A novel technique for global small bowel motility assessment using dynamic MRI

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Purpose

Aberrant small bowel motility is described in a range of diseases including chronic intestinal pseudo-obstruction, Crohn's disease and irritable bowel syndrome. Few tools exist to investigate abnormal motility and those that do are often invasive and fail to assess the whole of the small bowel. This article describes the validation of a novel MRI technique which safely and non-invasively quantifies global small bowel motility, reporting within-subject repeatability in healthy human subjects and sensitivity to the motility altering drugs butylscopolamine[1,2] and neostigmine.

Methods

Volunteer Selection: 20 healthy volunteers (13 male, mean age 29, age range 22-48) were recruited via advertisement. Volunteers were excluded where they had a history of GI disease, smoked, were on a medication regimen etc.

Study Design: A randomised subject and reader blinded placebo-controlled cross-over study was performed to examine 1) intra-subject repeatability of software-quantified MRI derived global small bowel motility and 2) sensitivity of the technique to pharmacological induced changes in small bowel motility. Two parallel arms were conducted. In the first arm, volunteers (n=9) were randomised between IV placebo and 20mg IV butylscopolamine (***Buscopan***). In the second arm, volunteers (n=11) were randomised between IV placebo and IV 0.5mg ***neostigmine***, due to its stimulatory effect on bowel motility. Volunteers attended for 2 MRI scans separated by a mean of 4 weeks (range 2-7 weeks) during which a baseline and cross over post drug/placebo motility MRI was performed.

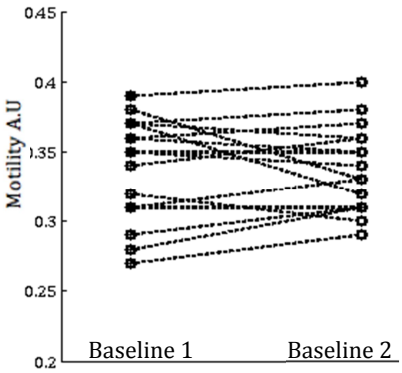

Fig.1 Baseline scans across two visits for the 20 volunteers

MR Protocol: The motility scan protocol used a 3D Balanced Turbo Field Echo (BTFE) motility sequence capturing one 15cm coronal volume through the abdomen and pelvis per second over a 20 second breath hold (2.5x2.5x10mm in plane resolution, FA 20, TE=1.7ms, TR=3.5ms).

Motility Analysis: The modified 2D optic-flow technique [3]. was used to register the dynamic time-series data for each slice through the abdominal volume. The deformation fields generated by the registration process were used to provide a motility metric expressed as the standard deviation of pixel's Jacobian (a measure of local area change) and averaged across a user defined ROI.

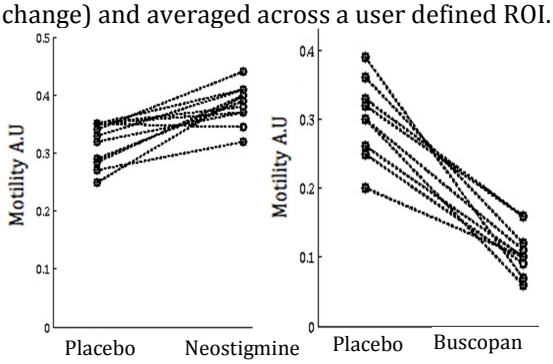

Fig. 2 A) Volunteer response to placebo and neostigmine and B) to placebo and Buscopan.

ROI Placement: Two radiologists (each with at least four years of experience of small bowel MRI) independently placed regions of interest (ROIs) around the small bowel in each coronal slice over the 15-slice volume. The study coordinator fully randomised presentation of the data sets to the readers. The mean of the two readers' score was thereafter used as the 'ground truth' global motility value for each individual volunteer scan.

Statistics: Data normality was assessed using Shapiro-Wilk testing, Within-subject variation was assessed using within subject coefficient of variation and Bland-Altman (BA) limits of agreement (LoA). Sensitivity to pharmaceutical intervention for both the neostigmine and butylscopolamine groups was assessed using paired t-test.

Results

Intra-subject variability: Baseline motility scores from the first scan attendance (mean score 0.34, range 0.28-0.39) and second scan attendance (mean score 0.34, range 0.30-0.40) are shown in figure 1. The within subject coefficient of variation was 4.85% and mean difference from BA was 0.0025 (LoA ±0.04).

Sensitivity to pharmaceutical intervention: The mean motility following the administration of placebo (Fig 2A). was 0.32AU and Neostigmine was 0.39AU with a mean group difference of 0.07 95% CI = 0.038 to 0.098, $p < 0.001$ representing a ***22% increase in small bowel motility.*** The mean motility scores following administration of placebo and Buscopan were 0.30AU and 0.13AU respectively, with a mean difference of 0.17 (95% CI from 0.10 to 0.23), P <0.0001 and representing a ***57% decrease in motility.***

Discussion & Conclusion

Bowel dysmotility contributes to many intestinal conditions and a non-invasive method of assessing small bowel motility could have a significant impact upon the diagnosis, management and treatment of these conditions. This study has shown that a surrogate of small bowel motility based on quantifying pixel movement acquired using motion capture MRI is both repeatable in normal subjects and sensitive to changes induced by medication with known pharmacological effects on gut function.

References: 1. Sprengers AM, van der Paardt MP, Zijta FM, et al. Use of continuously MR tagged imaging… JMRI 2012;36(2):492-7, 2. Gutzeit A, Evaluation of the anti-peristaltic effect of glucagon and.. European radiology 2012;22(6):1186-94 , 3. Odille F et al. Quantitative assessment of small bowel motility... MRM 2012;68(3):783-93