Preoperative Staging of Rectal Cancer Using Magnetic Resonance Imaging With External Phase-Arrayed Coils

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Hypothesis: Rectal cancer can be accurately staged preoperatively by magnetic resonance imaging (MRI) with external phase-arrayed coils.

Design: Comparison of MRIs with pathologic staging.

Setting: University hospital.

Patients: Twenty-eight consecutive patients with biopsy-proven rectal cancer who did not undergo irradiation.

Intervention: Patients underwent imaging using a 1.5-T MRI scanner with external phase-arrayed surface coils. Streaking of the perirectal fat and disruption of the bowel wall margin were interpreted as transmural invasion. Lymph nodes were defined as metastatic when they had a diameter of at least 0.5 cm. Tumors were staged according to the TNM staging system (American Joint Committee on Cancer guidelines) as confined to the bowel wall (T1-T2) and invading through the bowel wall (T3-T4). Patients underwent anterior resection (n = 15), abdominoperineal resection (n = 11), or local excision (n = 2).

Main Outcome Measures: Calculation of sensitivity, specificity, and accuracy for invasion through the bowel wall and lymph node status.

Results: Sensitivity of MRI in detecting invasion through the bowel wall was 89% (16/18), specificity was 80% (8/10), and accuracy was 86% (24/28). Sensitivity for malignant lymphadenopathy was 67% (8/12), specificity was 71% (10/14), and accuracy 69% (18/26).

Conclusion: Although more costly and not as accurate as endoscopic ultrasound, MRI with phase-arrayed coils had excellent sensitivity at detecting transmural penetration of rectal cancer.

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The prognosis and treatment of rectal carcinoma depend on the stage at presentation.1,2 Low-lying lesions confined to the rectal wall may be treated by local excision alone.3-5 Lesions that extend beyond the rectal wall have an increased recurrence rate when the mesorectum is inadequately excised8,7 and are best treated through laparotomy. The use of preoperative irradiation may downstage locally advanced disease8,9 and improve prognosis,10 but to date there are no established criteria to identify the patients who would benefit from this approach. For tumors known to invade adjacent organs, neoadjuvant chemotherapy and radiation therapy have been used to achieve tumor-free margins,11 and in selected cases resection of adjacent pelvic organs, such as the urinary bladder, with the appropriate reconstruction may be required. Accurate preoperative staging is therefore crucial to determine the most appropriate treatment modality.

Computed tomography (CT) and transrectal ultrasound (TRUS) offer a new dimension in the staging of rectal cancer because of their ability to evaluate extension of tumor into the perirectal fat, adjacent organs, and lymph nodes.12,13 In large series, CT was only 33% to 77% accurate for T staging and 22% to 73% for N staging.13 Transrectal ultrasound is better than CT in preoperatively staging rectal cancer, with accuracy between 67% and 93% for T staging and approximately 60% for N staging.11 The limitations of TRUS are operator dependency, the inability to stage upper rectal and obstructing lesions, and the limited depth of penetration. In recent years, magnetic resonance imaging (MRI) with external body coils or endorectal coils has been used in the diagnosis of pelvic pathologic conditions, including rectal cancer.12 Magnetic resonance imaging of-
PATIENTS AND METHODS

The biopsy-proven rectal cancers of 28 consecutive patients were staged with MRI. There were 18 men and 10 women; mean age was 63 years (range, 26-89 years). Patients who received neoadjuvant radiation therapy were excluded.

Fifteen patients underwent anterior resection; 11, abdominopelvic resection; 1, transanal excision, including full-thickness resection of the rectal wall; and 1, transsacral excision. Total mesorectal excision was performed in 13 of 14 anterior resections and 9 of 11 abdominopelvic resections. Vascular ligation was performed just distal to the first branch of the inferior mesenteric artery, other than for the patients undergoing transanal or transsacral excision.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging was performed using a 1.5-T MRI scanner (Signa; GE Medical Systems, Milwaukee, Wis). An external phase-arrayed surface multicoil consisting of 2 anterior and 2 posterior coils was used for all cases. All patients underwent imaging while in the prone position following the placement of a small Foley catheter in the rectum and insufflation of approximately 200 to 300 cm³ of room air. No bowel preparation was used. A sagittal fast-spoiled gradient echo sequence was used to localize the lesion. This was followed by axial, conventional, spin echo T1-weighted images. Respiratory compensation and anterior in-field-of-view, superior, and inferior saturation pulses were used. The anterior saturation pulse was placed at the air-subcutaneous fat interface to reduce motion ghost artifact. Coronal and sagittal fast-T2-weighted images were then obtained. All images were interpreted by the same radiologist (R.S.). Specific comment was made regarding depth of invasion of the rectal wall, adjacent organ involvement, and the presence of lymphadenopathy.

RESULTS

Correlation of T staging was available for all 28 patients; correlation of N staging was available for 26 patients, because no nodes were removed in the 2 patients undergoing local excision.

T STAGING

Ten tumors were staged by pathologic findings as T1-T2; MRI correctly staged 8 of these and 2 were overstaged as T3. Eighteen tumors were staged by pathologic findings as T3-T4; MRI correctly staged 16 and 2 were understaged as T1-T2. Overall sensitivity for invasion through the bowel wall was 89%, specificity was 80%, and accuracy was 86%.

Two tumors were identified by pathologic findings as invading adjacent organs (T4); MRI correctly staged 1 and 1 was understaged as T3. The limited number of patients with T4 tumors precludes statistical analysis of these tumors as a separate group.

N STAGING

Twelve patients were identified by pathologic findings as having malignant lymphadenopathy; MRI correctly staged 8. Overall sensitivity for lymph node involvement was 67%, specificity was 71%, and accuracy was 69%.

COMMENT

Accurate preoperative staging of rectal cancer is often required to construct the most appropriate treatment strategy. Full-thickness transanal excision has been studied extensively during the last decade and may be indicated in selected patients with tumors confined to the submucosa or muscularis propria (T1-T2).13 Distinction between stages

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T1 and T2 may have therapeutic implications, although most studies show that selection for adjuvant treatment or salvage resection can only be made based on the histologic characteristics of the resected specimen. Preoperative identification of malignant lymphadenopathy or invasion through the bowel wall allows patient selection for an abdominal approach and for possible neoadjuvant therapy. Regarding adjacent organ involvement (T4 disease), consideration must be given to the optimal approach whether it be preoperative irradiation to downstage the disease or resection of adjacent organs with possible urologic and flap reconstruction.

Our study was designed to determine the accuracy of MRI in this staging process. We excluded patients who underwent preoperative radiation therapy because this may confound interpretation of the MRI for the purpose of this study. Additionally, we have attempted to resolve a significant criticism of similar studies that correlated preoperative imaging with pathologic node positivity. This relates to the question of whether the lymph node identified as being positive by the preoperative study is in fact the involved node. Initially, we attempted to identify in the operating room or immediately thereafter the specific lymph node or nodes thought to be positive by the radiologist. Subsequently, we found that sectioning the specimen according to the axial images of the MRI allowed more specific correlation between MRI images and pathologic results (Figure).

Magnetic resonance imaging is a technique in continuous evolution. The use of external phase-arrayed coils has increased tissue discrimination and resolution and in our hands had an 89% sensitivity and an 80% specificity in detecting invasion through the bowel wall. The Table outlines the results of the studies evaluating different MRI techniques in preoperative staging of rectal cancer. The difference in the methods used makes comparison difficult. The only study using a 4-element surface coil is by Brown et al, who used a combination of dedicated surface coils, thin slices, and optimal patient orientation with a small field of view, which is comparable to our technique of 4 phase-arrayed coils. By this technique, Brown and colleagues were able to accurately quantify the extent of extramural invasion, which correlates directly with tumor recurrence. Combination of phase-arrayed coils with endorectal coils offers no advantage.

Numerous methods have been used in preoperative evaluation of rectal cancer and have been compared with MRI. The value of clinical examination should not be underestimated, because with experienced examiners the accuracy is 72%. Although CT is unable to depict the various layers of the bowel wall, it can detect invasion into adjacent organs. Accuracy for nodes is poor and sensitivity is better in advanced stages (17% for T1-T3 and 81% for T4). Most studies comparing CT with MRI have ob-
served greater accuracy with MRI. Endorectal ultrasound seems to be the current imaging modality of choice because it is sufficiently accurate, well tolerated, and inexpensive. The ultrasound technique we have adopted in our institution uses a combination of B-mode and color Doppler; accuracy rates in our hands are 86% for T stage and 80% for N stage. Advantages of MRI over TRUS include less interobserver variation and ability to stage bulky tumors and tumors high in the rectum. Transrectal ultrasound has 84% accuracy in distinguishing between T1 and T2 tumors, whereas MRI with external coils lacks this distinction. In addition, MRI may be more accurate than TRUS in assessing invasion of adjacent organs. This is possible with TRUS only at the expense of lower definition. MRI may be better then TRUS in distinguishing between tumor tissue and reactive fibrosis. Neither MRI nor TRUS can distinguish between tumor tissue and inflammatory infiltrate, which occurs in 25% of rectal cancers and extends for only a few millimeters outside the bowel wall, thereby minimally affecting overstaging. Among the 4 studies that compared MRI with TRUS, 2 use endorectal coils and show comparable results. One study comparing external body coil MRI with TRUS finds TRUS equivalent in T staging and better in N staging. A similar study reports better T staging with MRI because of a clearer discrimination between T1 and T2 tumors, whereas results for N staging are similar. To date, no imaging modality has been demonstrated to be consistently accurate in determining lymph node involvement. Combination of different imaging modalities, such as CT or MRI and positron emission tomography, may be the next step together with the development of lymph node–specific contrast media.

From our results, MRI with phase-arrayed multicoils identified 89% of tumors that invaded through the bowel wall with 86% accuracy. Sensitivity for lymph node involvement was 67% with 69% accuracy. These data and our review of the literature suggest that MRI with external phase-arrayed multicoils provides optimal assessment of tumor invasion through the bowel wall and invasion of adjacent organs. However, this particular MRI evaluation is a costly investigation, and because it does not yield higher accuracy rates than TRUS, it is unlikely to become a routine preoperative evaluation. In addition, MRI with external phase-arrayed multicoils has the advantage of low interobserver variation and may be of value in situations where the results of TRUS are not definitive and preoperative staging is critical.

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REFERENCES

Peter Cataldo, MD, South Burlington, Vt: I would like to congratulate the authors on some beautiful images of MRIs of rectal cancer and for emphasizing the importance of preoperative staging in the treatment of rectal cancer. As we know, preoperative selection is the key to appropriate therapy deciding between local excision, radical excision, and preoperative chemoradiation.

I have several questions for the authors today, but the main questions surround the utility of MRI vs endoanal ultrasound in the staging of rectal cancer. Several things are important here. Number one, in some individuals an MRI a full bowel preparation is necessary, whereas for ultrasound we generally require only a Fleet's enema. For an MRI, most studies require 60 minutes to do the procedure with additional time for interpretation. Endoanal ultrasound generally requires only 10 to 15 minutes. In terms of logistics, we generally perform the endoanal ultrasound at the time of colonoscopic diagnosis of rectal cancer. The cost is the biggie there. At the University of Vermont, it costs $1495 to get an MRI, whereas the poor colorectal surgeons only charge $338 for an ultrasound. Our accuracies are relatively similar. Access may be greater to the MRI than to the ultrasound unit. We only have 1 endoanal ultrasound unit in the entire state of Vermont, and we have at least 2 or 3 MRIs.

In summary, I would like to ask the authors to again tell me the role of MRI vs endoanal ultrasound in the staging of rectal cancer. Several things are important here. Number one, in some individuals an MRI a full bowel preparation is necessary, whereas for ultrasound we generally require only a Fleet's enema. For an MRI, most studies require 60 minutes to do the procedure with additional time for interpretation. Endoanal ultrasound generally requires only 10 to 15 minutes. In terms of logistics, we generally perform the endoanal ultrasound at the time of colonoscopic diagnosis of rectal cancer. The cost is the biggie there. At the University of Vermont, it costs $1495 to get an MRI, whereas the poor colorectal surgeons only charge $338 for an ultrasound. Our accuracies are relatively similar. Access may be greater to the MRI than to the ultrasound unit. We only have 1 endoanal ultrasound unit in the entire state of Vermont, and we have at least 2 or 3 MRIs.

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