Jose F. Botet, MD • Charles J. Lightdale, MD • Ann G. Zauber, PhD • Hans Gerdes, MD
Sidney J. Winawer, MD • Carlos Urmacher, MD • Murray F. Brennan, MD

Preoperative Staging of Gastric Cancer: Comparison of Endoscopic US and Dynamic CT[1]

Fifty consecutive patients with gastric adenocarcinoma proved by means of biopsy underwent preoperative staging with endoscopic ultrasonography (US). Dynamic computed tomography (CT) of the chest and abdomen was performed before surgery in 33 of the patients. In all 50 patients, the TNM classification of the American Joint Committee on Cancer was used to compare the imaging findings with pathologic findings in specimens resected at surgery. When the depth of tumor penetration was evaluated, the findings at endoscopic US and those at pathologic examination were concordant in 46 of 50 patients (92%), and the findings at dynamic CT and those at pathologic examination, in 14 of 33 patients (42%) ($P < .00042$). Evaluation of regional lymph node metastases showed a concordance of 78% with endoscopic US and 48% with dynamic CT ($P < .038$). Overall determination of stage with both dynamic CT and endoscopic US showed a concordance of 73%, compared with a concordance of 45% for dynamic CT alone ($P < .028$).

Index terms: Endoscopy, 728.12981 • Lymphatic system, neoplasms, 999.8323 • Stomach, CT, 728.1211 • Stomach, neoplasms, 728.321 • Stomach, US studies, 728.12989 • Ultrasound (US), tissue characterization, 728.321

Radiology 1991; 181:426–432

[1] From the Departments of Medical Imaging (J.F.B.), Medicine, Gastroenterology Service (C.J.L., H.G., S.J.W.), Epidemiology and Biostatistics (A.G.Z.), Pathology (C.U.), and Surgery (M.F.B.), Memorial Sloan-Kettering Cancer Center and Cornell University Medical College, 1275 York Ave, New York, NY 10021. From the 1988 RSNA scientific assembly. Received March 6, 1991; revision requested April 24; revision received June 18; accepted June 19. **Address reprint requests to** J.F.B.

See also the article by Botet et al (pp 419–425) and the editorial by Baker and Kopecky (pp 342–343) in this issue.

THE prevalence of gastric cancer has been steadily declining worldwide since 1930, when this disease was the most frequent cause of death from cancer (1). In 1991, however, it is estimated that 23,800 patients with new cases of gastric cancer would undergo examination and that approximately 13,400 patients would die from this disease during the same year (2).

Significant advances in diagnosis such as endoscopy and double-contrast studies of the upper gastrointestinal tract currently allow the detection of small lesions early in the course of the disease. However, more than 25% of patients who undergo surgical exploration undergo no procedure other than open biopsy because advanced disease is discovered at surgery (3–6). Multiple contradictory reports have been published in the radiology literature on the utility of both computed tomography (CT) (7–10) and magnetic resonance (MR) imaging (11,12) in the proper staging of gastric cancer. The major difficulties encountered with CT and MR imaging are their inherent incapacity to enable correct staging of the depth of tumor penetration of the gastric wall. The capacity of both CT and MR imaging to enable correct staging of regional lymph node involvement has also been proved limited.

The purpose of our study was to evaluate the role of a relatively new modality, endoscopic ultrasonography (US), in the preoperative staging of gastric cancer.

PATIENTS AND METHODS

Study Group

Between December 1986 and December 1988, 50 patients with gastric adenocarcinoma proved by means of biopsy underwent preoperative staging with endoscopic US. Patients were selected with the understanding that surgery was planned for either palliation or attempt at cure. Dynamic CT was performed preoperatively in 33 of the 50 patients after endoscopic US. The 17 patients not included in this part of the study underwent CT at other institutions; the scans from these patients were of good enough quality to obviate repeat CT but did not conform to our CT protocol and therefore were excluded from our results. All CT scans were read independently by radiologists of comparable experience. There were 26 male and 24 female patients. The oldest patient was aged 81 years; the youngest, 33 years (median age, 63 years; mean age, 61 years). Tumors were located in the fundus ($n = 13$), body ($n = 21$), and antrum ($n = 12$); four patients had linitis plastica. All tumors were adenocarcinomas. Lymphomas, leiomyosarcomas, and other nonadenocarcinomas were excluded.

Comparative studies of endoscopic US, dynamic CT, and pathologic examination were performed with use of the 1988 TNM system developed by the American Joint Committee on Cancer (AJCC) (13) (Tables 1, 2). The results from each diagnostic modality were interpreted separately without knowledge of other results.

Endoscopic US

Two models of US endoscopes were used (Olympus GF-UM2 and GF-UM3; Olympus, Lake Success, NY). These oblique viewing instruments have a US transducer attached to the tip of the endoscope. The scanning direction was orthogonal to the axis of the instrument, providing a 360° field of view. The images were obtained in real time with a scanning speed of 10 revolutions per second. An inflatable balloon with a 1.5-cm radius was placed over the transducer head for better acoustic coupling with the gastric wall. Electively, the stomach was filled with 300–600 mL of deaerated water introduced through a channel in the instrument. The model GF-UM2 has a 7.5-MHz transducer; the model GF-UM3, both a 7.5- and 12-MHz transducer. The frequencies can be switched from the console without removing the instrument. The resolution

Abbreviations: AJCC = American Joint Committee on Cancer, CI = confidence interval.

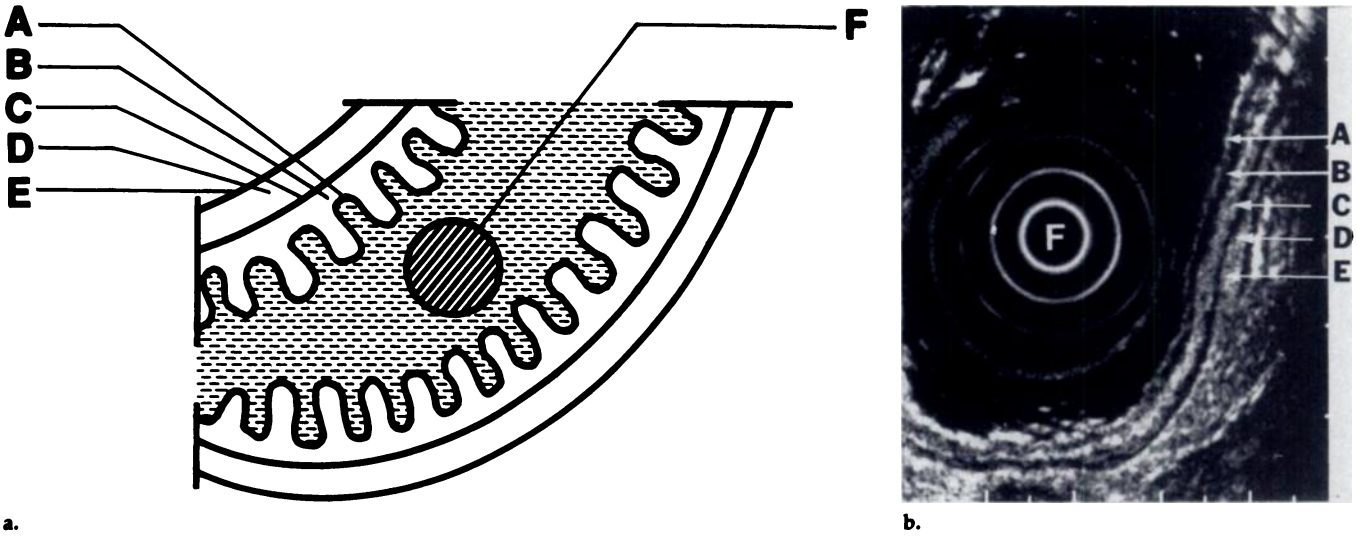


Figure 1. Diagram **(a)** and endoscopic US scan **(b)** depict normal gastric wall with five layered internal structures. *A* = mucosa (hyperechoic), *B* = deep mucosa (hypoechoic), *C* = submucosa (hyperechoic), *D* = muscularis propria (hypoechoic), *E* = serosal interface (hyperechoic), and *F* = transducer in water-filled gastric lumen.

for the 7.5-MHz transducer was 1 mm; for the 12-MHz transducer, greater than 0.5 mm. The depth of field was variable from patient to patient but was usually 5–7 cm for the 7.5-MHz transducer and approximately 3 cm for the 12-MHz transducer. Individual layers of the gastric wall could be identified, and five alternating hyper- and hypoechoic layers were routinely seen (Fig 1). The histologic correlates of the five layers have been somewhat controversial, but recent in vitro studies indicate that the first two layers represent the interface and superficial and deep mucosa, probably including the muscularis mucosa. The third layer represents the submucosa. The fourth layer corresponds to the muscularis propria. The fifth layer represents the serosa (14).

The thickness of the normal gastric wall varies according to the degree of distention but is usually 2–4 mm. There are also different anatomic patterns with multiple folds in the fundus that tend to disappear in the antrum. Alterations in the thickness or echogenicity of individual layers are easily and reproducibly identified.

Gastric wall layers are best seen in the water-filled stomach, and cancer is seen as a hypoechoic disruption. T1 tumor (invasion of the lamina propria or submucosa) is seen as a disruption of the first three layers (Fig 2a, 2b). T2 tumor (invasion of the muscularis propria) is seen as invasion of the fourth layer (Fig 3a). T3 (tumor invasion of the serosa) is seen as penetration through the fifth layer (Fig 4a). T4 tumor is seen as invasion of adjacent organs and structures (Fig 5a).

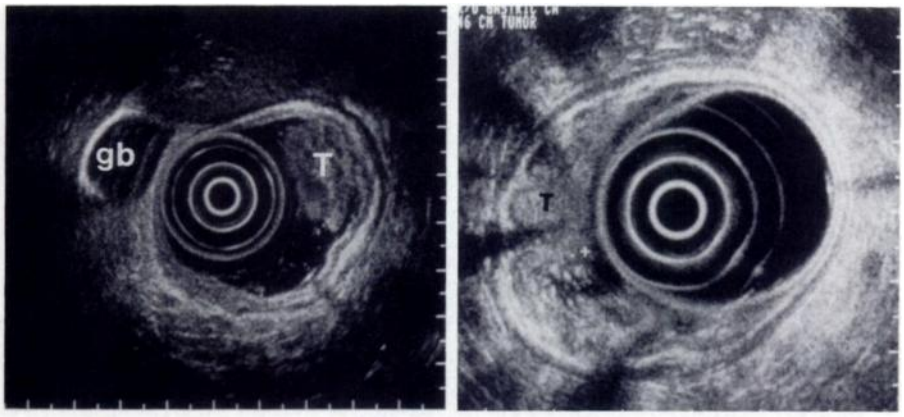
Lymph nodes are considered malignant if they appear round and hypoechoic or round and have an echogenic pattern similar to that of the primary tumor (Figs 6, 7a, 8a). The AJCC defines two types of regional nodal involvement in gastric cancer: N1 is defined as metastasis in perigastric lymph nodes within 3 cm of the tumor margin (Fig 7a). N2 is defined as metasta-

Table 1
AJCC Staging of Gastric Cancer

Tissue/Symbol	Stage	Criterion
Primary tumor/T		
	TX	Primary tumor cannot be assessed
	T0	No evidence of primary tumor
	Tis	Carcinoma in situ: intraepithelial tumor without invasion of the lamina propria
	T1	Tumor invades lamina propria or submucosa
	T2	Tumor invades the muscularis propria or the subserosa
	T3	Tumor penetrates the serosa (visceral peritoneum) without invasion of adjacent structures
	T4	Tumor invades adjacent structures
Regional lymph node/N		
	NX	Regional lymph nodes cannot be assessed
	N0	No regional lymph node metastasis
	N1	Metastasis in perigastric lymph node(s) within 3 cm of the edge of the primary tumor
	N2	Metastasis in perigastric lymph node(s) more than 3 cm from the edge of the primary tumor, or in lymph nodes along the left gastric, common hepatic, splenic, or celiac arteries*
Distant metastasis/M		
	MX	Presence of distant metastasis cannot be assessed
	M0	No distant metastasis
	M1	Distant metastasis†

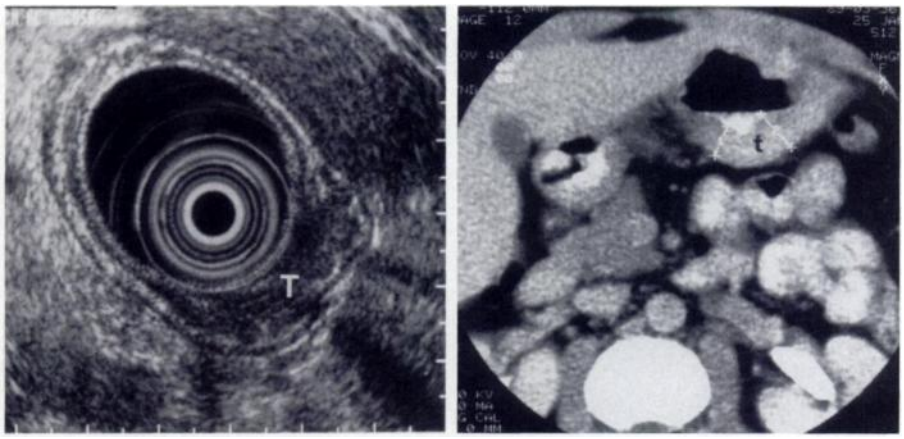
* Regional lymph nodes include perigastric lymph nodes not otherwise specified and those along the inferior (right) gastric, splenic, superior (left) gastric, celiac, and hepatic arteries. All other lymph nodes, including retropancreatic, hepatoduodenal, aortic, portal, retroperitoneal, and mesenteric nodes, are considered distant.

† The most common sites of metastases include the liver, lungs, supraclavicular lymph nodes, and widespread intraperitoneal sites.



a. b.

Figure 2. **(a)** Endosonogram of T1 antral tumor (*T*). Notice invasion of mucosa. *gb* = gallbladder. **(b)** Endosonogram of T1 gastric body tumor (*T*). Such tumors can be very bulky, as in this case. Notice that, despite the size of the tumor, only the mucosa is invaded.



a. b.

Figure 3. **(a)** Endosonogram of T2 antral tumor (*T*). Notice the involvement of the first three layers but not of the muscularis propria. **(b)** CT scan shows T1–T2 tumor (*t*) that does not extend beyond the serosa.

Table 2
Stage Grouping in the TNM System

Stage	Tumor	Node	Metastasis
0	Tis	N0	M0
IA	T1	N0	M0
IB	T1	N1	M0
	T2	N0	M0
II	T1	N2	M0
	T2	N1	M0
	T3	N0	M0
IIIA	T2	N2	M0
	T3	N1	M0
	T4	N0	M0
IIIB	T3	N2	M0
	T4	N1	M0
IV	T4	N2	M0
	Any T	Any N	M1

sis in perigastric lymph nodes more than 3 cm from the tumor margin or in lymph nodes along the left gastric, common hepatic, splenic, or celiac arteries (Fig 8a). Tumor in lymph nodes outside these areas is considered metastatic (M1).

We routinely scan the left hepatic lobe for the presence of metastasis (Fig 9a). The right hepatic lobe cannot be evaluated in its entirety with this modality.

Dynamic CT of the Chest and Abdomen

Dynamic CT was performed with approximately 150–200 mL of 60% iodinated contrast material injected through a 20-gauge plastic catheter placed in a vein of the antecubital fossa. Injection was performed with commercially available injectors (Mark V; Medrad, Pittsburgh) at a rate of 1.0 mL/sec for the first 60 seconds and then at a rate of 0.7 mL/sec for the duration of the injection. Patients also received 200 mL of diluted diatrizoate meglumine (Gastrografin; Bristol-Myers Squibb, Princeton, NJ). It has been our experience over the years that patients with gastric cancer tolerate less than optimal doses of orally administered contrast material because they usually develop nausea and vomiting with larger doses. To standardize the dose, we decided not to exceed these amounts. Ten-millimeter-thick contiguous sections were acquired in the dynamic mode, beginning at the level of the iliac crest inferiorly to the level of the thoracic inlet superiorly. Patients underwent scanning with a commercially available unit (1200 SX: Picker International, Highland Heights, Ohio; or GE 9800: GE Medical Systems, Milwaukee).

The thickness of the gastric wall varies considerably at CT, depending on the degree of distensibility. To standardize distensibility, all patients in this study drank the diatrizoate meglumine while sitting on the CT table with the equipment ready to scan. No differentiation between T1 and T2 tumors is possible with CT; thus, T1 and T2 involvement was defined as thickness greater than 1 cm, excluding folds, or exceeding by 50% that of the opposite wall, and the serosa had to appear intact (Fig 3b). T3 lesions showed these same characteristics, but with serosal irregularities or extension beyond the serosa without involvement of surrounding structures (Fig 4b). T4 lesions were defined by means of invasion of surrounding structures (Fig 5c).

Lymph nodes were considered positive if they exceeded 10 mm in diameter. Nodes less than 10 mm in diameter were considered negative. The lymphatic drainage areas examined were identical to those examined at endoscopic US (Figs 7b, 8b).

Distant metastases were defined according to AJCC criteria (Table 1).

Surgery

All patients underwent exploration and resection of their primary gastric tumor with perigastric lymph node resection. Forty-six patients underwent total gastrectomy; four underwent partial gastrectomy. Any other suspect lymph nodes present (palpable, firm) were also removed at surgery. Wherever direct invasion of surrounding structures—omentum, pancreas, or the left hepatic lobe—was detected, these were also dissected in continuity. If metastasis was present within the abdomen, biopsy was performed at the time of surgery.

Pathologic Examination

All resected specimens of the primary tumor were examined with special attention to wall invasion. Specimens resected at total gastrectomy had 18–22 nodes; at partial gastrectomy, eight to 12 nodes. The diameters of resected nodes proved malignant with pathologic examination ranged from 0.2 to 3.1 cm.

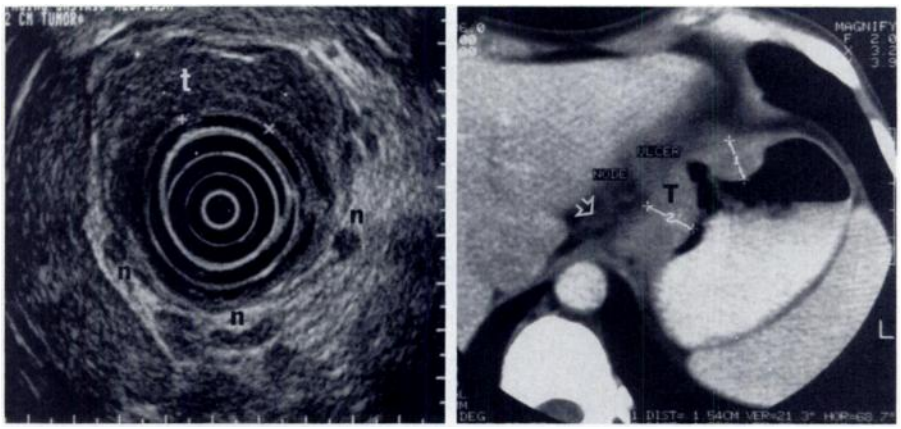
Statistical Methods

The percentage of cases in which the findings at endoscopic US and dynamic CT were in agreement or concordant with the pathologic classification is given for T, N, and stage in Tables 3–5. A 95% confidence interval (CI) about the percentage of concordant findings is also given. The McNemar test (15,16) for matched pairs with continuity correction was used to assess whether the percentage of cases

concordant with the pathologic classification differed for findings based on endoscopic US versus those based on dynamic CT. These statistical comparisons were based on the 33 patients who underwent both endoscopic US and dynamic CT. Also, in our determination of whether endoscopic US and CT differ with respect to concordance for T, the categories of T1 and T2 were combined because CT cannot enable differentiation between T1 and T2.

The McNemar χ^2 test (16) for matched pairs with continuity correction was also used to test whether a significant difference existed in direction, either overstaging or understaging, in the patients in whom findings at endoscopic US were discordant with findings at pathologic classification. Similar assessments were made for dynamic CT.

The McNemar test gave similar results as the exact test for the binomial distribution testing ($P = .5$); only the McNemar results are given in the text.



a. b.

Figure 4. **(a)** Endosonogram of T3 body tumor (*t*). Note invasion of all layers but absence of invasion of adjacent organs. Small nodes (*n*) (3–5 mm in diameter) are round and hypoechoic. **(b)** CT scan shows T3 body tumor (*T*) that extends beyond the serosa. Note ulcer crater (*ULCER*) as well as small nodes (*NODE*) (3–5 mm in diameter) that cannot be characterized. *L* = left.

RESULTS

Depth of Tumor Penetration

In 46 of 50 patients with gastric cancer (92%) (Table 3), findings at endoscopic US were concordant with pathologic findings for T (95% CI = 84%, 100%). When T1 and T2 classifications were combined, findings at endoscopic US were concordant with pathologic findings for T in 47 of 50 patients (94%) (95% CI = 87%, 100%). In the subset of patients who underwent both endoscopic US and CT, findings at endoscopic US were concordant with pathologic findings for T in 30 of 33 patients (91%) (95% CI = 81%, 100%). In contrast, CT findings were concordant with pathologic findings for T in only 14 of 33 patients (42%) (95% CI = 25%, 59%). A significant difference exists in the percentage of patients with findings at endoscopic US concordant with findings at pathologic examination (91%) and the percentage of patients with findings at endoscopic US concordant with findings at dynamic CT (42%) ($P < .00042$).

Findings at endoscopic US were concordant with pathologic findings in 11 of 12 T1 and T2 tumors (92%), in 30 of 31 T3 tumors (97%), and six of seven T4 tumors (86%) (Table 3). Findings at endoscopic US did not cause significant overstaging (one case only) or understaging (three cases only) of T in relation to pathologic findings ($P < .62$). Findings in four of eight T1 or T2 tumors (50%), seven of 19 T3 tumors (37%), and three of six T4 tumors (50%) at dynamic CT were concordant with findings at pathologic examination. Fourteen cases were understaged and five were understaged, but this difference was not statistically significant ($P < .07$).

Regional Lymph Node Metastasis

In 39 of 50 patients (78%; CI = 67%, 89%), findings at endoscopic US were concordant with findings at pathologic examination of regional lymph nodes (Table 4); in 25 of the 33 patients who underwent CT and endoscopic US (76%) (95% CI = 61%, 91%), findings at endoscopic US were concordant with findings at pathologic examination of regional lymph nodes. In 16 of 33 patients who underwent CT (48%) (95% CI = 31%, 65%), CT findings were concordant with pathologic findings for N, a result significantly different from that obtained with endoscopic US ($P < .038$).

Findings at endoscopic US were concordant with findings at pathologic examination in 10 of 11 N0 tumors (91%), 15 of 22 N1 tumors (68%), and 14 of 17 N2 tumors (82%). A significant difference exists ($P < .016$) in understaging (10 cases) versus overstaging (one case) for N by means of endoscopic US compared with such staging by means of pathologic examination. Findings at dynamic CT were concordant with findings at pathologic examination in three of five N0 tumors (60%), seven of 17 N1 tumors (41%), and six of 11 N2 tumors (54%); 12 cases were understaged, and five were overstaged ($P < .147$).

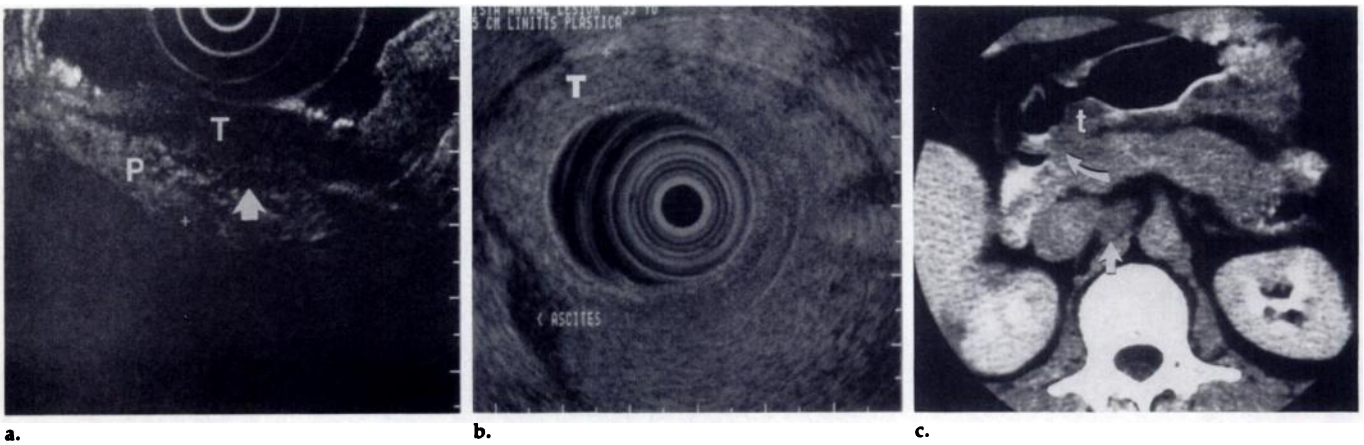
Distant Metastasis

With endoscopic US, the findings were in concordance with those at pathologic examination in staging M for 92% (46 of 50 distant metastases; 95% CI = 84%, 100%). In one patient, a metastasis with a diameter of 1.0 cm in the left lobe of the liver was detected with endoscopic US. In one patient with peritoneal metastases without ascites, distant metastases was understaged. With dynamic CT, the concordance in staging M was 79% (26 of 33 patients; 95% CI = 65%, 93%); this was not different from the concordance obtained with endoscopic US ($P < .23$). Overstaging occurred in four patients and understaging in three patients by use of dynamic CT.

Stage

Findings at endoscopic US were concordant with findings at pathologic examination for stage in 39 of 50 patients (78%) (95% CI = 67%, 89%). In the subset of patients who underwent both endoscopic US and CT, the concordance was 73% (24 of 33 patients; 95% CI = 61%, 85%). When T1 and T2 were combined, the concordance was the same in the 39 patients (78%) (95% CI = 67%, 89%). Findings at CT were concordant with findings at pathologic examination for stage in 15 of 33 patients (45%), and a significant difference ($P < .018$) in concordance with pathologic findings existed between staging with endoscopic US and staging with CT.

Findings at endoscopic US were concordant with pathologic findings in 15 of 16 patients with stage I or stage II tumors (94%), 19 of 25 patients with stage III tumors (76%), and five of nine patients with stage IV tumors (56%). Tumors were understaged in 10 patients and overstaged in one



a. b. c.

Figure 5. **(a)** Endosonogram shows large T4 antral tumor (*T*) invading (arrowhead) head of pancreas (*P*). **(b)** Endosonogram shows linitis plastica. Notice complete circumferential invasion of all layers (*T*) as well as the presence of ascites. **(c)** CT scan shows T4 antral tumor (*t*) invading the head of the pancreas (curved arrow). Note interaortocaval node (straight arrow).

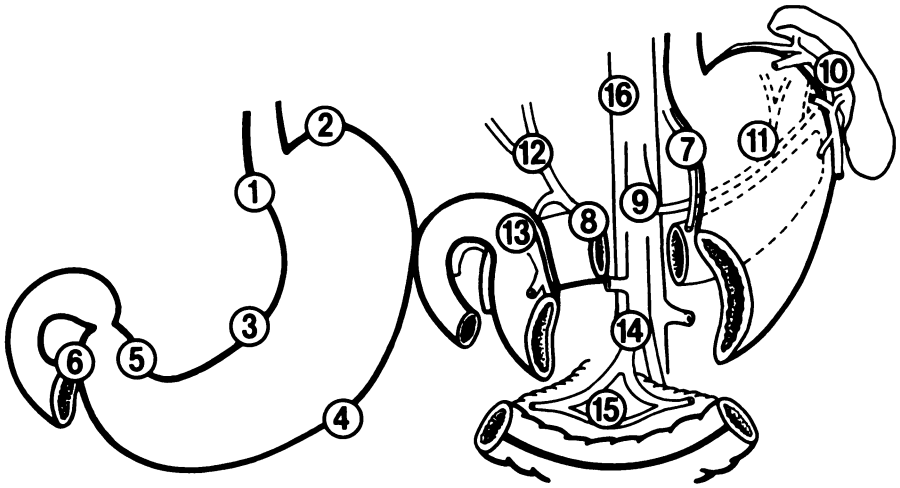
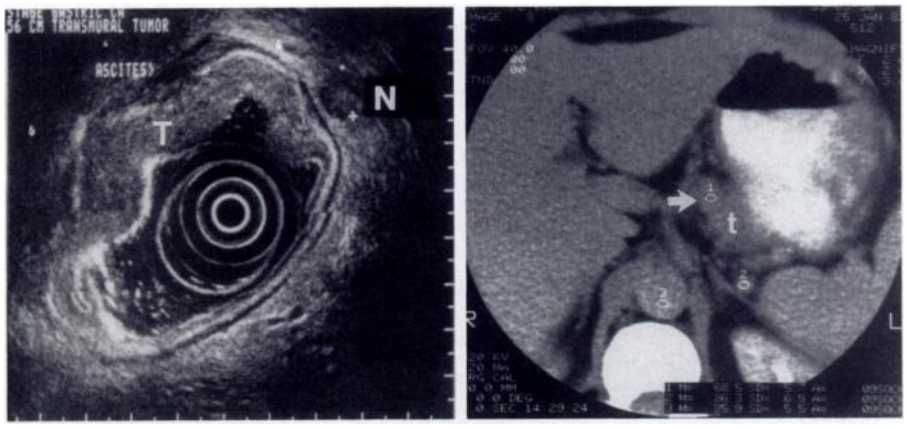


Figure 6. Lymphatic drainage of the stomach. Endosonography can enable evaluation of all the areas depicted except for the mesentery (*15*) and omentum. *1–6* = perigastric nodes, *7* = gastrohepatic nodes, *8* = common hepatic artery nodes, *9* = celiac axis nodes, *10* = splenic hilum nodes, *11* = splenic artery/vein nodes, *12* = porta hepatis nodes, *13* = periduodenal nodes, *14* = superior mesenteric artery nodes, *15* = mesenteric nodes, *16* = crural nodes.



a. b.

Figure 7. **(a)** Endosonogram shows round, hypoechoic N1 node (*N*) within 3 cm of a T3 tumor (*T*). **(b)** CT scan shows N1 node (arrow) within 3 cm of tumor (*t*). Ovals indicate attenuation readings of node (*1*), aorta (2), and splenic artery (3).

patient ($P < .016$). CT findings were concordant with pathologic findings in six of 11 patients with stageI or stage II tumors (54%), seven of 15 patients with stage III tumors (47%), and two of seven patients with stage IV tumors (29%). No significant difference existed in understaging (12 patients) or overstaging (six patients) ($P < .24$).

When endoscopic US and CT findings were combined, tumors in 24 of 33 patients (73%) were correctly staged. This concordance with pathologic findings is significantly different than that obtained with CT staging alone ($P < .028$) (Table 5).

DISCUSSION

The development of an accurate, reproducible method of staging gastric cancer has proved to be an elusive goal. Accurate staging is important in planning the most appropriate therapy, allows the study of the natural history of the disease, and permits comparison of results of different treatments.

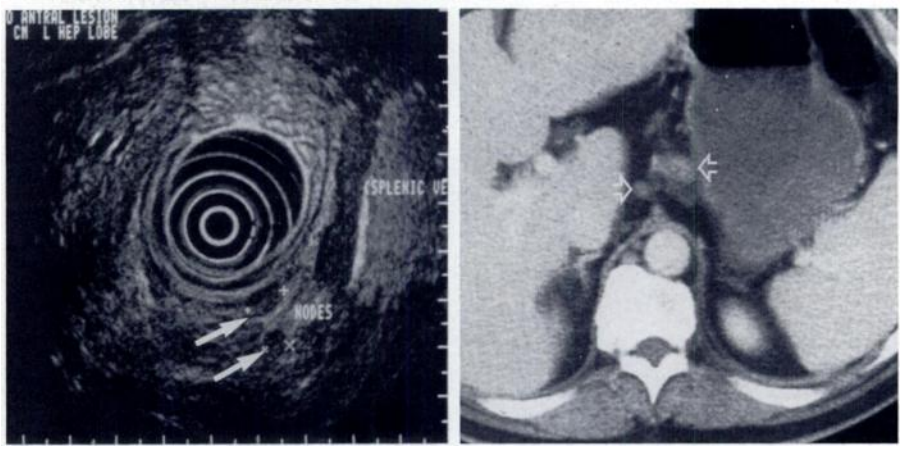
Preoperative staging of gastric cancer has undergone a rapid transformation in recent years. The traditional approach of the barium upper gastrointestinal series has given way to double-contrast studies with a significant increase in the ability to detect early tumors. Concurrent development of gastrointestinal endoscopy and CT added new dimensions to the evaluation of gastric cancer and, in the case of CT, involvement of lymph nodes and distant metastases (17–21). The introduction of MR imaging has not yet improved the ability to stage gastric cancer (11). The major pitfall common to all of these modalities is their incapacity to enable evaluation of the degree of penetration of the tumor into the gastric wall. In early studies of the TNM classification reported by Kennedy in 1970, it was demonstrated that the degree of

invasion of the gastric wall correlated strongly with survival (22).

The high resolution of the individual layers of the gastrointestinal wall seen with endoscopic US is a direct result of the relatively high frequencies used (7.5 and 12 MHz). To increase the depth of their field of view, most endorectal and transvaginal probes have single-frequency transducers that usually operate between 3.5 and 6.0 MHz. The GF-UM3 system (Olympus) has two console-switchable high-frequency (7.5- and 12-MHz) transducers that allow excellent near field of view as well as a reasonable resolution of deeper structures up to 7 cm from the transducer axis. This has improved staging of depth of wall penetration by cancer compared with that at CT and MR imaging, neither of which enables evaluation of individual layers of the gastrointestinal wall. Endoscopic US depicts a five-layer structure in evaluation of the stomach, which is enhanced by filling the gastric lumen with water (23–26). The degree of tumor penetration into each layer can be documented as a focal disruption (27,28). As seen in Table 3, endoscopic US enabled correct staging of four of five T1 tumors, six of seven T2 tumors, 30 of 32 T3 tumors, and six of six T4 tumors.

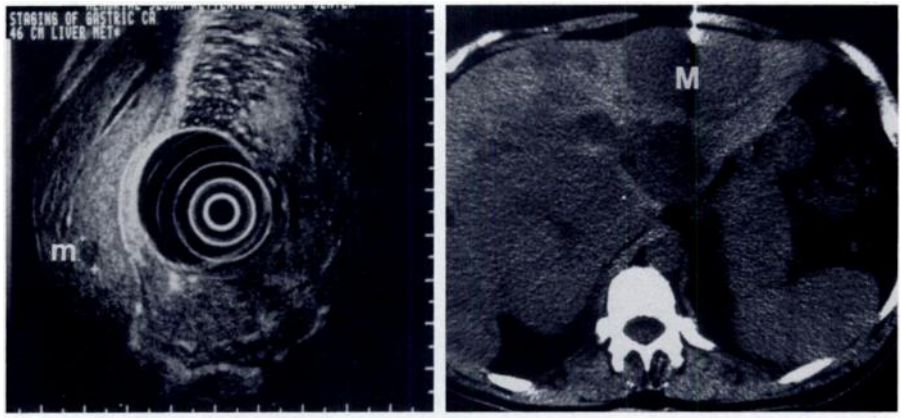
Multiple parameters in the appraisal of lymph nodes can be evaluated with high-frequency endoscopic US (29). Nodes can usually be differentiated from vessels or bowel loops by means of real-time imaging. If a lymph node is round, a high suspicion of malignancy exists; if elongated, a low suspicion exists. The internal echo pattern is important. Low echogenicity indicates high suspicion for most adenocarcinomas, whereas high echogenicity indicates low suspicion for tumor invasion. Nodal size, even though most commonly used in CT and MR imaging to differentiate benign nodes from malignant nodes, has proved to be a less reliable criterion. It is not uncommon for reactive or inflammatory nodes to be larger than 1 cm in diameter. In fact, our only error in overstaging nodes occurred in round nodes greater than 2 cm in diameter. In retrospect, the internal echo pattern was hyperechoic, which might have alerted us to their benign reactive or inflammatory nature. We tended to understage nodal involvement because of two factors. Small nodes (those less than 3 mm in diameter) are still difficult to see and characterize with endoscopic US. Also, we tend to be conservative in staging nodes, preferring to understage rather than overstage them so as not to deter an attempt at potentially curable resection.

The evaluation of distant metastasis with endoscopic US is necessarily limited. Endoscopic US can enable assessment of a maximum radius of only 7 cm immediately surrounding the bowel



a. b.

Figure 8. **(a)** Endosonogram shows N2 nodes (arrows) along the greater curve (9 mm in diameter) and celiac axis (5 mm in diameter), respectively, that are round and hypoechoic. **(b)** CT scan shows multiple small N2 nodes (arrows), all less than 5 mm in diameter, along the gastrohepatic ligament, crura, and porta hepatis. Except for their large number, these nodes are difficult to characterize.



a. b.

Figure 9. **(a)** Endosonography is poor at enabling detection of M1 metastasis. Only metastasis (*m*) in the left hepatic lobe and medial aspect of the right hepatic lobe may be detected. **(b)** Confirmation of metastatic disease (*M*) is aggressively sought with biopsy.

lumen. Therefore, a large part of the right hepatic lobe, as well as retroperitoneal and mesenteric nodes below the level of the superior mesenteric artery within the abdomen, and the lung parenchyma and supraclavicular space above the diaphragm will not be covered by this diagnostic procedure. The fact that we obtained good correlation with pathologic examination for M by means of endoscopic US most likely reflects methodologic artifact due to patient selection. Patients with obvious metastases in supraclavicular lymph nodes, the liver, or lungs were not referred for preoperative evaluation. The detection of a small amount of ascites with endoscopic US was assumed to indicate the presence of peritoneal metastases, and this assumption was correct in three of four patients. Further studies may confirm this interesting finding.

Although endoscopic US is limited in staging for M, its strength lies in the examination for T, in which it proved significantly better than CT in concordance with findings at pathologic examination (92% vs 42%; $P < .00042$), and for N, in which the concordance was significantly better than that of CT (78% vs 48%; $P < .038$). When endoscopic US and CT were combined, the concordance for overall stage was 73%, a significant improvement over the 45% concordance of CT alone ($P < .028$). In our study, no statistically significant difference existed in staging of tumors by means of location (the fundus, body, or antrum).

Furthermore, the procedure takes an average of 30 minutes (range, 20–40 minutes) and is performed immediately after a conventional endoscopic examination. No complications resulted from the procedure.

Endoscopic US appears to be an important advance in the clinical staging of gastric cancer, with potential value in

Table 3

Depth of Tumor Invasion in Gastric Cancer: Concordance of Endoscopic US Findings versus Dynamic CT Findings with Pathologic Classification

Pathologic Classification of Tumor	Endoscopic US					Dynamic CT				
	T0	T1	T2	T3	T4	T0	T1	T2	T3	T4
T0										
T1		4*						1†	1	
T2		1	6*	1		2	1†	2†	1	
T3			1	30*		1		8	7†	3
T4				1	6*				3	3†

Note.—Numbers are number of tumors.
* Findings were concordant in 46 of 50 tumors (92%).
† Findings were concordant in 14 of 33 tumors (42%). $P < .00042$ in 33 patients who underwent endoscopic US and dynamic CT.

Table 4

Regional Lymph Node Metastasis in Gastric Cancer: Concordance of Endoscopic US Findings versus Dynamic CT Findings with Pathologic Classification

Pathologic Classification of Nodes	Endoscopic US			Dynamic CT		
	N0	N1	N2	N0	N1	N2
N0	10*	0	1	3†	0	2
N1	7	15*		7	7†	3
N2	1	2	14*	2	3	6†

Note.—Numbers are number of lymph node metastases.
* Findings were concordant in 39 of 50 lymph nodes (78%).
† Findings were concordant in 16 of 33 lymph nodes (48%). $P < .038$ in 33 patients who underwent endoscopic US and dynamic CT.

Table 5

Tumor Stage in Gastric Cancer: Concordance of Endoscopic US and Dynamic CT Findings versus Dynamic CT Findings Alone with Pathologic Classification

Pathologic Classification of Tumor Stage	Endoscopic US and Dynamic CT					Dynamic CT				
	0	I	II	III	IV	0	I	II	III	IV
0										
I		3*					2†	1†		
II			7*	1		2	3†		2	1
III		1	4	10*		1	3	1	7†	3
IV				3	4*			1	4	2†

Note.—Numbers are number of tumors.
* Findings were concordant in 24 of 33 tumors (73%).
† Findings were concordant in 15 of 33 tumors (45%). $P < .028$.

guiding management decisions and facilitating research to improve outcome in this highly lethal disease. Currently we are performing a trial of neoadjuvant chemotherapy for patients with T3, T4, or any N-stage tumors on the basis of preoperative staging with endoscopic US. ■

Acknowledgments: The authors thank Robert T. Heelan, MD, and James Caravelli, MD, for their continued support, and Ronald A. Castellino, MD, for his thoughtful comments on the manuscript. We dedicate this article to the memory of Robin C. Watson, MD.

References

1. Lawrence W Jr. Gastric cancer. CA 1986; 36: 216–236.
2. Boring CC, Squires TS, Tong T. Cancer statistics 1991. CA 1991; 41:19–36.
3. Dehn TC, Reznek RH, Nockler IB, White FE. The pre-operative assessment of advanced gastric cancer by computed tomography. Br J Surg 1984; 71:413–417.
4. Cassell P, Robinson JO. Cancer of the stomach: a review of 854 patients. Br J Surg 1976; 63:603–607.
5. Costello CB, Taylor TV, Torrance B. Personal experience in the surgical management of carcinoma of the stomach. Br J Surg 1977; 64:47–51.
6. Lundh G, Burn JI, Kolig G, et al. A co-operative international study of gastric cancer (under the auspices of the International Federation of Surgical Colleges). Ann R Coll Surg Engl 1974; 54:219–228.
7. Halvorsen RA, Thompson WM. Computed tomographic staging of gastrointestinal malignancies. I. Esophagus and stomach. Invest Radiol 1987; 22:2–16.
8. Kleinhaus U, Militianu D. Computed tomography in the preoperative evaluation of gastric carcinoma. Gastrointest Radiol 1988; 13:97–101.
9. McFee AS, Aust JB. Gastric carcinoma and the CT scan (editorial). Gastroenterology 1981; 80:196–198.
10. Sussman SK, Halvorsen RA, Illescas FF, et al. Gastric adenocarcinoma: CT versus surgical staging. Radiology 1988; 167:335–340.
11. Winkler ML, Hricak H, Higgins CB. MR imaging of diffusely infiltrating gastric carcinoma. J Comput Assist Tomogr 1987; 11:337–339.
12. Laniado M, Kornmesser W, Hamm B, et al. MR imaging of the gastrointestinal tract: value of Gd-DTPA. AJR 1988; 150:817–821.
13. American Joint Committee on Cancer. Manual for staging cancer. Philadelphia: Lippincott, 1988; 69–74.
14. Kimmey MB, Martin RW, Haggitt RC, Wang KY, Franklin DW, Silverstein FE. Histologic correlates of gastrointestinal ultrasound images. Gastroenterology 1989; 96:433–441.
15. Dwyer AJ. Matchmaking and McNemar in the comparison of diagnostic modalities. Radiology 1991; 178:328–330.
16. Armitage P, Berry G. Statistical methods in medical research. 2nd ed. Oxford, England: Blackwell Scientific, 1987; 120–123.
17. Schein PS, Levin B. Neoplasms of the stomach. In: Berk JE, Haubrich WS, Kasler MH, et al, eds. Medical oncology: basic principles and clinical management of cancer. New York: Macmillan, 1985; 806.
18. Shirabake H, Maruyama M. Neoplastic disease of the stomach. In: Margulis AR, Burhenne HJ, eds. Alimentary tract radiology. 3rd ed. St Louis: Mosby, 1983; 721.
19. Gelfand DW, Ott DJ. Single vs double-contrast gastrointestinal studies: critical analysis of reported statistics. AJR 1981; 137:523–528.
20. Kurtz RC, Lightdale CJ, Winawer SJ, Sherlock P. Endoscopy and gastrointestinal neoplasia: diagnosis and management. Curr Probl Cancer 1980; 5:45–48.
21. Komaiko MS. Gastric neoplasm: ultrasound and CT evaluation. Gastrointest Radiol 1979; 4:131–137.
22. Kennedy BJ. TNM classification for stomach cancer. Cancer 1970; 26:971–983.
23. Botet JF, Lightdale CJ. Endoscopic sonography of the upper gastrointestinal tract. AJR 1991; 156:63–68.
24. Nakazawa S, Sugiyama H, Kimoto E, Naito Y. Specifications of endoscopic ultrasonography. Scand J Gastroenterol 1984; 19(suppl 94):1–6.
25. Tanaka Y, Yasuda K, Aibe T, et al. Anatomical and pathological aspects in ultrasonic endoscopy for GI tract. Scand J Gastroenterol 1984; 19(suppl 94):43–50.
26. Aibe T, Fuji T, Okita K, Takemoto T. A fundamental study of normal layer structure of the gastrointestinal wall visualized by endoscopic ultrasonography. Scand J Gastroenterol 1986; 21(suppl 123):6–15.
27. Tio TL, Coene PPLO, Schouwink MH, Tytgat GNJ. Esophagogastric carcinoma: preoperative TNM classification with endosonography. Radiology 1989; 173:411–417.
28. Bolondi L, Casanova P, Caletti GC, Grigioni W, Zani L, Barbara L. Primary gastric lymphoma versus gastric carcinoma: endoscopic US evaluation. Radiology 1987; 165:821–826.
29. Tio TL, den Hartog Jager FCA, Tytgat GNJ. The role of endoscopic ultrasonography in assessing local resectability of oesophagogastric malignancies: accuracy, pitfalls, and predictability. Scand J Gastroenterol 1986; 21(suppl 123):78–86.