Magnetic Resonance Colonography for the Detection of Colorectal Neoplasia in Asymptomatic Adults

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BACKGROUND & AIMS: Colonoscopy is the preferred screening test for colorectal neoplasia; the fecal occult blood test (FOBT) detects neoplasias with low levels of sensitivity. Computed tomographic colonography detects neoplasias with high levels of sensitivity but involves exposure to radiation. We investigated whether magnetic resonance colonography (MRC) can be used to screen for colorectal adenomas and cancers. **METHODS:** We analyzed data from 286 asymptomatic adults (40–82 years old) who underwent 3 Tesla MRC and colonoscopic examinations on the same day. FOBT was performed before bowel preparation. Colonoscopists were initially blinded to the findings on MRC and unblinded after withdrawal from the respective segments. Sensitivities for adenoma and per-patient sensitivities and specificities were calculated based on the unblinded results of colonoscopy. **RESULTS:** We detected 133 adenomas and 2 cancers in 86 patients; 37 adenomas were ≥6 mm, and 20 adenomas were advanced. Sensitivities of MRC and colonoscopy for adenomas ≥6 mm were 78.4% (95% confidence interval [CI], 61.8–90.2) and 97.3% (95% CI, 85.8–99.9); for advanced adenomas these values were 75% (95% CI, 50.9–91.3) and 100% (95% CI, 83.2–100.0), respectively. MRC identified 87.1% (95% CI, 70.2–96.4), colonoscopy 96.8% (95% CI, 83.3–99.9), and FOBT 10.0% (95% CI, 2.1–26.5) of individuals with adenomas ≥6 mm and 83.8% (95% CI, 58.6–96.4), 100% (95% CI, 81.5–100.0), and 17.6% (95% CI, 3.8–43.4) of individuals with advanced neoplasia. Specificities of MRC, colonoscopy, and FOBT for individuals with adenomas ≥6 mm were 95.3% (95% CI, 91.9–97.5), 96.9% (95% CI, 93.9–98.6), and 91.8% (95% CI, 87.6–94.9), respectively. **CONCLUSIONS: 3 Tesla MRC detects colorectal adenomas ≥6 mm and advanced neoplasia with high levels of sensitivity and specificity. Although MRC detects colorectal neoplasia with lower levels of sensitivity than colonoscopy, it strongly outperforms one-time FOBT.**

Keywords: Colon Cancer; Virtual Colonoscopy; Magnetic Resonance Colonography; CRC.

Colonic screening for neoplasia reduces not only the incidence of colorectal cancer but also the mortality rate.[1–3] Colonoscopy, sigmoidoscopy, and fecal occult blood tests (FOBTs) are widely recommended for screening asymptomatic adults.[4,5] However, these tests have limitations. Screening colonoscopy requires full bowel preparation, is usually performed under sedation, is associated with a low but not negligible risk of complications, and has low levels of acceptance in the population.[6] The sensitivity of conventional guaiac-based FOBT for advanced adenomas and cancer is low. Novel fecal immunochemical tests also have low sensitivity for advanced adenomas,[7] the primary target of screening.[8] The yield of sigmoidoscopy is limited to the distal colon. More recently, computed tomographic (CT) colonography has been proposed as another highly sensitive screening tool for the detection of colonic neoplasia.[9–12] Nevertheless, a major concern associated with CT colonography is the exposure of healthy individuals to ionizing radiation, albeit at a low dose.[13,14]

Magnetic resonance (MR) colonography is a radiation-free, intravenous contrast–enhanced examination of the entire abdomen with high spatial resolution. Thus far, the majority of studies on MR colonography have only recruited a few patients and have been retrospective in design.[15–22] Only one study has been performed in an asymptomatic population.[19] To date, no data are available on the performance of MR colonography in the detection of advanced adenoma. Because of considerable variations in study design, imaging technique, performance of the reference test, differences in study populations, and the reporting of the results,[23] only limited conclusions can be drawn from previous studies. Therefore, the objective of the present study was to analyze the diagnostic accuracy of high-field MR colonography in the detection of advanced and nonadvanced colonic neoplasia in asymptomatic adults undergoing same-day optical colonoscopy as the prime reference test after providing stool samples for FOBT.

Abbreviations used in this paper: CI, confidence interval; CT, computed tomographic; FOBT, fecal occult blood test; MR, magnetic resonance; NNS, number needed to screen; 3D, 3-dimensional.

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Subjects and Methods

Participants

The study protocol was approved by the institutional review board, and each participant provided written informed consent. Individuals were recruited via study flyers in local primary care practices and at our institution. Asymptomatic adults 50 years or older with an average risk and asymptomatic adults 40 years or older with a family history of colorectal cancer were interviewed for inclusion and exclusion criteria. Exclusion criteria were prior colonoscopy, symptoms of bowel disease or history of chronic inflammatory bowel disease, significant weight loss, body weight >150 kg, relevant cardiovascular or pulmonary comorbidity, and contraindications to MR scanning. All participants received detailed information regarding bowel preparation and a set of 3 conventional guaiac-based FOBTs (Beckman Coulter, Krefeld, Germany). Tests were returned on the day of the procedures.

Study Procedure

FOBT sampling was completed before the start of cathartic bowel preparation and not rehydrated before development. MR colonography and colonoscopy were performed on the same day. Bowel preparation was based on 20 mg bisacodyl, 30 mL sodium phosphate (Prepacol; Guerbet , Sulzbach, Germany), and 4 L polyethylene glycol solution (KleanPrep; Norgine, Marburg, Germany).

MR colonography was performed on a high-field 3 Tesla MR scanner (Magnetom Verio; Siemens Healthcare, Erlangen, Germany) equipped with a fast gradient system and 32-channel technology. For details of the MR examination protocol, see Supplementary Materials and Methods. In brief, participants were positioned on the MR scanner table in the left decubitus position and 2 to 2.5 L of warm tap water was introduced in accordance with individual patient tolerance into the colon. During distention of the colon, 40 mg of N-butyl-scopolamine (Buscopan; Boehringer Ingelheim, Ingelheim, Germany) was injected intravenously. Subsequently, patients were turned in the prone position and bowel filling was monitored by coronal 2-dimensional HASTE (half-Fourier single-shot technique) sequences; a high-resolution 3-dimensional (3D) fat-saturated volumetric interpolated breath-hold examination (VIBE) sequence was acquired before and 40 and 70 seconds after intravenous injection of 0.1 mL/kg body wt 1 mol/L gadolinium-based contrast agent (Gadovist; Bayer Healthcare, Leverkusen, Germany). The entire duration of the MR examination was 7 to 8 minutes, and total patient in-room time was 13 to 15 minutes.

Video colonoscopy was performed by one of 14 colonoscopists. Nine had performed >1000 and 5 had performed >500 colonoscopies before the start of the trial using standard video colonoscopes (Olympus Medical Systems, Hamburg, Germany). Sedation with propofol or midazolam was offered to all patients. Lesions were measured by comparison of their size with an open biopsy forceps. All polyps were removed or biopsy specimens were obtained and sent for histopathologic analysis. Before discharge, all participants were asked to give their preference for future screenings in the form of an anonymous questionnaire.

Documentation and Matching of Findings

MR images were interpreted before the start of colonoscopy on a 3D postprocessing workstation (MultiModality Workplace; Siemens AG Healthcare, Forchheim, Germany) equipped with standard 3D software by one of 3 experienced MR radiologists (A.G., A.M., and K.H.) with prior experience of interpretation of at least 100 MR colonographies. Interpretation times for MR colonography were documented starting with the loading of the data set to the viewing software. Each of the 6 colonic segments (cecum, ascending colon, transverse colon, descending colon, sigmoid colon, and rectum) was assessed for the presence of motion artifacts (1, none; 2, mild; 3, moderate; 4, severe) and the degree of colonic distention (1, optimal distention; 2, no segments collapsed but suboptimal distention; 3, segmental collapse of one segment; 4, segmental collapse of ≥2 segments). Only segments rated as 1, 2, or 3 for both criteria were considered as of adequate image quality. Subsequently, sequences were assessed for extracolonic findings. Only potentially important findings[24] requiring further workup were included in the analysis.

All findings were documented on a standardized report form. For each segment, the absence or presence of polyps was determined and lesion sizes were coded as diminutive (1–5 mm), small (6–9 mm), or large (≥10 mm). In the endoscopy suite, the report form containing the results of MR colonography was revealed to the endoscopist only after withdrawal of the endoscope from the respective colonic segment. In the case of a discrepancy between MR colonography and first-look findings on colonoscopy, an immediate colonoscopic reexamination ("second look") of the respective colonic segment had to be performed. First- and second-look detections were documented separately. This technique, known as "segmental unblinding," allows for the unbiased correlation of MR colonography and colonoscopy.[9,11] It results in the creation of an enhanced reference standard: combined first- and second-look colonoscopy.

Statistical Analysis

Determination of sample size for the one-sample setting is based on the following scenario: when the sample size is 250, it is possible to detect a difference in proportion between 70% (alternative) and 60% (null hypothesis) with an exact 2-sided binomial test on a significance level of 5% and with 90% power.

Statistical analysis was performed using SAS Statistical Software version 9.2 (SAS Institute, Cary, NC). An advanced adenoma was defined as an adenoma ≥10 mm or showing either high-grade dysplasia or a prominent villous component. Advanced neoplasia was defined as advanced adenoma or adenocarcinoma. The adenoma detection rate was defined as the proportion of subjects in whom at least one adenoma was identified.[25] The number needed to screen (NNS) was derived from the inverse of the probability to detect an advanced neoplasia. A lesion was rated a true positive if colonoscopy and MR colonography detected a polyp in the same segment of the colon and if the measured size of the lesion was within the same size category. In case of discrepancy, the MR-based size and location were accepted as true measures. Sensitivities and specificities were calculated for MR colonography and colonoscopy on a per-polyp basis. Per-patient sensitivities, specificities, accuracies, and positive and negative predictive values were calculated for all tests.

Results

In total, 311 of 360 individuals interviewed were eligible for participation and 293 individuals were included in the study between March 2008 and November 2011 (Figure 1). Seven cases were excluded from analysis because of lack of evaluable MR colonography or incom-