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Original Article

Radiology Section

Comparison of Water, Mannitol and Positive Oral Contrast for Evaluation of Bowel by Computed Tomography

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ABSTRACT

Introduction: Small bowel remains a challenging anatomical site. Imaging approaches like CT-enterography helps in diagnosing non specific clinical presentations and imaging aids in appropriate management. Hence, bowel evaluation by CT requires a oral contrast agent for diagnosing the bowel pathology. Thus, quantitative and qualitative analysis of three oral contrast agents i.e., water, mannitol and positive contrast was done for identification of ideal intraluminal contrast agent.

Aim: To assess the performance of mannitol as an endoluminal contrast agent as compared to water and positive contrast in the evaluation of bowel, to compare the distention of bowel with different oral contrasts and also to assess the usefulness of bowel distension in assessment of mural enhancement pattern of bowel.

Materials and Methods: A comparative observational study was performed which consisted of 75 patients who were divided into three groups of 25 patients each. Patients in each group were given 1500 ml of oral contrast. Group I was given mannitol, Group II was given water and Group III was given positive contrast. Assessments of bowel distention at various levels and mural enhancement of bowel were studied. Chi-square test was used as test of significance for qualitative data. ANOVA (Analysis of Variance) was the test of significance for quantitative data.

Results: Bowel distention was excellent in mannitol compared to water and positive contrast. Wall enhancement and mural pattern was better appreciated with mannitol compared to other two contrast agents.

Conclusion: Adequate bowel evaluation by CT requires an oral contrast agent which can cause maximal bowel distention, uniform intraluminal attenuation, increased contrast between intraluminal content and bowel wall with no artifacts and adverse effects. Mannitol has all the above characteristic and can be used as ideal neutral oral contrast agent.

Keywords: Bowel distention, Endoluminal contrast, Mural fold visibility

INTRODUCTION

Imaging of the bowel has been a challenge to the radiologists. Each imaging modality has its own merits and demerits. The small bowel is always a challenging area for surgeon and gastroenterologist because of its long length and patients with bowel pathology present with vague symptoms. Barium investigation is less sensitive [1,2]. Capsule endoscopy gives a lot of information about bowel but visualization of the outer wall of bowel is not possible and if there is bowel stenosis, capsule gets retained. Ultrasound has an advantage of real time imaging without ionizing radiation and is less expensive and easily available. But it is less sensitive for bowel pathologies especially small bowel because of the scatter of ultrasound beam by air within the bowel. CT with its good spatial and contrast resolution along with its multiplanar reconstruction provides a good platform for the evaluation of bowel. It also has the advantage of evaluation of mesentery which plays an important role in narrowing down differentials. Bowel distension is an important prerequisite in CT evaluation of bowel to open up the collapsed loops which might obscure the underlying pathology [2,3]. Contrast enhanced abdominal scan with oral contrast helps us to evaluate the bowel adequately. In this study we have compared water, 3% mannitol and diluted gastrografin for assessing intraluminal distention, mucosal fold visualization and mural enhancement.

MATERIALS AND METHODS

Comparative observational study was done on 75 patients in which 25 patients were given water, 25 patients were given mannitol and 25 patients were given positive contrast by selecting randomly for analysis for bowel distention, mural fold visibility and overall image quality was assessed by point scale system at different levels. This study was done in Sri Manakula Vinayagar Medical College and Hospital, Pondicherry in the Department of Radiodiagnosis between October 2016-December 2016 after getting approval from the ethical committee. Informed consent was obtained from all the three group of patients who received water, mannitol and positive contrast. The first group received 3% mannitol in water (45 g of mannitol was dissolved in 1500 ml of water to make a 3% solution). The second group received plain water without any additives. The third group received positive contrast containing sodium diatrizoate (20 ml dissolved in 1500 ml of water). All the 75 patients consumed 1200 ml of contrast over a period of 30-45 minutes and remaining 300 ml just prior to the scan. For standardization and uniform bowel distention patients were instructed to take 150 ml every 4-5 minutes for 30-45 minutes and scan is performed at one hour from beginning of contrast agent consumption.

Patients less than 25 and more than 50 years were excluded, also uncooperative patients, patients with fever, dehydration and previous history of contrast allergy were excluded from the study.

All examinations were performed on a 16-slice Philips MDCT scanner. Plain study was performed initially after administering the oral contrast agents. After the plain study post contrast study was performed. Intravenous contrast was administered using a power injector, 80-100 ml of intravenous non-ionic iodinated contrast was administered at a concentration of 300 mg/ml iodine, with an injection rate of 3 ml/s.

Multiphasic studies were performed depending upon the clinical and radiological indications.

Bolus tracking method was used for acquisition of arterial and portovenous phases with a delay of eight seconds post threshold achievement in lower thoracic aorta for arterial phase and a delay of 50 seconds post threshold for portovenous phase. Images were reconstructed in axial, sagittal and coronal planes.

Image analysis was done by two radiologists who were blinded to the neutral luminal contrast agents, i.e., mannitol and water. Qualitative and quantitative study was done for distention, mural fold visibility, homogeneity of intraluminal bowel content and overall image quality by measurements and point scale system for qualitative analysis.

STATISTICAL ANALYSIS

Collected data was entered in excel data sheet and was analysed by SPSS software. Frequencies and proportion was used for categorical data. Test of significance was Chi-square test for qualitative data and ANOVA was the test of significance for quantative data. Value <0.05 was considered as significant after assuming rules of statistical test.

RESULTS

Out of 75 patients, 25 patients consumed mannitol in water, 25 patients consumed water and 25 patients consumed positive contrast in water. Out of 75 patients, 35 were females and 30 were males [Table/Fig-1,2].

		Age (in Years)		p-value
		Mean	SD	
Group	Mannitol	42.9	11.4	0.176
	Water	46.0	11.4	
	Positive Contrast	48.8	10.0	

[Table/Fig-1]: Age distribution of subjects in three groups.
Note- Mean age of subjects in mannitol group was 42.9 ± 11.4 years, in water group was 46 ± 11.4 years and in positive contrast group was 48.8 ± 10 years. There was no significant difference in mean age distribution between three groups.

		Group					
		Mean		Water		Positive Contrast	
		Count	%	Count	%	Count	%
Sex	Female	12	48.0%	12	48.0%	11	44.0%
	Male	13	52.0%	13	52.0%	14	56.0%

[Table/Fig-2]: Gender distribution of subjects in three groups.
*$\chi 2 = 0.107$, df = 2, p = 0.948
Note- In the study majority of subjects in all the three groups were males. There was no significant difference in gender distribution between three groups.

Contrast Media Acceptance: 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.

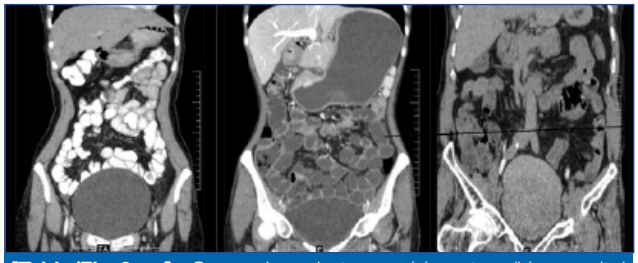
Quantitative Analysis for Bowel Distention and Mural Fold Visibility at Various Levels

Bowel Distention: Quantitative analysis of bowel distention was assessed in axial CT-scan at various levels. Outer to outer dimension at the place were there is maximum bowel distention was measured. Measurements were taken at the level of fundus and pylorus for stomach, at the level of superior mesenteric artery for jejunum and common iliac bifurcation for ileum and pelvis for ileocecal junction. Grading was given and collapsed bowel loop was graded as Grade I; bowel loops less than 1.5cm in diameter with incomplete fold visibility was

Grade II; and bowel distention more than 1.5cm with complete fold visibility was graded as Grade III [1]. Mean and standard deviations were calculated for bowel distention at various levels. 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 [Table/Fig-3a-c].

Hence, distension was highest in Mannitol>Positive contrast>Water [Table/Fig-4].

Mural Fold Visibility: Detailed mural fold features and fold visibility were better delineated with mannitol compared to positive contrast and water. More than 50% of patients were graded excellent (Grade III) whereas with positive contrast it was only <5% of patients and with water no one showed better mural fold visibility [Table/Fig-5,6]. The p-value difference was significant between the three groups [Table/Fig-7].



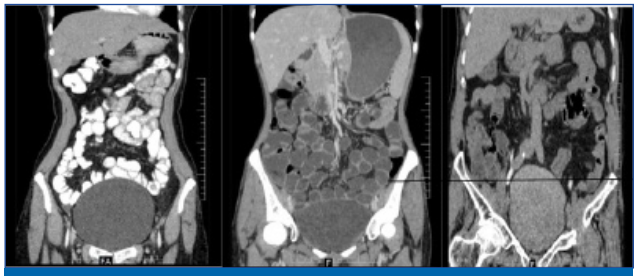
[Table/Fig-3a-c]: Comparison between (a) water, (b) mannitol and (c) positive contrast for overall distention of bowel Images showing bowel distension with positive contrast, mannitol and water respectively and mannitol is seen to have better distention.

	Group						p-value
	Mannitol		Water		Positive Contrast		
	Mean	SD	Mean	SD	Mean	SD	
Stomach	7.1	1.3	5.6	1.5	5.9	0.5	<0.001*
Pylorus	3.9	1.0	2.3	0.5	2.6	0.4	<0.001*
D2	2.8	0.8	2.2	3.5	2.9	0.5	0.527
D3	2.3	0.6	2.2	2.5	2.5	0.3	0.702
Jejunum	2.4	0.7	1.4	0.3	2.0	0.4	<0.001*
Ileum	3.8	1.1	1.4	0.3	2.0	0.5	<0.001*
IC Junction	3.9	0.9	1.9	0.5	2.6	0.5	<0.001*

[Table/Fig-4]: Distension at different abdominal levels comparison between three groups.

Qualitative Analysis for Overall Image Quality, Bowel Distention and Homogenity of Intraluminal Contents

Qualitative analysis was based on three point scoring system Score I to Score III. Score I was fair in which <25% of overall bowel loops showed adequate distention, fold visibility and

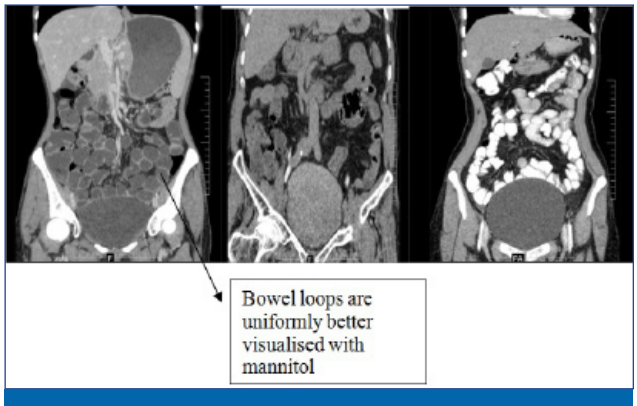


[Table/Fig-5]: Comparison between water, mannitol and positive contrast for the visibility of walls.

[Table/Fig-6]: Image showing mural fold visibility in mannitol.

		Group					
		Mannitol		Water		Positive Contrast	
		Count	%	Count	%	Count	%
Grade	I	1	4.0%	11	44.0%	11	44.0%
	II	14	56.0%	14	56.0%	14	56.0%
	III	10	40.0%	0	0.0%	0	0.0%

[Table/Fig-7]: Comparison of Grade between three groups.
*$\chi 2 = 28.69$, $\delta\phi = 4$, $\pi < 0.001$



[Table/Fig-8]: Image showing collapsed or incomplete bowel loop visualization is more with water then positive contrast and mannitol shows uniform and better visualization of bowel.

		Group					
		Mannitol		Water		Positive Contrast	
		Count	%	Count	%	Count	%
Score	I	1	4.0%	13	52.0%	6	24.0%
	II	11	44.0%	12	48.0%	18	72.0%
	III	13	52.0%	0	0.0%	1	4.0%

[Table/Fig-9]: Comparison of Score between three groups.
*$\chi 2 = 35.42$, $\delta\phi = 4$, $\pi < 0.001$
*There was significant difference in score between three groups.

intraluminal contrast homogeneity, Score II was 50-75% and Score III, considered excellent, was 75-100% of the overall bowel loops showed adequate distention, fold visibility and intraluminal contrast homogeneity [1]. Presence of artifacts and overall image quality was also considered. Around 56% of patients who were given mannitol showed excellent distention and fold visibility, whereas it was none in other two groups [Table/Fig-8]. The significant p-value difference was noted. between the three group of patients [Table/Fig-9].

DISCUSSION

With the advent of MDCT, there is increase in contrast and spatial resolution which helps in better visualization of bowel loops. With the previous modality of imaging like barium meal follow through studies it was difficult to assess all the pathologies of bowel and also it was unable to evaluate the extra luminal abnormalities [2].

Now using MDCT and via three dimensional image reconstruction, it has become more convenient to provide better diagnosis for intestinal abnormalities [3]. Better intraluminal contrast is needed for optimal bowel distention and mural fold visibility. Positive contrast was considered as best intraluminal contrast for assessment of bowel. But disadvantage of positive contrast is that obscuration of mucosal details especially at the ileocecal junction which is the most common site for small bowel pathologies [3,4].

Various neutral and negative contrast agents like water, milk, PEG and mannitol were used as endoluminal contrast to visualize bowel and diagnose inflammatory, ischemic and neoplastic pathologies. Ideal endoluminal contrast must have low attenuation, better bowel distention, mural fold visibility details [4-6]. Various studies have shown that neutral contrast is better than positive contrast for visualization of bowel loops and abdomino-pelvic pathologies. The major limitation of using neutral contrast is differentiating cystic lesions from bowel for which positive endoluminal contrast holds good [7].

In this study we have compared mannitol, water and positive contrast agents and found that mannitol shows better bowel distention, mural fold visibility and uniform homogeneity of all the bowel loops compared to other two contrast agents. Significant difference in p-value was noted in all aspects between the three endoluminal contrast agents and of which mannitol was proved to be the best endoluminal contrast agent compared to others. The better bowel distention with mannitol is due to high osmolarity. High osmolarity of oral contrast media is important factor for bowel distention. Adequate bowel distention can be observed by positive contrast also but mural fold visibility is difficult with positive contrast agent which is a major drawback.

Appreciation of mucosal fold enhancement is by the administration of intravenous contrast agent following consumption of endoluminal contrast. This is important in ischemic and inflammatory bowel disease. Homogeneity of bowel is best with mannitol because mannitol has similar attenuation to gastrointestinal secretions. Ileoceacal region is most common site for inflammatory, infectious or neoplastic conditions. Distention of bowel loop and mural fold visibility of ileoceacal region is best with mannitol when compared to water and positive contrast. With positive contrast, bowel wall demonstration is poor because of high density causing artifacts and partial voluming effects. In this study, we have showed that ileoceacal region is best seen with mannitol and there is significant difference in p-value. Few patients have some bowel alteration due to its high osmolarity. This may cause minimal discomfort, but this cannot be a determining factor for using mannitol [8]. Colonic distention is achieved with mannitol due to high osmolality and non-absorbable nature. The adequate colonic distention is important in assessment of pathologies like crohn's disease and tuberculosis especially in Indian population [9].

CT-enterography has certain advantages than CT-entroclysis, like not placing nasojejunal tube which improves patients' tolerance and it also reduces the exposure time. Optimal distention of bowel can be achieved by using mannitol. Hence, CT-enterography can be used as first line investigation for small bowel pathologies and mesenteric pathologies [10,11].

Multi-row detector CT with optimal enteral contrast agent has revolutionized the exploration of bowel and mesenteric pathologies [12].

Early diagnosis of small bowel pathologies and mesenteric pathologies are challenging for both clinician and radiologist because of its long course and also patients come with non-specific complains like vomiting, weight loss etc., [13-15]. The most common small bowel tumours are adenocarcinoma followed by carcinoid, lymphoma and stromal tumours. If these tumours are picked up early by CT after administration of optimal endoluminal contrast it will help in better prognosis for the patients [16,17].

LIMITATION

Major limitation of this study is the small sample size. Further, studies with larger sample size and multicentric trials would be required to establish a standard.

CONCLUSION

Small and large bowel distention, bowel homogeneity, mural fold features and overall image quality is better with mannitol than other two contrast agents. It is also cheap, well tolerated with minimal adverse effects. It produces bowel distention equivalent to CT-enteroclysis. Mannitol should be preferred as endoluminal contrast agent for bowel.

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