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Effectiveness of a Turbo Direction Change for Reduction of Motion Artifact in Magnetic Resonance Enterography

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The purpose of this study is to evaluate an effectiveness of switching turbo direction to improve motion artifacts of small bowels and aorta. From June to October 2015, 60 patients suspected of having Crohn's disease were enrolled. The MR Enterography scans were performed using same protocol other than the turbo direction: with the Z phase encoding (group A) and with Y phase encoding (group B). Qualitative analysis of each group was performed to evaluate the effectiveness of switching turbo direction from Z to Y. As a result, the 5-point Likert scale for paired observers were 2.33±0.88 for group A and 3.80±0.85 for group B on dynamic contrast enhanced coronal images. In conclusion, group B is proved to be superior to group A and can lessen the motion artifacts derived from phase shifts.

Keywords : MR enterography, Crohn's disease, turbo direction, phase encoding direction, motion artifact

1. Introduction

Magnetic resonance enterography (MRE) plays an important role in diagnosing and monitoring Crohn's disease (CD). A variety of tests have been used to diagnose and monitor CD in clinical imaging and each of them has limitations. In terms of X-ray, barium injection is contraindicated in case of a bowel obstruction or a perforation. In endoscopy, the mesenteric segment remains challenging to examine. In CT enterogrpahy, there have been concerns on side effects of contrast agent and ionizing radiation particularly for young patients of reproductive age requiring multiple imaging studies over time. On the other hand, MRE is a radiation-free alternative method to CTE providing real time and functional images by using multiphase sequences [1-14].

However, MRE has limitation due to motions of bowel and phase shift of aorta which can potentially obscure relevant findings particularly on the contrast enhanced images [15]. Motion artifact is predominantly manifested in the phase-encoding direction. In addition, the stronger gradients are applied, the larger phase shifts are induced from motion. In clinical practice, the extensive use of spatial gradients complicates and amplifies motion artifacts [16-18].

Therefore, the purpose of this study is to evaluate an effectiveness of switching turbo direction to improve phase changes of aorta and reduce motion artifacts of small bowels.

2. Materials and Methods

2.1. Patient populations and Image acquisition

MRE was performed for 60 patients suspected of having Crohn's disease from June to October 2015. MRI scanning was performed on a 3.0T MRI scanner (Ingenia, Philips Healthcare, the Netherlands). The body coil was used as the transmitter, and a dedicated, 16-channel, phased array coil was used as the receiver. Each sequence was performed with breath hold technique, and was acquired with the following parameters: Coronal T1-weighted turbo field echo sequence with fat suppression (TR/TE, 3.2/2; 3 mm thickness with a no gap; FOV, 400 × 350; matrix size, 512 × 512; number of slices. 50; number of excitations, 1; flip angle, 10 degrees; and scan time, 17.8 sec). Both of enteric phase and portal venous phase were acquired after intravenous administration of 0.2 mL per kilogram of body weight of gadoterate meglumine

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(Dotarem; Guerbet, Villepinte, France) at a rate of 2 mL/sec followed by a saline flush. To avoid bowel peristalsis, 10 mg of scopolamine-N-butyl bromide (Buscopan; Boehringer Ingelheim, Ingelheim, Germany) was administered intravenously in order to reduce motion artifact. The MR scans were performed using same protocol other than the turbo direction: with the Z axis phase encoding (group A) and with Y axis phase encoding (group B).

2.2. Image Evaluation and statistical analysis

Ten independent MR radiographers (over 5 years of experience in Enterography MRI) blinded to patient clinical information qualitatively assessed the quality of dynamic images separately with a following 5-point Likert scale (1 – Poor, 2 – Fair, 3 – Good, 4 – Very good, 5 – Excellent).

Statistical analysis was performed with paired t-test by using commercially available statistical software (SPSS version 22, SPSS for Windows, United States). When the P value was less than 0.05, it was determined to be statistically significantly different.

3. Results

60 patients constituted cohort for analysis (29 men and 31 women; range, 28-79 years; mean age, 58.73±122.2 years) (Table 1).

Qualitative assessment between group A and group B in each dynamic imaging is shown in Table 2. As a result of independent t-test, there is significant difference between group A and B (t = –6.562, p = 0.000). Group B shows significantly higher score than group A (Table 3).

An error bar chart with 95 % confidence interval shows the difference between the group A and B which means that it is significantly different (Figure 1).

The dynamic image quality of group B (Y-axis phase

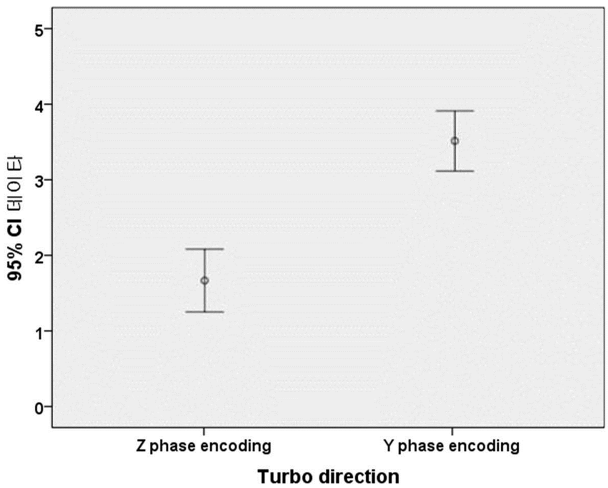
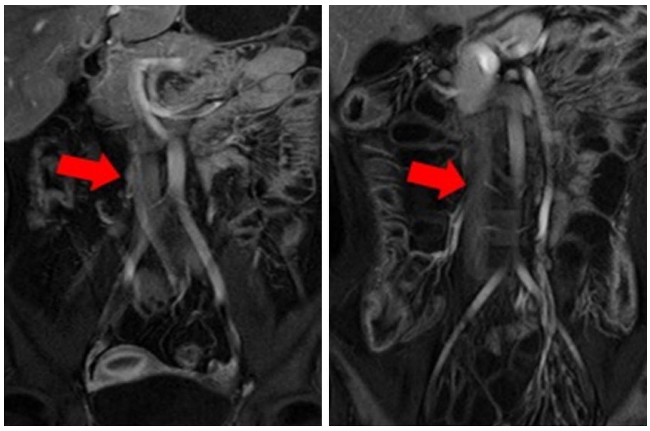


Fig. 1. (Color online) Total image quality scores. Error bar chart graph with 95 % confidence interval summarizes the total colon image quality from MR enterography. Higher scores are seen in cases with Y axis turbo direction (group B). The central circle represents the median value and the whiskers are approximately the highest and lowest values. No outliers were observed on both groups.



(a) Group A (Z phase encoding) (b) Group B (Y phase encoding)

Fig. 2. (Color online) Artifacts on MR enterography images in a 37-year-old male patient. Coronal, fat-suppressed CE T1 weighted images show marked improvement of the artifact. (a) The image shows ghost signal of abdominal aorta (arrow) adjacent to ileum which might obscures lesions like bowel wall enhancement, vasculature, lymph nodes, enteric fistulas and abscesses. (b) On the other hand, the image demonstrates that the ghost signal of abdominal aorta is significantly reduced (arrow).

Table 1. Characteristics of Study Subjects.

Category	Division	Frequency	Percentage (%)
Gender	Male	29	48.3
	Female	31	51.7
Age	40 under	5	8.3
	40-49	7	11.7
	50-59	19	31.7
	60 up	29	48.3

*There was no significant age difference between men and women according to results of the Mann-Whitney U test.

Table 2. A qualitative assessment of dynamic images.

Turbo direction	mean±SD
Group A (Z phase encoding)	2.33±0.88
Group BY phase encoding	3.80±0.85

*Data are means±standard deviations

Table 3. Independent t-test.

Mean Difference	Std. Error Difference	t	Sig.(2-tailed)
−1.467	.224	−6.562	.000

encoding) is superior to group B (Z-axis phase encoding) under the identical conditions (Figure 2).

4. Discussion

In clinical practice, MRE plays an important role in diagnosis and evaluating CD, active ileitis, and extra enteric complications [19-22]. Contrast Enhanced fat-suppressed T1-weighted imaging in the coronal plane is preferable because bowel wall enhancement, vasculature, lumph nodes, enteric fistula and abscesses can be evaluated through multiple vascular phases.

There have been several studies to minimize artifacts in abdominal MRI. Smith AS et al pointed out that the amount of chemical shift can be determined by changing the parameter like FOV, bandwidth, and resonant frequency for the field strength. And Cho *et al.* suggested the conversion of frequency encoding direction can reduce the metal artifact. In study of Lee *et al.* changing center frequency and transmission gain values can compensate metal and flow artifacts surrounding the tissues at 1.5 Tesla MRI. To our knowledge, problem with motion artifact was partially solved by using breath-holding examination, post-processing, respiration gating and intravenously administrating spasmolytic agent in abdominal MRI [23-27].

However there has been limitation on reducing the motion artifacts derived from phase shifts of aorta and small bowel in MRE. To improve the image quality this study suggested switching the turbo direction in coronal dynamic image.

As a result of qualitative assessment, changes of turbo direction appear effectively reduce the motion artifact without any burden such as changes of MR systems, purchasing the new software, complex post processing, and injection of medication. Conventionally, turbo direction is Z-axis in coronal turbo field echo. However Z-axis phase direction is not optimized with dynamic study in MRE. Group B can significantly minimize the artifact by reducing the phase shift.

Although our study is preliminary test of reducing motion artifact induced by bowel and aorta and seems valuable in qualitative assessment, it has some limitations. No quantitative evaluations are performed. Also, factors on motion artifact have not been considered. Therefore, further study is required to appropriately measure the motion artifact for quantitative analysis.

5. Conclusion

In conclusion, Y-axis turbo direction is optimized for dynamic coronal images after injection and can lessen the motion artifact by solving the problem with phase shift in MRE imaging.

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