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CT Enterography for diagnosis of Small Bowel Disorders

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Abstract
Objective: *The purpose of this study was to demonstrate the role of CT enterography in detection and characterization of small bowel diseases.*
Material and Methods: *A total of 65 patients (mean age 41 years; range, 16-70 years), including 42 males and 23 females who were suspected of having small bowel disorders on the basis of clinical examination underwent CT enterography examination on a 64-slice CT Scanner prospectively using neutral oral contrast (Polyethylene glycol).*
Results: *The mean distensionof the small intestine was 1.8cm in jejunum and 2.3 cm in ileum. Out of 65 patients, 32 patients (49%) presented with abnormal small bowel thickening. Intestinal tuberculosis was the most common diagnosis in 11 cases (16.9%). Ileocaecal junction was involved predominantly in 81%cases and 81% cases of tuberculosis depicted homogenous enhancement with either focal (46%) or segmental (54%) involvement. Small bowel tumors were seen in 9 cases with majority of them adenocarcinoma (7 cases). Malignancy was associated with marked asymmetric thickening in 81%cases, focal thickening in 54% cases, and heterogenous enhancement in 91% cases.*
Conclusion: *CT enterography is an effective modality to evaluate small bowel disorders. It can not only assess mural and intraluminal small bowel pathologies but also assess extraintestinal findings so as to make correct diagnosis.*

Introduction

Small bowel can be affected by diverse group of pathologies causing varied morphological alteration in and around bowel. Assessing it is difficult because of long and serpentine course of small bowel that is prone to change with breathing and peristalsis(1).

Earlier barium studies were routinely used because they were easily accessible, cheap and produced excellent mucosal contrast, but failure to depict extra-intestinal complications, long duration of examination, high radiation dose to staff and patients and higher operator dependence were few of the limitations that led to improvement in

diagnostic techniques[2]. Conventional CT could depict extraintestinal manifestations of small bowel disease but it fared poorly in depicting bowel wall and luminal abnormalities[3].

MDCT enterography combined advantages of better spatial and temporal resolution of multidetector CT with oral intake of large volume of negative oral contrast to depict mucosal and submucosal pathology in detail. Excellent visualization of the entire wall thickness and of mucosa, depiction of detailed information about extent and severity of disease process have made CT enterography the primary imaging modality in evaluation of bowel wall disease[4,5,6].

MDCT enterography has been tried and tested tool in western settings where Crohn's disease is prevalent[7,8]. However, in Indian setting where tuberculosis tends to be more prevalent, use of CT enterography has yet to be explored The aim of this study was to determine the role of CT enterography in early detection and characterization of small bowel pathologies that invariably go unnoticed.

Material and Methods

Institutional review board approved the study and informed consent was obtained from each participant. A total of 65 patients (mean age 41 years; range, 16-70 years), were included in the study conducted between July 2014 and June 2015. There were 42 male patients (64.61%) and 23 female (35.39%)patients.

Inclusion criteria consisted of suspected cases of inflammatory bowel disease/Crohn's disease, iron deficiency anemia with stool for occult blood, recurrent sub-acute intestinal obstruction, obscure gastrointestinal bleed, suspected mesenteric ischemia, suspected cases of intestinal tuberculosis, small bowel wall thickening on ultrasound.

Exclusion criterion consisted of pregnancy, renal insufficiency (glomerular filtration rate < 30 milliliter/second, that was calculated by Cockcroft-Gault formula), documented reaction to iodinated contrast material, previous intestinal resection or surgery or unwilling patient.

Preparation of the Patient

Patient preparation: Low residue diet, free of fruit and vegetables was taken the day prior to CT scan, nil per oral 6-10 hours before CT scan. IV Access (18 G cannula) preferably through the right ante-cubital vein. Optimal small bowel distension achieved by oral ingestion of iso-osmotic polyethylene glycol (PEGLEC) and water mixture according to following schedule:

450 ml, 60 minutes before scanning, 450 ml, 40 minutes before scanning, intramuscular buscopan injection 20 minutes prior to CT scan, followed by drinking of another 450 ml, 225 ml 10 minutes prior to scan, 225 ml on scanning table.

CT Enterography Protocol

All patients were imaged with a 64-row MDCT scanner (Light speed VCT- XTe, GE Medical Systems) using the following scanning parameters: Detector coverage of 40mm, table pitch of 1.375 a rotation of 0.6,slice thickness of 2.5mm with interval of 2.5 mm, and 0.625 mm reconstructed slice thickness, 120-140 kVp, reference mAs 100-250 mA. Automatic tube current modulation was used to minimize the radiation exposure. A standard reconstruction algorithm was used. 1.5 ml/kg of iodinated contrast material (XENETIX 350 OR OMNIPAQUE) was injected at a rate of 4 ml/s using an automated power injector. The scanning was done in enteric phase (50 seconds from start of injection of contrast). To evaluate mesenteric ischemia, three-phase CT (arterial, enteric and delayed phases) was performed. Images were obtained from the dome of the liver to the lower margin of the symphysis pubis during a single breath-hold.

Image Interpretation

The images were assessed according to pattern approach suggested by Macari[5]. Seven criteria were used to aid in the evaluation of the abnormal small bowel on contrast-enhanced MDCT. They included the pattern of enhancement, the length of bowel involvement, degree of thickening, whether the thickening is symmetric or asymmetric, location of the lesion along the course of the small

bowel (proximal or distal), location of the lesion in the wall of the small bowel (mucosal, submucosal, or serosal), and, finally, associated abnormalities in the mesentery and vessels. Optimal distension of small bowel loops was taken if luminal diameter was 1.5 cm, as it was sufficient to study the mucosal detail. The bowel was considered dilated when the luminal diameter of the jejunum was >3 cm and >2.5 cm for the ileum.

Bowel wall thickness above 3 mm was considered as abnormal mural thickening when luminal distension is adequate. Mural thickening was subdivided into three categories: mild (3- 4 mm), moderate (5- 9 mm), and marked (10 mm). Mural thickening can be symmetric or asymmetric and concentric or eccentric. Four patterns may be present during contrast-enhanced CT. These include a double-halo or target appearance, referred to as mural stratification; homogeneous or hyperenhancement; heterogeneous enhancement; and decreased or absent enhancement. The length of the affected small bowel can be focal (<5 cm), segmental (5-40 cm), or diffuse (>40)

Observations and Results

Out of sixty-five patients, twenty-three (35.39%) patients were females and forty-two (64.61%) patients were males with male to female ratio of 1.82:1. The predominant symptom in small bowel disease was abdominal pain, which was seen in 69.23% of cases, chronic diarrhea (18.46%) was the second most common indication. Other symptoms included vomiting, distension of abdomen, altered bowel habits, weight loss, mal-absorption, easy fatigability and anaemia. Over fifty percent of patients of the entire study group were referred with clinical diagnosis of sub-acute intestinal obstruction. In 23.08 % of cases, abdominal tuberculosis was the clinical suspicion. Hence, sub-acute intestinal obstruction and abdominal tuberculosis were the two major clinical diagnoses for which CT enterography was done in this study. Suspicion of Crohn's disease was present in 15.38 % of cases. Occult gastrointestinal bleed, stricture and celiac disease constituted other indications of CT enterography.

Table I: Assessment of loops distension

Small bowel loop	No. of loops having distension greater than 1.5 cm (Percentage)
Proximal jejunum (J1)	44(67.69%)
Distal jejunum (J2)	37(56.92%)
Proximal ileum (I1)	56 (86.15%)
Distal ileum (I2)	52 (80%)

Jejunal loops were showing a distension of greater than 1.5 cm in 56% to 67% cases only.

Table 11: Enhancement pattern in abnormal Small Bowel segments (N=32)

Enhancement Pattern	No. of Patients (Percentage)	Pathology	No. of Patients (Percentage)
Homogenous enhancement	18 (56.25%)	Tubercular pathology Non specific enteritis Stricture Malignancy	9 (28.12%) 3 (9.3%) 5(15.6%) 1 (3.1%)
Heterogenous enhancement	12 (37.5%)	Malignancy Tubercular	10 (31.25%) 2 (6.25%)
De enhancement	1(3.1%)	Ischaemic bowel disease	1(3.1%)
Bi-laminar stratification	1 (3.1%)	Non specific enteritis	1(3.1%)

Homogenous enhancement was seen in benign pathologies like tuberculosis (n=18), while heterogenous enhancement was seen predominantly in malignancies (n=10), (Fig 1, 2, 5)

Table III: Abnormal thickening of the small bowel (N=32 patients)

	Moderate thickening (Percentage) 5- 9mm	Marked thickening (Percentage) >10mm
Stricture due to adhesion	5 (16.66%)	0
Thickening in tuberculosis	8 (25%)	3 (9.37%)
		2 (6.25%)
Non specific enteritis	2 (6.25%)	
Ischemia	0	1 (3.1%)
Malignancy	2 (6.25%)	9 (28.12%)

Moderate thickening was mainly seen in benign cases like tuberculosis (n=8), while marked thickening was seen in malignancies (n=9), however tuberculosis (n=3) and non-specific enteritis (n=2) also caused marked thickening.

Table IV: Length of bowel wall involvement

	Disease break up	**Focal (< 5 cm)**	**Segmental (6-40cm)**	**Diffuse (> 40 cm)**
Benign etiology	Tubercular	5 (15.62%)	6 (25%)	0
	Non-specific enteritis	0	4 (12.5%)	0
	Stricture	4 (12.5%)	1 (3.12%)	0
	Ischaemic bowel disease	0	0	1 (3.12%)
Malignant etiology	Adenocarcinoma	6 (18.75%)	1 (3.12%)	0
	Metastasis	0	1 (3.12%)	1(3.12%)
	Gastrointestinal tumour	0	1 (3.12%)	0
	Lymphoma	0	0	1(3.12%)
Total		15(46.85%)	14 (43.75%)	3 (9.37%)

Both tuberculosis (n=5), (Fig 6,7) and adenocarcinoma (n=6) caused focal thickening (Fig 1,2). Segmental thickening was mainly seen in benign pathologies like tuberculosis (n=6) and non-specific enteritis (n=4). Diffuse involvement was seen in cases of lymphoma (n=1), (Fig 3,4), metastasis (n=1) and ischaemic bowel disease (n=1).

Table V: CT Enterography Diagnosis

	Findings	No. of Patients (Percentage)	Pathology	No. of Patients (Percentage)
A	Normal findings	25 (38.46%)		
B	Abnormal thickening located in small bowel	32 (49.23%)	Intestinal tuberculosis	11(16.92%)
			Stricture	5 (7.69%)
			Non specific enteritis	4 (6.15%)
			Adenocarcinoma small bowel	7 (10.76%)
			Metastasis to small bowel	2 (3.07%)
			Gastrointestinal tumour	1 (1.53%)
			Lymphoma small bowel	1 (1.53%)
			Ischaemic bowel disease	1 (1.53%)
C	Abnormal thickening located in large bowel with associated dilatation of small bowel with no abnormal small bowel thickening	3 (8.33%)	Thickening ascending colon	2(3.07%)
			Thickening transverse colon	1(1.53%)
D	Small bowel findings other than thickening:	2 (3.07%)	Celiac disease	1(1.53%)
			Malrotation of gut	1(1.53%)
E	Alternative diagnosis	3(8.33%)	Lymphadenopathy	1(1.53%)
			Ascitis	2(3.07%)
F	Extra intestinal findings		Lymphadenopathy	26 (40%)
			Fat stranding	18 (27.69%)
			Ascitis	15 (23.07%)
			Omental involvement (thickening)	9 (13.84%)

There were 11 cases of intestinal tuberculosis out of which 8 cases were proved on histopathology, in 3 cases response to antitubercular treatment in the form of resolutions of symptoms or radiologic improvement at the end of treatment was taken as standard of reference. There were 11 cases of malignancy of small bowel all of which were histopathologically proven.

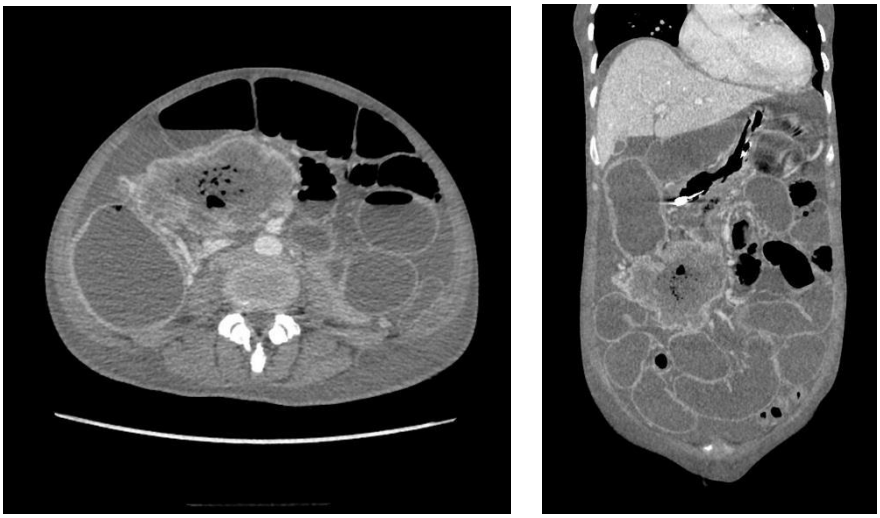

Fig No1 and 2: CT Enterography (Axial and Coronal) images showing focal, heterogeneously enhancing mass of transverse colon and terminal ileum with proximal small bowel dilatation and ascites proved to be adenocarcinoma.

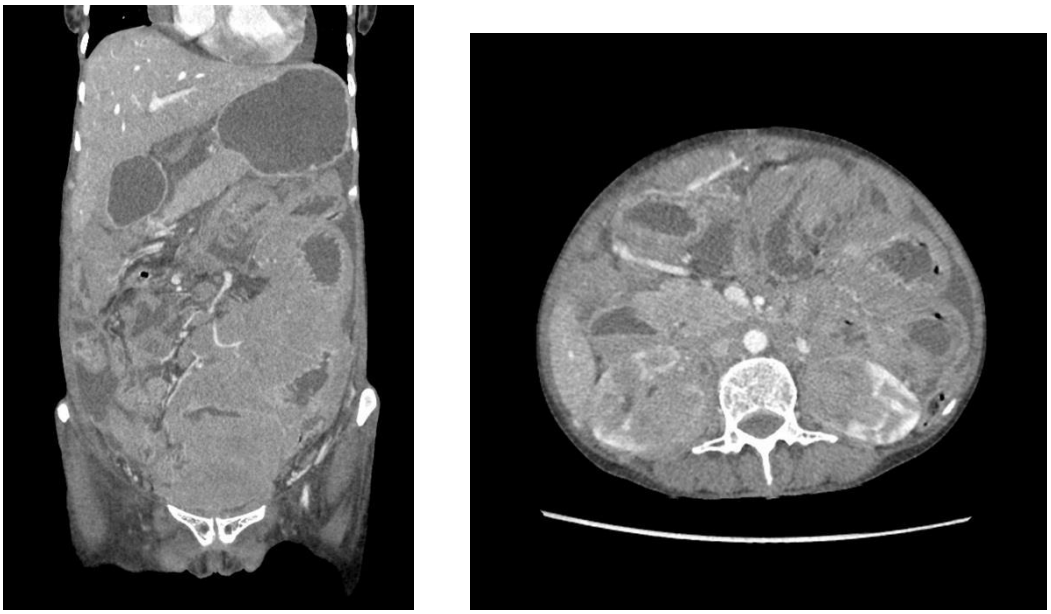

Fig No. 3 and 4: CT Enterography (Coronal and Axial) images showing diffuse and marked wall thickening with homogenous enhancement of small bowel proved to be lymphoma.

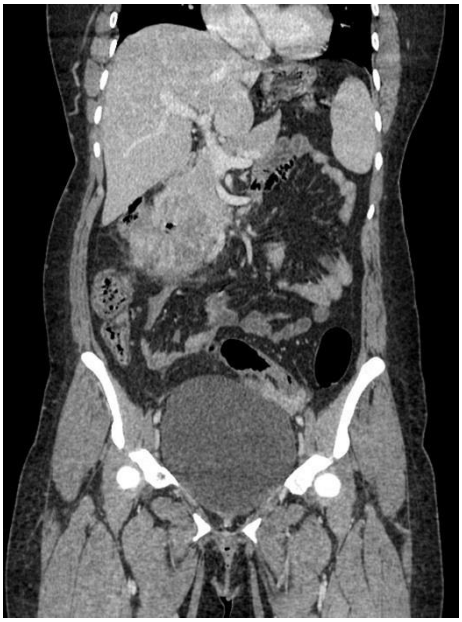

Fig No. 5: CT Enterography (Coronal) image showing focal heterogeneously enhancing exophytic mass in relation to duodenum proved to be GIST

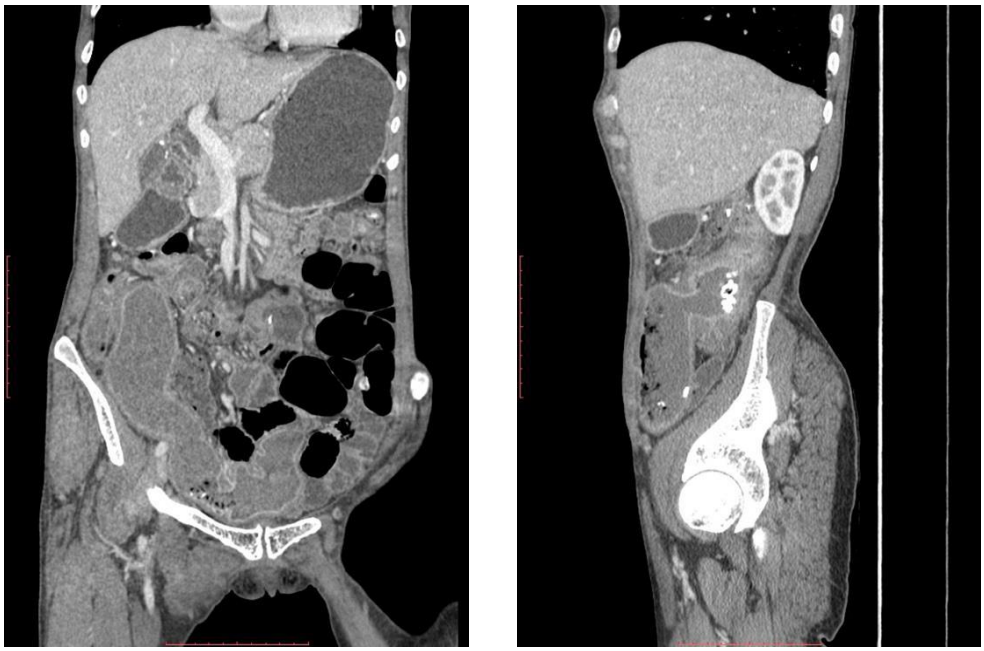

Fig No. 6 and 7: CT Enterography (Coronal and Sagittal) images depicting hetrogenously enhancing focal thickening in ileocaecal region with enteroliths and proximal dilatation proved to be tuberculosis

Discussion

Imaging of the small bowel is complicated by its length and overlapping loops. However faster acquisition at a cheaper cost, no extra radiation and no discomfort as associated with nasojejunal intubation are other advantages which have made CT enterography an ideal method for assessment of small bowel.

We used neutral contrast agents to load small bowel as they improve small bowel distension and result in superior visualization of its mural features and there is no interference with post processing techniques. The results were in concordance to the study done by Paulson et al[9]. In our study, Polyethylene Glycol mixed with 1800 ml water was used as neutral contrast to distend the bowel. Injection buscopan was given intramuscularly 45 min after initiation of drinking water to relieve

patient discomfort and increase the patient compliance for drinking water. The distension of the small bowel loops in our study using PEGLEC was optimal and in concordance to the mentioned studies of Young BM et al, Kalra et al and Minordi et al[10,11,12].

We performed the study at 50 seconds after intravenous contrast administration and achieved optimal enhancement in 98.46% (n=64) patients. Schnidera et al[14] in their study have seen that the meantime to peak enhancement of the small-bowel wall on average about 50 seconds after intravenous administration of contrast material or 14 seconds after peak aortic enhancement. Findings in our study were in concordance with his findings.

Distension greater than 1.5 cm seen in the proximal jejunal loops in 44/ 65 (67.69%) patients, distal jejunal loops in 37/65 (56.92%) patients, proximal ileum in 56/65 (86.1%) patients, distal ileum in 52/65 (80%) patients were achieved in our study, which was in concordance with Minordi et alexcept in the proximal jejunum where it is better in our study with 67% optimal distension as compared to 40% in their study.

In our study jejunal distension was not as consistently achieved as ileal distension. This was similar to the studies done by Young et al and Fletcher et al[10,13]. The reason may probably be lower acceptance of oral fluids by the time jejunum was to be distended.

In 11 cases of small bowel tuberculosis, predominant site of involvement was ileo-caecal region in 9 cases (81 %), with homogenous enhancement in 9 cases (81%). Moderate thickening was seen in 8 cases (72%). These findings are in agreement with Kalra et al and Balthazar et al[11,14]. Segmental involvement of the gut was seen in 6/11 cases (54%) and focal involvement in 5/11 cases (45%). Other associated findings in tuberculosis were abdominal lymphadenopathy, ascites, enteroliths, small bowel faeces sign and omental thickening.

We had 11 cases of malignancy in which ileal involvement was seen in 3 cases (27%), duodenum in 2 cases (18%), jejunum in 2 cases (18%), ileo-caecal involvement in 3 cases (27%) and small bowel diffusely in 1 case (9%). Adenocarcinoma was the most common histopathological diagnosis in 7 of 11 cases other being GIST, Lymphoma, and metastasis. Asymmetric thickening was seen in 9 of 11 cases (81%), focal thickening seen in 6 cases (54%), heterogenous enhancement seen in 10 cases ((91%) which are in concordance with Macari et al and Hasan et al[15,16].

The study demonstrates that CT enterography is useful in diagnosis of small bowel diseases if patterned approach is applied.

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