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Index terms:
Colon, CT, 75.1211
Colon neoplasms, CT, 75.311, 75.3192
Colonoscopy, 75.128
Computed tomography (CT), multi–detector row, 75.1211

Published online before print
10.1148/radiol.2303021624
Radiology 2004; 230:629–636

Abbreviation:
DCBE = double contrast barium enema

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Colorectal Polyps and Cancers in Asymptomatic Average-Risk Patients: Evaluation with CT Colonography[1]

PURPOSE: To compare thin-section multi–detector row computed tomographic (CT) colonography with conventional colonoscopy in the evaluation of colorectal polyps and cancer in asymptomatic average-risk patients.

MATERIALS AND METHODS: Sixty-eight asymptomatic men (age > 50 years) scheduled to undergo screening colonoscopy were enrolled in this study. CT colonography was followed by conventional colonoscopy, performed on the same day. Supine and prone CT colonography were performed after colonic insufflation with room air. A gastroenterologist measured all polyps, which were categorized as 1–5, 6–9, or over 10 mm. Biopsy and histologic evaluation were performed of all polyps. CT colonography and colonoscopy results were compared for location, size, and morphology of detected lesions. Point estimates and 95% CIs were provided for specificity and sensitivity of CT by using results at conventional colonoscopy as the reference standard.

RESULTS: At colonoscopy, 98 polyps were identified in 39 patients; 21 (21.4%) of 98 were detected at CT colonography. Sensitivity was 11.5% (nine of 78) for polyps 1–5 mm, 52.9% (nine of 17) for polyps 6–9 mm, and 100% (three of three) for polyps over 10 mm. Results at colonoscopy were normal in 29 (42.6%) of 68 patients; at CT colonography, results were correctly identified as normal in 26 of these 29 patients. In one of these patients, a lesion larger than 10 mm was detected at CT colonography. The per-patient specificity of CT was 89.7% (26 of 29; 95% CI: 72.7%, 97.8%). The mean time for CT image interpretation was 9 minutes.

CONCLUSION: In patients at average risk for colorectal cancer, CT colonography is a sensitive and specific screening test for detecting polyps 10 mm or larger; the sensitivity for detecting smaller polyps is decreased. Examination findings can be interpreted in a clinically feasible amount of time.

Computed tomographic (CT) colonography is a rapidly evolving technique that enables two- and three-dimensional views of the surface of the colon. In current clinical practice, CT colonography is used to evaluate those segments of the colon that are not visible as a result of incomplete colonoscopy and also to evaluate the colon proximal to an obstructing carcinoma (1–3). In addition, CT colonography can also be used to evaluate the colon in patients with a prior allergic reaction to sedation, in elderly and frail patients, and in patients with underlying cardiac or pulmonary disease who have symptoms referable to the colon (such as bleeding or a change in bowel habits) but in whom the gastroenterologist is reluctant to perform an endoscopic evaluation. CT colonography may play a role in general colorectal cancer screening by increasing public acceptance and thus increasing the number of patients who undergo colorectal cancer screening.

Despite current screening options, which include fecal occult blood testing, sigmoidoscopy, double contrast barium enema (DCBE) examination, and colonoscopy, there continue to be approximately 150,000 cases of colon cancer diagnosed annually in the United

States, resulting in 50,000 deaths (4). In the detection of polyps measuring 10 mm or larger, CT colonography has demonstrated a sensitivity ranging 75%–100% (5). When compared with the results of one study, in which the sensitivity of DCBE examination and colonoscopy was evaluated, CT colonography appears to be more sensitive than DCBE examination. In that study of patients who had undergone prior polypectomy, DCBE examination depicted less than 50% of the 10-mm polyps that were detected at conventional colonoscopy (6).

A limitation of current published data on CT colonography is that the majority of studies have been focused on patients who are at high risk for colon polyps or cancers. If a reviewer believes there is high likelihood that a colorectal polyp is present, the colon will be evaluated until a polyp is found. Indeed, many of the studies on the evaluation of CT colonography have used interpretation techniques that require up to 30 minutes to perform (5,7,8). Long interpretation times will ultimately decrease the utility of this examination as a screening test.

In one study of CT colonography performed with 5-mm collimation in a screening population, poor sensitivity was shown for large polyps, with only one of four flat adenomas measuring larger than 2 cm prospectively detected (9). The purpose of our study was to compare the results at thin-section multi–detector row CT colonography with those at conventional colonoscopy in the evaluation of colorectal polyps and cancer in a group of asymptomatic average-risk patients.

MATERIALS AND METHODS

Patients

Between November 2001 and September 2002, 68 men (mean age, 55 years; age range, 50–67 years) recruited from a veterans affairs hospital were enrolled in this study. Patients eligible for inclusion were those who were examined at a gastroenterology clinic and were scheduled to undergo screening colonoscopy. Patients eligible for screening were older than 50 years of age, had no colorectal symptoms, had negative results at fecal occult blood testing, and did not have a family history of colon cancer in a first-degree relative. None of the patients had a history of prior colorectal polyp or had undergone prior sigmoidoscopy, DCBE examination, or colonoscopy. All patients underwent CT colonography and colonoscopy within 1 month of recruitment. Eligible patients were informed of the study design and signed a consent form, approved by our institutional review board, that explained the procedure and study. The CT colonographic examination was performed first and was followed within 3 hours by a colonoscopic examination.

CT Colonography Technique

On the day prior to the study, two 45-mL doses of phosphosoda (Fleet Prep; Fleet Pharmaceuticals, Lynchburg, Va) were administered. Immediately prior to the CT colonographic examination, the patient was asked to evacuate any residual fluid from the rectum at a bathroom in the radiology facility.

CT colonography was performed with a four–detector row CT scanner (Plus 4 Volume Zoom; Siemens Medical Systems, Forcheim, Germany). A flexible rubber catheter was inserted into the rectum, and the colon was insufflated with room air up to patient tolerance (minimum of 40 puffs) by an experienced technologist or nurse practitioner. The catheter was left in the rectum, and a CT scout image was obtained, with the patient in the supine position, to verify adequate bowel distension. If adequate bowel distension was present, the CT examination was performed. If adequate bowel distension was not achieved, additional air was insufflated into the rectum. After air insufflation, supine CT colonography was performed in a cephalocaudad direction to encompass the entire colon and rectum. The patient was then placed in the prone position. Several additional puffs of air were administered. After a second CT scout image was obtained, the process was repeated over the same z-axis range. A trained CT technologist performed and monitored the entire examination.

CT parameters included 4 × 1-mm section collimation, 120 kV, 0.5-second gantry rotation, and 50 effective mAs. Pitch (table feed per gantry rotation/nominal section thickness) was varied between 6 and 7 so that the entire abdomen and pelvis could be scanned within a 30-second breath hold. The pitch needed to be varied to account for differences in patient length so that the acquisition could be completed in 30 seconds. CT images were reconstructed as 1.25-mm-thick sections with a 1-mm reconstruction interval.

CT Data Interpretation

Both the supine and prone reconstructed image data sets were transferred to an offline workstation (Vitrea 2; Vital Images, Plymouth, Minn) where they were reviewed by a radiologist (M.M.) with 5 years experience in CT colonographic data interpretation. The data sets were viewed as continuous 1.25-mm-thick sections in the transverse plane as the primary display method. Since the acquisition protocol allowed data to be obtained with near isotropic voxels, no secondary interpolation was required. When an abnormality was detected during review of transverse images, coronal and sagittal multiplanar reformatted images, as well as volume-rendered endoluminal views, were used to verify the morphology of the lesion. If no abnormality was seen on the transverse images, no further image processing was performed.

The presence, location, size, and morphology of colorectal polyps was assessed in six colonic segments (cecum, ascending colon, transverse colon, descending colon, sigmoid colon, and rectum) to facilitate polyp-to-polyp mapping with conventional colonoscopy.

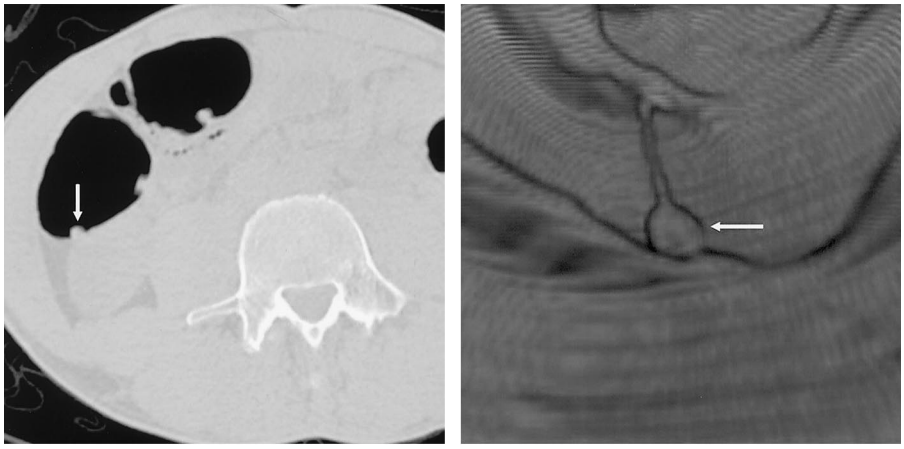
The evaluation time was defined as the time during which image data sets were reviewed and a statement was made as to the presence or absence of polyps. Findings in each patient were prospectively dictated on the same day that the procedure was performed. The reports were not made available to the colonoscopist.

Colonoscopy

Colonoscopy was performed without knowledge of CT findings; the examination was performed by a board-certified gastroenterologist (E.J.B.) with 5 years of experience or a gastroenterology fellow (R.R.) with the direct supervision of the attending gastroenterologist (E.J.B.). All polyps identified at colonoscopy were photographed, sampled for biopsy or removed at snare polypectomy, and sent for histologic analysis. Polyps were measured in millimeters with the open biopsy forceps technique. The location of each polyp was mapped within the same six colonic segments used in the CT analysis.

CT Colonography and Colonoscopy Data Comparison

The radiologist and the gastroenterologist reviewed the findings from each examination on a weekly basis. For purposes of analysis, colonoscopy was considered the standard of reference. Therefore, a true-positive result was defined when CT colonography and conventional colonoscopy both depicted a lesion in the same anatomic segment with similar morphology and



a. b.

Figure 1. CT images of a 7-mm false-positive finding in a 54-year-old man. **(a)** Transverse image shows a lesion (arrow) on the dependent wall of the ascending colon. **(b)** Endoluminal image shows the pedunculated morphology (arrow) of a lesion thought to be a polyp. At colonoscopy, no polyp was seen. The finding is believed to represent fecal residue.

size. In regard to morphology, all lesions were characterized as flat, sessile, or pedunculated. A lesion was considered a match if it was in the same segment, it had the same morphology, and there was a difference of 3 mm or less between the two examinations. A difference of 3 mm was considered acceptable since, when using an open biopsy forceps technique for size analysis, some variability exists in the exact size measurement at colonoscopy. In cases in which there was some discrepancy (within 3 mm) between the two examinations, the gastroenterologist and radiologist determined in consensus the best size estimate for the lesion. A true-negative finding was present when both CT colonography and conventional colonoscopy depicted no abnormalities within the same segment. A false-positive finding was defined as when CT colonography depicted an abnormality in a segment that was not depicted at conventional colonoscopy. A false-negative finding was present when a lesion was detected in a segment at conventional colonoscopy but not at CT colonography.

Histologic Analysis and Retrospective Image Review

In all cases in which a polyp was present at colonoscopy, a pathologist reviewed the biopsy material. The pathology report on this material was reviewed to determine the histologic diagnosis of all polyps on which biopsy had been performed. Moreover, in all cases where a polyp larger than 5 mm was present at colonoscopy but was not prospectively identified at CT colonography, CT data were retrospectively evaluated by the same radiologist who performed the initial data interpretation to determine reasons for initial nonvisualization. Finally, when a polyp was reported at CT but was not present at colonoscopy, the CT data were reviewed to determine reasons for false-positive results.

Statistical Analysis

All analyses were conducted by using SAS system software (version 8.01; SAS Institute, Cary, NC). Point estimates and 95% CIs are provided for the specificity and sensitivity of CT by using the results from conventional colonoscopy as the reference standard. The CIs for per-patient specificity and sensitivity were obtained by using binomial distribution and have exact 95% CIs. The CIs for per-polyp sensitivity were generated by inverting CIs for logistic regression model parameters that were obtained by using generalized estimating equations. For this analysis, the dependent variable was the binary indicator of whether a polyp detected at conventional colonoscopy was also detected at CT. The underlying logistic regression model included the indicator of polyp size ($\leq$5 mm, 6–9 mm, $\geq$10 mm) as a fixed classification variable and the number of polyps detected at conventional colonoscopy for each patient as a numeric covariate. The correlation structure introduced by the presence of multiple polyps in a subset of patients was modeled by using the indicator variable identifying patients as the subject factor in the repeated statement of PROC GENMOD in the SAS program.

RESULTS

The mean time to evaluate the CT colonographic data sets was 9 minutes (range, 5–15 minutes). Of the 68 patients enrolled in the study, 29 (42.6%) had normal results at colonoscopy, without evidence of polyp. CT colonographic images were interpreted as normal in 26 (89.6%) of these 29 patients. In one of the remaining three patients, a 7-mm lesion and a 3-mm lesion were identified in the ascending colon. In a second patient, a 4-mm lesion was seen in the sigmoid colon (Fig 1). None of these three lesions were seen at conventional colonoscopy. These two patients were noted to have a large amount of residual fecal material at both conventional colonoscopy and CT colonography, which probably accounted for the false-positive findings. In a third patient, a 16-mm lesion was seen in the splenic flexure, which was not noted at conventional colonoscopy (Fig 2). In retrospect, this finding likely represented a bulbous fold. In terms of depicting polyps of any size, the per-patient specificity of CT was 26 of 29, or 89.7% (exact 95% CI: 72.7%, 97.8%). Thus, we are at least 95% confident that the specificity of CT was no less than 72.7%. In terms of polyps at least 10 mm in size, the per-patient specificity of CT was 98.5% (64 of 65; exact 95% CI: 91.7%, 99.9%).

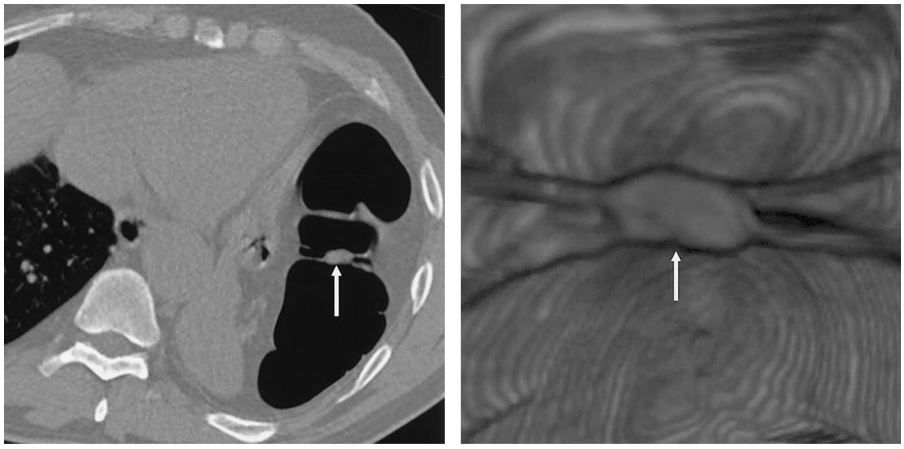
At least one polyp was identified at colonoscopy in each of the remaining 39 patients. In these 39 patients, colonoscopy depicted 98 polyps. Hence, the mean number of true-positive polyps detected per patient was 2.51 (98 in 39 patients), and the mean number of polyps per patient screened was 1.44 (98 in 68 patients). The maximum number of polyps detected in an individual patient was eight. The distribution of the number of polyps detected per patient at conventional colonoscopy is given in Table 1. Table 2 provides an analysis of the 98 polyps by size (as discerned at conventional colonoscopy). Table 3 provides an analysis of the 68 patients according to the size of the largest polyp detected at conventional colonoscopy. Note in particular that the three polyps 10 mm or larger were detected in three separate patients.

Of the 98 true-positive polyps found at conventional colonoscopy, 21 were depicted at CT colonography (21.4%; 95% CI: 14.2%, 31.1%. If categorized by polyp

size, CT colonography depicted nine (11.5%) of 78 of the 1–5 mm polyps (95% CI: 5.4%, 23.3%), nine (52.9%) of 17 of the 6–9 mm polyps (95% CI: 29.1%, 75.5%), and all three (100%) of the polyps 10 mm or larger (95% CI: 36.8%, 100%) (Figs 3–5; Table 4).

Among the 77 polyps not detected at CT colonography, results of histologic analysis were evaluated (Table 5). Analysis of the 69 polyps 5 mm or smaller at CT colonography showed that 20 (28.9%) were normal colon, 26 (37.6%) were hyperplastic polyps, 17 (24.6%) were tubular adenomas, four (5.8%) were tubulovillous adenomas, none were villous adenomas, and two were ulcers. Histologic analysis of the eight 6–9-mm polyps that were not detected at CT colonography showed that two (25.0%) were normal colon, two (25.0%) were hyperplastic polyps, two (25.0%) were tubular adenomas, one was a tubulovillous adenoma (12.5%), none were villous adenomas, and one (12.5%) was an ulcer.

No colorectal lesions measuring 10 mm or larger were missed in this series. However, there was a 10-mm lesion at the anorectal junction (dentate line) that was not detected at CT in this study. In retrospect, this area could not be evaluated, since it is not adequately distended with current insufflation techniques. Since this lesion was at the dentate line, it was not included in the analysis.



a. **b.**

Figure 2. CT images of a 16-mm false-positive finding in a 62-year-old man. **(a)** Transverse image shows a lesion (arrow) on a haustral fold in the splenic flexure. **(b)** Endoluminal image shows the sessile morphology (arrow) of a lesion thought to be a polyp. At colonoscopy, no polyp was seen. The finding is believed to represent a bulbous fold.

TABLE 1
Polyps Detected per Patient at Colonoscopy

No. of Polyps Detected	No. of Patients
0	29
1	12
2	13
3	6
4	4
5	1
6	1
7	1
8	1

TABLE 2
Number of Polyps by Size at Colonoscopy

Polyp Size (mm)	No. of Polyps
1–5	78
6–9	17
≥10	3

TABLE 3
Largest Polyp Detected per Patient at Colonoscopy

Largest Polyp (mm)	No. of Patients
No polyp detected	29
1–5	23
6–9	13
≥10	3

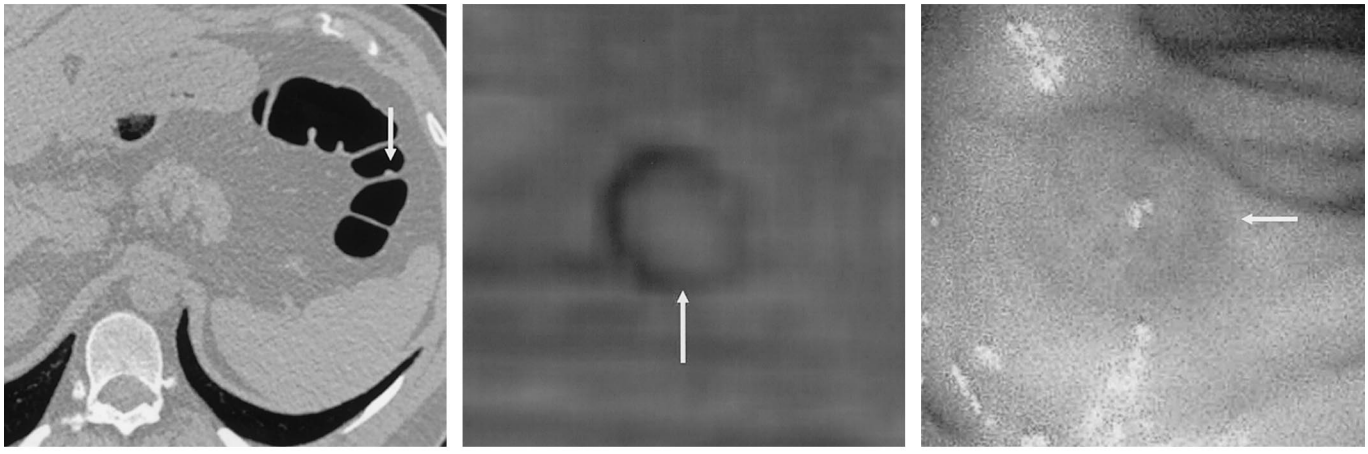
DISCUSSION

Colorectal cancer is a curable disease if detected and treated early. Screening may decrease the morbidity and mortality rates associated with colorectal cancer by enabling detection and removal of premalignant adenomatous polyps before they become invasive cancers (10–16). There is currently consensus among health care providers and policy makers that screening for colorectal cancer is justified (10). The Centers for Disease Control has set goals and committed funding to decrease the number of deaths from colorectal cancer. Among the strategic goals is to increase the number of patients accessing colorectal cancer screening from the current level, which is approximately 37%, to 50% by the year 2010 (*www.cdc.gov/cancer/screenforlife/index.htm*). Current options available for colorectal cancer screening include digital rectal examination, fecal occult blood testing, sigmoidoscopy, barium enema examination, colonoscopy, or some combination of these tests (16).

Despite consensus on the need for colon cancer screening and the multiple options currently available, there are 150,000 new cases of colorectal cancer diagnosed every year in the United States, with approximately 55,000 deaths (4). Since most colorectal polyps grow slowly from precancerous adenomas to invasive cancer, and since screening can enable us to detect precancerous adenomas, the high incidence of cancer is preventable. There are many reasons for the continued high incidence of colon cancer, including patient reluctance to undergo screening, limitations of current screening options, and confusion about when to perform current screening options. Study results have also demonstrated that even health care professionals are reluctant to undergo colon screening (17).

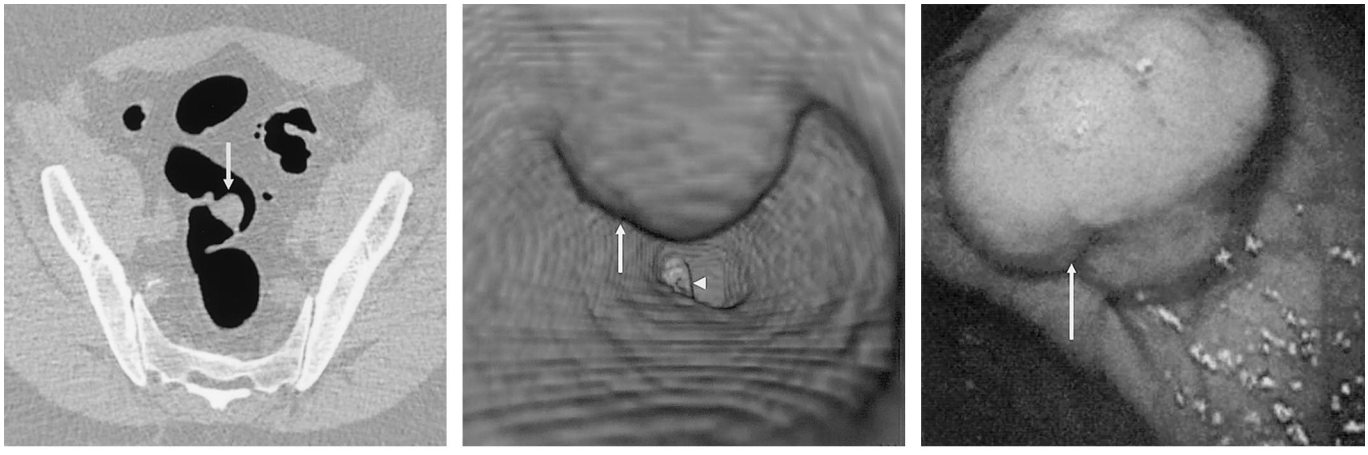
Each of the current screening options has important limitations. While the performance of yearly fecal occult blood testing has demonstrated a mortality reduction from colorectal cancer, fecal occult blood testing does not enable direct evaluation of the colonic mucosa (18). Many large adenomatous polyps do not bleed, and occasionally cancers will not bleed. In addition, there are many false-positive results with fecal occult blood tests for colon cancer, which can lead to further testing and expense. Results of one study demonstrated that in more than 50% of occult heme-positive stool examinations, the source was the upper gastrointestinal tract (19).

Screening with sigmoidoscopy has been shown to decrease the mortality rate of colorectal cancer (20). However, sigmoidoscopy fails to enable evaluation of the



a. b. c.

Figure 3. Images of a 5-mm true-positive finding in a 65-year-old man. **(a)** Transverse CT image shows a lesion (arrow) on a haustral fold in the splenic flexure. **(b)** Endoluminal CT image shows the raised morphology (arrow) of the lesion. **(c)** Conventional colonoscopic image shows the same lesion (arrow). Histologic evaluation showed this to be a hyperplastic polyp.



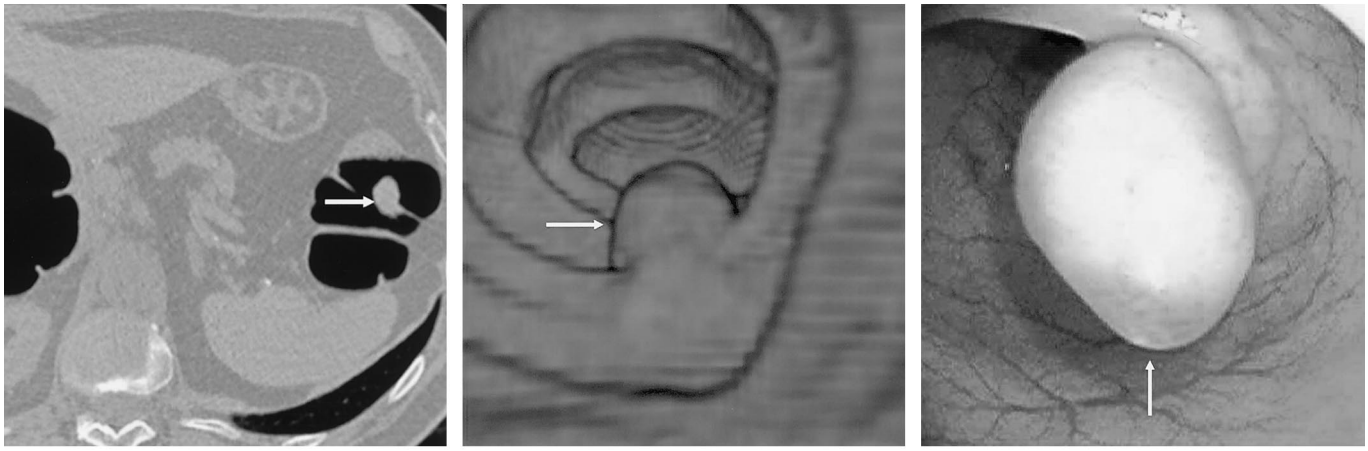
a. b. c.

Figure 4. Images of a 24-mm true-positive finding in a 58-year-old man. **(a)** Transverse CT image shows a large lesion (arrow) in the distal sigmoid colon. **(b)** Endoluminal CT image shows the rounded morphology (arrow) of the lesion. Note the tip of a rectal tube (arrowhead). **(c)** Conventional colonoscopic image shows same lesion (arrow). Histologic evaluation showed this to be a tubular adenoma.

entire colon and, therefore, complete colon screening is not performed (21,22). In two studies involving the evaluation of sigmoidoscopy and colonoscopy, similar results were found. If only sigmoidoscopy was performed for colon screening in an asymptomatic population, many advanced proximal carcinomas would be missed (21,22). This is true even after taking into account the fact that if a clinically important distal lesion was detected during sigmoidoscopy, it would prompt a complete colon examination with colonoscopy. In fact, in half the cases of proximal cancers in these studies, there was no distal polyp that would have prompted colonoscopy. Moreover, it appears that the combination of fecal occult blood testing and sigmoidoscopy does not result in a substantial improvement in the efficacy of screening (23,24). Results of one study showed that in a population of 2,884 screening patients with negative results at fecal occult blood testing who then underwent endoscopic evaluation of the distal colon (rectum and sigmoid), advanced colonic neoplasia was missed in 24% of patients (23).

There are currently two options for a full colonic evaluation: colonoscopy and DCBE examination. The sensitivity of the DCBE examination for polyp detection is incompletely documented. One study demonstrated a sensitivity of 81% for DCBE examination when compared with colonoscopy in diagnosing polyps of at least 10 mm (25). Norfleet et al (26) determined that the sensitivity of DCBE examination was 26% in depicting polyps larger than 5 mm, compared with a sensitivity of 13% for single contrast barium enema. Smith and O'Dwyer (27) found a sensitivity of 21.7% for DCBE examination compared with 91.4% for colonoscopy in depicting polyps larger than 10 mm. In a study comparing DCBE examination with colonoscopy for the detection of polyps in patients with prior polypectomy (surveillance evaluation), results demonstrated poor sensitivity for DCBE examination. In that study, more than 50% of polyps larger than 10 mm were missed with DCBE examination (6).

Complete colonoscopy allows the most



a. b. c.

Figure 5. Images of a 16-mm true-positive finding in a 55-year-old man. **(a)** Transverse CT image shows a large lesion (arrow) in the splenic flexure. **(b)** Endoluminal CT image shows the rounded morphology (arrow) of the lesion. **(c)** Conventional colonoscopic image shows the same lesion (arrow). Histologic evaluation showed this to be a tubular adenoma.

thorough evaluation of the colon, with the added benefit of biopsy or excision of suspicious lesions. It is considered the standard of colonic evaluation (10,23). There are many limitations to the widespread use of colonoscopy for screening, including the examination time, need for sedation, potential risk of perforation, and failure to complete the examination in up to 10% of patients (28,29). Other important limitations include an insufficient number of trained endoscopists to perform screening colonoscopy in all eligible patients and the expenses incurred. In the United States, the median reimbursement rate for colonoscopy is $1,736 (28,29).

CT colonography is a relatively new technique that is slowly gaining acceptance as a third technique for evaluating the entire colon (30). Currently, CT colonography is used to evaluate the colon in patients after an incomplete colonoscopy and in those patients with an obstructing carcinoma (1–3). In centers where CT colonography is performed, referrals are also made to patients who are poor candidates for conventional colonoscopy, including those with comorbid medical conditions. CT colonography is currently considered promising but investigational as an option for colorectal screening. No formal request of consideration for reimbursement has been submitted to the Centers for Medicare and Medicaid Service nor do any commercial insurers reimburse patients for the procedure.

Results of initial studies evaluating CT colonography and conventional colonoscopy showed promise in the ability of CT to depict colorectal polyps and cancers (5,8,31,32). Most published study results on CT colonography have demonstrated a sensitivity of over 90% for the depiction of colorectal polyps measuring 10 mm or larger when correlated with conventional colonoscopy (5). In a study of 100 patients undergoing CT colonography and conventional colonoscopy, results showed CT colonography to have a sensitivity of 100% for colorectal carcinoma, 91% for polyps that were 10 mm or larger, and 82% for polyps that were 6–9 mm (9).

TABLE 4
Polyp Detection Rate at CT Colonography

Polyp Size (mm)	No. of Polyps Detected (n = 98)	Sensitivity (%)
1–5	9/78	11.5
6–9	9/17	52.9
≥10	3/3	100

Note.—Total numbers of polyps determined by using conventional colonoscopy as the reference standard.

TABLE 5
Histologic Analysis of Polyps Missed at CT Colonography

Diagnosis	Polyp Size (mm) 1–5	6–9	≥10
Normal colonic mucosa	20 (28.9)	2 (25.0)	0
Hyperplastic polyp	26 (37.6)	2 (25.0)	0
Adenoma			
Tubular	17 (24.6)	2 (25.0)	0
Tubulovillous	4 (5.8)	1 (12.5)	0
Villous	0	0	0
Other*	2 (3.2)	1 (12.5)	0

Note.—Data are numbers of polyps, and data in parentheses are percentages.
* Lymphoid aggregate or ulcer.

At CT colonography, the detection of polyps measuring 5 mm or smaller is consistently poor. In our study, the sensitivity in this group was 11.5%. The clinical importance of these small raised polyps is questionable (33). Many represent hyperplastic polyps (37.6% in our series) or normal elevations of the colonic mucosa (28.9% in our series). However, a substantial percentage prove to be small adenomas (30.4% in our series). These lesions are difficult to detect at CT colonography. The importance of these lesions is debated by gastroenterologists, radiologists, colorectal surgeons, and oncologists.

Perhaps of more concern is the so-called flat adenoma, which is almost impossible to detect at CT colonography. In a previous report, the difficulty in detecting these lesions with CT colonography was discussed (9). These lesions are relatively rare among populations in Western countries. The ability of CT to depict the majority of clinically important lesions is still relative. It should be pointed out that even colonoscopy has limitations in its ability to depict all colorectal polyps (34).

There have been few series results published on the evaluation of CT colonography and conventional colonoscopy in a screening population (33,34). In a series of 42 asymptomatic patients undergoing

screening CT colonography and conventional colonoscopy, four of six (67%) polyps 6 mm or larger were detected at CT (35). Sensitivity for polyps 5 mm or smaller was 20%. In a study by Rex et al (9), in 46 patients undergoing screening CT colonography and colonoscopy, results demonstrated a low sensitivity of CT colonography in depicting not only small polyps (11% for polyps 5 mm or smaller) but also larger flat lesions. In that study, of four flat adenomas larger than 2 cm that were present at colonoscopy, only one was identified with CT colonography. The results of the study by Rex et al seem to suggest that CT colonography may not be an accurate screening test for colorectal polyps; however, as pointed out in an editorial accompanying the article on that study, it is too early to pass judgment regarding CT colonography on the basis of a single report (36). It is important to note that, in these screening studies, CT colonography was performed by using single– or two–detector row helical CT scanners and 5-mm-thick sections.

Despite the improved acquisition that is afforded by using multi–detector row CT, the majority of diminutive polyps are not seen at CT colonography. CT colonography did depict 56% of polyps 6–9 mm and 100% (three of three) colorectal polyps measuring 10 mm. Results of most studies evaluating CT colonography have found the sensitivity of the test to be between 50% and 70% for lesions measuring 6–9 mm (7,8). In our study, only nine (52.9%) of 17 lesions in this size range were detected at CT colonography. Yet if we look at the histologic analysis of the eight missed lesions in this size range, two were normal colonic mucosal protrusions, two were hyperplastic polyps, and one was an ulcer. Therefore, if these benign conditions were excluded, the sensitivity of CT colonography for polyps in this size range would be nine (75%) of 12. In the future, computer-aided detection techniques may improve the sensitivity of the test for colorectal polyps measuring 6–9 mm (37). In addition, there was a flat lesion at the dentate line that could not be seen even in retrospect because this area cannot be distended at CT colonography. This is another important limitation of CT colonography and screening. Very low rectal and/or anal lesions frequently cannot be identified because these segments cannot be distended. Therefore, in conjunction with CT colonography, a digital rectal examination should be performed by an experienced clinician.

While there are limitations of CT colonography in the detection of smaller polyps, current colorectal screening programs are limited in terms of numbers of patients evaluated and patient acceptance of the study. If a simpler and less painful screening examination exists, patients may be more willing to undergo the procedure. In a recent study of patient preferences comparing conventional colonoscopy and CT colonography, 82% favored CT colonography (38).

There are several limitations to this study. Our study group included only 68 men and, therefore, it cannot be called a "screening population." However, the inclusion criteria would allow this group to accurately be characterized as an average-risk population. Given the small number of patients in this study, further investigation of CT colonography in a screening population is warranted, and we are continuing to evaluate CT colonography for this indication. A multicenter trial in patients at average risk for colorectal cancer is currently underway, which should help to determine the performance characteristics of CT colonography in a screening population. Also, one experienced reader interpreted all data sets, and the results may not be similar with less-experienced readers. As with most examinations, there is a learning curve associated with CT colonographic data interpretation. Courses are now being set up around the United States, at academic institutions where CT colonography is performed, in an attempt to educate radiologists in data interpretation techniques.

In conclusion, the results of this study suggest that screening CT colonography is a sensitive and specific test for detecting colorectal polyps 10 mm and larger. In a screening population, the sensitivity for smaller polyps will be lower. This is a limitation of CT colonography. However, if patients undergo routine interval screening every 5 years, missing small lesions is likely to be clinically insignificant. It is important to note that by having a relatively noninvasive screening tool available for colorectal screening, more patients may ultimately undergo screening, thereby leading to increased detection and ultimately removal of clinically important adenomas.

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