Optimisation of minimal preparation MR colonography

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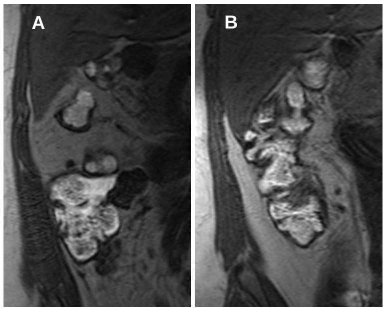
Introduction: MR colonography without colonic cleansing has potential for polyp and tumour detection[1]. Preparation with oral contrast media and dietary specification can modify intra-luminal signal to consistently differ from tumour to allow discrimination[2]. We propose a technique using ferric ammonium citrate (FAC) and complementary dietary manipulation (to shorten luminal T1 and T2 values (Figure 1)) in combination with gaseous insufflation[3] and comparative analysis of several sequences suitable for breath-hold imaging. This work aims to optimise the preparation strategy and sequence parameters for this technique of MR colonograhy.



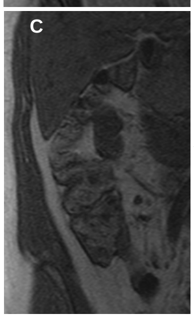


Figure 1: Matched location T1w FAME images (15° flip angle) of the caecum of a single volunteer after dietary preparation with strategies A, B and C. Strategies utilising FAC (i.e. A and B) shorten the T1 of feacal material, aiding discrimination from the bowel wall or potential lesions.

Materials and Methods: Six healthy volunteers (aged 25 - 75 years) each underwent 3 MRI examinations at fortnightly intervals. For 3 days before each examination they followed a dietary preparation strategy (randomised order): A: FAC (Lexpec + Iron-M, Rosemont, 2.5 ml qds) + high fat, low residue diet; B: FAC + *expanded* high fat, low residue diet; C: high fat, low residue diet only (*no FAC*). In consideration of volunteer comfort gaseous insufflation was not employed. Volunteers rated diet and contrast agent palatability by a visual analogue scale. Examinations were performed on a 1.5T (GEHT) MR system with an 8-channel torso phased-array coil. Coronal matched-location breath-hold sequences were investigated (28 slices, 44 cm FOV): 2D T2w SSFSE (TR/TEeff = 1100/80 ms), 2D PDw SSFSE (TR/TEeff = 1500/33 ms), 3D T1w FAME (TR/TE = 3.6/1 ms), and 3D T1w FGRE (TR/TE = 1.6/0.6 ms). The following imaging parameters were varied: T1w FAME and FGRE: flip angle ($5 – 25^{\circ}$, 5° increments).

Studies were assessed by sequence and anatomical colonic segment (6 segments: caecum, ascending, transverse, descending, sigmoid and rectum). Contrast to noise ratios (CNRs) were measured for matched-location areas of faeces, adjacent skeletal muscle (~SI colon wall) and air using an IDL-based tool: CNR = (SI Lumen - SI muscle) / SD Air. Also, signal of intra-luminal material relative to muscle was assessed by 2 experienced observers in consensus (blinded to preparation and sequence parameter details). The 'optimal' imaging parameter was selected for each sequence (i.e. best faecal discrimination *and* colon wall demonstration). Optimal images for all sequences were reviewed independently and simultaneously for the ability to exclude a 10mm luminal mass. If exclusion was not possible the cause was determined: a) luminal collapse, b) material of similar signal to tumour, c) combination. Sequences and preparation palatability were compared by a non-parametric Wilcoxon signed rank test.

Results: CNR values for T1w FAME (Figure 2) and FGRE increased with flip angle for all preparation strategies. CNRs and observer scores (Figure 3) both indicated diets A and B provide significantly better positive luminal contrast than C on FAME and FGRE imaging ($P < 0.001$) (Figure 1). For FAME (FGRE), 15° (10°) or greater flip angles provided better contrast than to lower angles ($P < 0.001$). The optimal flip angle selected for FAME (FGRE) imaging was 20° (20°) for A, 15° (15°) for B and 20° for C (15°).

Preparations A and B were significantly better than C for mass exclusion ($P < 0.01$): lesions could be excluded from 61% of segments following A, 61% B, and 28% C. The most frequent reason for failure of exclusion was luminal collapse: 71% of failures for A, 79% for B and 50% for C. However, in clinical practice segmental collapse would be minimised by using air insufflation. Assuming adequate distension is achieved (evaluating failed segments due to collapse as adequate), lesion exclusion should be possible in 89% of segments for A, 92% for B and 64% for C (A and B significantly better than C: $P < 0.015$). Preparation B was considered significantly more acceptable than A or C ($P = 0.03$) by volunteers.

Conclusion: This optimisation study indicated that FAC is a necessary component of a high fat, low residue preparation strategy to modify faecal signal to be consistently different from tumour. The extended dietary preparation (B) offers improved palatability to the strategy presently employed (A), and a trend towards increased contrast between intra-luminal material and the bowel wall. The optimal flip angle for discriminating faeces from tumour while retaining adequate signal from the bowel wall signal is 15° for T1w FAME and FGRE with preparation B. Evaluation of this optimised MR colonographic technique in a clinical setting is required.

References:
1. Lauenstein T et al Radiology, 2002. **223**: p248
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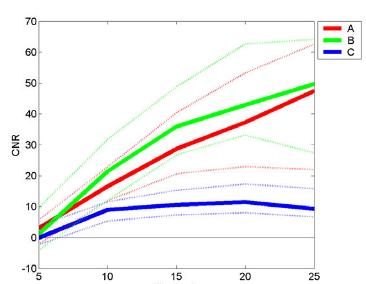

Figure 2: CNR values for T1w FAME ($5-25^{\circ}$ flip). Solid lines indicate the median for diets A, B, and C; doted lines indicate the corresponding inter-quartile ranges.

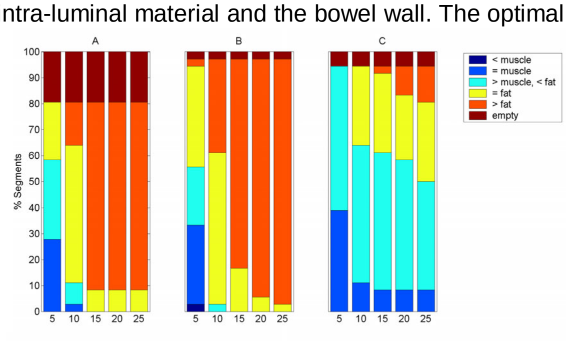

Figure 3: Observer scores indicating contrast between faeces and adjacent tissues on T1w FAME imaging (varying flip angle from 5 to 25°) for all preparation strategies.