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Original Research Article

Evaluation of bowel by computed tomography enterography: comparing the water, mannitol and iodinated oral contrast

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ABSTRACT

Background: Despite the small intestine's size and significance, disorders of it are comparatively uncommon and can pose difficulties for diagnosis and treatment. Even with the advent of cutting-edge imaging methods like double balloon endoscopy and capsule endoscopy, diagnostic tests are still unable to accurately evaluate the bowel. Recent innovations, including capsule endoscopy and MRI have emerged as an alternative small bowel imaging techniques that can be performed without ionizing radiations. In this study we have compared Water, mannitol and iodinated oral contrast for assessing intraluminal distension, mucosal fold visualization and mural enhancement.
Methods: A total of 150 patients fulfilling the selection criteria were studied. All patients of age group 25 to 70 years were included in the study. Patients with ileostomy, nasogastric tube in-situ and nil by mouth., with suspected intestinal obstruction, patient presenting with acute abdomen and fever were excluded.
Results: It was observed that mannitol, homogeneity and mannitol group showed better bowel distension than iodinated contrast and plain water group ($p<0.001$), iodinated contrast and plain water group. ($p<0.001$). Mannitol group showed better wall visibility than iodinated contrast and plain water group. ($p<0.001$). Mannitol is better endo-luminal contrast agent than, iodinated contrast in water and plain water to assess the overall image quality.
Conclusions: Computed tomography (CT) enterography using mannitol is excellent technique in better visualization of small bowel loops and thus helped to provide better diagnosis for intestinal abnormalities.

Keywords: Endoscopy, Enterography, Iodinated oral contrast, Mannitol

INTRODUCTION

Despite the small intestine's size and significance, disorders of it are comparatively uncommon and can pose difficulties for diagnosis and treatment. Even with the advent of cutting-edge imaging methods like double balloon endoscopy and capsule endoscopy, diagnostic tests are still unable to accurately evaluate the bowel.[1]

Imaging of bowel has been a challenge to a radiologist. The small bowel is always a challenging area for surgeons and gastroenterologist because of its long length and vague symptomatology of bowel.[2]

Imaging of pathologic processes occurring in the small bowel has traditionally been performed with barium small-bowel follow-through examinations, single- or double-contrast intubated enteroclysis and Computed tomography.[3]

Recent innovations, including capsule endoscopy and MRI have emerged as an alternative small bowel imaging techniques that can be performed without ionizing radiations. Technical advances have improved the imaging evaluation of small bowel using CT. These advances include the use of MDCT scanners that acquire isotrophic data, use of oral contrast agents and administration techniques, that improve small bowel distension.[4] These advances, coupled with imaging work-stations that allow multiplanar and 3D evaluation of these isotrophic data sets have allowed improved depiction and characterization of small bowel pathology.

Use of MDCT, neutral oral contrast agents to distend the small bowel, and multiplanar thin-section data evaluation hascome to be known as CT- enterography. Moreover, a vast array of pathologic processes occurring in the small bowel will be detected incidentally at MDCT in patients with abdominal pain. The differential diagnosis for these processes is broad and can be confusing.[5]

Capsule endoscopy gives a lot of information about bowel but visualization of outer wall of bowel is not possible and if there is bowel stenosis, capsule get retained.[2]

Computed Tomography enterography (CTE) has been validated as an important imaging tool for small bowel evaluation over recent years and has a clear established role as one of the primary diagnostic tools in the evaluation of patients with inflammatory bowel disease (IBD). Compared to endoscopic exams and barium studies, CTE has the ability to delineate both intestinal and extraintestinal pathology. CTE is noninvasive examination that offers relevant information in the diagnosis and management of patients with proven or suspected IBD such as crohn disease, intestinal tuberculosis (TB), and intestinal Behcet disease (BD).[6]

CT enterography differs from routine abdominopelvic CT in that it makes use of thin sections and large volumes of enteric contrast material to better display the small bowel lumen and wall. The use of neutral enteric contrast agents such as water, combined with use of intravenously administered contrast material, permits excellent assessment of hypervascular lesions and hyper enhancing segments. Compared with traditional small bowel follow-through examination, CT enterography has several advantages: *(a)* it displays the entire thickness of the bowel wall, *(b)* it allows examination of deep ileal loops in pelvis without superimposition, and *(c)* it permits evaluation of surrounding mesentry and peripancreatic fat. CT enterography also allows assessment of solid organs and provides a global overview of the abdomen.[7]

Neutral oral contrast materials, which demonstrate water or near-water attenuation at CT and follow water signal on MR imaging, are preferred over positive (high attenuation at CT) oral contrast materials at CT enterography because these agents improve the conspicuity of bowel mucosal and mural hyperenhancement. These neutral contrast agents also have favorable imaging characteristics at MR enterography, appearing hyperintense at T2-weighted imaging and hypointense at contrast materialenhanced T1-weighted imaging.[8]

In this study we have compared water, mannitol and iodinated oral contrast for assessing intraluminal distension, mucosal fold visualization and mural enhancement.[2]

METHODS

A hospital based observational comparative study conducted in the Department of Radiodiagnosis, R.N.T. Medical College, Udaipur during the period Feb 2022 to Jan 2023.

Patients between age group of 25 years to 70 years who were referred to CT examination in the Department of Radiodiagnosis, R.N.T. Medical College, Udaipur for CT abdomen for various indication. A total of 150 patients fulfilling the selection criteria were studied. The ethical clearance was obtained from Ethics Committee of tertiary care centre.

Inclusion criteria

All patients between age group 25 to 70 years. All patients referred to department of Radiology in R.N.T. Medical College, Udaipur for CT abdomen for various indications were included.

Exclusion criteria

All patients who did not give consent to be a part of the study. All patients with ileostomy, nasogastric tube in-situ and nill by mouth. Patient with suspected intestinal obstruction. Patient presenting with acute abdomen and fever. All patients having history of adverse reaction to the contrast agent and patients unable to consume 1500 ml of contrast agent were excluded from the study.

Materials

Contrast media used

Water, mannitol and iodinated contrast agent (non-ionic water-soluble contrast agent).

Machines

The examination was performed on SIEMENS SOMATOM Definition AS-128 slice CT scanner, PHILIPS Brilliance TM CT-16 slice CT scanner and MEDRAD STELLANT 105.2_SH pressure injector was used.

Detailed research plan

After obtaining institutional ethics committee approval and written informed consent from all the patients in their vernacular language total of 150 patients undergoing CT scan examination of abdomen and pelvis for various indications were randomly selected. All 150 patients were randomly divided into 3 groups of 50 each by computer generated random numbers. Age and sex matching was done with age group 25-70 yrs.

The study group as follows: Group mannitol: 3% mannitol in water (45 grams of mannitol dissolved in 1500 ml of water to make a 3% solution); Group Water: 1500 ml plane water; Group Iodinated contrast agent, non-ionic water-soluble contrast agent: Iohexol 20 ml in 1500 ml of water (non-ionic contrast media, concentration of 300mg/ml, iodine: particle ratio- 3:2).

Preparation and positioning of patient for abdomen scan

Patients were called in for CT scan with a fasting period of around 4-6 hours in order to avoid complications in case of an allergic reaction. A 20 or 22 G angiocath was placed in the ante-cubital or any other superficial upper limb vein for contrast injection. Pressure injector was connected to the patient through the IV cannula placed. Patients were asked to keep away the artifacts producing belongings during scanning.

Patient was made to lie on the gantry table in supine position with both arms raised above the head. The patient was instructed to follow the commands for breath hold during scanning in full inspiration. The pressure injector was connected to the intravenous angiocath after checking for its patency with sterile normal saline flush. After satisfactorily conforming the position, a digitalized topogram was obtained. A plain abdomen scan was run from the top of liver surface up to the pubic symphysis. The bowel loops were successively scanned in arterial, portovenous and delayed phases along with rest of the abdomen after administration of intravenous contrast. After preliminary viewing of the scan, the patient was taken out of the gantry and kept under observation for an hour to monitor any adverse reactions. An anesthetist was also kept on standby for any complications. After the observation period, the patient was sent back to the respective ward/OPD.

Scanning protocol

Non contrast CT study was done initially after administering the oral contrast agents. After non contrast study, contrast study was performed. Intravenous contrast was administered using a pressure injector, 80-100 ml of intravenous non-ionic iodinated contrast was administered in a concentration of 300 mg/ml iodine, with an injection rate of 3-5 ml/s. The administration of contrast was followed by a flush of 40 ml normal saline at the same injection rate.

Multiphasic studies were performed depending upon the clinical and radiological indications. Bolus tracking technique was used for multiphasic CT scan with marker set on the descending thoracic aorta and scanning commenced after attaining minimum attenuation of 100 HU. Acquisition of arterial and portovenous phases with a delay of eight seconds post threshold achievement in descending aorta for arterial phase and a delay of 50 seconds post threshold for portovenous phase. Images were reconstructed in axial, sagittal and coronal planes. Multi-phasic imaging is mandatory for abdomen examination. Non contrast, arterial, venous and delayed phase axial images were taken with reformation of coronal and sagittal images. Tolerance of contrast agent and risk involved were assessed.

Statistical analysis

The data obtained was coded and entered into Microsoft Excel Worksheet. The categorical data was expressed as rates, ratios, proportions and percentages. ANOVA test, Tukey's test and Chi square test were used for quantitative and qualitative analysis of bowel on CT. Pair wise comparison of bowel loops done by using Tukey's test.

RESULTS

Mannitol group showed better luminal distension than iodinated contrast and plain water group. There were statistically significant differences in distension of jejunal loops between three groups ($p<0.001$).

It was observed that mannitol group showed better luminal distension than iodinated contrast and plain water group. There were statistically significant differences in distension of bowel between three groups ($p<0.001$) ANOVA test used (Table 1).

There was statistically significant difference between three groups, $p<0.001$ (Chi-square test used) (Table 2).

Table 1: Quantitative analysis for distension of the bowel loops.

Variables	Mannitol		Water		Iodinated contrast		P value
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	43.48	5.26	43.62	4.92	44.04	4.78	0.843
Jejunum	2.15	0.33	1.39	0.12	1.98	0.12	<0.001
Ileal loops	3.38	0.667	1.38	0.490	2.08	0.274	<0.001
IC junction	3.34	0.73	1.96	0.21	2.30	0.43	<0.001

Table 2: Comparison of jejunal, ileal loops mural fold visibility between three groups at level of SMA for quantitative analysis of bowel.

		Mannitol	Water	Iodinated contrast	Total	P value
Jejunum (SMA)	Grade 0	2	21	20	43	<0.001
	Grade I	24	29	30	83	
	Grade II	24	0	0	24	
	Total	50	50	50	150	
Jejunum (renal artery)	Grade 0	2	21	20	43	<0.001
	Grade I	24	29	30	83	
	Grade II	24	0	0	24	
	Total	50	50	50	150	
Jejunum (IMA)	Grade 0	2	21	20	43	<0.001
	Grade I	24	29	30	83	
	Grade II	24	0	0	24	
	Total	50	50	50	150	
Ileal loops (aortic bifurcation)	Grade 0	2	20	20	42	<0.001
	Grade I	24	30	30	84	
	Grade II	24	0	0	24	
	Total	50	50	50	150	
Ileal loops (common iliac bifurcation)	Grade 0	2	20	20	42	<0.001
	Grade 1	24	30	30	84	
	Grade 2	24	0	0	24	
	Total	50	50	50	150	
IC junction (deep pelvis)	Grade 0	2	20	20	42	<0.001
	Grade 1	24	30	30	84	
	Grade 2	24	0	0	24	
	Total	50	50	50	150	

Table 3: Qualitative analysis of bowel loops for bowel distention, homogeneity of intra-luminal contents, wall visibility and overall image quality as per score.

		Mannitol	Water	Iodinated contrast	Total	P value
Bowel distension	Score 0	3	24	15	42	<0.001
	Score I	24	26	35	85	
	Score II	23	0	0	23	
	Total	50	50	50	150	
Homogeneity of luminal content	Score 0	3	25	15	43	<0.001
	Score I	24	25	35	84	
	Score II	23	0	0	23	
	Total	50	50	50	150	
Wall visibility	Score 0	3	25	15	43	<0.001
	Score 1	24	25	35	84	
	Score 2	23	0	0	23	
	Total	50	50	50	150	

It was observed that mannitol group showed better bowel distension than iodinated contrast and plain water group. The findings were statistically significant between three groups (p<0.001).

It was observed that homogeneity of luminal content was better with mannitol group than iodinated contrast and plain water group. The findings were statistically significant between three groups (p<0.001).

It was observed that mannitol group showed better wall visibility than iodinated contrast and plain water group. The findings were statistically significant between three groups (p<0.001) (Table 3).

Mannitol is better endo-luminal contrast agent than, iodinated contrast in water and plain water to assess the overall image quality (p<0.001) (Table 4).

Table 4: Comparison of overall image quality between three groups.

Overall Image quality	Groups			Total	P value
	Mannitol	Water	Iodinated contrast		
Unreadable	2	25	15	42	<0.001
Good	21	25	35	81	
Excellent	27	0	0	27	
Total	50	50	50	150	

Table 5: Comparison of presence of artifacts between three groups for qualitative analysis of bowel.

Presence of artifacts	Groups			Total	P value
	Mannitol	Water	Iodinated contrast		
Yes	0	0	15	15	<0.001
No	50	50	35	135	
Total	50	50	50	150	

It was observed that there were no artifacts with water and mannitol as endo-luminal contrast agent. While out 50 patients those consumed, iodinated contrast in water 15 patients (30%) showed some amounts of artifacts. Thus, these groups show statistically significant difference related to presence of artefacts (p<0.001) (Table 5).

DISCUSSION

Role of MDCT in visualization of small bowel

In this study we observed that with the recent advent of MDCT, increase in contrast and spatial resolution of images had helped in better visualization of small bowel loops and thus helped to provide better diagnosis for intestinal abnormalities. Macari et al also concluded in their study that CT played a more important role in evaluation of small bowel neoplasm and further thinner collimation possible with multi-detector CT (MDCT) along with water as oral contrast and a good intravenous contrast bolus may improve the sensitivity of CT for detecting small bowel tumors.[5]

Role of endo-luminal contrast agent in visualization of small bowel

The bowel loops are an anatomically and biomechanically complex intraabdominal organ. In our study of 150 patients, 50 patients were given mannitol in water, 50 patients were given plain water and 50 patients consumed iodinated contrast in water. We observed that endo-luminal contrast is needed for optimal visualization of small bowel.

Ilangovan et al also concluded that CT enterography is important in evaluation of small bowel lesions.[10] Prakashini et al and Padhmanaban et al also found similar finding in their respective studies.[11,2]

Contrast media acceptance

Out of 50 patients consumed mannitol in water, 2 patients (4%) experienced vomiting and 3 patients (6%) experienced nausea after consuming the mannitol in water. Other two group patients consuming water and positive contrast in water tolerated the contrast well. Most of the patients tolerated the contrast well.

Our study also correlates with the study done by Zhang et al which concluded that the taste of iso-osmotic mannitol is good (slightly sweet) and acceptable by all. It was also observed that multi-detector CT enterography with iso-osmotic mannitol as negative contrast to distend the small bowel is a simple, rapid, non invasive and effective method of evaluating small bowel disease.[12]

These similar results were also seen in a study Padhmanaban et al. In this study all the patients tolerated the contrast well. No complaints from the patients or from the referring doctor of any contrast reaction. Around four patients had few episodes of loose stools after mannitol consumption. However, none were reported with diarrhoea or intravenous fluid administration.[2]

Quantitative analysis of bowel loops for distension of the bowel loops

In our study quantitative analysis of bowel loops was done to look distension of bowel loops and mural fold visibility. Variable amount of distension of bowel loops was seen with all the three endo-luminal agents. Mean jejunal distension with mannitol was 2.15±0.33 cm, with plain water was 1.39±0.12 cm and with iodinated contrast in water was 1.98±0.12 cm. Mean ileal loops distension with mannitol was 3.38 +/0.667 cm, with plain water was 1.38±0.490 cm and with iodinated contrast in water was 2.08±0.274 cm. Mean ileocecal junction distension with mannitol group was 3.34±0.73 cm, with plain water group was 1.96±0.21 cm and with iodinated contrast group was 2.3±0.43 cm.

There was significant difference in distension of bowel between three groups. (Statistical p value was <0.001). Thus it was concluded that distension of abdomen is seen with all the three endo-luminal contrast agents. In the study significant difference in distension at the level of Jejunum, Ileum and IC junction was observed. Distension was highest in mannitol in water group followed by iodinated contrast in water and then plain water.

The study done by Berther et al presented the results showing neutral oral contrast agent (mannitol) produced better distension, better homogeneity and better delineation of the bowel wall leading to a higher overall image quality than the positive oral contrast medium in a non-selected patient population. The major limitation of using neutral contrast is differentiating cystic lesions from bowel for which positive endo-luminal contrast holds good.[13]

These findings corresponds to the study done by Kakkar et al showed the results as mannitol as endo-luminal contrast increases the diagnostic accuracy of the investigative studies in comparison to water and iodine-based contrast by producing significantly better bowel distension and visibility of mural features with improved image quality without additional adverse effects.[11]

Our study also correlates with study done by Padhmanaban et al. A comparative observational study was performed. Assessments of bowel distention at various levels were studied. In the study significant difference in distension at the level of stomach, pylorus, Jejunum, Ileum and IC junction was observed. Distension was highest in Mannitol group than the other two groups at all the levels of abdomen except at D3. After mannitol, positive contrast group had higher level of distension than water group.[2]

Quantitative analysis of bowel loops for mural fold visibility

Detailed mural fold features and fold visibility were assessed in these three groups. Out of the 50 subjects those consumed mannitol as endo-luminal contrast agent, Grade II mural fold visibility was seen in 24 patients (48%), grade I mural fold visibility was seen in 24 patients (48%) and only two patients (4%) showed grade 0 mural fold visibility. Iniodinated contrast group, out of 50 patients, Grade I mural fold visibility was seen in 30 patients (60%) and grade 0 mural fold visibility was seen in 20 (40%). In water group out of 50 patients, 29 patients (58%) were classified as grade I mural fold visibility and 21 patients (42%) were classified as grade 0 mural fold visibility. It was observed that mural fold visibility was better delineated by mannitol as compared to positive contrast and water. There was significant statistical p value difference between mannitol group and rest of the two groups that is plain water and iodinated contrast in water group. (Statistical p value was <0.001)

Our study also correlated with a study done by Elsayes et al concluded that multi detector CT scanners, combined with negative oral contrast agents shows good luminal distention with good bowel wall visualization.[1,14]

These findings corresponds to the study done by Kakkar et al showed in mannitol as endo-luminal contrast increases the diagnostic accuracy of the investigative studies in comparison to water and iodine-based contrast by producing significantly better visibility of mural features with improved image quality without additional adverse effects.[11]

Berther et al studied whether neutral contrast agents with water-equivalent intra-luminal attenuation can improve delineation of the bowel wall and increase overall image quality. Qualitative and quantitative measurements were done on different levels of the gastrointestinal tract. Patients given the neutral oral contrast agent showed significant better qualitative results for bowel distension ($p<0.001$), homogeneity of the luminal content ($p<0.001$), delineation of the bowel-wall to the lumen ($p<0.001$) and to the mesentery ($P<0.001$) and artifacts ($p<0.001$), leading to a significant better overall image quality ($p<0.001$) than patients receiving positive oral contrast medium. The quantitative measurements revealed significant better distension ($p<0.001$) and wall to lumen delineation ($p<0.001$) for the patients receiving neutral oral contrast medium. Thus this study presented the results showing neutral oral contrast agent (mannitol) produced better distension, better homogeneity and better delineation of the bowel wall leading to a higher overall image quality than the positive oral contrast medium in a non-selected patient population.[13]

Our study is in concordance with a study done by Sivaranjanie et al. Mural fold visibility was better appreciated by mannitol than positive contrast in water and plain water. The statistical p-value difference was significant between the three groups.[2]

Qualitative analysis of bowel loops for overall image quality, bowel distention and homogenity of intra-luminal contents

Qualitative analysis of small bowel loops was done for wall visibility, bowel distention, homogenity of intra-luminal contents and overall, Image quality. Qualitative analysis was based on three-point scoring system Score I to Score III. Out of 50 patients those given the mannitol in water as endo-luminal contrast agent, 23 patients (46%) showed score II, 24 patients (48%) showed score I and 3 patients (6%) showed score 0. Out of 50 patients those consumed water as endo-luminal contrast agent, 26 patients (52%) showed score I and 24 patients (48%) showed score 0. Out of 50 patients those consumed iodinated contrast in water as endo-luminal contrast agent

35 patients (70%) showed score I and 15 patients (30%) showed score 0. It was observed that wall visibility, bowel distention, homogenity of intra-luminal contents and overall, Image quality was better delineated by mannitol as compared to iodinated contrast in water and plain water. The significant p-value difference was noted between the three groups of patients (p<0.001).

Similar findings were also seen in study done by Megibow et al.[1] They concluded that oral administration of negative contrast agent provided excellent distention and excellent visualization of mural features in the gastrointestinal tract.[15]

Our study correlates with the study done by Prakashini et at and Padhmanaban et al which also concluded that around 56% of patients those were given mannitol showed excellent distention and fold visibility, whereas it was none in other two groups i.e. plain water and positive contrast in water. The significant p-value difference was noted between three groups of patients.[11,2]

Our study also correlates with the study done by Berther et al which also concluded that the patients given the neutral oral contrast agent showed significant better qualitative results for bowel distension (p<0.001), homogeneity of the luminal content (p<0.001), delineation of the bowel-wall to the lumen (p<0.001) and to the mesentery (p<0.001) and artifacts (p<0.001), leading to a significant better overall image quality (p<0.001) than patients receiving positive oral contrast medium.[13]

Presence of artifacts

Presence of artifacts due to endo-luminal contrast agents was also assessed in this study. It was observed that no artifacts seen with water and mannitol as endoluminal contrast agent. While out 50 patients those consumed positive contrast in water 15 patients (30%) showed some amounts of artifacts.

These findings were also supported by the study done by Ramsay et al which concluded that significantly more artifacts were caused by positive contrast media than with the collagen mixture which is negative contrast medium.[16]

Berther et al in his study also found that those patients given the neutral oral contrast agent showed significant better qualitative results for bowel distension (p<0.001), homogeneity of the luminal content (p<0.001), delineation of the bowel-wall to the lumen (p<0.001) and to the mesentery (p<0.001) and artifacts (p<0.001), leading to a significant better overall image quality (p<0.001) than patients receiving positive oral contrast medium.[13]

Prakashini et al and Elamparidhi et al also concluded in their study that contrary to neutral contrast agents, positive agents resulted in obscuration of wall and mucosa predominantly in distal ileal loops due to increasing concentration resulting in artifacts.[11,2]

Recent advent of MDCT, increase in contrast and spatial resolution of images is helpful in better visualization of small bowel loops and thus helped to provide better diagnosis for intestinal abnormalities. Computed tomography (CT) enterography using mannitol is excellent technique in better visualization of small bowel loops and thus helped to provide better diagnosis for intestinal abnormalities. Extra-luminal abnormalities can also be better studied with this technique.

CONCLUSION

Small bowel distention, bowel homogeneity, mural fold features and overall image quality is better with mannitol than other two contrast agents i.e. iodinated contrast in water and plain water.

Mannitol is widely available and cost effective, well tolerated with less adverse effects. Hence mannitol should be preferred as endo-luminal contrast agent for bowel. CT enterography with iso-osmotic mannitol as orally administered negative contrast is a simple, noninvasive, effective and economic method for assessing small bowel diseases and others.

Computed tomography (CT) enterography using mannitol is excellent technique in better visualization of small bowel loops and thus helped to provide better diagnosis for intestinal abnormalities.

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