

Motility assessment using continuously tagged imaging

A. M. Sprengers¹, M. P. van der Paardt¹, F. Zijta¹, M. W. Caan¹, R. M. Lamerichs^{1,2}, A. J. Nederveen¹, and J. Stoker¹

¹Radiology, Academic Medical Centre, Amsterdam, Netherlands, ²Research, Philips, Eindhoven, Netherlands

Purpose / Introduction:

Disturbed small bowel motility is both an indicator and a frequent cause of gastrointestinal disorders [1,2]. There are several methods available for assessment of small bowel motility such as scintigraphic techniques in the evaluation of transit time, impedance monitoring and manometry [3]. The challenge of motility measurement lies in image quality vs. invasiveness, temporal resolution vs. spatial resolution and diagnostic precision vs. workload. This research proposes the use of tagging as a fast, non-invasive method for automated motility assessment over the entire abdominal area by applying the tagging prepulse continuously and acquiring a full image readout after each prepulse.

Theory:

The tagging prepulse adds contrast to the MR image by saturating periodic bands or sheets of magnetization with two RF pulses interspersed with a dephasing gradient, resulting in a stripe pattern (also referred to as tags or tag pattern) in the MR image. Any motion occurring in between the tagging prepulse and the readout sequence causes the tag pattern to deform, from which motility information can be extracted. This added contrast decays with T1 and there is no option of ECG triggering as is common procedure in cardiac tagging [4]. Thus the imaging sequence must be fast and continuously repeated, to resolve the deformed tag sheets and avoid under sampling of the motion of interest.

Methods:

After approval by the Institutional Review Board 10 healthy, consenting volunteers were scanned on three separate occasions using the continuously tagged sequence. Prior to imaging, the volunteers were asked to drink 1000 ml Mannitol 2.5% solution and were administered 40 mg of butylscopolamine intravenously for the first scan, a placebo solution for the second, and 40 mg of metoclopramide for the third. The subjects were then scanned in supine position performing a breath hold over a period of 17 seconds. Within this period, 30 dynamic scans were acquired using a Transient Field Echo (TFE) readout with a scan duration of 330 ms. Before each dynamic scan the tagging prepulse was applied followed by a 250 ms delay, enabling motility to cause tag deformation. All scans were performed on a Philips 3T Achieva scanner with a Sense XL 16 channel torso coil. The voxel resolution was 3 mm isotropic, FOV= 400x400x36mm (12 slices), TR/TE = 2.9/1.8 ms. Tag sheet tracking and calculation of motion was performed automatically using a scalespace based algorithm [5]. Regions of interest were manually segmented in all scans to compare motility scoring of the jejunum, ileum, ascending colon, transverse colon and descending colon.

Results:

Continuously tagged dynamic sets were successfully acquired in all ten volunteers. Figure 1 shows a coronal dynamic slice of one of the volunteers after butylscopolamine (a), placebo (b) and metoclopramide (c). The slices were set in a 3D perspective for visualization of the tag planes (Figure 2). For all of the segmented regions of interest the mean tissue displacement was calculated for the butylscopolamine, metoclopramide and placebo sets (Figure 3). On average metoclopramide increased bowel motility whereas butylscopolamine decreased bowel motility. Paired t-tests between the effect of metoclopramide and placebo and between the effect of metoclopramide and butylscopolamine revealed statistically significant differences in 80 % of the segments for metoclopramide-butylscopolamine and 40% for metoclopramide-placebo (Figure 3). We attribute the spread in measured displacements mainly to the chaotic nature of peristaltic motion. Figure 4 illustrates that locally unchanged motility is measured after oral preparation.

Conclusion:

It was shown that the effectiveness of metoclopramide and butylscopolamine on motility patterns in the abdomen can be quantified using continuously tagged imaging. This method can be applied in the entire abdominal area with limited patient preparation. Because of the automated tag sheet determination the workload involved is limited to selecting the regions of interest. This method can therefore strongly aid the research of motility on a clinical large scale.

References:

[1] E. Husebye, Neurogastroenterology & Motility 11 (1999) 141-161. [2] J.M. Froehlich et al. Eur Radiol 20 (2010) 1945-51. [3] L.A. Szarka et al. Am J Physiol Gastrointest Liver Physiol 296 (2009) G461-75. [4] E.R. McVeigh, Magnetic Resonance Imaging 14 (1996) 137-150. [5] Sprengers et al. ISMRM 2010 nr 2660

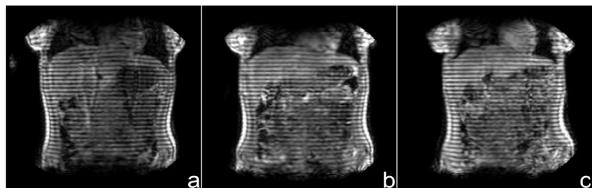


Fig 1: Coronal slices of the continuously tagged dynamic sets with oral preparations butylscopolamine (a), placebo (b) and metoclopramide (c).

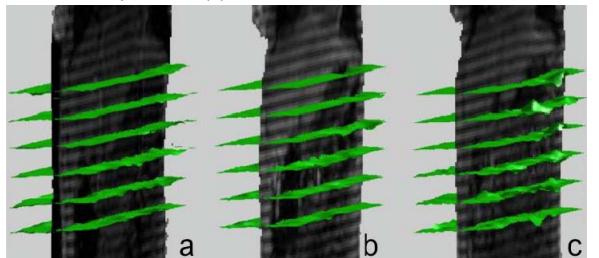


Fig 2: 3D views of the determined tag sheets indicated in green. For visibility only a few of the sheets are indicated. Notice the increase in deformation in the entire abdominal region from butylscopolamine (a) to placebo (b) to metoclopramide (c) while the sheets covering the liver and abdominal muscle area remain non-deformed in all three sets.

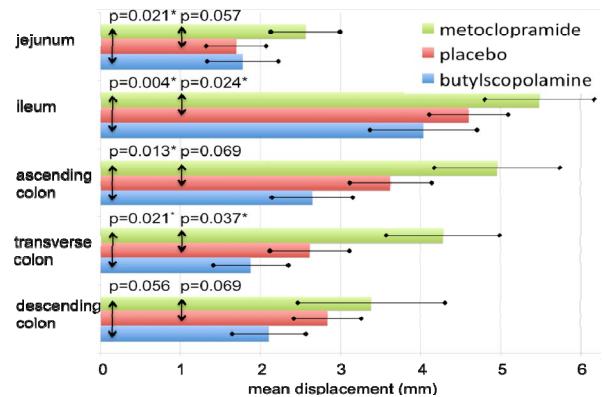


Fig 3: Mean displacements per segmented bowel region for butylscopolamine, placebo and metoclopramide. Error bars indicate the standard error of the mean. p-values are listed for all bowel segment (* if significant).

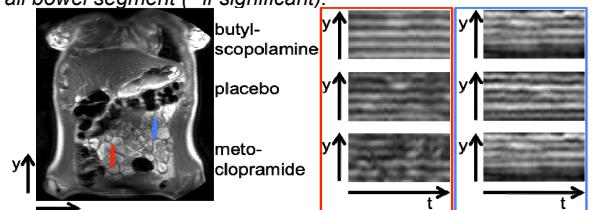


Fig 4: Visualization of the fluctuation in effectiveness of butylscopolamine and metoclopramide on motility. While the segment in the right lower quadrant (red) shows a clear increase in motility from butylscopolamine to metoclopramide, the motility of the segment in the left upper quadrant (blue) appears unaffected by butylscopolamine or metoclopramide for this volunteer.