



Impact of miniprobe ultrasonography on planning of minimally invasive surgery for gastric and colonic tumors

M. Hünérbein, T. Handke, C. Ulmer, P. M. Schlag

Department of Surgery and Surgical Oncology, Robert Rössle Hospital, Charité, Campus Buch, Helios Hospitals, University of Medicine, 13122, Berlin, Germany

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Abstract

Background: The use of minimally invasive procedures for the management of gastrointestinal cancer is increasing. The aim of this study was to investigate the role of high-frequency miniprobe endoscopic ultrasound (EUS) for therapeutic decisions making in patients with gastric or colonic tumors.

Methods: A total of 137 patients underwent EUS with a 12.5-MHz miniprobe for preoperative staging of tumors of the stomach ($n = 49$) or colon ($n = 88$). After resection, the surgical path was reviewed to analyze the role of preoperative staging with miniprobes.

Results: Miniprobe EUS enabled accurate assessment of the infiltration depth of gastric and colonic tumors. The overall accuracy rates were 88% and 87%, respectively. The lymph node status was predicted correctly in 82% of the patients (sensitivity, 61%, specificity, 94%). Based on the results of miniprobe EUS, patients with gastric cancer were accurately selected to undergo endoscopic mucosal resection, laparoscopic resection, or open surgery in 100%, 91%, and 86% of the cases, respectively. In patients with colonic tumors, the treatment decision analysis showed that the stratification was correct in 90% of the patients.

Conclusions: Miniprobe EUS is a reliable method for validating treatment decisions for patients undergoing minimally invasive procedures for gastric and colonic tumors. This method is particularly valuable in the management of colon cancer, because endoscopic and laparoscopic resections can be offered to selected patients as an alternative to open surgery.

Key words: Miniprobe — Endoscopic ultrasound — Staging — Colorectal cancer — Gastric cancer

Traditionally, the curative treatment of patients with gastric or colon cancer has been performed by radical surgery. Recently, however, there has been a trend toward a more sophisticated approach, with stage-adapted therapy applied to individual cases. Treatment options include a broader spectrum of therapeutic modalities, ranging from minimally invasive procedures to multimodality therapy.

Minimally invasive surgery has become increasingly attractive because it offers curative treatment of cancer patients with low perioperative morbidity and improved functional outcome. Endoscopic procedures such as endoscopic mucosal resection (EMR) have been successfully used to treat early gastrointestinal cancer, thus obviating the need for surgical resection. There is no doubt that endoscopic resections are appropriate for the treatment of precancerous lesions and mucosal cancers. However, in Japan, the indications for EMR have been extended to the treatment of selected patients with gastric and colorectal cancers invading the submucosa [9]. In Western countries, these lesions are often considered inappropriate for EMR because lymph node metastases and tumor recurrence are found in 10–15% of patients [1, 3]. Therefore, laparoscopic procedures such as intragastric laparoscopic resections and laparoscopic colectomy have been increasingly applied in patients with sumucosal cancers as a less aggressive alternative to open surgery [15]. There is evidence that laparoscopic resection of colorectal cancer can be performed with low morbidity and the according to oncologic principles [11, 13]. At the same time, the application of laparoscopic methods to advanced colorectal cancer has been questioned by some authors because of the risk of port site metastases and the problem of specimen retrieval [4, 19].

Clearly, there is a growing need for reliable staging modalities to select patients with gastric and colonic cancer who are good candidates for one of the minimally invasive treatment options. Preliminary data from several studies suggest that miniprobe ultrasonography can improve the preoperative evaluation of early gas-

trointestinal cancers. The major advantages of this technique include the high resolution of the transducer and its applicability to the colon. Therefore, we investigated the role of miniprobe ultrasonography in minimally invasive surgery for the management of gastric and colorectal cancer. For this purpose, the results of miniprobe ultrasonography in 137 cases were analyzed and correlated with the patients outcomes.

Patients and methods

Patients

Miniprobe ultrasonography was performed in 137 patients for the preoperative staging of gastric cancer ($n = 49$) or colorectal neoplasms ($n = 88$). The study population consisted of 77 men and 50 women with a mean age of 63 years (range, 38–87). All patients underwent surgical resection of the tumor ($n = 108$) or EMR ($n = 29$). The results of miniprobe endoscopic ultrasound (EUS) were correlated with the endoscopic assessment (malignant vs benign) and histopathology of the resection specimens. The impact of miniprobe ultrasonography on surgical decisions was evaluated by a retrospective review of the patient charts.

Technique

Miniprobe ultrasonography was performed during routine endoscopy. All examinations were carried out using a 12.5-MHz miniprobe with a diameter of 6F (Endosound; Boston Scientific, Watertown, MA, USA) and a B&K ultrasound unit (Brüel & Kjær 3553; Gentofte, Denmark). The patients underwent endoscopy in a conventional fashion. Pre-medication with 5 mg midazolam was administered intravenously. When a lesion was diagnosed endoscopically, the intestinal lumen was filled with 200–300 ml of water to achieve acoustic coupling between the transducer and the intestinal wall. Subsequently, the miniprobe was introduced through the biopsy channel of the endoscope and placed over the tumor. The lesions were assessed in real time while the catheter was moved over the tumor region. Based on the results of miniprobe EUS, the patients underwent either endoscopic or surgical resection of the tumor. EMR was considered to be appropriate only in patients with negative histology (adenoma) and negative EUS.

Staging criteria

The tumor infiltration depth was determined according to the TNM classification of the Union Internationale Contre le Cancer (UICC). Benign lesions confined to the inner hypoechoic layer (mucosa) were classified as adenoma (uT0). Malignant tumors involving the mucosa or infiltrating the submucosa (first hyperechoic layer) were classified as T1m or T1sm carcinoma. T2 or T3 tumors were diagnosed when penetration in the outer hypoechoic layer (muscularis propria) or in the peripheral echogenic layer (serosa) was observed. Infiltration of adjacent structures indicated a T4 situation. T3 and T4 tumors were grouped together, because infiltration in the mesocolon (T3) could not be distinguished from penetration of the serosa (T4).

The criteria for the diagnosis of metastatic lymph node involvement were low echogenicity, clearly defined boundaries, and a round shape. The endosonographic diagnosis was compared to the histopathologic classification of the resection specimen.

Results

Miniprobe ultrasonography provided high-resolution images of the gastrointestinal wall. All layers of the wall (i.e., mucosa, submucosa, and muscularis propria) were accurately delineated (Figs 1, 2, and 3).

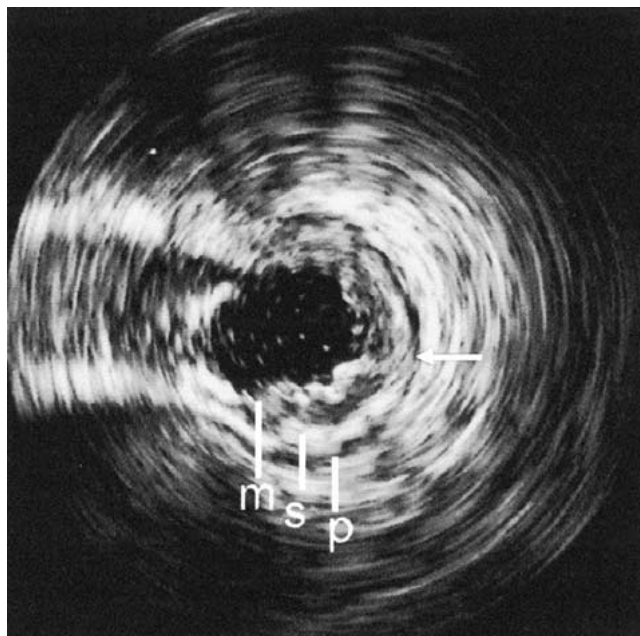


Fig. 1. Early gastric cancer. Miniprobe ultrasound shows a thickening of the mucosa (m). Submucosa (s) and muscularis propria (p) are accurately delineated.

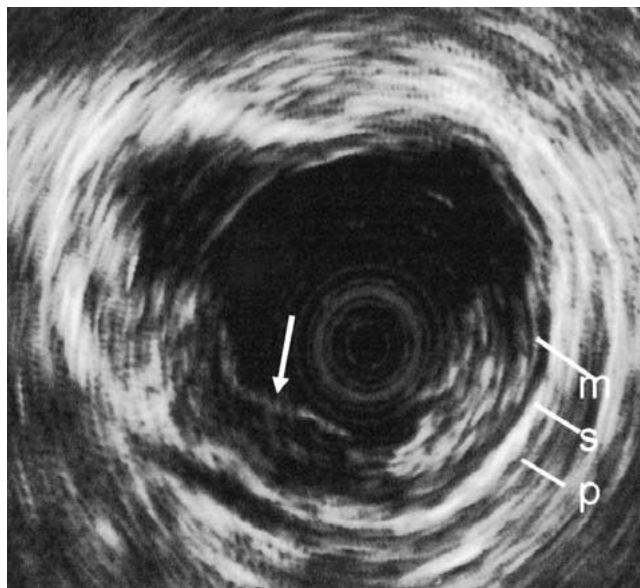


Fig. 2. Adenoma of the colon. Miniprobe EUS demonstrates a lesion of low echogenicity (arrow) confined to the mucosal layer (m). There is no penetration into the submucosa (s) or muscularis propria (p).

Miniprobe EUS correctly determined the tumor infiltration depth in 43 of 49 patients with gastric cancer (accuracy, 88%). The detailed results are summarized in Table 1. Notably, all mucosal gastric cancers (T1m) could be differentiated from tumors invading the submucosa (T1sm). Overstaging occurred in four of 14 patients with early gastric cancer of the submucosal type. Histology showed tumors with deep infiltration of the submucosa and fibrotic reactions in all of these cases.

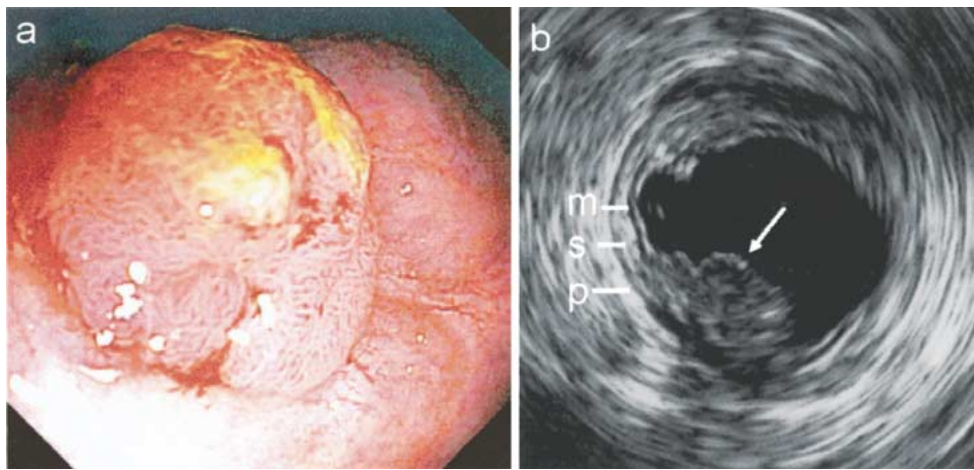


Fig. 3. Colon carcinoma.

a Endoscopic view of broad-based polyp (diameter 2 cm).

b Miniprobe ultrasonography reveals a uT2 tumor (arrow) that penetrates into the submucosa (s) and reaches the muscularis propria (p).

The results of miniprobe ultrasonography in the staging of colonic tumors are detailed in Table 2. The infiltration depth was correctly classified in 78 of 88 patients (accuracy, 87%). Overstaging occurred in three adenoma, three T1 carcinomas, and four T2 carcinomas.

Assessment of the lymph node status was accomplished successfully in 45 of 49 patients (92%) with gastric cancer and in 84 of 88 patients (95%) with colonic tumors, but it failed in eight patients due to the limited field of view of the probe. Metastatic lymph node involvement was identified in 26 of 43 patients with positive nodes. False-positive assessment of lymph nodes was observed in five of 86 patients with negative lymph nodes. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were 61%, 94%, 84%, and 91%, respectively.

Based on the results of miniprobe ultrasonography, four patients with mucosal gastric cancer were treated adequately by endoscopic resection. Primary laparoscopic or conventional resection was considered to be appropriate for 11 patients with uT1sm tumors. Histology revealed one T2 tumor in this group. Twenty-four patients with advanced tumors (T2–4) underwent staging laparoscopy. Metastatic spread—i.e., peritoneal seeding and M1 lymph nodes—was diagnosed in five patients who subsequently received palliative treatment. Gastrectomy was performed in the remaining 19 patients, including four patients with early gastric cancer of the submucosal type. According to institutional policy, patients with colonic tumors were assigned to three treatment groups. Endoscopic polypectomy was performed in 25 patients with adenoma (T0). Twenty-four patients with uT1 or uT2 tumors were considered to be candidates for laparoscopic surgery. This group included one patient with adenoma of the sigmoid colon that was overstaged by EUS (uT2) and two patients with advanced tumors. Two adenoma that were false-positively classified as T1 carcinoma were treated by endoscopic polypectomy because endoscopic biopsy did not confirm malignancy. Thirty-five of 39 advanced tumors were identified correctly, thus enabling the selection of patients for laparoscopic or conventional resections on the basis of individual risk assessment.

Discussion

Accurate preoperative staging of gastric carcinoma and colon cancer is essential to select patients who can be cured by endoscopic or laparoscopic surgery. It is generally accepted that EUS is the most sensitive technique for the preoperative evaluation of gastrointestinal tumors. However, there are technical limitations to conventional EUS, including the limited resolution of the linear transducers and difficulty in maneuvering the instruments. Therefore, EUS is not widely accepted as a means of examining colonic neoplasms.

Recently, miniprobos have been developed that can be introduced through the biopsy channel of endoscopes. Several authors have reported promising results for the evaluation of early esophageal and gastric cancer via miniprobos [14, 21]. To date, experience with the application of this new technique in colorectal cancer has been limited. The present study was performed to investigate the accuracy of miniprobe ultrasound for the staging of gastric and colonic tumors and to analyze its impact on preprocedure planning.

Miniprobe EUS provided high-resolution images of the intestinal wall layers. The overall accuracy for the assessment of the infiltration depth in gastric and colonic tumors was 88% and for 87%, respectively. Other authors have reported comparable accuracy rates for the evaluation of gastric cancer (61–82%) and colorectal tumors (82–88%) with miniprobos [5, 8, 17, 20]. However, it has also been suggested that the accuracy of miniprobos may decrease with increasing tumor size. Using a 15-MHz probe, Akakoshi et al. correctly classified the tumor invasion in 82% of the T1 tumors but only 57% of the T2–4 tumors [2]. In our experience, miniprobe ultrasonography was effective for all tumors regardless of the T category. However, it must be emphasized that very large and bulky gastric cancers were excluded from the study.

The accuracy of miniprobe EUS in determining the lymph node status was 83%. In the literature, accuracy rates ranging from 56% to 82% have been cited for lymph node staging with miniprobos [12]. One drawback of miniprobe ultrasonography was its limited sensitivity

Table 1. Staging of gastric cancer (*n* = 49): correlation between miniprobe EUS (uT) and histopathology (pT)

	pT1m	pT1sm	pT2	pT3–4
uT1m	4	—	—	—
uT1sm	—	10	1	—
uT2	—	4	13	—
uT3–4	—	—	1	16

Table 2. Staging of colon cancer (*n* = 88): correlation between miniprobe EUS (uT) and histopathology (pT)

	pT0	pT1	pT2	pT3–4
uT0	25	—	—	—
uT1	2	4	—	—
uT2	1	3	12	—
uT3–4	—	—	4	37

(61%) in the detection of lymph node metastases. However, the high specificity (90%) and the PPV of 84% suggest that undertreatment can be avoided if lymph nodes are detected.

The ability of miniprobe ultrasonography to categorize tumors as suitable for minimally invasive surgery according to institutional treatment guidelines was determined by reviewing the patient charts. In gastric cancer, EMR was considered appropriate only for mucosal cancer; patients with submucosal cancers were candidates for conventional or laparoscopic resection. Although most early gastric cancers could be identified by endoscopic criteria, it was impossible to differentiate between mucosal and submucosal invasion. Miniprobe ultrasonography correctly classified patients for EMR or primary resection 100% and 91% of the time, respectively. Patients with more advanced tumors (T2–4) underwent staging laparoscopy to exclude metastatic spread prior to laparotomy. Retrospectively, staging laparoscopy could have been avoided in four patients with T1 tumors (17%) that were overstaged by EUS. Therefore, in the further it may be reasonable to restrict the indication for staging laparoscopy to advanced tumors (T3–4).

Three treatment groups were analyzed for colonic cancer. EMR was the treatment of choice for adenoma and T1 carcinoma with low-risk histology. In our experience, miniprobe EUS considerably improved the assessment of sessile colorectal polyps (Figs. 2 and 3). Unsuspected malignancy was identified in five of 35 patients (two with negative histology), and the patients were referred directly to surgery without an attempt at endoscopic resection. Other investigators have shown that the endoscopic appearance and the lifting characteristics of colorectal polyps after submucosal injection can predict submucosal infiltration [10]. However, accurate assessment of both requires considerable experience and does not provide information on the lymph node status. Unintentional EMR in deeply invading lesions may expose patients unnecessarily to the risk of bleeding and perforation. In these cases, miniprobe EUS can help to reassure the endoscopist that it is safe to

perform EMR or, alternatively, prompt the consideration of surgery [6]. In the present study, the laparoscopic approach was favored for high-risk T1 or T2 tumors, whereas radical resection via laparotomy was considered appropriate for more advanced tumors. This approach seems reasonable because large studies indicate that there is an increased risk of port site metastases in tumors with penetration of the serosa [16, 18, 22]. Furthermore, the problem of specimen retrieval and the risk of liver metastases are arguments against laparoscopic surgery in advanced colorectal cancer.

The data presented here demonstrate that miniprobe ultrasonography can reliably differentiate between early and advanced colorectal cancers. Patients who were appropriate candidates for EMR, laparoscopic colectomy, and open surgery vs laparoscopic resection were identified with an accuracy of 100%, 91%, and 86%, respectively. It has recently been proposed that the extent of laparoscopic lymph node dissection can be modified according to the tumor stage. In their analysis of the distribution of lymph node metastases in 164 patients with colorectal cancer, Hidu et al. concluded that central lymph node dissection may not be required in those patients [7]. If these data can be confirmed, in the future less extensive laparoscopic resections can be performed for early-stage colon carcinoma as predicted by EUS.

In conclusion, miniprobe EUS is a valuable technique for the preoperative staging of gastric and colonic neoplasms. In our experience, miniprobe EUS enabled us to define the appropriate surgical technique in 90% of patients with gastric or colorectal cancer. Of course, the requirements for the preoperative staging of gastrointestinal cancer are strongly dependent on the therapeutic options that can be offered to the patient and may vary substantially between different institutions. Nonetheless, it seems likely that miniprobe EUS will improve the planning of minimally invasive surgery, particularly in patients with colorectal cancer.

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