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Magnetic resonance colonography with automated carbon dioxide insufflation: Diagnostic accuracy and distension

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ABSTRACT

Objectives: To evaluate the diagnostic performance of MR colonography using automated carbon dioxide (CO_2) insufflation for colonic distension, with colonoscopy serving as the reference standard.
Methods: Ninety-eight symptomatic patients underwent MR colonography with faecal tagging and automated CO_2 insufflation. Three readers (one expert (reader 1), and two less experienced (readers 2 and 3)) evaluated the images for the presence of colorectal lesions. Bowel distension was evaluated on a 4-point scale. Results were verified with colonoscopy and histopathological analysis.
Results: Per-patient sensitivity for lesions ≥10 mm was 91.7% (11 of 12) (reader 1), 75.0% (9 of 12) (reader 2), and 75% (9 of 12) (reader 3). Specificity was 96.5% (82 of 85) (reader 1), 97.7% (83 of 85) (reader 2), 95.3% (81 of 85) (reader 3). Per-patient sensitivity for lesions ≥6 mm was 85.7% (18 of 21) (reader 1), 57.1% (12 of 21) (reader 2), and 57.1% (12 of 21) (reader 3). Specificity was 86.8% (66 of 76), 98.7% (75 of 76), 90.8% (69 of 76), respectively. Per-patient sensitivity for advanced neoplasia of ≥10 mm and ≥6 mm was 88.9% (8 of 9) for all readers. Specificity for ≥10 mm and ≥6 mm was 98.9% (87 of 88) (reader 1), 97.7% (86 of 88) (reader 2), 96.6% (85 of 88) (reader 3). 94.4% of the colon segments were adequate to optimal distended with dual positioning.
Conclusion: MR colonography can accurately detect lesions ≥10 mm, and advanced neoplasia ≥6 mm. Sufficient distension was achieved using automated CO_2 insufflation for colonic distension in MR colonography.

1. Introduction

Colorectal cancer is the second most common cause of cancer-related death in Europe [1]. Several screening tools (i.e. flexible sigmoidoscopy, barium contrast enema, faecal occult blood test, and colonoscopy) have been evaluated for the detection of colorectal cancer and its precursors, with colonoscopy demonstrating the highest mortality reduction [2]. Yet, colonoscopy is associated with lower patient acceptance if compared to other screening methods, i.e. faecal occult blood test [3].

Colonography with either computed tomography (CT) or magnetic resonance imaging (MRI) comprises assessment of the colon with the use of bowel preparation and colon distension. Diagnostic accuracy of CT colonography is high for detecting large colorectal polyps and adenomas [4,5]. The key impetus for studying MR colonography as alternative for CT colonography is the presence of radiation exposure at CT. Although the median effective radiation dose for CT colonography screening protocols has been reduced, the radiation exposure remains a concern which is especially essential for screening purposes [6].

In CT colonography the use of automated carbon dioxide insufflation is standard [7]. It secures optimal distension while the continuous intracolonic pressure measurement precludes over distension and its associated risks [8].

Ongoing technical improvements in MRI have largely overcome the presence of disturbing artefacts effecting image quality when

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using gas, thereby paving the way for gaseous colonic distension [9].

The primary aim of our study was to prospectively assess the diagnostic accuracy of MR colonography with the use of automated insufflated carbon dioxide, in the detection of clinically relevant colorectal lesions, compared with colonoscopy and histopathological outcomes. Colonic distension was the secondary outcome to validate earlier results of the use of automated carbon dioxide insufflation for MR colonography in a larger cohort of symptomatic patients [9].

2. Material and methods

2.1. Patients

From January 2010 to June 2012 consecutive patients were recruited at the outpatient clinic of the department of gastroenterology of three participating hospitals: a university hospital Academic Medical Center Amsterdam, Amsterdam, the Netherlands and two secondary referral hospitals Sloter-vaartziekenhuis, Amsterdam, the Netherlands and Onze Lieve Vrouwe Gasthuis, Amsterdam, the Netherlands. To evaluate the diagnostic performance of our MR colonography technique and to ensure high prevalence of relevant colorectal lesions, we included symptomatic patients (rectal blood loss, altered bowel habits, iron deficiency). Other inclusion criteria were: referral for conventional colonoscopy and willingness to give informed consent. Exclusion criteria were: age < 18 years, patients not able to give informed consent, any suspicion of bowel perforation or pathologic obstruction in patients' medical history, contraindications for oral or intravenous administration of (iodine) contrast agents as used for this examination [9], contraindications for use of intravenous injection of butylscopalamine or glucagon, presence of a colostomy, and contraindications to undergo MRI (including claustrophobia and pregnancy).

MR colonography was performed prior to scheduled conventional colonoscopy.

The study was approved by local ethical committees of all participating centres. All patients gave written informed consent. Patient acceptance data are not discussed in this article.

2.2. Bowel preparation for MR colonography

All patients started preparation the day before imaging. Patients received a standardized bowel preparation of meglumine-ioxithalamate (Telebrix Gastro 300 mg I/mL; Guerbet, Cedex, France) [7,9]. Patients ingested 50 mL meglumine-ioxithalamate at lunch and dinner the day before imaging and 50 mL meglumine-ioxithalamate 1.5 h before imaging (total 150 mL) and were instructed to use a low-fibre diet the day before MR colonography [10]. On the examination day only a liquid diet was allowed.

2.3. MR colonography

MR colonography was exclusively performed at the university hospital by a dedicated radiology research physician or one trained radiographer.

A balloon-tipped flexible rectal catheter (20 French gauge) was inserted to insufflate the carbon dioxide into the colon. The rectal catheter was extended with a long tube of approximately 7 m for automated insufflation outside the MRI suite (MedicCO2LON, MedicSight PLC, UK). The long tube entered the MRI suite via the standard existing penetration panel in the wall, to bring the radiofrequency contamination to a minimum. This extended automated insufflation had been tested for maximum rectal pressure shutdown and loss of pressure due to leakage and proved to be a closed system [9].

Insufflation was performed in three positions (right side, supine, left side). Insufflation target pressure was set at 25 mmHg and after 3 L insufflation maintained at 20 mmHg throughout the examination [11]. Data acquisition started based on the symptoms of the patient and after 3 L of carbon dioxide was insufflated.

All MR scans were performed on a 3.0 Tesla (Intera, Philips Healthcare, Best, the Netherlands) MR scanner with a 16-channel SENSE-XL-Torso coil. The MR protocol consisted of contrast-enhanced T2-weighted two-dimensional (2D) half-Fourier single-shot turbo spin–echo (HASTE) sequences in coronal planes, followed by fast T1-weighted three-dimensional (3D) Turbo Field Echo (TFE). The sequences consisted of two stacks of coronal images in the *z*-axis from upper- and lower abdomen. To reduce examination time we did not acquire pre-contrast data. Scan parameters were: 2D T2-weighted HASTE: TR/TE 800/65 ms; FA 90°; number of slices: 36, FOV 400 mm × 456 mm, voxel: 1.56 mm × 2.00 mm × 4.00 mm; slice gap 1, SENSE factor 2.5. 3D T1-weighted TFE: TR/TE 2.3/1.0 ms; FA 10°; number of slices: 90, FOV 400 mm × 400 mm; non-interpolated voxel size 2.00 mm × 2.00 mm × 2.00 mm, SENSE factor 1.5 (RL), 2 (AP). The T1-weighted sequence was acquired both in supine and prone position for optimal distension of the colon.

To reduce bowel motion and discomfort, butylscopalamine-bromide (Buscopan; Boehringer-Ingelheim, Ingelheim, Germany) (or, if Buscopan was contraindicated; glucagonhydrochloride 1 mg, Glucagen; Novo-Nordisk, Bagsvaerd, Denmark) was administrated intravenously before insufflation and before T1-weighted data acquisition, in total 30 mL [9,12].

T1- and T2-weighted sequences were acquired during a breath-hold of 15–20 s. Prior to data acquisition, 0.2 mL/kg body weight dimeglumine gadopentetate 0.5 mmol/mL (Magnevist; Schering, Berlin, Germany) was administrated intravenously. No sedative or analgesic agents were administrated. The total in-room time was recorded.

2.4. Data evaluation

For reproducibility purposes multiple readers evaluated the images. The readers were aware of the inclusion and exclusion criteria, but were blinded to clinical history and colonoscopy results. The first reader (reader 1) was an expert reader (S.J., abdominal radiologist for three years with prior experience of 200 MR colonographies with colonoscopy verification, and >750 CT colonographies). Readers 2 and 3 were less experienced readers. Reader 2 F.M.Z. was a third-year resident in radiology and had interpreted over 180 CT colonographies with feedback of colonoscopy results and >100 CT colonographies. Reader 3 T.N.B. was a first-year radiology research physician who had interpreted 180 CT colonographies with feedback of colonoscopy results. Both less experienced readers had evaluated 40 MR colonographies, with feedback of colonoscopy results for learning purposes.

Images were interpreted on a picture archiving and communication system (IMPAX-SP4-SU4-DS3000; Agfa, Mortsel, Belgium). The readers used the multiplanar reformation setting (MPR) to evaluate the 3D datasets in all orthogonal planes. Lesion detection was based on the 3D T1-weighted images. T2-weighted images were used for problem solving. The readers recorded their total evaluation times.

Size (largest diameter), morphology (sessile, flat, pedunculated), segmental location (caecum, ascending colon, transverse colon, descending colon, sigmoid, rectum) and certainty (not probable (25%) to certain (100%)) were annotated by the readers. Lesions were measured by using electronic callipers, which were applied to the MPR setting that showed the maximal diameter of the lesion.