ORIGINAL ARTICLE

MRI of rectal carcinoma: Preoperative staging and planning of sphincter-sparing surgery

Usama Ghieda, Omar Hassanen, Mohamed A. Eltomey *

Radiology & Medical Imaging Department, Faculty of Medicine, Tanta University, Egypt

Received 5 April 2013; accepted 10 November 2013
Available online 5 December 2013

KEYWORDS
Rectal; Carcinoma; MRI; Staging

Abstract  Background: Rectal cancer constitutes about one-third of all gastrointestinal tract tumors. Because of its high recurrence rates reaching 30%, it is vitally important to accurately stage these tumors preoperatively, so that appropriate surgical resection can be undertaken. MRI is used to assist in staging, identifying patients who may benefit from preoperative chemotherapy–radiation therapy, and in surgical planning.

Aim: To determine the accuracy of MRI in the preoperative staging and planning of surgical management of rectal carcinoma.

Subjects and methods: Twenty-five patients (14 males, 11 females) with rectal carcinoma were included in this study. MRI scans were performed prior to surgery in all patients, on a 1.5T scanner, and images were evaluated by three experienced radiologists. Inter-observer agreement between the three radiologists and the correlation between the imaging findings, histopathology and operative findings were evaluated.

Results: MRI findings were correctly predictive of T category in 21 cases (accuracy, 84%). In 19 (86.4%) of the 22 resectable cases, sphincter-sparing surgical approaches were accurately chosen on the basis of MRI findings.

Conclusion: MRI of rectal cancer is accurate for prediction of tumor stage and the feasibility of sphincter-sparing surgery, which are the main factors affecting the outcome of surgery.

1. Introduction

Rectal cancer is one of the most common tumors in industrialized countries affecting about 40 cases in every 100,000 individuals, and one of the most common malignant tumors of the gastrointestinal tract (1). Rectal cancer has a slight male predilection and its prevalence increases steadily after the age of 50 years. Adenocarcinoma accounts for the vast majority (98%) of rectal cancer (2). The prognosis of rectal cancer is closely related to the stage at diagnosis and the choice of...
treatment (3). There is an increasing need for accurate preoperative staging because aggressive multimodality treatment approaches are being employed these days based on individual risk factors (4). Histopathologic tumor involvement of the circumferential resection margin (CRM), which is the peritoneal reflection of the mesorectal fascia has been shown to be an independent predictor of local recurrence and hence influences overall survival after primary resection (5). A distance greater than 1 mm between the tumor and the CRM at histopathologic examination has been shown to correlate with a decrease in local recurrence. Patients with involved or threatened margins, i.e., within 1 mm from the mesorectal fascia, are offered long course chemo-radiation to enable R0, i.e., microscopic tumor free, surgical resection (5) (see Fig. 4).

On the other hand the relationship between tumor and the peritoneal reflection is important in staging, since rectal tumors with invasion through the peritoneal reflection are categorized as stage T4 lesions (6).

MRI is a promising tool for staging rectal cancer preoperatively and can also provide measurements of the distance to the mesorectal fascia, which forms the potential resection margin in total mesorectal excision (7).

2. Subjects & methods

2.1. Patients

Between July 2011 and June 2012, twenty-five consecutive patients with adenocarcinoma of the rectum on the basis of their colonoscopic findings and the pathologic features of the biopsy specimen, were included in this study.

All patients were staged with MRI pre-operatively. After total mesorectal excision, the extent of local tumor staging was histopathologically assessed according to the tumor component of the TNM system (Table 1).

2.2. MRI technique

All the scans were performed on 1.5T MRI unit (Signa Excite, GE medical systems, Milwaukee, USA) with synergy body coil OR 8 channel cardiac coil.

The patients were asked to perform rectal cleansing 2 h before the MRI examination using two laxative rectal suppositories (e.g. Dulcolax bowel cleansing kit).

An initial three-plane localizer view covering the entire pelvis was obtained. Subsequent sequences included sagittal, axial and coronal T2WIs; the sagittal images were used to plan thin slices oblique axial images (the scan plane is angled to be perpendicular to the tumor bulk), and oblique coronal images (scan plane angled parallel to the long axis of the anal canal); TR/TE, 2500–5000/100; Echo train length 6; slice thickness 3 mm; image gap 0; 256 × 256 matrix; FOV 18–24; No. of signal acquired 4; acquisition time 4–6 min.

An additional axial T2 weighted scan through the pelvis, with a larger field of view and slice thickness of 6 mm, was performed up to the iliac crest for identifying lymph node involvement.

2.3. Image analysis

Three experienced radiologists independently reviewed the MR images in a random order and were blinded from each other’s results. MRI allowed visualization and delineation of layers of both the rectal wall and mesorectal fascia of all patients. The tumor had higher signal intensity (SI) than the muscle layer on T2WIs. The depth of cancer invasion on MRI (T stage) was interpreted as follows; T1 if tumor SI was confined to the submucosal layer and had relatively low SI compared with the high SI of surrounding submucosa, T2 if tumor SI extended to the muscle layer leading to irregularity or thickening of the muscle layer but without perirectal tissue invasion (Fig. 1), T3 if tumor SI extended through the muscular layer into the perirectal tissue or angiolymphatic tumor invasion, appearing as irregular thickened strands, was present in the mesorectum (Fig. 2), and T4 if tumor SI extended to visceral peritoneum, adjacent organ, or structure (Table 2).

The distance between the lower margin of rectal cancer mass to the point at which the levator ani muscle is attached to the rectum was measured and reported as a criterion for feasibility of sphincter sparing surgery (Fig. 3).

Observers recorded the number of lymph nodes in the MRI of each patient with the criteria for lymph node metastasis including size, indistinct border, irregular margins or mixed SI.

2.4. Statistical analysis

Agreement on the MRI findings between the three radiologists was analyzed using the kappa statistical method. Comparison between the MRI staging and operative and pathological findings was performed using two-tailed tests. A value of $p < 0.05$ was considered statistically significant. All analyses were performed with SAS software (version 9.1, SAS institute).

<table>
<thead>
<tr>
<th>Tumor stage</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx</td>
<td>Determination of tumor extent is not possible because of incomplete information</td>
</tr>
<tr>
<td>T is</td>
<td>Tumor in situ involves only the mucosa and has not grown beyond the muscularis mucosa (inner muscle layer)</td>
</tr>
<tr>
<td>T1</td>
<td>Tumor grows through the muscularis mucosa and extends into the submucosa</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor grows through the submucosa and extends into the muscularis propria</td>
</tr>
<tr>
<td>T3</td>
<td>Tumor grows through the muscularis propria and into the mesorectum</td>
</tr>
<tr>
<td>T3-A</td>
<td>Tumor extends &lt; 5 mm beyond the muscularis propria</td>
</tr>
<tr>
<td>T3-B</td>
<td>Tumor extends 5–10 mm beyond the muscularis propria</td>
</tr>
<tr>
<td>T3-C</td>
<td>Tumor extends &gt; 10 mm beyond the muscularis propria</td>
</tr>
<tr>
<td>T4</td>
<td>Tumor penetrates the visceral peritoneum</td>
</tr>
<tr>
<td>T4-A</td>
<td>Tumor directly invades or is adherent to other organs or structures</td>
</tr>
</tbody>
</table>

Table 1 Guidelines for the T staging of rectal cancer, adapted from the American joint committee on cancer staging system (8).
3. Results

Our study included 14 males and 11 females with an age range of 35–75 years; mean age of 56 years. The tumor size ranged between 2.5 and 8 cm; with the mean tumor size of 4.9 cm.

Interobserver agreement (k) on the MRI findings between the 3 radiologists ranged between 0.54, least agreement for depicting LN involvement, and 1, total agreement for adjacent organ invasion, with an average 0.8 for all the assessed findings (Table 3).

T category was correctly estimated with MRI for 21 cases, resulting in 84% accuracy. Mismatch between the MRI and histological staging occurred in 4 cases being understaged by MRI as T1–T2 whereas the pathological stage was T3. Three cases showed invasion of the rectal carcinoma into the adjacent organs, all were correctly diagnosed by MRI and confirmed by surgery and pathology, differentiating stage T4 from stage T3 with an accuracy of 100%.

A 2 cm distance or more between the lower margin of the mass and the point where the levator muscle attaches to the rectum was used as a criterion for applying a sphincter sparing surgery technique. In 22 cases that underwent surgical resection this measurement was correctly assessed in 19 cases by MRI with an accuracy of 86.4%.
Considering lymph node metastasis only 6 out of the 12 patients with metastasis and 12 out of the 13 patients without metastasis were correctly identified with an accuracy of 72%.

4. Discussion

The anatomic location, fixation in the pelvic fat, and lack of peristalsis make the rectum an ideal organ for imaging with MRI (9). Although rectal tumors can be diagnosed with digital examination, barium enema, and colonoscopy or sigmoidoscopy, these endoluminal techniques do not provide sufficient information about the extraluminal spread of tumor which is necessary for preoperative planning (10). Rectal MRI has the benefits of multiplanar imaging and excellent contrast between tumor and perirectal fat, which helps in tumor detection and its extent for surgical planning and staging especially for low-lying rectal tumors (11). The mesorectal fascia, which is the border for total mesorectal excision (TME), is clearly seen on MRI (2). MRI is also helpful for differentiating early recurrence from postoperative changes and for the evaluation of perianal fistulas and sinus tracts (12,13).

In other similar series the overall weighted agreement between MRI and histology for T staging has ranged from 66% to 94% (14–16). The main difficulty with MRI has been in the differentiation between T2 and T3 tumors. In our study T category was correctly estimated by MRI for 21 cases and in 4 cases there was a mismatch between the MRI findings and the histological staging.

Presence of perirectal fat invasion was correctly reported on MRI in 17 out of the 21 patients, and its absence was correctly reported in all 4 patients confirmed by surgical and pathological findings, resulting in an 84% accuracy.

MRI contributes to surgical planning by showing the relations among the tumor, the sphincter, and the levator ani muscle. Complete tumor resection and sphincter sparing are important goals of rectal surgery to improve quality of life and have fewer complications than abdominoperineal excision. Thus the length of normal rectum above the levator ani muscle is the key to determine whether sphincter-sparing surgery can be performed. A distal resection margin of the rectal cancer greater than 2 cm is considered optimal for avoiding recurrence (17). Ferri et al. (18) measured the distance of lower edge of the rectal cancer mass to the upper margin of the external sphincter, the point at which the levator ani muscle attaches to the rectum, on coronal and sagittal images to assess the feasibility of sphincter-sparing surgery with adequate tumor margins. In their study sphincter invasion is identified with an accuracy of 87% (18). For the 22 patients with resectable tumors involved in this study; sphincter invasion was accurately assessed by MRI in 19 patients allowing the feasibility of sphincter-sparing surgery and representing 86.4% accuracy. In 3 patients who had low rectal tumors the distance between the lower margin of the tumor and the sphincter was incorrectly underestimated above the correct level on MRI. This was due to an erroneous measurement in the range of 5 mm in two cases by 2 of the readers to one, and in the 3rd case a small mucosal nodule beneath the estimated lower margin of the tumor was detected on surgery.

As in other cancers, detecting lymph node metastasis is the most challenging aspect of MRI diagnosis of rectal cancer. Kim et al. (19) found that the accuracy rates of MRI, CT, and endoluminal sonography for local lymph node metastasis of rectal cancer were 63%, 56.5%, and 63.5%, respectively (19). The accuracy of imaging is low mainly because the diagnosis of metastasis is made only on the basis of the size and shape of lymph nodes, and thus micro-metastasis is missed. Because lymph nodes enlarge in both inflammatory and neoplastic processes, which are difficult to differentiate morphologically, false-positive and false-negative results occur. In numerous studies, lymph nodes larger than 1 cm have been considered metastasis (20); in other studies, cutoffs of 8 mm (21) and 6 mm (22) have been used. With greater than 6 mm as the criterion for the diagnosis of lymph node metastasis around the rectal wall and surrounding fat, the sensitivity, the specificity, and the accuracy were only 57%, 88%, and

<table>
<thead>
<tr>
<th>Findings</th>
<th>MRI findings (n)</th>
<th>True + ve</th>
<th>True − ve</th>
<th>False + ve</th>
<th>False − ve</th>
<th>Accuracy (%)</th>
<th>k</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasion to fat surrounding rectum</td>
<td>17</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>84</td>
<td>0.78</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Invasion to adjacent organs</td>
<td>3</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>1.00</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>L.N. metastasis</td>
<td>6</td>
<td>12</td>
<td>1</td>
<td>6</td>
<td>72</td>
<td>0.54</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Sphincter sparing possible</td>
<td>15</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>86.4</td>
<td>0.89</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>
76%, respectively (21). Brown et al. (22) analyzed 437 lymph nodes and concluded that benign and malignant lymph nodes were similar in size. Those authors believed that accuracy could be increased by evaluating lymph node borders and signal intensity. They proposed that using irregular borders and mixed signal intensity as the criteria for metastatic lymph nodes would improve sensitivity to 85–95% and specificity to 95–97%. In our study, criteria for lymph node metastasis include size greater than 6 mm, irregular border, or mixed signal intensity and the sensitivity, specificity, and accuracy were 50%, 92.3%, and 72%, respectively. Diffusion weighted imaging (DWI), for the detection of perirectal metastatic lymph nodes, is an effective tool (23). A limitation of the study is that DWI was not routinely applied to all patients so data were incomplete for a proper analysis.

Additional limitations to this study were the small number of patients. There was only one patient with a T1 lesion, and a small number of patients for assessment of the utility of MRI in differentiating T1 & T2 lesions. Therefore, T1 & T2 lesions were combined as T1 and T2 for statistical analyses. Also, this study was limited to the pelvis and separate examinations of the abdomen & chest were performed to assess the presence of hepatic and pulmonary metastasis.

5. Conclusion

MRI of rectal cancer is accurate for prediction of tumor stage and the feasibility of sphincter-sparing surgery, which are the main factors affecting the outcome of surgery.

Conflict of interest

We have no conflict of interest to declare.

References