Journal of Associated Medical Sciences 2023; 56 (1): 187-191

JAMS
Journal of Associated Medical Sciences

Scopus indexed & Thai-Journal Citation Index Centre (TCI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

Role of computed tomographic enterography for evaluation of small bowel diseases: A cross-sectional study

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ARTICLE INFO

Article history:
Received 6 October 2022
Accepted as revised 9 December 2022
Available online 16 December 2022

Keywords:
Computed tomographic enterography, small bowel diseases, Crohn's disease

ABSTRACT

Background: Computed tomographic enterography (CTE) is a newer non-invasive modality having distinct advantages over conventional CT and capsule endoscopy.

Objectives: This technique allows faster evaluation of small bowel diseases in the endoscopically inaccessible segments. Being an operator-independent procedure, CTE is widely available and allows a better depiction of extra enteric complications. The aim is to evaluate CTE features of various small bowel diseases and the role of 2% mannitol for adequate small bowel distension.

Materials and methods: A cross-sectional study comprising 105 patients had presented with small bowel diseases. Patients in the age group of 10 to 85 years with complaints of fever, abdominal pain, nausea, vomiting, altered bowel habits, loss of appetite and loss of weight were included in this study. CTE images were analyzed to compare the diagnosis with the available histopathological and ultrasonography results.

Results: Among the study population, the majority had presented CTE features such as symmetrical wall thickening (53.3%), peri-bowel inflammatory changes (61%), mucosal hyperenhancement (39%), and mural stratification, i.e., target sign (33.3%). The majority of diagnoses of CTE were ileocecal tuberculosis (11.5%), small bowel inflammation (7.6%), and Crohn's disease (6.7%). Other conditions such as small bowel neoplastic masses, diverticula, ischemic bowel disease, bowel strictures, intussusception, and ulcerative colitis.

Conclusion: CTE has the vital role of first-line modality in the work-up of suspected small intestinal diseases and helps evaluate disease activity before endoscopy, particularly in inaccessible segments. It allows a better depiction of extra enteric complications of the bowel.

Introduction

Small bowel segment of the alimentary tube is the most challenging part of being examined due to its length, caliber, and overlapping loops.[1] Due to the caliber and size, the small intestinal loops are always under-evaluated both by conventional radiography and endoscopic modalities. Computed tomography (CT) has significantly evaluated extra-enteric manifestations of small bowel disease. In contrast, it is restricted to depicting luminal and bowel wall pathologies.[2] CT enterography (CTE), a new robust technique for characterizing small bowel disease, uses the current advanced technology of multidetector-row CT (MDCT). This technology is used in CTE and provides

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doi: 10.12982/JAMS.2023.035
E-ISSN: 2539-6056

detailed evaluation and interpretation of mural and luminal features of the gut. An accurate depiction of peri-enteric tissues improves the assessment of disease complications and extends.[2,3] The modality allows better three-dimensional reconstructions (volume rendering, surface shading and multi-planar reconstruction display) and volume rendering through navigation (virtual CT endoscopy).[4] New scanners with the above technology help the isotropic acquisition of images during a single breath-hold and allow a high-resolution analysis of bowel features in a multiphasic manner.[2,5]

CTE differs from conventional abdominopelvic CT by using thin collimated slices and a high volume of contrast agent to display the small bowel wall and lumen effectively (Figure 1). This technique uses a neutral contrast material like water and an intravenous contrast agent to evaluate small bowel features such as hyper vascular lesions and hyper-enhancing segments, compared to the traditional follow-through examination.[6] Water is widely used as a neutral contrast material and has an excellent effect on the upper portion of the GIT. However, its use for distal small bowel is limited in clinical practice for the rapid absorption property.[7,8] An additive can cause slow water absorption by raising the solution's osmolarity.[1] *Mannitol* is one such additive, which is an inexpensive neutral oral contrast agent and easy to use. Due to iso-osmotic property, *mannitol* helps adequate small bowel distention making CTE an effective modality for evaluation of small bowel diseases.[9]

Our objective is to analyze CTE's role in detecting and characterizing small bowel pathologies by using mannitol for optimal bowel distension, thus making it more accessible in decision-making for further management.

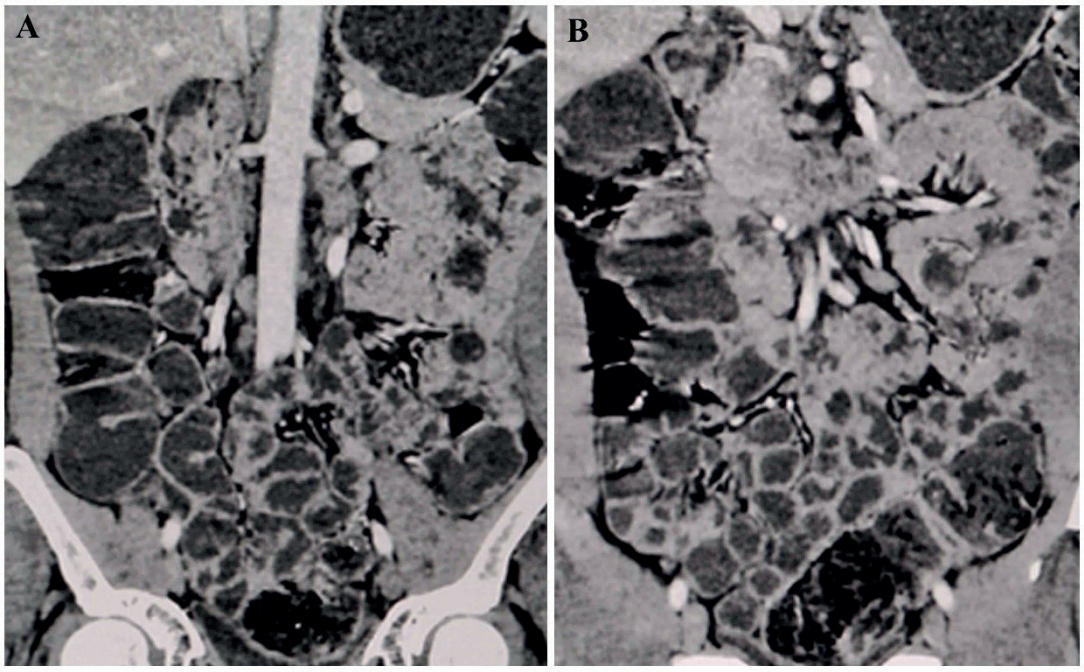

Figure 1 *CT enterography. Coronal images showing A: adequate luminal distention & uniform wall enhancement of normal jejunal and ileal loops, B: prominent mucosal pattern of normal jejunal loops.*

Materials and methods

This is a cross-sectional study with a two-year duration (September 2017-2019), with a study population comprising 105 patients presenting with bowel lesions in IMS & SUM Hospital, Bhubaneswar. Institutional Ethical Committee approval was obtained for the study. The radiological procedure was explained to the patients and obtained informed consent from all patients. While evaluating with MDCT (GE Optima CT660 128 slice with pressure injector), initially plain CT scan of the patient was done in the supine position. Mannitol was given 60-90 min before the contrast-enhancing CT image acquisition, as described in flow diagram (Figure 2). The post-contrast study was performed in dual phase/triphasic protocol after injecting approximately 100 mL water-soluble non-ionic iodinated intravenous contrast (350 mg% IOMERON). CTE images were analyzed to compare the diagnosis with the available histopathological and ultrasonography results. Patients in the age group of 10 to 85 years with complaints of fever, abdominal pain, nausea, vomiting, altered bowel habits, loss of appetite, and loss of weight were included in this study. Patients suspected of small bowel diseases and follow-up cases of small bowel diseases were included. The exclusion criteria were any suspected leak or perforation, postoperative studies, pregnancy, and patients with previous allergy history for intravenous contrast material use.

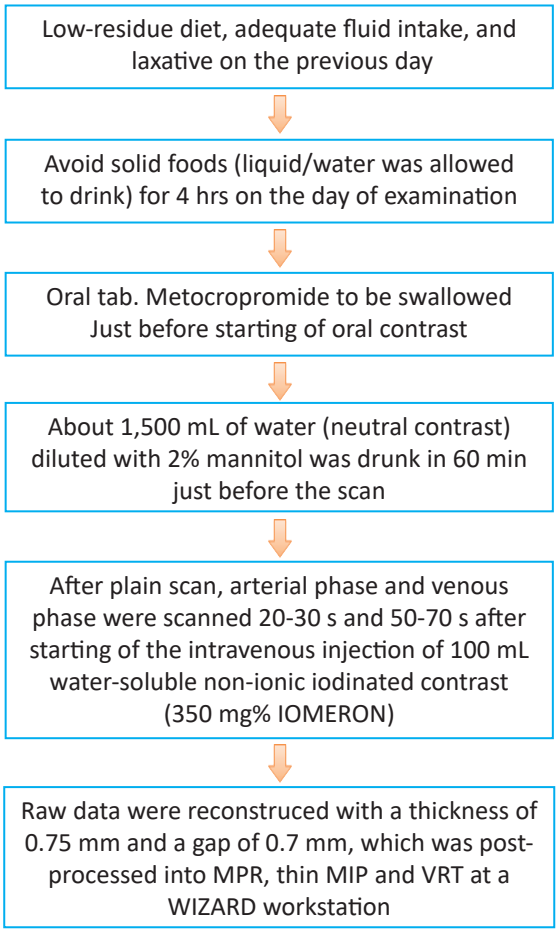

Figure 2 *Experimental flow diagram of CTE procedure.*

Statistical analysis

Quantitative data was represented using mean±SD or median with Interquartile range (IQR). The qualitative data was described in the form of frequency and percentage. The association among two qualitative variables was measured using the Chi-Square test. The diagnostic accuracy of MDCT imaging for small bowel lesions was also evaluated to detect abnormality in the patient. All associations were tested at a probability level of 0.05.

Results

The study population included 65 male and 40 female patients. The age of patients ranged from 10-85 years with a mean age of 42.3 years, while most were from the 40-49 years group (Figure 3). The luminal distension of the ileum, measured from outer wall to outer wall of the bowel loop, was adequate (≥2 cm) in 99% of cases using 2% mannitol as oral contrast.

Of the 105 patients studied, most had thickening of the jejunal loops (16.2%), followed by ileal thickening (14.3%). Ileum, caecum, and ileocecal junction were essential sites of wall thickening (13.3%). In patients with pathological wall thickening, most showed symmetrical wall thickening (53.3%), whereas asymmetrical wall thickening was seen only in 10.5% of patients. Patients with suspected bowel pathology had presented mucosal hyperenhancement of the distended bowel loops in 39% of patients, whereas

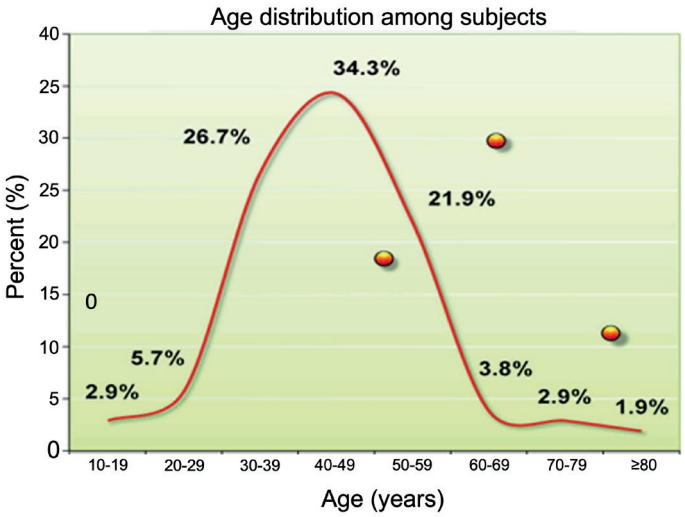

Figure 3 *Age distribution among the subjects (patients with small bowel diseases).*

it was absent in 61%. The mural stratification, i.e., target sign, was seen at the site of bowel pathology in 33.3% of patients, whereas 66.7% did not have any such finding. Around 61% of patients showed peri-bowel inflammatory changes at the site of bowel pathology, whereas it was absent in 39% of patients (Table 1).

Table 1 Prevalence of CTE features among the study population.

CTE feature	Study population (N=105)	
	Present (%)	Absent (%)
Symmetrical wall thickening	56 (53.3%)	49 (46.7%)
Asymmetrical wall thickening	11 (10.5%)	94 (89.5%)
Homogenous enhancement	54 (51.4%)	51 (48.6%)
Heterogenous enhancement	11 (10.5%)	94 (89.5%)
Mucosal hyperenhancement	41 (39.0%)	64 (61.0%)
Mural stratification	35 (33.3%)	70 (66.7%)
Peri bowel inflammation	64 (61.0%)	41 (39.0)

Most patients with suspected bowel diseases were diagnosed with ileocecal tuberculosis (11.5%), while 7.6% had small bowel inflammation (duodenitis, jejunitis, or ileitis) and 6.7% had presented with Crohn's disease. These three diseases formed the majority of diagnoses on CT enterography. Another group of 6.7% cases was diagnosed with small bowel neoplastic masses. Patients with small bowel obstruction (5.7%), including those having abdominal hernias with bowel as content (6.7%), were also encountered in the study. Small bowel diverticula, most commonly duodenal diverticula, was observed in 5.7% of patients. Pancreatic head masses with adjacent duodenal compression and invasion were observed in 5.7% of patients. Ischemic bowel disease (arterial or venous) was observed in 2.9% of patients. Strictures of small bowel narrowing with proximal bowel dilatation were observed

in 1.9% of patients. Small bowel intussusception was observed in 1.9% of patients, whereas ulcerative colitis was observed in 1.9%. Pyloric malignancy involving the proximal duodenum was also observed in 1.9% of patients. Other rare and miscellaneous observations were also made in the remaining patients, like necrotizing pancreatitis with jejunal involvement (1%), etc. (Table 2).

Table 2 Spectrum of small bowel diseases diagnosed on CTE.

Diagnosis	Number	Percentage
Ileocecal tuberculosis	12	11.5%
Abdominal hernia	7	6.7%
Crohn' s disease	7	6.7%
Generalized small bowel obstruction	6	5.7%
Pancreatic mass compressing and invading the duodenum	6	5.7%
Small bowel mass	7	6.7%
Jejunitis/duodenitis/Ileitis	8	7.6%
Ischemic bowel disease	3	2.9%
Adenocarcinoma of pylorus of stomach involving duodenum	2	1.9%
Ileo-ileal intussusception	2	1.9%
Small bowel diverticuli	6	5.7%
Small bowel stricture with proximal bowel dilatation	2	1.9%
Ulcerative colitis	2	1.9%
Miscellaneous	5	4.8%

Most patients diagnosed with bowel diseases related to jejunum had presented with jejunal wall thickening (>3mm). Thus, a statistically significant correlation is seen between jejunal wall thickening and bowel diseases diagnosed on CT enterography (p<0.001) using Pearson chi-square. The above table shows that most patients with CT diagnosis of bowel diseases and ileum as the site of suspected wall thickening had ileal wall thickening (>3mm). Thus, a statistically significant correlation is seen between ileal wall thickening and bowel diseases diagnosed on CT enterography (p<0.001) using Pearson chi-square.

Discussion

Various radiological features of small bowel diseases were evaluated using 2% mannitol for adequate small bowel distension and characterization of multiple small bowel diseases. The study population had a mean age of 42.3, with a distribution of males and females of 35.5% and 64.4%, respectively.[10] According to the study by Zhang LH *et al*. 2005 luminal distention of ileal loops was adequate and satisfactory in most of the normal volunteers, with the mean distention score being 2.52±0.22 cm, 2.81±0.31 cm, and 2.33±0.19 cm in duodenum, ileum, and jejunum respectively.[9] The small bowel distension was graded 0-3 (grade 0 was for no distension, while grade 3 was for optimal distension) by grading on the basis of diameters of ileum and jejunum.[11] Poor distension was observed in only 2 of the 107 patients. Most of the causes for symmetric wall thickening along the circumference of the bowel were benign in etiology. Crohn's disease and tuberculosis are common causes of such conditions, though they sometimes may cause asymmetric thickening.[12] At the same time, asymmetric wall thickening is evident in patients presenting with neoplasms. However, lymphomas sometimes can cause symmetric wall thickening.[9]

In our study, most patients with asymmetrical wall thickening were diagnosed with malignant abdominal masses (71.4%). In contrast, symmetrical wall thickening did not have abdominal mass as the diagnosis (98.1%). Lymphoma and intramural hemorrhage of the small bowel can cause noticeable thickening and homogenous mural enhancement.[13] A heterogeneous enhancement pattern is a typical characteristic of small intestinal neoplasms. It is also most common in adenocarcinomas and gastrointestinal stromal tumors (GIST). The enhancement pattern in GIST always depends upon its size, and small-sized tumors tend to be well-circumscribed and show homogenous enhancement.

In contrast, the large tumors present with more irregular morphology, ulcerated margin, and heterogeneous enhancement. Rarely, lymphomas may enhance heterogeneously.[14,15] The target appearance of an abnormal small intestinal segment indicates a benign process within the bowel wall. This abnormal appearance is due to mucosal and serosal enhancement with central low attenuation submucosa. Though it was specific to Crohn's disease, it could be observed in other conditions, such as ischemia, infection, radiation enteritis, hemorrhage, and angioedema.[16]

Limitations of the study

Although adequate bowel distension was achieved

in most patients, it was inadequate in some. The possible reason could be wrong and unsupervised drinking technique of the oral contrast by the patients, i.e., either drinking it very fast or too slow. Neutral oral contrast cannot differentiate between bowel loops and any postoperative collections as both will be fluid density.

Conclusion

In our study, using 2% mannitol as an additive and a negative oral contrast agent like water had shown excellent results for adequate small bowel distension. Hence by using this technique for the evaluation of various bowel pathologies, radiological features like patterns of wall thickening (symmetrical or asymmetrical) and wall enhancement (homogenous or heterogeneous) were better delineated with accuracy. Mucosal hyperenhancement, mural stratification and other mucosal details, and prominent vasa recta indicating active disease process in Crohn's disease were seen with greater details. As this technique can accurately diagnose bowel wall and mucosal details, including enhancement patterns and surrounding mesentery and lymph nodal accurately; mannitol based CTE is the modality of choice for diagnosis of the small bowel disease spectrum.

Conflicts of Interest

All the authors report no conflict of interest.

Funding

No funding was received for this study

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