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# Value and Limits of Endorectal Ultrasonography for Preoperative Staging of Rectal Carcinoma

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**Summary:** In rectal cancer, the depth of tumor infiltration and metastatic involvement of lymph nodes are important prognostic factors. Endosonography of the rectum, combining the advantages of both endoscopy and sonography, provides information not available from other imaging diagnostic techniques. From January 1989 to December 1997, 85 patients affected by rectal carcinoma were submitted to preoperative evaluation with endorectal ultrasonography. In 75 cases the results obtained with the endosonography were compared to the histology of the resected specimens. Overall accuracy in staging depth of infiltration was 90.7%. Overstaging occurred in 4% of patients, whereas understaging occurred in 5.3%. In staging lymph nodal involvement, overall accuracy was 76%, sensitivity was 69.8%, specificity was 84.4%, positive predictive value was 85.7%, and negative predictive value was 67.5%. Endorectal ultrasound is a safe and accurate diagnostic method for staging both tumor invasion and lymph node metastatic involvement, and for selecting an appropriate surgical strategy in patients affected by rectal cancer. **Key Words:** Rectal cancer—Preoperative staging—Endorectal ultrasonography.

Once a diagnosis of rectal carcinoma is made, the surgeon must correctly stage wall infiltration and nodal involvement in order to select the best surgical management and to predict the prognosis for the patient.

Digital examination, first codified by Mason (1) and later simplified by Nicholls and colleagues (2), is the easiest method for staging rectal carcinoma. Unfortunately, even when performed by experienced investigators, the extent of tumor invasion can be predicted in only 40% to 80% of cases (1–5). This explains the interest of surgeons in the development of instruments that compensate for the limits of clinical evaluation of rectal cancer. The diagnostic imaging methods used to stage rectal cancer are computed tomography (CT), and more recently, magnetic resonance imaging (MRI), and endoscopic ultrasonography (EUS).

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## MATERIALS AND METHODS

From January 1989 to December 1997, preoperative evaluation by EUS was performed on 85 patients with rectal carcinoma. There were 45 men and 40 women with a median age of 61 years (range, 51–86 years). In 75 cases the results obtained by EUS were compared with the histology of the resected specimens. Ten patients affected by rectal carcinoma were excluded from the study because of the presence of distant metastases. Patients with a stenotic tumor were excluded because a correct ultrasonographic evaluation was impossible.

All examinations were performed by an endoscopist in collaboration with an echographist using an Olympus instrument GF-EUM3 with 7.5–12 MHz echoprobe (Optical Co. Ltd.–Aloka Ltd., Tokyo, Japan). The patient was placed in the Sims' position and the echoendoscope was inserted in the rectum. In the absence of severe stenosis the instrument was passed through the lesion up to its distal part. By slowly retracting the ro-

tating probe any alterations of the rectal wall and perirectal structures were visualized.

Wall infiltration by rectal cancer was classified in 4 stages (6): (a) uT1, tumor confined to the mucosa and submucosa (Fig. 1); (b) uT2, tumor infiltrating the muscularis propria without penetrating the rectal wall (Fig. 2); (c) uT3, tumor invading the perirectal fat (Fig. 3); and (d) uT4, tumor infiltrating the surrounding organs (Fig. 4).

Benign enlargement of lymph nodes was classified by a hyperechoic pattern and indistinctly demarcated boundaries. Metastatic involvement was considered present in lymph nodes with hypoechoic inhomogeneous pattern and clearly delineated boundaries.

## RESULTS

Tumor infiltration depth (T parameter) was correctly classified by EUS in 68 out of 75 patients; the overall accuracy was 90.7% (Table 1). Overstaging occurred in 3 patients (4%): in 2 cases the histology of the resected specimen showed a T2 lesion versus T3 by EUS; and in 1 case, a T1 tumor versus T3 by EUS. Understaging occurred in 4 patients (5.3%): in 2 cases the histology showed a T3 tumor versus T2 by EUS; and in 2 patients, a T3 lesion versus T1 by EUS.

Perirectal inflammation, which may resemble tumor infiltration, was the major cause of overstaging, whereas understaging occurred in patients with tumor microinvasion. There was no difference in the overall accuracy in relation to the size of the neoplasm and its distance from the anal verge.

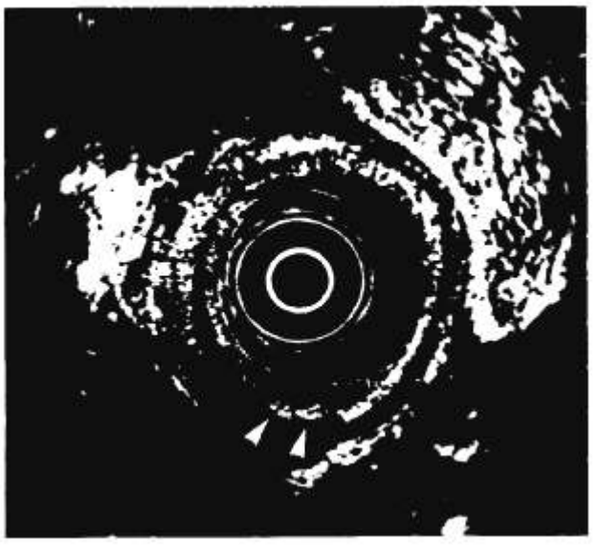

**FIG. 1.** EUS imaging of T1 tumor (arrows) infiltrating the mucosa and submucosa.

**FIG. 2.** T2 tumor (arrows) infiltrating the muscularis propria.

Endoscopic ultrasonography staged nodal metastatic involvement (N parameter) in 35 cases and absence of nodal involvement in 40 patients. Histology of resected specimens showed 30 true positive and 27 true negative; a 5 false positive and 13 false negative result was obtained. The overall accuracy in staging the N parameter was 76%; sensitivity, 69.8%; specificity, 84.4%; predictive positive value, 85.7%, and predictive negative value, 67.5% (Table 2).

In our series, overall accuracy was significantly worse in staging lymph nodes with diameters smaller than 5 mm.

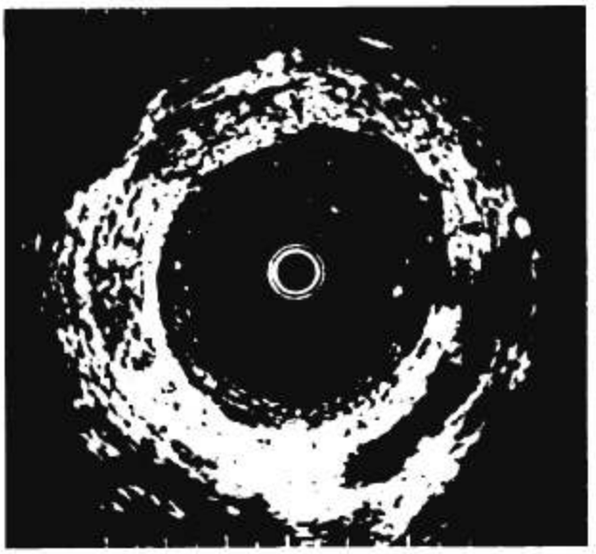

**FIG. 3.** T3 rectal carcinoma (arrows) invading the perirectal fat.

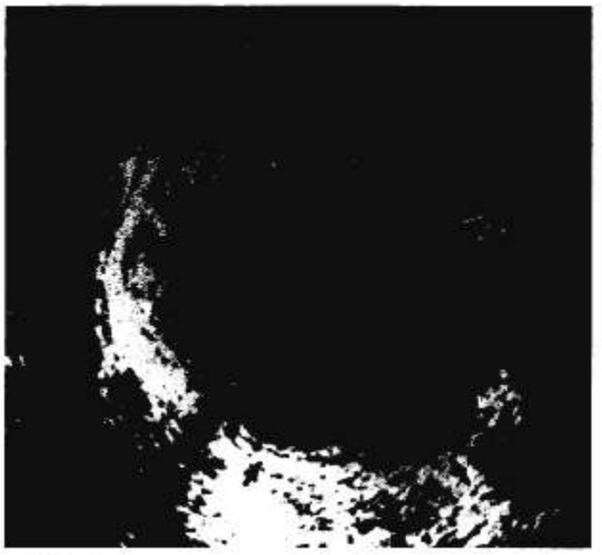

FIG. 4. T4 neoplasm (arrows) infiltrating the seminal vesicle.

## DISCUSSION

Outside of specialized colorectal units, the use of EUS in the study of the rectal pathologies is not widespread because there are still organizational and cost problems associated with a lack of qualified medical staff.

### T parameter staging

Several studies show the effectiveness of EUS in staging the T parameter in rectal carcinoma (Table 3). The percentage of overstaged cases ranges from 4% to 12%, whereas the percentage of understaged cases ranges from 1% to 9% (21,22,24,25).

Overstaging is usually due to:

1. Perineoplastic inflammation—in some cases inflammation around the tumor is significantly marked, and it is not possible to distinguish the neoplastic from the inflamed tissue (26–28);
2. Preoperative biopsy shows necrotic and hemorrhagic microfoci (28);
3. In preoperative radiotherapy edema around the tumor makes it difficult to distinguish the normal wall layers because the entire rectal wall becomes hypoechoic;
4. Fear of understaging the lesion (19).

Understaging, less frequent than overstaging, may occur for the following reasons:

1. Undetected presence of neoplastic microfoci (27);
2. In preoperative radiotherapy, necrotic and hemorrhagic microfoci with sclerosis lead to hyperechoic images (29–31);
3. Presence of stenotic neoplasm which is difficult to stage using the traditional linear or radial probes. The use of probes with a forward viewing and, more recently, instruments with other features such as a three-dimensional image reconstruction, may improve the results (32,33).

In evaluating EUS staging several factors must be considered:

1. Training of the physician. It has been demonstrated that the diagnostic accuracy increases by at least 10% in experienced hands (19);
2. Site of the neoplasm. Tumors of the lower third of the rectum are examined less easily (diagnostic error of about 16%) than tumors of the upper and middle third (diagnostic error of about 6%) (22). Two reasons for this are: (a) the use of rigid probes, and (b) several tumors of the lower third of the rectum are located in the posterior wall where the ultrasound waves are not able to penetrate correctly (17,22);
3. Size of the neoplasm. A small mass is generally examined more easily than a large one. However, if we consider the modality of tumor growth, it appears that diagnostic accuracy is greater in advanced neoplasms with a prevalently intramural growth (T3–T4) (8,10,14, 15,17,19,20,34). The decreased diagnostic accuracy for intramural neoplasms (T1–T2) is due to scanning difficulties for uT2 tumors that in 30% of cases are already uT3 tumors (18–20,34).

### N parameter staging

The extent of pararectal lymph node involvement is a considerable prognostic factor in rectal cancer. Because of this there has been justifiable enthusiasm for the development of diagnostic imaging techniques: lymphoscintigraphy (35), immunoscintigraphy (36), computed tomography (CT) (37), and more recently, MRI and EUS (38–40). The results obtained with these diagnostic modalities seem different (22), but it should be emphasized that even with all these diagnostic techniques, the accuracy in N parameter staging is lower than in T parameter staging (Table 4).

World literature shows that the diagnostic accuracy in staging N parameter ranges from 61% to 82%.

The easiest criterion for the detection of lymph nodal metastatic involvement is the nodal volume, which defines suspicious lymph nodes as those with a major diameter larger than 10–15 mm. In rectal surgery this criterion is not completely correct because in 90% of operated cases the involved lymph nodes have a major diameter smaller than 10 mm; and in 60% of patients, smaller than 5 mm (45).

**TABLE 1.** *Parietal infiltration in patients with rectal adenocarcinoma. Histology compared with endoscopic ultrasonography*

| Histology | | Endoscopic ultrasonography | | | |
|---|---|---|---|---|---|
| Parietal infiltration | Number of cases | Number of correct diagnoses | % | Overstaging | Understaging |
| T1 | 15 | 13 | 86.6 | 0 | 2 |
| T2 | 18 | 16 | 88.8 | 0 | 2 |
| T3 | 35 | 32 | 91.4 | 3 | 0 |
| T4 | 7 | 7 | 100 | 0 | 0 |
| Tx | 10 | — | — | — | — |

With EUS it is possible to detect small lymph nodes, especially those located closer to the anal verge (27); the accuracy in N parameter staging is about 80% for nodes smaller than 5 mm, and about 90% for nodes larger than 5 mm (22).

In EUS additional factors must be considered as giving a higher index of suspicion for metastatic nodal involvement (16,42,43):

1. If the node's shape is round rather than oval (Fig. 5).
2. If the node's margins are irregular and sharp (nodes with indistinctly demarcated boundaries are suspicious for inflammation).
3. If the node is hypoechoic and inhomogeneous (hyperechoic nodes are considered benign).

A transrectal ultrasound-guided nodal biopsy may give further information about nodal status even if it is not always technically easy to do (42,46,47).

### Evaluation of distal intramural spread

The widening of sphincter saving operations in rectal surgery has suggested to extend the use of EUS to study the neoplastic distal intramural spread (10,15). Histology of the resected specimens shows that the diagnostic accuracy of EUS in detecting neoplastic distal intramural spread is about 86%, with an underestimation of 8% and overestimation of 5% (5). The major cause of error is due to crushing the tumor with the water-filled latex balloon.

### Follow-up after surgery

Endorectal ultrasonography is of great value in the follow-up of patients operated on for rectal cancer in searching for an anastomotic recurrence (48–53). After surgical resection, the rectal wall preserves the normal echographic layers; the anastomosis appears as a crenate aspect for scar fibrosis, whereas a stapled anastomosis gives small shadow cones obstructing normal ultrasound penetration.

In EUS, local recurrence appears as an anastomotic hypoechoic inhomogeneous mass with irregular margins (52). The diagnostic accuracy is about 90% with a positive predictive value greater than 85% (48–53). Endorectal ultrasonography permits the detection of 15%–25% more local recurrences than can be obtained by endoscopic examination alone (49,53).

**TABLE 2.** *Preoperative staging with endoscopic ultrasonography (EUS) in rectal adenocarcinoma (number of patients = 75)*

| EUS | T parameter (%) | N parameter (%) |
|---|---|---|
| Accuracy | 90.5 | 76.0 |
| Sensitivity | 90.6 | 69.7 |
| Specificity | — | 84.3 |
| Predictive positive value | — | 85.7 |
| Predictive negative value | — | 67.5 |

### Comparison with CT and MRI

Endorectal ultrasonography is considered superior to CT both in tumor staging and in the follow-up of patients affected by rectal carcinoma (22,24,54–56). Overstaging is the most frequent error of CT; in fact, the major limitation of this diagnostic method is in distinguishing in-

**TABLE 3.** *Results of endoscopic ultrasonography (EUS) in staging of rectal carcinoma (T parameter): analysis of the literature*

| Author | Year | Rectal carcinoma (number of cases) | EUS accuracy (%) |
|---|---|---|---|
| Beynon (7) | 1986 | 67 | 91 |
| Saitoh (8) | 1986 | 88 | 93 |
| Accarpio (9) | 1987 | 54 | 94 |
| Di Candio (10) | 1987 | 55 | 92 |
| Hildebrandt (11) | 1988 | 98 | 89 |
| Holdsworth (12) | 1988 | 36 | 86 |
| Prevost (13) | 1988 | 20 | 85 |
| Rifkin (14) | 1989 | 102 | 71 |
| Dershaw (15) | 1990 | 32 | 75 |
| Glaser (16) | 1990 | 86 | 88 |
| Jochem (17) | 1990 | 50 | 80 |
| Milsom (18) | 1990 | 52 | 84 |
| Orrom (19) | 1990 | 77 | 75 |
| Tio (20) | 1991 | 61 | 85 |
| Katsura (21) | 1992 | 120 | 92 |
| Herzog (22) | 1993 | 118 | 89 |
| Scialpi (23) | 1993 | 35 | 94 |
| Deen (24) | 1995 | 209 | 82 |
| Fedyaev (25) | 1995 | 132 | 91 |

**TABLE 4.** *Results of endoscopic ultrasonography in staging of rectal carcinoma (N parameter): analysis of the literature*

| Author | Year | Number of cases | Accuracy (%) |
|---|---|---|---|
| Saitoh (8) | 1986 | 88 | 75 |
| Di Candio (10) | 1987 | 55 | 74 |
| Detry (41) | 1988 | 28 | 67 |
| Holdsworth (12) | 1988 | 36 | 61 |
| Prevost (13) | 1988 | 20 | 64 |
| Beynon (42) | 1989 | 95 | 83 |
| Rifkin (14) | 1989 | 102 | 81 |
| Glaser (16) | 1990 | 73 | 79 |
| Hildebrandt (43) | 1990 | 113 | 79 |
| Hinder (44) | 1990 | 20 | 80 |
| Jochem (17) | 1990 | 39 | 72 |
| Orrom (19) | 1990 | 77 | 82 |
| Herzog (22) | 1993 | 111 | 80 |
| Scialpi (23) | 1993 | 35 | 74 |

tramural masses (T1 from T2). It is, however, better in detecting infiltration into perirectal fat and neighboring structures (22). T parameter detection is better by EUS than CT (Table 5).

Regarding N parameter, since CT detects only lymph nodes greater than 1 cm, the superiority of EUS appears even more evident (EUS has diagnostic accuracy of 83%, sensitivity of 88%, and specificity of 89% versus CT's 57%, 25%, and 91%, respectively) (42). Even in follow-up after surgery, EUS seems superior to CT (8, 49), because CT can detect only those recurrences with diameters greater than 2 cm. Furthermore, CT has difficulty in differentiating the mass from scar perianastomotic areas.

Similar comparisons can be made between EUS and MRI (57). The former appears superior to the latter in T

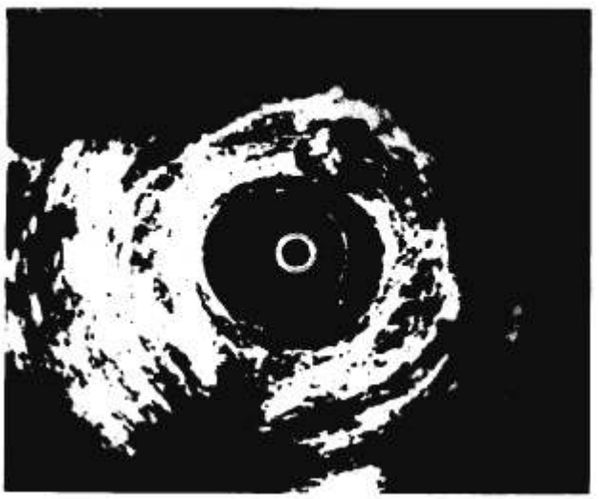

**FIG. 5.** EUS image showing a metastatic lymph node (arrows) in patient with rectal carcinoma

**TABLE 5.** *Comparison between CT and EUS in staging of rectal carcinoma (T parameter): analysis of the literature*

| Author | Year | Diagnostic accuracy (%) | |
|---|---|---|---|
| | | CT | EUS |
| Romano (54) | 1985 | 90 | 90 |
| Beynon (7) | 1986 | 79 | 91 |
| Kramann (56) | 1986 | 75 | 93 |
| Holdsworth (12) | 1988 | 86 | 94 |
| Rifkin (14) | 1989 | 53 | 56 |
| Herzog (22) | 1993 | 75 | 91 |

parameter staging (diagnostic accuracy of 83% for EUS versus 40% for MRI) and excels in the ability to detect T1 and T2 tumors. In N parameter staging, EUS and MR seem to give similar results (40). Even better results are given by endorectal magnetic resonance (EMR). Particularly, EMR seems slightly better in detecting local recurrence in patients operated on for rectal cancer (diagnostic accuracy 93%, predictive positive value 90%, and predictive negative value 100% for EMR versus 93%, 86%, and 100% for EUS, respectively) (38–40). Lower cost and shorter examination time are the major advantages of EUS in comparison with EMR; on the other hand, EMR is not linked to the experience of the investigator.

**Usefulness of EUS staging to the surgeon**

The standard operation to remove tumors of the upper and middle third of the rectum is the anterior resection, because the correct excision of the mesorectum allows an oncologically radical resection. Nevertheless local recurrence of T3 and T4 rectal carcinoma is high (25%–30%), and about one third of T4 carcinomas are surgically unresectable (32). Therefore, a multidisciplinary approach is recommended for advanced rectal carcinomas. Former treatment was based on radiotherapy, however, now treatment is based on neoadjuvant radiochemotherapy. This seems to be more effective in reducing local recurrences, in increasing the survival rate, and, in the case of lower rectum cancer growths, in increasing the number of sphincter-saving operations. Because of this, many carcinomas previously considered surgically unresectable now can be removed after radiochemotherapy. Therefore, accurate preoperative staging is necessary to separate patients who are candidates for surgical treatment from patients who first must be treated successfully by a neoadjuvant therapy.

At present, surgery for carcinomas of the lower third of the rectum is not limited to the abdomino-perineal excision. Intramural lesions (T1 N0) can be treated effectively by a transanal excision, even if local excision is possible in <15% of cases. In several patients with lower rectal carcinoma, the anterior resection with coloanal

anastomosis may give the same radicality as the rectal excision. Since the indications for a conservative operation have been extended, it is necessary to investigate with great accuracy the intramural spread and the anal sphincters (easily identified by EUS) for a correct choice of therapy.

Recently, a therapeutic algorithm has been proposed, conditioned by a preoperative EUS (58–60). For the upper and middle third of the rectum uT1–T2 carcinomas can be treated by anterior resection, whereas uT3 carcinomas always require total excision of the mesorectum with coloanal anastomosis. For the lower third of the rectum uT1 carcinomas can be removed surgically by a transanal approach, uT2 tumors can be treated by anterior resection with coloanal anastomosis, and uT3 carcinomas, by abdominoperineal excision.

With recent advances in minimally invasive surgery a new algorithm has been formulated: uT1 tumors can be treated by endoscopic transanal microsurgery, uT2 neoplasms can be treated by laparoscopic surgery with a correct lymphadenectomy, and uT3 tumors must always be operated by laparotomic approach.

In conclusion, we believe that recent advances in imaging diagnostic modalities, such as EUS, offer the surgeon a more accurate preoperative staging and are essential to the selection of an appropriate therapeutic strategy for patients affected by endorectal carcinoma.

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## REFERENCES

1. Mason AY. Rectal cancer: the spectrum of selective surgery. *J R Soc Med* 1976;69:237–44.
2. Nicholls RJ, Mason AY, Morson BC, Dixon AK, Fry IK. The clinical staging of rectal cancer. *Br J Surg* 1982;69:404–9.
3. Williams NS, Durdey P, Quirke P. Pre-operative staging of rectal neoplasms and its impact on clinical management. *Br J Surg* 1985; 72:868–74.
4. Waizer A, Zitron S, Ben-Baruch D, Baniel J, Wolloch Y, Dintsman M. Comparative study for preoperative staging of rectal cancer. *Dis Colon Rectum* 1989;32:53–6.
5. Rafaelsen SR, Kromborg O, Fenger C. Digital rectal examination and transrectal ultrasonography in staging of rectal cancer. *Acta Radiol* 1994;35:300–4.
6. Hildebrandt U, Feifel G. Preoperative staging of rectal cancer by intrarectal ultrasound. *Dis Colon Rectum* 1985;28:42–6.
7. Beynon J, Mortensen NJ, Foy MDA. Endorectal sonography: laboratory and clinical experience in Bristol. *Int J Colorectal Dis* 1986; 1:212–6.
8. Saitoh N, Okui K, Sarashima H, Suzuki M, Arai T, Nunomura M. Evaluations of echographic diagnosis of rectal cancer using intrarectal ultrasonic examination. *Dis Colon Rectum* 1986;29:234–42.
9. Accarpio G, Scorpinaro G, Claudiani F, Davini D, Mallarini G, Saitta S. Experience with local rectal cancer excision in light of two recent preoperative diagnostic methods. *Dis Colon Rectum* 1987;30:296–8.
10. Di Candio G, Mosca F. Endosonography of the rectum. In: Fornage B, ed. *Endosonography*. Dordrecht, Germany: Kluwer; 1989.
11. Hildebrandt U, Feifel G. The evaluation of the rectum by transrectal ultrasonography. *Ultrasound Q* 1988;6:167–79.
12. Holdsworth PJ, Johnston D, Chalmers AG. Endoluminal ultrasound and computed tomography in the staging of rectal cancer. *Br J Surg* 1988;75:1019–22.
13. Prevost F, Puech JL, Chalabi F. L'échographie endorectale dans le bilian d'éxtension des cancers du rectum. A propos de vingt cas operés. *Ann Chir* 1988;42:652–9.
14. Rifkin MD, Ehrlich SM, Marks G. Staging of rectal carcinoma: prospective comparison of endorectal US and CT. *Radiology* 1989; 170:319–22.
15. Dershaw DD, Enker WE, Cohen AM, Sigurdson ER. Transrectal ultrasonography of rectal carcinoma. *Cancer* 1990;66:2336–40.
16. Glaser F, Schlag P, Herfarth CH. Endorectal ultrasonography for the assessment of invasion of rectal tumors and lymph node involvement. *Br J Surg* 1990;77:883–7.
17. Jochem RJ, Reading CC, Dozois RR, Carpenter HA, Charboneau W. Endorectal ultrasonographic staging of rectal carcinoma. *Mayo Clin Proc* 1990;65:1571–7.
18. Milson J, Fraffner H. Intrarectal ultrasonography in rectal cancer staging and in the evaluation of pelvic disease. Clinical use of intrarectal ultrasound. *Ann Surg* 1990;212:602–6.
19. Orrom WJ, Wong WD, Rothenberger DA, Jensen LL, Goldberg SM. Endorectal ultrasound in the preoperative staging of rectal tumors: a learning experience. *Dis Colon Rectum* 1990;33:654–9.
20. Tio TL, Coene PLO, Delden OM, Tytgat GNJ. Colorectal carcinoma: preoperative TNM classification with endosonography. *Radiology* 1991;179:165–70.
21. Katsura Y, Yamada K, Ishizawa T, Yoshinaka H, Shimazu H. Endorectal ultrasonography for the assessment of wall invasion and lymph node metastasis in rectal cancer. *Dis Colon Rectum* 1992;35:362–8.
22. Herzog U, Von Flue M, Tondelli P, Schuppisser JP. How accurate is endorectal ultrasound in the preoperative staging of rectal cancer? *Dis Colon Rectum* 1993;36:127–34.
23. Scialpi M, Andreatta R, Augiaro S. Rectal carcinoma: preoperative staging and detection of postoperative local recurrence with transrectal ultrasound. *Abdom Imaging* 1993;18:381–6.
24. Deen KL, Madoff RD, Belmonte C, Wong WD. Preoperative staging of rectal neoplasms with endorectal ultrasonography. *Semin Colon Rectal Surg* 1995;6:78–85.
25. Fedyaev EB, Volkova EA, Kuznetsova EE. Transrectal and transvaginal ultrasonography in the preoperative staging of rectal carcinoma. *Eur Radiol* 1995;20:35–8.
26. Detry RJ, Kartheuser A, Kesten PJ. Endorectal ultrasonography for staging small rectal tumors: technique and contribution to treatment. *World J Surg* 1993;17:271–5.
27. Sentovich SM, Blatchford GJ, Falk PM. Transrectal ultrasound of rectal tumors. *Am J Surg* 1993;166:638–45.
28. Hulsmans FJ, Tio TL, Fockens P, Bosma A, Tytgat GM. Assessment of tumor infiltration depth in rectal cancer with transrectal sonography: caution is necessary. *Radiology* 1994;190:715–20.
29. Glaser F, Kuntz C, Schlag P. Endorectal ultrasound for control of preoperative radiotherapy of rectal cancer. *Ann Surg* 1993;217: 64–9.
30. Bernini A, Deen KL, Madoff RD, Wong WD. Preoperative adjuvant radiation with chemotherapy for rectal cancer: its impact on stage of disease and the role of endorectal ultrasound. *Ann Surg Oncol* 1996;3:131–5.
31. Williamson PR, Hellinger MD, Larach SW, Ferrara A. Endorectal ultrasound of T3 and T4 rectal cancers after preoperative chemoradiation. *Dis Colon Rectum* 1996;39:45–9.
32. Hunerbein M, Below C, Schlag PM. The dimensional endorectal ultrasonography of staging of obstructing rectal cancer. *Dis Colon Rectum* 1996;39:636–42.
33. Nielsen MB, Pedersen JF, Christiansen J. Rectal endosonography in the evaluation of stenotic rectal tumors. *Dis Colon Rectum* 1993; 36:275–9.
34. Anderson BO, Hann LE, Enker WE, Dershaw DD, Guillem JG,

Cohen AM. Transrectal ultrasonography and operative selection for early carcinoma of the rectum. *J Am Coll Surg* 1994;179: 513–7.
35. Montori A, Miscusi G, Saracca L, Dell'Anna A, Giofetta G, Risa L, Barbarossa C. Transrectal sonography and endoscopic lymphoscintigraphy in the preoperative staging of rectal cancer. *Dig Surg* 1984;1:200–4.
36. Doerr RJ, Abdel-Nabi H, Krag D, Mitchell E. Radiolabeled antibody imaging in the management of colorectal cancer: results of a multicenter clinical study. *Ann Surg* 1991;214:118–24
37. Dixon AK, Fry IK, Morson BC, Nicholls RJ, Mason AY. Preoperative computed tomography of carcinoma of the rectum. *Br J Radiol* 1981;54:655–9.
38. Fanucci E, Squillaci E, Giuliani S, et al. Preoperative staging and recurrence of rectal tumors: comparison of transrectal ultrasonography and magnetic resonance. *Radiol Med (Torino)* 1992;83: 622–9.
39. Golfieri R, Giampalma E, Leo P, et al. Comparison of magnetic resonance, computed tomography, and endorectal sonography in the preoperative staging of neoplasms of the rectum-sigma: correlation with surgical and anatomopathologic findings. *Radiol Med (Torino)* 1993;85:773–83.
40. Meyenberger C, Huch Boni RA, Bertschinger P, Zala GF, Klotz HP, Krestin GP. Endoscopic ultrasound and endorectal magnetic resonance imaging: a prospective, comparative study for preoperative staging and follow-up of rectal cancer. *Endoscopy* 1995;27: 469–79.
41. Detry RJ, Kartheuser A, Kerstens RJ. Endorectal ultrasonography for staging small rectal tumours: contribution to treatment. *World J Surg* 1988;17:271–5.
42. Beynon J, Mortensen NJ, Foy DM, Channer JL, Rigby H, Virjee J. Preoperative assessment of mesorectal lymph node involvement in rectal cancer. *Br J Surg* 1989;76:276–9.
43. Hildebrandt U, Klein T, Feifel G, Schwarz HP, Koch B, Schmitt RM. Endosonography of pararectal lymph nodes: in vitro and in vivo evaluation. *Dis Colon Rectum* 1990;33:863–8.
44. Hinder JM, Chu J, Bokey EL, Chapuis PH, Newland RC. Use of transrectal ultrasound to evaluate direct tumour spread and lymph node status in patients with rectal cancer. *Aust N Z J Surg* 1990; 60:19–23.
45. Herrera-Ornelas L, Justiniano J, Castillo N, Peterelli NJ, Stulc JP, Mittelman A. Metastases in small lymph nodes from colon cancer. *Arch Surg* 1987;122:1253–6.
46. Andersson R, Aus G. Transrectal ultrasound guided biopsy for verification of lymph node metastasis in rectal cancer. *Acta Chir Scand* 1990;156:659–65.
47. Milson J, Czyrko C, Hull T. Preoperative biopsy for pararectal lymph nodes in rectal cancer using endoluminal ultrasonography. *Dis Colon Rectum* 1994;37:364–8.
48. Mascagni D, Corbellini L, Urciuoli P, Di Matteo G. Endoluminal ultrasound for early detection of local recurrence of rectal cancer. *Br J Surg* 1989;76:1176–80.
49. Beynon J, Mortensen NJ, Foy MD. The detection and evaluation of locally recurrent rectal cancer with rectal endosonography. *Dis Colon Rectum* 1989;32:509–15.
50. Feifel G, Hildebrandt U. New diagnostic imaging in rectal cancer: endosonography and immunoscintigraphy. *World J Surg* 1992;16: 841–7.
51. Kuntz C, Glaser F, Buhr HJ, Herfarth C. Endo-anal ultrasound: indications and results. *Chirurgie* 1994;65:352–7.
52. Finne CO. The role of endorectal sonography in the follow-up of malignant disease of the anorectum. *Semin Colon Rectal Surg* 1995;6:86–93.
53. Ramirez JM, Mortensen NJ, Takeuchi N. Endoluminal ultrasonography in the follow-up of patients with rectal cancer. *Br J Surg* 1994;81:692–97.
54. Romano G, De Rosa P, Vallone G, Rotondo A, Grassi R, Santangelo ML. Intrarectal ultrasound and computed tomography in the pre- and post-operative assessment of patients with rectal cancer. *Br J Surg* 1985;72(suppl):S117–8.
55. Beynon J, Mortensen NJ, Foy DM, Channer JL, Virjee J, Goddard P. Preoperative assessment of local invasion in rectal cancer: digital examination, endoluminal sonography or computed tomography? *Br J Surg* 1986;73:1015–7.
56. Kramann B, Hildebrandt U. Computed tomography versus endosonography in the staging of rectal carcinoma: a comparative study. *Int J Colorectal Dis* 1986;1:216–8.
57. Weizer A, Pewsner E, Russo I. Prospective comparative study of magnetic resonance imaging versus transrectal ultrasound for preoperative staging and follow-up of rectal cancer. *Dis Colon Rectum* 1991;34:1068–75.
58. Lindmark C, Elvin A, Paehlmann L, Glimelius B. The value of endosonography in the preoperative staging of rectal cancer. *Int J Colorectal Dis* 1992;7:162–6.
59. Hildebrandt U, Schuder G, Feifel G. Preoperative staging of rectal and colonic cancer. *Endoscopy* 1994;26:810–6.
60. Hildebrandt U, Feifel G. Importance of endoscopic ultrasonography staging for treatment of rectal cancer. *Gastrointest Endosc Clin N Am* 1995;5:843–9.