Original Article

Role of endorectal coil magnetic resonance imaging in local staging of rectal cancer: Experience from a single center

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ABSTRACT

Purpose: In order to obtain an improvement in preoperative staging accuracy for rectal cancer, new imaging modalities are now under investigation. The purpose of our study was to evaluate the accuracy of endorectal coil magnetic resonance imaging (ECMRI) in the preoperative local staging of rectal cancer and correlation with intraoperative and histopathologic staging of retrieved specimen with respect to depth of tumor invasion and lymph node metastasis. **Materials and Methods:** The study was a prospective one and included 38 patients with biopsy proved rectal cancer. ECMRI studies were performed on a 1.5 Tesla MR unit using a standard endorectal coil. All patients underwent surgery and a comparative evaluation of ECMRI and surgical and pathological staging was done. Accuracy, sensitivity, specificity, and positive and negative predictive value (PPV and NPV) were assessed. **Results:** The diagnostic accuracy of ECMRI for T1/T2 tumors was 90%; for T3 and T4 tumors accuracy was 100% each. For perirectal lymph node metastasis, the diagnostic accuracy of ECMRI was 83.3%. **Conclusion:** ECMRI is a reliable radiologic tool for local (T) staging of rectal cancer and has excellent diagnostic accuracy, sensitivity, and specificity. ECMRI is also useful in detecting perirectal lymph node metastasis, but accuracy is not as good as that for T staging.

Key words: Endorectal coil, magnetic resonance imaging, rectal cancer, staging

INTRODUCTION

Rectal cancer is one of the most common tumors in industrialized countries and one of the most common malignant tumors of the gastrointestinal tract.[1] Globally, colorectal cancer is the third most common cancer in men.[2,3] It is the second most common tumor after lung cancer in the developed countries. Over the last few decades, many improvements have been made in the surgical, radiologic, and oncologic treatment of rectal cancer. However, this neoplasm continues to have a highly variable outcome and is associated with a poor prognosis owing to the high risk of metastasis and local recurrence. After surgical treatment, local recurrence rates for rectal cancer varied from 3 to 32%.[4-8] The success of tumor excision depends largely upon accurate tumor staging and appropriate surgical technique. Tumor staging is crucial for the prognosis and planning of therapy in the individual patient and aims at precisely determining the extent of tumor as a basis for deciding whether surgery alone or surgery in combination with neoadjuvant therapy is the most suitable strategy. Of course, it is of great importance to avoid over treatment or under treatment of the patient. Preoperative staging techniques for rectal cancer should allow identification of patients with extrarectal spread, who might benefit from preoperative chemoradiation therapy; and patients with minimal or no sphincteral involvement, who might be suitable for sphincter-sparing surgery.

Several modalities exist for the preoperative staging of rectal cancer including; endorectal ultrasonography (EUS), computed tomography (CT), body coil or endorectal coil MRI, and positron emission tomography (PET).

EUS is mostly accurate both in the evaluation of early stages (T1 and T2) and in demonstrating the perirectal

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spread of tumor (T3 tumors), however, it has several limitations: Operator dependency, limitation to tumors located in the upper rectum when a rigid probe is used; no assessment of stenotic tumors, and inability to visualize the mesorectal fascia.[9,10] EUS also shows low sensitivity in detecting perirectal lymph node metastasis and low accuracy in evaluating the patients who had previously received neoadjuvant chemo/radiotherapy.

Although CT was the first technique introduced, it has limitations in differentiating and distinguishing different layers of rectal wall, and has overall lower accuracy than EUS and MRI. The accuracy has since been improved by the advent of the multidetector row CT (MDCT), with reconstructions in multiplanar reformations (MPR's). Despite major progress of image quality with the multidetector row technique, its poor soft tissue contrast resolution compared to MRI remains.[11]

With the advent of powerful gradient coil systems and high resolution surface coils, magnetic resonance imaging (MRI) has recently extended its role in the staging of rectal cancer. MRI is currently the only imaging modality that is highly accurate in predicting whether or not a tumor free margin can be achieved, and thus provides important information for planning of an effective therapeutic strategy especially in patients with advanced rectal cancer. MRI of the rectum may be performed with either an endorectal coil or a phased-array body coil. MR imaging with a body coil has been used to stage rectal cancer and has demonstrated little advantage over CT. Endorectal coils are designed to maximize signal return from the small area being imaged. These comprise a loop coil mounted on the inner surface of an inflatable balloon and have an advantage of placement against the surface of the tissue being imaged such as rectal wall. These coils can produce images of very high signal with little unwanted signal from tissues around. Use of an endorectal coil yields high resolution images that fully depict the wall layers of the bowel. Endorectal coil MRI (ECMRI) has a good diagnostic accuracy in local staging of rectal cancer; in particular the degree of rectal wall infiltration is well demonstrated.

Rectal cancer is common in our valley and our institute, being a tertiary care center, is a high volume center for these cancers. So we thought it worthwhile to study the role of the latest radiological technique, that is, ECMRI in preoperative evaluation of rectal cancer.

The aim of our study was to assess the accuracy of ECMRI in preoperative staging of rectal cancers and correlation with intraoperative and histopathologic staging of retrieved specimen with respect to depth of tumor invasion (T staging) and perirectal lymph node metastasis (N staging).

MATERIALS AND METHODS

The study was a prospective one and was conducted from May 2008 to March 2011. Institutional approval was obtained for this study. The study population consisted of 38 patients (24 men and 14 women) with histopathologically proved rectal cancer by means of endoluminal biopsy. The initial diagnosis was made at digital rectal examination/proctoscopy/sigmoidoscopy and all patients were subjected to colonoscopy to detect synchronous lesions. Written informed consent was obtained from all patients for the procedure. Patients with following conditions were not included in the study: Acute painful perianal conditions like fissure, perianal abscess, rectal stenosis, postsurgical procedures, coagulopathy, patients having any contraindication to MRI like pacemakers, cochlear implants, joint prosthesis, and patients with claustrophobia.

The mean age of the patients was 53 years (range: 22-84 years). MRI was performed with a 1.5 Tesla MR unit (Siemens Avanto, Erlangen, Germany). All patients were imaged using a standard endorectal coil (Medrad, Pittsburgh).[12] Patients were fully informed about the length of time required for scanning and were positioned comfortably in the supine position on an MR table with feet entering MR gantry. No bowel preparation or enema was given prior to procedure. Before placement of an endorectal coil, a digital examination was performed to ensure that the lumen was large enough to pass the coil. The center of coil was positioned over the center of lesion. The balloon coil was inflated with 30–50 ml of air to maintain position. On table, patients received 10 ml of intravenous contrast agent gadodiamide. A sagittal localizing image was obtained to selected axial locations. Axial images were obtained with a T_1-weighted spin-echo sequence and a T_2-weighted fast spin echo (FSE) sequence. Axial images were acquired through the entire tumor. Additional T_2-weighted FSE images were obtained in a longitudinal plane perpendicular to a tangent drawn at the center of the lesion. Images were acquired in the axial, coronal, and sagittal planes to better depict the length of tumor and all three of its spatial dimensions. All images were read prospectively by an experienced radiologist who was not blinded to clinical information available at the time, but read images without knowledge of the results of any other staging examination that may had been performed (CT or USG). Lesions were staged according to the TNM staging system.[13] T1 was defined as tumor invading submucosa: Low signal in submucosal layer, replacement of submucosal layer by abnormal signal not extending into circular muscle layer. T2 was defined as tumor invading but does not penetrate muscularis propria: Intermediate signal intensity (higher signal than muscle, lower signal than submucosa) in muscularis propria; outer muscle coat replaced by tumor of

intermediate signal intensity that does not extend beyond outer rectal muscle into rectal fat [Figures 1a and b]. T3 was defined as tumor invading subserosa through muscularis propria: Broad-based bulge or nodular projection of intermediate signal intensity projecting beyond outer muscle coat [Figures 2a and b]. Tumor invading other organs: Extension of abnormal signal into adjacent organ, extension of tumor signal through peritoneal reflection was defined as T4. The next step was to look in more detail at the mesorectal lymph nodes. Lymph nodes were studied using high resolution images. Uniform nodes having homogenous signal intensity were not considered to be suspicious. The nodes were judged suspicious of malignancy (N+) if they had irregular borders, mixed signal intensity, or both.[14,15]

ECMRI findings were then correlated with surgical and histopathological findings. Intraoperative staging was carried out using frozen section biopsy. It is important to mention here that all patients with T4 lesions on ECMRI and in whom surgical procedure was carried out received adjuvant chemoradiotherapy to prevent recurrence. Specimen sent for histopathological examination (HPE) was opened along the opposite side of the tumor proximal to the segment containing the tumor. Before the specimens were fixed in formalin, a pathologist harvested the lymph nodes in the mesorectum. All specimens were fixed by total immersion in buffered formalin for 48 h and were sliced transversely at 3-mm intervals. The slices were embedded in paraffin, sectioned, and examined histologically after hematoxylin and eosin staining [Figures 1c and 2c]. The extent of local tumor staging in each slice was assessed according to the tumor component of the TNM system.

The accuracy, sensitivity, specificity, and positive and negative predictive value (PPV and NPV) of ECMRI were calculated.

RESULTS

The study population consisted of 38 patients (24 men and 14 women). The mean age of the patients was 53 years (range: 22-84 years). Table 1 shows the radiological findings of patients. T1 and T2 rectal cancers were grouped together in our study. This is because the radiological modality is relatively new in our country and less expertise of our radiologists to differentiate between these two early lesions. However, there was no difficulty to differentiate T2 from T3 or T3 from T4 lesions. T3 was the most common tumor found as is evident from Table 1. All patients underwent surgical intervention. Lower anterior resection with total mesorectal excision (TME) was the most common surgical procedure performed (58%). Open and close laparotomy for unresectable growth was done in two patients. Thirty-six resected specimens were sent for HPE. Patients with T4 lesions on ECMRI and in whom surgery was performed received adjuvant chemoradiotherapy to decrease chances of recurrence. Table 2 shows the histopathological findings. T3 was the most common (50%) tumor detected on HPE.

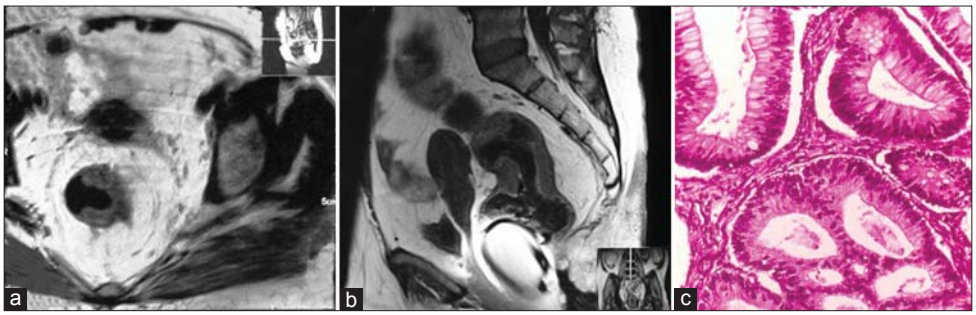

Figure 1: Endorectal coil magnetic resonance imaging (ECMRI); (a) axial view and (b) sagittal view of a 55-year-old patient showing circumferential rectal growth with no perirectal fat stranding (T2) and no perirectal lymphadenopathy (N0). (c) Histopathology of specimen showing well-differentiated adenocarcinoma which was not breaching serosa (T2) and no nodal metastasis (N0)

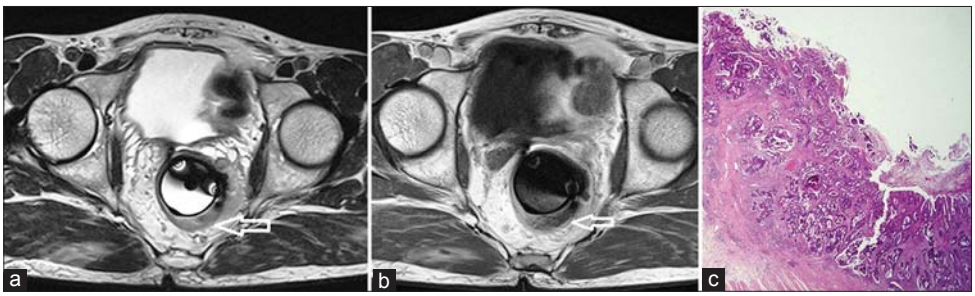

Figure 2: (a and b) Axial views of ECMRI of a 75-year-old patient. There is a lesion along posterior wall of rectum with infiltration of mesorectal fat posteriorly (T3) (arrow) with no evidence of perirectal node enlargement (N0). (c) Histopathology of specimen revealed well-differentiated adenocarcinoma which was infiltrating perirectal fat (T3) with no nodal metastasis (N0)

T4 was identified after taking biopsy from adjacent viscera. Nodal metastasis was found in 13 (36%) patients.

Table 3 shows the comparison of endorectal MRI T staging with intraoperative and histopathological T staging. 84.6% patients with T1/T2 lesion on ECMRI were identified correctly as having T1/T2 lesion both intraoperatively as well as on histopathology. There was understaging for T3 lesion in two patients on ECMRI. Intraoperatively as well as on HPE, 94% patients with T3 lesion on ECMRI were identified correctly as having T3 lesion. There was overstaging for T1/T2 lesion in one patient. All the eight patients with T4 lesion on ECMRI were found to have T4 lesion intraoperatively using frozen section biopsy. Out of these, open and close laparotomy was performed in two patients due to unresectable nature of the tumor. In remaining six patients with T4 lesion and operated, specimen were sent for HPE which confirmed the T4 stage. Accuracy of ECMRI in differentiating T1/T2 lesion from T3 lesion at surgery and HPE was 90% with a sensitivity of 84.6% and specificity of 94%. PPV and NPV were 91.6 and 88.9%, respectively. Similarly, accuracy of ECMRI in differentiating T3 from T4 lesion at surgery and HPE was 100% with a sensitivity and specificity of 94 and 100%, respectively.

Table 4 shows comparison of ECMRI N Staging with histopathological N staging. On ECMRI, 13 (34.2%) patients had nodal metastasis (N+), whereas 25 (65.8%) patients had no nodal metastasis (N--). Out of 13 patients, ten (77%) were identified correctly as having nodal metastasis on histopathology. Among patients with N-disease, two patients had unresectable growth and only 23 specimens were sent for histopathology; and 20/23 (87%) patients were identified correctly as having N-disease on histopathology.

Overall results of ECMRI in staging of carcinoma rectum are shown in Table 5.

DISCUSSION

Colorectal cancer is the second most common form of cancer in developed countries and is responsible for significant morbidity and mortality rates. Prognosis of cancer is directly related to depth of tumor invasion beyond the bowel wall, lymph node metastasis, and the tumor involvement of circumferential resection margin. The accurate preoperative locoregional staging of rectal cancer is important in choosing and planning therapy and to decrease local recurrence by selecting appropriate patients for preoperative neoadjuvant chemoradiotherapy.

Conventional CT is not able to differentiate and distinguish different layers of rectal wall, and has lower overall accuracy than EUS and MRI. The recent technical developments, however, have revolutionized the capability of CT and as a result its clinical applications. The introduction of

Table 1: Distribution of 38 patients with respect to findings on endorectal coil magnetic resonance imaging

ECMRI staging	*N* (%)
T stage	
T1/T2	13 (34.2)
T3	17 (44.7)
T4	08 (21.1)
N stage	
N−	25 (65.8)
N+	13 (34.2)

N+: Nodal metastasis present, N−: Nodal metastasis absent, ECMRI: Endorectal coil magnetic resonance imaging

Table 2: Distribution of patients with respect to the histopathological staging of tumor

Histopathological stage	*n* (%)
T	
T1/T2	12 (33.3)
T3	18 (50)
T4	06 (16.7)
N	
N-	23 (64)
N+	13 (36)

N+: Nodal metastasis present, N−: Nodal metastasis absent

Table 3: Comparison of endorectal coil magnetic resonance imaging T staging with intraoperative and histopathological T staging

	ECMRI T stage *n* (%)			
	T1/T2	T3	T4	Total
Intraoperative T stage (*n*=38)				
T1/T2	11 (84.6)	01 (06)	0 (0.0)	12 (31.6)
T3	2 (15.4)	16 (94)	0 (0.0)	18 (47.4)
T4	0 (0.0)	0 (0.0)	08 (100.0)	08 (21)
Histopathological T stage (*n*=36)				
T1/T2	11 (84.6)	1 (06)	0 (0.0)	12 (33.3)
T3	2 (15.4)	16 (94)	0 (0.0)	18 (50)
T4	0 (0.0)	0 (0.0)	06 (100.0)	06 (16.7)
Total	13 (34.2)	17 (44.7)	08 (21.1)	38 (100)

ECMRI: Endorectal coil magnetic resonance imaging

Table 4: Comparison of N staging on endorectal coil magnetic resonance imaging with histopathological N staging

	ECMRI N staging	
	N+, *n* (%)	N−, *n* (%)
Histopathological N stage (*n*=36)		
N+	10 (77)	3 (13)
N−	3 (23)	20 (87)

ECMRI: Endorectal coil magnetic resonance imaging

MDCT allowed faster scanning, thinner slice, increased spatial resolution, and better image quality of both axial and multiplanar reconstruction (MPR) images. Despite major progress of image quality with the multidetector row technique, its poor soft tissue contrast resolution compared to MRI remains and individual wall layers of rectum cannot be

Table 5: Overall results of ECMRI in T and N staging of rectal cancer

Staging	Accuracy (%)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
T1/T2	90	84.6	94	91.6	88.9
T3	100	94	100	100	100
T4	100	100	100	100	100
N+	83.3	77	87	77	87

ECMRI: Endorectal coil magnetic resonance imaging

demonstrated; making it impossible to differentiate T1 from T2 tumors on MDCT. The data suggests that MDCT had no difficulty in the detection of lymph nodes but had difficulty in discrimination of benign from malignant lymph nodes.

MRI is presently the only imaging modality that is highly accurate in predicting whether or not a tumor-free margin can be achieved, and thus provides information for planning of an effective therapeutic strategy especially in patients with advanced rectal cancer. MRI with a body coil has been used to stage rectal cancer and has demonstrated little advantage over CT. The depth of bowel wall invasion cannot be determined, and the accuracy of staging with MR imaging has been reported to be 60%. This low accuracy is primarily due to the low resolution of conventional MR techniques. Improvement of MRI sequences and availability of endorectal coils allowed visualizing the single layers of rectal wall, making it a reliable imaging technique to stage rectal cancer. In one study,[16] ECMRI was found to have an accuracy of 92% in T1-T2 stage and 94% in T3. In evaluating perirectal lymph node metastasis, ECMRI showed 69% accuracy, 82% sensitivity, and 55% specificity. In our study, accuracy of ECMRI for T staging matched well with those of above study. The results of our work demonstrate a good diagnostic accuracy of ECMRI in local staging of rectal cancer, in particular, the degree of rectal wall infiltration was well demonstrated and single layers of rectal wall were well visualized. On ECMRI, we correctly staged 84.6% patients with T1/T2 lesion, whereas two patients were under staged; 94% patients with T3 lesion were correctly staged, whereas one patient was over staged. We correctly staged eight patients with T4 disease with no false positive or false negative results. In our study, the accuracy, sensitivity, specificity, PPV, and NPV of ECMRI differentiating N+ from N- disease was 83.3, 77, 87, 77, and 87%, respectively. Our results matched to some extent with those of Tatli *et al*.,[17] where sensitivity of ECMRI for T3 tumors was 93% and that for nodal metastasis was 85%. Our results also matched to some extent with those of Donmez *et al*.,[18] with regards to T staging, but as far as N staging is concerned, the results of our study were better. The major limitation of ECMRI is difficulty in evaluating stenosing and high rectal carcinomas, complete assessment of perirectal structures, inability to detect distant metastasis, lengthy procedure, movement related artifacts, and high cost of endorectal coils. Moreover, in patients with advanced tumors, insertion of the coil system may be impossible or is very painful. Another limitation in our study was relatively small patient size. Further studies based upon larger patient series are probably needed to draw a definitive conclusion.

CONCLUSION

From the above study, evaluating role of ECMRI in preoperative staging of rectal cancer, we conclude that ECMRI is a reliable radiologic tool for local (T) staging of rectal cancer and has excellent diagnostic accuracy, sensitivity, and specificity. It is unusual for ECMRI to understage the disease which is important because it could prevent patients with highly invasive disease from being undertreated. ECMRI is also useful in detecting perirectal lymph node metastasis, but accuracy and sensitivity is not as good as that for T staging.

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