Dynamic MRI evaluation of small bowel peristalsis pattern using software: a feasibility study

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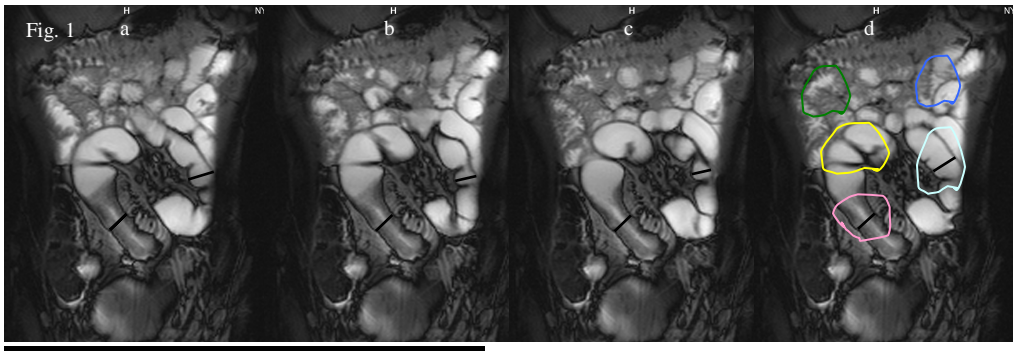
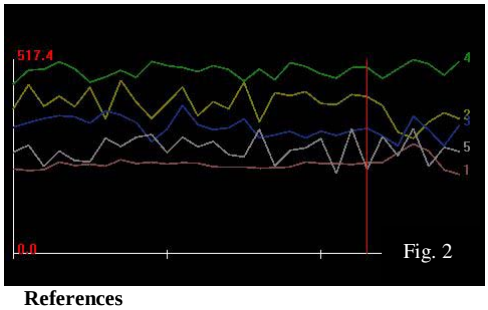
Introduction: Gastrointestinal function is complex and physiological measurements are difficult due to a variety of technical difficulties and practical limitations. Dynamic MRI can observe volume changes and peristaltic contraction, however, quantitative assessment of small bowel peristalsis is difficult because of unpredictable movement and the complex 3D structure formed by the convoluted bowel. Nevertheless the analysis of small bowel motility function has been shown to be feasible.[1-4] Previous studies evaluated peristaltic motion by manually measuring cross-luminal diameters of selected small-bowel segments on each of the dynamic images. However, software has not been applied to evaluate small bowel peristalsis to date. Thus, the purpose of our study is to assess the feasibility using a Fourier-based software model as a tool to evaluate the pattern of small bowel peristalsis in inflammatory bowel disease to compare normal versus abnormal bowel segments.

Methods: Ten patients (mean age 38 years, F=7) referred for MR enterography for evaluation of Crohn's disease (n=2), ulcerative colitis (n=1), ischemic bowel disease (n=3), abdominal pain (n=4) were evaluated at 1.5 T (Avanto, Siemens Medical Solutions). After standard oral preparation of 900 mL VoLumen (E-Z-Em), patients underwent continuous 2D coronal dynamic steady state free precession sequence (true FISP) imaging for 120-140 seconds with shallow breathing using following parameters:TR/TE/flip angle = 3.3/1.6/70°, slice thickness 8 mm, bandwidth 675 Hz/Pixel, FOV 250 x 350 mm, matrix 184 x 256, acquisition time 590 msec each slice. One or two slices were selected by a radiologist at the time of scanning. Best coronal image plane showing abnormal bowel segment was selected for imaging. In case with no abnormal bowel segment, coronal plane showing maximum coverage of small bowel loop was selected. Images were reviewed by two radiologists on an independent workstation (Syngo, Siemens Medical Solutions). 5 small bowel segments were selected for each patient, and the outer luminal diameter of each selected small bowel segment was measured manually perpendicular to the long axis of the lumen on each of the dynamic images. Data were plotted over time. A third observer defined ROI of same selected bowel segments using semi-automated software developed based on Fourier transformation, tissue compression and expansion from a deformation field. Average temporal variance of the intensity values within a region of interest were plotted over time. Data obtained and analysis time from manual measurements and software were compared.

Results: Three subjects had abnormal segments, and the total 3 abnormal segments and 47 normal segments were analyzed. Both manual and semi-automated measurements showed paralytic pattern of abnormal thickened segments involved from inflammatory bowel disease. Normal bowel segments demonstrated periodic constant sinusoidal contraction with contraction frequency 6.5/min (range 4-9 min). Analysis time per each patient from manual measurements was average 20 minutes and analysis time using software was average 1 minute.

Discussion: Abnormal bowel segment involved with inflammatory bowel disease demonstrates not only thickened wall but also abnormal peristalsis pattern. In our preliminary experience, MRI assessment of small bowel peristalsis pattern using software is feasible and provides a reliable and rapid noninvasive method in inflammatory bowel disease. In addition, we acquired MR imaging with breathing and software was able to correct baseline position change of organs during respiration. To our knowledge, this is the first report of a MRI method using software permitting rapid evaluation of small bowel peristaltic pattern. These advances have stimulated investigation of MRI techniques for the study of GI function as well as structure and promise much for future applications in the clinic.





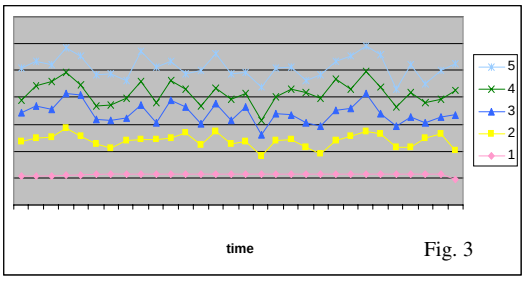


Fig. 1: Four examples of serial dynamic coronal 2D true FISP images of patient with Crohn's disease. Cross section lumen diameters measured manually from selected bowel segment are demonstrated (black lines in a-d). Free hand drawing ROIs for semi-automated software are defined (d).

Fig. 2: Time-resolved graphical presentation of luminal diameters measured using software over a period of 120 seconds of selected bowel segments. Paralytic pattern of distal ileum (region 1) involved with Crohn's disease is demonstrated. Other selected segments demonstrate regular constant contraction (region 2-5).

Fig. 3: Time-resolved graphical presentation of luminal diameters with manual measurement over a period of 120 seconds of same selected bowel segments. Same patterns are demonstrated showing paralytic pattern of distal ileum (region 1).

References

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