel disease (IBD). It simultaneously offers visualization of the small bowel and extra intestinal status, which is helpful for diagnosing IBD. Crohn disease has long segmental enhancing wall thickening related with the eccentric longitudinal distribution. In addition, mural stratification, fibrofatty proliferation, positive comb sign by increased mesenteric vascularity and internal/perianal fistula are characteristics of Crohn disease and can be identified on CTE. Each of CTE findings for the IBDs is helpful for differential diagnosis. The main disadvantage of this technique is the requisite radiation exposure of patients, particularly in young patients. However, recent development of advanced CT techniques is promising for radiation dose reduction without compromising diagnostic image quality

Keywords: Crohn's disease, Ulcerative colitis, Inflammatory bowel disease, Computed tomography enterography ,multi detector computed tomography.

INTRODUCTION

Inflammatory bowel disease (IBD) comprises two major disease entities: Crohn's disease (CD) and ulcerative colitis (UC). Its etiology is not completely understood, but it is characterized by chronic inflammation of the gastrointestinal tract. Typically, these diseases evolve with a relapsing and remitting course. Exacerbations are characterized by diarrhea, abdominal pain and rectal bleeding.[1]

Crohn's disease could be missed by ileocolonoscopy if the condition skips the distal ileum or is limited to the mesentary or intramural portion of the bowel wall, but CT enterography can aid its detection and can complements endoscopic assessment.[2]

CT enterography was first introduced by Raptopoulos et al [3] in 1997 as a modification to "standard" abdomino-pelvic CT examination to specifically examine the small bowel in detail, notably to assess the extent and severity of Crohn's disease [3,4] . They combined neutral (low-density) oral contrast with "enteric phase" CT to optimise contrast resolution between mucosa and lumen, thereby maximizing conspicuity of abnormalities arising from the small bowel wall.

Former conventional radiological imaging techniques using oral contrast as small bowel follow through and small bowel enteroclysis were not accurate in diagnosing active CD in the small bowel because the findings provided by both methods are limited and indirect as regards the bowel wall and the extra-luminal manifestations of CD. In addition, overlapping of bowel loops may hinder the effectiveness of these methods.[5]

CT enterography is particularly useful for differentiating between active and fibrotic bowel strictures in patients with CD disease, thus enabling selection of the most appropriate treatment (medical management or intervention) for an improved outcome. CT enterography allows excellent visualization of the entire thickness of the bowel wall and depicts extra enteric involvement as well, providing more detailed and comprehensive information about the extent and severity of the disease process. [6]

This study aims at evaluation of IBD by computed tomography enterography (CTE) in correlation to endoscopy as well as detection of extra-enteric manifestations and complications of the disease.

PATEINTS AND METHODS:

Patients selection

Thirty patients were included in this study. They were referred to radiology departments of Ain Shams university

DOI: 10.12816/0012175

hospitals, Cairo, Egypt and some of private Radiologic centers in the period from May 2010 to April 2014. These patients were referred for radiological assessment complaining from one or more of the following symptoms: vague abdominal pain, chronic diarrhea, recurrent vomiting or for follow up of a known case of IBD. The age range was 17 to 65 years with a mean of 41 years, 19 patients were males and 11 were females.

Methods of Study

- Full clinical assessment including recording of age, sex and presentation.
- Revision of the patient's laboratory investigations including renal function tests (blood urea and serum creatinine).
- Revision of the radiological & endoscopic diagnostic investigations previously done for the patients.
- Patients were scheduled to undergo MSCTE and the results were compared to the upper and lower GIT endoscopies.

MSCTE Examination:

A- CTE protocol

Thirty patients were examined in this study using 64 channels MSCT scanners (Philips easy vision & GE Medical Systems). All patients who underwent CTE were asked to take nothing by mouth for 6 hours before scanning. The day of examination, patients were asked to come 60 minutes before exam time, in which patients are asked to ingest a total of 2000 mL of oral water as a neutral contrast material mixed with mannitol (250 mL hyperosmotic mannitol solution to 1750 mL water) over a 60-min period as follows: 0, 15, 30 and 40 minutes, the last ingestion is just before the scanning. Intramuscular buscopan 20 mg(Hyoscine-N- butyl bromide 0.2 mg / Kg body weight) was given just before imaging to relax any smooth muscle spasm that mimics bowel wall thickening & abnormal enhancement (Five patients did not take the spasmolytic drug due to presence of contraindications. eg; glucoma, cardiac disease and prostatic enlargement). IV contrast medium (about 70 – 120 ml) of non ionic contrast medium iopromide (Ultravist 300; Berlin, Germany) according to the body built (1.5 ml/kg body weight) was given by infusion pump at rate 4 ml/second .then patients were scanned from the porta hepatis to the symphysis pubis through single enteric phase acquisition 30-40 s after IV contrast injection. - Total scanning time 6 to 10 seconds Section thickness used was 1.0 mm and the reconstruction interval was 1 mm. The CT parameters are 280–320 mA, 120 kVp, a pitch of 1.0. CT scans were then transferred to Syngo.via work station for multiplanar reconstructions with section thickness 2mm and interval 1 mm. two separate sets of 3-D reconstructions are interactively created at an independent workstation: (1) Maximum intensity projection (MIP) imaging is based upon a computer algorithm which extracts the highest attenuation voxels in a data set, and projects these voxels into a 3-D display which can be manipulated and rotated into the desired plane; and (2) Volume rendering (VR) is based upon a more complex computer algorithm which assigns a specific color and transparency to each voxel in a data set based on its underlying attenuation (and relationship to other adjacent voxels), before projecting this data into an interactive 3-D display.

B- CTE images interpretation

CTE images were interpreted by experienced consultants of gastrointestinal tract radiology who were blinded to patients' clinical and endoscopic evaluations. They were asked to evaluate the bowel in each CTE exam for; mural thickness and report its value in millimeters (mural thickening is considered if the mural thickness > 3 mm) and CT signs of active disease which include; mural hyperattenuation (hyperenhancement) which was detected visually and quantitatively by measuring the CT density at the bowel wall in Hounsfield units (HU), mural hyperattenuation was defined as segmental hyperenhancement of the small bowel wall which exceeds the enhancement of the adjacent small bowel loop. Absolute hyperenhancement >109 Hounsfield Units (HU) correlates with active disease,[7] Enhancement/stratification patterns will be determined (white, target-water or target - fat), mesenteric fat edema defined as increased density and stranding in perienteric mesenteric fat compared to the perienteric fat adjacent to non-inflamed bowel loops, and comb's sign which refers

to segmental dilatation of the vasa recta supplying a bowel loop. Also CTE signs of inactive CD were interpreted as mural thickening of the bowel wall or bowel stricture in absence of CTE signs of active disease. The extra-enteric manifestations and complications of CD were also reported with respect to the presence of abscesses, fistula or stricture.

RESULTS

Our study included thirty patients presenting with already known or suspected chronic inflammatory bowel disease were examined by CTE and the results were compared to the results of GIT endoscopies and histopathology as well as other laboratory data in all patients. The patients' age ranged between 17 to 65 years . The mean age of patients group is 41 years old .

We found that most of radiological findings were seen within the ileum , specifically at its terminal part (sixteen out of twenty five cases ,64 %, were terminal ileum).

According to the affected intestinal segments it was divided into: jejunum ,ileum, cecum and rectum with other colonic segments. The percentile prevalence of lesions among them is shown in table 1.

Table 1:Distribution of the lesions at different intestinal segments & their percentage.

Intestinal segment	Number (n= 40)	Percent
Jejunum	1	2.5 %
Ileum	25	62.5 %
Cecum	4	10 %
Rectum and other colon segments	10	25%

16 out of 25 ileum (64%) was terminal ileum.

In our study CTE findings are demonstrated in Table 2. The most distinguished visual CT finding of active disease was the mural hyperenhancement, followed by mural thickening (Figure 1, Figure 2 and Figure 3).

Table 2: Radiological findings of the studied group.

Characteristics	Number (n=30)	Percent %
Mural thickening	27	90%
Mural stratification/enhancement pattern		
Homogenous white	20	66.7%
enhancement	6	20%
Water halo sign	12	40%
Fat halo sign	2	10%
Comb sign	14	46.7%
Mesenteric and perirectal fat stranding	18	60%
Stricture	11	36.7%
Fistula	4	13.3%
Abscess formation	8	26.7%
Lymphnodes	11	36.7%
Fat creeping sign	14	46.7%
Skip lesion	16	53.3%
Gall bladder stone	4	13.3%
Renal stone	3	10%
Sacroiliitis	1	3.3%

Correlation of CTE diagnosis of IBD and their activities with endoscopic and pathological results

Endoscopy and pathological results of our patients revealed that 24 patients were Crohn's disease, 18 with active disease and 6 were inactive. Ulcerative colitis was diagnosed in 6 cases, 4 with activity and 2 were inactive.

In our study, we correctly diagnosed Crohn's disease in 15 out of 18 patients of active disease with 3 false negative cases and diagnosed 5 out of 6 cases with disease inactivity(Fig 4) .In ulcerative colitis cases, our results revealed correct diagnosis of 3out of 4 cases of active disease, and correctly diagnosed of 1 out of 2 with inactive disease (Table 3 & 4)

Table3 : CTE signs of activity in correlation to endoscopic results.

CTE signs of activity	Endoscopic findings		P Value
	Active cases (n= 22)	Inactive cases (n=8)	
Mural thickening (mean value in mm +/- standard deviation and percentage)	**9.6± 0.39 21 (95.4 %)**	**5.53± 02 6 (75 %)**	**< 0.001 0.089**
Mural hyperenhancement (mean value in HU +/- standard deviation and percentage)	**121±28 20(91 %)**	**74 ± 15 0 (0 %)**	**< 0.001 < 0.001**
Comb sign	**14 (63.6 %)**	**0 (0 %)**	**0.016**
Mesenteric fat oedema	**15 (68.2 %)**	**3 (37.5 %)**	**0.165**

Table4 : percent of CTE diagnosis of IBD versus endoscopic result

	Endoscopic diagnosis	CTE diagnosis	percent
Crohn's disease	24	20	83.3%
Ulcerative colitis	6	4	66.7%

Efficiency of CTE in diagnosis of chronic IBD and detect activity:

Our study included 30 patients with already known or suspected chronic inflammatory bowel disease. Their ages ranged between 17 and 65 years (21 male and 9 female), came with different symptoms, commonest was abdominal pain, followed by chronic diarrhea and loss of weight.

In our study, CTE demonstrated the site and extent of the lesions , signs of activity as well as the surrounding and extra enteric complications . Statistical analysis of CTE signs of activity revealed highly significant difference in the mural hyperenhancement sign ($p< 0.001$) followed by comb sign ($p< 0.05$) between the active and inactive cases, while no statistically significant difference was found concerning the mesenteric fat edema sign .As regards the mucosal thickening sign, there was highly statistical significant difference in terms of mean values between active and inactive cases denoting much higher thickenings values of bowel wall in the active cases, while no significant difference was detected in terms of percentages values.

In correlation to ileocolonoscopic results, CTE correctly diagnosed Crohn's disease in 15 out of 18 patients of active cases with 3 false negative cases and 5 out of 6 cases with Crohn's disease inactivity. While in ulcerative colitis cases CTE correctly diagnosed 3 out of 4 cases of active disease and 1 out of 2 with inactive disease.

Our study revealed equal sensitivity and specificity (83.3 %) of CTE in detecting Crohn's disease and its activity and the positive predictive value (PPV) was 93.7 % and negative predictive value (NPV) was 62.5 %.

With ulcerative colitis cases, our results revealed sensitivity = 75%, specificity =50%, PPV was 75% and NPV was 50%.

Fig 1: Male patient 30 years old complaining of diarrhea, abdominal pain and weight loss.
CTE findings (axial A,oblique B & coronal C**)** showing skip lesion of wall thickening of ileal loops ,mucosal hyper enhancement with sub mucosal edema ,halo sign ,is demonstrated in an ileal loop and involvement of the terminal ileum (arrow head). Engorged vasa recta, comb sign, is noted (asterisk) Surrounding phlegmon (thin arrows) is seen with creeping fat sign. Enlarged mesenteric lymph nodes are also noted (arrows). diagnosis: active Crohn's disease terminal ileum.
Endoscopic findings revealed chronic non specific duodenitis ,ileitis and chronic active colitis. Crohn's disease is proven pathologically.

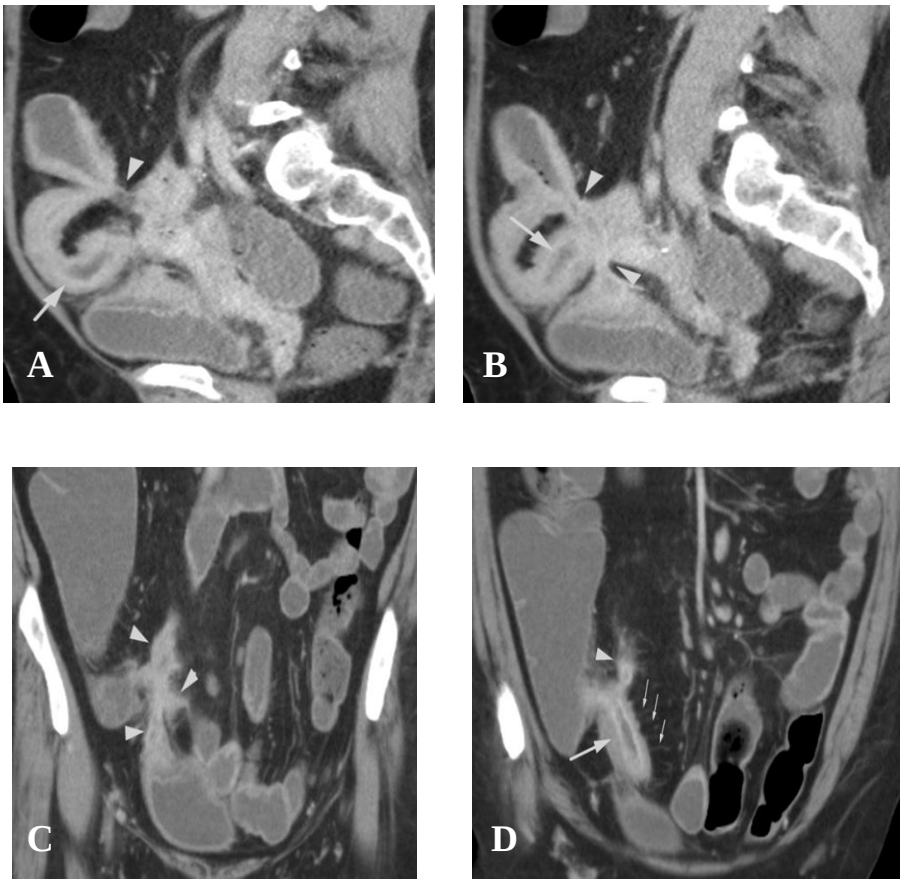

Fig. 2: Male patient, 40 years old with 18 years history of Crohn's disease. CTE (sagital a & b, coronal c & d) shows imaging findings of active Crohn’s disease in which there is multiple ileoilial fistulae. The distal ileum shows mural thickening and hyperenhancement (arrow), it forms a central pocket where the adjacent small bowel loops are sucked in and from which multiple fistulae originate (arrow heads). Engorged vasa rectae "comb sign" is also noted (thin arrows). Ileocolonoscopic examination of this case revealed multiple deep ulcers in edematous terminal ileum with an opening giving to a sinus tract.

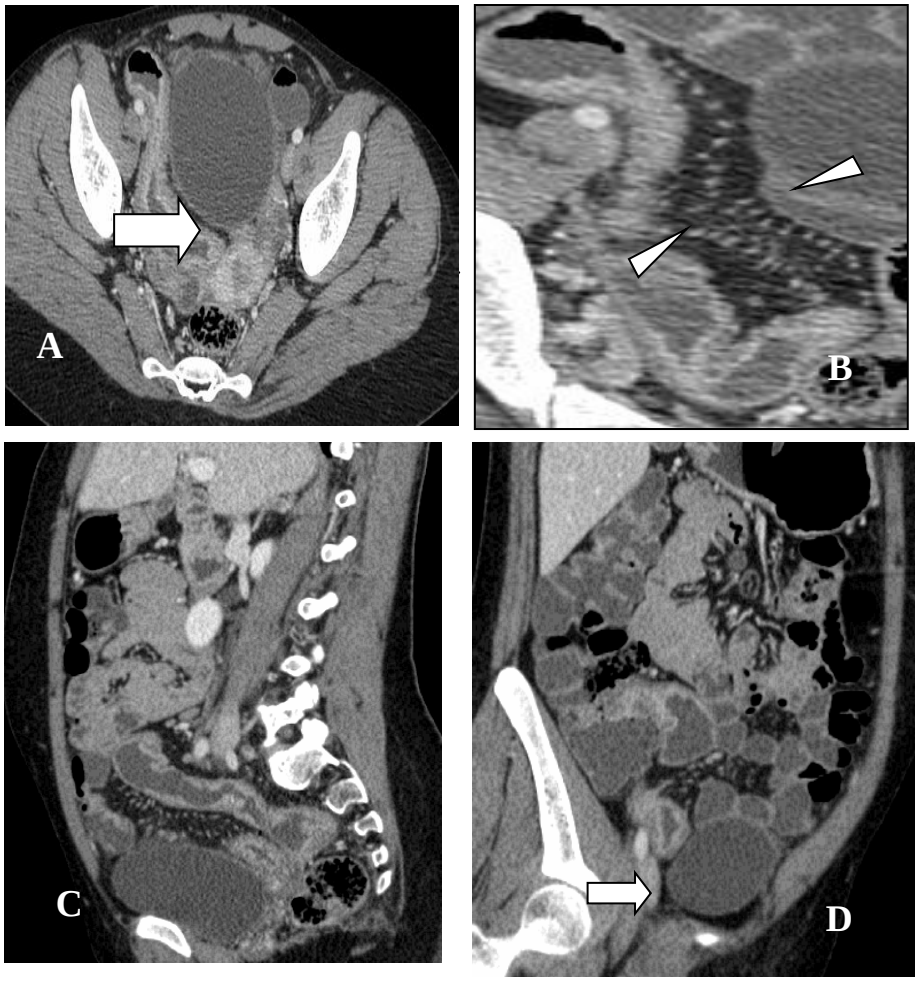

Fig 3:A male patient 32 years old was complaining of abdominal pain and diarrhea, clinically diagnosed as Crohn's disease. CTE findings:(axial A&B, sagittal C, oblique D) The terminal ileal loop and recto sigmoid show mucosal hyper enhancement and sub mucosal edema, halo sign (arrows).dilated perpendicular vasa recta ; comb's sign is noted (arrow heads).diagnosis is active Crohn's disease involving the terminal ileum and recto sigmoid which is proved by endoscopy.

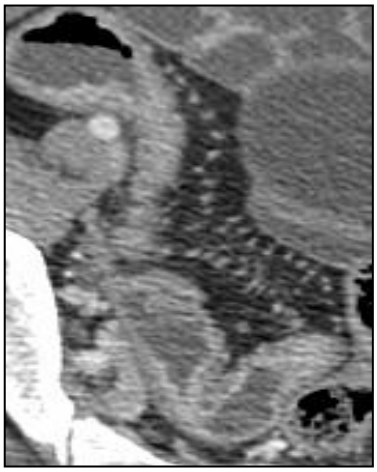

Fig. 4: Female patient, 31 years old with 4 years history of crohn's disease. a & b) CT enterography (axial a, coronal b) showing circumferential mural thickening of the terminal ilieum with no hyperenhancement (arrow) and narrowing of its lumen and dilatation of the proximal ileal loops (arrowhead), mild ascites is also seen (asterisk). This was an inactive case of crohn's disease by CTE which coincides with ileocolonoscopic findings of multiple mucosal ulcers scars.

Discussion

CTE has been one of the primary diagnostic tools in the evaluation of patients with Crohn's disease.[8]

In our study ,Statistical analysis of CTE signs of activity revealed highly significant difference in the mural hyperenhancement sign ($p< 0.001$) followed by comb sign ($p< 0.05$) between the active and inactive cases, while no statistically significant difference was found concerning the mesenteric fat edema sign .As regards the mucosal thickening, there was highly statistical significant difference in terms of mean values , denoting much higher thickenings values of bowel wall in the active cases, while no significant difference was detected in terms of percentages values.

In correlation to ileocolonoscopic results, Our study revealed equal sensitivity and specificity (83.3 %) of CTE in detecting Crohn's disease and its activity and the positive predictive value (PPV) was 93.7 % and negative predictive value (NPV) was 62.5 %. In ulcerative colitis cases, our results revealed sensitivity and specificity were 75% and 50% respectively, PPV was 75% and NPV was 50%.

In their comparative study on 23 patients with ulcerative colitis, Patel et al. [9] found that the cumulative CT score and individual CECT scores for bowel wall thickening, mucosal hyperenhancement, and mural stratification showed positive correlation with clinical severity ($P < 0.05$). All individual CECT features as well as the cumulative CT score demonstrated statistically significant correlation with colonoscopic severity ($P < 0.0001$). Only wall thickening on CECT demonstrated significant correlation with histopathologic severity ($P = 0.01$). . In a study of 96 patients who underwent CTE and ileoscopy, bowel wall thickening and hyperenhancement on CTE correlated significantly ($p< 0.001$) with ileoscopic and histologic findings of active CD. [10]

We found mural hyperenhancement sign to be the most visually distinguishable CT finding of disease activity followed by mural thickening. Mural hyperenhancement was highly significant in patients with active disease than in patients with inactive disease ($p< 0.001$) in respect to both percentages and mean values correlation denoting the significant incidence and quantitative value of mural hyperenhancement in the active patients. This quantitative finding correlated with visual estimates of disease activity by the reporting radiologists.

Mural thickening was the second significant CTE sign after mural hyperenhancement between patients of the active and inactive groups. There was highly statistical significant difference in terms of mean values only between both groups ($p< 0.001$) denoting much higher thickenings values of bowel wall in the active group, while no significant difference was detected in terms of percentages values revealing the existing incidence of mural thickening in inactive disease. Wu et al. [11] reported that CTE findings have high correlation with clinical remission . After treatment, thickness of bowel wall was decreased from 8.8 ± 2.8mm to 6.4 ± 1.9 mm ($P<0.001$). CT value of bowel wall in portal stage was also declined from 90.0 ± 15.4 (HU) to 73.4 ± 14.2 (HU ($P<0.001$). The percentage of patients with comb sign was decreased from 88% to 60% ($P=0.001$). The percentage of patients with moderate or severe luminal stenosis was reduced from 74% to 32% ($P<0.001$). The bowel wall attenuation ($OR=9.56$, $P<0.001$) and bowel wall thickness ($OR=3.32$, $P=0.001$) were significantly correlated with the disease activity.

The commonest extra-enteric complications reported in our study included stricture (fig. 4) followed by abscess and fistula (fig. 2). Park et al.[12] reported that abscesses are easily detected by CTE which is usually contiguous to the diseased bowel segment and is seen in the mesentery or retroperitoneal space . The accurate detection of abscesses and fistulas has high importance not only because it affects the decision to treat medically or surgically, but also it can affect the method of surgical approach (laparoscopic vs. open). Booya et al. [13] demonstrated that CT enterography correctly identifies the presence or absence of fistulae in 94% of patients and early adhesions, resulting in changes in the treatment regimen in 61 % of patients.

In correlation to ileocolonoscopy, CTE in our study provided significant correlation in both the active and inactive cases. CT criteria for active disease especially mucosal hyperenhancement and comb sign were good predictors of active disease. In addition, CTE findings aided to assess for extra-enteric manifestations of IBD and their complications.

CTE has a major disadvantage; the use of ionizing radiation. Yung et al.[14] in a recent study of Korean patients with IBD showed that 34.7% of patients with Crohn's disease were exposed to harmful levels of radiation (cumulative effective

dose >50 mSv) and CT accounted for 81.6% of total effective dose. Kielar et al.[15] also reported that modified small Bowel CT (MBCT) is a low-radiation technique used to determine the involved bowel segments, presence of obstruction, and degree of disease activity in patients with known Crohn's disease. For this indication, MBCT is a highly reproducible imaging technique with good and very good kappa scores for evaluating parameters such as presence of active disease versus stricture, the presence of abscess, strictures, and skip lesions.

5. Conclusions

In conclusion, MSCTE with negative oral contrast medium in addition to intravenous iodinated contrast injection is a safe and well tolerated technique that is easily done and is sensitive to early intestinal wall changes. This technique is complementary to other imaging methods, endoscopy and laboratory studies for full assessment of the inflammatory bowel diseases.

REFERENCES

1- Vilela E G, Torres H O, Martins F B, Evaluation of inflammatory activity in Crohn's disease and ulcerative colitis: World J Gastroenterol. 2012 Mar 7; 18(9): 872–881

2- Andy M .CT enterography improves detection if Crohn's disease skips the distal ileum. Nature Reviews Gastroenterology and Hepatology 9, June 2012 304:10.1038

3- Raptopoulos V, Schwartz RK, McNicholas MM, Movson J, Pearlman J, Joffe N. Multiplanar helical CT enterography in patients with Crohn's disease. AJR Am J Roentgenol 1997;169:1545–50

4- Paulsen SR, Huprich JE, Fletcher JG, Booya F, Young BM, Fidler JL, 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

5- Bernstein CN, Greenberg H, Boult I, Chubey S, Leblanc C, Ryner L. A prospective comparison study of MRI versus small bowel follow-through in recurrent Crohn's disease. Am J Gastroenterol 2005; 100(11):2493–502.

6- Elsayes K, Al Hawary MM, Jagdish J, et al.: CT Enterography: Principles, Trends, and Interpretation of Findings 2010 RadioGraphics,30, 1955-1970.

7- Bodily KD, Fletcher JG, Solem CA, Johnson CD, Fidler JL, Barlow JM 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.

8- Al-Hawary MM, Kaza RK, Platt JF. CT enterography: concepts and advances in Crohn's disease imaging. Radiol Clin North Am 2013; 51(1):1-16.

9- Patel B1, Mottola J et al, MDCT assessment of ulcerative colitis: radiologic analysis with clinical, endoscopic, and pathologic correlation: 2012 Feb;37(1):61-9. doi: 10.1007/s00261-011-9741-x.

10- Hashimoto S, Shimizu K, Shibata H, Kanayama S, Tanabe R, Onoda H et al. Utility of computed tomographic enteroclysis/enterography for the assessment of mucosal healing in Crohn's disease. Gastroenterol Res Pract. 2013; 2013:984916.

11- Wu YW, Tang YH, Hao NX, Tang CY, Miao F. Crohn's disease: CT enterography manifestations before and after treatment. Eur J Radiol. 2012;81:52–59

12- Park M J and Lim J S: Computed Tomography Enterography for Evaluation of Inflammatory Bowel Disease Clin Endosc. 2013 Jul; 46(4): 327–366.

13- Booya F, Akram S, Fletcher JG, Huprich JE, Johnson CD, Fidler JL et al. CT enterography and fistulizing Crohn's disease: clinical benefit and radiographic findings. Abdom Imaging 2009; 34(4):467–75

14- Yu L, Bruesewitz MR, Thomas KB, Fletcher JG, Kofler JM, McCollough CH. Optimal tube potential for radiation dose reduction in pediatric CT: principles, clinical implementations, and pitfalls. Radiographics. 2011;31:835–848

15- Kielar AZ, Tao H, and Thipphavong S : Modified small bowel CT (MBCT) for evaluating sub-acute and chronic conditions affecting the small bowel: a low radiation-dose, unenhanced CT protocol .Insights Imaging. 2011 Oct; 2(5): 539–542.