MRI Colonography in the Era of CT Colonography:

Is there any meaningful role?

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INTRODUCTION

MR colonography (MRC) is a non-invasive method to evaluate colorectal disease. After the rectal administration of a water-based enema or gasiform distending media such as CO₂ [1-4], an assessment of the bowel wall can be performed either on the acquired source data or on virtual endoscopic reformations [5, 6]. MRC enables a visualization of the colon even in the presence of high grade stenoses [7, 8]. In terms of acceptance virtual colonography is preferred over optical colonoscopy by a majority of patients [9, 10].

MRC TECHNIQUE

General contraindications to MR imaging should be excluded such as presence of cardiac pacemakers. Some form of bowel preparation needs to be performed as examinations of un-prepped bowel may result in both false positive (stool particles simulating colorectal masses) and false negative results (colorectal lesions masked by residual stool). Patients should undergo bowel cleansing and / or fecal tagging [11-13]. Furthermore, the colon needs to be distended to allow for a reliable evaluation of the bowel wall. Otherwise, non-distended colonic segments can mimic bowel wall thickening thereby leading to possible misinterpretations of inflammation or even colorectal malignancy.

The rectal application of different agents has been proposed for colonic distension, including water-based fluids, CO₂ or room air. Furthermore, spasmolytic agents should be administered intravenously [14, 15]. This will help to obviate bowel spasms, minimize artifacts due to bowel motion and provide higher levels of bowel distension. The patient can be positioned either prone or supine depending on the patient’s preferences. For signal reception, dedicated surface array coils should be used.

MRC SEQUENCES

A high contrast between bowel lumen and wall is mandatory for the depiction of colorectal pathologies. The contrast mechanisms strongly depend on the type of the rectal enema and the applied MR sequences. Similar to other abdominal MRI applications, it is important to collect data under breath-hold conditions in order to avoid (respiratory) motion artifacts. Hence, acquisition times should not exceed 20 seconds. Especially the implementation of parallel imaging has been helpful to decrease acquisition times. After the collection of a localizer sequence, a comprehensive MRC protocol should encompass different types of sequences:

1. **T2 single shot fast spin echo (SSFSE)**
   The differentiation between active and non-active (i.e. fibrotic) inflammatory changes of the colon is one of the clinical questions that often need to be addressed. To that end, the acquisition of single-shot T2w sequences with fat saturation is important. Edema in or adjacent to the bowel wall as a marker for active disease can be easily depicted on the T2 fat saturated images [16, 17].

2. **Fast imaging with steady state precession (FISP)**
   FISP images allow for a good anatomical overview of abdominal and pelvic structures by providing a mixture of both T1- and T2-contrast. One eminent advantage of this sequence is its relative motion insensitivity, which is helpful in patients who are unable to hold their breath. FISP data should be acquired without fat suppression as mesenteric changes can be better depicted.

3. **T1w 3D gradient echo**
   T1w images should be collected with and without intravenous gadolinium. The 3D acquisition should be performed at 20s (arterial phase), 60s (portal venous phase), 120s (delayed contrast phase) and 180s (equilibrium contrast phase). Strength of this sequence is related to the high spatial resolution with nearly isotropic voxel size, but also to information about tissue perfusion. Hence, polyps or carcinomas can be reliably distinguished from residual stool particles or air bubbles, which can mimic colorectal lesions. While tissue enhancement is always found in real colonic masses, pseudo-lesions never enhance after gadolinium administration.

CLINICAL VALUE OF MRC

Most clinical studies assessing the diagnostic impact of MRC have been conducted at 1.5T. Kuehle et al. examined 315 subjects of a screening population by MRC [18]. All participants were prepped using a fecal tagging protocol. A rectal water enema was applied for bowel distension and data acquisition included pre- and post gadolinium T1w images as well as FISP images. As a standard of reference optical colonoscopy was performed in all patients. Regarding lesion-based sensitivity of MRC for the detection of colorectal masses, apparent differences were noted depending on the lesion...
size. While polyps < 5mm were detected with a sensitivity of only 10.5%, this value was as high as 73.9% for lesions > 10mm. Most of the lesions missed on MRC were hyperplastic polyps. However, sensitivity of MRC amounted to almost 85% for clinically relevant adenomatous polyps > 5mm, which are the main target for colorectal cancer screening. Furthermore, specificity and negative predictive values of MRC were found to be higher than 90%, which is particularly important for a screening method.

A similar trial was performed by Hartmann et al. [19]. They included 100 patients with a higher risk profile for colorectal disease and examined them by MRC. Other than in the study by Kuehle et al., all patients underwent bowel cleansing for the MRI examination and optical colonoscopy was performed on the same day. All adenomatous lesions >10mm were correctly identified by MRC and sensitivity for the detection of polyps between 6-9mm amounted to nearly 85%. On a per-patient basis over-all sensitivity was 89% and specificity was 96%.

First clinical results of MRC at 3.0T were presented by Saar et al. [20]. They proved feasibility of MRC at 3.0T in 50 patients and compared MRI results to findings of subsequent colonoscopy. Diagnostic image quality in their trial was achieved in over 90%. Sensitivity and specificity of MRC for the detection of colorectal masses amounted on a patient basis to 92% and 96%, respectively. 10 of 46 polyps were not seen on MRC images, but all missed lesions were smaller than 5mm.

PATIENT ACCEPTANCE

Patient acceptance plays a main role regarding the impact of a diagnostic tool. Bowel cleansing prior to virtual or optical colonoscopy has been considered the most inconvenient part of the examination. New strategies to obviate bowel cleansing for MRC, such as fecal tagging, might significantly increase acceptance levels of virtual colonoscopy [21, 22]. Patient acceptance of a fecal tagging based MRC protocol has been compared to optical colonoscopy (OC) in a large screening cohort [10]. 284 asymptomatic patients over 50 years underwent MRC and OC within 4 weeks. MRC was based on a fecal tagging technique. To that, a solution containing gastrografin, barium and locust bean gum was ingested in portions of 250ml with each main meals starting 2 days prior to the MR examination. Subsequent OC, however, was performed after bowel cleansing. Patients were to evaluate both modalities and different aspects of the examinations. In this trial, no significant difference was noted for the overall-acceptance of MRC and OC. This result may be related to the administration of sedatives and analgesics during OC. Thus, perception of discomfort is reduced and the entire procedure is considered less painful. For MRC, the placement of the rectal tube was rated as the most inconvenient part whereas bowel cleansing was regarded most unpleasant for OC. Beyond the implementation of tagging approaches investigators should be encourage to use small tubes or even flexible catheters, which leads to sufficient bowel distension.

VIRTUAL COLONOSCOPY: MRI OR CT?

Only few trials compared MRC and CT colonoscopy (CTC). Wesseling et al. used a colon phantom with simulated haustreae and polyps between 2 and 8mm in size [23]. The phantom was scanned using a multislice-CT as well a 1.5T and 3.0T MRI. While detection rate of polyps <4mm was significantly higher for CT colonoscopy, there was no relevant difference as for the depiction of larger lesions. In another study 42 patients were examined both by means of MRC and CTC [24]. MRC was found to be even more sensitive for the depiction of colorectal lesions than CT. However, the protocol of the underlying trial was tailored in favor of MRC using a fluid enema. Furthermore, data acquisition was performed only by spiral CT. In terms of diagnostic accuracy, it can be concluded that both CT and MRI provide similar accuracy rates for the visualization of relevant lesions >6mm.

Although CTC provides promising diagnostic outcomes regarding the depiction of colorectal lesions, the future of virtual colonoscopy based on CT as a screening method remains uncertain. The associated ionizing radiation raises the possibility of even a public health concern [25-28]. Lifetime risk estimates for developing a radiation induced malignant cancer in a screening population using CT have been estimated as high as one in fifty patients [28]. Thus, a mayor cause for favouring MR colonography is avoidance of risks associated with ionizing radiation exposure. Even though low-dose protocols for CT colonoscopy have been applied [29, 30], a modality without radiation exposure should be preferred if it provides similar diagnostic accuracy. This issue might not be of lower importance in an older patient population, but should be particularly concerned when young patients with IBD are involved. Besides, there are further arguments in favour of MRC: intravenous MR contrast agents are coupled with a more favorable safety design than CT contrast compounds since they are associated with far fewer anaphylactoid reactions and lack any nephrotoxicity.
SUMMARY

MRC at 1.5T is an established method for the assessment of colorectal disease. Most clinical studies have revealed an excellent diagnostic accuracy of MRC for the detection of clinically relevant adenomatous polyps >5mm. Feasibility of MRC at the higher field strength has been proven and first clinical results indicate an improved sensitivity for the depiction of smaller polyps compared to MRC at 1.5T mainly due to improvements in contrast-enhanced 3D T1w GRE.

REFERENCES