Endorectal Ultrasound in the Preoperative Staging of Rectal Tumors

A Learning Experience

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The preoperative staging of rectal cancer has important implications for treatment as local therapies become increasingly utilized. Seventy-seven patients underwent preoperative staging using endorectal ultrasonography. All patients had complete pathologic staging and none had preoperative radiotherapy. Depth of invasion of the tumor was accurately predicted in 75 percent of cases in the entire group, with 22 percent overstaged and 3 percent understaged. Accuracy improved greatly over the study period, and in the past six months, 95 percent have been accurately staged for depth of invasion with 5 percent overstaged. Lymph nodes have been properly classified into positive and negative groups in 88 percent of cases in the past year, with a specificity of 90 percent and a sensitivity of 88 percent. Endorectal ultrasound is an accurate preoperative staging modality. Accuracy is improved greatly with increased experience and it has been found that the 5-layer anatomical model facilitates accurate staging. Introduction of the ultrasound probe through a previously placed proctoscope ensures complete scanning of the entire lesion and should be used for the majority of examinations.

[Key words: Endorectal ultrasound; Preoperative staging; Rectal cancer]

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LOCAL METHODS ARE being applied increasingly in the treatment of rectal cancer. The success of local therapy is predicated upon the selection of tumors amenable to such therapy. Generally these are small, mobile, nonulcerated cancers without lymph node involvement.[1-4] More accurate staging methods are mandatory to select appropriate treatment for the patient and to properly compare groups of patients treated with different modalities.

Endorectal ultrasound is proving to be a very accurate method for preoperative staging of rectal tumors. It is relatively easy to perform and inexpensive compared with other imaging techniques. This study is a report of patients who have undergone preoperative endorectal ultrasound in the staging of neoplastic tumors of the rectum with attention to factors that have affected the accuracy of the examination.

Patients and Methods

Patients were selected from those referred for endorectal ultrasound in the investigation of various benign and malignant lesions of the rectum from October 1986 to March 1989. Only patients with an adenocarcinoma or with a villous adenoma of the rectum, in whom complete pathologic assessment of the primary lesion was available, were studied. Patients who underwent preoperative radiotherapy were excluded.

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Seventy-seven patients fulfilled the study criteria. There were 45 men and 32 women. The mean age was 66 years (range, 32 to 88 years). Fifty-nine patients had a radical resection (40 low anterior resection and 19 abdominoperineal resection), one patient had laparotomy only, two patients had proximal diverting colostomies, and 15 patients had a wide local excision. In those undergoing palliative procedures, complete pathologic staging was obtained at the time of laparotomy.

Depth of tumor invasion was assessed in a manner similar to the TNM classification proposed by Hildebrandt *et al.*[5-7] In this system, a uT1 lesion is an invasive malignancy confined to the mucosa and submucosa, a uT2 lesion penetrates the muscularis propria but is confined to the rectal wall, a uT3 lesion invades perirectal tissues, and a uT4 tumor penetrates into surrounding organs. All identified lymph nodes were classified as positive if echo poor (hypoechoic) ultrasonically, as suggested by Tio and Tygat[8] in upper gastrointestinal studies and subsequently by Hildebrandt[9] and Beynon *et al.*[10] in rectal malignancies.

Ultrasound assessment was compared with permanent histologic slides and the accuracy of the examination was determined. Accuracy was assessed for the entire study period and, to determine if any improvement in accuracy occurred with increased experience with the technique, three time periods were assessed: October 1986 to December 1987, January 1988 to October 1988, and October 1988 to March 1989. In the first time period, examinations were performed by several clinicians including nonsurgical staff. A proctoscope was not used to introduce the ultrasound probe and a model was used that recognizes three anatomical layers to interpret scans, as described by Hildebrandt and Feifel.[5] In the second and third time periods, all of the examinations were performed or supervised exclusively by one of the authors (W.D.W.) and introduction of the ultrasound probe through a proctoscope became a routine part of the procedure. In the third time period, all scans were interpreted according to a model that recognizes five anatomic layers on the ultrasound image, in the manner of Beynon *et al.* (Fig. 1).[11-14] Statistical analysis was performed using the chi-square test with Yates' correction.

Current Technique: Endorectal ultrasound is now performed as follows. After a cleansing enema, sigmoidoscopic examination of the lesion is performed. Endorectal ultrasound is then performed with an 1846 Brüel and Kjaer (Naerum, Denmark) scanner with an 1860 rotating endosonic probe. A 7.0 MHz type 8539 transducer with a 90° scanning plane and a focal length of 2 to 5 cm is used for all examinations. The transducer is rotated at a rate of 4 to 6 cycles per second. A thin rubber sheath is placed over the transducer and the probe is inserted into the rectum, most often through a proctoscope to expedite advancement of the probe through the entire extent of the tumor. The rubber sheath is then filled with approximately 50 to 60 ml of water to provide the necessary acoustic pathway for the ultrasound waves.

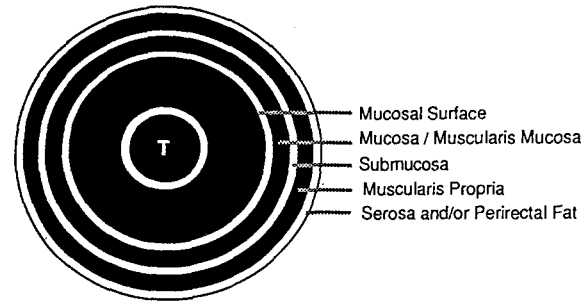

FIG. 1. The five-layer model for the interpretation of endorectal ultrasound scans (T = transducer). Three echogenic (white lines) and two echo-poor (dark lines) are recognized. At times, the outer dark layer (muscularis propria) is split into 2 layers by another white line. This is believed to represent the inner longitudinal muscle and outer circular muscle of the rectum. Seven layers are seen in this situation.

Results

Depth of Invasion: Benign or *in situ* lesions were identified by expansion of the second layer (hypoechoic), which corresponds to the mucosa, with an intact, undistorted third layer (second echogenic layer) corresponding to the submucosa. Malignant lesions confined to the mucosa and submucosa (uT1) again show expansion of the mucosa with some degree of irregularity to the submucosal hyperechoic line (Fig. 2). With interruption of the second hyperechoic layer and expansion of the hypoechoic fourth layer, which corresponds to the muscularis propria, invasion of the muscle is indicated and a uT2 lesion is present (Fig. 3). Disruption of the outer hyperechoic layer is diagnostic of complete penetration of the rectal wall with extension to the perirectal tissues and is staged as a uT3 lesion (Fig. 4). If there is loss of the normal tissue planes separating the rectum from adjacent structures, such as the vagina, a uT4 lesion is present (Fig. 5).

Overall staging accuracy for the entire group of patients was 75 percent (Table 1). Twenty-seven patients were studied in the first time period with an accuracy of only 58 percent, with 37 percent overstaged (ultrasound stage higher stage than pathologic stage) and 4 percent understaged (ultrasound stage lower than pathologic stage). In the second time period, with 30 patients, accuracy increased to 77 percent with 20 percent overstaged and 3 percent understaged. In the final time

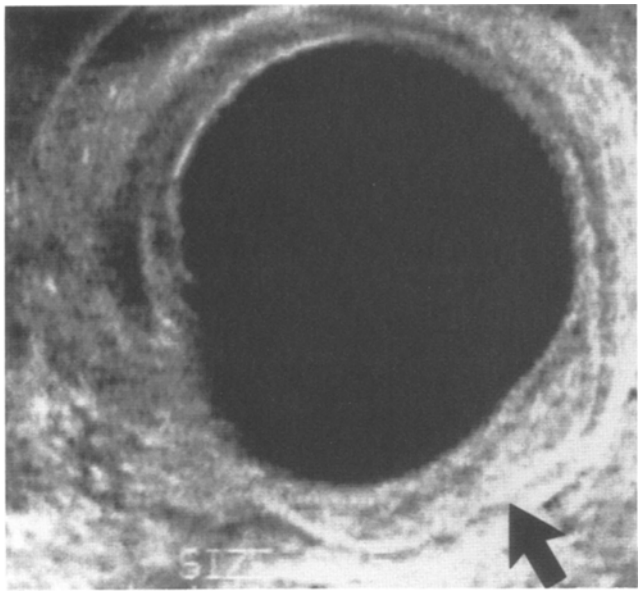

FIG. 2. A uT1 adenocarcinoma of the rectum. The submucosal white line can be identified around the circumference of the tumor, but it becomes irregular (arrow) in one area, indicative of an invasive lesion rather than a benign or *in situ* carcinoma.

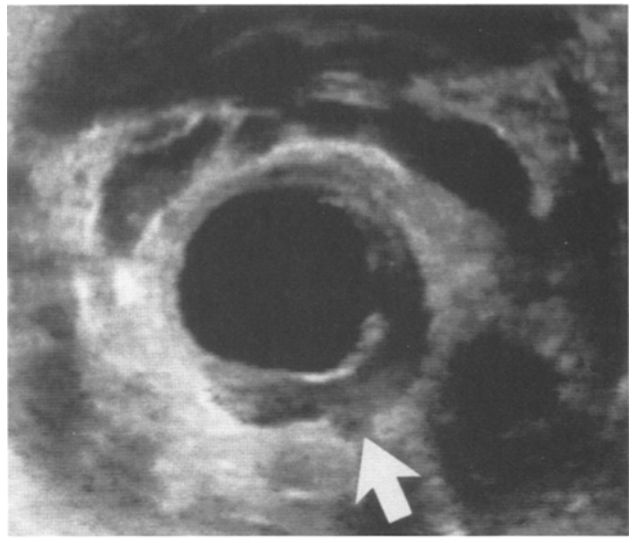

FIG. 4. A uT3 lesion. The submucosal white line is destroyed with expansion of the outer dark line (muscularis propria). In one area (arrow), the outer white line of perirectal tissue is interrupted, indicating perirectal invasion.

period, 20 patients were studied with an accuracy of 95 percent ($P < 0.05$ compared with the first time period) and 5 percent were overstaged ($P < 0.05$ *vs.* the first time period). No tumor was understaged. The only inaccuracy in this latter period was seen in the uT2 group, where 1 patient was overstaged (Fig. 6). Combining the last two time periods with a total of 50 patients, accuracy was 84 percent ($P < 0.05$ *vs.* the first time period) with 14 percent overstaged and 2 percent understaged.

Nodal Disease: Lymph nodes with metastatic disease were identified in the perirectal tissues and/or the mesorectum as hypoechogenic structures (Fig. 7). Using this criteria, 82 percent of cases were accurately staged with regard to nodal disease. The sensitivity was 62

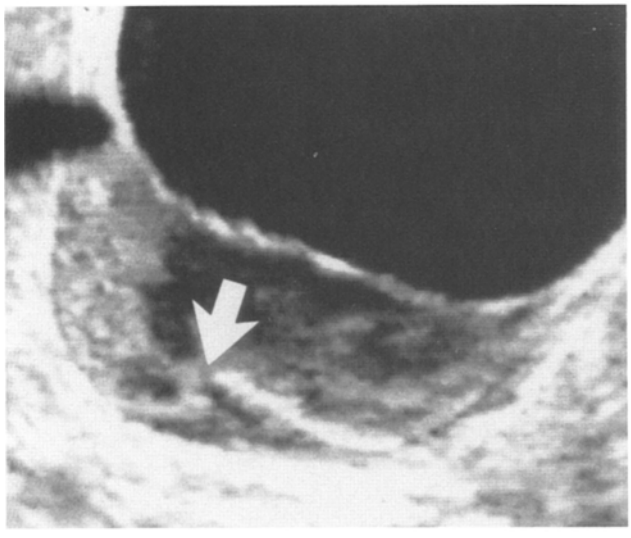

FIG. 3. A uT2 lesion. The submucosal white line is interrupted (arrow) with expansion of the outer echo-poor layer (muscularis propria) indicating invasion of the muscle. The outer white line (serosa and/or perirectal fat) is intact demonstrating that the tumor is confined to the bowel wall.

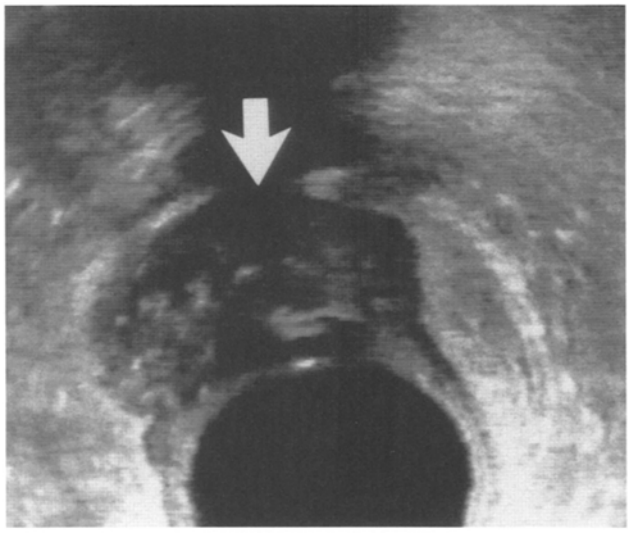

FIG. 5. In this scan a large tumor is seen invading well beyond the rectal wall. There is loss of the normal tissues interposed between the rectum and the vagina (arrow) indicative of a uT4 tumor. Invasion of this structure was confirmed at laparotomy.

TABLE 1. *Results of Preoperative Ultrasound Staging**

Ultrasound Diagnosis	Benign	Pathologic Diagnosis pT1	pT2	pT3	pT4
Benign	2(2)	2(2)	0(0)	0(0)	0(0)	0(0)
uT1	15(10)	3(1)	12(9)	0(0)	0(0)	0(0)
uT2	24(16)	0(0)	4(3)	18(12)	2(1)	0(0)
uT3	34(20)	1(0)	1(0)	8(3)	24(17)	0(0)
uT4	2(2)	0(0)	0(0)	0(0)	0(0)	2(2)
TOTAL	77(50)	6(3)	17(12)	26(15)	26(18)	2(2)

*Ultrasound staging is shown on the left hand column and pathologic staging on the right for each ultrasound stage. The results in the last 50 patients are shown in parentheses (examinations performed from January 1988 to March 1989).

percent and the specificity was 88 percent. In the first year of the study, 21 patients were assessed for lymph node disease, 71 percent were correctly classified with 83 percent specificity and 0 percent sensitivity. In the second year of the study, 40 patients were assessed and 88 percent were correctly classified with a specificity of 90 percent and a sensitivity of 88 percent.

Discussion

The treatment of rectal cancer, particularly of the middle and lower thirds, may involve one of several treatment approaches, including low anterior resection, abdominoperineal resection, adjuvant preoperative and postoperative radiotherapy, local excision, and nonoperative options such as endocavitary irradiation. A local form of therapy is generally restricted to those cancers having favorable features, which suggest that the tumor

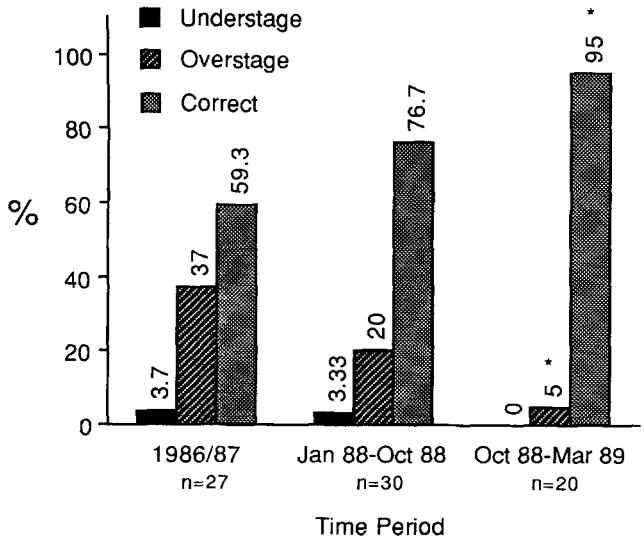

FIG. 6. Accuracy of ultrasound staging is shown for each time period. A dramatic improvement is shown as experience increased and alterations in technique and scan interpretation were made (*$P < 0.05$ *vs.* 1986/87).

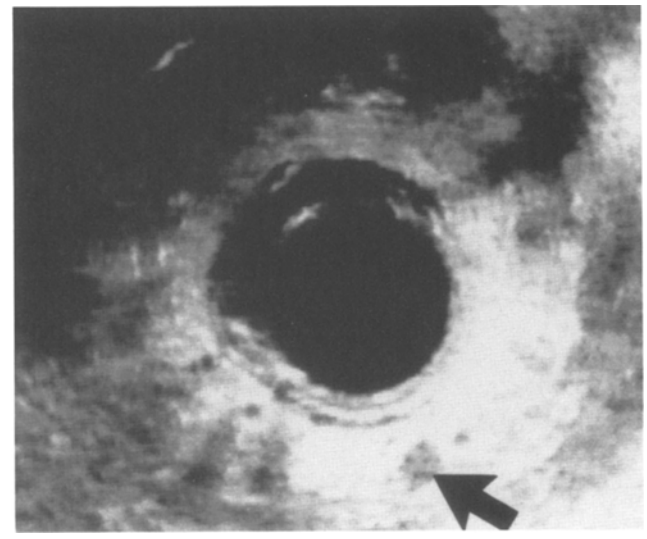

FIG. 7. In this scan, a large tumor is seen invading the perirectal fat. Posteriorly in the scan, a hypoechoic structure is seen in the mesorectum (arrow). This was interpreted as a metastatic lymph node and was confirmed on pathologic examination of the specimen.

is adequately treated by such an approach, with minimal risk of local tumor progression after treatment. Two of the most important factors in determining the feasibility of local treatment are the depth of invasion of the tumor and the presence or absence of lymph node metastasis. Although some authors believe digital assessment is an adequate and accurate method of tumor assessment,[15] objective trials have not substantiated this belief. Nicholls *et al.*[16] found that clinical assessment could only define the depth of invasion in very broad terms and it did not correlate well with pathologic definitions of different stages of disease. Inaccuracy was especially common in early lesions. Assessment of lymph node involvement by clinical examination was even less reliable. In the same study, approximately one third of patients believed to have negative nodes on clinical examination were found to have positive lymph nodes on examination of the specimen. Similarly, one third of cases believed to be positive were actually negative histologically.

Clearly, to make an accurate assessment of the primary tumor and the lymph nodes, more accurate imaging modalities are required. Computed tomographic scanning has been of use in assessing tumor extent beyond the bowel wall but is of little use in determining the depth of invasion within the wall and in the diagnosis of nodal disease.[17-20] Endorectal ultrasound is proving to be the preferred modality in the staging of rectal neoplasia both with respect to the depth of invasion and in the diagnosis of nodal disease.

Some controversy exists in the interpretation of the images obtained from endorectal ultrasonography. The number of anatomic layers recognized on scans using

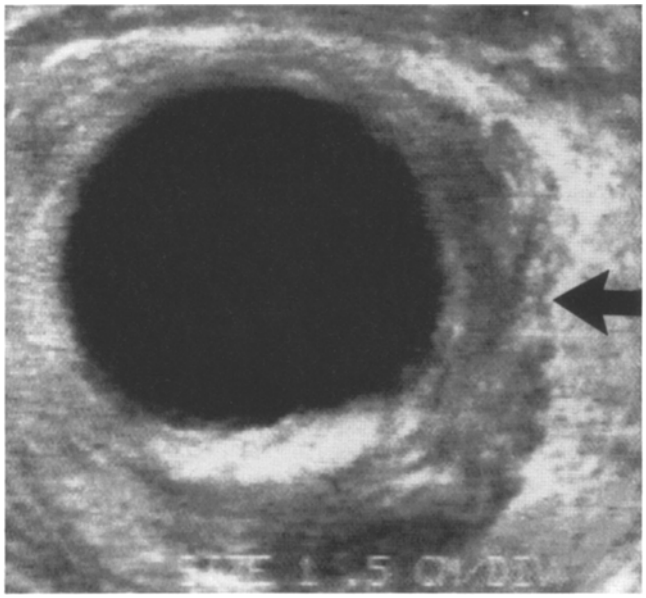

FIG. 8. It is sometimes difficult to be sure if frank invasion beyond the wall is present. In this scan, the tumor has invaded into the muscularis propria, expanding this layer while the outer white line has a scalloped appearance (arrow). The tumor is obviously extremely close to complete penetration. The tumor was staged as uT3 and this was confirmed pathologically, although the invasion into perirectal tissue was slight. More distal scans in this tumor showed a uT2 lesion only, highlighting the great importance of scanning the entire length of the tumor.

a 7 or 7.5 MHz transducer has varied from 3 to 7.[6,11,21-23] We have had more accurate results using the five layer model described by Beynon *et al.*[11] In this model, benign lesions are seen filling the mucosal layer with a completely intact second hyperechoic layer. With invasive lesions confined to the submucosa, this layer becomes less distinct and moth-eaten. When this hyperechoic layer is breached, the tumor is through the submucosa and may or may not be invading the muscularis propria. If the outer hypoechoic layer is enlarged, the muscle is clearly involved with tumor and is staged a uT2 lesion. Once the outer hyperechoic layer is shown to be incomplete, perirectal fat invasion is present, and the tumor is staged uT3. In some cases, the outer white line has a crenated, moth-eaten appearance (Fig. 8). It is difficult in this situation to differentiate a tumor as clearly uT2 or uT3. The diagnosis of a uT4 lesion can be difficult because of the short focal length of the transducer. The two cases in this series were correctly identified as invading the vagina in one and the prostate in another. Computed tomographic scanning can be complementary to endorectal ultrasound in this situation, as it is reasonably accurate in defining the extent of tumor outside the bowel wall in perirectal fat.[18,20]

In addition to selecting cases for local therapy, we are using endorectal ultrasound to select patients for preoperative radiotherapy. Those patients with clear evidence of extrarectal extension (uT3) or positive lymph nodes undergo preoperative radiotherapy in an attempt to avoid dissection close to or through viable tumor cells outside the bowel wall at the time of resection.

TABLE 2. *The Accuracy of Endorectal Ultrasound in the Preoperative Staging of Rectal Tumors: A Summary of Reported Series*

	n	Accuracy, percent	Overstage, percent	Understage, percent
Current Study				
Total group	77	75	22	3
Last year of study	50	84	14	2
Last 6 months	20	95	5	0
Beynon *et al.*[14]	49	90	6	4
Hildebrandt *et al.*[6]	76	88	11	1
Boscaini *et al.*[23]	11	91	0	9
Romano *et al.*[24]	23	87	4	9
Accarpio *et al.*[25]	54	94	4	2

As we have shown, the assessment of depth of invasion of the tumor requires considerable experience to have an acceptable accuracy. After limiting this examination to one investigator and through routine use of a proctoscope to introduce the ultrasound probe, accuracy improved significantly. The proctoscope is invaluable in ensuring complete imaging of the tumor from its most proximal to most distal extent, thus avoiding the understaging of large tumors with areas, particularly more proximally, that are more deeply invasive than the more distal extent of the tumor. These proximal areas may be missed through simple blind insertion of the probe. In the past year (the second and third time periods combined), our accuracy compares favorably with that of other workers in this area (Table 2). In the last time period studied, a five-layer model has been used to interpret scans. Although it is not possible to state conclusively that this model has resulted in the observed high accuracy in the small number of patients studied, we have found scans easier to interpret since adopting this model.

The assessment of lymph node metastases with endorectal ultrasound is controversial. The hypoechoic appearance of positive lymph nodes imaged on ultrasound was originally described in upper gastrointestinal studies[8] and was subsequently applied to rectal endosonography.[9,10] The accuracy of ultrasound in the diagnosis of lymph node metastasis varies from 74 to 86 percent.[6,10,18,22,26] Beynon *et al.*[10] have recently reported an accuracy of 83 percent with a sensitivity of 88 percent and specificity of 79 percent. This is comparable to our own experience in the final year of this study. The major problem in the diagnosis of lymph nodes metastases is with false-positive diagnoses. However, the technique is considerably more accurate than either digital

examination,[16] computed tomographic scanning,[18] and magnetic resonance imaging.[27]

In conclusion, endorectal ultrasound is an accurate method of staging rectal tumors, both in the assessment of depth of invasion and lymph node disease. The accuracy is closely related to experience and, therefore, it is advantageous to have the investigation performed by one or two individuals at an institution to maximize the extent of this experience. Proctoscopic expertise is essential to ensure correct insertion of the probe to obtain a complete scan of the entire length of the tumor.

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