Non-contrast enhanced 3.0 Tesla MRI of the rectum and upper abdomen as a "one-stop-shop" for rectal cancer staging

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Aims and objectives

Colorectal carcinoma (CRC) is one of the leading causes of cancer death worldwide, in which the rectum is involved in about 30% ¹. Approximately 20% of patients with CRC have synchronous liver metastases at diagnosis, which is an important prognostic factor that influences therapeutic decision-making ². Patients with rectal cancer are preferably submitted for a Magnetic Resonance Imaging (MRI) of the rectum for local staging. In the Dutch guidelines there is no consensus however, about the most appropriate imaging method for screening for distant liver metastases and lymph node evaluation ³. For logistic reasons usually a portal phase Computed Tomography (CT) scan of the abdomen is performed ⁴. MRI is becoming more and more available and used in abdominal diagnostics. In addition developments involving Diffusion Weighted Imaging (DWI), could lead to a different strategy in the initial screening for patients with rectal cancer.

Recent literature involving non-contrast enhanced 3-Tesla MRI including DWI of the liver, shows promising results in the detection of liver metastases with a sensitivity of 92% per lesion ⁵ surpassing contrast enhanced CT, which has a sensitivity of 74% that further declines in smaller lesions ⁶. 3T-MRI has a high spatial resolution and detection rate ⁵, but also has excellent ability to grade lesions for its malignant potential, especially in smaller lesions ⁷,⁸. MRI is also presumed a safe method when safety precautions are taken and unlike CT uses no ionizing radiation. A non-contrast enhanced MRI would not only prevent possible adverse effects such as anaphylactic shock and nephrogenic systemic fibrosis, but also could reduce the costs involved in the primary and follow-up screening by eliminating costly contrast agents. Finally combining MRI of the rectum and upper abdomen in a one-stop-shop procedure, instead of a separate CT investigation often performed on another day, would also be more convenient for the patient.

This pilot study assesses the feasibility of a one-stop-shop unenhanced MRI of the rectum combined with the upper abdomen as a screening method for distant liver metastases.

Methods and materials

This prospective study was approved by the Institutional Review Board and patient informed consent was obtained.
Patients

The study was conducted in a large teaching hospital in the Netherlands, a dedicated centre for liver surgery. From August 2013 to January 2014, ten consecutive patients with a high suspicion for rectal cancer after rectoscopy and no contraindications for MRI were included in this pilot study. All requested patients were willing to participate. Four female and six male patients were included (age range 54-84 years, mean 59,1 SD 10.1. Patient characteristics, including rectal cancer stages are outlined in table 1.

Methods

The regular staging protocol for rectal cancer included a 3.0-Tesla MRI of the rectum and portal phase 64-slice CT of the abdomen and thoracic radiograph as screening for distant metastases. This protocol was applied within 7 days after rectoscopy. In this study the rectum MRI was combined with an unenhanced MRI of the upper abdomen, including DWI. A 16 element phased array body surface coil was combined with an 12 element posterior coil. The following sequences of the upper abdomen were performed: Axial T2 single shot TSE (FOV, 40 cm; slice thickness 4 mm, gap 0.4mm; acquisition matrix 400x279; NEX 1; TSE factor 72, TR/TE 909.50/80, SENSE 2.5); axial T2TE (FOV 40cm; slice thickness, 4 mm, gap 0.4mm ; matrix 308x217, NEX 1; TSE factor 103; TR/TE, 1395.51/235, SENSE 2); axial SE epi DWI ( FOV 40 cm; slice thickness 5mm; matrix 132x115; fat saturation, SPAIR; SENSE 2; b-values 0, 150, 400, 800; TR/TE, 2143.80/65.79); axial T1-weighted mDIXON GRE (FOV 40 cm, slice thickness 1.75mm; matrix 252x204; NEX, 1; TR 3.5ms; TE 1.20ms and 2.3ms, Flip-angle 10 degrees, opposed phase and in phase images were reconstructed); coronal T2 TSE (FOV 40cm; slice thickness 4mm; matrix 308x273; NEX 1; TSE factor 90; TR/TE: 1131.34/80, SENSE 2).

Scans were reviewed with a special focus on focal liver lesions. All findings in MRIs and CTs were evaluated separately and combined by two abdominal radiologists with at least 5 years experience in the interpretation of liver diagnostics including DWI. The radiologists were blinded for patients history and identifying information. Liver lesions were scored as benign, undetermined or malignant/metastases. Descriptive analysis were used.

Images for this section:
<table>
<thead>
<tr>
<th>Male: Female</th>
<th>M 6: F 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean 59.5 (SD 10.1), range 54-84</td>
</tr>
<tr>
<td><strong>Stage</strong></td>
<td>2 * stage I</td>
</tr>
<tr>
<td>(7th edition TNM classification)</td>
<td>1* stage IIA</td>
</tr>
<tr>
<td></td>
<td>1* stage IIIA</td>
</tr>
<tr>
<td></td>
<td>5* stage IIIB</td>
</tr>
<tr>
<td></td>
<td>1* stage IVA</td>
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</table>

**Table 1**: Patient characteristics, including rectal cancer stages (7th edition TNM classification).
Results

Pathology after rectal biopsy confirmed rectal adenocarcinoma in all ten investigated patients. Standard screening tests were performed following Dutch guidelines and extra MRI time to scan the upper abdomen was well tolerated by all patients without delay or drop-out. No side-effects occurred and no anesthesia or sedative drugs were used. Fifty-four percent more lesions were depicted on MRI compared to CT (twenty versus thirteen). There was consensus in nine out of thirteen lesions depicted on CT. MRI showed better interobserver agreement, with consensus in nineteen out of twenty lesions. Five out of thirteen lesions were scored as undetermined on CT, of which four could be further characterized as benign with MRI. One patient showed three lesions scored as malignant on both CT and MRI, MRI detected one additional metastasis. Additional lesions in spleen, kidneys and vertebra were better discernible on MRI images, lymph nodes were visualized equally. One patient showed a small hypodens region in the liver in segment 4 abutted to the gallbladder on CT scored as malignant by one radiologist. As no abnormalities on MRI were present, this was presumed to be caused by a perfusion abnormality.

Images for this section:
<table>
<thead>
<tr>
<th>Liver lesions</th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lesions</td>
<td>13 (consensus 11) (10/13 &lt; 1cm)</td>
<td>20 (consensus 19) (17/20 &lt; 1 cm)</td>
</tr>
<tr>
<td>Benign</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Malignant</td>
<td>4 (consensus 3)</td>
<td>4 (consensus 4)</td>
</tr>
<tr>
<td>Undetermined</td>
<td>5 (all &lt; 1 cm)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1 hypodens area</td>
<td>No abnormalities on MRI; perfusion abnormality</td>
</tr>
</tbody>
</table>

**Table 2:** Liver lesions detected by CT and MRI scored as benign, undetermined or malignant.
Fig. 1: CT and DWI image of a liver metastasis in segment 6.
**Fig. 2:** T2 and T1 (mDIXON in-phase and opposed phase) of a liver metastasis in segment 6.
Conclusion

This pilot study involves ten patients with rectal adenocarcinoma who underwent standard screening tests combined with an extra MRI of the upper abdomen.

In this study MRI was more sensitive in detecting liver lesions than CT: 19 lesions were detected on MRI versus 11 on CT. MRI also dominated in characterization of liver lesions, especially small lesions. Multiple small hepatic lesions were too small to characterize in the portal phase CT scan probably due to partial volume artifacts. All these small lesions turned out to be benign hepatic cysts or hemangiomas on MRI. Both liver metastases and lymphnodes were equally visualized on CT and MRI.

Ionizing radiation used in CT scans is still a reason for concern, especially in the younger or pregnant patient. Accumulating radiation applied in multiple follow-up scans in cancer patients should raise the question to whether a more DNA friendly method should be used. Acute tubulus necrosis in the kidney and allergic reactions due to nephrotoxic intravenous contrast agents are possible complications. Gadolinium enhanced MRI lowers the risk of these complications, but does not entirely exclude it. It would be more ideal to perform a test that lacks the use of intravenous contrast agents without compromising sensitivity and specificity. Although probably a non contrast enhanced MRI has a slightly lower sensitivity and specificity than contrast enhanced MRI, we still think that unenhanced imaging using latest technology in 3 T MRI is ready to replace a portal phase enhanced CT scan. The fact that the small liver lesions detected with enhanced CT scan often require an additional imaging technique or biopsy suggest that this technique is less appropriate with a higher risk of allergic and nephrotoxic reactions.

Combining staging of the rectum and upper abdomen with MRI in a one-stop shop way, instead of a separate CT investigation, is more convenient for the patient and takes less time. Since the amount of MRI scanners are increasing, there will be more time for extended scans. Time involved in checking patients ID, indications and possible contraindications routinely performed for CT and MRI and also positioning patients in and outside a scanner will only have to be done once, which saves working time and reduces possible flaws in the screening process.

The extra time involved in the non-enhanced MRI of the upper abdomen is about 20 minutes, which in our clinic is cheaper than an enhanced CT scan. A MRI with Gadolinium remains more expensive than a contrast enhanced CT scan. We believe that an unenhanced 3-Tesla MRI scan including DWI has more value than a portal phase CT
scan and the lesser costs involved further promote this diagnostic approach. More data will be necessary to show significant differences or equal performance.

In conclusion, this prospective pilot study shows a more accurate detection and characterization of liver lesions with unenhanced 3 Tesla MRI compared to portal phase CT. Unenhanced 3 Tesla MRI is likely to be a cost-effective imaging modality in patients who are to be screened for potential liver metastasis, and also lacks the potentially allergic side effects or nephrotoxic complications.

**Personal information**

**References**


