Recent Advances in Radiology for the Diagnosis of Gastric Carcinoma

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Introduction

Radiographic diagnosis of gastric carcinoma [1] was first introduced in the 1960s in Japan, which led the world in the early diagnosis of gastric carcinoma by double-contrast method using film-screen systems (FSS) [2,3]. Qualitative diagnostics, including diagnosis of the depth of tumor invasion, were explored thoroughly in the 1970s, and it could be claimed that the radiographic diagnosis of gastric carcinoma was completely established by the beginning of the 1980s [4]. Gastric radiography has now become a standard examination modality in the screening and preoperative staging of gastric carcinoma and is widely used across the globe. The mortality rate from gastric carcinoma is especially high in Japan, and gastric radiography has made a substantial contribution to the detection of gastric carcinoma in mass screening. With recent advances in endoscopic techniques, the primary role in the diagnosis of gastric carcinoma, including its early diagnosis, has been inherited by endoscopy, but it is also a fact that radiography is still widely used in clinical diagnosis in screening and preoperative staging [5]. The demand for computerization of medical information grew in the 1980s, and against a background of advances in image engineering, the digitalization of medical images has proceeded apace [6,7]. In gastric radiography, too, digitalization via digital radiography (DR) using high-resolution charge-coupled device (CCD) cameras (CCD-DR) has been established and disseminated rapidly, and we also have reported its usefulness in the diagnosis of gastric carcinoma [8]. Meanwhile, a recent major development in the field of radiology has been the emergence of multidetector row computed tomography (CT) (MDCT) [9]. With the advent of MDCT in the second half of the 1990s, CT has achieved increased efficiencies and improved image quality in a revolutionary scanning modality [10]. In the preoperative staging of gastric carcinoma, it is now possible to accurately evaluate local inva-

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sion and small metastases, and three-dimensional (3D) MDCT imaging (MDCT gastrography) has arrived on the scene as a new diagnostic tool for primary lesions.

In this chapter, we describe the present status of radiologic diagnosis of gastric carcinoma using CCD-DR at our center, report our experience of MDCT gastrography in the preoperative staging of gastric carcinoma, and discuss the future prospects for radiographic diagnosis of gastric carcinoma using these new diagnostic techniques.

Advanced Digital Radiographic Systems for Gastric Diagnosis

In our hospital, images yielded by radiography of the gastrointestinal tract became completely digitalized with the adoption of CCD-DR (DR-2000H; Hitachi Medical, Tokyo, Japan) in 1999. At present, hard copies of diagnostic images are prepared for interpretation, but monitor-based diagnosis is yet to become a reality. Our radiographic investigations of the gastrointestinal tract use three CCD-DR systems: one C-arm type, one over-tube type, and one under-tube type. Each CCD-DR is connected by a DR network to two laser printers and an image server, and in parallel with the scanning procedure, reference images are forwarded to the hospital information system via a gateway after DICOM (digital imaging and communication in medicine) conversion at the same time as the diagnostic images are processed. After DICOM

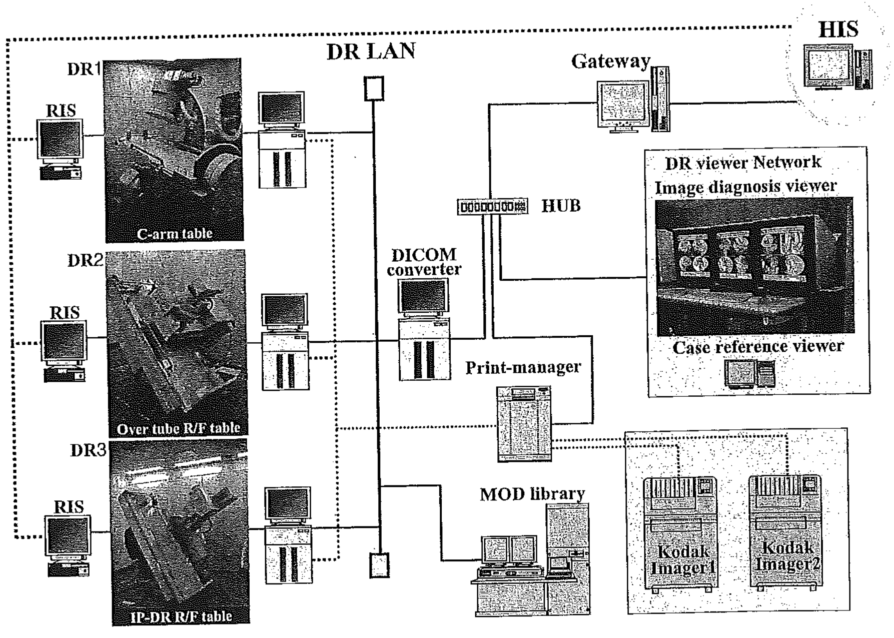

FIG. 1. Advanced digital radiography system for gastric diagnosis. Three charge-coupled device-digital radiography (CCD-DR) units are routinely used for gastric examinations in our hospital. Each unit connects with a DR network, and the images can be diagnosed on an image workstation

conversion, the images are accessible for monitor diagnosis at an image workstation with three viewers (Fig. 1).

The Status of CCD-DR-Based Radiographic Examination of Gastric Carcinoma

At our center, we use 250–300 ml barium at a 130–140 w/v% concentration in gastric radiographic studies. The scanning methods employed are the filling method, double-contrast radiography, and the compression method, but the core diagnostic technique in radiographic diagnosis of gastric carcinoma is double-contrast imaging obtained with barium (positive contrast medium) and gas (negative contrast medium). After barium is swallowed, the patient is given 5 g of a foaming agent, and by distending the stomach via the CO_2 gas so produced, we are able to easily obtain double-contrast images. The barium contained in the gas-distended stomach moves with changes in posture, and double-contrast images of excellent quality are obtained by ensuring that the barium adheres uniformly to the mucosal surfaces. Unlike the filling and compression methods, double-contrast imaging is indispensable for the visualization of early gastric carcinoma, which is characterized by few irregularities of the mucosal surfaces (Fig. 2). With gastric radiography based on the double-contrast method, we can easily identify the macroscopic types of gastric carcinomas, their exact extensions and locations in the stomach (Figs. 3–6). However, viewing double-contrast images obtained with contrast provided by gas and barium requires a broad dynamic range. The dynamic range for CCD-DR images adequately covers the image quality required for gastric radiography, and the image quality matches that in conventional FSS. Additionally, CCD-DR digital images also enable the optimization of image quality via image processing after scanning and, compared with FSS, are relatively well matched image by image and allow standardized diagnostic images to be obtained.

Comparative Evaluation of FSS and CCD-DR in the Diagnosis of Gastric Carcinoma

We conducted a prospective study to evaluate the difference in diagnostic accuracy between FSS and CCD-DR, and reported in a publication of *Radiology* [8]. From January to February 1997, we randomly assigned patients scheduled for gastric radiography to either FSS or CCD-DR; 112 patients were examined by FSS and 113 by CCD-DR. Six radiologists who were blinded to the clinical details assessed the films for each patient with a six-level confidence rating for the presence or absence of gastric carcinoma. The CCD-DR images in this study were prepared as hard copies for diagnosis. The diagnoses for each patient were rated against those produced by three other radiologists who conducted the actual radiographic examinations and were aware of all clinical data, such as endoscopic findings and the pathology of biopsy specimens. The sensitivity and specificity of FSS and CCD-DR for gastric carcinoma were determined from the assessments obtained, the difference between the two modalities was statistically analyzed, and a comparison was performed by receiver-operating characteristic (ROC) analysis. The study yielded a diagnosis of gastric carcinoma by FSS in 24 patients and by CCD-DR in 27 patients; the sensitivity for diagnosing the presence of gastric carcinoma was 64.6% and 75.3%, respectively

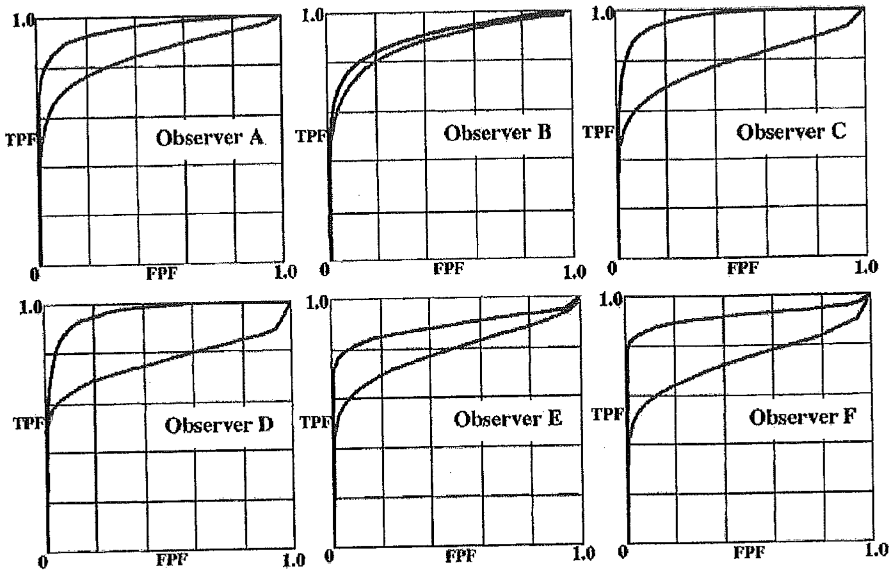

FIG. 7. Receiver operating characteristic (ROC) curves obtained from six observers. All observers achieved more accurate results with CCD-DR than with conventional radiography. Diagnostic accuracy of CCD-DR is clearly superior to that of conventional radiography. (Used with permission from Radiological Society of North America)

($P = 0.278$), and the specificity was 84.5% and 90.5%, respectively ($P = 0.011$). The ROC analysis [11] also showed that the diagnostic performance of CCD-DR was clearly superior (Fig. 7).

Usefulness of Radiography of Gastric Carcinoma by CCD-DR

The diagnostic performance of CCD-DR for gastric carcinoma is adequately comparable to that of FSS, indicating that the digitalization of images in gastric radiography is entirely feasible. The future adoption of diagnosis by monitor display will make possible the real-time display and optimization of diagnostic images and enable greater ease of image storage and retrieval. Capitalizing on these advantages of digitalization promises to yield an efficient and effective diagnostic environment for screening and preoperative staging, as compared with the conventional FSS modality.

Preoperative Evaluation of Gastric Carcinoma Using MDCT

To date, the role of radiographic CT studies in the preoperative staging of gastric carcinoma has primarily involved evaluating invasion of surrounding organs or metastasis to lymph nodes or other organs, and it was rare for it to be used for evaluation of the primary tumor itself [12,13]. However, the advent of MDCT has made possible the arrival of full-scale volume scans, facilitating high-speed, detailed image acquisition over an extensive area. The degree of resolution of CT images has improved dramatically with MDCT, enabling the detailed evaluation of local lesions and the detection of small metastases, even in ordinary axial images [14]. Moreover, workstations that are capable of processing the massive quantities of image data produced by MDCT have been developed, and the three-dimensional CT visualization of gastric lesions, which is called MDCT gastrography, has become straightforward. This trend is fairly flourishing in the diagnosis of colorectal cancer as MDCT colonography, which is considered to have a great potential of being a modality for colorectal cancer screening [15–17].

Three-Dimensional Visualization of the Stomach by MDCT Gastrography

To visualize gastric lesions in three dimensions using MDCT, it is necessary to distend the gastric lumen with a foaming agent (CO_2 gas). As a consequence of the contrast between the gas and the inner gastric surface, owing to the substantial difference in density, it is possible to effortlessly prepare 3D images of the inner gastric surface. MDCT gastrography employs two methods for visualization, virtual endoscopic views and 3D gas insufflation views, obtained by 3D processing of the CT image data (Fig. 8).

Evaluation of the Detectability of Gastric Carcinoma by MDCT Gastrography

In the 3-month period between March and June 2003, we evaluated 4-row MDCT (Aquilion; Toshiba Medical Systems, Tokyo, Japan) in 84 gastric carcinoma patients who underwent MDCT for preoperative staging. Each scan was performed with the standard abdominal scan parameter settings for preoperative staging using automatic exposure control [18]. We prepared virtual endoscopic and 3D gas insufflation views from the image data obtained for each patient by MDCT volume scans, and two radiologists prepared responses on the basis of all clinical data for each patient, including gastroscopic findings, and the detectability of gastric carcinoma was evaluated by consensus for each display method. Eighty-six gastric carcinoma lesions (44 early and 42 advanced lesions) were diagnosed in the 84 patients. The detectability by virtual endoscopic and 3D gas insufflation views by MDCT gastrography was 47.7% and 40.9%, respectively, for early lesions (Table 1), and 59.5% and 76.2% for advanced lesions (Table 2). Hence, the detectability was less than 50% for early lesions, but about 60%–70% for advanced lesions of gastric carcinoma [19]. Especially in early lesions, all protruded-type lesions could be recognized, while less than half of depressed-type lesions, which is a common type of early gastric carcinoma, were missed (Figs. 9, 10).

TABLE 1. Detectability for 44 early gastric carcinomas by multidetector row computed tomography (MDCT) gastrography

	Protruded type	Flat elevated type	Depressed type	Total
Virtual endoscopic views	100% (2/2)	50.0% (1/2)	45.0% (18/40)	47.7% (21/44)
Three-dimensional gas insufflation views	100% (2/2)	50.0% (1/2)	37.5% (15/40)	40.9% (18/44)

TABLE 2. Detectability for 42 advanced gastric cancers by MDCT gastrography

	Borrman I type	Borrman II type	Borrman III type	Borrman IV type	Total
Virtual endoscopic view	0% (0/1)	84.6% (11/13)	68.8% (11/16)	25.0% (3/12)	59.5% (25/42)
Three-dimensional gas insufflation view	0% (0/1)	76.9% (10/13)	68.8% (11/16)	91.7% (11/12)	76.2% (32/42)

MDCT gastrography is presently inadequate for the detection of gastric carcinoma and its potential for clinical application is low.

Potential for MDCT Gastrography in Preoperative Staging for Gastric Carcinoma

MDCT gastrography is simpler and less invasive than endoscopy and radiography, and permits evaluation of the stomach overall in an examination of short duration. Detection of early lesions is challenging, and although it therefore has low potential as a screening method, it is capable of detecting lesions that are advanced to a certain extent, and also of simultaneously detecting lesions in other organs of the abdomen. In preoperative staging, as for radiography, it is capable of objectively ascertaining the position and overall picture of the primary lesion, and of diagnosing the relations between the degree of extramural invasion and surrounding organs. With the axial images of MDCT, representing a quantum leap in resolution compared with normal CT, it was possible to also diagnose correctly lymph node metastasis. Because MDCT itself is an examination method required for the preoperative diagnosis of local spread or remote metastasis of gastric carcinoma, it is highly likely at present that it can partially replace the role of radiography or ultrasound endoscopy. As well, because the image data of MDCT is digitalized density information, it is possible to selectively visualize 3D information in a manner that is effective for diagnosis, and has a great potential of being a modality for computer-aided diagnosis [20]. By digitally combining the 3D view of the primary lesion and the 3D image data of diagnosed lymph node metastasis, it will be possible to provide surgeons with effective preoperative 3D views of gastric carcinoma (Fig. 11).

Conclusions

As a result of future advancements in image engineering and computer technology, digital radiographic systems and MDCT systems will continue to evolve, and it can be predicted that new diagnostic methods that utilize the advantages of digitalization in the radiological diagnosis of gastric carcinoma will also be developed. MDCT gastrography has little potential at present as a diagnostic method for the primary lesions of gastric carcinoma. However, with further advances in MDCT, higher-speed examinations, improved image quality, and optimization of exposure dose, it appears certain that MDCT gastrography will gradually replace radiography, endoscopy, and ultrasound endoscopy.

Acknowledgments. This work was supported by Grants for Scientific Research Expenses for Health and Welfare Programs and the Foundation for the Promotion of Cancer Research, and by the 3rd-term Comprehensive 10-year Strategy for Cancer Control from the Ministry of Health, Labor and Welfare.

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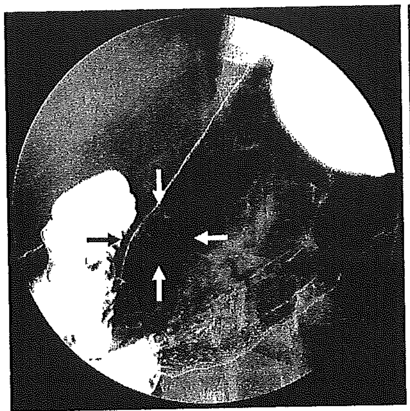

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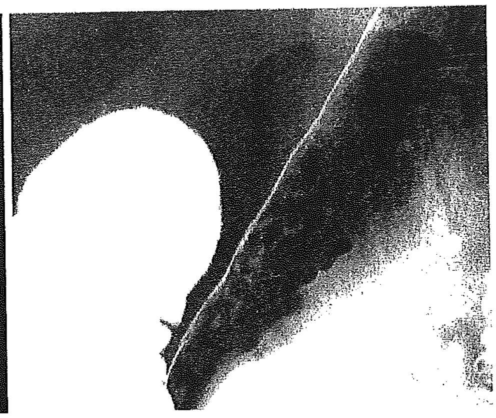
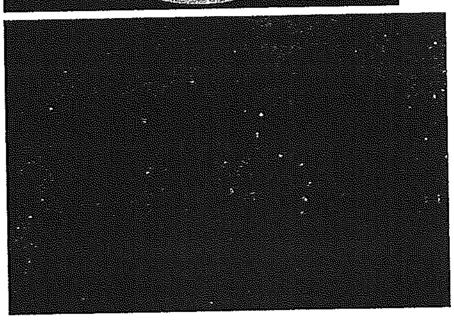
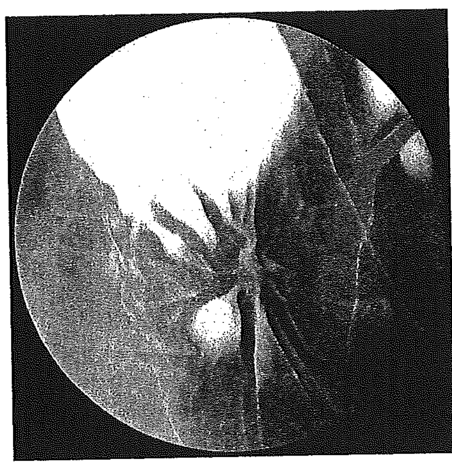
b





c

Fig. 2. A 55-year-old man. A flat lesion is visualized at the lesser curvature side of the lower gastric body (**a**, *arrows*). CCD-DR clearly delineates the irregular surface of the lesion (**b**). Gross specimen shows a flat type of early gastric cancer, 2.5 × 1.5 cm in size (**c**)



a

b

Fig. 3. A 65-year-old woman. A depressed type of advanced cancer with converging folds is clearly demonstrated by CCD-DR at the anterior wall of the middle gastric body (**a**). Gross specimen shows a relatively deep carcinomatous erosion of 5.5 × 4.5 cm. The converging folds partially make some protuberance at the margin of the lesion (**b**)

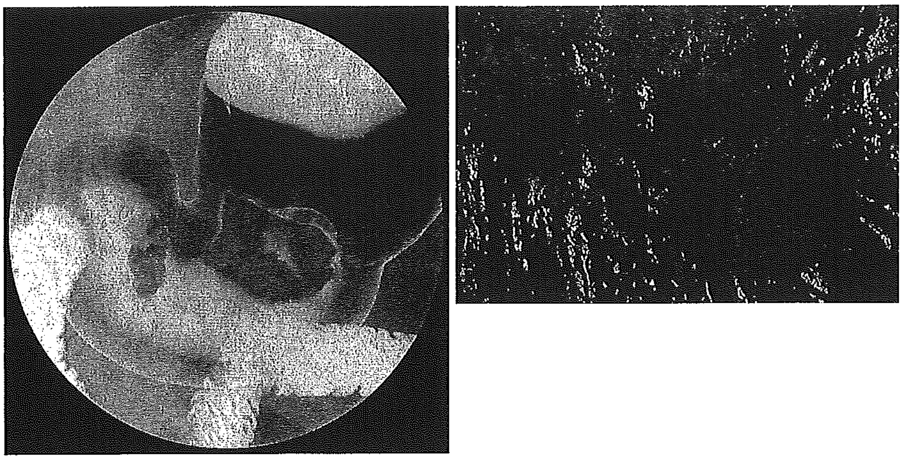


FIG. 4. A 70-year-old man. CCD-DR visualizes two gastric cancers at the posterior of the lower gastric body to the antrum (a). Gross specimen demonstrates a protruded advanced cancer with central ulceration measuring 4.0 cm and a protruded type of early cancer measuring 2.0 cm (b)

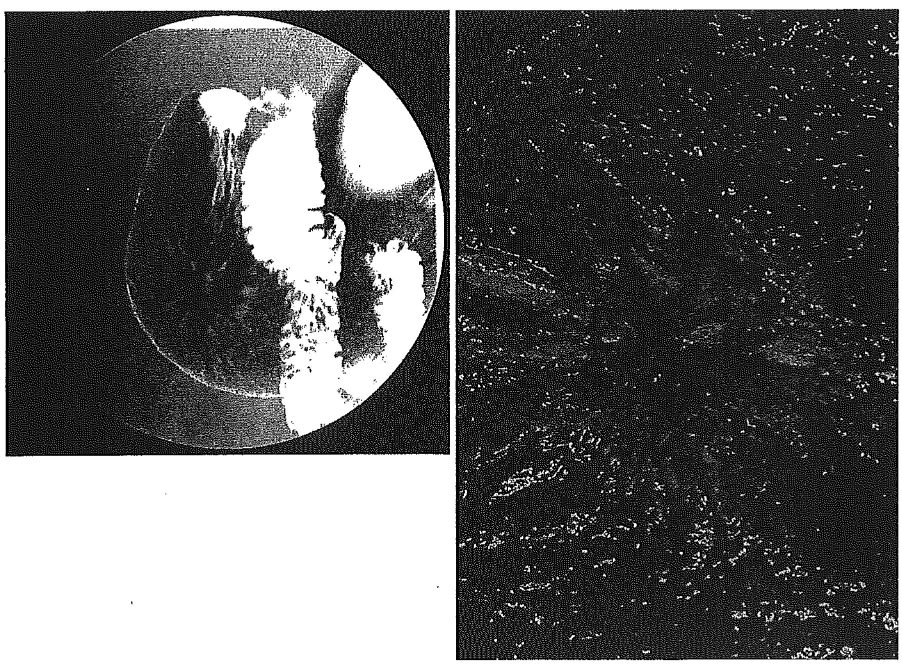


FIG. 5. A 55-year-old man. CCD-DR demonstrates a depressed type of gastric cancer at the posterior wall of the antrum (a). Gross specimen shows a depressed type of advanced cancer 5.0 × 4.5 cm in size (b)

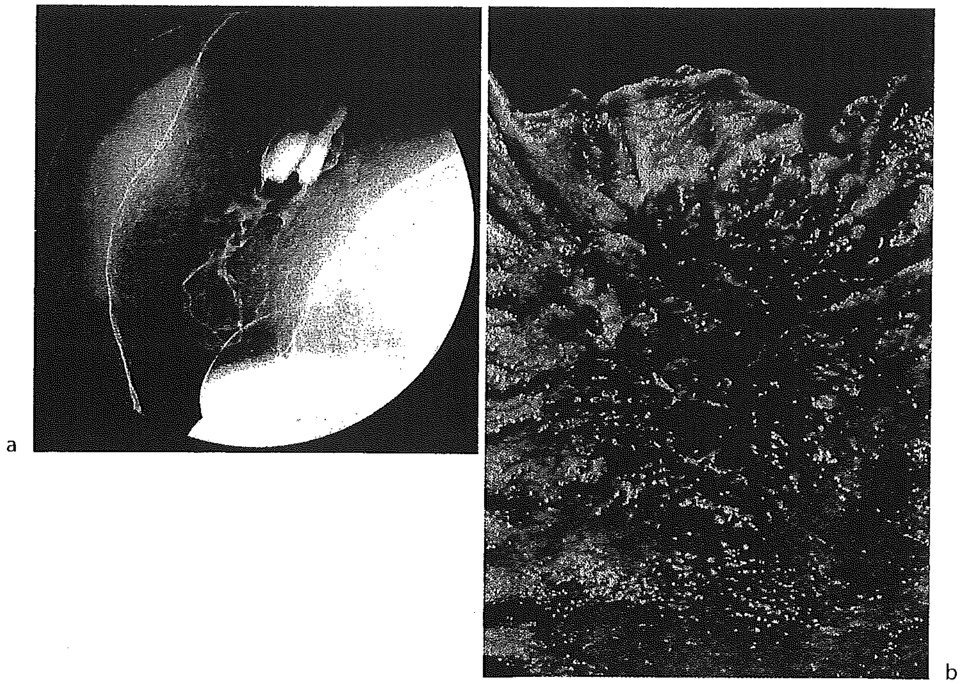


FIG. 6. A 71-year-old man. An advanced cancer is demonstrated by CCD-DR just below the cardia (**a**). Gross specimen shows an ulcerative type of advanced gastric cancer 6.0 cm in diameter (**b**)

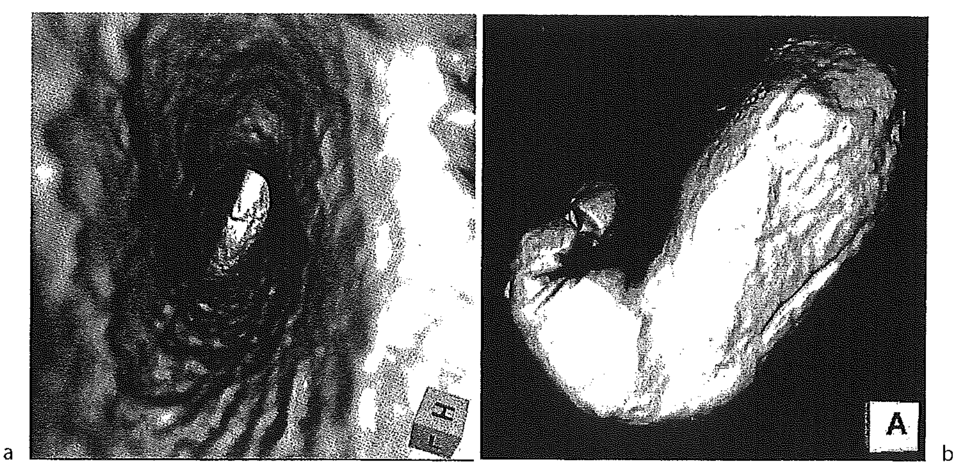
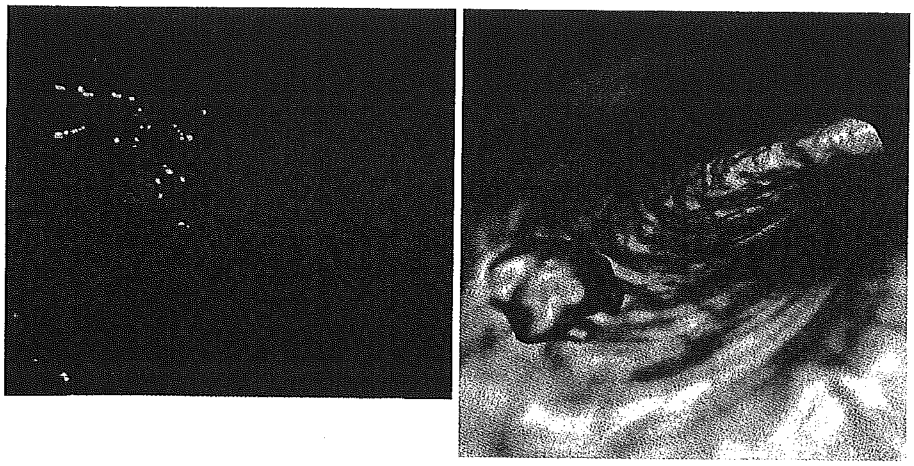
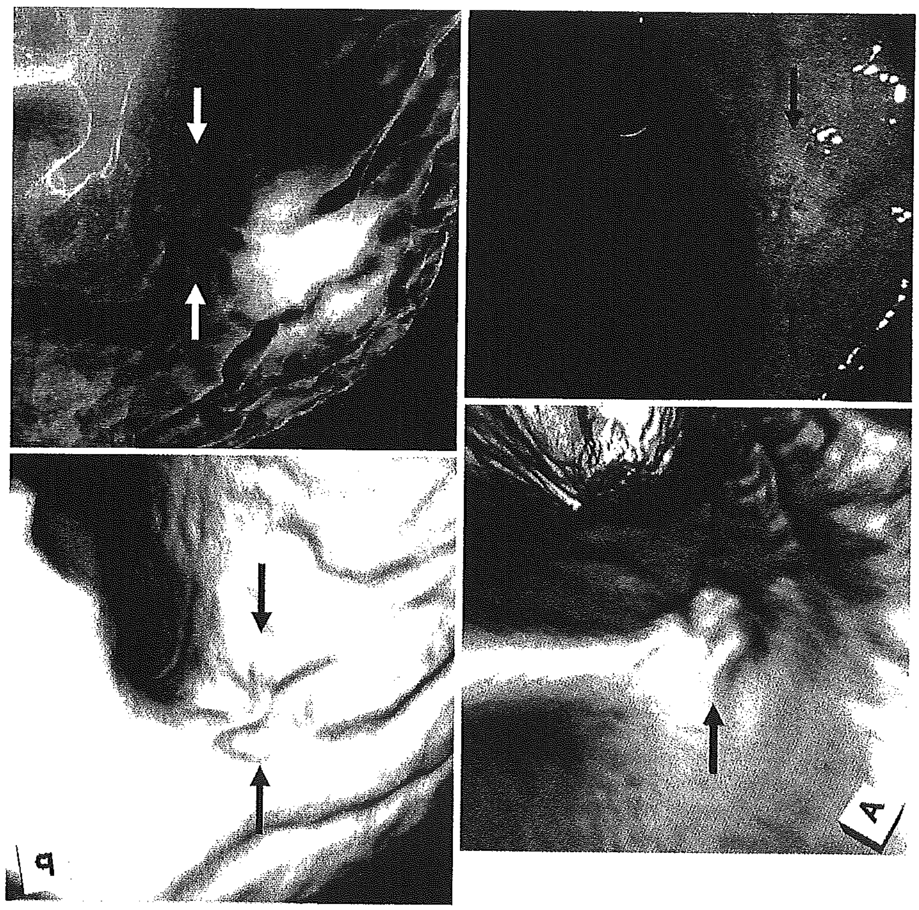


FIG. 8. Two imaging modes of multidetector row computed tomography (MDCT) gastrography. **a** A representative virtual endoscopic view, resembling gastroscopic images. **b** A representative 3D gas insufflation view, resembling radiographic images



a b

Fig. 9. A 63-year-old man. Conventional endoscopy demonstrates a protruded type of early gastric cancer 2 cm in size at the greater curvature side of the upper gastric body (**a**). The lesion is clearly visualized by virtual endoscopic view (**b**)



a b c d

Fig. 10. A 33-year-old man. A small depressed type of early gastric cancer measuring 1.5 cm is identified at the posterior side of the gastric angle by gastric radiography and gastroscopy (*arrows* in **a**, **b**). The lesion can barely be recognized by virtual endoscopic and 3D views of MDCT gastrography (*arrows* in **c**, **d**)

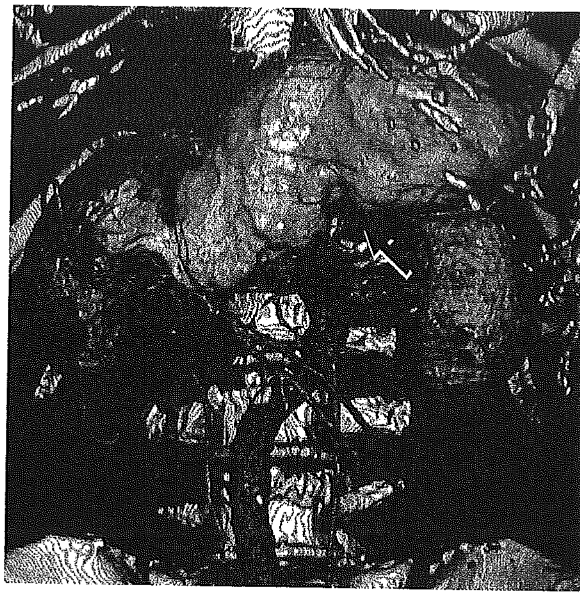


FIG. 11. Three-dimensional imaging of a gastric cancer and lymph node metastases. The 3D view of the primary lesion (*arrow*) and the 3D image data of diagnosed lymph node metastases can be combined digitally to produce effective 3D views of gastric carcinoma in the preoperative staging

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Vascular Virtual Endoluminal Visualization of Invasive Colorectal Cancer on MDCT Colonography

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Technical Innovation

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Vascular Virtual Endoluminal Visualization of Invasive Colorectal Cancer on MDCT Colonography

OBJECTIVE. The purpose of this study was to assess the utility of vascular views for visualization of invasive colorectal cancers on contrast-enhanced MDCT colonography.

CONCLUSION. By means of Hounsfield-transparency settings, we obtained virtual endoluminal images that show vascular structures and delineate invasive cancers of the colorectal wall, and we call these images "vascular views." Using this technique for contrast-enhanced MDCT colonography, we found that the increase in flow and pooling of blood related to angiogenesis of cancerous lesions is easy to identify and that this finding is useful in the detection of invasive colorectal cancers.

CT colonography, a technique for visualizing colorectal lesions using 3D volumetric data generated by helical CT, has developed rapidly over the past several years [1, 2]. This method has been reported to be useful for improving the diagnosis of colonic polyps and is now being considered for colorectal cancer screening in the United States [3, 4]. This potential has been markedly enhanced by the advent of MDCT, which allows acquisition of entire images of the colorectum during a single breath-hold [5]. A major merit of MDCT is its high acquisition speed that can be used to cover large volumes with thin collimation, resulting in good spatial resolution and reduction of the partial volume effect artifact [6]. The thinness of the reconstructed axial CT slices has allowed an increase in the image quality of CT colonography to depict colonic tumors more accurately. Furthermore, in contrast-enhanced studies with MDCT, the ability to scan through the entire abdomen in 20 sec or less means that data for the whole colon can be acquired within the time generally regarded as the arterial-dominant phase.

Detection of lesions on CT depends on lesion size, slice thickness, and contrast differentiation [7]. By means of Hounsfield-transparency settings, we obtained virtual endoluminal images that show vascular structures and delineate invasive cancers of the colorectal wall, called "vascular views," on contrast-enhanced MDCT colonography. Using this technique, we found that the increase in flow and pooling of blood related to angiogenesis of cancerous lesions is easy to identify and that this is useful in the detection of invasive colorectal cancers.

The purpose of this study was to assess the utility of vascular views for the visualization of invasive colorectal cancers on contrast-enhanced MDCT colonography.

Materials and Methods

From January to March 2002, 28 consecutive patients presenting with 30 invasive colorectal carcinomas underwent contrast-enhanced MDCT examinations at our hospital for preoperative staging. The series included 15 men and 13 women, ranging in age from 37 to 77 years (median, 60 years). Of these patients, 22 (78.6%) underwent MDCT after preoperative colonoscopic examinations with standard bowel preparation of up to 3 L of a polyethylene glycol–electrolyte solution, and the remaining six patients (21.4%) with advanced colorectal carcinomas underwent MDCT without preparation. Patients with rectal cancers underwent MDCT in the prone position, whereas a supine position was used for those with colon cancers. Before treatment, patients re-

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AJR 2005;184:1194–1198

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ceived muscular injection of anticholinergic drugs, and room-air insufflation via the anus was performed just before each scan.

Pathologic diagnosis with endoscopic biopsy or surgically resected specimens was confirmed in each case. All colonic tumors had been initially diagnosed at colonoscopy, and the presence and site of the lesion were known at the time of the CT examination.

CT colonography was performed on an MDCT scanner (Aquilion, Toshiba Medical Systems). The scans were obtained through the abdomen and pelvis with the following parameters: 120 kV, 250–350 mA with automatic exposure control [8], 4 rows × 2-mm collimation, and helical pitch of 5 (pitch factor, 1.25). All patients received an IV bolus injection of 150 mL

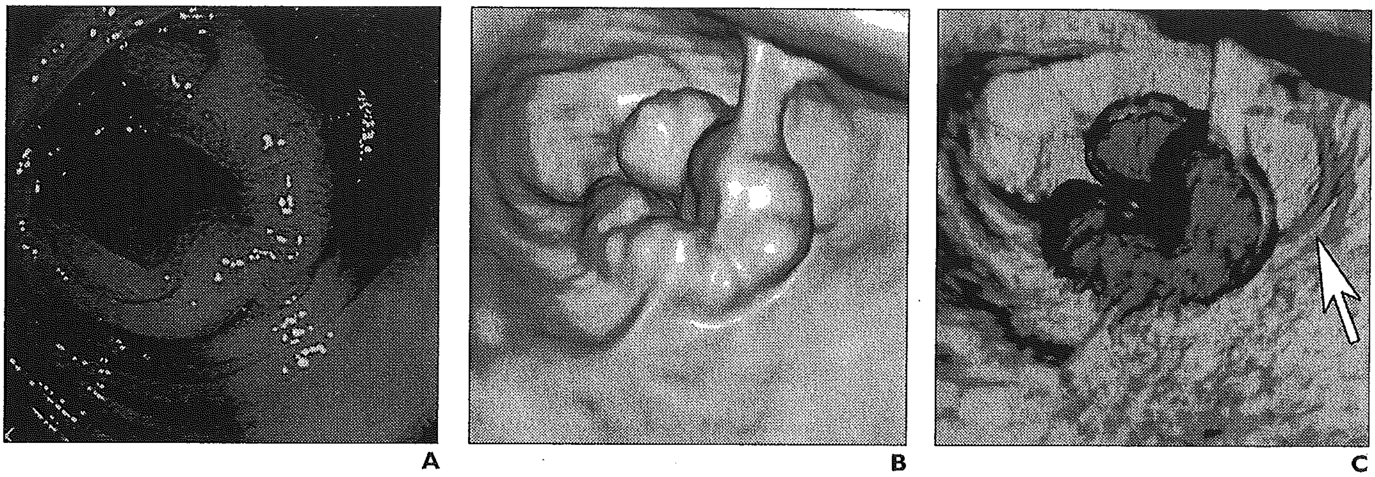


Fig. 1.—Colonoscopic view and surface and vascular virtual endoluminal images for representative case of advanced colorectal cancer in 60-year-old woman.
A, Colonoscopic view shows advanced cancer in sigmoid colon.
B, Surface virtual endoluminal image shows lesion.
C, Vascular virtual endoluminal image clearly shows blood pooling of tumor and vessels (*arrow*) in colorectal wall.

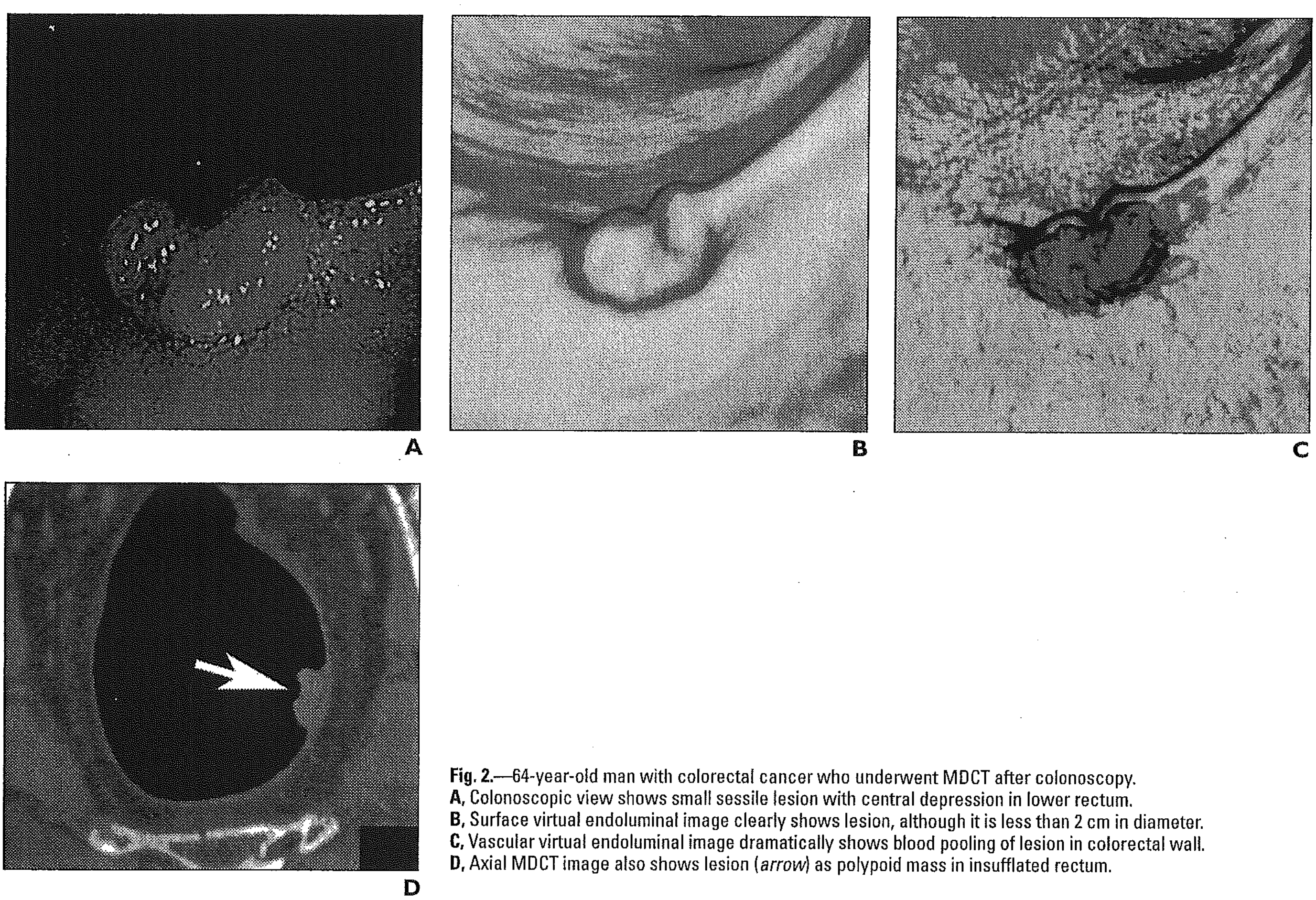


Fig. 2.—64-year-old man with colorectal cancer who underwent MDCT after colonoscopy.
A, Colonoscopic view shows small sessile lesion with central depression in lower rectum.
B, Surface virtual endoluminal image clearly shows lesion, although it is less than 2 cm in diameter.
C, Vascular virtual endoluminal image dramatically shows blood pooling of lesion in colorectal wall.
D, Axial MDCT image also shows lesion (*arrow*) as polypoid mass in insufflated rectum.

of iohexol 350 (Omnipaque, Daiichi Pharmaceutical) with a power injector at a rate of 3 mL/sec through a 20-gauge plastic IV catheter placed in an antecubital vein, and the whole abdomen was scanned 50 sec after this introduction of contrast material during the arterial phase. All images were reconstructed at a thickness of 1 mm, and the slices were transferred to an image workstation (M900/Pegasus, AMIN) for generation of 3D images of each patient.

We used virtual endoluminal images obtained with Hounsfield-transparency settings in MDCT colonography to show a surface or vascular view of the colorectal wall on a videotape monitor (Figs. 1–5). Hounsfield-transparency settings are based on Hounsfield units, which are the CT attenuation values. First, we adjusted the CT monitor's transparency and opacity setting to a value of 1 to display only the contour of the lumen and the mucosa. Next, we adjusted the transparency and opacity setting to a value of 2 to display only the arterial-dominant blood with contrast medium. Third, we adjusted the spatial parameters to display only to a depth of 3 mm surrounding the lumen and the mucosa, which corresponds to the thickness of the intestinal wall. Fourth, we overlaid the data displayed in steps one through three to produce a surface and vascular view of the colorectal wall, and then we reduced the surface opacity to produce an unobstructed vascular view.

The workstation was also equipped with navigation software for virtual colonoscopy, and the two types of virtual endoluminal images were displayed on the monitor. Two radiologists retrospectively evaluated primary lesions using the virtual endoluminal images with or without the Hounsfield-transparency settings—first, with a conventional surface view and then with a vascular view. Consensus interpretations were rated against all clinical information, including the results of colonoscopy; pathologic findings from biopsy and surgically removed specimens served as the gold standard.

Results

In the 28 patients, a total of 30 invasive carcinomas were confirmed by the preoperative colonoscopic examinations. Of the 30 lesions, 18 were in the rectum, five in the sigmoid colon, four in the transverse colon, and three in the ascending colon. The number of lesions over 2 cm in diameter was 21 (70.0%). Of the total, 19 (63.3%) were well differentiated and 11 (36.7%) were moderately differentiated on histologic diagnosis.

Lesions showing invasion limited to the submucosal layer were defined as early invasive colorectal cancer, whereas invasion farther than the submucosal layer was characterized as advanced colorectal cancer. Among the 30 lesions, 23 (76.7%) were advanced colorectal cancer lesions and seven (23.3%) were early invasive colorectal cancer lesions. Invasive lesions larger than 2 cm are generally of more advanced stage, but four (44.4%) of nine small lesions, 2 cm or smaller, were found to be advanced colorectal cancer.

Of the 30 confirmed cancerous lesions, 22 were revealed on conventional surface virtual endoluminal images, whereas 28 could be identified with vascular views (Table 1). The respective figures for lesions 2 cm or smaller were 44.4% (4/9) and 77.8% (7/9). Of lesions larger than 2 cm, three (14.3%) of 21 were missed on surface virtual endoluminal images,

TABLE 1 Detection of Colorectal Lesions Using Conventional Surface Versus Vascular Views for Virtual Endoluminal Imaging with Lesions Categorized by Size

Size of Lesion	No. (%) of Lesions Detected on Virtual Endoluminal Images	
	Conventional Surface View	Vascular View
≤ 2 cm	4/9 (44.4)	7/9 (77.8)
> 2 cm	18/21 (85.7)	21/21 (100)
Total	22/30 (73.3)	28/30 (93.3)

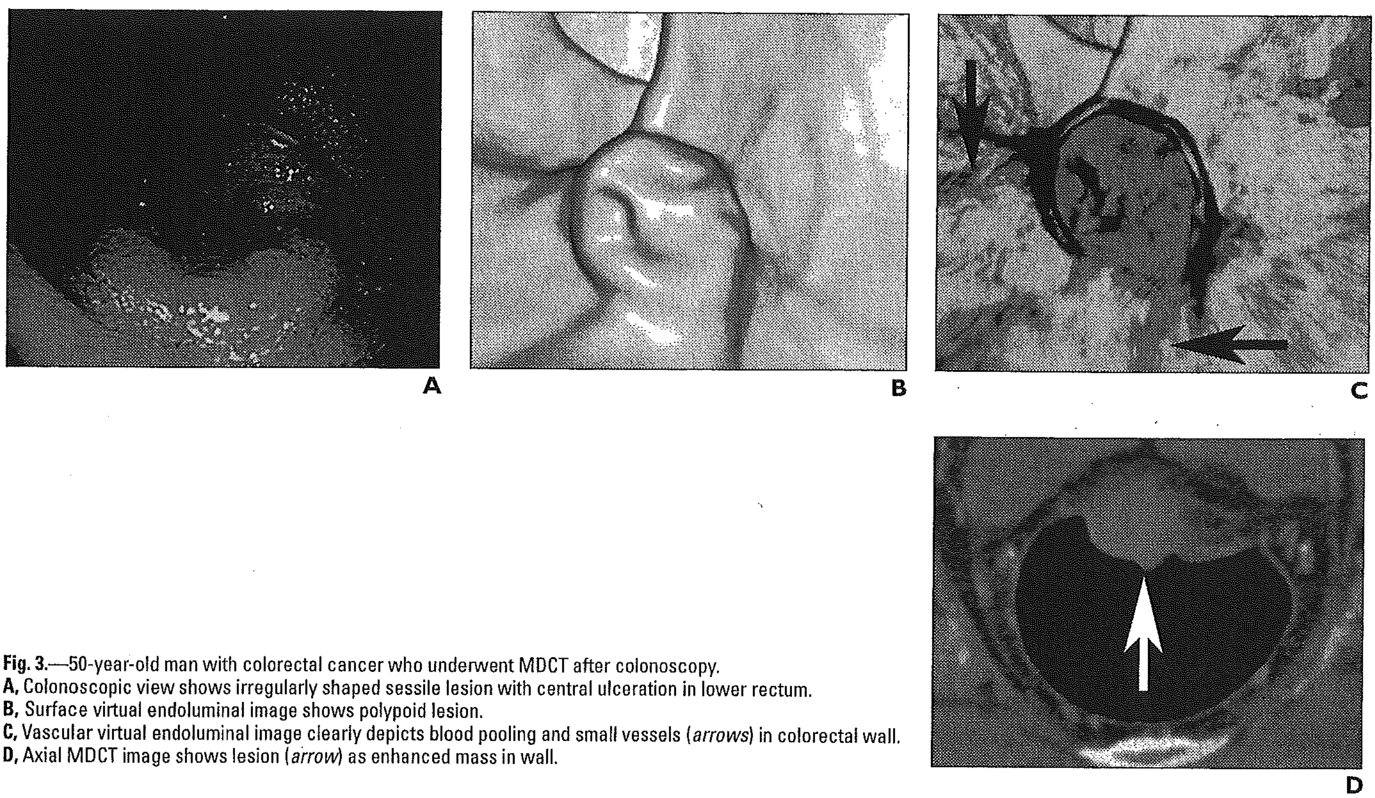
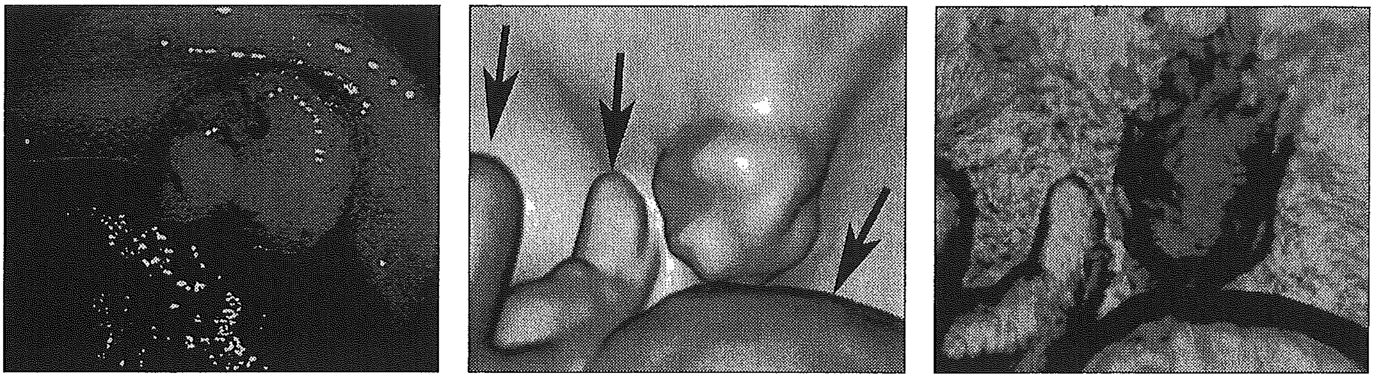


Fig. 3.—50-year-old man with colorectal cancer who underwent MDCT after colonoscopy.
A, Colonoscopic view shows irregularly shaped sessile lesion with central ulceration in lower rectum.
B, Surface virtual endoluminal image shows polypoid lesion.
C, Vascular virtual endoluminal image clearly depicts blood pooling and small vessels (*arrows*) in colorectal wall.
D, Axial MDCT image shows lesion (*arrow*) as enhanced mass in wall.



A B C

D

Fig. 4.—59-year-old man with colorectal cancer who underwent MDCT without preparation.
A, Colonoscopic view shows nodular protrusion in lower rectum.
B, It is hard to recognize lesion in residual stool (*arrows*) on surface virtual endoluminal image.
C, Vascular virtual endoluminal image successfully shows lesion as mass having blood pooling in colorectal wall.
D, Axial MDCT image shows lesion (*arrow*) as enhanced mass in colorectal wall.

A B C

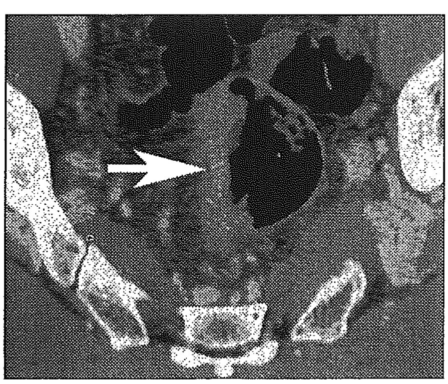


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Fig. 5.—63-year-old man with colorectal cancer who underwent MDCT without preparation.
A, Colonoscopic view shows large mass with central ulceration in upper rectum.
B, Because of stool material, lesion cannot be identified on surface virtual endoluminal image.
C, Vascular virtual endoluminal image dramatically distinguishes lesion from stool.
D, Axial MDCT image shows lesion (*arrow*) as irregular thickening of rectal wall.

TABLE 2 Detection of Colorectal Lesions Using Conventional Surface Versus Vascular Views for Virtual Endoluminal Imaging with Lesions Categorized by Severity of Invasion

Severity of Colorectal Cancer	No. (%) of Lesions Detected on Virtual Endoluminal Images	
	Conventional Surface View	Vascular View
Early invasive		
With preparation	3/7 (42.9)	5/7 (71.4)
Advanced		
With preparation	17/17 (100)	17/17 (100)
Without preparation	2/3 (33.3)	6/6 (100)
Total	22/30 (73.3)	28/30 (93.3)

but all could be visualized on the vascular views. Invasive lesions larger than 2 cm are generally considered to have high potential for malignancy. However, even with the small lesions (≤ 2 cm), almost half were advanced colorectal cancers, so the use of the vascular approach allowed identification of most lesions that should be treated as a high priority (Table 1).

Of the 30 lesions, three of the seven early invasive colorectal cancer lesions were revealed on conventional surface virtual endoluminal images, whereas five of seven could be identified with vascular imaging. All 17 advanced colorectal cancer lesions in cases with preparation could be recognized on the surface and vascular virtual endoluminal images. This finding is especially noteworthy because among six advanced colorectal cancer lesions in patients without preparation, four (66.7%) were missed with the conventional surface approach, but all could be visualized on the vascular virtual endoluminal images (Table 2).

Discussion

Amin et al. [9] first described the merits of dynamic contrast-enhanced CT study with the air-insufflation technique for the detection of colorectal cancers. Subsequently, the same group reported the value of contrast-enhanced CT colonography for the improvement of colorectal polyp detection [10]. With contrast-enhanced CT studies, the advent of MDCT allows acquisition of images of the entire abdomen during a single breath-hold, which is regarded as the arterial-dominant phase. The resulting thinner-collimated transverse images with blood flow information provide better-quality MDCT colonographic data than conventional CT, and these data should further increase the ability to detect not only colonic polyps but also invasive lesions more accurately. In addition, we can manipulate the 3D volumetric data on an image workstation with navigation software for virtual endoscopy or with various display modes including Hounsfield-transparency settings, such as the vascular views, to show information about the blood flow within and around the colorectal wall.

With conventional surface virtual endoluminal images of CT colonography, a surface is just that—a surface. However, as shown in this study, pooling of blood related to angiogenesis of invasive cancers and small vessels of the colorectal wall can be more clearly visualized with vascular views of within the colorectal wall. With the introduction of 16-MDCT scanners, the image quality of virtual endoluminal images is expected to improve even further; therefore, vascular views are going to be more and more in demand not only by radiologists and gastroenterologists, but also by patients who, we believe, will be happy that vascular views require no preparatory fasting, because vascular views are not confused by the absence or presence of stool.

Vascular views also have a great potential for using blood flow information to detect small invasive cancers with computer-aided diagnosis, which is expected to improve radiologists' and gastroenterologists' diagnostic performance enormously [11, 12]. We therefore believe that a focus on the blood supply with the vascular views should be used in conjunction with conventional surface virtual endoluminal images whenever diagnostic or screening contrast-enhanced MDCT is performed until safer contrast media are developed.

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肺腫瘍のCTガイド下気管支鏡検査

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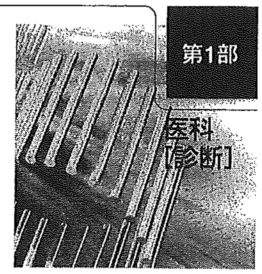

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開発の背景

CTガイド下気管支鏡検査の開発は，気管支鏡検査の限界を解決するための一つのアプローチと考えられる。気管支鏡検査は，合併症が少ないことから末梢肺野病変の確定診断のための第一選択検査であるが，病変を直視下にとらえることができずにX線透視下で病変に達する概念は血管カテーテル検査に近く，むずかしかった。さらに微小で淡い病変は，とくに縦隔に隠された場合など，X線透視下に位置を確定することはむずかしいため，生検もむずかしかった。

CTが普及してくると，理由のいかんを問わず微小で淡い病変が多数発見され，とくに限局性すりガラス状病変などが，病理組織学上は肺がんと診断されることがあるなど，早期診断，治療を可能とする確定診断への要求が高まってきた。

これらの微小病変に対してCTガイド下経皮的肺針生検が施行されていたが，通常のCTを使用した場合には呼吸停止位置の再現性がないため，とくに微小病変ではむずかしく，簡易的ではあるがリアルタイムに近く病変を確認できるCT透視の開発は一つの解決法となった。また胸腔鏡下生検も確定診断手技として施行されたが，良性疾患であった場合の侵襲には大きな問題があった。

これらの背景下にCTガイド下気管支鏡検査は開発された。

開発の経過

まったく新規の手技の開発にあたり，専用の機器装置まで開発することはむずかしい。そこで，高分解能ヘリカルCTによるCT透視を，気管支内腔が確認できない末梢気管支内での誘導ガイドに使用して病変や検体採取器具の3次元的位置を確認する，CTガイド下気管支鏡検査が1995年から開始された。しかしCTのスライス面という二次元平面では，検査器具の方向が確認しづらいことから，初回の検査では外径3 mmの超細径気管支鏡を使用して行なった。

このような誘導補助上のCT透視の限界から，初期では超細径内視鏡などを使用することもあったが，超細径内視鏡は先端の操作性が劣るとともに採取できる検体量が少なく，根本的な問題解決とはなりえなかった。その後，ヘリカルCTにCアームX線透視装置を併置して血管カテーテル検査を補助する，通称IVR-CT装置が開発されると，CTガイド下気管支鏡検査における誘導の問題は一つ