

Original Research Article

Utility of CT enterography in the evaluation of small bowel pathologies

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ABSTRACT

Background: Radiology has been the primary investigation tool for small intestine because of technical challenges in endoscopy. Barium studies and computed tomography (CT) have been the most useful modalities over the years; however, neither is a complete investigation by itself. CT enterography offers the possibility of a single comprehensive radiological evaluation. The present study was undertaken to study the accuracy of CT enterography in characterising various small bowel pathologies.

Methods: A total of 84 patients clinically suspected or known to have small intestinal disease underwent CT enterography on a 64 slice MDCT. The radiologic findings were correlated with clinical, endoscopy, histopathology and operative findings.

Results: A wide variety of pathologies can be diagnosed accurately on CT enterography. In our study, majority of the patients had non-neoplastic pathologies (79%). Neoplastic lesions were detected in 21% of the patients of which 14% were malignant. There was good correlation between CT enterography and endoscopy, histopathology and operative findings. The ability of CT enterography to differentiate acute inflammation from chronic changes is valuable in management of Crohn's disease.

Conclusions: CT enterography should be considered as the investigation of choice for radiological evaluation of small bowel pathologies as it provides a comprehensive evaluation of the disease process.

Keywords: Computed tomography, Enterography, Small bowel

INTRODUCTION

Barium follow through and enteroclysis were the radiological investigations of choice for evaluation of small bowel pathologies for many decades. They could display luminal and mucosal abnormalities well but could not demonstrate the state of the bowel wall and extension of the disease process outside the bowel.¹

CT scan was able to overcome this particular limitation and demonstrate bowel wall thickening and associated extraluminal changes such as inflammatory change,

lymphadenopathy or local metastatic tumour spread from small bowel neoplasms. But conventional CT lacked the mucosal detail of small bowel barium studies

CT enterography was first introduced by Raptopoulos et al, as 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.² They combined neutral (low-density) oral contrast with "enteric phase" CT to optimize contrast resolution between mucosa and lumen, thereby maximizing conspicuity of abnormalities arising from the small bowel wall.

The present study was conducted to study the accuracy of CT enterography in characterising various small bowel pathologies.

METHODS

A total of 84 patients who were clinically suspected to have small bowel disease underwent CT enterography at a tertiary medical institution in Mumbai. The radiologic findings were correlated with endoscopy, histopathology and operative findings. The study was approved by the institutional ethics committee.

Imaging technique and Interpretation

Patients undergoing CT enterography were asked to withhold oral intake starting 4hours before the examination. 0.1% mannitol suspension was administered as a negative oral contrast agent. Our regimen with regard to the timing of administration of mannitol involved the ingestion of a total of 1.35 L over 1 hour (450 ml at 60 minutes, 450 ml at 40 minutes, 225 ml at 20 minutes, 225 ml at 10 minutes before scanning). Injection Buscopan was administered 10 minutes before the CT scanning to avoid focal bowel spasms. After the oral contrast agent was injected, a bolus of intravenous contrast material (125 ml) followed by 50 ml of saline solution was administered with a power injector at a rate of 4ml/sec.

Helical scanning using 64 slice MDCT scanner was performed from the diaphragm to the symphysis pubis, included a triple phase study (arterial, venous and delayed). Postprocessing techniques include axial image reconstruction with a section thickness of 1 mm, reformatting of axial image data for maximum intensity projections and volume rendering when required.

Small bowel abnormalities were evaluated according to the criteria proposed by Macari et al.³

Statistical analysis

Analysis of the study was done as per standardized statistical methods.

Diagnostic efficacy of CT Enterography as compared to operative findings, endoscopy and histopathology was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio.

RESULTS

Age distribution

The mean age of the study population was 44.14±18.84 years.

Benign pathologies were commoner in age group less than 40 years and the prevalence of malignant neoplasms increased after 50 years

Location of pathology in small bowel

Jejunum and ileum were the commonest locations noted in 30.18% and 31.65% respectively. Non-neoplastic pathologies affected the ileum more commonly (34.92%). 50% of the benign neoplasms were detected in jejunum and duodenum. Malignant neoplasms were most commonly noted in duodenum.

Table 1: Type of diagnosis.

Type	Distribution	
	Number	Percentage
Non-neoplastic	66	78.57
Benign neoplasm	6	7.14
Malignant neoplasm	12	14.28
Total	84	100.00

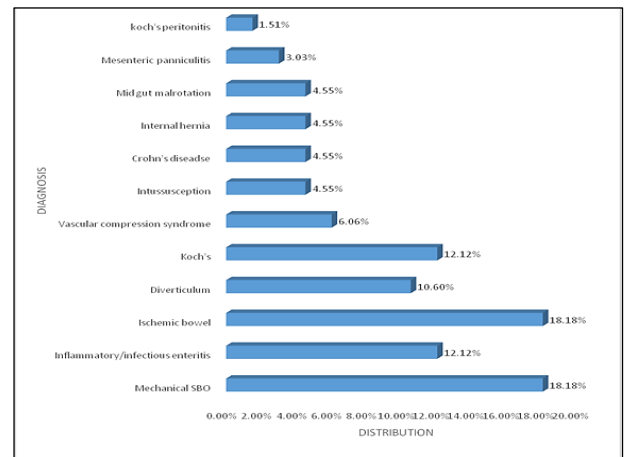


Figure 1: Distribution of non-neoplastic pathologies.

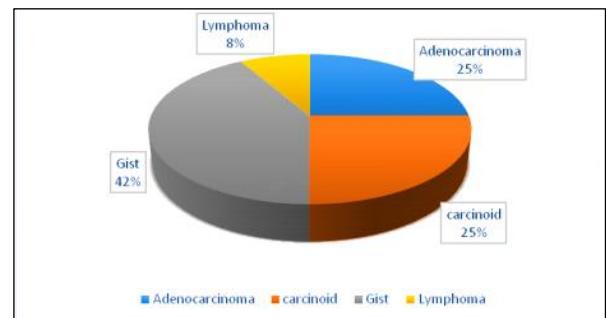


Figure 2: Distribution of malignant lesions.

Bowel wall involvement

Bowel wall involvement was observed in 69.04% of the patients. Following features regarding bowel wall involvement were evaluated

Pattern of contrast enhancement

Majority of the patients had target pattern of enhancement (37.25%) followed by homogenous pattern of enhancement (29.41%). Among the patients with benign lesions, 46.34% had target enhancement whereas in those with malignant neoplasm, heterogeneous enhancement pattern was noted in all the cases.

Length of the thickened segment

For the purpose of differential diagnosis, Macari et al⁴ has classified the length of the thickened bowel segment under three categories: focal (<5 cm), segmental (6-40 cm) and diffuse (>40 cm). Segmental type was most common in our study, seen in 54.90% of the patients.

Layer of wall involved

50.98% of the patient with thickened bowel walls had submucosal layer involvement. Simultaneous involvement of mucosa and submucosa was noted in 13.73% of the cases. In patients with malignant lesions, 90% of the patient had involvement of all the layers and 10% had involvement of submucosal layer alone.

Mesentery involvement

Involvement of mesentery in the form of mass/fat stranding or vascular engorgement was seen overall in 26.19% of the patients and in 50.00% of the patient with malignant neoplasm.

Statistical analysis

The sensitivity of CT enterography for non-neoplastic diseases, benign neoplasm and malignant neoplasm is 93.7%, 66.66% and 83.33% respectively. The specificity of CT enterography for non-neoplastic diseases, benign neoplasm and malignant neoplasm is 72.22%, 66.66% and 67% respectively. Positive predictive value of CT enterography for non-neoplastic pathologies is 90%, for benign neoplasm 66.66% and for malignant neoplasm it is 71.42%. Similarly, negative predictive value of CT enterography for non-neoplastic pathologies is 81.25%, for benign neoplasm is 66.66% and for malignant neoplasm 80%.

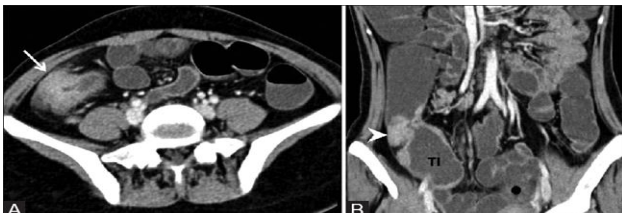


Figure 3: Axial (A) and coronal (B) CT enterography images show gross thickening of ileocecal valve (arrow) and contracted cecum (arrow head) with pericecal fat stranding. Terminal ileum (TI) is dilated.

Diagnosis: Ileocecal tuberculosis.

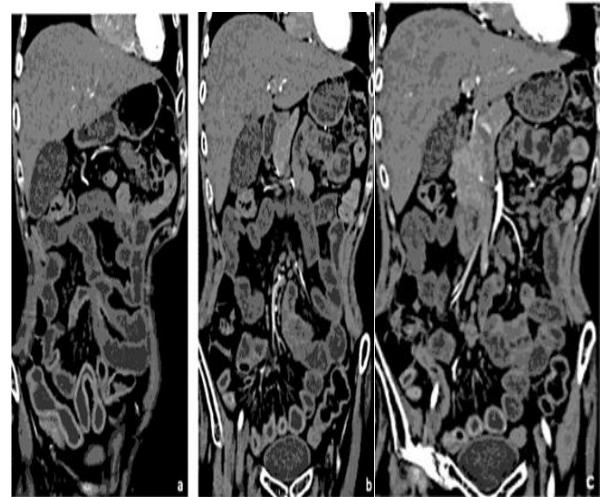


Figure 4: (a) Coronal reformatted CT enterography images shows intense uniform enhancement of the ileal loops with short narrowed segments alternating with normal calibered ones; (b) Engorgement of vasa recta (+ve comb's sign) and multiple subcentimetric mesenteric lymphnodes.

Diagnosis: Crohn's disease

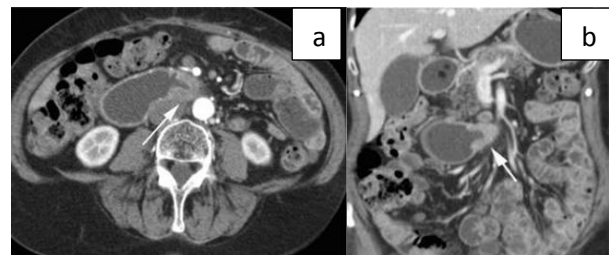


Figure 5: (a) Axial and (b) coronal CT images show circumferential wall thickening of the horizontal part of the duodenum (arrow) causing stenosis.

Diagnosis: Duodenal adenocarcinoma.

DISCUSSION

The pattern approach for interpreting abnormalities detected on CT enterography was popularized by Macari et al.³ The criteria include location of abnormality in duodenum/jejunum/ileum, degree and symmetry of wall thickening, pattern of contrast enhancement, location of pathology within the bowel wall (mucosal/submucosal/serosal) and associated abnormality in the adjacent mesentery or vessels.

Small bowel wall enhancement patterns have been divided into a "target" appearance, homogenous, heterogeneous and diminished. Target appearance with stratification of the layers of the small bowel wall is generally found with benign conditions-for example, active Crohn's disease, venous thrombosis with associated bowel edema or ischaemia. If wall

enhancement is homogenous and mild, chronic inflammatory conditions should be considered, particularly those producing fibrosis within the small bowel wall (for example Crohn's disease, ischaemia and radiation). Heterogeneous enhancement is seen in small bowel neoplasms, including gastrointestinal stromal tumours, adenocarcinomas, metastases and peritoneal deposits. Decreased enhancement is typical of bowel ischaemia and usually precedes the development of intramural gas and subsequent perforation.⁴

In this study, majority of the patients had target pattern of enhancement (37.25%) followed by homogenous pattern of enhancement (29.41%). Among the patients with benign lesions, 46.34% had target enhancement whereas malignant neoplasms displayed heterogeneous enhancement pattern in all the cases.

The appearance of the gastrointestinal wall varies on contrast-enhanced CT as the bowel wall progresses from ischemia to infarction. When the wall is ischemic, it is often circumferentially thickened and may contain a target or halo configuration of attenuation. In other cases of ischemic bowel, the wall is thickened and diminished enhancement is identified. Etiologies of ischemia and infarction include thromboembolism, low flow (related to poor cardiac output) and strangulation obstruction.⁵

12 patients (18.18%) were diagnosed with ischemic small bowel disease. 7 patients (58.3%) had diminished bowel wall enhancement and rest had target pattern of wall enhancement. 4 patients (33.3%) had intramural air pockets along with submucosal edema. In these patients, 3 patients had gas in the portal vein and 5 patients had thrombus in superior mesenteric artery. 2 patients also showed splenic infarcts.

Identification of the layer of the small bowel wall that is predominantly affected is helpful in differential diagnosis. The mucosa is seen to be predominantly affected in inflammatory conditions like Crohn's disease, tuberculosis and neoplasms such as adenocarcinoma. Mucosa is affected predominantly in infectious conditions and vasculitides. The predominant abnormality is seen in the submucosa in conditions like intramural hemorrhage, vasculitis, ischaemia, hypoalbuminaemia and angio-oedema. The serosa is predominantly involved in metastases, endometriosis, carcinoid and other inflammatory conditions in the peritoneum.⁵ In this study, majority (50.98%) of the patients had submucosal layer involvement. Simultaneous involvement of mucosa and submucosa was noted in 13.73% of the cases.

Patients with Crohn's disease who present with an acute flare often have bowel wall thickening with mural stratification that results in a target-like or "halo" appearance of the bowel. The "halo" appearance refers to alternating layers of hyper-dense mucosa, hypodense submucosal edema and hyper-dense serosa. The presence

of low-density submucosal edema suggests an active inflammatory process.⁶ A more sensitive yet less specific indicator of active disease is mucosal hyperemia, which is best demonstrated on CT enterography compared to conventional CT study.

Extra-intestinal findings are also helpful indicators of active disease. The "comb sign" describes the engorged vasa rectae within the mesentery that run perpendicular to the bowel wall and correlates with more advanced and active disease that may warrant more aggressive medical therapies. An increase in the density of the mesenteric fat surrounding an abnormal loop of bowel is found to correlate with elevated C-reactive protein levels and histopathologic severity of disease.⁶ Fibrofatty proliferation or fatty deposition along the mesenteric border of inflamed bowel segments is highly specific for transmural inflammation secondary to Crohn's disease but can be seen with both active and chronic disease. Other important extra-enteric findings include abscesses and fistulas, as these may determine a need for surgical intervention.

In this study, out of the 3 cases of Crohn's disease, 2 were diagnosed to have active inflammation with mild wall thickening, submucosal edema, target wall enhancement and adjacent fat stranding with abscess as extra-enteric complication. The patient who had chronic disease showed submucosal fat deposition.

66 (79.7%) out of 84 cases in our study had non-neoplastic pathologies. 12 patients (18.18%) were diagnosed to have mechanical small bowel obstruction. Most common cause was small bowel strictures (61.5%) followed by adhesions and volvulus (15.3% each).

Internal hernias were diagnosed in 3 patients. All were paraduodenal hernias, the two patients with right paraduodenal hernia also had associated midgut malrotation.

All the patients with intussusception were adults in 2nd or 3rd decade of life. In all cases, the site of telescoping was jejunum. None of the patients had features of small bowel obstruction or a lesion at the lead point.

Among the other entities, 4 patients had vascular compression syndromes - 2 cases each of superior mesenteric artery syndrome and median arcuate artery ligament syndrome. Also 3 cases of midgut malrotation, 2 cases of mesenteric panniculitis and 1 case of tubercular peritonitis were diagnosed.

Primary neoplasms of the small bowel, both benign and malignant, are rare. In the present study 12 patients were diagnosed to have malignant lesions among which gastrointestinal stromal tumor (GIST) was the commonest diagnosis (41.67%) followed by adenocarcinoma and carcinoid (25% each) and

lymphoma (8.33%). In 50% of the patients with malignant neoplasms, mesentery was also involved.

Malignant tumors account for upto 70% of small-bowel neoplasms.⁷ Adenocarcinomas are the most common of these. In this study, it was the second most common lesion, which is probably due to the small sample size. Adenocarcinomas occurred only in males with age of 50-60 years, most commonly in duodenum. They show heterogeneously enhancing moderate bowel wall thickening. One of those cases in duodenum resulted in intrahepatic biliary duct dilatation due to compression on common bile duct. Obstruction due to severe luminal narrowing was observed in one case. Extraluminal findings such as mesenteric lymphadenopathy was also detected.

The second most common malignant neoplasms in the small bowel is the neuroendocrine or carcinoid tumor. In our study 25% of the malignant neoplasms were carcinoid tumors. These lesions were intraluminal homogeneously enhancing lesions.

Lymphoma is the third most common malignant neoplasm of the small bowel and may arise from mucosa-associated lymphoid tissue (MALT). Lymphoma most often affects the ileum. In our study, 8.33% of the cases were diagnosed as small bowel lymphoma located in ileum. In these cases, there was segmental involvement of ileum with moderate wall thickening and heterogenous enhancement. Extraluminal findings such as mesenteric lymphadenopathy which showed classical encasement of the vessels were observed. Spleen also showed few non-enhancing lymphomatous deposits.

While most GISTs are benign tumors, they also have the potential for malignant transformation. In this study, GIST comprised of 41.67% of neoplastic lesions. Most commonly they occurred in jejunum. Larger lesions typically showed infiltration of the adjacent mesentery as well as cavitations, necrosis and hemorrhage.

CONCLUSION

CT enterography is able to diagnose all major pathologies originating in the lumen and different layers of the small bowel and also evaluate the disease spread outside the bowel.

The technique is not complex; the time taken for the procedure is less than standard conventional small bowel procedures and no more than a standard CT abdominopelvic study. At the same time, it combines the advantages of enteroclysis and CT scan without any additional radiation risk. Hence, we propose that CT enterography should be considered as the investigation of choice for evaluating small bowel pathologies.

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Conflict of interest: None declared

Ethical approval: The study was approved by the institutional ethics committee

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