Preliminary investigations of colonic motility from Cine MRI; use of registration techniques for quantitative analysis

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Introduction: Chronic constipation is a common gastrointestinal disorder. A small proportion of patients require further investigation for optimal management. Current tests are invasive and usually involve ionising radiation which is undesirable as many patients are female of childbearing age. We have shown that oral dosing with a common laxative, polyethylene glycol (PEG), provokes a response in the colon readily visualised with MRI[1,2]. Cine MRI can capture information on colonic contractions[3,4], important for propelling chyme through the colon.

Aim: To determine whether registration techniques to reduce breathing effects and parameterise the motility (previously used in the small bowel[5,6]) could be applied to Cine MRI of the ascending colon (AC) to characterise differences in motility in the AC observed before and after a PEG challenge.

Methods: The study was carried out using a 1.5 T Philips Achieva Scanner and 16 Element SENSE torso coil. 10 healthy subjects (3 male, mean age 27 yrs, range 20-50 yrs) were scanned after at least a 6 hour fast. Subjects were scanned before and 1 hour after consuming either 1L (N=4) or 2L (N=6) of a PEG formulation. A variety of scans were acquired including a bTFE single sagittal slice scan through the centre of the AC (FOV 330 x 228 mm^2, resolution 1.5 x 1.5 mm^2, 15 mm slice thickness, FA 70°, TR/TE 3/1.5 ms). Cine data were acquired using this sequence every second for 2 minutes under shallow free breathing conditions to assess the motility of the AC.

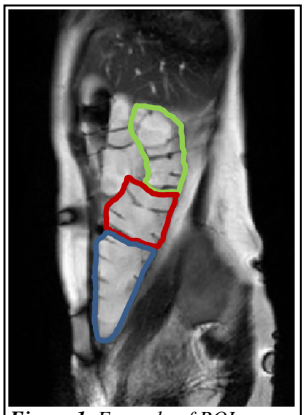

Figure 1. *Example of ROIs drawn on AC. Data from post PEG consumption.*

Data Analysis: Data were first registered using Robust Data Decomposition Registration (RDDR) to remove the effects of breathing from the cine data[7]. These images were then further registered using an optic flow technique[5] to generate deformation fields which could be used to propagate user placed ROIs through the time series data to allow wall motion to be tracked. To generate a colonic motility metric, the AC was split into three regions of interest (ROIs) shown in Fig 1; 3 regions were chosen to help identify smaller wall movements which may not have been found if using a large ROI of the whole AC. The ROIs were then automatically propagated through the time series data and the areas of the ROIs plotted against time, having been smoothed to reduce noise. Each area was normalised to its mean area and the number of time points which were either above 3, 5 and 10% different from the mean (Figure 2) was counted and summed over all 3 regions to give a motility index metric (percentage values chosen to give a range of sensitivity). These scores were compared to an observer based score of bowel contraction, (Table 1) carried out by a Radiologist with extensive experience of MR Bowel motility scans, to determine which percentage level was the most appropriate to use as the cut-off for significant wall movement, using Spearman Rank correlation coefficient. To confirm whether the metric provided similar information to the observer scores, median data were compared pre and post PEG ingestion which is known to increase bowel motility[2].

Score	Description of contractions throughout time series
1	No contractions seen
2	Mild contractions seen – small region involved or small amount of time for contraction
3	Moderate contractions seen – larger region involved or prolonged time for small region
4	Severe contractions seen – large regions over prolonged time period

Table 1. *Description of observer contraction scoring system used.*

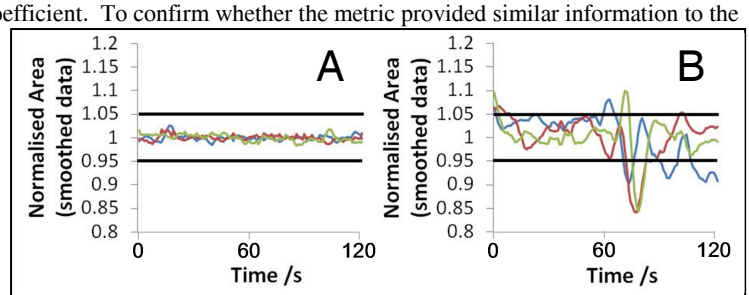

Figure 2. *Example graphs showing normalized areas of the ROIs. (A) No wall motion observed. (B) Considerable wall motion observed. Black lines show the 5% cutoff; data points outside the lines would be counted in the motility index.*

Results: A scatter plot of the motility index against the Observer contraction scores across all data (pre and post PEG) are shown in Figure 3 for the different cut-off levels. The Spearman Rank correlation coefficients were 0.631 (p=0.003), 0.657 (p=0.002) and 0.444 (p=0.05) for the 3, 5 and 10% cut-offs respectively. Between baseline and 1 hour post PEG median (IQR) Motility index increased from 2.5 (0.25-12.5) to 62.5 (19.75-74.5) and observer contraction scores increased from 2 (1-2) to 3 (3-3.75).

Discussion and Conclusions: Using the change in ROI area to generate a motility index provided good agreement with observer scoring of bowel contractions, with the 5% cut-off providing the best correlation. This method does have some limitations; if the data sets are not well corrected for free breathing using the RDDR due to large scale movements, wall movements are overestimated as the poor correction for the breathing gets translated into large movements from the optic flow analysis which then overestimates the motility index. Also if the colon volumes become very large due to great distension by fluid, modest wall movement does not get picked up due to the small fractional change in area leading to an underestimation of motility; this could be overcome by setting a maximum size for each area used, looking at line ROIs across the AC or using absolute changes in area. In general this preliminary study has shown potential to use registration to derive a meaningful colonic motility metric from large quantities of cine data with minimum user input. Future work will determine if other parameters derived from the registration process can provide additional information.

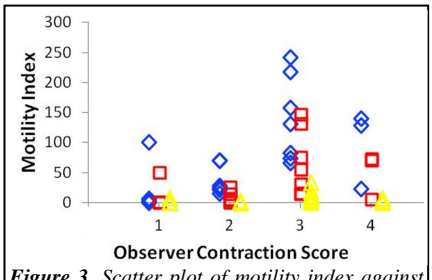

Figure 3. *Scatter plot of motility index against observer scores. Cutoff levels of 3% (Blue), 5% (Red) and, 10% (Yellow)*

References: [1] Garsed *et al*. Gastroenterology 2012:142(S1):S814 [2] *Lam et al*. 21st UEG Week, Berlin, 2013:p1531, [3] Kirchhoff *et al.* Abdom Imag 2011:36:24-30 [4] Buhmann *et al.* Invest Radiol. 2005:40:689-94 [5] Odille *et al*. MRM 2012:68:783-93 [6] Menys *et al.* Eur Radiol. 2012:22:2494-501 [7] Hamy *et al*. MedIA in press. **Acknowledgements:** Funding from Norgine Pharmaceuticals Limited.