MR colonography without bowel cleansing or water enema: a pilot study

¹A SAMBROOK, MRCS, FRCR, ¹D MCATEER, FRCP, FRCR, ¹S YULE, MRCP, FRCR and ²P PHULL, MD, FRCP

¹Department of Radiology, Aberdeen Royal Infirmary, Aberdeen, UK, and ²Department of Gastroenterology, Aberdeen Royal Infirmary, Aberdeen, UK

Objectives: The value of screening for colorectal cancer has been well demonstrated, and national programmes are being implemented. At present the primary imaging modality is colonoscopy, which has an associated morbidity and mortality. CT colonography (CTC) has been proposed as an alternative, but this is associated with radiation exposure and generally requires bowel preparation. The aim of this pilot study was to assess the feasibility of MR colonography (MRC) without bowel preparation or water enema for the detection of colorectal neoplasia.

Methods: Patients scheduled for colonoscopy were invited to participate in the study; informed consent was obtained. MRC (with oral barium faecal tagging and colonic air distension) was performed 1–2 weeks before the colonoscopy. Axial T_2 weighted single-shot fast spin-echo (prone and supine) and axial T_1 weighted fast spoiled gradient-recalled (pre- and post-iv gadolinium) supine MRI sequences were performed. The examinations were reported by two gastrointestinal radiologists by consensus. Colonoscopy following standard bowel preparation was performed by a single endoscopist blinded to the MRC results. Significant lesions were defined as polyps or masses >10 mm in diameter.

Results: 29 patients were studied. Colonoscopy revealed 25 mass lesions in 13 patients. MRC correctly identified four of the nine lesions >10 mm in diameter (sensitivity 44%; specificity 100%). Although specificity remained high for smaller lesions, sensitivity was poor.

Conclusion: This pilot study has demonstrated the feasibility of performing MRC without bowel preparation or water enema. This would seem to be a promising modality for colorectal cancer screening. Larger studies are required to determine the accuracy of this modality for the detection of colorectal neoplasia.

Received 8 November 2010
Revised 19 March 2011
Accepted 23 March 2011

DOI: 10.1259/bjr/26473479

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Radiology

Colorectal cancer (CRC) develops from pre-existing adenomatous polyps. Screening for CRC has been shown to reduce cancer-related mortality by detection of colorectal carcinoma at an earlier stage and by removal of polyps prior to malignant transformation [1]. The mainstay of CRC screening is colonoscopy; however, this is associated with a low morbidity and mortality [2], which assumes greater significance in the context of a screening programme. Discomfort is associated with the procedure itself, but also with the bowel cleansing that is required.

There has been considerable interest in the development of non-invasive diagnostic imaging procedures that could offer a more acceptable alternative to colonoscopy. CT colonography (CTC) demonstrates good sensitivity and specificity for polyps ≥ 10 mm in diameter. However, there is a drop-off in lesion detection at <10 mm, and even more so at <5 mm [3]. Furthermore, radiation exposure may be a concern in a screening programme and, as for colonoscopy, bowel preparation is necessary.

MR colonography (MRC), first developed in 1998 [4], offers the advantage over CTC of not involving radiation

exposure. The technique for performing MRC has been refined with the development of fast breath-hold sequences with adequate anatomic coverage. Both “bright lumen” (using a gadolinium-spiked water enema) and “dark lumen” (water or gas enema) techniques have been developed [5]. MRC has been shown to have a high sensitivity and specificity for colonic lesions measuring >10 mm [6], and even lesions >5 mm but <10 mm [7, 8], when compared with colonoscopy. As with colonoscopy and CTC, however, these techniques required full bowel cleansing.

In an attempt to further reduce the discomfort and increase the acceptability of the procedure, Lauenstein et al [9] developed a faecal tagging technique that avoided bowel cleansing. The signal of the intraluminal faecal material was nulled by coating it with a high-concentration barium mixture taken orally over 36 h prior to the procedure. This MRC technique has demonstrated a high sensitivity and specificity for colonic lesions >5 mm in diameter [10].

Another attempt at decreasing any discomfort associated with MRC has focused on using room air instead of water for bowel distension [11]. Leung et al [12] have evaluated this technique in a large study and demonstrated a high specificity, although sensitivity was poor for lesions <10 mm.

Address correspondence to: Dr Dymphna McAteer, Consultant Radiologist, Department of Radiology, Aberdeen Royal Infirmary, Foresterhill, Aberdeen AB25 2ZN, UK. E-mail: d.mcateer@abdn.ac.uk

The aim of this pilot study was to assess the feasibility and acceptability of performing MRC without bowel cleansing and using air insufflation instead of water enema for the detection of colorectal neoplasia.

Methods

The study was approved by the ethics committee of our institution. Patients already scheduled for colonoscopy were invited to participate in the study, and written, informed consent was obtained. Exclusion criteria were known inflammatory bowel disease, pregnancy and standard contraindications to MRI (such as the presence of a pacemaker).

MRC was performed 1–2 weeks prior to colonoscopy. Participants were asked to avoid high-fibre foods, chocolate and fruit.

Barium sulphate (Micropaque; Guerbet Laboratories, Birmingham, UK), 200 ml q.d.s was administered orally with food for 36 h prior to MRC. The examinations were performed on a 1.5T system (Sigma CV1/NNV1; GE Healthcare, Little Chalfont, UK) following distension of the colon by manual per rectum air insufflation to the level of patient comfort and administration of a single injection of Buscopan® 20 mg (hyoscine butylbromide, Boehringer Ingelheim, Bracknell, UK) intravenously to reduce peristaltic artefact. With the subject in a supine position the following axial sequences were obtained:

- (a) T_2 weighted single-shot fast spin-echo (SSFSE), TR (repetition time) 1294 s, TE (echo time) 60 ms, bandwidth 31.23, field of view 40, slice thickness 8 mm, spacing 0 mm, matrix 192×256 , 0.8 phase rectangular field of view.
- (b) T_1 weighted fast spoiled gradient-recalled (FSPGR), TR 8.7 ms, TE 4.2 ms, flip angle 60, bandwidth 31.25, field of view 40, slice thickness 8 mm, spacing 0 mm, matrix 192×256 , 0.75 phase rectangular field of view, pre- and post-intravenous Omniscan (gadodiamide, GE Healthcare, Little Chalfont, UK), 0.2 mmol kg^{-1} , 3 ml s^{-1} , imaging delay 75 s.

Sequence (a) was repeated with the subject in the prone position.

Following initial studies the FSPGR sequence was refined to a three-dimensional sequence with fat saturation [fast acquisition with multiphase (FAME)] using two overlapping volumes. The total examination involved the patient being on the table for approximately 45 min.

The MRC examinations were reported by two experienced gastrointestinal radiologists. Each radiologist reviewed the axial images independently and in the event of discrepancy the final report was reached by consensus. The image resolution did not permit diagnostic quality reformatting. Significant lesions were defined as polyps or masses $\geq 10 \text{ mm}$ in diameter. Scoring of the parameters of bowel distension, faecal tagging and image quality was performed by consensus opinion of the radiologists. Bowel distension was considered good if all segments were well distended, fair if any segments were partially collapsed and poor if any segments were completely collapsed. Faecal tagging was considered good if the signal from faecal residue was completely suppressed,

fair if some of the residue retained high signal (making it indistinguishable from small polyps) and poor if there was a large amount of high signal residue (making it difficult to exclude even large lesions). Image quality was scored good when the resolution and contrast were felt to be adequate to detect lesions of 10 mm and less, fair when only lesions greater than 10 mm were felt to be detectable and poor when it was considered that even large cancers could escape detection.

Colonoscopy was performed by a single endoscopist (PSP) using a Fujinon EG350 HR colonoscope (Endoscopy UK Ltd, Aylburton, UK). All patients received standard bowel preparation with Picolax (sodium picosulphate plus magnesium citrate, Ferring Pharmaceuticals Ltd, Langley, UK) according to the manufacturer's instructions. The procedure was performed under conscious sedation (midazolam 1.5 mg, pethidine 25 mg, Buscopan 20 mg, median doses). Complete colonoscopy was defined as terminal ileal intubation. The colonoscopist was blinded to the MRC results until the start of scope withdrawal, when a segmental unblinding technique was used [13]. The size of any polyps or masses was measured using the open jaws of a biceps forceps (5 mm). A standard polyp matching strategy was employed using a location of same or adjacent segment and a size of within 50%. Polyps were removed and retrieved for histology, and any lesions not suitable for endoscopic removal were biopsied.

Results

29 patients were enrolled in the study (17 males and 12 females, mean age 61 years, range 40–75 years). Consensus assessment of each MRC examination for adequacy of colonic distension, faecal tagging and image quality was performed by the radiologists with each parameter classified as good, fair or poor (Table 1). Colonic distension was adequate for diagnostic purposes in all cases, with 93% of examinations scored as good and 7% scored as fair. Faecal tagging was also considered successful, with 79% of examinations scored as good and 21% as fair. Image quality, however, was scored fair in all cases due to the marked limitation of spatial resolution, a function of the technology available. The T_2 weighted images provided superior image quality, with no additional colonic polyps/tumours identified on the T_1 and/or post-gadolinium images. Complete colonoscopy was performed in all cases, with a total of 25 colonic lesions identified in 13 patients (Table 2). Histology of these lesions revealed 2 adenocarcinomas, 13 adenomas, 8 hyperplastic polyps and 1 lymphoid aggregate. One 10 mm polyp was excised but not retrieved for histology.

MRC revealed six lesions in five patients. For significant lesions ($\geq 10 \text{ mm}$ in diameter), the sensitivity

Table 1. Scoring of imaging parameters

Imaging parameter	Good	Fair	Poor
Distension	27	2	0
Faecal tagging	23	6	0
Image quality	0	29	0

Table 2. Number of colonic lesions identified by MR colonography and colonoscopy

Polyp/mass		MR colonography	
Size (mm)	Colonoscopy	True positive	False positive
<5	9	1	0
5–9	7	0	1
≥10	9	4	0

of MRC was 44% and the specificity was 100%; both of the cancers were correctly identified by MRC. For lesions 5–9 mm in diameter, the specificity remained high at 94.7%, with one false-positive 9 mm lesion; however, the sensitivity was very poor at 6%, with only 1 of 16 lesions being identified. Even in retrospect, the additional polyps detected at colonoscopy could not be confidently identified on the false negative MRC examinations. MRC images and corresponding colonoscopic views for a large polyp are shown in Figure 1 and for the two cancers in Figures 2 and 3.

Diverticulosis was seen in 18 patients at colonoscopy (including one in whom there was associated inflammation, also detected on MRC) and in 9 patients at MRC. Extracolonic lesions were detected by MRC in 12 patients: gall stones, psoas bursitis, ovarian cysts, horseshoe kidney, hiatus hernia, parapelvic renal cysts, liver cysts, liver haemangiomas and myelomatous deposits in the lumbar spine.

Discussion

The pilot study of MRC has allowed us to develop a working methodology combining oral faecal tagging and manual air insufflation of the colon. A variety of strategies have been employed in the performance of MRC without bowel cleansing [14, 15]. Bright lumen (hyperintense on T_1) images have been obtained using gadolinium enemas, whereas dark lumen (hypointense on T_1) techniques have employed water or air. The introduction of faecal tagging obviates the requirement

Figure 2. T_2 MR colonography image showing a caecal carcinoma (arrow).

for bowel cleansing with gadolinium as the tagging agent for bright lumen and barium for dark lumen MRC. Comparison of three non-bowel cleansing strategies, (1) gadolinium faecal tagging with gadolinium enema (bright lumen), (2) barium faecal tagging with water enema (dark lumen) and (3) barium faecal tagging with air enema (dark lumen), showed good and comparable diagnostic confidence [14]. The bright lumen technique showed the best contrast between the bowel wall and lumen, but is more susceptible to artefact on T_1 weighted imaging. The dark lumen technique using an air enema performed slightly better than that using water. A study by Gomez et al [15], however, comparing barium faecal tagging with either a water or air enema demonstrated more artefacts, less successful faecal tagging and poorer colonic distension with air. The advantages of MRC with faecal tagging and air enema include avoidance of bowel cleansing, a cheap, readily available tagging agent and a quicker procedure. The potential disadvantages are reduced diagnostic accuracy due to susceptibility artefact from the air/bowel wall interface, incompleteness of faecal tagging, poor bowel distension, and limited

(a)

(b)

Figure 1. Axial T_2 MR colonography image and corresponding colonoscopic view showing a 3 cm sigmoid polyp (arrow).

Figure 3. Axial T_2 MR colonography image showing a stenosing sigmoid carcinoma (arrow).

patient acceptability of the oral barium regime and air enema. However, our experience showed very little impact of these factors: artefact did not limit image interpretation, barium tagging and dietary instructions resulted in excellent signal suppression from bowel content, and patients found the examination and its preparation more acceptable than colonoscopy. In this study, however, MRC was less accurate than colonoscopy for detecting neoplasia. The low sensitivity for detection of significant lesions would prevent implementation of the examination as a diagnostic technique in clinical practice. The reason for this, however, was felt to relate to the limited resolution and speed of image acquisition by the available equipment, which led to a compromise between duration of examination and image-quality factors such as slice thickness and additional series in the coronal plane. With the ongoing advances in MR technology, the sensitivity of the technique is expected to attain acceptable levels of diagnostic accuracy. Faster scanning times with reduced slice thickness and multiplanar imaging, are now available, as well as virtual colonoscopic reconstructions, and we would expect this to result in a significant increased sensitivity in the detection of colonic polyps. Manual air insufflation provided sufficient colonic distension and was acceptable to our patient population. However, we would expect improvement in both these areas using continuous carbon dioxide insufflation. The faecal tagging regime proved very successful, which we hope will be maintained in higher resolution images. Little additional information was gained with the T_1 and post-gadolinium images, but this may become more relevant in the characterisation of smaller lesions. As a large bowel imaging modality, MRC has the potential to play a major role in colorectal cancer screening, with the advantage over CTC of a lack of ionising radiation. The avoidance of bowel cleansing would increase acceptability and improve uptake of the screening procedure.

Conclusion

This study has demonstrated that oral faecal tagging with barium and rectal air insufflation is a feasible technique, but larger studies employing more advanced MR technology are required to determine the accuracy of this modality in the detection of colorectal neoplasia.

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