

Retrospective comparison of Computed Tomography Enterography and Magnetic Resonance Enterography in diagnosing small intestine disease

Gong Pei-You,^{1*} Li Jun-Xia,^{2*} Liu Feng-Li,³ Zhang Liang-Ming,⁴ Xie Hai-Zhu,⁵ Sui Yan-Bin⁶

Abstract

Objective: To compare the efficacy of computed tomography enterography and magnetic resonance enterography in diagnosing small intestinal diseases.

Methods: The retrospective study comparing computed tomography enterography and magnetic resonance enterography for diagnosing diseases related to small intestine was conducted at Department of Radiology, Yantai Yuhuangding Hospital, Shandong, China, from July 2012 to February 2014. The efficacy of computed tomography enterography and magnetic resonance enterography results were evaluated for randomly-selected cases to compare the location and characteristics of small intestinal diseases together with small bowel endoscopy and clinical pathology observations.

Results: Of the 30 patients in the study, 19(63.3%) were males and 11 (36.7%) were females with an overall mean age of 33.6±19.2 years (range: 24-67 years). the clinical diagnostic accuracy of computed tomography enterography and magnetic resonance enterography was 24(80%) and 21(70%) cases respectively (p>0.05).

Conclusions: Computed tomography enterography and magnetic resonance enterography are two techniques that complement each other for diagnostic purposes.

Keywords: Computed tomography enterography, Magnetic resonance enterography, Small intestinal diseases. (JPMA 65: 710; 2015)

Introduction

The small intestine is a difficult part of the gastrointestinal tract (GIT) for clinical diagnostic radiology because of its length and complex loops. New imaging methods for diagnosing small intestine diseases, including computed tomography enterography (CTE) and magnetic resonance enterography (MRE), are becoming increasingly popular.^{1,2} CTE is performed after the intestinal lumen is filled with contrast agent. Not only can CTE identify intestinal pathologies such as bowel wall thickening, mucosal enhancement, bowel wall stratification, luminal stenosis, and mesenteric vasodilation, but it also has unique advantages in diagnosing extra-intestinal diseases.³⁻⁵ MRE involves filling the small intestine with isotonic mannitol.⁵ It boosts high soft-tissue resolution and displays tissue and structures both inside and outside the intestine, which is especially useful for diagnosing intestinal obstruction caused by cancer.⁵⁻⁷ The three-dimensional dynamic contrast-enhanced (DCE) scans clearly show bowel wall and the intensified regions of intestinal lesions.^{8,9} In addition, it was reported that coronal scans can display the mesenteric vessels.¹⁰ Diffusion-weighted imaging is

currently the only available clinical method for imaging water molecules and measuring their diffusion. To date, many publications³⁻⁵ have reported the utility of CTE and MRE in assessing small intestinal diseases, but very few studies have actually compared the efficacy of the two techniques and indicated whether or not they can complement each other for better diagnosis.³⁻⁵

The current study was planned to retrospectively compare the imaging utility of CTE and MRE in diagnosing small intestinal diseases.

Patients and Methods

The retrospective study was conducted from July 2012 to February 2014 and comprised randomly selected data related to patients who were diagnosed with small bowel disease in the Department of Radiology, Yantai Yuhuangding Hospital, Shandong, China. Data included was related to only those who had undergone both CTE and MRE for clinical reasons. CTE and MRE has different advantages in gastrointestinal stromal tumour (GIST) or cancer and Crohn's disease, and they are non-invasive in nature. Gastrointestinal stromal data of patients who had acute bleeding was excluded. Pathological diagnosis of postoperative results by operation or biopsy results by small intestinal endoscopy were used as the gold standard. Written informed consent was obtained from all participants before the examination.

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*Contributed equally.

^{1,3,5,6}Department of Radiology, ^{2,4}Department of Oncology, Yantai Yuhuangding Hospital, Yantai 264000, Shandong Province, PR China.

Correspondence: Gong Pei-You. Email: gongpeiyou1970@126.com

For CTE, patients were required to fast for 12 hours before the examination. Intestinal tract cleaning was not needed for the study. Prior to the examination, patients had to drink 2,000ml of 2.5% isotonic mannitol solution four times within 45 minutes. Mannitol acts as a negative contrast agent and fully dilates the intestine and tastes slightly sweet. The CT value of isotonic mannitol is close to that of water, and mannitol is not easily absorbed in the intestine after oral administration. Previous studies demonstrated that isotonic mannitol effectively dilated the intestine, allowing visualisation of intestinal mucosal lesions, without adverse reactions.^{3,4} Non-enhanced, arterial-phase and portal-phase scans were conducted on each patient using a GE64-slice CT (GE Healthcare, USA). Scans ranged from the diaphragm level to the pubic symphysis level and included the entire small intestine. One millimetre-thick reconstruction slices, spaced at 0.7mm, were transmitted to an Advanced Workstation 4.3 (GE Healthcare, USA) for reconstruction with post-processing software.

For MRE examination, to enhance imaging contrast, isotonic mannitol (1,500-2,000 ml) was orally administered and allowed to transit to the caecum within 30 minutes. At this point, 20mg anisodamine (654-2) was injected intravenously (IV) to inhibit intestinal peristalsis, and multi-axis MRE scanning was performed. Each sequence, with fat suppression, included: (1) coronal T2-weighted image of the single-shot fast-spin echo sequence, and required an approximately 25-second breath-hold to complete the scan; (2) coronal T1-weighted image fast spoiled-gradient echo sequence; and (3) an enhanced MR imaging via IV injection of gadopentetic acid, obtaining breath-hold scans of coronal and cross-sectional fast spoiled-gradient echo sequences.

Two experienced radiologists, blinded to the imaging methods, made the evaluation on both CTE and MRE imaging performance of the small intestine lumen, intestinal wall, mesentery, blood vessels, and other morphological changes. Based on these observations, the radiologists assessed the relative diagnostic value of CTE and MRE for imaging small bowel lesions. If they agreed with each other, diagnosis was considered to have been arrived at. If there was a difference, the diagnosis was reached after consultation or discussion at the group meeting.

For statistical analysis, Fisher χ^2 test was performed for comparison between CTE and MRE imaging. $P < 0.05$ was taken as statistically significant.

Results

Of the 30 patients, 9(30%) had undergone MRE which had

Table-1: Comparison of Magnetic Resonance Enterography (MRE) and Computed Tomography Enterography (CTE) results.

Diagnostic Method	Total No. of cases	Detected (%)	Fisher Statistics*
CTE	30	24 (80)	$\chi^2=0.8$ P=0.371
MRE	30	21(70)	

*The statistic analysis was performed by Fisher test, $P > 0.05$.

Table-2: Computed Tomography Enterography (CTE) results.

	Gold standard		Total
	Detect	Non-detect	
Detect	24	6	30
Non-detect	6	24	30
Total	30	30	60

Table-3: Magnetic Resonance Enterography (MRE) results.

	Gold standard		Total
	Detect	Non-detect	
Detect	21	9	30
Non-detect	6	24	30
Total	27	33	60

Table-4: Comparison of Magnetic Resonance Enterography (MRE) and Computed Tomography Enterography (CTE).

	Sensitivity	Specificity	PPV	NPV
CTE	80%	80%	80%	80%
MRE	78%	73%	70%	80%

PPV: Positive predictive value
NPV: Negative predictive value.

missed the diagnosis and they had to have CTE done to have a definite further diagnosis. The remaining 21(70%) patients then underwent both CTE and MRE. Overall, 19(63.3%) patients were males, while 11(36.7%) were females. The mean age of the patients was 33.6 ± 19.2 years (range: 24-67 years). Besides, 22(73.3%) patients had active disease with intestinal symptoms, including abdominal pain, diarrhoea and haemafaecia. However, 8(26.6%) haemafaecia patients displayed no additional clinical symptoms. The CTE and MRE imaging results displayed no significant difference in diagnosis ($p > 0.05$), with an accuracy of 80% for CTE and 70% for MRE (Table-1).

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for the two methods were worked out (Tables 2-4).

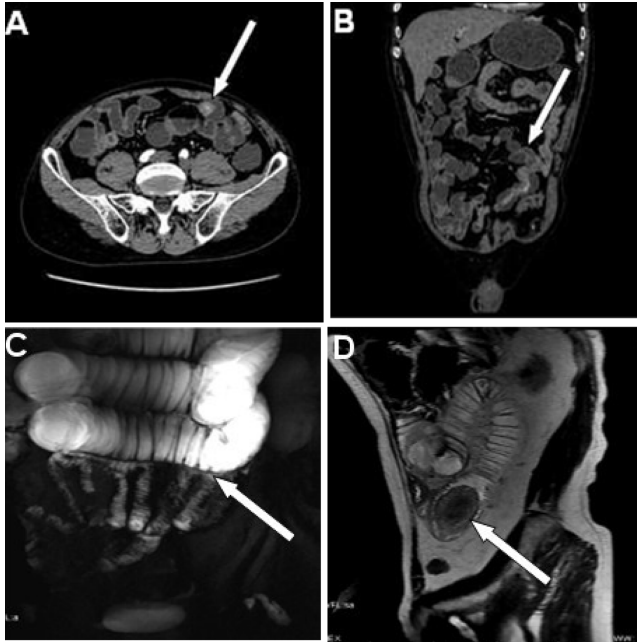


Figure-1: Images of intestine stromal tumours indicated by Computed Tomography Enterography (CTE) and Magnetic Resonance Enterography (MRE). (A) CTE image at transverse position, the arrow indicated an ileum filling defect and homogenous enhancement. (B) CTE image at coronal position, the same patient's coronal section; the arrow indicated a bowel filling defect and intestinal mucosal oedema. MRE hydrography showed a stromal tumour of the small intestine demonstrated at coronal (C) and sagittal position (D). The intestinal tract above the obstruction point significantly expanded as it filled with fluid, while the region below the obstruction point collapsed, as indicated by arrows.

Further, 11 (36.6%) cases were diagnosed with small bowel tumour lesions by both CTE and MRE, with a consistent, accurate diagnosis. Using CTE, the tumours were identified by rich blood supply and some intestinal

obstruction. Eight cases of the primary tumours were located in the extra-intestine, and there were calcification spots in the tumours. In three cases, tumours showed significantly enlarged feeding arteries and draining veins, and there was significant intestinal obstruction (Figure-1A and B). When intestinal obstruction images were merged, MRE made use of the fluid retention to facilitate imaging, which indicated a clear dilation of the intestinal canal (Figure-1C). The obstruction point and collapse of the intestinal canal distal to the obstruction could be determined (Figure-1C and D). Metastatic lesions were identified far from the intestine.

Diagnosis of intestinal vascular malformations was missed in 3 (50%) of the 6 (20%) cases when MRE alone was used to evaluate intestinal vascular malformations. This might be due to poor visualisation of vascular malformations by MRE. There were abnormally thickened blood vessels on the arterial wall, and revascularisation showed the blood vessels' arterial sources (Figure-2A-C). Because of the long imaging times required, MRE was ineffective for diagnosing vascular malformations.

Further, 7 (23.3%) patients were diagnosed with Crohn's disease both by CTE and MRE. The two techniques were found to be equally accurate for Crohn's diagnosis. Multiple small intestine segments and the colon were affected. All affected small intestine segments had bowel wall-thickening, obvious small bowel enhancement, fuzzy serosa, dirty mesentery, and increased numbers of tortuous, dilated small blood vessels around the intestine to varying degrees (Figure-3A-C). Lumen narrowing and slight dilation of the proximal bowel were also observed. MRE showed thickening of multiple small bowel wall segments. Low signal was seen in T1-weighted images, whereas high signal was observed in T2-weighted image

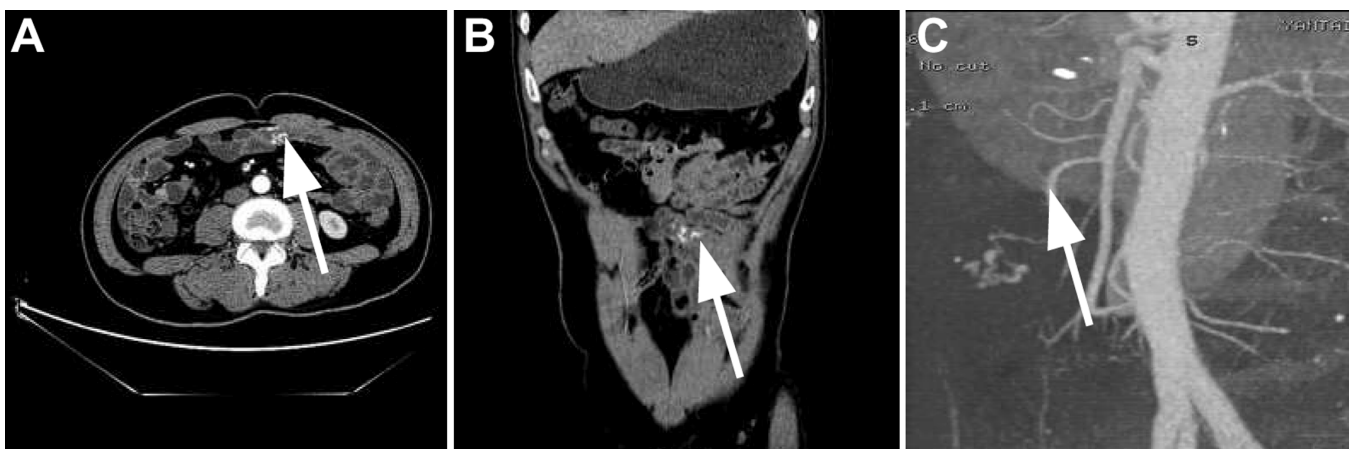


Figure-2: Computed Tomography Enterography image of vascular malformations in the intestinal tract. Panels are for the same patient. The arrows point to arterial information at the jejunal/ileal junction. (A) A transverse section. (B) A coronal section. (C) A maximum intensity projection (MIP) image.



Figure-3: Computed Tomography Enterography image indicated the malformations at different positions. All panels were from the same patient. There were irregular stenoses in the transverse colon and ileocaecum, and bowel wall oedema, as indicated in a transverse section (A) and represented in curved planar reformation images (B and C) at different positions.

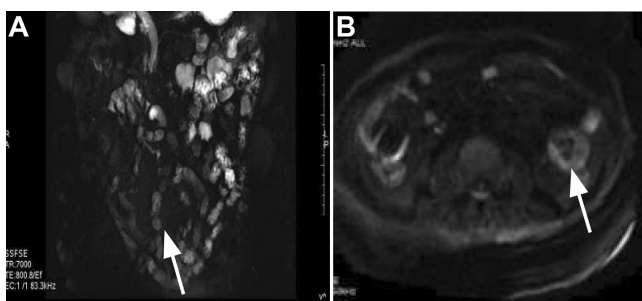


Figure-4: Magnetic Resonance Enterography (MRE) Diffusion-weighted imaging. MRE showed multiple segmental thickenings of the intestinal wall indicated by arrow in (A). Fat suppression sequence in MR imaging clearly showed small bowel wall oedema by arrow in (B).

and hydrography (Figure-4A). In fat suppression sequences, bowel wall oedema was evident (Figure-4B). After the scan was enhanced, an even signal with a thickened bowel wall was represented. Bowel stenosis was observed to varying degrees. Occasionally, stenosis and dilation alternated, and the intestinal rim was irregular. Where fistulas of Crohn's disease had been formed, high signal was seen at the fistula, which was surrounded by relatively low signal tissue.

Both CTE and MRE missed diagnosis of 7(23.3%) cases of small intestinal diverticulosis, telangiectasia, and simple small intestine congestion and oedema. This was considered the blind spot of imaging diagnosis.

Discussion

The results of the study make it evident that CTE and MRE were very accurate in examining tumour lesions in the intestine. Most primary tumours were indicated with the

manifestation of rich blood supply and some intestinal obstruction clearly identified by CTE. On the other hand, MRE showed homogeneous signal mass, rim finishing and clear boundaries; and with enhanced scanning, the signal was obviously and uniformly enhanced. With malignant tumours, the mass showed an image of intermediate signal soft issue, and the signal was uneven after enhanced scanning. In line with some previous studies,⁵⁻⁷ our study demonstrated that both CTE and MRE provided a panoramic view of small intestine cavity, wall, mesentery, lymph nodes, blood vessels, and adjacent organs.

For Crohn's disease, the lesions often caused inflammation of lymph nodes at the mesentery root, and small vessel accumulation in peripheral lesions. CTE imaging revealed the typical "comb sign." MRE could also evaluate the activity of Crohn's disease through analysis of parameters such as the degree of enhancement and signal strength of the intestine wall, and steatohepatic fibrotic proliferation on T2-weighted fat-suppressed images. Significantly enhanced, high signal images of the intestinal wall and steatohepatic fibrosis proliferation are indicative of active Crohn's. This assessment provides guidance for the clinical treatment and prognostic evaluation of Crohn's disease.^{6,7} CTE also has advantages in diagnosing intestinal polyps.⁸ For intestinal obstruction caused by lesions, tumours, or unknown causes, CTE shows an accurate diagnosis rate of upper intestinal obstruction, whereas CTE provided an accurate diagnosis rate of only 48% for lower intestinal obstruction^{9,10} MRE can make use of fluid retention for imaging to diagnose intestinal obstruction without increasing patient pain. Earlier studies^{11,12} reported that MRE demonstrates a higher diagnostic accuracy rate for intestinal obstruction

than does CTE. For diagnosing vascular malformations of the small intestine, CTE is superior to MRE because of high time-resolution and powerful post-processing software technology based on our experiences and consensus in the practice (Gong et al, unpublished data). However, MRE has advantages in locating and quantitatively and qualitatively determining small intestine disease.¹⁰ MRE is especially suitable for examining pregnant women, children and adolescents because of its inherent multi-planar imaging and high-resolution capabilities in soft tissue contrast, and because of its non-invasiveness and non-ionising radiation improves patient tolerance.^{7,13} One study¹⁴ proposed that MRE should be the preferred method in diagnosing paediatric Crohn's disease. Both CTE and MRE missed diagnosis of 7 cases of small intestinal diverticulosis, telangiectasia and simple small intestine congestion and oedema. The reason for missing the diagnosis of small intestinal diverticulosis might be that the small intestine is tortuous and diverticulosis appears similar to the structure of the normal small intestine. The missed telangiectasia, and simple small intestine congestion and oedema diagnoses might have been due to the small size of the dilated capillaries and the relatively minor simple small intestine congestion and oedema, which were not discernible using CTE or MRE.

Conclusion

Both CTE and MRE can be valuable in diagnosing small intestinal diseases. However, both procedures have advantages and disadvantages. Evolving CTE and MRE technologies are likely to play increasingly important roles in diagnosing small bowel disease. The accuracy of diagnosis will be improved when the results of both techniques can be compared. A larger trial is under way to confirm the findings of this study, which was limited by a small sample size.

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Department of Yantai Yuhuangding Hospital, Yantai, Shandong, China.

Disclosure

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References

1. Wu XW, Liu B, Zhao H. The effect of window setting technique on measuring colon disease in CT virtual colonoscopy. *Chin J Radiol* 2007; 41:316-318.
2. Furukawa A, Saotome T, Yamasaki M, et al. Cross-sectional imaging in Crohn disease. *Radiographics* 2004;24:689-702.
3. Zhang LH, Zhang SZ, Hu HJ. Multi-detector CT enterography with isoosmotic mannitol as oral contrast for detecting small bowel disease. *World J Gastroenterol* 2005;11:2324-9.
4. Fletcher JG. CT enterography technique: theme and variations. *Abdom Imaging* 2009;34:283-8.
5. Lee SS, Kim AY, Yang SK. Crohn disease of the small bowel: comparison of CT enterography, MR enterography, and small-bowel follow-through as diagnostic techniques. *Radiology* 2009;251:751-61.
6. Maccioni F, Bruni A, Viscido A. MR imaging in patients with Crohn disease: value of T2- versus T1-weighted gadolinium-enhanced MR sequences with use of an oral superparamagnetic contrast agent. *Radiology* 2005;238:517-30.
7. Sempere GA1, Martinez Sanjuan V, Medina Chulia E, Benages A, Tome Toyosato A, Canelles P, et al. MRI evaluation of inflammatory activity in Crohn's disease. *AJR Am J Roentgenol* 2005;184:1829-35.
8. PJ Pickhardt, SM Wise, DH Kim. Positive predictive value for polyps detected at screening CT colonography. *Eur Radiol* 2010;20:1651-6.
9. Maglinte DD, Gage SN, Harmon BH. Obstruction of the small intestine: accuracy and role of CT in diagnosis. *Radiology* 1993;186:61-4.
10. Maglinte DD, Reyes BL, Harmon BH. Reliability and role of plain film radiography and CT in the diagnosis of small bowel obstruction. *Am J Roentgenol* 1996;167:1451-5.
11. Beal DP, Regan F. MRI of bowel obstruction using the HASTE sequence. *J Comput Assist Tomogr* 1996;20:823-5.
12. Regan F, Beal DP, Bohlman ME. Fast MR imaging and the detection of small bowel obstruction. *Am J Roentgenol* 1998;170:1465-9.
13. Maccioni F, Bruni A, Viscido A. MR imaging in patients with Crohn disease: value of T2-versus T1-weighted gadolinium-enhanced MR sequences with use of an oral superpara magnetic contrast agent. *Radiology* 2005;238:517-30.
14. Casciani E, Masselli G, Di Nardo G, Poletini E, Bertini L, Oliva S, et al. MR enterography versus capsule endoscopy in paediatric patients with suspected Crohn's disease. *Eur Radiol* 2011;21:823-31.