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Intravenous, contrast-enhanced MR colonography using air as endoluminal contrast agent: Impact on colorectal polyp detection

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ABSTRACT

Purpose: To compare diagnostic accuracy and patient tolerance of MR colonography with intravenous contrast and luminal air (MRC) to conventional colonoscopy (CC).
Materials and methods: IRB approval and written informed consent were obtained. Forty-six patients, both screening and symptomatic, underwent MRC followed by CC. The MRC technique employed 3D T1W spoiled gradient echo sequences performed after the administration of gadopenetate dimeglumine, with parallel imaging. The diagnostic accuracy and tolerance of patients for MRC was compared to CC.
Results: Twenty-four polyps were detected in eighteen patients with CC (5 polyps ≥10 mm, 4 polyps 6–9 mm, 15 polyps ≤5 mm). MRC was 66.7% (12/18) sensitive and 96.4% (27/28) specific for polyp detection on a per-patient basis. When analyzed by polyp size, sensitivity and specificity of MRC was 100% (5/5) and 100% (19/19), respectively, for lesions greater than 10 mm, 100% (4/4) and 100% (20/20) for lesions 6–9 mm, and sensitivity of 20% (3/15) lesions less than 5 mm. The sensitivity and specificity of MRC for detecting significant lesions (>6 mm) was 100% (9/9) and 100% (15/15), respectively. Regarding tolerance of the exams, there were no significant differences between MRC and CC. Thirty-five percent ($n = 16$) of patients preferred MRC as a future screening test compared to 33% ($n = 15$) for CC.
Conclusion: MRC using air as an intraluminal contrast agent is a feasible and well-tolerated technique for detecting colonic polyps ≥6 mm in size. Further studies are warranted.

1. Introduction

Colorectal cancer is the third leading cause of cancer related death within the Western world. Despite scientific evidence that colorectal screening can reduce mortality [1], only 40% of eligible Americans undergo screening by faecal occult blood testing, flexible sigmoidoscopy, barium enema, or colonoscopy [2]. While the current screening tests provide high sensitivity and specificity, low patient acceptance has led to low screening rates, especially among women [2]. The need for an accurate, minimally invasive, colorectal cancer screening test that is more acceptable to the public has led to the development of virtual colonoscopy which encompasses both CT colonography (CTC) and MR colonography (MRC) [3].

Potential advantages of MRC over CTC as a screening test include the lack of ionizing radiation, and potential for more accurate characterization of detected lesions [4,5]. However, patient acceptance of bright lumen MRC may be limited by the administration of a 1.5–2 L gadolinium enema necessary to generate positive contrast with the colon wall and false positives occur due to retained faeces and air [6]. Bright lumen MRC allows visualization of dark filling defects (polyps) against the bright gadolinium spiked colonic lumen, similar to arterial plaque detection with contrast enhanced 3D MRA.

In an effort to maximize patient tolerance a previous study explored the feasibility of the dark lumen MR colonography technique that uses room air insufflation rather than gadolinium enema [7]. Dark lumen MRC consists of distending the colonic lumen with air, CO_2 or water. With T1-weighted imaging and intravenous contrast, this then results in strong contrast between the brightly enhancing colonic wall and the enhancement within target polyps versus the dark colonic lumen. With T2-weighted imaging the target lesions are higher in signal intensity compared to the air or CO_2 rendered dark lumen. At 1.5 T, MRC using room air has been shown to be a feasible technique, but may be associated with poor signal-to-noise ratio (SNR) at the mucosal/lumen interface and at the edge of the field coverage afforded by the phased

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array coil where modest colorectal polyp detection rates may result [8].

The advent of parallel imaging can allow reduction in MR image acquisition time, improved spatial resolution or a combination of the two. Therefore, this imaging technique has the potential to increase coverage/unit time and in certain circumstances (e.g., single shot imaging), may allow for SNR boosts over the entire colon; when used to improve temporal resolution parallel imaging can help reduce motion artefacts. Parallel imaging as applied to MRC in patients should lead to more rapid imaging with improved polyp detection, as was previously demonstrated in a phantom model [9]. The aim of this study was to assess diagnostic accuracy, image quality and patient tolerance of MR colonography performed with air contrast and parallel imaging, compared to conventional colonoscopy.

2. Materials and methods

Institutional Review Board approval for this study was obtained from the Hospital Institutional Review Board and written informed consent was obtained from all individual patients. Compliance with HIPPA (Health Insurance Portability and Accountability Act) was maintained.

2.1. Patient study

We conducted a prospective study, over an eight month period, from January 2004 to July 2005. Inclusion criteria required consecutive patients referred from gastroenterologists for conventional colonoscopy, both screening and symptomatic, at least 18 years of age and capable of providing written informed consent. Exclusion criteria included patients unwilling to give written informed consent, patients unable to cooperate for a period of 1 h, patients with known contraindications to MRI (e.g., claustrophobia, metallic foreign bodies, aneurysm clips, metallic cardiac valves, pacemakers, renal failure (eGFR < 30 mL/min/1.73 m^2), pregnancy or obesity, weight > 300 lbs) and patients with a history of allergy to gadolinium contrast or glucagon hydrochloride. All patients were scheduled for conventional colonoscopy. Forty-five patients had CC on the same day, with one patient having their CC one week later.

Prior to MRC, full clinical history was taken, including current symptoms, to ascertain if they were in the screening group (patients with no clinical symptoms or signs, but deemed at risk for colorectal carcinoma (CRC)) or symptomatic group (patients with altered bowel habit, weight loss, melena, blood per rectum, or iron deficiency anaemia).

2.2. Demographics

Seventy-two patients were enrolled in the study following informed consent. Twenty-six patients were unable to complete the MRC due to claustrophobia ($n = 9$), obesity ($n = 10$), diabetes ($n = 6$), as well as technical problems with the scanner ($n = 1$) (Fig. 1). Therefore, forty-six patients completed MRC, comprising the study population. Males accounted for 47.8% ($n = 22$) population, mean age of 55 years (range 41–84 years, inter-quartile range (IQR) 46–64 years). Of the patients referred for CRC investigation, 53% were deemed 'average risk' for colorectal carcinoma, thus were from a screening population, with the remainder being symptomatic.

2.3. Patient preparation prior to MRC

All of the subjects underwent standard bowel preparation 24 h prior to MR colonography (90cc Phosphosoda). As the majority ($n = 45$) of patients had the CC on the same day, only one bowel preparation was necessary. The remaining patient had a second

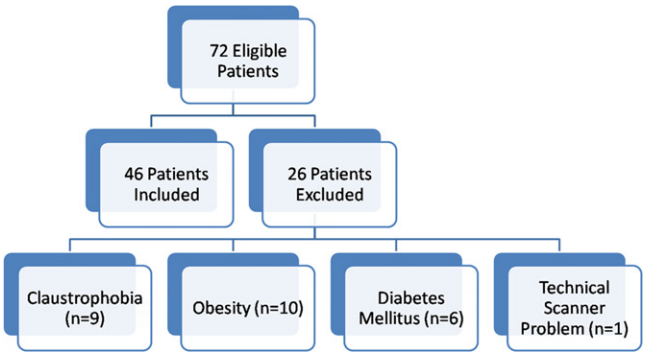

Fig. 1. Flow chart demonstrating eligible patients, included patients and reasons for exclusion of patients from the study population.

preparation (90cc Phosphosoda) for the CC one week later. Subjects were placed in the right lateral decubitus position on the MR table and a 12-French soft-tipped rectal tube was inserted and approximately 2 L of room air was gently insufflated into the colon and titrated to patient tolerance, with number of insufflations ranging from 25 to 45 bulb compressions. Patients had direct control of the air insufflation bulb and self insufflated further air on request of the operator. A 0.5 mg dose of glucagon hydrochloride (glucagon; Bedford Laboratories, Bedford, OH, USA) was administered intramuscularly prior to acquisition of the non contrast spoiled gradient echo (SPGR) T1 weighted (T1W) sequence in the prone position and an additional 0.5 mg was given immediately prior to non contrast SPGR T1W sequence in the supine position due to the 15 min time interval between the two acquisitions to compensate for the short half life of glucagon.

2.4. MR technique: image acquisition

All of the patients were scanned in the prone and supine positions using a 1.5-T MR scanner (Excite TwinSpeed, GE Medical Systems, Waukesha, WI, USA). An eight element phased array body array multicoil was employed, centered to achieve maximum coverage of the colon. Following colonic air insufflation as described above, scout images using T1-weighted gradient echo sequences performed in the coronal, sagital, and axial planes were used followed by sequential T2W single shot fast spin echo (SSFSE) in the coronal plane to confirm adequate colonic distention and bowel preparation. The MRC technique employed 3D T1W SPGR obtained both pre and post contrast, Gadopentetate dimeglumine (Magnevist, Berlex, Wayne, NJ, USA) was intravenously administered at a dose of 0.1 mmol/kg and at a rate of 2 mL/s, immediately followed by a 20 mL saline flush at 2 mL/s using a mechanical power injector (Medrad, Indianola, PA, USA) and images were acquired at 75 s (early) and 90 s (delayed) after initiating the contrast injection. Scan parameters included 3 mm true-slice thickness with no gap, TR/TE: 4.2 ms/0.8 ms, 62.5 kHz BW, 192 × 256 matrix, 480 mm × 336 mm FOV, performed with the array spatial sensitivity encoding technique (ASSET) parallel imaging strategy. Overall scan time averaged 30–40 min.

2.5. Conventional colonoscopy

All patients underwent conventional colonoscopy following MRC. Conscious sedation with a combination of intravenous midazolam (Hypnovel 10 mg/2 mL Roche) and fentanyl (Fentanyl Citrate 100 μg/2 mL, Janssen-Cilag) was routinely administered, provided no contra-indications existed. A video colonoscope (Olympus, USA) was inserted into the caecum and sequentially withdrawn segment by segment for the detection of polyps. Polyps were photographed