Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 2, 2024

Original Research Article

MDCT Enterography with Iso-osmotic Mannitol as Oral Negative Contrast for Detecting Small Bowel Disease

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Received: 25-12-2023 / Revised: 30-12-2023 / Accepted: 29-01-2024

ABSTRACT

Background*:* The purpose of this study was to assess the diagnostic value of CT enterography using mannitol as a negative contrast agent for the demonstration and diagnosis of bowel diseases in correlation with the histological diagnosis.

Methods: Its a prospective cross-sectional observational study was carried out among 60 patients with suspected bowel pathologies in the Department of Radiology at the Mysore Medical College and Research Institute, attached to K. R. Hospital, Mysore, over the course of 18 months, from January 2021 to June 2022, After getting approval from the institutional ethics committee and signed informed consent from the study participants,

Results: Of the 60 patients studied, 35 were males and 25 were females, with a slight male predominance. Most of the patients with benign lesions were in the age group of 30-39 years and those with malignant lesions were in the age group of 50-59 years. Most of the patients had bowel distension grade 3 (>80%) and grade 2 (50- 80%), suggesting bowel distension was excellent in most of the patients. Sensitivity, specificity, positive predictive value and negative predictive value of CTE in the diagnosis of benign intestinal diseases were 97%, 93%, 97%, and 93% respectively and sensitivity, specificity, positive predictive value and negative predictive value of CTE in the diagnosis of malignant intestinal diseases were 93%, 97%, 93% and 97% respectively.

Conclusion: In routine practice, CT enterography is an acceptable and applicable modality for the diagnosis and differentiation of intestinal pathologies, as well as for differentiating benign from malignant lesions. The taste of mannitol is good, acceptable, and tolerable, all of which helped in achieving adequate luminal distension and a good quality of image with the fewest artefacts.

Keywords: Bowel Distension, Bowel Wall Thickening, Computed Tomography Enterography

INTRODUCTION

Radiologic imaging continues to play an integral role in the diagnosis and management of diseases of the small and large bowels. Furthermore, small-bowel imaging is complicated by its length and

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 2, 2024

overlapping loops. The only portion of the gastrointestinal system for which endoscopic viewing is not the primary means of diagnostic investigation is the mesenteric small intestine. The diagnostic examination of the small intestine is primarily the duty of radiologists; hence, it is imperative that techniques that can precisely depict small intestinal morphology are used. In the past, enteroclysis and barium contrast investigations were the cornerstones of small-bowel imaging. In comparison to fluoroscopic barium examination, cross-sectional imaging of the small intestine (CT and MRI) provides specific benefits, such as the ability to show intraluminal diseases, the complete gut wall, and extraintestinal symptoms. Additionally, the advantage of multiplanar imaging is also provided. The enhanced spatial and temporal resolution of MDCT combined with intravenous contrast and negative oral contrast allow for better evaluation of the small intestinal wall and lumen in CTE (Computed Tomographic Enterography). By using oral hyperhydration to create enough luminal distension, nasoenteric intubation can be avoided, making CT enterography a valuable and well-tolerated investigation. Compared with conventional studies, CT enterography has several advantages[1] precise localisation and accurate characterisation of the lesion.[2]. Detection of mesenteric lymph nodes and better appreciation of vascular structure which can be overlooked on conventional CT.[3] 3-D displays are helpful in surgical planning.[4] Coronal projections of CTE provide for a formulation to surgeons and physicians. In order to demonstrate small intestinal illnesses, the current study attempts to evaluate the viability and use of CT-enterography using orally given iso-osmotic mannitol as a negative oral contrast.

AIMS AND OBJECTIVES

To assess the diagnostic utility of CT enterography in comparison to histopathological diagnosis for the demonstration and diagnosis of bowel diseases using mannitol as a negative contrast agent.

MATERIAL AND METHODS:

This was a hospital-based prospective cross-sectional observational study conducted among 60 patients with suspected bowel pathologies at the Department of Radiology, Mysore Medical College and Research Institute, attached to K. R. Hospital, Mysore, over a period of 18 months from January 2021 to June 2022 after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

Inclusion Criteria

Patients of all age groups with clinically suspected bowel disease.

Exclusion Criteria

- A patient not consenting for imaging study as per protocol.
- Uncooperative patients during imaging
- Contraindications to contrast-enhanced CT scans include pregnancy, hemodynamic instability, renal failure, and allergy to intravenous iodinated contrast media.
- Perforation or acute high-grade intestinal obstruction (complete obstruction; no fluid or gas passes beyond the obstruction)
- Acute intestinal infections
- Severe dehydration
- Known mannitol hypersensitivity
- Other relevant findings

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Statistical Methods Data obtained from the study were entered in Microsoft Excel sheets and statistics such as percentages, proportions, sensitivity, and specificity were calculated to meet the objectives.

RESULTS:

Table 1 Correlation between Bowel Obstruction and CT Pathologies

Enhancement Pattern	**No. of Patients**	**Percentage (%)**
Bright	33	55
Gray	20	33.3
Water Target Sign	2	3.3
Fat Target Sign	2	3.3
Gas Pattern	3	5
Total	**60**	**100**
Distribution of Enhancement Pattern		
Intestinal Obstruction	**No. of Patients**	**Percentage (%)**
Present	10	6%
Absent	50	94%
Total	**60**	**100**
Distribution of Intestinal Obstruction		
CT-Findings	**No. of Patients with Bowel Obstruction**	**Percentage (%)**
Adhesion	3	30
Internal Hernia	2	20
Carcinoma Small Bowel	2	20
V olvulus	1	10
Jejuno-Jejunal Intussusception	1	10
Mesenteric Carcinoid	1	10
Total	**10**	**100**

Distribution of Enhancement Pattern

Bright enhancement pattern and water target sign were co-related with infective or inflammatory lesions and ischemia. Gray enhancement pattern was co-related with malignant lesions such as adenocarcinoma or lymphoma and ischemia. The fat-target sign pattern was co-related with inflammatory lesions, and the gas pattern, also known as the black attenuation pattern was co-related with cases of perforation.

Distribution of Intestinal Obstruction

Among the 60 study participants, 10 patients were found to have bowel obstruction.

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Correlation between Bowel Obstruction and CT Pathologies

In our study, among 60 study participants, 10 patients were found to have bowel obstruction due to different causes. The most common cause of bowel obstruction was found to be adhesion, accounting for 3 out of 10 cases, followed by internal hernia and carcinoma of the small bowel, each accounting for 2 cases; volvulus, intussusception, and mesenteric carcinoid, accounting for 1 case each.

Table 2: Distribution of CT Findings in Bowel Pathology

CT-Findings	No. of Patients	Percentage (%)
Intussusception	1	2
Perforation	1	2
V olvulus	1	2
Internal hernia	2	3
Adhesion	3	5
Ischemia	4	7
Extra luminal	4	7
Normal	11	18
Neoplastic	15	25
Infective or inflammatory	18	30
Total	**60**	**100**

Regarding the enhancement pattern of the bowel wall, 33 patients gave a bright pattern, 20 showed a grey pattern, 2 showed a water target sign, 2 showed a fat target sign, and 3 showed a gas pattern type of enhancement.

Among the 60 study participants in our study, 11 cases (18%) were normal and 49 cases (82%) had pathologies as follows: the infectious/inflammatory group accounting for the highest number of cases (n = 18), followed by neoplastic (n = 15), extraluminal (n = 4), ischemia (n = 4), adhesions (n = 3), internal hernia (n = 2), perforation (n = 1), volvulus (n = 1) and intussusception (n = 1) in decreasing order. The following discussion is done considering only the 49 patients who were found to have bowel pathologies.

Table 3

Involved Bowel		**No. of Patients**
Small Bowel (SB)		**25**
IC Junction	IC+SB+LB	8
	IC+SB	4
	IC+LB	1
Large Bowel (LB)		11
Total		**49**
Location Wise Distribution of Bowel Pathologies (n=49)		
Involved Part of Small Bowel	**No. of Patients**	**Percentage (%)**
Proximal	9	36
Distal	9	36
Diffuse	7	28

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Total	25	100
Distribution of Small Bowel Pathology (n=25)		
Involved Part of Large Bowel	**No. of Patients**	**Percentage (%)**
Proximal	5	46
Distal	3	27
Diffuse	3	27
Total	11	100
Distribution of Large Bowel Pathology (n=11)		

Location Wise Distribution of Bowel Pathologies (n = 49)

Among 49 patients, small bowel was involved in 25 cases, large bowel in 11 cases, and IC junction/IC junction with small bowel/IC junction with large bowel in 13 cases. Hence, the location-wise prevalence of bowel pathologies was higher in small bowls.

Distribution of Small Bowel Pathology (n = 25)

Regarding the distribution of the bowel pathologies in the small bowel (n = 25), the proximal and distal small bowel were the most commonly affected parts, accounting for 9 (36%) cases, respectively, and diffuse involvement was seen in 7 patients (28%).

Distribution of Large Bowel Pathologies

Regarding the distribution of the bowel pathology in the large bowel (n = 11), the proximal large bowel was the most commonly affected part (n = 5) (46%), the distal part was involved in 3 patients (27%), and diffuse involvement was seen in 3 patients (27%).

Table 4: Age and Location Wise Distribution of Bowel Pathologies

Age (in yrs.)	SB	IC+SB+LB	IC+SB	IC+LB	LB
0-9	1	0	0	0	0
10--19	2	1	1	0	0
20-29	3	0	1	0	0
30-39	3	1	0	0	3
40-49	5	0	1	0	0
50-59	6	2	1	0	4
60-69	1	3	0	1	2
70-79	2	1	0	0	2
Total	**25**	**8**	**4**	**1**	**11**

Among 25 cases of small bowel pathologies, the maximum cases were between 50 and 59 years' age group (n = 6), and the minimum cases were seen between 0 and 9 years and 60 and 69 years (n = 1). Among 11 cases of large bowel pathologies, the majority were between 50 and 59 years of age (n = 4). Among the three cases of pathologies involving the ileocecal junction, small bowel, and large bowel, the maximum prevalence is seen in 60–69 year olds.

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Table 5 **Role of CTE in Diagnosis and Differentiation of Benign and Malignant Lesions with Histopathological Correlation**

Lymph Nodes	**No. of Patients**	**Percentage (%)**		
Present	39	65		
Absent	21	35		
Total	**60**	**100**		
Presence of Lymph Nodes				
Adjacent Fat Stranding	**No. of Patients**	**Percentage (%)**		
Present	37	62		
Absent	23	38		
Total	**60**	**100**		
Presence of Fat Stranding				
CT Impression		**Histopathology**		**Total**
		Benign	**Malignant**	
Benign	n	33	1	34
	%	97.1%	2.9%	100%
Malignant	n	1	14	15
	%	6.7%	93.3%	100%
Total	**n**	**34**	**15**	**49**
	%	**69.4%**	**30.6%**	**100%**
Pearson Chi square 40.037, p= < .001 (significant)				

Presence of Lymph Nodes
In our study, lymph nodes were present in 39 cases, accounting for 65% of the cases.

Presence of Fat Stranding
In our study, fat stranding adjacent to the pathology was identified in 37 patients, accounting for 62%.

CTE in Diagnosis of Benign Lesions with Histopathological Correlation
Among 49 cases with bowel pathologies, 34 cases were identified as benign in CTE, of which 1 case came out as malignant on histopathology (in the case of jejuno-jejunal intussusception, the CTE diagnosis made was a malignant lesion as the leading point, on histopathological examination it was diagnosed as an inflammatory lymphnode).

Sensitivity, specificity, positive predictive value and negative predictive value of CTE in the diagnosis of benign intestinal diseases are 97%, 93%, 97% and 93% respectively.

CTE in the Diagnosis of Benign Lesions
Sensitivity: 97% Specificity: 93% Positive predictive value: 97% Negative predictive value: 93%

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CTE in the Diagnosis of Malignant Lesions

Sensitivity: 93% Specificity: 97% Positive predictive value: 93% Negative predictive value: 97%

DISCUSSION

A new method for evaluating small intestinal problems in place of conventional fluoroscopy is computed tomographic enterography, or CTE. The primary imaging modality for detecting occult gastrointestinal tract bleeding, small bowel neoplasms, and mesenteric ischemia, as well as for investigating proven or suspected inflammatory bowel disease, is CT enterography. This is due to the significantly improved spatial and temporal resolution offered by multidetector CT scanners, good luminal distention provided by negative oral contrast agents, and good bowel wall visualisation.

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. The use of mannitol as a negative contrast agent combined with an MDCT scanner allows for the visualisation of the bowel and its vascular supply with minimal artefacts and the accurate diagnosis of various inflammatory, infective, neoplastic and ischemic pathologies.

This is a cross-sectional observational study carried out to assess the diagnostic efficacy of CTE in diagnosing and differentiating various bowel pathologies. The current study included 60 patients, all of whom were evaluated for bowel pathology under the parameters of luminal distension, wall thickness, enhancement pattern, site or location of thickening, which involved length of bowel and extraluminal features such as mesentery, vascular structures and last but not the least an image quality. CT-enterography findings were correlated with operative and histopathological follow-up wherever relevant.

These features that were used in our study have also been used in other studies (1) Macari et al.[5] (2) Geng Shang Wen et al. and (3) Erturk et al.[6] Schindera et al.[7] reported maximum small bowel enhancement on MDCT, 50 seconds after administration of intravenous contrast or 14 seconds after aortic peak enhancement.

In our study, we therefore administered contrast intravenously during this enteric phase (50 seconds). Zhang LH et al.[8] in 2005 assessed the feasibility and usefulness of MDCT-enterography on 51 subjects (38 patients and 13 normal volunteers) with orally administered 500 ml of 20% mannitol as a negative contrast in demonstrating small bowel disease. In our study, we used 100 ml, and here, small bowel distension was excellent in most volunteers and patients. CT features of many kinds of diseases, such as infective diseases such as. ileo-cecal tuberculosis, tumours, inflammatory diseases, small and large bowel obstruction, etc., were clearly displayed.

According to Zhang LH et al., all volunteers had normal small bowel outer diameters and wall thicknesses of less than 30 and 3 mm, respectively. A comparative study between positive (diluted iodinated), neutral (plain water), and negative (3% mannitol in plain water) contrasts of 1500 ml in 300 patients was conducted by K Prakashini et al.[9] in 2013. Actual diameter measurement and a point scale system at different bowel levels were used to analyse the images qualitatively and quantitatively for distension, fold visibility, and overall image quality. In terms of small bowel distension, intraluminal homogeneity, and mucosal fold visibility, the group that took mannitol performed better.

In our study, we used mannitol as a negative oral contrast. Out of the 60 cases studied, 41 had

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distension of grade 3 (>80%), and 14 cases had grade 2, suggesting bowel distension was excellent in most of the patients. A similar study was done by Geng Shang Wen et al. (2011) in which 60 adult volunteers were divided into two groups: one using the conventional method and the other improved with 2.5% mannitol. Bowel distension was graded 0, 1, 2, and 3 points. They concluded that the improved method can engorge the small intestine much better than the conventional method. A similar result regarding bowel distension was achieved by Erturk et al.

In the research mentioned above, three instances of adenocarcinoma-two in the duodenum and one in the jejunum— presented as small intestinal obstructions and lobular small masses. The masses are much bigger than they used to be (mean CT values for the plain scan phase, the artery phase, and the venous phase are 42.03±8.70, 91.30±11.51, and 95.30±9.08 HU, respectively). They have a mean diameter of 3.05±1.23 cm.

In our study, we found 7 cases of small bowel tumours, of which 3 were lymphomas and the rest 4 were adenocarcinomas, 4 cases of large bowel tumours, all of which were adenocarcinomas; and 3 cases involving the IC junction, all of which were adenocarcinomas. 4 out of 7 small bowel tumors had severe mural thickening (>10mm); 1 case had moderate (thickening 5–9 mm). Out of 11 cases of bowel tumours, 9 had thickness graded "severe" (thickness > 10 mm), and 7 showed "gray" enhancement.

In 2006, Backer et al.[10] examined the abdominal and pelvic CT scans as well as the magnetic resonance imaging (MRI) studies of six patients who had intestinal tuberculosis that had been proven by microbiology and histopathology. Researchers found that the results were the same for both CT and MR imaging. In both types of images, tuberculous bowel involvement is linked to signal intensities that are slightly lower on T1-weighted images and slightly higher on T2-weighted images. A slight heterogeneous enhancement is visible on contrast-enhanced photos.

In our study, we found 18 cases of infective and inflammatory diseases, out of which the majority were tuberculosis (n = 8), 5 cases were ulcerative colitis, 4 cases were Crohn's disease, and 1 case was nonspecific ileitis. Four patients had extraluminal pathologies: sclerosing mesenteritis, mesenteric carcinoid, omental deposits from ovarian carcinoma, and appendicular abscess.

Out of 60 patients, 11 had complaints of altered bowel habits but had normal CTE findings. Mao Zji Qun et al. (2008) did a comparative study between CT-enterography and conventional CT in 50 patients and used 2.5% mannitol in 1800 ml. Sensitivity of the diagnosis of intestinal diseases, specificity, positive predictive value, and negative predictive value of 97.8%, 98%, 100% and 80% in CT enterography, while conventional CT scanning was 90.9%, 88%, 95.2%, and 50%. The CT-intestinal lesion detection rate was higher in CTE than the conventional CT scan.

In our study, the sensitivity, specificity, positive predictive value, and negative predictive value of CTE in the diagnosis of benign intestinal diseases were 97%, 93%, 97%, and 93%, respectively. Which was well correlated with the previous studies.

The best endoluminal contrast agent is mannitol because of its low attenuation, which promotes appropriate luminal distension and improves the visibility of mural features. In diagnostic imaging, a variety of neutral and negative contrast agents have been employed. Mannitol is an excellent endoluminal contrast agent that brings out excellent small and large bowel distension, delineation of the wall, distal small bowel, including IC junction visualisation, excellent enhancement pattern, mesentery, vascular structures, lymph nodes, and improved overall image quality. CT features of diseases such as tuberculosis, enteritis, obstruction due to adhesions, internal hernia, intussusceptions, small as well as large bowel neoplasms, and ischemia were well delineated.

Mannitol was able to cause colonic distension because of its quick transit and non-absorbable qualities. This was a standout characteristic that may have resulted from changing the volume and

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 2, 2024

the time period during which the contrast was applied. This would have also helped achieve the best possible big bowel distension.

CONCLUSION

CT enterography is an acceptable and applicable modality in routine practice in the diagnosis and differentiation of bowel pathologies and also in differentiating benign from malignant lesions. The taste of mannitol is good, acceptable, and tolerable by all, which helped in achieving adequate luminal distension and a good quality of image with the fewest artefacts.

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